APEX

Groundwater Source Control Evaluation and Alternatives Analysis Willamette Cove Upland Facility Portland, Oregon

Prepared for:
Port of Portland

June 21, 2019
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1.0 Introduction

1.1 Purpose

This report presents a combined Source Control Evaluation and Source Control Alternatives Evaluation (SCE/SCAE) for groundwater at the Willamette Cove Upland Facility (the Facility). This SCE/SCAE was performed in response to a request by the Oregon Department of Environmental Quality (DEQ) to identify, evaluate, and recommend remedial actions to address sources of groundwater contamination that may reach the Willamette River, consistent with the DEQ-U.S. Environmental Protection Agency (EPA) Portland Harbor Joint Source Control Strategy (JSCS; DEQ/EPA, 2005). This work was performed under Voluntary Cleanup Agreement EC-NWR-00-26 (VCP Agreement) between the Port of Portland (Port), Metro, and the DEQ. The Facility is defined in the DEQ Environmental Cleanup Site Information (ECSI) database as ECSI No. 2066.

1.2 Objectives

The objectives of the SCE/SCAE are to:

1. Identify potential sources of groundwater contamination;
2. Evaluate the potential sources identified; and
3. Recommend controls of potential sources of groundwater contamination that may adversely impact the Willamette River.

1.3 Report Organization

This report is divided into 12 additional sections.

- Section 2 discusses background information on the Facility, including historical and current site use, potential sources of contamination, nearshore sediment data, chemicals of interest, and regulatory history. Nearshore sediment data are summarized in Appendix A.
- In Section 3, hazardous releases and previous site investigations are summarized.
- In Section 4, potentially complete groundwater migration pathways from the Facility to the river are identified.
- Section 5 describes the groundwater conditions on the Facility, including sampling locations, events, and a summary of depth to groundwater.
- Section 6 contains a screening evaluation of groundwater data. Groundwater data are presented in tables and figures.
- In Section 7, a weight-of-evidence evaluation of the potential for contaminant transport to the river is presented.
- Section 8 presents the nature and extent of source control contaminants of concern (COC) in groundwater.

- Section 9 presents the objectives, goals, and evaluation criteria for groundwater source control alternatives evaluation.
- In Section 10, potential groundwater source control technologies are evaluated, and feasible alternatives are developed.
- Section 11 presents a detailed evaluation of the developed alternatives.
- Section 12 compares each alternative based on the evaluation criteria.
- In Section 13, a source control alternative is recommended.

2.0 Site Description and History

2.1 Site Description

The Facility is located along the northeast bank of the Willamette River in the St. Johns area of Portland, Oregon. Figure 1 shows the location of the Facility. The Facility is situated between River Miles 6 and 7 on the Willamette River and is mostly in Section 12 of Township 1 North, Range 1 West, Willamette Meridian. The Facility has been owned by Metro since 1996. Figure 2 provides a current plan of the Facility as well as the surrounding area. For purposes of describing the Facility, it has been divided into West, Central, and East Parcels as shown on Figure 2.

Extent of the Upland Facility. The upland portion of the Facility is approximately 3,000 feet long and varies from 110 to 700 feet in width. The cove is set in up to 800 feet from the main river channel; it was created primarily as a result of the placement of the embankment leading up to the Burlington Northern Santa Fe (BNSF) railroad bridge. The Facility as defined in the VCP Agreement covers approximately 24 acres of upland area that is inland from the ordinary low water line (OLWL). However, the scope of work for the VCP Agreement limits the work to inland from the mean high water (MHW) line (defined as 13.3 feet, North American vertical datum 88 [NAVD88] datum) to the property line with the Union Pacific Railroad (UPRR). DEQ, the U.S. Environmental Protection Agency (EPA), and the Port have agreed that the site riverbank at the Facility (defined as the area from the waterline to the top of bank [TOB]) will be addressed as part of in-water activity associated with the Portland Harbor Superfund Site (PHSS).

Access. The Facility is accessible by vehicle from North Edgewater Street. A locked gate is present at the north end of North Edgewater Street one block south of its intersection with North Willamette Boulevard. A gravel roadway is present on the Central and East Parcels, but vehicle access is limited by concrete blocks/rubble at the North Edgewater Street entrance. Access to the area by foot or from the river is possible.

Structures and Improvements. There are no structures on the Facility. Indications of previous structures include a large concrete foundation and a paved roadway in the eastern portion of the Facility, several smaller concrete structures or foundations, and structural piling within the cove and along the riverbank. Riprap is present along much of the riverbank. Sandy beaches are present at the west end of the Central Parcel and at the inner portion of the cove on the East Parcel.

Topography. The Facility is situated on a terrace created by historical filling. Overall, the topography of this terrace is flat, with an elevation ranging between 30 and 45 feet (all elevations in the report refer to NAVD88 unless otherwise noted). The southern portion of the West Parcel is slightly higher, at elevation 50 to 55 feet. Berms and hummocks are occasionally present. The riverbank is generally a steep slope down to the river. The river water elevation is typically less than 10 feet and is subject to a mean tidal range of about 2 feet.

The BNSF railroad embankment along the southeast perimeter of the cove rises steeply about 50 feet above the cove. North of the property, across the UPRR tracks, is a naturally formed 120- to 150-foot-high bluff. By the Central and East Parcels, this bluff rises at approximately 5H:4V. Near the West Parcel, the slope is approximately 10H:3V.

Surrounding Properties. The Facility is bordered on the north by the UPRR tracks. Farther to the north is a vegetated bluff. A residential area is present on top of the bluff and farther inland. Bordering the northwest side of the Facility is a vacated portion of North Richmond Avenue with industrial property beyond. To the southeast is an embankment for the BNSF railroad bridge over the Willamette River. On the opposite side of this embankment is the former McCormick & Baxter Creosoting Company, a federal Superfund Site (McCormick & Baxter). Soil and groundwater beneath the southern portion of the East Parcel of the Facility have been impacted by a contaminant plume (including polycyclic aromatic hydrocarbons [PAHs], semi-volatile organic compounds [SVOCs], dioxins/furans, arsenic, chromium, copper, zinc, pentachlorophenol, and non-aqueous phase liquids [NAPL]) emanating from McCormick & Baxter . The McCormick & Baxter contaminant plume has migrated northwestward from McCormick & Baxter's former wood treatment operations, under the railroad embankment, and has emerged in the sediments of the cove. DEQ, acting on behalf of the EPA, implemented a remedial action consisting of a subsurface barrier wall on the McCormick & Baxter site and a sediment cap that includes a portion of the cove sediments. The McCormick & Baxter remedy was implemented prior to cleanup levels being established for the PHSS.

2.2 Historical Site Use

West Parcel. The West Parcel was originally developed in 1901 as a plywood mill and operated as a wood products facility into the 1970s. An inlet from the river on this parcel was used as a log pond to supply the mill. The log pond was filled in approximately 1973 (see Figure 2). The property was purchased by the Portland Development Commission (PDC) in 1979. The property has remained vacant since. In 1996, the property was sold to Metro for the purpose of creating a green space area to be used as a public park.

Central Parcel. The Central Parcel was developed in 1903 in conjunction with the construction of the St. Johns Dry Docks at the Facility. Between 1903 and 1924, shops and ancillary structures that provided support for dry dock activities were constructed. The dry docks were closed in 1953. The western portion of the Central Parcel was sold in 1950 and it was incorporated into the plywood and lumber mill operations on the adjacent West Parcel. The remainder of the Central Parcel was sold in 1953 and developed as a sawmill. By 1970, the sawmill was no longer in use. Up until 1981, portions of the property were used for a variety of purposes such as log rafting, a marine salvage company, a demolition contractor facility, woodworking facilities, and boat building. By 1981, the property was purchased by PDC, and PDC demolished the buildings by 1982. The property has remained vacant since. In 1996, the property was sold to Metro for the purpose of creating a green space area to be used as a public park.

East Parcel. The East Parcel was historically occupied by a cooperage plant (i.e., wood barrel manufacturer) from 1915 until the 1950s (when declining demand led to a focus on plywood production). Until 1980, a variety of wood-product-related businesses occupied the parcel. PDC purchased the property in 1980 and demolished the buildings by 1982. The property has remained vacant since. In 1996, the property was sold to Metro for the purpose of creating a green space area to be used as a public park.

2.3 Current Site Use

The Facility is currently vacant, covered with invasive and native vegetation, and it provides habitat for opportunistic use by wildlife. The site is not managed for any human use and is posted to prohibit trespassing. However, trespassers do come on the site (e.g., houseless persons and joggers).

The Facility is currently zoned as an open space (OS) zone with “g” (River General) and “q” (River Water Quality) greenway overlay zones (City of Portland, 2018). The open space zone is intended to preserve and enhance public and private open, natural, and improved park and recreational areas. Greenway regulations are also intended to protect, conserve, enhance, and maintain the natural, scenic, historical, economic, and recreational qualities of lands along Portland’s rivers. Specifically, the “g” overlay is intended to allow public use and enjoyment of the waterfront and for enhancement of the river’s scenic and natural qualities. The “q” overlay is designed to protect the functional values of water quality resources by limiting or mitigating the impact of development in the 50- to 200-foot setback from the top of bank. Other nearby zoning includes commercial (EG2), residential (R2 and R5), open space (OS), and industrial (IH and IG2).

The Facility is included in a citywide inventory that identified scenic resources (City of Portland, 2012). The Facility is identified as a scenic viewpoint. The zoning map shows a multi-use trail through the Facility (City of Portland, 2001). However, this trail is only proposed as part of the regional trail plan adopted by Metro (Alta Planning and Design, 2010). The location of the proposed trail is shown on Figure 2.

2.4 Potential Sources of Contamination

West Parcel. As presented in the Remedial Investigation (RI) report (Hart Crowser, 2003), historical features on or adjacent to the West Parcel posing a potential environmental concern included a glue mixing and gluing room, glue storage, presses, debarkers, an oil house, a blacksmith shop, a grinding room, and fuel tanks.

Possible contaminants associated with these features are phenol and formaldehyde (from glues); total petroleum hydrocarbons (TPH) and PAHs (from fuel and hydraulic oil use); metals (from grinding); volatile organic compounds (VOCs; from use of solvents to clean metal); and polychlorinated biphenyls (PCBs; from hydraulic oil). The soil used to fill the log pond was sourced from within the PHSS, reportedly from the Arkema Chemicals Company site located directly upstream and across the river from the Facility (Integral, 2008). The material imported to fill the log pond may have contained these or other chemicals associated with the PHSS such as pesticides, PAHs, PCBs, and dioxins/furans.

Central Parcel. As presented in the RI report, historical features on or adjacent to the Central Parcel posing a potential environmental concern included a machine shop, blacksmith shops, an air compressor room, an oil warehouse, a paint shed, a fuel oil standpipe, a debarker, a saw filing room, dry docks, a power house, and transformers. Possible contaminants include TPH, PAHs, metals, VOCs, and PCBs.

Additionally, an area of concentrated debris was encountered and removed during a soil removal action in 2015. During the excavation, a layer of multi-colored soil was found directly on top of areas of concentrated debris. This layer of soil ranged from approximately one to three inches thick and consisted of white, red, and black layers. Distinct from and below the multi-colored soil was debris. The debris consisted of brick and metal from surface to a depth of up to 5 feet below ground surface (bgs), but the debris was concentrated from approximately 2 to 5 feet bgs. A matrix of white to gray colored soil was observed in the debris within areas of concentrated brick. The location of the debris area coincided with the highest concentrations of dioxin/furans found in soil at the Facility. The source of the debris is not known.

East Parcel. As presented in the RI report, historical features on or adjacent to the East Parcel posing a potential environmental concern included a machine shop, a grinding room, a saw filing room, an oil house, a transformer house, a battery charging room, a glue mixing and gluing room, presses, and a debarker. Possible contaminants include phenol, formaldehyde, TPH, PAHs, metals, VOCs, and PCBs.

Adjacent Properties. Immediately adjacent properties include railroads to the north (UPRR) and southeast (BNSF), and the McCormick & Baxter facility is beyond the BNSF railroad to the southeast. In addition, an underground petroleum pipeline is present in the UPRR railroad right-of-way to the north. Potential contaminants from these facilities include TPH, PAHs, metals, PCBs, and dioxins/furans.

2.5 Nearshore Sediment Data

Sampling of sediments has been conducted in the cove adjacent to the Facility (LWG, 2011; AECOM/Geosyntec, 2019). Appendix A presents sediment sample locations within 100 feet of -2 feet Columbia River Datum (CRD) and tables listing the sediment results.

During the Lower Willamette Group's (LWG's) RI process, sediment areas of potential concern (AOPCs) were established for the Portland Harbor. DEQ prepared the *Portland Harbor Upland Source Control Summary*

Report (DEQ, 2016) that summarized the chemicals of interest (COI) in sediments for each Portland Harbor sediment AOPC. In that report, DEQ referred to the AOPCs and associated contaminants as a conservative line of evidence for source control evaluation. As the in-water feasibility study progressed, EPA refined AOPCs into sediment decision units (SDUs; EPA, 2016). Sediments in the cove adjacent to the Facility are located within SDU RM6.5E. SDUs were established based on a list of focused COCs used to simplify the remedial selection process. Based on the list of COIs within AOPC 13, the focused COC list for SDU RM6,.5E, and the sampling summarized in Appendix A, the COIs for sediments adjacent to the Facility are listed below.

- Cadmium;
- Copper;
- Mercury;
- Zinc;
- PAHs;
- Bis(2-ethylhexyl)phthalate (BEHP);
- Carbazole;
- PCBs;
- Total dichlorodiphenyltrichloroethane, dichlorodiphenyldichloroethylene, and dichlorodiphenyldichloroethane (DDx); and
- Dioxins/furans.

2.6 Groundwater Chemicals of Interest

The historical research conducted for the RI and supplemental sampling identified past activities and features that were identified as potential areas of concern as contaminant sources on the Facility. The potential areas of concern were investigated in the RI and subsequent sampling. Groundwater COI, considering both upland potential sources and nearshore sediment data were identified as follows:

- Metals;
- PAHs;
- PCBs;
- Pesticides;
- Dioxins/furans;
- VOCs;
- SVOCs;
- Phthalates;
- Phenols; and
- TPH.

2.7 Regulatory History

In November 2000, the Port and Metro entered into a VCP Agreement (Agreement No. EC-NWR-00-26) with the DEQ for remedial investigation and upland source control measures for the Facility.

To inform the remedial investigation activities, the Port conducted a detailed investigation of the site use and environmental investigation history at the Facility. That information is documented in the *Existing Data/Site History Report* (Hart Crowser, 2000).

