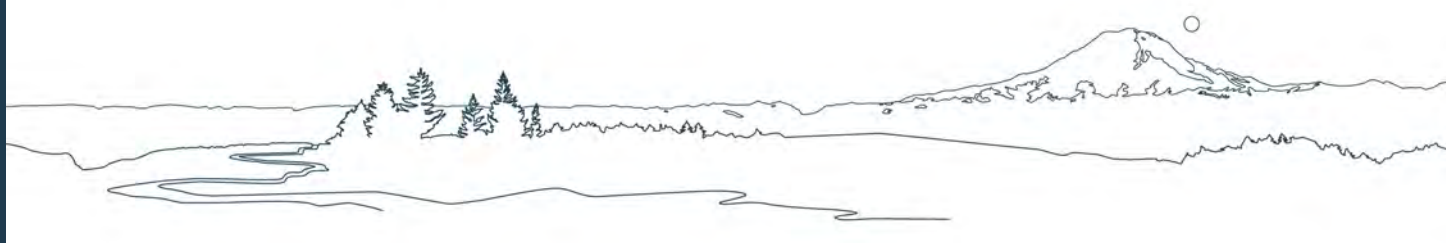
# Remedial Investigation/Feasibility Study

## Port of Longview TPH Site

**Prepared for**
Port of Longview

June 2025



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# Remedial Investigation/Feasibility Study

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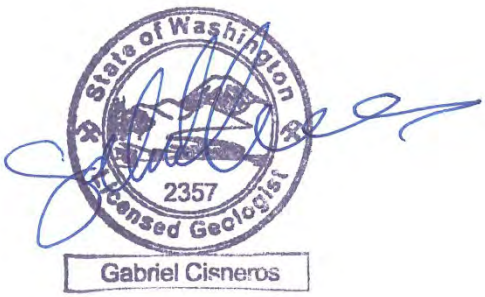


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# Executive Summary

## INTRODUCTION AND BACKGROUND

The Port of Longview (Port) Total Petroleum Hydrocarbons (TPH) Site (Site) is located in Longview, Washington, on the north side of the Columbia River, directly east of the Lewis and Clark Bridge. The Site is currently zoned as heavy industrial and is used for Port operations and marine cargo operations, which includes a rail-dependent bulk export facility. The Port has been operating at its location on the Columbia River since the early 1900s and the Site contains a ship berth, active railyard, and associated warehouse and transit shed buildings to accommodate the marine cargo (refer to Section 1.0 of this Remedial Investigation [RI]/Feasibility Report [FS]).

Since the early 1900s, the Port and other entities (and their predecessors), including Chevron U.S.A. Inc. (Chevron),[1] Georgia-Pacific LLC (Georgia-Pacific),[2] Wilson Oil, Inc. (Wilson),[3] and Smurfit Westrock LLC (WestRock),[4] operated facilities at the Site. These facilities included the following:

- A set of pipelines referred to as the Standard Pipelines[5] were installed on the Site in 1926 and decommissioned by 1986. The Standard Pipelines run parallel to Port Way beneath the rail lines and historically transferred petroleum products between a bulk plant located to the northeast of the Site and the shipping berths along the Columbia River.
- An 80,000-barrel aboveground storage tank (AST) was used for storage of Bunker C fuel, ballast seawater, and diesel. The AST was constructed by Longview Fibre in approximately 1935 and the tank was removed in 1996.
- A fuel loading station and a pipeline, referred to as the Longview Pipeline,[6] was located between the loading station and a wharf on the Columbia River at what is now Berth 2. The Longview Pipeline was operated from 1935 to 1973 primarily to transfer and store Bunker C fuel from tanker ships for use as fuel. The fuel loading station was reportedly used to load fuel, including Bunker C fuel, from ships and the AST into railroad tank cars for transport to the Longview Fibre Facility.

[1] Standard Oil Company of California is Chevron U.S.A. Inc.'s predecessor. Chevron Environmental Management Company manages environmental matters for the Chevron family of companies.

[2] James River Corporation and Crown Zellerbach are corporate predecessors of Georgia-Pacific.

[3] Wilson is doing business as Wilcox & Flegel Oil Company.

[4] WestRock Longview, Longview Fibre Paper and Packaging, Inc., Longview Fibre Company, and KapStone Kraft Paper Corporation are predecessors to WestRock.

[5] Many of the named facilities were owned or operated by multiple potentially liable parties. References to these facilities by name (e.g., Standard Pipelines or Longview Pipeline) are not intended to suggest that those entities, their predecessors, or their successors are liable or otherwise responsible for possible releases from them described in the Agreed Order or in this report.

[6] Refer to note 5.

- Several other pipelines constructed between 1926 and 1973 were used to transport a variety of petroleum products from ships berthed on the Columbia River to the Site. By 1986, the former Standard Pipelines beneath the Port property were reportedly cleaned, decommissioned, and abandoned in place (refer to Section 2.2 of this RI/FS).
- Several underground storage tanks (USTs) including the following:
  - A 675-gallon gasoline UST that was installed in the former Calloway Ross Parcel sometime prior to 1960 and removed in 1991.
  - A 4,000-gallon UST and an 8,000-gallon gasoline UST, operated by the Port, located in the former maintenance/mechanic's shop and removed in 1993.
  - A 2,800-gallon heating oil UST located adjacent to the former U.S. Army Reserve building to supply fuel for the building's steam boiler. The UST was installed in approximately 1949 and reportedly cleaned out in the 1970s.

**SITE DESCRIPTION**

The Site is designated Ecology Facility Site ID No. 42978181 and is officially referred to as the Port of Longview TPH Site. The Site is almost entirely paved, except for areas of rail track infrastructure and a material storage area north of the former Warehouse 9 building footprint. The Site is expected to have similar land use in the future. A log export facility owned by Weyerhaeuser NR Company and an active bulk fuel facility owned by Wilson are located northwest- and northeast-adjacent to the Site, respectively. The Columbia River and Port property border the Site to the southwest and southeast, respectively. The rail lines are operated by the Port and owned by either the Port and/or BNSF Railway Company.

**CONCEPTUAL SITE MODEL**

The Site sits on a broad, flat alluvial floodplain consisting of unconsolidated and consolidated sediments (refer to Section 5.0 of the RI/FS). Soils across the Site generally consist of a sandy fill layer underlain by native alluvial sediments, which consist of varying mixtures of sand and silt, including some laterally extensive silt lenses in the central portion of the Site. The silt lenses separate the two sandy water-bearing units at the Site: the perched water-bearing zone (perched zone) and alluvial aquifer. Hydrogeologic data indicate that the perched zone and alluvial aquifer are distinct water-bearing units with limited hydraulic connection and that interaction between the units resembles slow leakage through a low-permeability, non-continuous aquitard.

Groundwater is typically encountered at elevations between 7 and 19 feet North American Vertical Datum of 1988 (perched zone), and groundwater elevation measurements indicate that the primary directions of groundwater flow in both water-bearing units are to the north and northwest, away from the Columbia River. Hydrogeologic data from the Site indicate that groundwater flow away from the Columbia River is maintained by the nearby pumps associated

with the Consolidated Diking Improvement District #1, which maintain shallow Site groundwater at a head lower than the Columbia River.

RI sampling and analysis, as well as historical environmental investigations, indicate that soil and groundwater beneath the Site have been impacted by incidental releases and leaks from historical sources associated with the storage and transfer of petroleum fuels on the Site, including gasoline, diesel, Bunker C fuel, and PS300 fuel (refer to Section 9.0 of this RI/FS). These results of extensive investigations over the past 30 years indicate that the two media of concern at the Site are soil and groundwater.

Areas of residual TPH soil impacts, which include contaminants of concern, such as gasoline-range organics (GRO), total diesel-range organics (DRO) and oil-range organics (ORO), and benzene, are present throughout the Site but concentrated primarily on the former Calloway Ross Parcel, in the area of the former loading racks, and along and around the subsurface Standard and Longview Pipelines beneath the rail lines, and near the former 80,000-barrel AST. TPH-impacted soil in the central and northern parts of the Site is concentrated between approximately 8 and 17 feet below ground surface (bgs), which is below the estimated depth of the pipelines (3 to 4 feet bgs). In the southern portion, TPH-impacted soil is concentrated deeper, between approximately 13 and 24 feet bgs, which corresponds to the area where the pipelines are buried more deeply.

Groundwater impacts currently exist in both the perched zone and alluvial aquifer. The perched zone is hydrologically isolated from the alluvial aquifer by a low-permeability silt aquitard at its base. In the perched zone, total DRO and ORO groundwater impacts are approximately centered around MW-09 and MW-28 and include areas beyond the edge of the Port's property: MW-04 is downgradient of the source area around MW-09, and MW-30 is downgradient from the source area around MW-28. Data gaps pertaining to the dissolved-phase extent within the perched zone and alluvial aquifer will be filled during a predesign investigation prior to submittal of the Engineering Design Report. A smaller dissolved-phase GRO and benzene plume in the perched zone is centered around MW-09 beneath the railroad tracks. It is correlated to areas with elevated GRO and benzene soil concentrations, which are located just west of the rail lines and northwest of the former loading racks. In the alluvial aquifer, dissolved-phase plumes of total DRO and ORO are present in three main areas underlying the rail tracks, former fuel loading rack area, and the former Standard and Longview Pipelines. These plumes are associated with areas of greatest total DRO and ORO concentrations in soil. Measurable light non-aqueous phase liquid (LNAPL) is present only within the alluvial aquifer at MW-09. There is no pathway to surface water at the Site.

Groundwater cleanup standards were developed to be protective of human health via drinking water exposure, and soil cleanup standards are protective of human exposure and groundwater via the direct contact and leaching pathways. Ecological receptors are not exposed to soil contamination at levels of concern, and there is no pathway to surface water. Site environmental investigations indicate that the primary historical sources of petroleum impacts to soil and groundwater include the following:

- Former Standard Pipelines
- Former 80,000-barrel AST

- Former Longview Pipeline
- Former fuel loading racks
- Former Calloway UST

Impacts likely resulted from discharges of petroleum products to the surface and subsurface by leaks or spills during fuel handling and storage activities, which include historically known leaking USTs and an AST, which have been removed. From each point source, impacts may have migrated downward by infiltration and gravity drainage through vadose zone soil and reached both water-bearing units. In some instances, petroleum fuels accumulated as LNAPL on the groundwater surface and as soluble constituents dissolved into shallow groundwater.

In 2021, Ecology confirmed that the Site was adequately characterized (Ecology 2021a); the horizontal and vertical extent of soil and groundwater impacts have been delineated, and the risks of soil vapor to indoor air and groundwater discharge to surface water have been precluded.

## IDENTIFICATION OF COCS AND DEVELOPMENT OF CLEANUP STANDARDS

Based on historical information and data from Site environmental investigations, GRO, total DRO and ORO, and benzene were identified as contaminants of concern (COCs). Groundwater and soil proposed COCs and their proposed cleanup standards are summarized in the following table.

**Summary of Proposed Site COCs and Proposed Cleanup Standards**

| Proposed COC | Proposed Cleanup Level [1] | | Point of Compliance |
|---|---|---|---|
| | Value | Basis | |
| **Groundwater** | | | |
| GRO | 800 µg/L | Protection of drinking water | Site-wide |
| Total DRO and ORO | 500 µg/L | Protection of drinking water | Site-wide |
| Benzene | 5.0 µg/L | Protection of drinking water | Site-wide |
| **Soil** | | | |
| GRO | 30 mg/kg | Protection of groundwater [2] | Site-wide |
| Total DRO and ORO | 2,000 mg/kg | Protection of groundwater [2] | Site-wide |
| Benzene | 0.030 mg/kg | Protection of groundwater | Site-wide |

Notes:

1 Proposed CULs are based on MTCA Method A protection of groundwater (Tables 720-1 and 740-1).

2 The CULs for protection of leaching to groundwater and protection of direct contact are equivalent for TPH including GRO and total DRO and ORO. CULs based on leaching for benzene are also protective of the direct contact pathway.

Abbreviations:

CUL Cleanup Level
µg/L Micrograms per liter
mg/kg Milligrams per kilogram
MTCA Model Toxics Control Act

Soil COCs at concentrations greater than proposed CULs are concentrated primarily in the source areas impacted by historical site uses. Groundwater COCs at concentrations greater than proposed CULs exist in both the perched zone and alluvial aquifer, in most cases being immediately downgradient of areas of impacted soil (refer to Section 9.2 of this RI/FS). The dissolved-phase groundwater plumes also include areas beyond the edge of Port property. Data from off-property wells MW-04 and MW-30 installed in 1991 and 1998 show that the dissolved-phase plume is stable or degrading. These off-property wells contain low concentrations of COCs or intermittent proposed CUL exceedances.

**DEVELOPMENT AND EVALUATION OF REMEDIAL ALTERNATIVES**

Multiple remedial technologies, including passive, in situ, ex situ, and LNAPL removal technologies, were considered to address the soil and groundwater impacts in two Cleanup Action Areas (CAAs): impacts outside of the active rail lines (CAA-1) and impacts within the active rail lines (CAA-2). Following a preliminary screening process, the retained technologies were aggregated into five remedial alternatives, which include combinations of the following:

- Surfactant injection and extraction
- Sorption and biodegradation
- In situ soil and groundwater remediation by in situ chemical oxidation (ISCO) injections
- Targeted excavation and disposal of soil with concentrations of COCs greater than proposed CULs
- Institutional controls (ICs), which include a Soil Management Plan (SMP)
- MNA of groundwater

The five alternatives were evaluated within the disproportionate cost analysis (DCA) framework required under the Model Toxics Control Act (MTCA; WAC 173-340-360(5)(c)(iv)). The DCA evaluates remedial alternatives to identify the cleanup action that uses permanent solutions to the maximum extent practicable, while also achieving cleanup standards within a reasonable restoration time frame. In making this determination, each remedial alternative was assessed using MTCA comparative evaluation criteria, including protectiveness, permanence, effectiveness over the long-term, management of short-term risks, technical and administrative implementability, and consideration of public concerns. The final step in evaluating alternatives is identifying the protective alternative that is permanent to the maximum extent practicable. This requires weighing incremental costs and benefits of protective remedial alternatives. Costs are considered disproportionate to benefits when the incremental costs of an alternative exceed the incremental benefits compared to alternatives that are lower cost but still protective.

**PREFERRED REMEDIAL ALTERNATIVE**

The Preferred Remedial Alternative (Preferred Alternative) was identified by selecting the alternative with the greatest benefit per unit cost score. Alternative 3 was selected as the

Preferred Alternative because it is permanent to the maximum extent practicable and will treat approximately 77% of the hydrocarbon mass; the remaining 23% will be located in isolated areas on the Port property and protective of the public and environment.

The Preferred Alternative is a comprehensive remedy that complies with all the applicable remedy selection requirements under MTCA and provides the greatest environmental benefit for the associated cost based on the DCA. This remedy includes the following components:

- Targeted ISCO injections on Washington State Department of Transportation property in the vicinities of MW-04 and MW-30
- Surfactant injection and LNAPL extraction activities within the vicinity of MW-09 (former fuel rack loading area)
- Targeted ISCO injections within accessible areas where soil impacts exceed proposed CULs (CAA-1)
- Targeted ISCO injections along the rail lines where soil concentrations exceed remediation levels (CAA-2)
- Installation of additional monitoring wells along the northwestern and northern Port property boundary
- Inspection of the former Longview Pipeline contents
- Long-term groundwater monitoring for assessment of MNA
- Implementation of ICs and an SMP to protect human health and the environment from exposure to a hazardous substance at the Site

The Preferred Alternative for soil and groundwater meets the minimum requirements for selection of a cleanup action under MTCA (WAC 173-340-360(3)) because it is protective of human health and the environment, complies with cleanup standards, complies with applicable or relevant and appropriate requirements, and provides for compliance monitoring. The predicted restoration time frame for the Preferred Alternative to meet groundwater CULs at the downgradient property boundary for this alternative is estimated to be approximately 5 to 10 years, and the site-wide restoration is estimated to occur less than 10 years to approximately 28 years after remedy implementation is complete. The Preferred Alternative meets Site remedial action objectives and other MTCA requirements for selection of a cleanup action, including using permanent solutions to the maximum extent practicable, providing for a reasonable restoration time frame, and consideration of public concerns.