In December 2000, a portion of the Willamette River within Portland was placed on the National Priorities List, officially creating the PHSS. Pursuant to the terms of a *Memorandum of Understanding* for the PHSS, the DEQ is the lead agency for assessment and cleanup of upland facilities that could pose a source of sediment contamination to the PHSS. The Facility was identified by the DEQ as an upland facility in which PHSS cleanup goals should be considered as part of the upland remedy.

Initial remedial investigation activities were conducted from April 2001 through September 2002. The results of that investigation were presented in the *Remedial Investigation* (Hart Crowser, 2003) and *Remedial Investigation Addendum* (Port, 2003). Additional sampling requested by DEQ was conducted in December 2005.

An analysis of the baseline risk for human health and ecological receptors at the Facility was submitted in draft form to DEQ in 2007 (NF/ACA, 2007). The baseline risk assessment was revised based on comments from DEQ and additional data collected during the revision process. The revisions were presented in the separate *Residual Risk Assessment* (RRA) documents for human health and ecological receptors, respectively (Formation, 2013 and 2014a). The conclusions of the RRAs have been updated to include new information as additional remedial investigation and actions have been completed. These updated evaluations have been documented in technical memoranda (Formation, 2014b; Port, 2018).

Based on site characterization completed during remedial investigation activities, an SCE was completed, and the results submitted to DEQ in February 2013 (Apex, 2013). An evaluation of remedial options and recommendation of remedial alternatives to address unacceptable risk at the Facility was documented in the *Feasibility Study* submitted in October 2014 (Apex, 2014).

Soil with the higher concentrations of Facility contaminants of concern (COCs) was removed during an interim remedial action performed from October 2015 through January 2016. Excavated soil was taken off-site for disposal at a landfill. In the area on the Facility landward of the top of bank, most of the soil with concentrations above human health hot spot levels was removed with the exception of a small area on the Central Parcel; soil with concentrations above ecological hot spot levels was removed except for the lower-concentration dioxin/furan hot spots.

Based on the comments provided by DEQ in response to the FS and SCE submittals, the amount of coordination required between source control and upland remedial actions, and the nexus of source control activities within the PHSS, DEQ requested that the FS and SCE be combined. As a result, these normally separate documents were revised and provided as one submittal. The *Combined Feasibility Study and Source Control Evaluation* (Combined FS/SCE) was submitted in September 2017 (Apex, 2017b).

Between February and September 2018, the Port, DEQ, and Metro conducted six meetings to discuss the comments received from DEQ, EPA, and Metro and proposed revisions to the Combined FS/SCE. The *Revised Feasibility Study and Source Control Evaluation* (Revised FS/SCE), submitted in March 2019, addressed comments, and incorporates the extensive discussion between DEQ and the Port in subsequent meetings (Apex, 2019).

Comments provided to the Port from DEQ and EPA requested additional evaluation of the source control pathways at the Facility to support a source control decision. This current document presents the additional evaluation of groundwater source control.

3.0 Hazardous Substance Release

3.1 Release History

Because the major industrial activities at the Property ended some 40 to 50 years ago, few records exist which document actual releases of hazardous substances. Available information from regulatory agencies and Port records were reviewed for information on spills and releases. It should be noted that most regulations mandating the reporting of spills and releases did not come into effect until after 1970; therefore, there are few if any reported spills and releases from before 1970. No documented surface releases have been identified at the Facility.

3.2 Previous Investigations

Numerous investigations, assessments, and environmental actions have been performed at the Facility since 1988. The following sections summarize the scope and results of work performed relevant to the groundwater SCE.

3.2.1 Pre-Remedial Investigation Groundwater Sampling

Investigations conducted prior to the RI (1988 through 2001) included grab groundwater sampling from borings. Sample locations are shown on Figure 3. The results of the historical groundwater investigations were presented in the RI Report (Hart Crowser, 2003). Tables summarizing the screening and a searchable database are included in Appendix B.

3.2.2 Remedial Investigation Groundwater Sampling

As part of the RI for the Facility, seven groundwater monitoring wells were installed (Figure 3) and the wells were sampled twice in 2002. The well locations and analytes were selected based on the results of the prior grab groundwater sampling and the historical review. In the December 20, 2003 DEQ letter commenting on the RI Report, the DEQ requested additional groundwater monitoring be conducted. In 2005, the Port and Metro conducted two additional groundwater monitoring events (one during the rainy season and one during the dry season). Groundwater samples were collected from the seven on-site wells. Results of the groundwater monitoring, as well as historical groundwater results, were documented in the RI Report (Hart Crowser, 2003) and two subsequent groundwater monitoring reports (BBL/Ash Creek/NF, 2005, 2006b). The data are listed in Appendix B.

3.2.3 Additional Groundwater Sampling

In 2010, groundwater samples were collected from test pits to assess conditions at the Wharf road area in the Central Parcel and the inner cove on the East Parcel (Ash Creek/NF, 2010). Sample locations are shown on Figure 3, and the data are listed in the screening tables in Appendix B.

To support source control decision making, DEQ requested additional groundwater monitoring for the Facility. Monitoring wells MW-1 through MW-7 were reconditioned and two additional monitoring wells, MW-8 and MW-9, were installed in 2016. Four rounds of groundwater monitoring were conducted in 2016. The results of the groundwater monitoring showed detectable concentrations of PCBs. These detections of PCBs, along with new information regarding possible origins of the fill material in the former log pond prompted DEQ to request additional investigation of soil and groundwater on the West Parcel. In December 2016 through January 2017, five borings were advanced, and groundwater was sampled on the West Parcel. Results are presented in the December 2016 Groundwater Data Report (Apex, 2017a). Sample locations are shown on Figure 3, and the data are included in the groundwater screening tables in Appendix B.

4.0 Identification of Migration Pathways

In accordance with the JSCS guidance document (DEQ/EPA 2005; screening criteria revised July 16, 2007), the SCE includes the identification of each known or potentially complete migration pathway to the river. Migration pathways related to soil, direct discharges, and overwater activities are addressed in the *Revised Feasibility Study and Source Control Evaluation* (Apex, 2019) and forthcoming responses to comments on that document. This SCE/SCAE addresses groundwater. Groundwater at the Facility is presumed to flow toward the Willamette River. Constituents present in groundwater, if any, therefore have the potential to migrate to the river. The groundwater pathway is further evaluated in Sections 5 through 8.

5.0 Groundwater Conditions

5.1 Groundwater Sampling

Groundwater sampling was conducted on multiple occasions from 1988 to 2017. The following summarizes the groundwater monitoring activities.

- Pre-Remedial Investigation sampling for due diligence investigations:
    - 1988/1989 – “SE” grab samples analyzed for metals, TPH, SVOCs, PAHs, PCBs, pesticides, VOCs, and total halides;
    - 1995 – “TB” grab samples analyzed for metals, TPH, SVOCs, PAHs, PCBs, and VOCs;
    - 1999 – MW-35s (McCormick & Baxter monitoring well) analyzed for TPH, SVOCs, pesticides, and VOCs;
    - 2001 – “B” grab samples analyzed for metals, SVOCs, PAHs, PCBs, VOCs, and phenols;
- Remedial Investigation sampling: 2002 and 2005 – MW-1 through MW-7 sampled and analyzed for metals, TPH, PAHs, and VOCs;
- Wharf Road and Inner Cover sampling: 2010 – “WC” series grab samples analyzed for metals, TPH, PAHs, PCBs, and VOCs;
- Additional Source Control sampling:
    - 2016 – MW-1 through MW-9 sampled and analyzed for metals, TPH, SVOCs, PAHs, PCBs, pesticides, dioxins/furans, VOCs, natural attenuation parameters, and total organic carbon;
    - 2016/2017 – “DP” series grab samples analyzed for metals, SVOCs, PAHs, PCBs, pesticides, and dioxins/furans.

The sample locations are shown on Figure 3 and the data are listed in Appendix B. Table 1 lists the monitoring well installation details. Screening of groundwater data is discussed in Section 6.

5.2 Depth to Groundwater

Table 2 lists the groundwater elevation monitoring data. Depth to groundwater at the Facility has ranged from 21 to 37 feet bgs. Groundwater elevations have ranged from 7 to 15 feet, except at MW-2 where groundwater elevations ranged from 17 to 21 feet (NAVD88).

Water level data from the USGS Willamette River gauging station (located at the Morrison Bridge in downtown Portland approximately 6 miles upriver from Willamette Cove) were compared to the well elevation data collected during the 2016 monitoring events to assess the direction of groundwater flow (Table 3; Apex, 2017a). The minimum, maximum, and average river levels for the day, the week prior, and the month prior to the 2016 gauging events were calculated. The averages for the week and month prior to the gauging event were calculated to account for the slower movement of groundwater compared to surface water and the effect of the tidal variation in the river levels. Groundwater at the Facility was higher than the daily, weekly, and monthly average river level with a few exceptions. In general, water levels at the site indicate that the overall groundwater gradient is toward the river. Short-term, local reversals in gradient may occur near the riverbank, but these reversals would occur only during maximum water level events that are of short duration.

5.3 Groundwater Sheen/NAPL Observations

Observations of oil sheen or non-aqueous phase liquid (NAPL) during site investigations are summarized on Figure 4 and described as follows.

- A petroleum NAPL seep was observed between 1983 and 1991 in the cove adjacent to the southern portion of the East Parcel (Hart Crowser, 2003). Figure 4 shows the location of the former seep. The seep originated from historical releases at the McCormick & Baxter site southeast of the BNSF railroad embankment. The area where the seep was observed was capped as part of the McCormick & Baxter cleanup and the seep is no longer present.
- In 1988/1989, prior to sale of the property to PDC, a due diligence investigation was conducted at the Facility. Geophysical traverses were performed over a portion of the upland area to assess for buried objects such as USTs. Buried drainage pipes and sumps were found, but no USTs were located. Explorations included 19 soil borings (SE/E-1 through SE/E-13) and four hand-augured soil borings (HA-1 through HA-4). Oil sheens were observed on grab groundwater samples collected from borings SE/E-12, SE/E-13, and SE/E-19 on the West Parcel, and from borings SE/E-9 and SE/E-10 on the Central Parcel. An oil sheen was observed on river water in the area of the NAPL seep described above.
- In 2004, during construction of the McCormick & Baxter cap in the cove, a sheen was observed on the water in the innermost portion of the cove adjacent to the East Parcel. Test pits were completed and petroleum NAPL was observed in one test pit. The extent of NAPL was confined to the zone between MHW and ordinary low water line (OLWL). The soil where the NAPL was observed was removed and disposed of off-site (Ash Creek, 2005).
- In 2007, DEQ observed on the beach in the Former Wharf Road area of the Central Parcel gray silty surface sediment that had an apparent sheen when disturbed or dropped into water. This material was investigated, and it was concluded that it did not originate from the upland area of the Facility.
- During two groundwater sampling events in 2002, slight sheens were observed on water from monitoring wells MW-1 (February and May) and MW-3 (May only) on the West Parcel, and from monitoring well MW-4 (May only) at the west end of the Central Parcel. In six subsequent sampling events in 2005 and 2016, sheens were not observed on water from the monitoring wells.

6.0 Groundwater Data Screening

In this section, groundwater monitoring data (used as a surrogate for groundwater potentially entering surface water) are screened to assess groundwater as a potential source to sediments and surface water. Both grab sample and monitoring well sample data collected during investigations at the Facility were considered during data screening. The results of the data screening were used to identify chemicals of potential concern (COPCs) for further consideration in the weight of evidence evaluation in Sections 7 and 8.

The following screening levels, listed in Table 3, were used to assess groundwater with the potential to migrate to surface water or sediments.

- Groundwater Cleanup Levels (CULs) from Table 17 of the PHSS ROD; and
- JSCS SLVs for Water.

Groundwater CULs were used for primary screening. For COI that do not have a CUL, JSCS SLVs were used for screening.

Appendix B presents groundwater data compared to the screening levels listed above. For COPC screening purposes, it was assumed that the groundwater would be transported to surface water without a change in concentration of the analyte. This assumption is conservative and adds uncertainty to the evaluation. The COI that exceeded a relevant screening level at least once were retained as COPCs. The COPCs thus identified include the following:

- Metals – Aluminum, antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, vanadium, and zinc;
- PAHs – Each individual PAH plus benzo(a)pyrene toxicity equivalent (BaP Eq);
- TPH-diesel[1];
- PCBs – Aroclor 1254 and total PCBs;
- Dioxin/Furans – 2,3,7,8-TCDD and dioxin/furan TEQ;
- Pesticides – 4,4'-Dichlorodiphenyldichloroethane (4,4'-DDD);
- SVOCs – 2-methylnaphthalene, Bis(2-ethylhexyl)phthalate (BEHP), butylbenzyl phthalate, dibenzofuran, diethyl phthalate, di-n-butyl phthalate, and pentachlorophenol; and
- VOCs – Benzene, chlorobenzene, chloromethane, naphthalene, tetrachloroethylene (PCE), and trichloroethylene (TCE).

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[1] The TPH-Dx groundwater data are compared to the Portland Harbor CL for TPH-Diesel. The CL applies only to carbons in the C10-C12 aliphatic range. Results from groundwater sampling at Willamette Cove are reported in the C12-C24 range according to the NWTPH method. Samples analyzed prior to the implementation of the NWTPH method have an unknown range. Therefore, the screening level is not directly applicable, and is used only for preliminary screening.

7.0 Source Control Evaluation

In accordance with the JSCS guidance, the following evaluation considers multiple lines of evidence to be considered independently and collectively to identify the potential for adverse effects on surface water or sediments from groundwater. These include the following.

- Factors related to COPC properties and concentrations
  - Contaminant concentrations (magnitude of exceedance above the CUL or SLV)
  - Regional background concentrations of metals
  - Potential presence of NAPL or sheen
  - Presence of bioaccumulative chemicals
  - Consideration of available in-water data (e.g., sediment, bioassay)
- Factors related to fate and transport of COPCs in groundwater
  - Nature and extent of groundwater COPCs in each affected water-bearing zone
  - Location of wells within the groundwater plume
  - Stability of the groundwater plume (e.g., predictive modeling)
  - Potential hydraulic connection between site groundwater and surface water and sediments
  - Fate and transport of groundwater COPCs
- Estimate of potential contaminant loading to the river
- Potential for groundwater discharge to result in an accumulation in sediments above protective concentrations (i.e., potential for groundwater discharge to result in sediment contamination or recontamination following sediment cleanup).

Using the screening level factors and concentrations related to the COPCs, this section assesses each of the COPCs to identify COPCs for further evaluation. For the COPC screening, it is recognized that as groundwater moves to the river, the concentrations of COPCs will not remain constant. Therefore, groundwater concentrations that only slightly exceed screening levels are generally not considered to be at levels of concern. More than 95% of samples collected at the Facility included analysis of both total and dissolved fractions for metals. Total and dissolved fractions were analyzed for PAHs, PCBs, and dioxin/furans at select monitoring wells during one event. Dissolved fraction concentrations are considered more representative of concentrations that will be encountered by sediment and surface water. Monitoring wells are located near the TOB along the length of the Facility except for the portion of the East Parcel near the BNSF railroad. Based on both the locations of the monitoring wells and the quality of the samples collected from wells, data from monitoring wells are considered more representative of COPC concentrations in groundwater than data from grab samples. Other factors such as frequency of detection and adjacent sediment data are also considered on a qualitative or semi-quantitative basis when evaluating potential COPCs. Table 5 summarizes the frequency and magnitude of exceedances for each COPC.

- **Metals.** Metals were analyzed for both grab samples from borings and from monitoring wells. Results for individual COPC metals are discussed below.
    - **Aluminum**. There is no CUL for aluminum. Aluminum was detected above the SLV in 21 of 46 total aluminum samples and 9 of 46 dissolved aluminum samples. The maximum exceedance ratio (ER) for total aluminum is 780. The maximum ER for dissolved samples is 120. Aluminum is not bioaccumulative and is not identified as a COI in sediments adjacent to the Facility. Based on the non-bioaccumulative properties of aluminum, the reduction of SLV exceedances and concentration in dissolved versus total samples, and it not being a COI for sediment adjacent to the Facility, aluminum is not retained for further evaluation.
    - **Antimony**. There is no CUL for antimony. Antimony was not detected above the SLV in total antimony samples and was above in 1 of 95 dissolved antimony samples (at an ER of 8.9). Antimony is not bioaccumulative and is not identified as a COI in sediments adjacent to the Facility. Based on the low number of detections, antimony not being bioaccumulative, and antimony not being a COI in sediments adjacent to the Facility, antimony is not retained for further evaluation.
    - **Arsenic**. Arsenic was detected above the CUL in 89 of 98 total arsenic samples and 65 of 101 dissolved arsenic samples. The maximum ERs are 7,100 for total arsenic and 8,200 for dissolved arsenic. Arsenic is bioaccumulative. Arsenic is not identified as a COI in sediments adjacent to the Facility. Based on arsenic being bioaccumulative, the high frequency of CUL exceedances, and relatively higher ERs, arsenic is retained for further evaluation.
    - **Cadmium**. Cadmium was detected above the CUL in 19 of 98 total cadmium samples and 5 of 104 dissolved cadmium samples. The maximum ERs are 550 for total cadmium and 55 for dissolved cadmium. In samples collected from monitoring wells and analyzed for dissolved cadmium, only two results exceeded the CUL, and at least two rounds collected after those samples were below detection limits. Cadmium is bioaccumulative and is identified as a COI in sediments adjacent to the Facility. Based on the low number of CUL exceedances in dissolved samples from monitoring wells, cadmium is not retained for further evaluation.
    - **Chromium**. Chromium was detected above the CUL in 42 of 98 total chromium samples and 3 of 104 dissolved chromium samples. The maximum ER is 164 for total chromium and 3.4 for dissolved chromium. Chromium was not detected above CULs in dissolved samples from monitoring wells. Chromium is not bioaccumulative. Chromium is not identified as a COI in sediments adjacent to the Facility. Based on the lack of dissolved chromium in monitoring wells, chromium not being bioaccumulative, and chromium not being a COI in sediments adjacent to the Facility, chromium is not retained for further evaluation.

- **Copper**. Copper was detected above the CUL in 64 of 98 total copper samples and 13 of 104 dissolved copper samples. The maximum ER for is 1,100 for total copper and 170 for dissolved copper. Five of the dissolved copper samples above the CUL were from monitoring wells (ERs ranging from 1.4 to 4). Copper is not bioaccumulative. Copper is identified as a COI in sediments adjacent to the Facility. Based on the low number of dissolved samples above the CUL in monitoring wells, and copper not being bioaccumulative, copper is not retained for further evaluation.

- **Lead.** Lead was detected above the CUL in 65 of 98 total samples. Lead was detected above the CUL in 20 of 104 dissolved samples with 6 of those exceedances from a monitoring well sample (ERs ranging from 1.1 to 16). The maximum ERs are 2,500 for total lead and 16 for dissolved lead. Lead is bioaccumulative. Lead is not identified as a COI in sediments adjacent to the Facility. Based on the low number of CUL exceedances in dissolved monitoring well samples and lead not being a COI in sediments adjacent to the Facility, lead is not retained for further evaluation.

- **Mercury.** There is no CUL for mercury. Mercury was detected above the SLV in 20 of 98 total mercury samples and none of 101 dissolved mercury samples. The maximum ER is 28 for total mercury. Mercury is bioaccumulative. Mercury is identified as a COI in sediments adjacent to the Facility. Based on lack of SLV exceedance in dissolved samples, mercury is not retained for further evaluation.

- **Nickel.** There is no CUL for nickel. Nickel was detected above the SLV in 43 of 98 total nickel samples and 1 of 101 dissolved nickel samples (grab sample). The maximum ER is 130 for total nickel and 15 for dissolved nickel. Nickel is not bioaccumulative. Nickel is not identified as a COI in sediments adjacent to the Facility. Based on the lack of exceedances in dissolved samples from monitoring wells, nickel not being bioaccumulative, and nickel not being a COI in sediments adjacent to the Facility, nickel is not retained for further evaluation.

- **Selenium.** There is no CUL for selenium. Selenium was detected above the SLV in 3 of 92 total selenium samples and 2 of 95 dissolved selenium samples (grab samples). The maximum ER is 25 for total selenium and 2.5 for dissolved selenium. Selenium was not detected above CULs in dissolved samples from monitoring wells. Selenium is bioaccumulative. Selenium is not identified as a COI in sediments adjacent to the Facility. Based on the low number of CUL exceedances, selenium not being detected in dissolved samples from monitoring wells, and selenium not being a COI in sediments adjacent to the Facility, selenium is not retained for further evaluation.

- **Silver.** There is no CUL for silver. Silver was detected above the SLV in 13 of 92 total silver samples and 2 of 95 dissolved silver samples (grab samples). The maximum ER is 109 for total silver and 17 for dissolved silver. Silver was not detected above CULs in dissolved samples from monitoring wells. Silver is not bioaccumulative. Silver is not identified as a COI in sediments adjacent to the Facility. Based on the low number of SLV exceedances, silver not being bioaccumulative, silver not being detected in dissolved samples from monitoring wells, and silver not being a COI in sediments adjacent to the Facility, silver is not retained for further evaluation.

  - **Vanadium.** Vanadium was detected above the CUL in 10 of 46 total vanadium samples and 1 of 46 dissolved vanadium samples. The maximum ER is 9 for total vanadium and 1.1 for dissolved vanadium. Vanadium is not bioaccumulative. Vanadium is not identified as a COI in sediments adjacent to the Facility. Based on the low number of CUL exceedances in dissolved samples, the low ER for dissolved samples, vanadium not being bioaccumulative, and vanadium not being a COI in sediments adjacent to the Facility, vanadium is not retained for further evaluation.
  - **Zinc.** Zinc was detected above the CUL in 47 of 98 total zinc samples and 7 of 101 dissolved zinc samples. The maximum ER is 195 for total zinc and 3 for dissolved zinc. Zinc was detected above the CUL in one dissolved sample from a monitoring well. Zinc is not bioaccumulative. Zinc is identified as a COI in sediments adjacent to the Facility. Based on the low number of CUL exceedances in dissolved samples from monitoring wells, the relatively low ER in dissolved samples, and zinc not being bioaccumulative, zinc is not retained for further evaluation.
- **TPH-Diesel.** TPH-diesel was detected above the C10-C12 aliphatic range CUL in 10 of 41 samples with a maximum ER of 540. TPH-diesel was detected above the screening level in 6 of 28 samples from monitoring wells with ERs ranging from 17 to 150 (five of the six detections were in wells MW-2 and MW-3 located within/near the former log pond fill). TPH is not bioaccumulative. TPH is not identified as a COI in sediments adjacent to the Facility, but TPH is an indicator for PAHs that are COI in sediments adjacent to the Facility. Based on the conservative nature of the CUL as applied to TPH-diesel, TPH-diesel not being bioaccumulative, TPH-diesel not being a COI for sediment adjacent to the Facility, and the robust PAH dataset making it unnecessary as an indicator compound, TPH is not retained for further evaluation.
- **SVOCs.** SVOCs were analyzed for both grab samples from borings and from monitoring wells. Results for individual COPC SVOCs are discussed below.
  - **2-Methylnaphthalene.** There is no CUL for 2-methylnaphthalene. 2-Methylnaphthalene was detected above the SLV in 12 of 112 samples. 2-methylnaphthalene is not bioaccumulative and is not identified as a COI in sediments adjacent to the Facility. The maximum ER of 133 is from a grab sample. The maximum ER from monitoring well samples is 4.7. Based on the relatively low ER in monitoring well samples, that 2-methylnaphthalene is not bioaccumulative and is not identified as a COI in adjacent sediment, it is not retained for further evaluation. Additionally, 2-methylnaphthalene is related to PAHs and the detections of 2-methylnaphthalene are co-located with higher detected concentrations of PAHs.
  - **BEHP.** There is no CUL for BEHP. BEHP was detected above the SLV in 4 of 62 samples with a maximum ER of 32. No SLV exceedances were detected in monitoring well samples. BEHP

is not bioaccumulative. BEHP is identified as a COI in sediments adjacent to the Facility. Based on the lack of CUL exceedances in monitoring wells, BEHP is not retained for further evaluation.

  - **Butylbenzyl phthalate.** There is no CUL for butylbenzyl phthalate. Butylbenzyl phthalate was detected above the SLV in 1 of 62 groundwater samples with an ER of 2.9. Butylbenzyl phthalate was not detected above the SLV in samples collected from monitoring wells. Butylbenzyl phthalate is not bioaccumulative. Butylbenzyl phthalate is not identified as a COI in sediments adjacent to the Facility. Based on the low number of SLV exceedances, butylbenzyl phthalate not being bioaccumulative and not being a COI in sediments adjacent to the Facility, butylbenzyl phthalate is not retained for further evaluation.
  - **Dibenzofuran.** There is no CUL for dibenzofuran. Dibenzofuran was detected above the SLV in 1 of 60 groundwater samples with an ER of 2.9. Dibenzofuran was not detected above the SLV in samples collected from monitoring wells. Dibenzofuran is not bioaccumulative. Dibenzofuran is not identified as a COI in sediments adjacent to the Facility. Based on the lack of SLV exceedances in monitoring wells, dibenzofuran not being bioaccumulative, and dibenzofuran not being a COI in sediments adjacent to the Facility, dibenzofuran is not retained for further evaluation.
  - **Diethyl Phthalate.** There is no CUL for diethyl phthalate. Diethyl phthalate was detected above the SLV in 1 of 62 groundwater samples with an ER of 1.7. Diethyl phthalate was not detected above the SLV in samples collected from monitoring wells. Diethyl phthalate is not bioaccumulative. Diethyl phthalate is not identified as a COI in sediments adjacent to the Facility. Based on the low number of SLV exceedances, lack of exceedances in monitoring wells, diethyl phthalate not being bioaccumulative, and not being identified as a COI in sediments adjacent to the Facility, diethyl phthalate is not retained for further evaluation.
  - **Di-n-butyl Phthalate (DBP).** There is no CUL for DBP. DBP was detected above the SLV in 1 of 62 groundwater samples with an ER of 3.3. DBP was not detected above the SLV in samples collected from monitoring wells. DBP is not bioaccumulative. DBP is not identified as a COI in sediments adjacent to the Facility. Based on the low number of SLV exceedances, DBP not being bioaccumulative, and not being a COI in sediments adjacent to the Facility, DBP is not retained for further evaluation.
  - **Pentachlorophenol.** Pentachlorophenol was detected above the CUL in 8 of 71 groundwater samples with a maximum ER of 25. Pentachlorophenol is bioaccumulative but is not identified as a COI in sediments adjacent to the Facility. Based on exceedances of the CUL and pentachlorophenol being bioaccumulative, pentachlorophenol is retained for further evaluation.

- **4,4’-DDD.** 4,4’DDD was detected above the CUL in 2 of 16 samples with a maximum ER of 1,660. Both samples were collected from well MW 2. DDx is identified as a COI in sediments adjacent to the Facility. Based on the CUL exceedances in a monitoring well and DDx being a COI in sediments adjacent to the Facility, 4,4’-DDD is retained for further evaluation.

- **PAHs.** PAHs were detected above the CUL or SLV in 57 of 184 samples. ERs ranged up to 13,000. Fluoranthene and pyrene are bioaccumulative. PAHs are identified as COI in sediments adjacent to the Facility. Based on relatively frequent detection, relatively higher ERs, some PAHs being bioaccumulative, and PAHs being COI in sediments adjacent to the Facility, PAHs are retained for further evaluation.
- **PCBs.** Total PCBs were detected above the CUL in 16 of 81 groundwater samples, and 3 of 34 samples exceeded the SLV for Aroclor 1254. ERs ranged up to 401. PCBs are bioaccumulative. PCBs are identified as COI in sediments adjacent to the Facility. Based on the number of CUL exceedances, relatively higher ERs, PCBs being bioaccumulative, and PCBs being a COI in sediments adjacent to the Facility, total PCBs are retained for further evaluation. The three samples with Aroclor 1254 SLV exceedances also have total PCB CUL exceedances and Aroclor 1254 is considered in the total PCB calculation. Therefore, Aroclor 1254 is not evaluated independently of total PCBs.
- **Dioxins/Furans.** There is no CUL for dioxins/furans. Dioxin/furan TEQ was detected above the SLV in 8 of 15 samples (maximum ER of 14,600) and 2,3,7,8-TCDD was detected above the SLV in 2 of 15 samples (maximum ER of 450). The December 2016 groundwater sample from MW-3 was analyzed for total and dissolved dioxin/furans to assess the mobility of the dioxin/furans in groundwater. Dioxin/furans were not detected in the dissolved sample from MW-3. Dioxins/furans are bioaccumulative and are identified as a COI in sediments adjacent to the Facility. Based on lack of detections in the dissolved fraction of groundwater, dioxins/furans are not retained for further evaluation.
- **VOCs.** Results for individual COPC VOCs are discussed below.
    - **Benzene.** Benzene was detected above the CUL in 3 of 85 groundwater samples with a maximum ER of 2.8. Benzene was detected in two samples collected from monitoring wells. Benzene is not bioaccumulative. Benzene is not identified as a COI in sediments adjacent to the Facility. Based on the low number of CUL exceedances, benzene not being bioaccumulative, and benzene not being a COI in sediments adjacent to the Facility, benzene is not retained for further evaluation.
    - **Chlorobenzene.** Chlorobenzene was detected above the CUL in 2 of 86 groundwater samples with a maximum ER of 1.4. Chlorobenzene is not bioaccumulative. Chlorobenzene is not identified as a COI in sediments adjacent to the Facility. Based on the low number of CUL exceedances, chlorobenzene not being bioaccumulative, and chlorobenzene not being a COI in sediments adjacent to the Facility, chlorobenzene is not retained for further evaluation.
    - **Chloromethane.** There is no CUL for chloromethane. Chloromethane was detected above the SLV in 1 of 96 groundwater samples with an ER of 1.1. Chloromethane is bioaccumulative. Chloromethane is not identified as a COI in sediments adjacent to the Facility. Based on the

low number of SLV exceedances, and chloromethane not being a COI in sediments adjacent to the Facility, chloromethane is not retained for further evaluation.