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## List of Abbreviations

| Abbreviation | Definition |
|---|---|
| ADEC | Alaska Department of Environmental Conservation |
| Agreed Order | Agreed Order # DE 15907 |
| AOPC | Area of potential concern |
| ARAR | Applicable or relevant and appropriate requirement |
| AS | Air sparging |
| AST | Aboveground storage tank |
| bgs | Below ground surface |
| BTEX | Benzene, toluene, ethylbenzene, and xylenes |

| Abbreviation | Definition |
|---|---|
| CAA | Cleanup Action Area |
| CAP | Cleanup Action Plan |
| CDID | Consolidated Diking Improvement District |
| Chevron | Chevron Environmental Management Company |
| CMP | Compliance Monitoring Plan |
| COC | Contaminant of concern |
| Columbia Report | Columbia Technologies, LLC's High-Resolution Fluorescence/Hydraulic Profile Characterization Report |
| COPC | Contaminant of potential concern |
| cPAH | Carcinogenic polycyclic aromatic hydrocarbon |
| CPOC | Conditional point of compliance |
| CSM | Conceptual site model |
| CUL | Cleanup level |
| DPE | Dual-phase extraction |
| DRO | Diesel-range organics |
| DTW | Depth-to-water |
| Ecology | Washington State Department of Ecology |
| EDR | Engineering Design Report |
| EPH | Extractable petroleum hydrocarbons |
| FBI | Friedman & Bruya, Inc. |
| FOE | Frequency of exceedance |
| Fremont | Fremont Analytical, Inc. |
| FS | Feasibility Study |
| GAC | Granular activated carbon |
| Georgia-Pacific | Georgia-Pacific LLC |
| GMP | Groundwater Monitoring Plan |
| GPR | Ground-penetrating radar |
| GRO | Gasoline-range organics |
| HPT | Hydraulic profiling tool |
| IC | Institutional control |
| ISCO | In situ chemical oxidation |
| LNAPL | Light non-aqueous phase liquid |

| Abbreviation | Definition |
|---|---|
| MCL | Maximum contaminant level |
| µg/L | Micrograms per liter |
| µg/$m^3$ | Micrograms per cubic meter |
| mg/kg | Milligrams per kilogram |
| mL/min | Milliliters per minute |
| MNA | Monitored natural attenuation |
| MPE | Multiphase extraction |
| MTCA | Model Toxics Control Act |
| NAVD 88 | North American Vertical Datum of 1988 |
| NOAA | National Oceanic and Atmospheric Administration |
| OIP | Optical image profiler |
| ORC-A | Advanced Oxygen Release Compound |
| ORO | Oil-range organics |
| OSHA | Occupational Safety and Health Act |
| PAH | Polycyclic aromatic hydrocarbon |
| PCUL | Preliminary cleanup level |
| PDI | Predesign investigation |
| perched zone | Perched water-bearing zone |
| PLP | Potentially liable party |
| PLP Group | Port of Longview TPH Site PLP Group |
| POC | Point of compliance |
| Port | Port of Longview |
| PRB | Permeable reactive barrier |
| Preferred Alternative | Preferred Remedial Alternative |
| PSET | Portland Sediment Evaluation Team |
| PVC | Polyvinyl chloride |
| QAPP | Quality Assurance Project Plan |
| RAO | Remedial action objective |
| REL | Remediation Level |
| RI | Remedial Investigation |
| RIWP | Remedial Investigation Work Plan |

| Abbreviation | Definition |
|---|---|
| ROW | Right-of-way |
| SAP | Sampling and Analysis Plan |
| SEF | Sediment Evaluation Framework |
| Site | Port of Longview Total Petroleum Hydrocarbons Site |
| SMS | Sediment Management Standards |
| SVE | Soil vapor extraction |
| TEE | Terrestrial ecological evaluation |
| TEQ | Toxic equivalent |
| TPH | Total petroleum hydrocarbons |
| UIC | Underground injection control |
| USACE | U.S. Army Corps of Engineers |
| UST | Underground storage tank |
| VI | Vapor intrusion |
| VOC | Volatile organic compound |
| VPH | Volatile petroleum hydrocarbons |
| WAC | Washington Administrative Code |
| WestRock | WestRock Longview LLC |
| Wilson | Wilson Oil, Inc. |
| WSDOT | Washington State Department of Transportation |

# 1.0 Introduction

This document presents the Remedial Investigation (RI) and Feasibility Study (FS) for the Port of Longview (Port) Total Petroleum Hydrocarbons (TPH) Site (Site) in Longview, Washington (Figure 1.1). The RI/FS was prepared per the requirements of Agreed Order # DE 15907 (Agreed Order) between the Port, Chevron U.S.A. Inc. (Chevron),[7] Georgia-Pacific LLC (Georgia-Pacific),[8] and the Washington State Department of Ecology (Ecology). Other potentially liable parties (PLPs) include Wilson Oil, Inc. (Wilson)[9] and Smurfit Westrock LLC (WestRock).[10] References to a successor PLP include its predecessors, and references to a predecessor include its successors. The Port, Chevron, Georgia-Pacific, Wilson, and WestRock are collectively referred to as the Port of Longview TPH Site PLP Group (PLP Group).

The RI portion of this report describes the Site, characterizes impacts to Site media, and presents a conceptual site model (CSM). The FS portion of this report describes remedial alternatives that meet Model Toxics Control Act (MTCA) requirements and support current and future property uses.

## 1.1 PURPOSE AND OBJECTIVES OF REPORT

The purpose of this report is to present an RI/FS consistent with the requirements of the MTCA Cleanup Regulations (Chapter 173-340 of the Washington Administrative Code [WAC]). In particular, this report aims to meet the following objectives:

- Fully describe soil and groundwater quality at the Site using available data.
- Evaluate exposure pathways to chemicals found in soil, groundwater, and vapor.
- Present a CSM.
- Define remedial action objectives (RAOs), applicable or relevant and appropriate requirements (ARARs), and cleanup levels (CULs) appropriate to the Site contaminants of concern (COCs) and continued use of the Site for heavy industrial purpose.
- Define and evaluate remedial action alternatives for cleanup of the Site for future use for heavy industrial purpose.
- Present a preferred remedial action for the Site.

## 1.2 BACKGROUND

The Site is located at 10 Port Way in Longview, Washington, on the north side of the Columbia River, directly east of the Lewis and Clark Bridge. The total area of the Port's property

[7] Standard Oil Company of California is Chevron U.S.A. Inc.'s predecessor. Chevron Environmental Management Company manages environmental matters for the Chevron family of companies.

[8] James River Corporation and Crown Zellerbach are corporate predecessors of Georgia-Pacific.

[9] Wilson is doing business as Wilcox & Flegel Oil Company.

[10] WestRock Longview, Longview Fibre Paper and Packaging, Inc., Longview Fibre Company, and KapStone Kraft Paper Corporation are predecessors to WestRock.

that comprises the Site is approximately 28.2 acres and consists of an office building, multiple buildings and transit sheds, two berths, and an active railyard (Figure 1.2). Land uses at the Site and in the surrounding area are industrial and zoned as heavy industrial.

As a result of the discovery of releases of petroleum products to soil and groundwater associated with various historical uses, the Site was included on the Ecology list of confirmed and suspected impacted sites in 1991. In the past, investigation and remediation work, as well as routine groundwater monitoring, have been accomplished cooperatively between and among members of the PLP Group.

Following the cessation of routine groundwater monitoring in 2014, the following activities occurred:

- In 2015, the Port conducted a review of data gaps and conducted an additional investigation to address priority data gaps. The results of the 2015 investigation are described in the Data Gaps Report (Floyd|Snider 2015).
- In 2016, Ecology issued PLP letters to the Port, Chevron, Georgia-Pacific, Wilson, and WestRock. The Port, Chevron, and Georgia-Pacific worked with Ecology to prepare the Agreed Order, which underwent public comment and was entered with an effective date of February 13, 2019.
- In 2019, an Ecology-approved RI Work Plan (RIWP) addressed the remaining data gaps not assessed during the 2015 investigation and provided the basis for much of the scope of the RI activities (Floyd|Snider 2019a).
- Additionally, in 2019, the Port performed interim action activities to remove exposed portions of the pipelines located beneath Berth 1 and Berth 2 (Floyd|Snider 2019b). Only a small, capped stub from each pipeline remains where the pipelines extend out of the bulkhead (refer to Section 2.3.11 for additional detail).
- In 2021, the Interim Data Report was submitted presenting the results of the initial RI and concluded that soil and groundwater impacts have been defined at the Site (Floyd|Snider 2021; Appendix A).

## 1.3 REPORT ORGANIZATION

The remainder of this RI/FS is organized as follows:

- **Section 2.0—Site Description and Background:** Provides information on the location, ownership, and historical and current land use at the Site. A summary of previous Site investigations and remedial actions is included.
- **Section 3.0—Remedial Investigation Activities:** Summarizes the RI activities conducted by Floyd|Snider between 2020 and 2021 in accordance with the Ecology-approved 2019 RIWP.
- **Section 4.0—Remedial Investigation Results:** Summarizes soil, groundwater, and soil vapor sample results from RI activities conducted between 2020 and 2021. Section 4.0

includes a discussion on all RI sample results but focuses on results that are not presented in the Interim Data Report, which is attached as Appendix A.

- **Section 5.0—Physical Setting:** Presents the regional and Site geology and hydrogeology, including a description of the two water-bearing zones at the Site.
- **Section 6.0—Exposure Pathway Analysis:** Presents possible exposure pathways for Site media and provides an assessment on whether these pathways should be considered complete/incomplete.
- **Section 7.0—Preliminary Cleanup Levels:** Provides a summary of the approach used to identify the preliminary cleanup levels (PCULs) for contaminants of potential concern (COPCs) and other chemicals of interest in groundwater and soil.
- **Section 8.0—Development of Contaminants of Concern and Proposed Cleanup Standards:** Identifies proposed COCs in groundwater and soil and proposes cleanup standards for the proposed COCs.
- **Section 9.0—Conceptual Site Model:** Presents the CSM for the Site, including potential release mechanisms and historical sources of proposed COCs and the nature and extent of COCs in Site media.
- **Section 10.0—Remedial Investigation Summary and Conclusions:** This section presents a summary of Site COC impacts in soil and groundwater. In addition, this section concludes that the nature and extent of contamination and the current and potential exposure pathways have been determined for the purposes of assessing and selecting remedial alternatives in the FS.

The FS sections of this document are organized as follows:

- **Section 11.0—Feasibility Study Introduction and Objectives:** Presents RAOs, points of compliance (POCs), cleanup standards, and remediation levels (RELs) for the Site.
- **Section 12.0—Identification and Screening of Remedial Technologies:** Lists and summarizes the technologies that could be applied to address COCs and identifies the technologies that are feasible for specific Site conditions. Technologies are either retained for further consideration/evaluation or rejected from consideration.
- **Section 13.0—Description of Remedial Alternatives:** Describes components of the five remedial alternatives, which are aggregations of the technologies retained in Section 12.0.
- **Section 14.0—Alternatives Evaluation and Disproportionate Cost Analysis:** Evaluates the remedial alternatives according to MTCA requirements and evaluation criteria for a cleanup action. This evaluation is then summarized in a disproportionate cost analysis (DCA).
- **Section 15.0—Preferred Remedial Alternative:** Describes in more detail the alternative recommended to Ecology for selection as the Preferred Remedial Alternative (Preferred Alternative) for the cleanup of the Site based on the results of

the alternatives evaluation and DCA, and how the Preferred Alternative meets the RAOs and complies with MTCA and ARARs.

- **Section 16.0—References:** Presents the sources cited in the RI/FS.

Documentation supporting this RI/FS are provided in the following appendices:

- **Appendix A—Interim Data Report:** Includes a summary of the field work and results associated with the RI field work.
- **Appendix B—MTCA Method B and C Calculation Workbooks:** Includes the workbook calculations for all soil sample results used for developing direct-contact CULs.
- **Appendix C—EPH/VPH Plots:** Shows the extractable petroleum hydrocarbons (EPH)/volatile petroleum hydrocarbons (VPH) data for select samples in relation to carbon ranges for gasoline, diesel, and Bunker C fuel.
- **Appendix D—Monitored Natural Attenuation at Port of Longview TPH Site:** Provides a summary and conclusions of the monitored natural attenuation (MNA) data.
- **Appendix E—Laboratory Analytical Reports:** Includes all laboratory analytical reports associated with the RI activities.
- **Appendix F—Aquifer Testing Report:** Provides a summary and conclusions of the aquifer testing conducted.
- **Appendix G—Historical Groundwater Data:** Includes historical groundwater analytical data collected prior to 2015.
- **Appendix H—Terrestrial Ecological Evaluation:** Includes the simplified terrestrial ecological evaluation (TEE) completed for the Site.
- **Appendix I—Detailed Cost Estimates:** Includes detailed cost estimates for each remedial alternative.
- **Appendix J—Boring Logs:** Includes all historical and recent borings logs.
- **Appendix K—OIP and Fluorescence Response Cross Sections:** Includes transects and cross sections across the entire Site showing the fluorescence and optical image profiler (OIP) results. The lateral and vertical extent of the proposed remedial activities for Alternatives 3 and 4 are included for a clearer understanding of the volume of mass to be targeted with these two alternatives. Transects and cross sections were created in Columbia Technologies' web-based software Smart Data Solutions®, a real-time data, information processing, and visualization platform.

# 2.0 Site Description and Background

This section provides a description of the Site and relevant historical Site operations based on information provided in previous reports (Golder 1994, 2000; Landau 2012) and supplemented by the Agreed Order and by Floyd|Snider's review of additional Site records. This section also includes a summary of previous environmental investigations and interim actions conducted between 1991 and 2019. The general location of the Site is shown in Figure 1.1, and the Site and its surroundings, including vicinity property ownership, are show in Figure 1.2. Figure 2.1 shows locations of historical Site features.

## 2.1 SITE DESCRIPTION

The Site is designated Ecology Facility Site ID No. 42978181 and is officially referred to as the Port of Longview TPH Site. The Site is located at 10 Port Way in Longview, Washington, on Cowlitz County parcels 10180, 1018101, and a portion of 10171, Section 8/Township 7N/Range 2W. The total area of the Site, shown on Figure 1.1, is approximately 28.2 acres, and the mean Site elevation is approximately 25 feet North American Vertical Datum of 1988 (NAVD 88).

The Site is currently zoned as heavy industrial and is used for Port operations and marine cargo operations, which include a rail-dependent bulk export facility. Activities, uses, and structures in support of those operations include storage of cargo handling equipment, cargo storage, conveyers, rail dump pit, baghouses, ship loader, office, maintenance shop, wastewater pre-treatment plant, transit sheds, and maintenance material storage. Site buildings include the former U.S. Army Reserve building and Former Port of Longview Office. Both buildings contain office space and are occupied. The Site also has a number of unoccupied storage warehouses and sheds. The Site is almost entirely paved except for areas of rail track infrastructure and a material storage area north of the former Warehouse 9 building footprint.

The Site is expected to have similar land use in the future. A log export facility owned by Weyerhaeuser NR Company and an active bulk fuel facility owned by Wilson are located northwest- and northeast-adjacent to the Site, respectively. The Columbia River and Port property (formerly owned by International Paper Company) border the Site to the southwest and southeast, respectively. The rail lines are owned by the Port and/or BNSF Railway Company, and the Port operates the rail lines that traverse the Site (Figure 1.2).

## 2.2 SITE AND OPERATIONAL HISTORY

The Port has been operating at this location on the Columbia River since the early 1900s and supports a variety of regional, national, and international industries as a bulk and break bulk marine cargo facility. The Port property, which includes portions of the Site and extends beyond the Site, contains ship berths, railyard, and associated warehouse and transit shed buildings to accommodate the marine cargo. Historical Site features are shown in Figure 2.1. Many of the historical Site features were owned or operated by multiple PLPs. References to these facilities

by name (e.g., Standard Pipelines or Longview Pipeline) are not intended to suggest that those entities, their predecessors, or their successors are liable or otherwise responsible for possible releases from them described in the Agreed Order or in this RI/FS. The following summary is repeated from the Agreed Order findings of fact:

"A. The Port of Longview consists of multiple parcels along the Columbia River spanning approximately 835 acres. The parcel where the Site is primarily located is owned by the Port of Longview, and is designated as Heavy Industrial in the City of Longview's zoning code (Chapter 19.58 Longview Municipal Code) and lies approximately 31 feet above mean sea level, and is depicted in Exhibit A [of the Agreed Order] (Port Property). The investigation data to date indicate the Site is approximately 28.2 acres in size, as depicted in Exhibit A [of the Agreed Order]. The Site is almost entirely paved, except for areas of rail track infrastructure.

"B. The Site is bordered in each direction by the following: The Columbia River to the southwest; Washington State Route 433 (Lewis & Clark Bridge) and an active lumber production facility owned by Weyerhaeuser NR Company to the northwest; an active bulk fuel facility (Bulk Plant) owned by Wilson and formerly owned by Chevron to the northeast; and property currently owned by the Port and formerly owned by International Paper Company to the southeast. BNSF Railway Company owns and operates rail lines that traverse the Site.

"C. The area of land within the Site has been owned primarily by the Port since the early 1900s. The Port formerly operated a 4,000-gallon underground storage tank (UST) and an 8,000-gallon UST on the Port Property (Port USTs). Calloway Ross, Inc. (Calloway) operated a 675-gallon UST (Calloway UST) on the Port Property. The United States Army Reserve operated a 2,800-gallon UST on the Port Property (Army UST). Correspondence between Wilson and the Port in 1993 suggests an additional UST used to stored gasoline may have been located near the [former] Army Reserve building on the Port Property.

"D. Chevron, or its predecessor, Standard Oil Company of California (Standard Oil) installed pipelines on the Site in 1926 that ran parallel to Port Way beneath the BNSF rail lines, to transfer petroleum products between the Bulk Plant and shipping berths along the Columbia River (Standard Pipelines). Standard Oil or Chevron owned the Standard Pipelines until 1986, when they were conveyed to the Port under the terms of a Termination of License Agreement (Termination Agreement). In accordance with the Termination Agreement, Chevron removed hydrocarbon liquids from the Standard Pipelines, cleaned the Standard Pipelines between the Bulk Plant and their terminus at the shipping berths, and flushed the Standard Pipelines with water and air.

"E. KapStone (formerly Longview Fibre Company) constructed and began operating a pipeline (Longview Pipeline), fuel loading racks, and an

80,000 barrel aboveground storage tank (AST) on the Port Property in approximately 1935 to transfer and store petroleum products. The Longview Pipeline was positioned slightly east of the Standard Pipelines. In the 1950s, the AST was connected to the Standard Pipelines. After the connection was made, petroleum products were transferred to the AST from the Standard Pipelines. KapStone owned the Longview Pipeline, fuel loading racks, and AST until 1973, when it sold the AST to Crown Zellerbach Corporation ("Crown Zellerbach"), a corporate predecessor of Georgia-Pacific.