- **Naphthalene.** There is no CUL for naphthalene. Naphthalene was detected above the SLV in 46 of 277 groundwater samples. The highest concentration was in 2002 (ER of 4,750) and concentrations have decreased over time. The maximum ER for naphthalene during the four 2016 monitoring events was 16. Naphthalene is bioaccumulative in aquatic organisms. Naphthalene is not identified as a COI in sediments adjacent to the Facility, but naphthalene is a member of the PAH family. The higher concentrations of naphthalene were detected in the same area as the higher PAH detections. Based on the decreasing trend in concentration, naphthalene not being a COI in sediments adjacent to the Facility, and naphthalene being a PAH that are being further evaluated, naphthalene is not retained for further evaluation.

- **PCE.** PCE was detected above CUL in 2 of 96 groundwater samples with a maximum ER of 40. PCE was not detected in samples collected from monitoring wells. PCE is not bioaccumulative. PCE is not identified as a COI in sediments adjacent to the Facility. Based on PCE not being detected in monitoring wells, PCE not being bioaccumulative, and PCE not being a COI in sediments adjacent to the Facility, PCE is not retained for further evaluation.

- **TCE.** TCE was detected above the CUL in 2 of 96 groundwater samples with a maximum ER of 42. TCE was not detected in samples collected from monitoring wells. TCE is not bioaccumulative. TCE is not identified as a COI in sediments adjacent to the Facility. Based on TCE not being detected in monitoring wells, TCE not being bioaccumulative, and TCE not being a COI in sediments adjacent to the Facility, TCE is not retained for further evaluation.

Based on the above discussion, the following analytes are considered contaminants of concern (COCs) for the groundwater source control pathway at the Facility. Figures 5 through 9 present the locations of groundwater samples with CUL exceedances for groundwater COCs.

- Arsenic;
- Pentachlorophenol;
- PAHs;
- 4,4'-DDD; and
- Total PCBs.

8.0 Nature and Extent of Contamination

This section summarizes the nature and extent of COCs in groundwater that have the potential for adverse effects on surface water or sediments. To assess COCs with the potential to adversely impact sediment and surface water, all data collected at the Facility were considered including data collected over more than a 20 year time span, grab samples, monitoring well samples, and dissolved and total analyses. Of these samples, data collected from monitoring wells during 2016 are considered the most representative of current conditions; therefore, these data are given more weight. Additionally, dissolved concentrations are considered more representative of concentrations with the potential to mobilize towards the river. Figures 10 through 14 illustrate the extent of COCs in groundwater based on the average concentrations of monitoring well samples during the four sampling events conducted in 2016.

- **Arsenic.** Figure 10 presents the average concentration of dissolved arsenic in groundwater monitoring well samples collected in 2016. In the Central and East Parcels, arsenic concentrations are at or below 2 µg/L except at MW-7 where concentrations are near 9 µg/L. Concentrations in wells MW-4 through MW-9 are consistent with background groundwater concentrations for arsenic (Hinkle, 1999), although the groundwater at MW-7 may be impacted by historical activities at the McCormick & Baxter facility. Arsenic concentrations exceeding 10 µg/L are present on the West Parcel (MW-1 through MW-3). Concentrations of arsenic exceed the CUL by factors of over 2,000. These higher arsenic concentrations could result from soil concentrations above background (e.g., in the former log pond fill), groundwater conditions conducive to leaching natural arsenic from soil, or a combination of both. Figure 10 shows the groundwater contours in a configuration that suggests the higher concentrations could be reaching surface water. However, additional sampling would be required to verify the concentrations that are actually reaching surface water. Based on current information, it was assumed that groundwater with concentrations of arsenic with the potential to adversely impact sediment and surface water is located on the West Parcel in the vicinity of the former log pond.
- **Pentachlorophenol.** Figure 11 shows the extent of pentachlorophenol CUL exceedances based on average concentrations in monitoring wells in 2016. MW-2, located on the West Parcel in the former log pond fill, is the only location where pentachlorophenol was detected. The average concentration in that well exceeded the CUL by a factor of 17. Given the limited extent of pentachlorophenol in groundwater, pentachlorophenol may not have an adverse impact on surface water or sediment. Additional sampling would be required to verify. However, the pentachlorophenol in groundwater is co-located with other COCs that have a larger extent. Therefore, pentachlorophenol is retained as a source control COC in the vicinity of MW-2.
- **PAHs.** Figure 12 presents the average concentration of BaP Eq from 2016 monitoring events. BaP Eq was used as an indicator for all PAHs. BaP Eq was not detected in wells MW-4, MW-6, MW-7, and MW-8. BaP Eq was detected in each of MW-5 and MW-9 in one out of four sampling events in 2016. Given the infrequent detection and the limited extent in MW-5 and MW-9 and the lack of detections on the other wells on the Central and East Parcels, adverse impacts from BaP Eq in groundwater on the Central and East Parcels is unlikely. The concentrations in wells MW-1 through MW-3, all located on the West Parcel, exceeded the CUL in three of four sampling events in 2016, and concentrations exceeded the CUL by factors of up to 5,000. Based on this analysis, groundwater containing BaP Eq concentrations with the potential to adversely impact sediments

and surface water is located on the West Parcel in the vicinity of the former log pond. Figure 12 shows the groundwater contours in a configuration that suggests the higher concentrations could be reaching surface water. However, additional sampling would be required to verify the concentrations that are actually reaching surface water.

- **4,4’-DDD.** Figure 13 shows the extent of 4,4’-DDD CUL exceedances based on average concentrations in monitoring wells in 2016. MW-2, located on the West Parcel in the former log pond fill, is the only location where 4,4’-DDD was detected. The average concentration in that well exceeded the CUL by a factor of 1,300. Given the limited extent of 4,4’-DDD in groundwater, 4,4’-DDD may not have an adverse impact on surface water or sediment. Additional sampling would be required to verify. However, the 4,4’-DDD in groundwater is co-located with other COCs that have a larger extent. Therefore, 4,4’-DDD is retained as a source control COC in the vicinity of MW-2.
- **Total PCBs.** Figure 14 presents the average concentration of total PCBs from 2016 monitoring events. The average total PCB concentration was less than the CUL in MW-1 and MW-4 through MW-9. The average total PCB concentration exceeded the CUL only in well MW-3 (by a factor of 100) and was equal to the CUL in MW-2. MW-2 and MW-3 are located on the West Parcel in the former log pond fill. The sample collected from MW-3 in December 2016 was also analyzed for dissolved PCBs. The dissolved PCB concentration was less than the CUL. This result suggests PCBs in groundwater may not be reaching surface water or sediments at adverse concentrations, but additional sampling would be required to verify the concentrations that are actually reaching surface water. Based on current information, it was assumed that groundwater containing PCB concentrations with the potential to adversely impact sediments and surface water is located on the West Parcel in the vicinity of the former log pond.

Summary of the Extent of the Groundwater Source Control Area. Figure 15 compiles the information from Figures 10 through 14 to show the overall extent of groundwater with COCs having the potential for adverse impacts on surface water or sediment. Based on the extent exceeding CULs and the magnitude of exceedance of the CUL, PAHs and arsenic are the primary source control COCs. The secondary COCs are 4,4’-DDD, total PCBs, and pentachlorophenol.

It is possible that some or all of the COCs are not reaching surface water or sediments at concentrations that would cause adverse impacts. For example, groundwater chemistry changes could reduce the solubility of arsenic prior to reaching surface water. Or COCs that only moderately exceed the CUL or that are relatively insoluble (such as 4,4’-DDD, total PCBs, and pentachlorophenol) may attenuate prior to reaching surface water. Additional sampling from the monitoring wells and/or pore water sampling would be required to better understand the concentrations that are actually reaching surface water.

The location of the groundwater source control area corresponds to the West Parcel. The former log pond, located within the West Parcel, was filled with material sourced from within the PHSS, reportedly from the Arkema Chemicals Company site located directly upstream and across the river from the Facility. Based on historical records and soil borings, the log pond fill is estimated to extend from the surface to approximately 45 feet bgs. That fill, and the historical sediments placed on the West Parcel may be the sources of the COCs in groundwater.

9.0 Source Control Alternatives Evaluation

9.1 Source Control Objective

The evaluations in Sections 6 through 8 have identified five COCs that have the potential for adverse impacts to river sediments or surface water. If it can be demonstrated (e.g., through additional sampling, modeling, etc.) that migration of groundwater will not result in sediment or surface water exceeding background or CULs, no source control actions will be necessary. Otherwise, groundwater source control may be required. The objective of groundwater source control at the Facility is to prevent contaminants in groundwater from adversely impacting surface water or sediments. This objective can be achieved by one of the following:

- Reduce groundwater concentrations to at or below the groundwater CULs (see Table 6);
- Reduce groundwater concentrations such that the concentrations achieve the surface water CULs (see Table 6) at the transition zone to surface water; or
- Prevent migration to the river of groundwater with concentrations exceeding the groundwater CULs.

9.2 Evaluation Criteria

The groundwater alternatives were evaluated using the criteria referenced in JSCS for Source Control Alternative Evaluation and Design. These criteria are effectiveness, implementability, and cost as described below in this section.

9.2.1 Effectiveness

This criterion includes both the long-term effectiveness of the technology to prevent groundwater from reaching the river and the feasibility of minimizing short-term risk (i.e., implementation risk) of groundwater intrusion during construction, as further described below.

- **Protectiveness.** The protectiveness criterion considers the ability of an alternative to be protective of public health, the community, workers during implementation, and the environment. In addition, this criterion assesses if the alternative complies with the applicable or relevant and appropriate requirements (ARARs). It is assumed that the CULs comply with ARARs. ARARs for the PHSS include:
    - Federal National Recommended Water Quality Criteria;
    - Oregon Water Quality Standards;
    - Maximum Contaminant Levels and Maximum Contaminant Level Goals;

    - Oregon Hazardous Substance Remedial Action Standards;
    - Federal and state solid and hazardous waste regulations;
    - The Endangered Species Act;
    - Section 404 of the Clean Water Act;
    - Section 401 of the Clean Water Act;
    - Section 10 of the Rivers and Harbors Act; and
    - Federal Emergency Management Agency floodplain regulations.
- **Ability to Achieve Removal Objectives.** The objective of this criterion is to assess the level of treatment/containment in the alternative and the ability to control site risks until the longer-term solution is implemented. In addition, this criterion considers residual effects of each alternative.

9.2.2 Implementability

The implementability criterion considers a number of factors that affect the practicability of constructing a particular alternative. These factors include the following:

- **Technical Feasibility.** Proposed technologies for each alternative must have demonstrated performance and useful life, be adaptable to Facility conditions, and contribute to the ability of the alternative to achieve remedial goals. In addition, the technology must be implementable within one year of project initiation.
- **Availability.** The proposed alternative must be implementable using available resources. Resources include but are not limited to equipment, personnel and services, laboratory testing capacity, disposal facilities, and post-removal site controls.
- **Administrative Feasibility.** This factor considers the ease of obtaining permits for the source control alternative, or the ease of fulfilling the substantive requirements of permits exempted under the Comprehensive Environmental Response, Compensation, and Liability Act and/or DEQ rules. Other considerations include the impact on adjoining properties, the ability to sustain the remedy including long-term implementation of institutional controls, and the ability to obtain exemption from statutory limits.

9.2.3 Cost

The relative cost to implement a source control alternative is developed at a conceptual level by estimating overall costs using general unit costs for various technologies. The categories of costs considered include capital cost, post-removal site controls, and present worth.

10.0 Technology Evaluation/Alternatives Development

This section describes and evaluates the source control technologies applicable to a Source Control Measure (SCM) for groundwater.

10.1 Screening of General Approaches

General approaches for SCMs to address Facility groundwater include the following:

- **No Action.** This alternative is retained for comparison with other alternatives.
- **Institutional Controls.** Institutional Controls consist of informational or legal barriers to monitor impacts, restrict access, or restrict activities in areas of concern. Institutional Controls would not prevent the migration of groundwater to the river. However, monitoring could provide data to assess the need for and effectiveness of implemented SCMs. Monitoring was retained for further consideration.
- **Engineering Controls.** These technologies include changes to infrastructure or substitutions that prevent direct contact with groundwater. Examples include vapor barriers to prevent migration of VOCs from groundwater or providing alternative water supplies. These technologies are generally not applicable to preventing groundwater migration to the river. Therefore, engineering controls were eliminated from further consideration.
- **Containment.** Containment technologies are physical or hydraulic barriers that prevent migration of groundwater to the river. When used for containment, these approaches are generally expected to be implemented in perpetuity. Both of these approaches are retained for further evaluation.
- **Removal/Discharge.** Groundwater pump and treat is similar to hydraulic containment except that with pump and treat there is an expectation that groundwater cleanup levels will be achieved in some reasonable time frame. Given that the COCs are generally recalcitrant, pump and treat is not likely to achieve cleanup levels within a reasonable timeframe. Additionally, a groundwater pumping alternative (containment) is being retained for further evaluation. Therefore, pump and treat is not further evaluated. Another removal approach is complete removal of the source soil that is contributing to the groundwater contamination; this approach is retained for further consideration.
- ***In-Situ* Treatment.** Depending on the particular COC, there are a variety of *in-situ* treatment options available. Due to the relatively large treatment volume, active treatment of the entire groundwater plume is not likely to be practicable, so active treatment technologies are not retained. Passive treatment (generally consisting of various adsorptive media through which the groundwater flows but may also include enhancements from biological activity) within a permeable reactive wall or a reactive sediment cap were retained for further evaluation. In addition, monitored natural attenuation (MNA) was retained as an applicable passive treatment technology.

- ***Ex-Situ* Treatment.** There are a variety of treatment technologies to address groundwater after it is pumped from the ground. Given the non-volatile nature of the COCs, the most effective treatment technology would be filtration through an adsorptive medium such as carbon or resins targeted to the specific COCs. Adsorption was retained as the representative technology to treat pumped groundwater.

Descriptions of technologies within the general approaches, and the reasons for retaining or not retaining a technology are presented in Table 7. Feasible technologies for further development include:

General Response Action	Groundwater Technologies
No Action	• No Action
Institutional Controls	• Monitoring
Containment	• Pumping • Cutoff Wall
Removal/Discharge	• Source Soil Removal
In Situ Treatment	• Permeable Reactive Wall • Reactive Sediment Cap • Monitored Natural Attenuation
Ex Situ Treatment	• Adsorption

10.2 Development of Alternatives

Based on the retained technologies, the following alternatives for groundwater source control measures at the Facility were developed for further evaluation.

1. Alternative 1 – No Action
2. Alternative 2 – Containment Pumping
3. Alternative 3 – Cutoff Wall
4. Alternative 4 – Source Soil Removal
5. Alternative 5 – Permeable Reactive Wall
6. Alternative 6 – Reactive Sediment Cap

11.0 Detailed Evaluation of Alternatives

11.1 Alternative 1 – No Action

The No Action alternative assumes that no action is taken, no monitoring is performed, and no costs are incurred.

11.2 Alternative 2 – Containment Pumping

Alternative 2 would consist of installing extraction wells with submersible pumps to remove contaminated groundwater with the goal of hydraulic containment. It is estimated that 6 wells to a depth of 60 feet would be required to capture groundwater sufficiently to prevent migration to the river. The groundwater would be treated by adsorption using resins/activated carbon targeted for the COCs. The pumping and treatment systems would require long-term operation and maintenance including replacement and disposal of treatment medium.

Effectiveness. Assuming hydraulic containment could be achieved, this alternative would be protective of public health, the community, and the environment. Impacts to workers can be addressed through standard construction engineering controls and personal protective equipment (PPE). It is expected that this alternative could achieve CULs, but there is uncertainty in the number of wells and pumping volumes needed to achieve complete hydraulic containment.

Implementability. Technologies to implement this alternative are readily available. The proximity to the river and the likely steep groundwater gradient at the Facility may require installation of additional and larger wells and high pumping rates. Discharge of treated water would need to be permitted.

Cost. Estimated costs are summarized as follows.[2] The contingency reflects the significant uncertainty associated with gradients, number of wells, and flow rates.

Mobilization (15% of direct construction)	$170,000
Pumping Wells (6 wells at $20,000 each)	$120,000
Piping and Treatment System	$1,000,000
Long-Term O&M – in perpetuity; present worth ($100,000/yr)	$2,000,000
Contingency (100% of total construction and O&M)	$3,290,000
Indirect Costs[3] (25% of total construction)	$330,000
Total Cost	**$6,910,000**

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[2] Unit prices derived from prior work on upland sites and Federal Remediation Technologies Roundtable Screening Matrix.

[3] Includes design, project management, oversight, insurance, bonding.

11.3 Alternative 3 – Cutoff Wall

This alternative consists of installing a physical barrier to prevent the migration of groundwater to the river. The cutoff wall could be constructed of a bentonite soil mixture or driven sheet pile. The wall would be installed along the length of the former log pond area which is approximately 800 linear feet. Due to the steep groundwater gradient anticipated at the Facility, the cutoff wall will need to be sufficiently deep to prevent downward flow from directing groundwater under the wall and into the river. The required depth is unknown but is expected to be at least 60 feet bgs. Supplemental pumping of groundwater is often necessary to prevent pressure buildup behind a cutoff wall. Proximity to the river and an anticipated steep groundwater gradient makes it possible that a cutoff wall at the Facility would require supplemental pumping. The pumping and treatment systems would require long-term operation and maintenance including replacement and disposal of treatment medium. Alternatively, the wall could be extended inland at the ends to reduce flow around the wall. For this option, it was assumed that there would be no pumping and the wall would extend inland 200 feet at each end.

Effectiveness. Cutoff walls are effective at preventing lateral migration of groundwater. Often, hydraulic control is required in addition to the cutoff wall to prevent buildup of groundwater behind the wall. In addition, the ability to direct groundwater flow into the hydraulic unit under the river is unknown. Impacts to workers can be addressed through standard construction engineering controls and personal protective equipment (PPE). It is expected that this alternative could achieve CULs at the transition zone, but there is uncertainty in the depth and length of wall that would be required.

Implementability. This alternative requires the use of specialized construction equipment to install the barrier wall. Equipment to install supplemental pumping wells is readily available. Due to the likely steep groundwater gradient and proximity to the river, and to prevent downward flow of groundwater under the cutoff wall into the river, the cutoff wall length would be greater than that of the area of impacted groundwater.

Costs. No long-term costs are assumed. Estimated costs are summarized as follows.[4] The contingency reflects the uncertainty associated with depth of the wall.

Mobilization (15% of direct construction)	$660,000
Cutoff Wall (72,000 square feet at $60/square foot)	$4,320,000
Contingency (60% of total construction)	$3,030,000
Indirect Costs (25% of total construction)	$1,260,000
Total Cost	**$9,330,000**

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[4] Unit prices derived from Federal Remediation Technologies Roundtable Screening Matrix.

11.4 Alternative 4 – Source Soil Removal

For this alternative, it was assumed that the former log pond fill is the source of the groundwater impacts. The fill material would be excavated and disposed of off-site. The estimated depth of excavation is 45 feet. The former log pond covered an area of 100,000 square feet. The estimated removal volume is 165,000 cubic yards. The upper 20 to 25 feet can be excavated using conventional construction equipment during low river levels. The lower portion will need to be dredged and dewatered prior to disposal with the bulk of the dredging being conducted from the shore. It was assumed that the excavation would not be backfilled. Rather, the excavation area would be graded and enhanced to create shallow water and riparian habitat.

Effectiveness. This alternative removes the source material to a controlled upland landfill, permanently addressing the source of contaminants to groundwater and the river. Waste materials would be moved out of the site by barge. Impacts to workers can be addressed through standard construction engineering controls and PPE. Moving materials by barge will reduce impacts to the community. It is anticipated this alternative could meet the CULs. There is some uncertainty that the fill is the only source of groundwater impacts.

Implementability. This alternative uses standard construction techniques and can be implemented in a single construction season. Permit requirements are consistent with other upland and in-water work activities that will be implemented at the same time.

Costs. No long-term costs are assumed. Estimated costs are summarized as follows.[5]

Mobilization (15% of direct construction)	$4,200,000
Soil excavation and dispose (90,000 cy at $100/cy)	$9,000,000
Dredge and dispose (75,000 cy at $250/cy)	$18,800,000
Restoration (4.8 ac at $100,000/ac)	$480,000
Contingency (40% of total construction)	$13,000,000
Indirect Costs (25% of total construction)	$8,100,000
Total Cost	**$54,000,000**

11.5 Alternative 5 – Permeable Reactive Wall

This alternative consists of installation of a reactive barrier wall. This wall, placed across the direction of groundwater movement, allows passage of water while facilitating degradation or removal of contaminants. Reactive materials can be incorporated into the wall to treat groundwater prior to emergence into the river. To address the COCs at the Facility, the reactive wall would consist of sand mixed with activated carbon. Zero-valent iron may be added to enhance arsenic removal, if needed based on design sampling/modeling. The

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[5] Unit prices derived from prior work on upland sites and cost estimates for Portland Harbor remediation.

wall would be installed along the length of the former log pond area which is approximately 800 linear feet, to a depth of 60 feet bgs, with a width of 4 feet.

Effectiveness. The addition of zero-valent iron and activated carbon to the permeable reactive wall can be effective at addressing the specific COCs for the Facility. Modeling would be needed during design to verify long-term effectiveness of the treatment medium. Impacts to workers can be addressed through standard construction engineering controls and personal protective equipment (PPE). It is expected that this alternative could meet CULs. There is some uncertainty in the long-term effectiveness of the wall that would be addressed with design modeling but could require a thicker wall.

Implementability. This alternative requires the use of specialized construction equipment to install the reactive wall.

Cost. No long-term costs are assumed. Estimated costs are summarized as follows.[6] The contingency reflects the potential for additional wall thickness.

Mobilization (15% of direct construction)	$1,730,000
Permeable Reactive Wall (96,000 cubic feet at $60/cubic foot)	$11,520,000
Contingency (40% of total construction)	$5,300,000
Indirect Costs (25% of total construction)	$3,320,000
Total Cost	**$21,900,000**

11.6 Alternative 6 – Reactive Sediment Cap

Alternative 6 would consist of placement of a cap amended with a reactive substance to adsorb COCs as the groundwater emerges through the cap. The barrier placed across groundwater movement allows passage of water while facilitating degradation or removal of COCs. Activated carbon amendments will address all of the COCs, although zero-valent iron may be added to enhance arsenic removal, if needed based on design sampling/modeling. Prior to application of the reactive cap, monitoring would be required to determine the concentration of groundwater entering the river through porewater sampling. This data would then be used to model COC breakthrough to determine the cap thickness and the type and quantity of the reactive substance. It was assumed that the cap would consist of 18 inches of sand mixed with zero-valent iron and activated carbon. The base cap layer would be covered with 12 inches of armor/beach mix consisting of sand/gravel with an average particle size of 4 inches. Because the cap would be in the shallow and intermediate water zones, it was assumed that existing sediment would be dredged the full depth of the cap (2.5 feet). The cap would run the full length of the West Parcel (700 feet) and extend outward into the river 250 feet (total area of 4 acres). The in-water remedy is not yet designed, but it was conservatively assumed that only 0.5 acres of

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[6] Unit prices derived from Federal Remediation Technologies Roundtable Screening Matrix.

this area is already targeted for dredge and cap, so the total area of additional cap needed for source control is 3.5 acres. It is possible that final design of the in-water remedy could change the size of the cap needed to address sediment contamination. That could have a significant impact on scope of the cap needed to address groundwater (from a large reduction to a moderate increase).

Effectiveness. The addition of amendments in a cap is effective at addressing the specific COCs for the Facility. This alternative would be protective of the public health, the community, and the environment. All work would be performed in-water, minimizing disturbance to the local community. Worker protection against Facility COCs would not be necessary as contact with groundwater is not necessary for implementation. Impacts to workers from construction techniques can be addressed through standard construction engineering controls and personal protective equipment (PPE). It is anticipated that this alternative could achieve CULs.

Implementability. This alternative uses standard construction techniques. As this work will be conducted at the same time as in-water work, equipment and qualified personnel will be available. Permit requirements are consistent with other upland and in-water work activities.

Cost. No long-term costs are assumed. Estimated costs are summarized as follows.[7]

Mobilization (15% of direct construction)	$690,000
Reactive Sediment Cap, Including Dredging (3.5 ac at $1,300,000/ac)	$4,550,000
Contingency (40% of total construction)	$2,100,000
Indirect Costs (25% of total construction)	$1,310,000
Total Cost	**$8,650,000**

12.0 Comparative Analysis of Alternatives

The potentially applicable source control alternatives were compared within the criteria given in Section 9.2.

12.1 Effectiveness

Each of the technologies addresses the migration of groundwater COCs to the river and would have relatively low risks of contamination during construction. Removal of source soil would be the most effective as contaminants are removed and disposed of off-site, making this alternative the most protective of public health, the community, and the environment, and the most effective at meeting CULs. Containment pumping would also be effective, as groundwater movement to the river is prevented and COCs are removed and treated; however, this technology is required in perpetuity, and complete removal of COCs may never be

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[7] Unit prices derived from costs estimates for Portland Harbor remediation.

achieved. The permeable reactive wall and reactive cap are considered equally effective, as groundwater is treated in both alternatives. These technologies have defined lifespans based on capacity to sorb or treat COCs, so breakthrough modeling and suitable safety factors will be required for adequate performance. The cutoff wall is considered the least effective alternative with the exception of no action as contaminants are not removed or treated. Combining limited pumping with the cutoff wall could greatly improve effectiveness of the cutoff wall.

12.2 Implementability

The no action alternative is considered the easiest to implement. The reactive cap is the most implementable of the active alternatives as the coordination with in-water work makes equipment and personnel readily available, standard construction techniques are utilized, and the area is easily accessible over water. Source soil removal is considered less implementable than the reactive cap due to the large amount of material to remove. However, soil removal is more implementable than other alternatives due to the standard construction techniques utilized and good access from the water side. Hydraulic containment utilizes standard technologies but is considered less implementable because of the need to operate the pumps and treatment system in perpetuity. The cutoff wall and permeable reactive barrier are considered the most difficult to implement due to the required specialized equipment, unknown subsurface conditions, and expected steep groundwater gradient at the Facility.

12.3 Cost

There is significant uncertainty in the costs at this stage of the evaluation. Therefore, the alternatives have been grouped into categories based on relative costs, as follows.

Category	Cost Range	Alternatives
Excellent	$0	1. No Action ($0)
Good	$1-5 million	--
Fair	$5-10 million	2. Containment Pumping ($6,910,000) 3. Cutoff Wall ($9,330,000) 6. Reactive Sediment Cap ($8,650,000)
Poor	$10-20 million	--
Bad	>$20 million	4. Source Removal ($54,000,000) 5. Permeable Reactive Wall ($21,000,000)

12.4 Comparative Summary

The comparative analysis discussed above is summarized in the chart below. Each alternative is given a qualitative ranking.

Alternative	Effectiveness	Implementability	Cost	Overall
1. No Action	○	●	●	◕
2. Containment Pumping	◕	◑	◑	◑
3. Cutoff Wall	◑	◔	◑	◑
4. Source Soil Removal	●	◑	○	◑
5. Permeable Reactive Wall	◕	◔	○	◔
6. Reactive Cap	◕	◕	◑	◕

● Excellent
◕ Good
◑ Fair
◔ Poor
○ Bad

Overall, five of the six alternatives are rated as fair to good. As discussed previously, additional sampling is needed to verify that COCs in groundwater are reaching surface water or sediment and causing adverse conditions. In the event that sampling demonstrates conditions are acceptable, No Further Action would be the selected alternative. Otherwise, one of the fair to good alternatives should be selected. The Source Soil Removal alternative has a very high cost so is impractical to implement. Of the remaining alternatives, the Reactive Sediment Cap has the best overall rating and is favored in the event that the in-water work includes at least some capping in the vicinity of the source control area of concern. If no capping is needed to address sediments adjacent to the West Parcel, groundwater containment may be a more suitable approach. By combining elements for both a cutoff wall and containment pumping, uncertainties associated with each are reduced: some containment pumping combined with a cutoff wall reduces the chance that groundwater will move beneath or around the wall; containment pumping will reduce the size of the wall needed; and the presence of the wall will reduce the amount of groundwater needed to be pumped/treated.

13.0 Recommended Source Control Alternative

Based on the evaluation above, the following approach is recommended for groundwater source control at the Facility.