"F. Crown Zellerbach owned the AST from 1973 to 1983. Crown Zellerbach used the AST and Standard Pipelines to transfer and store petroleum products and ballast seawater from tanker ships.

"G. Wilson operated the Standard Pipelines on behalf of Chevron and Standard Oil between 1971 and 1985. Wilson operated the AST on behalf of Crown Zellerbach between 1974 and 1983.

"H. The Standard Pipelines, Longview Pipeline, loading racks, AST, Calloway UST, Port USTs, and Army UST have been abandoned and/or removed in various phases. No petroleum products have been stored or distributed at the Site since 1996.

"I. Petroleum contaminated soil and groundwater was first discovered in 1991 during the decommissioning and removal of the Calloway UST, located in the northwestern corner of the Site. The Port conducted several phases of subsurface investigations between 1992 and 1994 in response to this discovery. The results of the subsurface investigations are generally summarized in a *Phase IV Characterization Report – Bunker C and Diesel Fuel Investigation,* prepared by Golder Associates, dated December 7, 1994. A brief summary of each of these phases is provided below and a figure of the related areas is included in Exhibit A [of the Agreed Order].

  "i. Phase 1: Gasoline, diesel fuel, and Bunker C were detected in soil and groundwater in the railyard east of [former] Warehouse 9, as well as in the area formerly leased by Calloway.

  "ii. Phase 2: Petroleum contaminated soil and groundwater were detected and associated with the Calloway UST and the Standard Pipelines and Longview Pipeline.

  "iii. Phase 3: Two separate zones of soil and groundwater contamination were characterized, suggesting that at least two separate and distinct leaks from pipes have occurred.

  "iv. As a separate action from the investigations originating with the Calloway UST, the Port removed the Port USTs from the vicinity of the [former] mechanics shop at the time of the Phase 3 investigation. Analysis of groundwater samples near the mechanic shop indicated the

presence of gasoline, diesel, and Bunker C. Because the USTs only contained gasoline, a Phase 4 investigation was conducted to investigate the mechanic shop area and the pipeline locations between the mechanics shop and the Columbia River for the source of diesel and Bunker C contamination.

"v. Phase 4: Soil and groundwater were found to contain significant concentrations of gasoline, diesel, and Bunker C throughout the investigation area. The identified impacts to soil and groundwater were generally located north of the [former] mechanics shop area along the pipeline corridor.

"J. The investigations identified petroleum products in the gasoline, diesel, and oil carbon-ranges, and other petroleum-related constituents (e.g., benzene, toluene, ethylbenzene, and xylenes) in the subsurface at concentrations exceeding MTCA Method A soil and groundwater cleanup levels for unrestricted land use. The investigations suggest the Standard Pipelines, the Longview Pipeline, the fuel loading racks, the AST, the Calloway UST, the Port USTs, the Army UST, and the practices commonly associated with the storage and transfer of fuel are likely the principal sources of subsurface contamination at the Site.

"K. Remedial activities at the Site began in the 1990s as part of an independent cleanup action. In 1992, gasoline was detected in soil at depths below the groundwater table on the southwest side of the AST, and diesel and Bunker C fuel were detected at depths between 1.5 to 8 feet below ground surface (bgs) on the east and south sides of the AST. The highest concentrations of petroleum in surface soils were located beneath the AST. In 1996, soil in the vicinity of the AST was excavated to the soil and groundwater interface at a depth of approximately six feet bgs. Confirmation samples taken from the final limits of the excavation indicated residual petroleum products in the diesel carbon-range were present at concentrations above the MTCA Method A soil cleanup level for unrestricted land use and were left in place in a localized area at the southern extent of the excavation. Further excavation was limited by high groundwater, sandy soils, and the proximity to the BNSF rail lines.

"L. In spring 1996, approximately 800 cubic yards of surface soils impacted with petroleum were removed from the parcel formerly leased by Calloway. The impacts were likely related to historical activities occurring on the parcel. This remedial action did not fully address the subsurface impacts related to the Calloway UST.

"M. In December 2013, Ecology performed a Site Hazard Assessment (SHA) of the Site. The Site was given a hazard ranking of 2 out of 5 (1 being Ecology's highest priority for cleanup).

"N. In 2015, the Port retained Floyd|Snider to conduct a data gap analysis to further delineate the extent of soil and groundwater impacts at the Site (Floyd|Snider investigation). The Floyd|Snider investigation included 30 direct-push soil borings focused on the south and west portions of the Site, collection of 16 grab groundwater samples from those borings, and collection of a groundwater sample from an existing monitoring well. The Floyd|Snider investigation indicated that petroleum-impacted soils are primarily located beneath the BNSF rail lines and that petroleum-impacted groundwater does not extend beyond the Port Property boundary to the northwest and not extend to the Columbia River to the southwest. The Floyd|Snider investigation identified several additional tasks to aid in the development of the remedial investigation and feasibility study.

"O. In February 2016, approximately 5 gallons of petroleum product were released from abandoned pipelines beneath shipping berths 1 and 2 along the Columbia River through two separate corroded areas. The Port conducted spill response actions, plugged the leaks, and reported the releases to the United States Coast Guard and Ecology."

## 2.3 PREVIOUS ENVIRONMENTAL INVESTIGATIONS

The nature and extent of impacted soil and groundwater at the Site has been investigated through multiple environmental investigations, which were conducted between 1991 and 2019. Additionally, multiple interim actions, including excavation and offsite disposal of petroleum-impacted soil, capping of exposed pipelines, and removal and disposal of pipelines beneath the berths, have also been implemented during this time period. Boring logs from historical and recent investigations are compiled in Appendix J.

### 2.3.1 1991 Extent of Contamination Investigation

In February 1991, the Port retained Petroleum Services Unlimited, Inc., to investigate soil and possible impacts associated with a recently decommissioned 675-gallon UST on the Calloway Ross Parcel that reportedly contained gasoline hydrocarbon product (PSU 1991). Eight soil borings were advanced and multiple soil samples were collected and analyzed for TPH products. Additionally, five monitoring wells, MW-01 through MW-05, were installed in areas upgradient and downgradient of the decommissioned UST (Figure 2.2).

Results from the investigation showed subsurface soil diesel-range organics (DRO) and gasoline-range organics (GRO) impacts up to 13,000 and 1,500 milligrams per kilogram (mg/kg), respectively, north (downgradient) of the former UST. Results are summarized in the 1991 report (PSU 1991).

### 2.3.2 1992 Phase I Investigation

In September 1992, Golder Associates was retained to further investigate and delineate the diesel impacts identified in the 1991 Extent of Contamination Investigation.

The Phase I investigation expanded the investigation area to include the former Calloway UST area, the pipelines underlying the east-adjacent railyard, and the 80,000-barrel AST and associated fuel area (Golder 1993a). Six additional monitoring wells, MW-06 through MW-12, and one soil boring were installed within the study area, and eight test pits (2 to 15 feet deep) were excavated around the perimeter of the AST (Figure 2.2). Results showed elevated concentrations of GRO, DRO, and other (Bunker C fuel) detections in soil boring locations, and elevated concentrations of GRO (up to 3,100 micrograms per liter [µg/L]) and DRO (up to 1,650 µg/L) in groundwater samples collected from monitoring wells. Further results are summarized in the Phase 1 report (Golder 1993a).

### 2.3.3 1993 Phase II Investigation

In March 1993, Golder conducted a Phase II investigation, which included using ground-penetrating radar (GPR) to map locations of underground pipelines and collecting shallow soil samples to identify potential soil impacts related to the former Calloway UST, pipelines, and 80,000-barrel AST. Results confirmed three north–south target trends, parallel to and under the railroad tracks, varying from 3 to 6 feet in depth (Golder 1993b). Based on historical records, two of the north–south trends were identified as the Standard and Longview Pipelines, and the third was hypothesized as being potentially a water line. The GPR survey did not detect any additional USTs within the vicinity of the former Calloway UST or 80,000-barrel AST; however, GPR results identified four "anomalous soil areas." Results are summarized in the Phase II report (Golder 1993b).

### 2.3.4 1993 Phase III Investigation

Following the Phase II investigation, Golder conducted a Phase III investigation, intending to further characterize the nature and extent of soil and groundwater impacts as well as identify potential source areas (Golder 1993c). This involved installing nine new monitoring wells, MW-13 through MW-21, located in the 80,000-barrel AST vicinity and in the railroad tracks between the Calloway Ross Parcel and the AST, and sampling existing monitoring wells (Figure 2.2). Soil samples were also collected during drilling.

Groundwater samples showed the presence of two diesel plumes: a plume between the Calloway Ross Parcel and the AST with DRO in groundwater detected at concentrations up to 250,000 µg/L, and a second, smaller plume north of the AST underneath the railroad tracks. Elevated concentrations of GRO in groundwater were also detected up to 5,800 µg/L in two areas: the vicinity of the former Calloway UST and southwest of the AST underneath the rail lines. Results from the soil investigation showed three zones of elevated DRO and TPH-other concentrations: a zone in the northern portion of the Site near the former Standard Pipelines, a zone adjacent to the AST, and an elongated zone in the central portion of the study area, stretching from the location of the former Calloway UST south underneath the rail lines. A zone of GRO impacts was identified, stretching east–west through the center of the study area. The investigation is summarized in the Phase III report (Golder 1993c).

### 2.3.5 1993 Underground Storage Tank Investigation

In July 1993, Golder performed a UST investigation of soil and groundwater surrounding two USTs that had recently been removed near the former mechanic's shop, in the southern portion of the study area, southeast of former Warehouse 9 and the Calloway Ross Parcel (Golder 1993d). Approximately 15 cubic yards of petroleum-contaminated soil was removed during the decommissioning of the 4,000- and 8,000-gallon gasoline USTs associated with the Port's former mechanic's shop. Three soil borings were advanced and sampled and one monitoring well was installed. Analytical results indicated that petroleum hydrocarbons were not detected in the soil samples, although groundwater from one sample point contained elevated concentrations of GRO, DRO, and TPH-other.

### 2.3.6 1994 Phase IV Investigation

In March and June 1994, Golder performed a Phase IV investigation, which expanded the study area of the earlier investigations to the south and provided additional detail on sources of soil impacts as identified by previous GPR surveys and on the extent of southward groundwater impacts (Golder 1994). GPR and visual inspections were used to confirm the location of the pipelines in the southern portion of the Site; the Standard Pipelines were observed to "branch" approximately 50 feet south of the former mechanic's shop, with one branch terminating underneath present-day Berth 1 and the other under Berth 2. GPR results determined that the Longview Pipeline terminated at present-day Berth 2.

Additionally, eight new monitoring wells were installed, MW-22 through MW-29, and existing monitoring wells were sampled (Figure 2.2). One soil boring was advanced, and a groundwater grab sample was collected through a temporary well point. Analytical results from the Phase IV investigation identified an additional zone of DRO soil impacts, as well as a DRO- and GRO-impacted groundwater plume, located in the area around and to the north of the former mechanic's shop.

### 2.3.7 1995–1996 Focused Feasibility Studies and Interim Actions

In August 1995, the 80,000-barrel AST was removed, two monitoring wells were installed, T-1 and T-2, and surface soil samples that were collected from the foundation sand immediately beneath the AST indicated TPH ranging in concentrations from 55 to 66,000 mg/kg. Soil sample results from T-1 show DRO and oil-range organics (ORO) impacts in the top 3 feet at T-1; hydrocarbons were not detected at T-2. In 1996, Golder prepared focused FSs for two areas at the Site, the soil impacts on the Calloway Ross Parcel and soil impacts associated with the 80,000-barrel AST, based on results from their previous investigations (Golder 1996b). Based on an evaluation of all proposed alternatives, biotreatment with off-site landfill was proposed for both areas containing soil impacts.

In May 1996, TPH-impacted soil was excavated from three shallow excavations on the Calloway Ross Parcel and stockpiled on-site. Initial verification samples indicated that impacted material remained in the northern part the excavation near the rail lines, and the excavation was

subsequently expanded. On December 10, 1996, 800 cubic yards of stockpiled impacted soil was transported off-site for thermal treatment and disposal.

In 1996, an interim cleanup action was conducted below and around the footprint of the former 80,000-barrel AST, during which approximately 5,000 cubic yards of petroleum-impacted soil was removed and transported off-site for disposal, including material associated with the surface soil samples in 1995. Twelve compliance soil samples were collected from below the footprint of the former AST. Concentrations from all compliance samples, except one floor sample, were less than their respective MTCA Method A CULs (Golder 1996b).

### 2.3.8 1999–2014 Groundwater Monitoring

In June 1998, three perimeter wells, MW-30, MW-31, and MW-32, were installed and included as part of the groundwater sampling program conducted by Golder between 1999 and 2014 (Figure 2.2). The groundwater sampling program during this period included groundwater monitoring at select monitoring wells along the perimeter (MW-1, MW-4, MW-23, MW-27, MW-30, MW-31, and MW-32) and interior (MW-10 and MW-12) of the groundwater contaminant plumes identified in previous Site investigations. All wells were sampled on an annual basis, except for MW-30, which was sampled quarterly between 1999 and 2000 before being sampled annually. In 1999, absorbent socks were installed in four monitoring wells (MW-3, MW-7, MW-9, and MW-20) to absorb accumulated petroleum hydrocarbon product previously observed. Socks were monitored quarterly by Golder until 2000 when Port staff took over monitoring and annual sock replacement, which occurred until 2014.

Analytical results from annual groundwater monitoring indicated that no detectable concentrations of petroleum hydrocarbons were found in the seven perimeter monitoring wells throughout the duration of monitoring. Interior monitoring wells MW-10 and MW-12 showed detections of GRO, benzene, and 2-methylnaphthalene, as well as sporadic DRO concentrations, greater than MTCA Method A CULs. Maximum detections of GRO, benzene, 2-methylnaphthalene, and DRO at the interior wells were 5,800, 840, 99, and 3,200 µg/L, respectively (Golder 2015). Annual monitoring reports concluded that impacts underlying the railroad yard, Calloway Ross Parcel, the former 80,000-barrel AST, and loading racks had not migrated laterally away from source areas.

### 2.3.9 2011 and 2016 Sediment Investigations

In June 2011, the Port characterized sediments offshore of the Site in support of a maintenance dredging and berth deepening project in accordance with a U.S. Army Corps of Engineers (USACE) Regional Sediment Evaluation Team-approved Sampling and Analysis Plan (SAP; Anchor QEA 2011). The Port performed additional sediment characterization in October 2016 under a separate USACE Portland Sediment Evaluation Team (PSET)-approved SAP in support of maintenance dredging (Anchor QEA 2017). The work in both 2011 and 2016 included collection and characterization of composited sediment samples from four dredged material management units spanning between Berths 1 and 9. Chemical analysis of the sediments included DRO, ORO, and polycyclic aromatic hydrocarbons (PAHs), among other Sediment Evaluation

Framework (SEF) and Sediment Management Standards (SMS) freshwater COCs, such as metals, semivolatile organic compounds, polychlorinated biphenyls, and pesticides. The analytical results were compared to both MTCA Method A unrestricted land use and industrial land use for potential upland disposal and SEF freshwater toxicity-based screening levels for in-water disposal.

The analytical results from both 2011 and 2016 investigations indicate that no chemicals exceeded the SEF and SMS freshwater criteria or the MTCA Method A industrial criteria (Floyd|Snider 2019a). One sample collected in 2011 near Berths 6 and 7, approximately 3,000 feet east of Berth 2, exceeded the MTCA Method A unrestricted land use criterion for benzo(a)pyrene; the sample was collected from a deeper interval identified as native material, however, and the detected PAHs were determined to be likely naturally occurring. Another sample collected in 2011 near Berth 2 was noted to have a very slight hydrocarbon odor in the surface interval of the core; however, subsequent chemical analysis detected neither DRO nor ORO. In 2016, all analytical results were less than the MTCA Method A criteria for unrestricted land use. During this event, PAHs were detected only near Berth 1, at concentrations less than the SEF screening levels. The 2017 Anchor QEA Sediment Characterization Report indicated that these detections were likely due to a limited crude oil spill in February 2016 (refer to Section 2.3.11 for additional information; Anchor QEA 2017); no petroleum was detected in this area.

As such, the sediment characterization investigations in both 2011 and 2016 indicate that dredged sediments were suitable for a variety of uses including upland beneficial reuse or in-water disposal. Additionally, prior to 2011, the sediments were ranked as “low-moderate” risk for potential biological effects or elevated concentrations of contaminants as described in the Dredged Material Management Program User Manual (DMMP 2013). The 2011 report concluded that based on the chemical concentrations, the ranking should be recharacterized to “low” (Anchor QEA 2011). The investigation conducted in 2016 confirmed this site recommended ranking of “low,” which is established after lines of evidence, such as chemical analysis, indicate that depositional materials do not originate from or near impacted areas and do not contain chemical contaminants at levels of concern (Anchor QEA 2017). In addition to the detected sediment concentrations being less than the SEF (and therefore SMS) freshwater screening levels, the 2016 chemical concentrations were also compared by PSET to the Oregon Department of Environmental Quality fish-based screening level values for bioaccumulative COCs. The concentrations were also less than those values. The basis of both of those comparisons supported the determination that the dredge prism sediment is suitable for in-river unconfined aquatic disposal and is not a risk to the environmental or human health. The Port received a suitability determination for dredged berth sediments from USACE PSET in 2017 (USACE 2017). Relative to protection of human health, there is no intertidal beach area or pathway for human exposure.