- Conduct additional sampling to determine if concentrations of COCs in groundwater are causing adverse conditions in surface water or sediment. If results are acceptable, no further action is needed.
- Coordinate with the in-water design efforts.
    - If capping will be conducted adjacent to the West Parcel, use a Reactive Sediment Cap to address groundwater. This could range from simply adding reactive elements to the planned cap to also expanding the footprint of the proposed cap.
    - If no capping sediment action is required adjacent to the West Parcel, conduct a pre-design study to further evaluate containment versus a reactive sediment cap. Based on the current information, a hybrid containment alternative using a cutoff wall with containment pumping overall rates similarly to the reactive sediment cap. The pre-design study will provide the information needed to verify constructability of the cutoff wall and the amount of pumping that would be needed. That information would be used to select between the hybrid containment alternative and the reactive sediment cap.
- The estimated cost for the source control action is in the range of less than $1 million to $9 million. The low-end corresponds to amending an already planned in-water cap with the reactive component. The high end corresponds to either a hybrid containment alternative (combining a cutoff wall with containment pumping) or a reactive cap installed solely to address groundwater.

14.0 References

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Table 1
Monitoring Well Construction Details
Willamette Cove Upland Facility
Portland, Oregon

Well ID	Date Installed	TOC Elevation (feet)	Depth to Bottom (feet bgs)	Screened Interval (feet bgs)
MW-1	1/21/2002	37.84	41.5	25-40
MW-2	1/22/2002	46.14	41.5	25-40
MW-3	1/23/2002	44.07	43.0	27-42
MW-4	1/23/2002	37.30	36.5	19-34
MW-5	1/24/2002	38.13	37.0	22-37
MW-6	1/25/2002	38.05	37.0	22-37
MW-7	1/28/2002	36.67	35.0	20-35
MW-8	2/9/2016	37.79	38.00	23-38
MW-9	2/9/2016	35.41	33	18-33

Notes:

1. TOC = top of casing
2. Elevations relative to NAVD88 datum.
3. bgs = below ground surface.
4. Elevation for wells MW-2, MW-8, and MW-9 are from survey on June 16, 2016. All other well elevations from survey conducted in 2002.

Table 2
Groundwater Elevations
Willamette Cove Upland Facility
Portland, Oregon

Well ID	Date	Top of Casing Elevation (feet)	Depth to Water (feet bgs)	Groundwater Elevation (feet)
MW-1	2/7/2002	37.84	26.83	11.01
	5/28/2002		26.25	11.59
	8/29/2005		28.43	9.41
	12/16/2005		28.04	9.80
	2/23/2016		24.60	13.24
	6/3/2016		25.40	12.44
	9/14/2016		28.40	9.44
	12/14/2016		25.91	11.93
MW-2	2/7/2002	46.14	29.25	16.89
	5/28/2002		24.67	21.47
	8/29/2005		27.81	18.33
	12/16/2005		28.91	17.23
	2/23/2016		26.38	19.76
	6/3/2016		25.93	20.21
	9/14/2016		28.54	17.60
	12/14/2016		29.35	16.79
MW-3	2/7/2002	44.07	30.02	14.05
	5/28/2002		30.97	13.10
	8/29/2005		36.93	7.14
	12/16/2005		34.80	9.27
	2/23/2016		30.99	13.08
	6/3/2016		32.7	11.37
	9/14/2016		36.05	8.02
	12/14/2016		32.4	11.67

Please see notes at end of table.

Table 2
Groundwater Elevations
Willamette Cove Upland Facility
Portland, Oregon

Well ID	Date	Top of Casing Elevation (feet)	Depth to Water (feet bgs)	Groundwater Elevation (feet)
MW-4	2/7/2002	37.30	26.1	11.20
	5/28/2002		24.92	12.38
	8/29/2005		27.97	9.33
	12/16/2005		27.68	9.62
	2/23/2016		24.23	13.07
	6/3/2016		24.96	12.34
	9/14/2016		27.90	9.40
	12/14/2016		25.62	11.68
MW-5	2/7/2002	38.13	27.12	11.01
	5/28/2002		26.53	11.60
	8/29/2005		29.95	8.18
	12/16/2005		29.21	8.92
	2/23/2016		25.01	13.12
	6/3/2016		26.15	11.98
	9/14/2016		29.84	8.29
	12/14/2016		26.34	11.79
MW-6	2/7/2002	38.05	27.08	10.97
	5/28/2002		25.15	12.90
	8/29/2005		29.98	8.07
	12/16/2005		29.29	8.76
	2/23/2016		25.01	13.04
	6/3/2016		26.14	11.91
	9/14/2016		30.85	7.20
	12/14/2016		26.4	11.65

Please see notes at end of table.

Table 2
Groundwater Elevations
Willamette Cove Upland Facility
Portland, Oregon

Well ID	Date	Top of Casing Elevation (feet)	Depth to Water (feet bgs)	Groundwater Elevation (feet)
MW-7	2/7/2002	36.67	23.12	13.55
	5/28/2002		23.49	13.18
	8/29/2005		26.45	10.22
	12/16/2005		26.49	10.18
	2/23/2016		21.62	15.05
	6/3/2016		22.35	14.32
	9/14/2016		26.60	10.07
	12/14/2016		24.34	12.33
MW-8	2/23/2016	37.79	24.68	13.11
	6/3/2016		25.51	12.28
	9/14/2016		30.55	7.24
	12/14/2016		26.01	11.78
MW-9	2/23/2016	35.41	20.93	14.48
	6/3/2016		22.01	13.40
	9/14/2016		26.12	9.29
	12/14/2016		23.29	12.12

Notes:

1. Elevations relative to NAVD88 datum.
2. bgs = below ground surface.
3. Elevation for wells MW-2, MW-8, and MW-9 are from survey on June 16, 2016.
   All other well elevations from survey conducted in 2002.

Table 3
River Stage Evaluation
Willamette Cove Upland Facility
Portland, Oregon

Groundwater Monitoring Event	Date[4]	Measurement	River Stage[5] (feet)	River Gauge Reference Elevation (feet)	River Elevation (feet)
February 2016	Day - 2/23/16	Minimum	7.03	5.02	12.05
		Maximum	8.14		13.16
		Average	7.55		12.57
	Week - 2/17/16-2/23/16	Minimum	6.88		11.90
		Maximum	9.11		14.13
		Average	8.04		13.06
	Month - 1/24/16-2/23/16	Minimum	3.84		8.86
		Maximum	9.11		14.13
		Average	6.83		11.85
June 2016	Day - 6/3/16	Minimum	4.14		9.16
		Maximum	7.40		12.42
		Average	5.57		10.59
	Week - 5/28/16-6/3/16	Minimum	3.17		8.19
		Maximum	7.40		12.42
		Average	4.84		9.86
	Month - 5/4/16-6/3/16	Minimum	3.17		8.19
		Maximum	9.11		14.13
		Average	6.30		11.32
September 2016	Day - 9/14/16	Minimum	0.08		5.10
		Maximum	3.78		8.80
		Average	2.04		7.06
	Week - 9/8/16-9/14/16	Minimum	-0.40		4.62
		Maximum	4.08		9.10
		Average	1.49		6.51
	Month - 8/15/16-9/14/16	Minimum	-0.40		4.62
		Maximum	6.17		11.19
		Average	2.57		7.59
December 2016	Day - 12 /14/16	Minimum	5.95		10.97
		Maximum	7.91		12.93
		Average	6.84		11.86
	Week - 12/8/16-12/14/16	Minimum	4.24		9.26
		Maximum	8.22		13.24
		Average	6.14		11.16
	Month - 11/15/16-12/14/16	Minimum	3.88		8.90
		Maximum	8.36		13.38
		Average	6.06		11.08

Notes:

1. Elevations relative to NAVD88 datum.
2. The minimum, maximum, and average river stage shown for the day of the gaging event, and the week and month prior.
3. United States Geologic Survey (USGS) Sta. 14211720.

Table 4
Groundwater Screening Levels and Soil Background Concentrations
Willamette Cove Upland Facility
Portland, Oregon

Analyte	Groundwater	
	PHSS Cleanup Level	JSCS Screening Level Value
	µg/L	
Metals		
Aluminum	--	50
Antimony	--	6
Arsenic	0.018	--
Cadmium	0.091	--
Chromium	11	--
Copper	2.74	--
Lead	0.54	--
Mercury	--	0.77
Nickel	--	16
Selenium	--	5
Silver	--	0.12
Vanadium	20	--
Zinc	36.5	--
Petroleum Hydrocarbons		
Diesel Range Hydrocarbons	2.6	--
Semi-Volatile Organic Compounds		
2,3,4,6-Tetrachlorophenol	--	1100
2,4,5-Trichlorophenol	50	--
2,4,6-Trichlorophenol	--	2.4
2,4-Dichlorophenol	--	110
2,4-Dimethylphenol	--	730
2,4-Dinitrophenol	--	73
2,4-Dinitrotoluene	--	3.4
2,6-Dinitrotoluene	--	37
2-Chloronaphthalene	--	490
2-Chlorophenol	--	30
2-Methyl-4,6-dinitrophenol	--	150
2-Methylnaphthalene	--	0.2
2-Methylphenol	--	13
2-Nitroaniline	--	110
2-Nitrophenol	--	150

See notes at end of table.

Table 4
Groundwater Screening Levels and Soil Background Concentrations
Willamette Cove Upland Facility
Portland, Oregon

Analyte	Groundwater	
	PHSS Cleanup Level	JSCS Screening Level Value
	µg/L	
Semi-Volatile Organic Compounds		
3,3'-Dichlorobenzidine	--	0.028
3-Nitroaniline	--	3.2
4-Chloroaniline	--	150
4-Chlorophenyl Phenyl Ether	--	0.06
4-Methylphenol	--	180
4-Nitroaniline	--	3.2
4-Nitrophenol	--	150
Aniline	--	12
Benzoic Acid	--	42
Benzyl Alcohol	--	8.6
Bis(2-chloroethyl) Ether	--	0.06
Bis(2-ethylhexyl) phthalate	--	2.2
Butylbenzyl phthalate	--	3
Carbazole	--	3.4
Dibenzofuran	--	3.7
Diethyl Phthalate	--	3
Dimethyl Phthalate	--	3
Di-n-butyl phthalate	--	3
Di-n-octyl Phthalate	--	3
Hexachlorobenzene	--	0.00029
Hexachlorocyclopentadiene	--	5.2
Hexachloroethane	--	3.3
Isophorone	--	71
Nitrobenzene	--	3.4
N-Nitrosodimethylamine	--	0.00042
N-Nitrosodi-n-propylamine	--	0.0096
N-Nitrosodiphenylamine	--	6
Pentachlorophenol	0.03	--
Phenol	--	2560

See notes at end of table.

Table 4
Groundwater Screening Levels and Soil Background Concentrations
Willamette Cove Upland Facility
Portland, Oregon

Analyte	Groundwater	
	PHSS Cleanup Level	JSCS Screening Level Value
	µg/L	
Pesticides		
2,4'-DDD	0.000031	--
2,4'-DDE	0.000018	--
2,4'-DDT	0.000022	--
4,4'-DDD	0.000031	--
4,4'-DDE	0.000018	--
4,4'-DDT	0.000022	--
Aldrin	--	0.00005
alpha-BHC	--	0.0049
beta-BHC	--	0.017
delta-BHC	--	0.037
Dieldrin	--	0.000054
Endosulfan I	--	0.051
Endosulfan II	--	0.051
Endosulfan Sulfate	--	89
Endrin	--	0.036
Endrin Aldehyde	--	0.3
gamma-BHC (Lindane)	--	0.052
Heptachlor	--	0.000079
Heptachlor Epoxide	--	0.000039
Methoxychlor	--	0.03
Total Chlordane	--	0.00081
Toxaphene	--	0.0002
trans-Nonachlor	--	0.19
Phenols		
Dinoseb	--	7

See notes at end of table.

Table 4
Groundwater Screening Levels and Soil Background Concentrations
Willamette Cove Upland Facility
Portland, Oregon

Analyte	Groundwater	
	PHSS Cleanup Level	JSCS Screening Level Value
	µg/L	
Polycyclic Aromatic Hydrocarbons (PAHs)		
Acenaphthene	23	--
Acenaphthylene	--	0.2
Anthracene	0.73	--
BaP Eq	0.00012	--
Benzo(a)anthracene	0.0012	--
Benzo(a)pyrene	0.00012	--
Benzo(b)fluoranthene	0.0012	--
Benzo(g,h,i)perylene	--	0.2
Benzo(k)fluoranthene	0.0013	--
Chrysene	0.0013	--
Dibenzo(a,h)anthracene	0.00012	--
Fluoranthene	--	0.2
Fluorene	--	0.2
Indeno(1,2,3-cd)pyrene	0.0012	--
Phenanthrene	--	0.2
Pyrene	--	0.2
Polychlorinated Biphenyls (PCBs)		
Aroclor 1016	--	0.96
Aroclor 1221	--	0.034
Aroclor 1232	--	0.034
Aroclor 1242	--	0.034
Aroclor 1248	--	0.034
Aroclor 1254	--	0.033
Aroclor 1260	--	0.034
Total PCBs	0.014	--
Dioxins/Furans		
2,3,7,8-TCDD	--	5.1E-09
Dioxin/Furan TEQ	--	5.1E-09

See notes at end of table.

Table 4
Groundwater Screening Levels and Soil Background Concentrations
Willamette Cove Upland Facility
Portland, Oregon

Analyte	Groundwater	
	PHSS Cleanup Level	JSCS Screening Level Value
	µg/L	
Volatile Organic Compounds		
1,1,1,2-Tetrachloroethane	--	2.5
1,1,1-Trichloroethane	--	11
1,1,2,2-Tetrachloroethane	--	0.33
1,1,2-Trichloroethane	--	1.2
1,1-Dichloroethane	--	47
1,1-Dichloroethene	7	--
1,2,3-Trichloropropane	--	0.0095
1,2,4-Trichlorobenzene	--	8.2
1,2-Dibromoethane	--	0.033
1,2-Dichlorobenzene	--	49
1,2-Dichloroethane	--	0.73
1,2-Dichloropropane	--	0.97
1,3-Dichlorobenzene	--	14
1,4-Dichlorobenzene	--	2.8
2-Butanone	--	7100
2-Hexanone	--	99
4-Methyl-2-pentanone	--	170
Acetone	--	1500
Benzene	0.44	--
Bromodichloromethane	--	1.1
Bromoform	--	8.5
Bromomethane	--	8.7
Carbon disulfide	--	0.92
Carbon tetrachloride	--	0.51
Chlorobenzene	64	--
Chloroethane	--	23
Chloroform	--	0.17
Chloromethane	--	2.1
cis-1,2-Dichloroethene	9.9	--
cis-1,3-Dichloropropene	--	0.055
Dibromochloromethane	--	0.79

See notes at end of table.

Table 4
Groundwater Screening Levels and Soil Background Concentrations
Willamette Cove Upland Facility
Portland, Oregon

Analyte	Groundwater	
	PHSS Cleanup Level	JSCS Screening Level Value
	µg/L	
Volatile Organic Compounds		
Dibromomethane	--	61
Dichlorodifluoromethane	--	390
Ethylbenzene	7.3	--
Hexachlorobutadiene	--	0.86
Isopropylbenzene	--	660
m,p-Xylene	--	1.8
Methylene chloride	--	8.9
Methyl-tert-butyl-ether	--	37
Naphthalene	--	0.2
o-Xylene	--	13
Styrene	--	100
Tetrachloroethene	0.24	--
Toluene	9.8	--
Total Xylenes	13	--
trans-1,2-Dichloroethene	--	110
trans-1,3-Dichloropropene	--	0.055
Trichloroethene	0.6	--
Trichlorofluoromethane	--	1300
Vinyl acetate	--	16
Vinyl chloride	0.022	--
Natural Attenuation Parameters		
Arsenic III	--	190

Notes:

1. PHSS = Portland Harbor Superfund Site
2. Cleanup Levels from Record of Decision, Portland Harbor Superfund Site, EPA, January 2017.
3. JSCS Screening Level Value = Joint Source Control Strategy Screening Level Values from Portland Harbor Joi
Control Stratey, DEQ, 2005. Riverbank soil screened against JSCS SLVs if no PHSS Cleanup Level available.
4. Default Background - Portland Basin from Background Levels of Metals in Soils for Cleanups, DEQ 2013.
5. µg/L = micrograms per liter
6. Dioxin/Furan TEQ = 2,3,7,8-Tetrachlorodibenzodioxin Toxic Equivalent
7. Total PCBs is calculated as the sum of all detected values.
8. BaP Eq = Benzo(a)pyrene Equivalent

Table 5
Groundwater Screening Summary
Willamette Cove Upland Facility
Portland, Oregon

Analyte[1]		Screening Levels (µ/L)		Frequency						Highest Concentration Sample			
		CUL	JSCS SLV	Analyzed		Above MDL		Above Screening Level		Sample Name	Sample Type	Result (µg/L)	ER
				Grab	Well	Grab	Well	Grab	Well				
Metals													
Aluminum	Total	--	50	6	40	6	17	6	15	DP-5 (55-60)	Grab	39,200	784
	Dissolved			6	40	4	7	3	6	MW-3	Well	5,990	120
Antimony	Total	--	6	24	68	4	13	0	0	DP-5 (40-45)	Grab	3.01	0.5
	Dissolved			29	66	4	10	1	0	B-6	Grab	53.6	8.9
Arsenic	Total	0.018	--	30	68	28	61	28	61	MW-3	Well	128	7,111
	Dissolved			35	66	21	44	21	44	B-6	Grab	148	8,222
Cadmium	Total	0.091	--	30	68	15	13	12	7	SE/E-4	Grab	50	549
	Dissolved			38	66	6	2	3	2	SE/E-3	Grab	5	55
Chromium	Total	11	--	30	68	28	38	22	20	SE/E-4	Grab	1,800	164
	Dissolved			38	66	21	13	3	0	B-6	Grab	37.3	3.4
Copper	Total	2.74	--	30	68	29	48	27	37	SE/E-4	Grab	3,000	1,095
	Dissolved			38	66	18	22	8	5	B-6	Grab	472	172
Lead	Total	0.54	--	30	68	28	50	27	38	MW-5	Well	1,370	2,537
	Dissolved			38	66	19	12	14	6	MW-3	Well	8.52	16
Mercury	Total	--	0.77	30	68	14	22	8	12	DP-1 (35-40)	Grab	21.5	28
	Dissolved			35	66	4	4	0	0	MW-1	Well	0.423	0.5
Nickel	Total	--	16	30	68	29	63	23	20	SE/E-4	Grab	2,100	131
	Dissolved			35	66	26	60	1	0	MW-6	Well	247	15
Selenium	Total	--	5	24	68	9	25	1	2	DP-1 (35-40)	Grab	125	25
	Dissolved			29	66	5	13	2	0	DP-1 (35-40)	Grab	12.7	2.5
Silver	Total	--	0.12	24	68	6	7	6	7	B-4	Grab	13.1	109
	Dissolved			29	66	3	0	2	0	DP-1 (35-40)	Grab	2.01	17
Vanadium	Total	20	--	6	40	6	28	5	5	MW-1	Well	180	9
	Dissolved			6	40	5	22	0	1	MW-35s	Well	22.4	1.1
Zinc	Total	36.5	--	30	68	29	48	25	22	SE/E-4	Grab	7,100	195
	Dissolved			35	66	29	29	6	1	TB-3W	Grab	110	3.0

See notes at end of table.

Table 5
Groundwater Screening Summary
Willamette Cove Upland Facility
Portland, Oregon

Analyte[1]	Screening Levels (µ/L)		Frequency						Highest Concentration Sample			
	CUL	JSCS SLV	Analyzed		Above MDL		Above Screening Level		Sample Name	Sample Type	Result (µg/L)	ER
			Grab	Well	Grab	Well	Grab	Well				
Petroleum Hydrocarbons												
Diesel Range Hydrocarbons	2.6	--	12	29	4	6	4	6	TRENCH 4	Grab	1,400	538
Semi-Volatile Organic Compounds												
2-Methylnaphthalene	--	0.2	32	80	12	7	5	7	B-30	Grab	26.6	133
Bis(2-ethylhexyl) phthalate	--	2.2	21	41	5	3	4	0	B-30	Grab	69.7	32
Butylbenzyl phthalate	--	3	21	41	1	0	1	0	B-30	Grab	8.56	2.9
Dibenzofuran	--	3.7	19	41	6	3	1	0	B-30	Grab	10.9	2.9
Diethyl Phthalate	--	3	21	41	5	0	1	0	DP-4 (40-45)	Grab	5.06	1.7
Di-n-butyl phthalate	--	3	21	41	6	0	1	0	TB-3W	Grab	10	3.3
Pentachlorophenol	0.03	--	30	41	5	3	5	3	MW-2	Well	0.735	25
Pesticides												
4,4'-DDD	0.000031	--	9	7	0	2	0	2	MW-2	Well	0.0514	1,658
Polycyclic Aromatic Hydrocarbons (PAHs)												
Acenaphthylene	--	0.2	73	111	9	12	0	1	MW-1	Well	0.331	1.7
Anthracene	0.73	--	73	111	18	46	0	2	MW-2	Well	1.5	2.1
BaP Eq	0.00012	--	52	70	52	70	12	30	MW-1	Well	1.56	12,970
Benzo(a)pyrene	0.00012	--	73	111	15	32	15	32	MW-1	Well	1.27	10,583
Benzo(a)anthracene	0.0012	--	73	111	13	38	13	38	MW-1	Well	0.776	647
Benzo(b)fluoranthene	0.0012	--	60	111	16	28	16	28	MW-1	Well	1.15	958
Benzo(g,h,i)perylene	--	0.2	73	111	11	29	2	13	MW-1	Well	0.689	3.4
Benzo(k)fluoranthene	0.0013	--	60	111	8	26	8	26	MW-1	Well	0.822	632
Chrysene	0.0013	--	73	111	15	40	15	40	MW-1	Well	1.08	831
Dibenzo(a,h)anthracene	0.00012	--	73	111	8	4	8	4	WC-4	Grab	0.047	392
Fluoranthene	--	0.2	73	111	25	68	12	35	B-4	Grab	9.65	48
Fluorene	--	0.2	73	111	21	25	12	25	B-4	Grab	13.3	67
Indeno(1,2,3-cd)pyrene	0.0012	--	73	111	11	25	11	25	MW-1	Well	0.776	647
Phenanthrene	--	0.2	73	111	26	58	18	30	B-6	Grab	25.6	128
Pyrene	--	0.2	73	111	27	74	14	39	B-6	Grab	6.46	32

See notes at end of table.

Table 5
Groundwater Screening Summary
Willamette Cove Upland Facility
Portland, Oregon

Analyte[1]	Screening Levels (µ/L)		Frequency						Highest Concentration Sample			
	CUL	JSCS SLV	Analyzed		Above MDL		Above Screening Level		Sample Name	Sample Type	Result (µg/L)	ER
			Grab	Well	Grab	Well	Grab	Well				
Polychlorinated Biphenyls (PCBs)												
Aroclor 1254	--	0.033	34	0	3	0	3	0	SE/E-12	Grab	2.5	76
Total PCBs	0.014	--	40	41	9	36	8	8	MW-3	Well	5.62	401
Dioxin/Furans												
2,3,7,8-TCDD	--	5.1E-09	6	9	2	0	2	0	DP-4 (40-45)	Grab	2.28E-06	447
Dixoin/Furan TEQ	--	5.1E-09	6	9	5	3	5	3	DP-4 (40-45)	Grab	7.46E-05	14,627
Volatile Organic Compounds												
Benzene	0.44	--	32	53	1	4	1	2	B-6	Grab	1.25	2.8
Chlorobenzene	64	--	33	53	2	13	0	2	MW-2	Well	86.6	1.4
Chloromethane	--	2.1	33	63	0	1	0	1	MW-6	Well	2.22	1.1
Naphthalene	--	0.2	103	174	17	37	13	33	MW-2	Well	950	4,750
Tetrachloroethene	0.24	--	33	63	2	0	2	0	B-2	Grab	9.66	40
Trichloroethene	0.6	--	33	63	2	0	2	0	B-10	Grab	25	42

Notes:

1. Results for the total and dissolved metals analysis are grouped together by analyte as the frequency of analysis for each is similar. PAHs, PCBs, and dioxin/furans each have a single dissoved sample. As such, the result of the single dissolved analysis is not grouped by analyte with the total results for these groups due to the large difference in frequency of analaysis.
2. Cleanup Levels from Record of Decision, Portland Harbor Superfund Site, EPA, January 2017.
3. JSCS Screening Level Value = Joint Source Control Strategy Screening Level Values from Portland Harbor Joint Source Control Stratey, DEQ, 2005. Riverbank soil screened against JSCS SLVs if no PHSS Cleanup Level available.
4. Grab sample collected from temporary sample location during a one time event.
5. Well sample collected from an on-site monitoring well.
6. MDL = Method detection limit
7. µg/kg = micrograms per kilogram
8. ER = Exceedance Ratio
9. Mean Well Concentration is the mean concentration of the samples collected from monitoring wells during the four sampling events conducted in 2016. One-half of the method detection limit was used for concentrations below the MDL.
10. BaP Eq = Benzo(a)pyrene Equivalent
11. Dioxin/Furan TEQ = 2,3,7,8-TCDD toxicity equivalent

Table 6
Source Control Objective Screening Levels
Willamette Cove Upland Facility
Portland, Oregon

Contaminant of Concern	PHSS Cleanup Level		JSCS Screening Level Value
	Groundwater	Surface Water	
	µg/L		
Arsenic	0.018	0.018	--
Pentachlorophenol	0.03	0.03	--
4,4'-DDD	0.000031	0.000031	--
Acenaphthylene	--	--	0.2
Anthracene	0.73	--	--
BaP Eq	0.00012	0.00012	--
Benzo(a)anthracene	0.0012	0.0012	--
Benzo(a)pyrene	0.00012	0.00012	--
Benzo(b)fluoranthene	0.0012	0.0012	--
Benzo(g,h,i)perylene	--	--	0.2
Benzo(k)fluoranthene	0.0013	0.0013	--
Chrysene	0.0013	0.0013	--
Dibenzo(a,h)anthracene	0.00012	0.00012	--
Fluoranthene	--	--	0.2
Fluorene	--	--	0.2
Indeno(1,2,3-cd)pyrene	0.0012	0.0012	--
Phenanthrene	--	--	0.2
Pyrene	--	--	0.2
Total PCBs	0.014	0.0000064	--

Notes:

1. PHSS = Portland Harbor Superfund Site
2. Cleanup Levels from Record of Decision, Portland Harbor Superfund Site, EPA, January 2017.
3. JSCS Screening Level Value = Joint Source Control Strategy Screening Level Values from Portland Harbor Joint Source Control Stratey, DEQ, 2005. JSCS SLVs listed only if no PHSS Cleanup Level available.
4. µg/L = micrograms per liter
5. Dioxin/Furan TEQ = 2,3,7,8-Tetrachlorodibenzodioxin Toxic Equivalent
6. BaP Eq = Benzo(a)pyrene Equivalent

Table 7
Initial Screening and Evaluation of Technologies for Groundwater
Willamette Cove Upland Facility
Portland, Oregon

General Response Actions	Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
NO ACTION	None	No Action	Not effective in achieving RAOs.	Easy to implement.	No capital or O&M costs incurred.	Retained as a baseline for comparison.
INSTITUTIONAL CONTROLS	Groundwater Use Restrictions	Restrict use of groundwater within impacted areas.	Effective at preventing direct contact, but is not effective at preventing migration. Does not address contaminant reduction.	As there is no planned future use of on-site groundwater, or off-site property owners to coordinate with, this can be easily implemented.	Low costs associated with implementing restrictions.	Not applicable as it does not address migration to Willamette River.
	Monitoring	Laboratory analyses of groundwater samples. Could include transition zone water sampling in the river.	Effective for documenting site conditions to evaluate migration and current risks. Does not address contaminant reduction.	On-site monitoring wells already exist. Assessing contminant concentrations at receptors may require in-water porewater sampling.	Moderate to high costs relative to other institutional controls. Relatively low costs compared to active cleanup technologies. Higher relative costs for transition zone monitoring.	Applicable to document site conditions and effectiveness of any action.
ENGINEERING CONTROLS	Control of Building HVAC System	Use HVAC system to maintain positive pressure in buildings.	Not effective as depth to groundwater is expected to be too great for volitalization of compounds to indoor air, and there are no building on the site. Does not address contaminant reduction. Generally used in conjunction with other engineering controls.	Not applicable to site as there no current or planned structures.	No capital or O&M costs.	Not applicable to current or future site conditions.
	Vapor Barriers	Installation of low-permeable barriers beneath buildings to prevent vapor intrusion.	Not effective as depth to groundwater is expected to be too great for volitalization of compounds to indoor air, and there are no building on the site. Does not address contaminant reduction.	Not applicable to site as there no current or planned structures.	No capital or O&M costs.	Not applicable to current or future site conditions.
	Sub-Slab Depressurization or Sub-Floor Venting	Installation of sub-slab or sub-floor venting systems or suction pits to create negative pressures beneath structures to prevent vapor migration to ambient air. Vapors are collected in the suction pit or venting pipes below the building and vented to the outside of the building, either passively or with fans.	Not effective as depth to groundwater is expected to be too great for volitalization of compounds to ambient air, and there are no building on the site. Does not address contaminant reduction.	Not applicable to site as there no current or planned structures.	No capital or O&M costs.	Not applicable to current or future site conditions.
	Alternative Water Supply	Develop new water supply in uncontaminated area to provide potable water in the areas of impact.	Effective in preventing use of contaminated groundwater. No contaminant reduction. Does not address risks associated with vapor intrusion.	Conventional construction, requires local and WRD approvals.	High capital costs, low to moderate O&M costs.	Site groundwater not used. Does not address source control pathway.