These findings, as well as Site hydrological studies confirming the groundwater flow direction in the alluvial aquifer is to the north, away from the river, indicate there is no upland source of impacts to sediments.

### 2.3.10 2015 Data Gaps Investigation

In 2015, Floyd|Snider conducted a priority data gaps investigation to fill priority data gaps related to the extent of soil and groundwater impacts at the Site; specifically, the southern and western edges of known impacts, uninvestigated areas adjacent to the pipelines in the southern portion of the property, and along the shoreline of the Columbia River (Floyd|Snider 2015). The results from the data gaps investigation were used to identify areas of potential concern (AOPCs) that needed further investigation to fully characterize the Site.

As part of the investigation, 30 soil borings (GP-1 through GP-30) were advanced at the Site immediately following the demolition of Warehouse 9, the mechanic's shop, and the Gear Locker A buildings (Figure 2.2). Groundwater screening samples were also collected from 16 direct-push soil borings and MW-23. Groundwater samples were analyzed for DRO; GRO; and benzene, toluene, ethylbenzene, and xylenes (BTEX), and soil samples were analyzed for hydrocarbon identification, GRO, DRO, and ORO.

Soil samples collected from borings in the footprint of former Warehouse 9 indicated that concentrations of all constituents were less than either their respective MTCA Method A CULs or the laboratory quantitation limits. Groundwater data indicated that DRO concentrations exceeded the MTCA Method A CUL in locations GP-1, GP-2, and GP-6. Despite the exceedances of the CUL, the detected concentrations were concluded to be low enough to indicate the edge of the dissolved-phase plume.

Additionally, four soil borings (GP-5, GP-7, GP-8, and GP-9) were advanced adjacent to an inferred portion of the Weyerhaeuser pipeline that reportedly traverses the southern part of the Site (Figure 2.2). The concentrations of all analytes were less than their respective MTCA Method A CULs or the laboratory quantitation limits.

Groundwater samples were collected from direct-push borings adjacent to the pipelines in the southern portion of the property, including five borings adjacent to the Columbia River. The groundwater analytical results indicate that DRO, GRO, and BTEX were detected at concentrations less than their respective MTCA Method A CULs. In addition, the soil analytical data from the five borings adjacent to the Columbia River, GP-13 through GP-17, show concentrations of all constituents less than their respective MTCA Method A CULs.

The analytical results from soil samples from all but two borings adjacent to the eastern pipelines show residual hydrocarbons at concentrations less than the MTCA Method A CULs. Soil samples from those two borings (GP-18 and GP-27) resulted in detections exceeding the MTCA Method A CULs. DRO and ORO were detected in soil at concentrations exceeding their respective MTCA Method A CULs at depths ranging between 14 and 15 feet bgs in boring GP-27, which is located east of the former mechanic's shop and adjacent to the former Longview Pipeline.

Farther south in soil boring GP-18, impacted soil was encountered at depths ranging between 27 and 28 feet bgs. The impacted soil encountered in GP-18 is limited in vertical extent to a 1-foot depth interval and is geographically isolated from impacts present to the north at the Site.

Soil boring GP-18 is located in the southwestern portion of the Site, northeast of Transit Shed 2 and adjacent to the easternmost Longview and Standard Pipelines.

During the September 2015 investigation, an effort was made to delineate the extent of residual hydrocarbons in soil boring GP-18. Soil borings GP-16, GP-28, and GP-29 were advanced to the south, west, and east of GP-18, respectively (Figure 2.2). Soil analytical data from these borings show petroleum hydrocarbon concentrations less than the MTCA Method A CULs or the laboratory quantitation limits. Due to the presence of utilities and current operations in Transit Shed 2, soil borings could not be advanced along the pipeline southwest of GP-18. The data gaps investigation also included a review of boring logs and groundwater level data that resulted in a refinement of the CSM that distinguished between the shallow perched water-bearing zone (perched zone) in the central portion of the Site and an underlying alluvial aquifer. This change is reflected throughout the RI; refer to Sections 3.5, 4.5, and 5.2.

### 2.3.11 2016–2019 Spill Response and Interim Action

On February 17, 2016, Port personnel noticed a small petroleum sheen on the water in front of Berth 1. The cause of the sheen was found to be drippage from a corroded section of a former pipeline underneath the berth. Best management practices, including deploying hard and oil-only adsorbent booms around the drip location, were used to contain the drippage and sheen, and oil-adsorbent pads were used to collect any oil within the booms. The National Response Center, U.S. Coast Guard, and Ecology were notified within hours of discovery, as was NRC Environmental Services, the Port's spill response contractor. The Port developed an initial response plan to inspect the booms and check on the pipe and plug daily and to eventually remove the pipes. No further drips were noted after the hole was plugged.

On March 4, 2016, a second leak was discovered close to the location of the first leak but from another pipeline underneath the berths. It is suspected that the initial activity in responding to the leak caused a shift in the adjacent pipelines, resulting in the second leak. The Port responded by redeploying the hard boom on the outer perimeter and using oil-only adsorbent booms and adsorbent pads, as was done before. Due to the advanced corrosion on that section of pipe, it was not possible to cut and plug the leak. Therefore, the Port had to evacuate the product in that section of pipe and place a bucket with pads under the pipe to contain any remaining drippage. It is estimated that approximately 5 gallons of petroleum product was released from abandoned pipelines beneath shipping Berths 1 and 2.

After consultation with Ecology, it was determined that the final action to prevent future releases should be conducted under Ecology's authority via an interim action conducted under the Agreed Order with the Toxics Cleanup Program. All containments and sorbent booms remained in place and weekly inspections were conducted until interim action activities began. In April and May 2019, the interim action was completed at the Port to remove the deteriorating portions of the Standard and Longview Pipelines that were exposed under Berths 1 and 2. All activities associated with the interim action were in accordance with the Interim Action Work Plan, which is included as Exhibit C in the Agreed Order. The Final Interim Action Completion Report that documents the removal activities was submitted to Ecology in September 2019 (Floyd|Snider 2019b).

### 2.3.12 2019 Early Season Groundwater Sampling and Monitoring

Floyd|Snider performed groundwater monitoring and sampling activities between February 27 and March 1, 2019. The intent of the Site-wide sampling event was to collect data during winter from wells that have typically been dry at other times of year and to obtain current Site-wide groundwater data. Groundwater samples were collected from 29 of 32 monitoring wells and analyzed for GRO, DRO, and ORO (with and without silica gel cleanup) and BTEX. Prior to collecting groundwater samples, depth to groundwater, total depth, and light non-aqueous phase liquid (LNAPL) thickness measurements were collected from all existing monitoring wells on the property, except for MW-8, which could not be opened due to a damaged well box and bolts.

Groundwater analytical results, included in the Interim Data Report, were consistent with previous sampling, although typically at lower concentrations than previous efforts, that delineated impacts and indicated MTCA Method A CUL exceedances of benzene, GRO, and DRO in monitoring wells screened within the alluvial aquifer located in the central portion and northern portions of the Site (Floyd|Snider 2021; Appendix A). Additionally, MW-28, screened in the vadose zone, had detections of DRO and ORO at concentrations greater than MTCA Method A CULs. MW-09 contained LNAPL at a thickness of 0.01 feet and was not sampled (Floyd|Snider 2021; Appendix A). Absorbent socks were present in monitoring wells MW-03, MW-07, MW-09, and MW-20 and were removed and disposed of as non-hazardous waste, except for the sock in MW-09. The sock in MW-09 was raised to hang above the groundwater. The goal of removing the socks was to assess whether LNAPL thicknesses would recover.

# 3.0 Remedial Investigation Activities

As outlined in the RIWP (Floyd|Snider 2019a), site characterization activities were conducted at the Site between 2019 and 2021 to further evaluate and delineate environmental impacts from historical Site activities within nine AOPCs (Figure 3.1). RI work activities were based on the following data needs, identified in the RIWP:

- Nature and extent of impacts, including focused questions of spatial extent, data density for quantifying contaminant volumes, and other data needed for evaluation of remedial alternatives, as might be required
- Assessing seasonal change in the extent of groundwater impacts based on four quarters of groundwater monitoring
- Collecting sufficient data to confirm Site COPCs and COCs and determine CULs
- Collecting sufficient hydrogeologic data to understand the hydrogeology potentially affecting contaminant fate and transport at the Site

Initial RI work activities were conducted during two mobilizations (Phase I and Phase II), including all utility locating, monitoring well surveying, soil collection, sampling analyses, and other data needs, summarized in Sections 3.1 and 3.2 and detailed in the Interim Data Report (Floyd|Snider 2021; Appendix A). Following the Phase I and Phase II activities in 2019 and 2020, described in Sections 3.1 and 3.2 respectively, additional RI work was performed in 2020 and 2021, including four consecutive quarters of groundwater monitoring and sampling as described in Section 3.1.3; two rounds of soil vapor sampling as described in Section 3.4; and hydrogeologic characterization as described in Section 3.5. All activities were conducted in accordance with the Ecology-approved RIWP and associated SAP/Quality Assurance Project Plan (QAPP). Results from RI activities are summarized in Section 4.0.

## 3.1 PHASE I ACTIVITIES

Phase I fieldwork occurred between November 13, 2019, and November 22, 2019, and consisted of Columbia Technologies, LLC, conducting a high-resolution fluorescence/hydraulic profile characterization of the Site with oversight by Floyd|Snider personnel. This was accomplished using an optical image profiler (OIP) manufactured by Geoprobe and a hydraulic profiling tool (HPT) attached to a direct-push drill rig to investigate the potential for remaining LNAPL and TPH impacts in the subsurface at 73 locations across the Site (OIP-01 through OIP-73; Figure 3.1). The objective of the OIP sampling was to provide detailed delineation of remaining LNAPL and residual TPH impacts. The HPT was used to obtain hydrostratigraphic data in relevant AOPCs.

In addition to the OIP/HPT boring locations, six direct-push boring locations were advanced immediately adjacent to select OIP/HPT locations during Phase I of RI fieldwork to collect continuous soil samples and analytical data (OIP-08, OIP-30, OIP-42, OIP-52, OIP-53, and OIP-66; Figure 3.1). The lithology and analytical results from these direct-push borings were compared to the OIP/HPT results prior to selecting direct-push locations during Phase II. The select direct-push

locations were advanced in areas with low to significant hydrocarbon impacts and varying hydrostratigraphy to evaluate the OIP/HPT response data. The OIP/HPT and direct-push locations advanced during the Phase I activities are shown on Figure 3.1. Boring logs are included in Appendix B of the Interim Data Report (Floyd|Snider 2021; Appendix A).

## 3.2 PHASE II ACTIVITIES

Phase II fieldwork occurred between March 9 and March 13, 2020, and included advancing 32 soil borings, installing two soil vapor points (VP-1 and VP-2) and eight monitoring wells (MW-33 through MW-40), collecting surface soil samples beneath Berth 1 and Berth 2, and conducting a survey for all monitoring wells and vapor points. Direct push borings were advanced adjacent to 24 Phase I OIP/HPT borings (OIP-02, OIP-04, OIP-05, OIP-06, OIP-15, OIP-18, OIP-19, OIP-20, OIP-21, OIP-23, OIP-31, OIP-39, OIP-46, OIP-47, OIP-49, OIP-54, OIP-57, OIP-64, OIP-67, OIP-68, OIP-69, OIP-70, OIP-72, and OIP-73) and at eight additional locations (GP-31 through GP-38; Figure 3.1). The Phase I OIP/HPT and soil data results, along with results from previous investigations (designated GP-1 through GP-30), were used to determine the direct-push and monitoring well locations. Phase I and Phase II soil boring and monitoring well locations, as well as previous investigation locations, are shown on Figures 3.1 and 3.2. Soil and groundwater samples were collected from direct-push borings and soil samples were collected during the installation of monitoring wells to help obtain quantitative soil and groundwater results. A total of 23 soil samples from these boring locations were collected for EPH/VPH analysis to calculate median Site-specific MTCA Method B and C TPH CULs.

Direct-push locations were selected to collect vertical and lateral laboratory analytical samples to delineate the extent of impacts and to assist in future assessments of the volume of TPH-impacted soil. Within each AOPC, at least one direct-push boring was advanced in an area containing residual TPH impacts identified by OIP/HPT to obtain quantitative results and to delineate the vertical extent of TPH impacts within the AOPC. The soil samples for additional EPH/VPH analysis were collected at a range of depths to characterize impacts within each AOPC.

## 3.3 QUARTERLY GROUNDWATER MONITORING

Four consecutive quarters of groundwater monitoring and sampling were performed in accordance with the Ecology-approved RIWP: May, August, and November 2020 and February 2021. Prior to collecting groundwater samples, depth-to-water (DTW) measurements were collected in all accessible wells, and wells were checked for the presence of LNAPL. If there was a sufficient volume of water, groundwater samples were collected in accordance with the RIWP and any applicable Ecology-approved amendments to the sampling program. Monitoring well locations are shown on Figure 3.2.

In May and August 2020, groundwater samples were collected from 35 of 40 and 36 of 41 planned sampling wells, respectively. Selected monitoring wells not sampled for the following reasons:

- LNAPL was present (MW-09).
- There was an insufficient volume of groundwater (MW-05 and MW-28 in May, and MW-11, MW-16, and MW-20 in August).
- The monitoring wells could not be accessed (MW-04 and MW-30 in May).

MW-30 and T-2 were added and redeveloped to the groundwater sampling program for the August 2020 event.

All groundwater samples were analyzed for GRO, DRO, ORO, BTEX, and carcinogenic polycyclic aromatic hydrocarbons (cPAHs) in accordance with the RIWP. A subset of seven spatially representative monitoring wells located in different areas of the Site were sampled and analyzed for volatile organic compounds (VOCs); additionally, samples from four wells were analyzed for lead, 1,2-dibromoethane, 1,2-dichloroethane, methyl *tert*-butyl ether, and naphthalenes to meet the GRO and DRO requirements of Table 830-1 Required Testing for Petroleum Releases in WAC 173-340-900, as per the RIWP. Additionally, 15 samples from monitoring wells screened in both Site water-bearing zones were analyzed for MNA parameters (i.e., nitrate, sulfate, manganese, alkalinity, methane, and field measurements of ferrous iron, dissolved oxygen, oxidation–reduction potential, pH, temperature, and conductivity). All groundwater samples were submitted to Friedman & Bruya, Inc. (FBI) of Seattle, Washington, except for the MNA parameters, which were submitted to Fremont Analytical, Inc. (Fremont) of Seattle, Washington. Result summaries from the May and August 2020 groundwater monitoring events are presented in the Interim Data Report (Floyd|Snider 2021; Appendix A) and results are integrated into this RI/FS.

In October 2020, Ecology approved a change in the quarterly groundwater monitoring program originally proposed in the RIWP (Floyd|Snider 2019a). This change included a reduction in the number of monitoring wells and analytes to be sampled given expansive non-detect results for select analytes during both wet and dry season sampling events (Morris 2020). Consequently, seven monitoring wells were removed from the sampling program, VOC analyses at all monitoring wells were reduced to BTEX compounds, semivolatile organic compound analyses at all monitoring wells were reduced to naphthalenes, and cPAH and total lead analyses were eliminated at all monitoring wells.

Therefore, in November 2020 and February 2021, monitoring wells were sampled according to the modified program described above. In November 2020 and February 2021, 30 of 34 and 33 of 34 planned monitoring wells were sampled, respectively. Some monitoring wells were not sampled for the following reasons:

- There was an insufficient volume of water (MW-04, MW-20, and MW-28 in November).
- LNAPL was present (MW-09 in November and February).

All collected groundwater samples were analyzed at FBI for GRO, DRO, ORO, and BTEX, and a subset of 15 samples was submitted to Fremont and analyzed for MNA parameters.

### 3.4 SOIL VAPOR SAMPLING

Two soil vapor monitoring events were conducted in May and November 2020 at VP-1 and VP-2, located in the former Warehouse 9 slab and installed as part of Phase II activities. Samples were collected in accordance with the RIWP and Ecology guidance for vapor intrusion (VI) assessment (Ecology 2022) using laboratory-certified 1-liter evacuated Summa canisters equipped with a flow control device and laboratory-provided manifolds and polytetrafluoroethylene tubing. Prior to sample collection, a shut-in (or closed-valve) test was performed to assess the sampling train for air leaks. The closed-valve test was conducted for 5 minutes. All canisters maintained their vacuum for the duration of the test.

Helium and isopropyl alcohol were used as tracer gases during the May and November sampling events, respectively, to test for leaks in the vapor point seal and connections in the manifold during the filling of the Summa canisters. Samples were collected after purging the tubing and vapor screen of at least three volumes of vapor within the sampling train at a flow rate less than 200 milliliters per minute (mL/min). A 6-liter Summa canister was used to purge the tubing. After the sampling train was purged, soil gas samples were collected over 5 minutes at a flow rate of less than 150 mL/min. Sample collection was stopped before the vacuum in the canister was fully depleted. A field duplicate sample was collected at VP-1 using a laboratory-supplied flow splitter.

Soil vapor samples were submitted to FBI for analysis of air-phase petroleum hydrocarbons, BTEX, and naphthalene by USEPA Method TO-15. For leak detection, samples from the May event were analyzed for helium by ASTM D1946, and samples from the November event were analyzed for isopropyl alcohol by TO-15.