Please refer to note at end of table.

General Response Actions	Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
	Wellhead Construction or Treatment	Site-specific construction techniques to avoid pumping from contaminated zones or treatment at individual impacted water supply wells with use of *Ex-Situ* Physical/Chemical/Thermal treatment technology.	Effective in reducing contaminant concentrations in groundwater prior to use eityher through use of a well design that does not pump impacted groundwater or wellhead treatment. Does not address risks associated with vapor intrusion.	Easy to implement. Treatment units are readily available. Requires ongoing testing and system maintenance to remain effective.	Low to high capital costs and O&M costs, depending on treatment technology. Moderately low costs for small residential carbon vessel systems or industrial application at plume perimeter.	Site groundwater not used. Does not address source control pathway.
CONTAINMENT	Vertical / Physical Barrier	Installation of vertical barriers (e.g., sheet piling, soil-bentonite slurry wall, grout, etc.) to prevent migration of groundwater contamination.	Effective at preventing lateral migration. Requires keying into underlying confining unit. Hydraulic control often necessary as supplemental measure to achieve containment. Cannot prevent downward migration.	Difficult to implement, given proximity to riverbank, and likely steep downard gradient of groundwater due to bluffs upgradient from site. Depth required to place containment unit below groundwater impacts unknown. Specialized equipment required for construction.	High capital costs, low to moderate O&M.	Applicable technology for site conditions.
	Pumping / Hydraulic Containment	Extraction well(s) with submersible pumps to lower the water table and create hydraulic gradients that direct contaminant migration into the extraction well. Extracted groundwater would require treatment before discharge (see *Ex-Situ* Physical/Chemical/ Thermal Treatment).	Effective in porous soils for preventing further contaminant migration. May also be used in conjunction with other technologies. Not efficient for removal of contaminant mass.	Existing monitoring wells could be utilized, although new and/or larger wells likely needed to capture full length of area of concern. High pumping rates would be required to contain the discharge of groundwater river due to the likely steep vertical gradient present at the Facility. Discharge of treated water would need to be permitted.	Moderate to high capital costs due to anticipated high pumping rates and anticipated treatment required prior to disposal.. New extraction wells likely required. Moderate to high O&M costs.	Applicable technology for site conditions.
REMOVAL/DISCHARGE	Pumping (Pump & Treat)	Extraction well(s) with submersible pumps to remove contaminated groundwater with goal of hydraulic containment. Treatment of extracted groundwater likely required before discharge (see *Ex-Situ* Physical/Chemical/ Thermal Treatment).	Effective in porous soils for preventing contaminant migration and removing contaminants from extracted groundwater. Less effective for achievement of cleanup of source areas. May also be used in conjunction with other technologies.	Existing monitoring wells could be utilized, although new and/or larger wells likely needed to capture full length of area of concern. High pumping rates would be required to contain the discharge of groundwater river due to the likely steep vertical gradient present at the Facility. Discharge of treated water would need to be permitted.	Moderate to high capital costs due to anticipated high pumping rates and anticipated treatment required prior to disposal.. New extraction wells likely required. Moderate to high O&M costs.	Not substantially different from Pumping/Hydraulic Containment in this application.
	Source Removal	Complete removal of source of contamination. This could include removal of soil, infrastructure, NAPLs, or other sources.	Effective at preventing ongoing contamination. Does not address contamination that has already migrated away from source.	There is no infrastructure or slope considerations to prevent removal of source soil at the Facility. The depth of removal necessary is unknown.	High capital cost due to anticipated depths, particularly in the former log pond area and large volume of soil for off-site disposal.	Applicable technology for site conditions.

Please refer to note at end of table.

Table 7
Initial Screening and Evaluation of Technologies for Groundwater
Willamette Cove Upland Facility
Portland, Oregon

General Response Actions	Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
	Subsurface Drains	Trench or horizontal boring filled with porous media - gravity drains to sump/pump. Treatment of extracted groundwater likely required before discharge (see Ex-Situ Physical/Chemical/Thermal Treatment).	Effective for shallow groundwater at preventing contaminant migration. Not effective for impacted deeper groundwater. May also be used in conjunction with other technologies.	Not practical to install at groundwater depths.	Moderate to high capital and O&M costs.	Not retained since groundwater depth greater than appropriate for subsurface drains.
	Discharge to Sewer / Surface Water	Discharge of water (which may require treatment) into surface water, storm sewer, or sanitary sewer.	Effective for disposal of extracted groundwater. Treatment of water may be necessary prior to disposal.	Connection to sanitary sewer system is not readily available. Sanitary sewer may not have adequate capacity, depending on extraction flow rate. NPDES permit required for storm sewer discharge (treatment needed to meet NPDES discharge requirements).	High costs to connect to storm sewer. Moderate to high disposal costs depending upon treatment required, permit fees, and monthly usage fees.	Not practical due to lack of available infrastructure and anticipated treatment required prior to disposal.
	Discharge to Reinjection Wells	Discharge of water (which may require treatment) into aquifer by reinjection wells.	Moderate effectiveness, depending upon whether injection wells can be adequately located to prevent increaseing groundwater gradient.	Underground injection control permit required for reinjection.	Moderate to high capital and O&M costs for reinjection wells.	Not applicable as there is no suitable location fo reinjection that will not be directly upgradient or off site.
	Reuse	Reuse of treated water for non-potable use such as irrigation or wetland enhancement.	Effective for treated, extracted groundwater.	A suitable use would need to be identified that can accommodate a steady flow rate in all seasons and within reasonable proximity. May need to be treated prior to reuse.	Moderate to high costs depending upon storage and pumping requirements, length of discharge piping, and if treatment required.	No identified potential use suitable for flow rate expected from extraction system.
IN-SITU PHYSICAL/ CHEMICAL/ THERMAL/ BIOLOGICAL TREATMENT	Aeration / Air Sparging	Increasing the contact between water and air to enhance volatilization. Air sparging involves injecting air into saturated matrices.	Effective for volatile contamination. May require shallow vapor extraction to prevent uncontrolled vapor migration. Sparging will turn plume aerobic which will interfere with MNA processes already in effect.	Proximity to river may limit amount of air that can be injected into subsurface. Equipment and technology for air sparging are readilly available. Vapor mitigation would likely be required.	Moderate capital and O&M costs for air sparging. High capital and O&M costs with addition of SVE system to control vapors.	Not retained because not applicable to contaminants of concern.
	Multi-Phase Extraction (MPE)	MPE provides simultaneous extraction of soil vapor, contaminated groundwater, and separate phase liquid using single vacuum pump, multiple in-well pumps, or bioslurping.	Effective for source removal at with moderate to low soil permeability. Soils at site may have soil permeability too high. May require vapor effluent treatment.	Equipment and technology for MPE are readily available. Treatment of recovered soil vapors and groundwater would be required prior to discharge.	Moderate to high capital and O&M costs. Higher costs if vapor treatment needed.	Separate phase liquid not present.
	Steam Flushing/ Steam Stripping	Steam is injected into the contaminated aquifer to vaporize less volatile organics.	May increase temperature of water discharging into river. Used in conjunction with vapor recovery. May be effective for increasing usability of SVE for low-volatility compounds.	Equipment and technology are readily available. Treatment of recovered vapors would likely be required.	High capital costs.	Not retained as the possible increase in groundwater temperature is not feasible adjacent to river.

Please refer to note at end of table.

Table 7
Initial Screening and Evaluation of Technologies for Groundwater
Willamette Cove Upland Facility
Portland, Oregon

General Response Actions	Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
	Chemical Oxidation	Chemically converts hazardous contaminants to less toxic compounds. Effective in destroying organic contaminants and oxidizing inorganic contaminants to less toxic/less mobile forms. Can include oxidant chemicals such as peroxides, permanganates, or ozone.	Effective in destroying organic contaminants (including free product) and oxidizing inorganic contaminants to less toxic/less mobile forms. Difficult to provide adequate coverage in subsurface. May cause settling in organic soils. Most applicable to source-area concentrations or NAPLs.	Equipment and vendors are readily available. May not adequately address likely large vertical area that requires treatement.	High implementation costs (potentially requiring multiple applications).	Not retained as no source area (NAPLs) identified.
	Passive/Reactive Treatment Walls/Reactive Caps	Barriers placed across groundwater movement that allows passage of water while facilitating degradation or removal of contaminants. Reactive materials can be incorporated in to in-river caps to treat groundwater prior to emergence into river (reactive cap).	Can be effective in the remediation of site contamination. Not cost-effective for very wide or deep plumes. Cost effective to add reactive materials to already planned in-water caps.	Difficult to implement due to proximimty to river and possible depth to contaminated groundwater. Specialized equipment required for construction. Gradient is not consistent (requires overly large wall installation). Relatively easy to add reactive materials to planned in-water caps.	High costs for installation. Moderate costs for performance and compliance monitoring, and periodic maintenance. Relatively low cost to add to already planned in-water cap.	Applicable technology for site conditions.
	Enhanced Bioremediation (Bioaugmentation, Biostimulation)	Adding nutrients, electron acceptor, or other amendments to enhance bioremediation. Addition of specific microbial cultures can be included if indigenous species not suitable for complete degradation of COIs.	Effective with addition of suitable amendments. Strategic placement of amendments can be effective in conjunction with other technologies. May be less effective with site contaminants.	May be unable to inject required concentrations to be effective due to proximity to river and concerns of discharge. Equipment and technology for direct injection are readily available. Suitable amendments for PCBs may be difficult to obtain.	Moderate costs depending on number of injection events required.	Not retained due to site proximity to river and contaminants less suited to biological reduction.
	Monitored Natural Attenuation	Using natural processes to reduce contaminant concentrations to acceptable levels. Process is closely monitored to verify exposures are acceptable prior to concentrations reaching acceptable levels.	May be effective, especially in areas of low concentrations (near plume boundaries), but is dependant upon site conditions. Site contaminants moderately conducive to natural attenuation.	Easy to implement. Monitoring wells already exist. May require significant timeframe to reach cleanup goals.	Low costs for monitoring relative to other active technologies.	Applicable technology for site conditions.
	Phytoremediation	Phytoremediation is a process that uses plants to remove, transfer, stabilize, and destroy contaminants.	Can be effective at removing a variety of organic and inorganic compounds from contaminated groundwater through plant uptake.	Requires significant land area suitable for large plants. Contamination below typical plant root zones.	Moderate implementation cost.	Not compatible with site conditions or deep contamination.
EX-SITU PHYSICAL/ CHEMICAL/ THERMAL/ BIOLOGICAL TREATMENT	Adsorption	Concentrating solutes on the surface of a sorbent material, such as activated carbon, to remove the solute from the bulk liquid.	Highly effective at removing many organic compounds from extracted water stream.	Depth of water that would need treatment is unknown. Treatment equipment is readily available. Disposal of water would be required.	Moderate to high capital and O&M costs.	Applicable technology for site conditions.

Please refer to note at end of table.

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General Response Actions	Technology	Description	Screening Criteria			Screening Comments
			Effectiveness	Implementability	Cost	
	Air Stripping	Volatile organics are partitioned from extracted groundwater by increasing surface area exposed to air.	Highly effective at removing many volatile organic compounds from extracted water stream. May require treatment of vapor effluent.	Applicable for treatment of site contaminants in extracted water. Treatment equipment is readily available. Requires air emission testing and modeling to determine if offgas treatment is required. Disposal of water would be required.	Moderate capital and O&M costs. Higher costs if offgas treatment needed.	Not practical due to anticipated high pumping rates required to achieve cleanup in a reasonable timeframe.
	Separation/ Reverse Osmosis	Extracted groundwater is forced through a selectively permeable membrane under pressure. Water is allowed to pass through the membrane while contaminants are trapped.	Highly effective at removing many contaminants from the extracted water stream.	Applicable for treatment of site contaminants in extracted water. Treatment equipment is readily available. Disposal of water would be required.	High capital and O&M costs.	Not retained since more cost-effective treatment methods exist for removal of site contaminants from water.
	Ultraviolet (UV) Oxidation	Ultraviolet radiation is used to destroy organic contaminants as water flows through treatment cell.	Effective at removing many organic contaminants from the extracted water stream.	Applicable for treatment of site contaminants in extracted water. Treatment equipment is readily available. Disposal of water would be required.	High capital and O&M costs.	Not retained since more cost-effective treatment methods exist for removal of site contaminants from water.
	Sprinkler Irrigation	Contaminated water is distributed through a pressurized sprinkler irrigation system (generally onto a highly porous media), allowing transfer of VOCs from aqueous phase to vapor phase.	Effective at removing many organic contaminants from the extracted water stream. Simpler system than more aggressive treatment technologies (such as air stripping).	Applicable for treatment of site contaminants in extracted water, but requires significant treatment system area.	Low to moderate capital and O&M costs.	Not retained since land use not compatible with site conditions.
	Ion Exchange	Ion exchange removes ions from the aqueous phase by exchange with counter ions on the exchange medium.	Effective for treatment of inorganic contaminants.	Treatment equipment is readily available. Disposal of water would be required.	Moderate to high capital and O&M costs.	Not compatible with site contaminants.
	Precipitation/ Coagulation/ Flocculation	This process transforms dissolved contaminants into an insoluble solid, facilitating the contaminant's subsequent removal from the liquid phase by sedimentation or filtration.	Effective for treatment of inorganic contaminants.	Treatment equipment is readily available. Disposal of water would be required.	Moderate to high capital and O&M costs.	Not compatible with site contaminants.
	Bioreactors / Trickling Filter	Contaminants in extracted groundwater are put into contact with microorganisms in attached or suspended growth biological reactors.	Effective at removing many organic contaminants from the extracted water stream. May be less effective during cold weather. May not reach treatment goals without followup polishing treatment.	Difficult to maintain effectiveness with variable operating parameters (i.e., influent concentrations, ambient concentrations). Requires significant area for reactors. Would require significant maintenance.	Moderate capital costs and moderate to high O&M costs	Not retained since required space not suitable for site conditions.

Please refer to note at end of table.

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General Response Actions	Technology	Description	Screening Criteria			Screening Comments
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	Constructed Wetlands	Utilizes natural geochemical and biological processes inherent in an artificial wetland ecosystem to remove contaminants from extracted groundwater.	Highly effective at removing many organic and inorganic contaminants from the extracted water stream.	Requires large land area to implement. May introduce attractive nuisance hazard for local wildlife.	Moderate to high capital costs. Low O&M costs.	Not retained since land use not compatible with site conditions.

Note:

1) Shading indicates technologies that have been eliminated from consideration.