### 3.5 ADDITIONAL HYDROGEOLOGIC CHARACTERIZATION

Hydrogeologic information was gathered as part of the RI to characterize the two shallow water-bearing zones, the perched zone and the alluvial aquifer, to assess any connection between the two units. Components of the hydrogeologic characterization program included four synoptic DTW measurement events prior to quarterly groundwater monitoring, a transducer study, and aquifer testing.

#### 3.5.1 Transducer Study

Six unvented pressure transducer dataloggers were installed on May 8, 2020, in monitoring wells MW-01, MW-17, MW-23, MW-29, MW-31, and MW-33, and were monitored quarterly for approximately 10 months until they were removed on February 23, 2021. These wells were instrumented with Solinst Levelogger Junior transducers in accordance with the RIWP.

A Solinst barologger was deployed to measure ambient atmospheric pressure. Transducers were installed to obtain necessary data to resolve the following data gaps, outlined in the RIWP:

- The effects (if any) of the Oregon Way pump station, part of the flood control system operated and maintained by Consolidated Diking Improvement District (CDID) #1, north of the Site (Figure 1.1) on the alluvial aquifer and perched zone
- The effects (if any) of the Columbia River tidal fluctuations on the alluvial aquifer and perched zone
- The nature of the perched zone (i.e., if it is a substantial water-bearing zone or an ephemeral accumulation)
- The vertical gradient between the perched zone and the alluvial aquifer over a multi-month period

Manual water levels were collected at the time of transducer deployment and at the time of uploading, and the transducers were returned to the wells. Details on transducer placement and results of the initial 3-month transducer study are presented in the Interim Data Report (Floyd|Snider 2021; Appendix A).

### 3.5.2 Aquifer Testing

In accordance with the RIWP and SAP/QAPP, Floyd|Snider conducted aquifer drawdown testing on November 4, 2020. Constant-rate pumping tests were conducted at two locations, MW-17 (perched zone well) and MW-33 (alluvial aquifer well). Although the RIWP proposed a pumping test at a perched zone well only, an additional pumping test was performed at an alluvial aquifer well to collect data from both water-bearing units that underlie the Site. The objectives of the aquifer tests were to: (1) determine if the perched zone is a substantial water-bearing unit; (2) determine if the perched zone and alluvial aquifer are hydraulically isolated; and (3) to collect sufficient data to estimate aquifer parameters.

# 4.0 Remedial Investigation Results

The data discussed in this section reflect samples collected in accordance with the RIWP: data collected during Phase I and Phase II activities, soil vapor and quarterly groundwater sampling events between May 2020 and February 2021, and data collected for the hydrogeologic study. Phase I and Phase II field data collection activities are detailed in the Interim Data Report (Floyd|Snider 2021; Appendix A), which includes Columbia Technologies, LLC's High-Resolution Fluorescence/Hydraulic Profile Characterization Report (Columbia Report), the laboratory reports, and the soil parameters.

## 4.1 REMEDIAL INVESTIGATION SCREENING CRITERIA

Screening criteria for COPCs and other chemicals of interest (such as petroleum additives) were established in the RIWP (Floyd|Snider 2019a). Based on the COPCs and potential exposure pathways identified in the RIWP, MTCA Method A CULs, when available, were used as the default screening levels in the Interim Data Report and are similarly included for comparison to RI results in the following subsections. Soil screening levels are based on worker protection in an industrial setting and protection of potable groundwater; groundwater screening levels are also based on the MTCA Method A CULs for protection of drinking water; and soil vapor results are compared to MTCA Method B sub-slab soil gas screening levels. Table 4.1 provides a summary of RIWP screening levels used for comparison with RI results in the following sections.

For soil and groundwater, the most stringent CUL in cases where a mixture of both DRO and ORO are present is the CUL for summed DRO and ORO. Detected summed total DRO and ORO concentrations, as well as results for the individual petroleum constituents, are included in data tables described in Sections 4.2 and 4.3. The RIWP and Interim Data Report also considered preliminary screening levels for soil to determine areas where the potential exists for accumulation of LNAPL on groundwater in accordance with MTCA. These residual LNAPL saturation screening levels were originally presented in Floyd|Snider's 2015 Data Gaps Report (Floyd Snider 2015), which are based on values published in a Mercer and Cohen paper (Mercer and Cohen 1990):

- GRO: 5,700 mg/kg
- DRO: 13,000 mg/kg
- ORO: 30,000 mg/kg

These LNAPL saturation screening levels are retained for the purposes of presentation and evaluation of the Site soil data to determine preliminary areas with the potential for LNAPL occurrence on groundwater. Therefore, soil results for DRO and ORO are presented separately in figures showing soil analytical results, rather than as summed total DRO and ORO concentrations, to understand where DRO or ORO concentrations are distributed and predictive of LNAPL occurrence based on their individual residual saturation screening levels, in the following section.

Selection of preliminary cleanup levels (PCULs) for the Site is presented in further detail in Section 7.0, and LNAPL occurrence as it correlates to Site soil conditions is discussed in Section 11.4.1.

## 4.2 SOIL RESULTS: PHASE I AND II SAMPLING EVENTS

A summary of the Phase I OIP/HPT and subsequent Phase II soil results is presented in the following sections for the following specific areas at the Site:

- Southern pipelines and berths (formerly AOPC 1)
- Former 80,000-barrel AST (formerly AOPC 2)
- Former mechanic's shop (formerly AOPC 3)
- Northern portion of the former Standard Pipelines (formerly AOPC 4)
- Central portion of the Site, including the former Calloway Ross Parcel, the former fuel loading rack area, and within the vicinity of the monitoring wells MW-26 and MW-28 (formerly AOPC 5 through AOPC 8)
- Former U.S. Army Reserve Heating Oil UST (formerly AOPC 9)

The extents of contamination have been delineated and expand across one or more of the former AOPCs; therefore, the term "AOPC" and the use of "potential" is no longer needed or carried forward in the RI/FS. However, the extents of the AOPCs and their locations are shown on the Interim Data Report figures (Appendix A).

During the 2019 and 2020 Phase I and Phase II activities, soil samples were initially screened by the laboratory using HCID by NWTPH-HCID. If the reported value of the HCID screening analysis for DRO, ORO, or GRO exceeded the quantitation limits, then the appropriate analytical method was used to quantify the product type detected. Additional EPH and VPH analyses by NWEPH/VPH were conducted on selected soil samples in varying areas across the Site, and at 16 different locations within AOPCs, if substantial petroleum impacts to soil were encountered, based on field screening observations, which included odor, sheen, or elevated OIP fluorescent responses. The 16 locations were selected to be representative of different source areas and the analysis was conducted at various depths (within the perched and alluvial aquifer). The EPH and VPH data were used to calculate MTCA Method B and Method C CULs for TPH (Appendix B).

Analytical data from the RI soil investigation are presented in Tables 4.2 through 4.4 and Figures 4.1 through 4.4. EPH and VPH analytical results, shown as plots on Figure 4.4, are included in Appendix C. In addition to calculating MTCA Method B and Method C CULs, EPH and VPH data were used to provide a simple, broad understanding of the distribution of carbon range fractions across the Site laterally and vertically; locations were selected to be representative of different source areas. OIP fluorescence response results are shown on Figure 4.5, and Table 4.5 compares OIP fluorescence response results with analytical results from select OIP borings. Cross sections showing the vertical and lateral fluorescence response are included in Appendix K. Phase I and Phase II activities are detailed in the Interim Data Report (Floyd|Snider 2021; Appendix A), which

includes the Columbia Report, the laboratory reports, and the soil parameters. Based on laboratory analytical results and OIP fluorescence response data from the RI and historical Site investigations, the Site contains a rough order of magnitude estimate of 22,000 cubic yards of TPH-impacted soil.

### 4.2.1 Southern Pipelines and Berths

Phase I activities consisted of advancing two OIP borings, OIP-05 and OIP-06, on each side of the former Longview Pipeline, within Transit Shed 2. Figure 4.5 shows that fluorescence responses were not observed in these two OIP/HPT locations. In addition, discrete soil samples collected during Phase II indicate that analytical results for OIP-05 and OIP-06 were either less than their respective laboratory quantitation limits or screening levels (Table 4.2). These results indicate that DRO and ORO impacts observed at GP-18, a 1-foot interval of impacted soil at a depth that may correspond to the pre-fill ground surface, is very limited in extent and has been delineated. Additionally, groundwater samples collected from GP-18 and adjacent borings show results less than their respective quantitation limits or screening levels, which indicate that the DRO and ORO impacts in soil are not leaching to groundwater.

Discrete soil samples were also collected during the installation of monitoring wells MW-37 and MW-38 (Figures 4.1 through 4.3). Field screening did not indicate TPH impacts during their advancement; therefore, soil samples were collected from the capillary fringe at depths of 27.5 feet bgs from MW-37 and 23.5 feet bgs from MW-38. Soil analytical results from MW-37 and MW-38 indicate that all constituents were at concentrations less than their respective laboratory quantitation limits (Table 4.2).

Surface samples P3 and P4, beneath the decking of Berth 2, were collected near historical surface samples (P-1 and P-2) and below the eastern pipelines that daylight beneath Berth 2. Samples were collected from the limited soil present on and between the riprap. Due to the lack of soil, deeper subsurface soil samples could not be collected. Surface samples P5 and P6 were collected beneath the westernmost pipelines beneath Berth 1 (Figures 4.1 through 4.3). Deeper soil samples were not collected from P5 and P6 due to no indications of petroleum hydrocarbon impacts in the shallow surface samples during field screening, which included sheen tests, odor, and PID readings. Soil results show ORO concentrations exceeding the screening level in P3 and P6 at concentrations of 4,200 and 2,300 mg/kg, respectively. GRO concentrations were less than the quantitation limit, and DRO concentrations were less than the screening level. cPAHs were detected in P3 and P4 at toxic equivalents (TEQs) of 2.3 and 0.51 mg/kg, respectively, exceeding the PCUL of 0.1 mg/kg for total cPAHs TEQ (Table 4.3).

### 4.2.2 Former 80,000-Barrel AST

Four OIP/HPT boring locations, OIP-01 through OIP-04, were advanced within the vicinity of the former 80,000-barrel AST during Phase I activities. OIP results showed a slight fluorescence response (less than 10%) in the top 5 feet bgs and no fluorescence response at depths greater than 5 feet bgs in all four locations (Figure 4.5 and Appendix K).

During the second mobilization, discrete soil samples were collected at locations OIP-02 and OIP-04 using a direct-push drill rig. Soil analytical data indicate that DRO and ORO are present in OIP-02 at 5 feet bgs at concentrations of 1,900 and 3,400 mg/kg, respectively (Table 4.2). No other petroleum compounds were detected in these soil samples at concentrations greater than their respective laboratory quantitation limits (Table 4.2). The impacts detected in the shallow soil at OIP-02 are limited vertically, and adjacent soil boring locations with results less than the screening levels indicate that these impacts are limited and delineated laterally.

### 4.2.3 Former Mechanic's Shop

During the Phase I activities, four OIP/HPT borings (OIP-18 through OIP-21) were advanced within the vicinity of the former mechanic's shop and former USTs. OIP results show a fluorescence response (71.4%) in OIP-20 between approximately 11 and 12 feet bgs (Figure 4.5 and Table 4.5). No other location within this area showed a measurable fluorescence response, indicating no hydrocarbon impacts are expected to be present (Appendix K).

During the second mobilization, a direct-push rig was used to obtain quantitative soil analytical results at locations OIP-18 through OIP-21. Lithology observations and field screening results indicated a thin zone of impacted soil from 10.5 to 12 feet bgs between silty sand and silt layers in OIP-20, which corresponds to the observed OIP/HPT fluorescence response. Therefore, to delineate the western extent of contamination in this area, an additional step-out location, GP-38, was advanced downgradient to the west of OIP-20, and a discrete soil sample was collected at the same depth as TPH impacts encountered in OIP-20 (Table 4.2). GRO exceeding the screening level was detected in OIP-20 between 11 and 11.5 feet bgs at a concentration of 630 mg/kg (Table 4.2 and Figure 4.1). All other soil samples collected within this area, including from GP-38, resulted in concentrations less than laboratory quantitation limits for GRO, DRO, and ORO (Table 4.2). Therefore, the impacts detected in OIP-20 at 11 feet bgs are limited and considered delineated.

### 4.2.4 Northern Portion of the Former Standard Pipelines

During the Phase I activities, 11 OIP/HPT borings (OIP-57 through OIP-63, OIP-69 through OIP-71, and OIP-73) were advanced within the vicinity of MW-19 in the northern portion of the former Standard Pipelines (Figure 3.1). OIP results show up to 100% fluorescence response at the locations near MW-19 at depths between approximately 6 feet bgs and 15 feet bgs, depending on the location (Figure 4.5, the Columbia Report in Appendix A, and Appendix K). Fluorescence responses in the outermost locations (OIP-57, OIP-69, OIP-70, and OIP-73) were limited to smaller unsustained responses at less than 10% and 60% immediately at the surface at locations OIP-57 and OIP-73, respectively. The fluorescence response observed in OIP-73 was detected within the top 0.3 feet with a thickness of 0.05 feet and is likely from vehicles parking at this location.

During the Phase II activities, a direct push rig was used to obtain discrete soil samples at OIP-57, OIP-69, OIP-70, and OIP-73 to confirm that the lateral extent of impacted soil had been defined as reflected in the OIP/HPT results. All soil samples collected to delineate the extent of impacts in the northern portion of the former Standard Pipelines resulted in GRO, DRO, and ORO

concentrations less than laboratory quantitation limits (Table 4.2). Laboratory results corresponded well with OIP/HPT fluorescence responses (Table 4.5). Additionally, four discrete soil samples were collected at varying depths during the installation of MW-39. Soil samples collected at MW-39 resulted in TPH concentrations with exceedances of screening levels for GRO and DRO within the 8 to 9 feet bgs and 13 to 14 feet bgs interval samples (Figures 4.1 and 4.2). The 13 to 14 feet bgs sample at MW-39 had the greatest TPH impacts with a GRO concentration of 990 mg/kg and a DRO concentration of 18,000 mg/kg. GRO and DRO results were less than laboratory quantitation limits in the shallow subsurface sample and the deepest sample at 18.5 feet bgs. ORO results were less than quantitation limits in all subsurface samples except one (MW-39-13-14), which resulted in a sample chromatogram pattern that did not resemble the fuel standard used for quantitation. Samples collected at MW-39 for cPAH and VOC analysis resulted in concentrations either less than laboratory quantitation limits or less than their respective screening levels for all other analytes (Table 4.3).

### 4.2.5 Central Portion of the Site

The central portion of the Site consists of petroleum impacts in soil and groundwater that are present within and in the vicinity of the former Calloway Ross Parcel, the former fuel loading rack area, and within the vicinity of the monitoring wells MW-26 and MW-28.

#### *4.2.5.1 Former Calloway Ross Parcel*

The former Calloway Ross Parcel is located at the north end of the former Warehouse 9 building footprint and west of the rail lines (Figure 2.1). Eleven OIP/HPT borings (OIP-07 through OIP-14 and OIP-66 through OIP-68) were advanced within and in the vicinity of the former Calloway Ross Parcel during the Phase I mobilization (Figure 3.1). OIP results show fluorescence response at the OIP locations throughout the south to north and west to east transects between 9 and 23 feet bgs (Table 4.5, Figure 4.5, Appendix A, and Appendix K). Fluorescence response within this area of the Site is typically represented by multiple fluorescence spikes up to 100% within high-permeability areas located above and below zones of increasing fines with low permeability. OIP results indicate that fluorescence response decreases in percentage and thickness to the northeast and northwest and is not present to the north-northeast at OIP-68 and to the north-northwest at OIP-14; therefore, this area is delineated (Figure 4.5).

During both phases, select discrete soil samples from GP-36, GP-37, OIP-08, OIP-66, OIP-67, and OIP-68 were submitted for laboratory analyses to delineate the lateral and vertical extent of TPH impacts, to assist in determining volume of TPH impacts present, and to help in identifying product type. Soil analytical data indicate that the lateral extent of hydrocarbon impacts within the vicinity of the former Calloway Ross Parcel is delineated to the west at location GP-37 and to the north at OIP-68, with TPH concentrations in these locations less than their respective screening levels (Table 4.2 and Figures 4.1 through 4.3).

The discrete soil samples collected from OIP-08, OIP-66, and OIP-67 were used to confirm the hydrocarbons detected in the OIP/HPT borings. At OIP-08, the sample collected from the 19 to 20 feet bgs interval resulted in GRO and DRO concentrations of 4,900 mg/kg and

12,000 mg/kg, respectively (Table 4.2). Benzene and ethylbenzene exceeding the screening levels were detected at 1.1 mg/kg and 27 mg/kg, respectively, in the sample collected from 19 to 20 feet bgs at OIP-08. At OIP-66, the sample collected from the 12 to 12.5 feet bgs interval resulted in a GRO concentration of 2,000 mg/kg (Table 4.2). The analytical results at both OIP-08 and OIP-66 exceeded the screening levels as expected based on the high fluorescence response during OIP/HPT advancement. Discrete soil samples from OIP-67 show GRO and DRO screening level exceedances between 11 and 15 feet bgs with the greatest GRO concentration, 2,200 mg/kg, detected between 14.5 and 15 feet bgs and the greatest DRO concentration, 4,300 mg/kg, between 11 and 12 feet bgs (Table 4.2). TPH impacts are vertically delineated at a maximum depth of 18 feet in OIP-67, with TPH concentrations less than respective laboratory quantitation limits. With the exception of analytes at GP-36, analytes including BTEX and cPAHs did not exceed their respective screening levels in any other samples collected from this area (Tables 4.2 and 4.3). ORO was less than quantitation limits for all samples collected, with the exception of OIP-08 and OIP-67 (11 to 12 feet bgs), which both had detected ORO at concentrations less than the screening level and chromatographic patterns that did not resemble the fuel standard used for quantitation.

#### *4.2.5.2 Former Fuel Loading Rack Area*

The former fuel loading rack area extends from OIP-56 in the north-northeast to the vicinity of MW-17 in the southwest, and from the east near MW-12, OIP-49, and OIP-72 to the former Warehouse 9 building footprint, west of the rail lines. Twenty-six OIP/HPT borings (OIP-15 through OIP-17, OIP-33 through OIP-51, OIP-55, OIP-56, OIP-64, and OIP-72) were completed within the former fuel loading rack area (Figure 4.5). OIP results throughout the former fuel loading rack area show up to 100% fluorescence response at the surface down to 24 feet bgs, with an unsustained response with less than 75% fluorescence at the surface in some locations and the greatest response between 9 and 22 feet bgs (Table 4.5, Figure 4.5, Appendix A, and Appendix K). The thickest fluorescence response was observed beneath the rail lines and immediately adjacent to the former pipelines in the area between OIP-38 to the north and OIP-44 to the south, and to the east within the vicinity of OIP-47 (Floyd|Snider 2021; Appendix A). OIP results indicate that fluorescence response decreases in percentage and thickness to the north-northeast at OIP-56, to the southwest at OIP-64, to the northeast at OIP-72, to the east at OIP-49, and is not present to the south at OIP-33 or OIP-46 (Figure 4.5).

Discrete soil samples were collected during both Phase I and Phase II activities from nine direct-push locations and during installation of monitoring wells MW-33 and MW-40. Soil analytical data indicate that the lateral extent of hydrocarbon impacts within the former loading rack area is delineated to the northeast at GP-35; to the southeast at OIP-46; to the southwest at OIP-64; and to the west at locations GP-1, GP-2, and GP-30 (installed in 2015; Figures 4.1 through 4.3). Soil analytical results at locations OIP-49 and OIP-72 to the east show detections of GRO at concentrations exceeding the screening level, indicating that impacts in this area extends slightly outside the investigated area. The GRO detections in OIP-49 and OIP-72 were at concentrations of 960 mg/kg and 520 mg/kg, respectively (Figure 4.1). OIP results from

OIP-49 and OIP-72 show that these impacts are limited in thickness, less than 1 foot thick, indicating that impacts are pinching out to the east (Figure 4.5 and Table 4.5).

Within the former loading rack area, the greatest GRO concentration was detected in OIP-47 at 5,700 mg/kg between 11 and 12 feet bgs (Table 4.2). The greatest DRO, ORO, and benzene detections were in MW-40 between 10.5 and 11 feet bgs at concentrations of 18,000 mg/kg, 7,900 mg/kg, and 12 mg/kg, respectively (Table 4.2). Based on OIP results and soil analytical data, TPH soil impacts are present at varying depths between 1 foot bgs and 24 feet bgs (Tables 4.2, 4.3, and 4.5). Two distinct zones of impacts are present within the perched zone and the alluvial aquifer, which are typically separated by a layer of finer-grained, impermeable soils.

The soil sample results, and fluorescence response observed, indicate that the greatest impacts are present beneath and immediately adjacent to the rails, but concentrations and thickness decrease to the west and east of the rail lines. Therefore, the extent in this area is considered delineated.

#### *4.2.5.3 Monitoring Wells MW-26 and MW-28*

During Phase I and II activities, 15 OIP/HPT borings (OIP-22 through OIP-32, OIP-52 through OIP-54, and OIP-65) were completed, seven direct-push borings (OIP-23, OIP-30, OIP-31, OIP-52, OIP-53, GP-33, and GP-34) were advanced to collect discrete soil samples, and one monitoring well (MW-34) was installed within the vicinity of monitoring wells MW-26 and MW-28.

OIP locations were advanced in two transects, one parallel to the rail lines from northeast to southwest and one perpendicular to the rail lines from approximately west to east (Figure 4.5). OIP results throughout this area show up to 100% fluorescence response at the surface down to 24 feet bgs, with a slight, less than 60%, unsustained response at the surface in some locations and with the greatest response between 11 and 24 feet bgs (Table 4.5, Appendix A, and Appendix K). The thickest fluorescence responses, up to 100%, were observed beneath the rail lines, adjacent to the former Standard Pipelines at locations OIP-22 through OIP-29. Fluorescence responses indicate that thickness of impacts decrease to the west and east at OIP-52 and OIP-30, respectively. OIP results indicate that TPH impacts are bounded along the southwest and northeast transect by OIP-54 and OIP-55 (Figure 4.5). OIP results along the east–west transect show no fluorescence response to the west at OIP-53 and to the east at OIP-31. Most of the elevated fluorescence responses along this transect are present at depths between approximately 11 and 24 feet bgs. A slight fluorescence response was present within the top 2 feet in OIP-30 and OIP-52 with responses of less than 20% and less than 60%, respectively (Floyd|Snider 2021; Appendix A).

Discrete soil samples were collected from direct-push and monitoring locations during Phase II activities. GRO was detected in soil at concentrations exceeding the screening level at depths between 14 and 24.5 feet bgs in OIP-23, OIP-30, OIP-52, GP-33, and MW-34. The greatest GRO concentration was detected in OIP-23 at 790 mg/kg between 19 and 20 feet bgs (Table 4.2). DRO was detected at concentrations exceeding the screening level at depths between 14 and 24 feet bgs in OIP-23, OIP-30, OIP-52, and MW-34 (Table 4.2 and Figure 4.2). The greatest DRO

concentration was detected in OIP-23 at 48,000 mg/kg between 19 and 20 feet bgs; OIP fluorescence response data indicate that soil impacts are not present at depths greater than 24 feet bgs at this location. ORO was detected at concentrations exceeding the screening level at depths between 14 and 21 feet bgs in OIP-30 and GP-33 (Table 4.2). The greatest ORO concentration was detected in OIP-30 at 12,000 mg/kg from 20 to 21 feet bgs (Table 4.2).

BTEX and other VOC concentrations did not exceed their respective screening levels in any samples collected within the MW-26 and MW-28 area (Table 4.2). A single cPAH TEQ concentration of 0.54 mg/kg detected in OIP-30 between 20 and 21 feet bgs exceeded the screening level (Table 4.3).

Soil concentrations exceeding MTCA Method A screening levels are delineated in the south-central portion of the Site to the east and west at OIP-31 and OIP-53, respectively, by samples with results less than the screening levels or the laboratory quantitation limits (Tables 4.2 and 4.3 and Figures 4.1 through 4.3). OIP fluorescence response data indicate that soil impacts are delineated to the north by locations OIP-55 and OIP-65 and to the south by locations OIP-21 and OIP-54 (Figure 4.5).

### 4.2.6 Former U.S. Army Reserve Heating Oil UST

Although there were no OIP/HPT locations advanced during Phase I, two Geoprobe boring locations were drilled adjacent to the location of the former heating oil UST associated with the former U.S. Army Reserve building during Phase II (GP-31 and GP-32). Soils collected from both Geoprobe locations were analyzed for DRO, GRO, and ORO by NWTPH-HCID and resulted in concentrations less than laboratory quantitation limits (Table 4.2).

## 4.3 GROUNDWATER RESULTS: PHASE II AND QUARTERLY SAMPLING EVENTS

Results from groundwater samples collected from direct-push borings during the Phase II activities and from permanent monitoring wells during four quarterly monitoring events (May, August, and November 2020 and February 2021) are summarized for the following areas at the Site:

- Southern pipelines and berths
- Former 80,000-barrel AST
- Former mechanic's shop
- Northern portion of the former Standard Pipelines
- Central portion of the Site, including the former Calloway Ross Parcel, the former fuel loading rack area, and within the vicinity of monitoring wells MW-26 and MW-28
- Former U.S. Army Reserve Heating Oil UST
- Perimeter monitoring wells

Analytical groundwater data from the RI groundwater investigation are shown in Tables 4.6 through 4.9, and GRO, DRO, and ORO analytical results from the November 2020 and February 2021 quarterly monitoring events are presented in Figures 4.6 through 4.11. Table 4.8 provides analytical results for MNA parameters, which are discussed and interpreted in Section 9.2.1.3 and Appendix D. Phase II groundwater investigation activities are detailed in the Interim Data Report (Floyd|Snider 2021; Appendix A), which includes figures and laboratory reports summarizing the May and August 2020 sampling events as well as the 2019 sampling results. Groundwater sample results collected from direct-push borings are typically slightly more turbid than samples collected from wells and are considered to be biased high; however, results less than screening levels or laboratory quantitation limits can be used to delineate the dissolved-phase extent. Laboratory reports for the November 2020 and February 2021 groundwater sampling events are included in Appendix E.

### 4.3.1 Southern Pipelines and Berths

Groundwater samples were collected from OIP-06 during the Phase II activities and from monitoring wells MW-37 and MW-38 during the four quarterly sampling events conducted in 2020 and 2021. No compounds were detected in these samples at concentrations greater than their respective screening levels, and all GRO, DRO, and ORO results were less than laboratory quantification limits, except for the following:

- In the November 2020 monitoring event, MW-38 had a low-level DRO detection that was flagged by the laboratory as not matching a typical diesel standard.
- In the February 2021 monitoring event, MW-37 had low-level detections of GRO and DRO, the DRO detection being flagged by the laboratory as not matching a typical diesel standard. Low-level DRO was also detected in the May 2020 event.

These results demonstrate that the dissolved-phase plume is not present in the southern portion of the property and there is no potential for impacts to be transported to the Columbia River via groundwater.

### 4.3.2 Former 80,000-Barrel AST

Discrete groundwater samples were collected from OIP-02 and OIP-04 during the Phase II activities. Groundwater samples were collected from monitoring well MW-32 during the first two quarterly sampling events conducted in May and August 2020, and from monitoring well T-2 during the August 2020, November 2020, and February 2021 sampling events.

DRO and ORO were detected in the discrete groundwater sample for direct-push boring OIP-04 at concentrations of 660 µg/L and 870 µg/L, respectively, which exceeded the screening levels. The detections of DRO and ORO in OIP-04 resulted in the addition of monitoring well T-2 to the sampling program for future quarterly sampling events. The results from monitoring well T-2 were less than the quantitation limits for GRO, DRO, and ORO for each sampling event. No other constituents were detected at concentrations greater than their respective screening

levels or laboratory quantitation limits in groundwater samples during the sampling events (Tables 4.6 and 4.7).

### 4.3.3 Former Mechanic's Shop

Groundwater samples were collected from UST-4 during the four quarterly groundwater monitoring events in 2020 and 2021. In addition to the typical analyses, 1,2-dibromoethane, 1,2-dichloroethane, methyl *tert*-butyl ether, and naphthalenes were analyzed for in the first two quarters of monitoring (May and August 2020) in accordance with the SAP/QAPP, Ecology's Table 830-1 Required Testing for Petroleum Releases (WAC 173-340-900), and guidelines for UST decommissioning (WAC 173-360A). These additional components were not detected at concentrations greater than their respective RIWP screening levels or laboratory quantification limits during the first two quarters of monitoring, so they were removed from the analyte list for the last two quarterly monitoring events with Ecology's approval (Morris 2020).

DRO and ORO results detected in UST-4 during the May 2020 sampling event show that the sum of their concentrations of 230 and 320 µg/L, respectively, slightly exceeds the screening level of 500 µg/L. However, the laboratory report flagged the May 2020 results noting that the sample chromatographic pattern does not resemble the fuel standard used for quantitation. The chromatogram resembles highly weathered compounds that are missing the *n*-alkanes within the diesel and oil ranges. Additionally, the USTs associated with the former mechanics' shop contained gasoline not diesel, and DRO and ORO concentrations in all soil samples collected at or within the vicinity of the UST-4 and former mechanic's shop show detections less than the laboratory quantitation limit or less than the CUL for total DRO and ORO. Therefore, the May 2020 result is likely anomalous and not considered to be representative of Site conditions at this location. UST-4 is not included within the extent of total DRO and ORO exceedances in groundwater. However, additional groundwater will be collected during a predesign investigation to confirm that the total DRO and ORO exceedance is anomalous. All other constituents for May 2020 and both the prior and subsequent sampling events were either less than their respective screening levels or less than the laboratory quantitation limit (Tables 4.6 and 4.7).

### 4.3.4 Northern Portion of the Former Standard Pipelines

During Phase II, temporary wells were utilized to collect discrete groundwater samples at OIP-69 and OIP-70. Temporary screens were set within the alluvial aquifer at OIP-69 and OIP-70 at depths between 12 and 17 feet bgs and 10 and 15 feet bgs, respectively. Groundwater depths and dissipation tests indicate that the alluvial aquifer is present in this area of the Site at depths between 10 and 14.5 feet bgs. Groundwater samples collected from both locations were analyzed for GRO, DRO, ORO, VOCs, and select PAHs. Results indicate low-level detections for DRO at OIP-69 and OIP-70 of 140 µg/L and 220 µg/L, respectively. Sample results at both locations were below laboratory quantitation limits for all other analytes (Tables 4.6 and 4.7).

Groundwater samples were collected from MW-06, MW-19, and MW-39 during the quarterly groundwater monitoring events in 2020 and 2021. Samples collected at MW-19 did not exceed screening levels for any of the analyzed analytes during the first two sampling events, and thus

MW-19 was removed from the sampling program for the last two quarterly monitoring events (Tables 4.6 and 4.7).

Samples collected from MW-06 contained total DRO and ORO screening level exceedances in each monitoring event and ranged between 630 and 2,300 µg/L, detected in February 2021 and August 2020, respectively. Total DRO and ORO concentrations at MW-39 also exceeded screening levels during all 2020 and 2021 quarterly sampling events. The greatest total DRO and ORO concentration in MW-39 was detected during the August 2020 sampling event at a concentration of 7,300 µg/L.

The dissolved-phase plume at this location is delineated by locations MW-01, MW-19, OIP-69, and OIP-70, which surround MW-06 and MW-39.

### 4.3.5 Central Portion of the Site

The central portion of the Site consists of wells located within the former Calloway Ross Parcel, former fuel loading rack area, and within the vicinity of the monitoring wells MW-26 and MW-28.

#### *4.3.5.1 Former Calloway Ross Parcel*

During Phase II, temporary wells were utilized to collect discrete groundwater samples at OIP-67 and OIP-68. Collected groundwater samples were analyzed for GRO, DRO, ORO, VOCs, and select PAHs. Samples collected at OIP-67 resulted in screening level exceedances for both GRO and total DRO and ORO with concentrations of 3,200 µg/L and 2,000 µg/L, respectively. Samples collected at OIP-68 also resulted in screening level exceedances for GRO and total DRO and ORO of 860 µg/L and 1,200 µg/L, respectively.

Monitoring wells MW-02, MW-03, MW-05, MW-08, and MW-10 are considered within or adjacent to the former Calloway Ross Parcel. These wells were sampled during all four quarterly sampling events that occurred in 2020 and 2021, except for MW-05, which had sufficient water for sampling only during the February 2021 event. The following analytes were detected at concentrations exceeding their respective screening levels during the noted quarterly sampling events:

- GRO in monitoring wells MW-08 (all four sampling events) and MW-10 (August and November 2020 and February 2021 only), with the greatest concentration in MW-10 at 5,800 µg/L detected during the February 2021 event
- Total DRO and ORO in monitoring wells MW-02 (August and November 2020 only), MW-03, MW-05 (February 2021 only), MW-08 (all four sampling events), and MW-10 (August and November 2020 and February 2021 only), with the greatest concentration in MW-08 at 2,800 µg/L detected during the August 2020 event
- Benzene in monitoring well MW-10 (all four sampling events), with the greatest concentration of 180 µg/L detected during the February 2021 event

All other analytes were either not detected at laboratory quantitation limits or were detected at concentrations less than their respective screening levels (Tables 4.6 and 4.7).

#### *4.3.5.2 Former Fuel Loading Rack Area*

A discrete groundwater sample was collected from OIP-15 during the Phase II activities and analyzed for GRO, DRO, ORO, BTEX, and select PAHs. The total DRO and ORO concentration of 1,700 µg/L at OIP-15 exceeded the screening level. All other analytes from this sample were either not detected at laboratory quantitation limits or did not exceed their respective screening levels (Table 4.6).

Monitoring wells MW-07, MW-09, MW-11, MW-12, MW-13, MW-14, MW-15, MW-16, MW-17, MW-20, MW-25, MW-33, and MW-40 are considered within or adjacent to the former loading rack. All of these wells were sampled during each quarterly sampling event, except for MW-09 during all events, MW-20 during the August and November 2020 events, MW-13 during the November 2020 and February 2021 events, and MW-11 and MW-16 during the August and November 2020 and February 2021 events. MW-09 was not sampled because it contained a measurable LNAPL thickness of between 0.07 and 0.53 feet during the quarterly sampling events. MW-11, MW-16, and MW-20 were not sampled during the August 2020 event because they had an insufficient volume of water. Additionally, MW-20 was not sampled during the November event because it had an insufficient volume of water. MW-11, MW-13, and MW-16 were removed from the sampling program for the last two quarterly monitoring events.

Quarterly groundwater analytical results from monitoring wells MW-11, MW-13, MW-14, MW-16, MW-17, and MW-25 show that analytes either were not detected at laboratory quantitation limits or were detected at concentrations less than their respective screening levels (Table 4.6). The following analytes were detected at concentrations exceeding their respective screening levels within wells located in the vicinity of the former fuel loading racks during the 2020 or 2021 sampling events:

- GRO in monitoring wells MW-07 (August 2020 only), MW-12 (August and November 2020 and February 2021), MW-20 (May 2020 and February 2021), and MW-40 (all four sampling events), with the greatest concentration in MW-12 at 7,100 µg/L detected during the August 2020 event
- Total DRO and ORO in monitoring wells MW-07 (all four sampling events), MW-12 (August and November 2020 and February 2021), MW-15 (May 2020 only), MW-20 (May 2020 and February 2021), MW-33 (all four sampling events), and MW-40 (all four sampling events), with the greatest concentration in MW-40 at 3,800 µg/L detected during the November 2020 event
- Benzene in monitoring wells MW-12 and MW-40 (all four sampling events), with the greatest concentration in MW-12 at 910 µg/L detected during the August 2020 event

All other analytes either were not detected at laboratory quantitation limits or were detected at concentrations less than their respective screening levels (Tables 4.6 and 4.7).

#### *4.3.5.3 Monitoring Wells MW-26 and MW-28*

During Phase II, a temporary well was utilized to collect a reconnaissance groundwater sample at GP-34. Collected groundwater samples were analyzed for GRO, DRO, ORO, BTEX, and select PAHs. Groundwater analytical results in GP-34 show that no analytes were detected at concentrations exceeding their respective screening levels (Table 4.6).

Monitoring wells MW-18, MW-24, MW-26, MW-27, MW-28, MW-29, and MW-34 are considered within or adjacent to the area formerly known as AOPC 7. These wells were sampled during the four quarterly groundwater monitoring events, except for MW-28, which had an insufficient volume of water during the May and November 2020 events, and MW-27, which was removed from the sampling schedule for the final two quarterly events.

Groundwater analytical results from 2020 and 2021 quarterly sampling events from these monitoring wells show that most analytes either were not detected at laboratory quantitation limits or were detected at concentrations less than their respective screening levels (Tables 4.6 and 4.7). The following analyte was detected at concentrations exceeding its screening level:

- Total DRO and ORO in monitoring wells MW-26 (May, August, and November 2020 only), MW-28 (August 2020 and February 2021), and MW-34 (all four sampling events), with the greatest concentration in MW-28 at 6,100 µg/L detected during the August 2020 event

### 4.3.6 Former U.S. Army Reserve Heating Oil UST

During Phase II activities, temporary wells were utilized to collect reconnaissance groundwater samples from GP-31 and GP-32. Samples were analyzed for GRO, DRO, ORO, BTEX, and select PAHs. Samples collected from both locations had low-level detections of total DRO and ORO at concentrations of 55 and 150 µg/L, respectively; neither detection exceeded the screening level. GRO did not exceed the laboratory quantitation limit. Analytical results for all other analytes were not detected at laboratory quantitation limits (Table 4.6).

### 4.3.7 Perimeter Monitoring Wells

Monitoring wells MW-01, MW-04, MW-22, MW-23, MW-30, MW-31, MW-35, and MW-36 are located primarily along the perimeter of the Site or are not closely associated with any source area. Analytical data from these wells are useful in defining the bounding edge of the dissolved-phase plume along the upgradient and downgradient extents of the Site. These wells were sampled during 2020 and 2021 quarterly sampling events except for MW-04 and MW-30, which were inaccessible during the May 2020 event, and MW-04, which had an insufficient volume of water during the August and November 2020 sampling events. Additionally, MW-01 was removed from the sampling program for the final two quarterly sampling events.

Quarterly groundwater analytical results from monitoring wells MW-01, MW-22, MW-23, MW-31, and MW-36 show that analytes were not detected at laboratory quantitation limits.

The following analyte was detected at concentrations exceeding its screening level during the 2020 or 2021 sampling events:

- Total DRO and ORO in monitoring wells MW-04 (February 2021), MW-30 (August and November 2020 and February 2021), and MW-35 (all four sampling events), with the greatest concentration in MW-30 of 2,500 µg/L detected during the November 2020 event

The DRO and ORO detections for MW-04, MW-30, and MW-35 were flagged with a laboratory note indicating that the sample chromatographic pattern does not resemble the fuel standard used for quantitation. Previous sampling events at MW-04 and MW-30 have analyzed DRO and ORO with and without silica gel cleanup. Results with silica gel are nondetect or less than PCULs (Golder 2000). Additionally, groundwater sampling observations at MW-30 have noted the presence of a reddish-brown bacterial growth that is likely associated with iron-reducing organisms. As presented in Appendix D, MW-04 and MW-30 have high average dissolved oxygen and total DRO and ORO concentrations relative to other locations, which are likely due to a portion of the reported total DRO and ORO concentrations instead being detections of organic material. Table 4.8 provides analytical results for MNA parameters, which are discussed in Section 9.2.1.3 and Appendix D. Additional data will be collected during a predesign investigation (PDI) to further investigate and confirm the downgradient edge of the dissolved-phase plume at these locations.

No other analytes at these locations were detected at laboratory quantitation limits (Tables 4.6 and 4.7).

## 4.4 SOIL VAPOR RESULTS

Soil vapor samples were collected in May and November 2020 from locations VP-1 and VP-2, located northwest of the rail lines in the former Warehouse 9 footprint (Figure 3.2), and were analyzed for the following:

- Air-phase petroleum hydrocarbons, BTEX, and naphthalene by USEPA Method TO-15
- Helium by ASTM D1946 (May) and isopropyl alcohol by USEPA Method TO-15 (November) for leak detection

Soil vapor results are presented in Table 4.9. Soil vapor concentrations are compared to screening levels presented in the updated January 2020 MTCA Method B sub-slab soil gas screening levels listed on Ecology's Cleanup Levels and Risk Calculation worksheet[11] and in Appendix E of Ecology's VI guidance (Ecology 2022).

Laboratory analytical data from both sampling events show that TPH was detected at concentrations between 160 and 450 micrograms per cubic meter (µg/$m^3$) and total xylenes was detected at concentrations between 5.6 and 56.0 µg/$m^3$; both analytes were detected at

[11] https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Contamination-clean-up-tools/CLARC/Data-tables

concentrations less than their respective MTCA Method B soil vapor screening levels of 4,700 µg/m$^3$ and 1,500 µg/m$^3$, respectively. Naphthalene was not detected at the laboratory quantitation limit, and other BTEX results were not detected or were less than screening levels in samples from both events. Helium was not detected at the laboratory quantitation limit in the May event, indicating that there were no leaks in the sampling manifold or vapor point surface seal. Isopropyl alcohol detections during the November sampling event were less than 0.05% of the total sample volume, which indicates that there is little to no influence from outside ambient air and leaks in the sampling manifold or vapor point surface seal were not an issue. The results indicate that there were no detected exceedances when compared to conservative residential MTCA Method B sub-slab soil vapor screening levels.

## 4.5 HYDROGEOLOGIC RESULTS

This section provides a summary of groundwater elevations for the November 2020 and February 2021 quarterly monitoring events, aquifer testing results, and the findings of the transducer study to elucidate the effect of the nearby Oregon Way pumping station on the site groundwater flow regime. Table 4.10 shows groundwater elevations at Site monitoring wells for all four quarters of RI data collection, and Figures 4.12 through 4.15 show November 2020 and February 2021 groundwater contours in both Site water-bearing zones. Aquifer testing details, including testing parameters and results, are provided in Appendix F.

Results from previous hydrogeologic characterizations associated with the RI, including the effects of Columbia River tidal fluctuations on both water-bearing zones, the vertical gradient between the perched zone and alluvial aquifer, and synoptic DTW measurements from the first two quarters of groundwater monitoring are detailed in Section 3.4 of the Interim Data Report (Floyd|Snider 2021; Appendix A).

### 4.5.1 Wet Season Groundwater Elevations

Groundwater elevations for both water-bearing units were measured during the November 2020 and February 2021 monitoring events in accordance with the RIWP (Floyd|Snider 2019a). Potentiometric groundwater contour maps and approximate flow directions for these monitoring events are presented in Figures 4.12 through 4.15. In the perched zone, groundwater elevations ranged between 6.98 and 16.94 feet NAVD 88 during the November 2020 event and between 12.24 and 19.12 feet NAVD 88 during the February 2021 event. In the alluvial aquifer, groundwater elevations ranged between 5.74 and 6.71 feet NAVD 88 during the November 2020 event and between 8.02 and 9.11 feet NAVD 88 during the February 2021 event. A discussion of groundwater flow directions and a comparison to dry season data are presented in Section 5.2.1.

### 4.5.2 Aquifer Testing

Drawdown and recovery data from the two limited constant-rate aquifer tests were used to further characterize the perched zone and alluvial aquifer and to assess any connection between the two units (Appendix F). Data from perched zone well MW-17 showed a linear response curve

and did not indicate the presence of a typical cone of depression at a scale suitable for analysis. Therefore, MW-17 data were not suitable for analysis using curve-fitting techniques, and aquifer parameters were not calculated. The low sustainable yield achieved at MW-17 indicates either low-permeability surrounding geology and/or limited hydraulic connection between the well and the surrounding water-bearing zone.

Data from alluvial aquifer well MW-33 showed drawdown and recovery curves more representative of typical aquifer response and were analyzed using a variety of different curve-matching techniques applicable to unconfined, leaky-confined, and/or confined aquifer types (Appendix F). As described in Section 5.2, the conceptual hydrogeologic model for the Site is most consistent with that of a leaky-confined aquifer; groundwater from the overlying perched zone is inferred to slowly "leak" through the underlying silt aquitard to the underlying alluvial aquifer at a rate much slower than the horizontal flow in both units. However, results from all curve-fit solutions were reported to add robustness to the analysis and to account for any variations in aquitard permeability throughout the Site. The leaky-confined aquifer solution produced a hydraulic conductivity of approximately 49 feet per day or $1.7 \times 10^{-2}$ centimeters per second, which falls within the range of expected values for sandy aquifers.

Notably, no connection between the perched zone and the alluvial aquifer was observed during the alluvial aquifer test; water levels in MW-17 and other nearby perched zone observation wells remained constant during the alluvial aquifer pumping test. This observation indicated that there was no measurable leakage through the silt aquitard despite the reduction in head in the alluvial aquifer and increased vertical gradients between the two water-bearing zones. The lack of induced flux of groundwater between the two units (during the test) is consistent with the Site conceptual hydrogeologic model of negligible transmissivity across the aquitard.

### 4.5.3 Transducer Study

The CDID #1 encompasses a network of 35 miles of dikes and drainage ditches in the Longview-Kelso Basin constructed for flood protection during high river levels and large storm events. The system consists of six primary pumping stations with a combined total capacity of 628,000 gallons per minute. Active pumping of these drainage ditches at the six pumping stations maintains water levels several feet below the typical stage of the Columbia River (KJC 2010). The Oregon Way pump station, which consists of two pumps, is located approximately 0.9 miles north of the Site. Figure 1.1 shows the location of the CDID #1 Oregon Way pump station and CDID #1 drainage ditch network relative to the Site.

To determine the effect (if any) of Oregon Way pump operation on the Site groundwater flow regime, Site water level data from the 10-month period of transducer deployment (May 2020 to February 2021) were compared to frequency of pumping data from the CDID #1 Oregon Way pump station, obtained from CDID #1. Figure 4.16 shows seasonal groundwater levels at perched zone well MW-17 and alluvial aquifer wells MW-01 and MW-31 as well as pump activations at the Oregon Way pump station between May 1, 2020, and February 4, 2021. Pump activations at the Oregon Way station correspond to one or both pumps at the station being turned on to maintain drainage ditch water levels. The average pumping duration for

each activation was approximately 3 hours and 15 minutes, and 84% of all pumping durations were less than 4 hours. The two pumps at the Oregon Way station were most active between September 1, 2020, and February 4, 2021 (Figure 4.16).

Comparison of Site groundwater levels and Oregon Way pump activations over time show that the individual activations have no direct impact on either perched zone or alluvial aquifer groundwater levels at the Site (Figure 4.16) and are instead used to maintain consistent head conditions at the collection ditch, which exert a permanent influence on the groundwater flow direction in the alluvial aquifer. Periods of increased pump activations at the Oregon Way pumping station correspond with groundwater level increases in both water-bearing zones and do not appear to dampen trends of rising water levels, which are likely controlled by seasonal local and regional precipitation. Additionally, Site groundwater flow in both water-bearing zones were relatively constant throughout low- and high-frequency pumping periods, indicating that the pump activations did not significantly affect the Site groundwater flow regime during the period of examination. These data and observations are consistent with the CDID #1 system acting as a constant head boundary for shallow groundwater at the Site. By maintaining a head lower than the Columbia River, the system maintains an overall northerly groundwater flow direction across the Site, away from the Columbia River.

# 5.0 Physical Setting

This section describes updated Site geology and hydrogeology based on the results of RI data collection activities described in Section 4.0. Preliminary geologic and hydrogeologic settings based on historical data for the Site were presented in the RIWP and subsequently revised in the Interim Data Report (Floyd|Snider 2019a and 2021; refer to Appendix A). The geology and hydrogeology presented in this section informs the CSM presented in Section 9.0.

## 5.1 GEOLOGY

The Site is located on the northern bank of the Columbia River, adjacent to its confluence with the Cowlitz River to the east. The Site lies on a relatively flat alluvial floodplain at elevations ranging from approximately 18 to 31 feet NAVD 88. Longview, Washington, is situated in a topographic basin surrounded by bedrock uplands. The broad, northwest- to southeast-trending alluvial floodplain consists of unconsolidated and consolidated sediments, which filled in a trough that had been carved by the Columbia River into the underlying Quaternary and Tertiary sedimentary and volcanic rocks. The youngest deposits are unconsolidated Quaternary alluvium generally consisting of interbedded sand, silt, and gravel that extend beneath the Site and the Columbia River as deep as approximately 300 feet bgs (KJC 2012). In the Site vicinity, these native materials typically consist of silty, fine- to medium-grained sand that is interbedded with silty sand and sandy silt lenses and occasional thin layers of volcanic ash, clay, and organic-rich material. In addition, a noncontinuous, soft to stiff silt layer with low to high plasticity and occasional organic debris is sometimes present within the native fine- to medium-grained sand.

Geologic cross-sections based on soil borings and OIP/HPT field measurements advanced at the Site are shown in Figures 5.1 through 5.3. Figure 3.2 shows the cross-section transects in plan view. These borings characterize the shallow subsurface as fill material of an unknown origin, reportedly placed during the late 1880s (Golder 2000), overlying the alluvial sediments. The fill material consists of a heterogeneous mixture of predominantly silt and sand, with a maximum thickness of approximately 20 feet near the areas adjacent to the Columbia River. In the southwestern portion of the Site, underlying the shipping berths and transit sheds, Site boring logs and OIP/HPT field measurements characterize multiple discrete silt lenses within the native sands (Figure 5.1). In the central portion of the Site, underlying the rail tracks and beneath the eastern side of the former Warehouse 9 footprint, the silt lenses increase in frequency and connectivity within the native sands; two approximately 1 to 5 feet thick continuous silt lenses occur between 15 and 10 feet NAVD 88 and between 10 and 5 feet NAVD 88; however, these finer-grained silt lenses thin and/or are not present to the north, east, south, and west of the Site (Figures 5.1 through 5.3). The perched zone present in the central portion of the Site is associated with these less permeable silt lenses with approximately 64% to 88% silt and/or clay and an average porosity of 0.572. The perched zone is discussed in more detail in Section 5.2.

## 5.2 HYDROGEOLOGY

Groundwater at the Site occurs in two laterally extensive, sandy water-bearing zones, the perched zone and the alluvial aquifer. Water level elevations measured at monitoring wells screened in each zone during the wet and dry seasons (August 2020 and February 2021) are shown on geologic cross-sections A-A', B-B', and C-C', which are presented in Figures 5.1 through 5.3. Groundwater contour maps and inferred flow directions for May and August 2020 are provided in the Interim Data Report (Floyd|Snider 2021; Appendix A), and maps for the November 2020 and February 2021 event are shown in Figures 4.12 through 4.15.

### 5.2.1 Water-Bearing Units and Groundwater Flow

Descriptions of the perched zone and alluvial aquifer, including horizontal and vertical extensivity, grain size distribution, and groundwater flow characteristics, are presented in the following subsections. Site monitoring wells are classified according to the deepest water-bearing unit that the well screen penetrates (Table 4.10). There are several Site monitoring wells that have portions of their screened interval in both water-bearing zones. MW-09 is screened primarily in the alluvial aquifer but head from the perched zone may artificially raise the measured water level elevations in the alluvial aquifer. MW-25, MW-29, MW-30, and MW-35 are screened primarily in the perched aquifer but may have a limited hydraulic communication with the alluvial aquifer that in turn may artificially lower the measured water level elevations in the perched zone. No anomalous water level values have been specifically identified. These locations are known and effects on inferred flow directions have been considered in descriptions of site hydrogeologic conditions.

#### *5.2.1.1 Perched Water-Bearing Zone*

The perched zone is inferred to extend from the location of the former mechanic's shop to MW-39 and spans approximately between the rail lines and Port Way. The unit occurs between approximately 10 and 15 feet NAVD 88 across the Site and sits largely below an upper confining silt/clay unit that gradually slopes downward toward the north. Boring logs and grain size results characterize the perched zone as a medium- to fine-grained sand with approximately 11% to 13% silt and/or clay and an average porosity of 0.551.

In the perched zone, measured groundwater elevations ranged between 6.98 and 19.12 feet NAVD 88 between May 2020 and February 2021, and were, on average, higher in the wetter months (i.e., November and February) than the drier months (i.e., May and August). Groundwater was observed in all four quarters of monitoring in the perched zone wells located in the center of the Site along the rail lines (i.e., MW-17 and MW-29), whereas wells screened at similar depth intervals to the west (i.e., MW-04 and MW-30) were dry or had very low water levels during the drier months. In the central portion of the Site, where the perched zone was consistently saturated during both the wet and dry months, saturated thickness ranged from approximately 4.9 to 10.7 feet at MW-17 to between 2.61 and 5.02 feet at MW-24.

In May, August, and November 2020 and February 2021, a localized high groundwater elevation point was present at MW-14, located in the northern portion of the perched zone. Radial flow outward from MW-14 was the predominant groundwater flow direction in all quarters, except May 2020, where groundwater flow direction was primarily toward the north. Measured groundwater elevations from the southern portion of the perched zone (between approximately MW-13 and MW-35) in all four quarters of groundwater monitoring show apparent groundwater flow to the west. These results are generally consistent with prior findings of radially outward apparent groundwater flow directions from the center of the Site. The variation in heads and apparent flow directions within the perched zone is consistent with a thin saturated thickness and sensitivity to local recharge.

#### *5.2.1.2 Alluvial Aquifer*

Based on site investigations, the alluvial aquifer is inferred to underlie the entirety of the Site and generally sits at elevations below approximately 9 feet NAVD 88. Boring logs and grain size results characterize the alluvial aquifer as a predominantly coarse- to fine-grained sand unit with trace silt that is overlain by a 2- to 5-foot-thick silt/clay aquitard throughout most of the Site north of MW-23. Boring logs and grain size results characterize the alluvial aquifer as a predominantly coarse- to medium-grained sand with approximately 2.5% silt and/or clay and a porosity of 0.445. A deep well log, located north of the Site, indicates that this sandy aquifer unit is approximately 85 feet thick and is underlain by a confining silt layer (KJC 2010).

Measured groundwater elevations in the alluvial aquifer ranged between 5.74 and 9.11 feet NAVD 88 between May 2020 and February 2021 monitoring events and were, on average, higher in the wetter months (i.e., November and February) than the drier months (i.e., May and August). During quarterly groundwater monitoring events, the predominant groundwater flow direction was to the north-northwest, especially in the northern part of the Site, and groundwater elevations were slightly lower in the wells along the rail lines and former Standard Pipelines in the central portion of the Site relative to wells east and west of the rail lines. Alluvial aquifer groundwater elevations were, on average, lower than the average Columbia River Stage elevation, which is also consistent with north-northwest groundwater flow, away from the river (Appendix A). However, throughout the period of monitoring, there was variability in head measurements in the central and southern portions of the Site that suggest local exceptions to the overall north-northwesterly groundwater flow direction.

Locally, groundwater flow directions in the central portions of the Site included some apparent southerly flow directions. These apparent southerly flow directions are based on a few tenths of a foot in head difference over distances of several hundred feet and are associated with the relatively flat hydraulic gradient across this area of the Site. They are also combined with local aquifer heterogeneities that influence head measurements. These apparent local flow directions in the central portion of the Site are not considered important factors in contaminant transport. They do not change the overall north-northwest flow direction that is clearer at the southern and northern edges of the Site. Southerly flow is not likely to be a significant component

of the flow direction in the alluvial aquifer, which is consistently measured to the north-northwest away from the Columbia River.

Additionally, water level elevations from February 2021 include a measurement from adjacent to the Columbia River (MW-38), which was lower than nearby wells, suggesting local hydraulic gradient reversal and a component of southerly groundwater flow in the Berth 2 area (Figure 4.14). This local flow direction differs from the northerly flow direction that was indicated by the previous three quarters of water level measurements, which were collected during low tides. Transducer data show that the average elevation of the Columbia River is consistently higher than alluvial aquifer groundwater and that the absolute elevation of the Columbia River is predominantly higher than the alluvial aquifer (Figures 3.20a through 3.20i in Appendix A). These data also support a net hydraulic gradient to the north and a consistently northerly flow direction. Temporary hydraulic gradient reversals that result in low magnitude hydraulic gradients toward the south from locations north of the bank area (e.g., MW-22) may slow the northerly flow of groundwater, but they are not sufficient to reverse the flow direction of the system. The local apparent deviation in hydraulic gradient observed in February 2021 is attributed to local effects including the proximity of this monitoring well to the riverbank and does not suggest significant southerly flow or southerly flow from portions of the Site located north of the bank area where MW-38 is located.

### 5.2.2 Perched Water-Bearing Zone and Alluvial Aquifer Interaction

Head differences between paired wells in the central (MW-17 and MW-33) and south-central (MW-29 and MW-23) portion of the Site indicate both the direction and magnitude of vertical gradients in the water-bearing zones. Heads measured in the perched zone were significantly greater than those in the alluvial aquifer at both pairs, indicating downward vertical gradients. Significant head differences were observed in both well pairs. Heads at MW-17 were between 5.96 and 9.83 feet greater than those at MW-33 throughout the year, and heads at MW-29 were 5.46 to 6.95 feet greater than those in MW-23. Notably, MW-29 and MW-23 are farther laterally apart than MW-17 and MW-33 and their respective elevations may, therefore, be influenced by other factors as compared to the more geographically proximal well pair. Throughout the four quarters of monitoring, vertical gradients between the perched zone and the alluvial aquifer were strongly downward (greater than +0.6 feet per foot), indicating a potential for downward groundwater flow. The large head difference between the perched zone and the alluvial aquifer, the aquitard soil parameters, and aquifer testing results are consistent with negligible actual flow through the aquitard. This is true even in the case of MW-29, the screened interval of which appears to penetrate into the alluvial aquifer.

As reported in the Interim Data Report, tidal influence was observed in monitoring wells screened in the alluvial aquifer and to a lesser extent, the perched zone, up to approximately 1,600 feet from the Columbia River (Floyd|Snider 2021; Appendix A). In general, the Columbia River tidal influence decreased with distance from the river, and water levels in alluvial aquifer monitoring wells showed a greater degree of tidal influence than those measured in perched zone wells. This observation is consistent with reduced transmissivity between the units from the low

permeability aquitard separating the two water-bearing zones. In addition, measurable water level changes in perched zone monitoring wells (MW-17 and MW-29) in response to tidal variations suggests that the aquitard is saturated and that groundwater is transmitted between units; in the case of MW-29, the low but measurable response may be a result of the screened interval penetrating into the alluvial aquifer. Low to no transmissivity of groundwater between the perched zone and alluvial aquifer units was demonstrated by the aquifer tests, which were designed to collect three log scales of data over 100 minutes. During the constant pumping test of the alluvial aquifer (MW-33), no measurable drawdown was observed in the paired perched zone monitoring well (MW-17) or other perched zone observation wells.

Together, these data indicate that perched zone and the alluvial aquifer are distinct water-bearing units with limited hydraulic connection and that the lack of measured flux of groundwater between units resembles slow leakage through a low-permeability aquitard.

# 6.0 Exposure Pathway Analysis

MTCA (WAC 173-340-200) defines an exposure pathway as: "the path a hazardous substance takes or could take from a source to an exposed organism. An exposure pathway describes the mechanism by which an individual or population is exposed or has the potential to be exposed to hazardous substances at or originating from a site." Primary exposure pathways at the Site are those routes that are known to be currently transporting petroleum contaminants to or within a certain medium (such as soil impacts to groundwater). Secondary exposure pathways are those routes that: (a) have transported contaminants in the past, but may not be currently, such as releases from USTs; or (b) may transport contaminants in the future, but do not currently. Precluded exposure pathways are those that are not possible at any time, based on physical evidence, and are, therefore, considered closed pathways.

Petroleum constituents have been detected in soil and groundwater samples. Therefore, soil and groundwater (with LNAPL) are impacted media but may also be considered secondary contaminant sources. The potential exposure pathways associated with each medium/source are discussed in the following sections, along with the rationale for excluding or including that pathway, and are shown on Figure 6.1. The primary migration pathways are the following:

- **Soil to Direct Contact.** There is soil impacted with TPH in the top 15 feet. Workers routinely excavate shallow soil, within the top 15 feet, to maintain rail and utility lines within the Site. Therefore, there is a potential for these workers to come into direct contact with shallow TPH-impacted soil.
- **Soil to Groundwater.** Releases of petroleum product(s) to the surface and subsurface that occurred during historical Site operations could result in a continued release, or leaching, of contaminants entrained in soil to groundwater. Soil to groundwater is a primary exposure pathway.
- **Soil to Surface Water and Sediment.** Historical observations noted that small amounts of petroleum product had leaked from the abandoned pipes under Berths 1 and 2. All of the pipelines were removed and capped at the bulkhead during the 2019 interim action activities to prevent future leaks. Most of the surface material beneath Berths 1 and 2 is riprap with very limited areas of exposed soil. There are no visible signs of erosion or downslope movement. Routine inspections are conducted beneath the pier to confirm that the pathway of surface soil erosion to surface water and sediment remains protective and incomplete.
- **Soil to Air.** Volatile contaminants in soil have the potential to volatilize to the vapor phase. Based on an empirical demonstration with soil vapor samples collected at the Site, as further described in Section 6.1, this pathway may have been complete in the past but is currently incomplete. The soil to air pathway is considered a secondary exposure pathway and will need to be re-evaluated if buildings are to be constructed within or adjacent to known soil impacts.

- **Groundwater to Surface Water and Sediment.** The Site hydrogeological studies and empirical data have confirmed that groundwater in the perched zone and alluvial aquifer does not flow to the Columbia River (refer to Section 5.2.1). The CDID #1 flood control system permanently maintains flow away from the river. This pathway is considered precluded and, therefore, does not warrant further assessment.
- **Groundwater to Air.** Volatile contaminants in shallow groundwater have the potential to volatilize to the vapor phase. Based on the Site empirical data demonstration, as described in Section 6.2, this pathway may have been complete in the past but is currently incomplete. The groundwater to air pathway is considered a secondary exposure pathway. It will need to be re-evaluated if buildings are to be constructed within or adjacent to known groundwater impacts.

## 6.1 SOIL AND SOIL VAPOR—EXPOSURE PATHWAYS

### 6.1.1 Soil Direct Contact, Soil Leaching to Groundwater, and Soil to Surface Water and Sediment

**Soil Direct Contact:** Based on human exposure via direct contact, the standard POC is throughout the Site from ground surface to 15 feet bgs. Areas of residual TPH soil impacts (GRO, DRO, and/or ORO) within the 15-foot POC for direct contact are present throughout the Site but concentrated primarily on the former Calloway Ross Parcel, along and around the subsurface near the Longview and Standard Pipelines beneath the rail lines, within the vicinity of the former fuel loading racks, and in limited areas near the former 80,000-barrel AST within the vicinity of OIP-02 and OIP-72. Minor surface impacts are also present beneath Berths 1 and 2 where the pipelines daylight.

Potential soil exposure pathways consist of direct contact with shallow impacted soil in unpaved areas by current and future site workers based on industrial exposure scenarios and direct contact with deeper impacted soil by utility workers entering the subsurface soil within the top 15 feet. Unpaved areas that are not covered with railroad spalls, gravel, and/or asphalt pavement are generally limited to the northern portion of the Site, on the former Calloway Ross Parcel (Figure 2.1). Shallow soil impacts at the surface are very limited, noncontinuous, and not expected to pose risks to casual site visitors, current and future site workers, or ecological receptors (i.e., burrowing animals) because residual soil impacts are either beneath gravel, railroad spalls, or asphalt paving that are in areas with restricted access to the public. Site workers routinely excavate shallow soil to maintain rail and utility lines within the Site; therefore, there is a potential for these workers to directly come into contact with shallow TPH soil impacts. Impacted soil with concentrations exceeding the site-specific direct contact CULs can be addressed with institutional controls (ICs) and a Soil Management Plan (SMP).

**Soil Leaching to Groundwater:** TPH-impacted soil with COC concentrations exceeding their respective MTCA Method A CULs is present within the saturated and capillary zones. Therefore, residual TPH impacts in soil is a contaminant transport pathway for leaching to both the perched zone and the shallow alluvial aquifer.

**Soil to Surface Water and Sediment:** Field observations confirm that the Under Pier Area is physically stable with no signs of erosion or sloughing that indicates downslope movement of limited soil or riprap. Most of the surface material beneath Berths 1 and 2 is riprap with very limited areas of exposed soil. Sample locations beneath the pier with ORO and cPAH exceedances (P3 and P4) are approximately 13 to 14 feet above the Columbia River at highest high tide. The isolated pockets of petroleum-impacted soil underneath Berths 1 and 2 do not pose a risk to the Columbia River via groundwater migration. Routine inspections are conducted beneath the pier to confirm that the pathway of surface soil erosion to surface water and sediment remains protective and incomplete (Floyd|Snider 2020).

### 6.1.2 Soil Vapor

MTCA (WAC 173-340-740(3)(b)(iii)(C)) also specifies that the soil to vapor pathway shall be evaluated. Currently, no occupied buildings, which include only the Former Port of Longview Office and the former U.S. Army Reserve building (noted on Figure 2.1), overlie areas of impacted soil or groundwater exceeding proposed cleanup standards. Additionally, no occupied buildings are planned within or immediately adjacent to impacted soil or groundwater. However, the potential for a compete VI pathway into future buildings was evaluated in the RI, focusing on the former Calloway Ross Parcel, within the footprint of former Warehouse 9. Results from the VI pathway analysis are representative of the area of the Site with some of the greatest elevated TPH impacts in soil and groundwater. TPH impacts in this area are not only among the most elevated in soil (residual saturation exceedances) and groundwater, but also where the smear zone is the thickest. TPH impacts in this area are present at depths between 12 and 23 feet bgs, or 7 feet beneath the vapor points installed at 5 feet bgs. Soil vapor data from vapor points VP-1 and VP-2 (i.e., measured concentrations less than the soil vapor screening levels for TPH and BTEX; refer to Section 4.4) were compared to residential screening levels. They indicate that TPH impacts are unlikely to pose a future VI threat; therefore, the soil gas to indoor air pathway is not considered a complete exposure pathway for occupants of any buildings that may be constructed on this portion of the Site.

There is no VI risk to the Former Port of Longview Office, which is outside the lateral inclusion zone based on soil results from GP-5 through GP-8 and MW-32. TPH impacts in soil were detected at a depth of 10 feet bgs in location OIP-72, which is approximately 140 feet to the north-northwest of the former U.S. Army Reserve building. These soil impacts are downgradient from the former U.S. Army Reserve building, along the eastern edge of the impacted soil extent, and are limited in thickness to less than 1 foot (Appendix A and Appendix K). Additionally, the former U.S. Army Reserve building is laterally separated from soil impacts by multiple locations with groundwater results less than the vertical separation thresholds shown on Table B-1 of Ecology's VI guidance (refer to Section 6.2.3; Ecology 2022). Based on these data and the VI data from VP-1 and VP-2, there is likely no VI risk to the former U.S. Army Reserve building.

Figure 6.1 shows the soil vapor pathway as potentially complete because VI risk for industrial land use will need to be reassessed if future occupied buildings are proposed to be built in areas within or immediately adjacent to known soil impacts.

## 6.2 GROUNDWATER—EXPOSURE PATHWAYS

### 6.2.1 Groundwater Potability and Direct Contact

The perched zone and the shallow alluvial aquifer at or within the immediate vicinity of the Site are not currently used as a source of water for any purpose by any known individuals, and no known drinking water wells exist in the Site vicinity. The nearest domestic well is approximately 2 miles to the north, or downgradient, of the Site (Ecology 2021b). The use of Site groundwater within the perched zone and shallow alluvial aquifer is highly unlikely given the industrial location and the non-potable characteristics of Site groundwater.

Perched zone groundwater is classified as non-potable, based on evaluation of the criteria presented in WAC 173-340-720(2). As noted above, groundwater in this unit does not serve as a current source of drinking water. Groundwater is also not a potential source of future drinking water due to a low sustainable yield of less than 0.05 gallons per minute measured during the pumping test, which occurred in the portion of the perched zone with the greatest saturated thicknesses (Appendix D). In addition to the low sustainable yield, select perched zone monitoring wells (e.g., MW-04, MW-11, and MW-30) had very low water levels in the drier months relative to the wet season (Section 5.2.1.1), indicating a seasonal sensitivity to local recharge, which may preclude the use of this water-bearing zone as a reliable source of future drinking water. Lastly, aquifer testing data indicate no measurable connection between the perched zone and alluvial aquifer, indicating that impacts present in perched zone groundwater will not migrate to the alluvial aquifer (Appendix D).

The alluvial aquifer exhibits some non-potable characteristics, including mixing with Columbia River surface water during temporary gradient reversals and high natural background concentrations of inorganic constituents present in wells screened in native units below the alluvial aquifer (KJC 2012). Therefore, potable or direct contact to groundwater exposure pathways to receptors are unlikely. However, Ecology classifies groundwater as potable unless determined otherwise by specific criteria listed under WAC 173-340-720(2). The alluvial aquifer does not meet these exclusion criteria, considering the water quality and productivity of the alluvial aquifer; therefore, potable groundwater and direct contact to groundwater are considered further as an exposure pathway for determination of Site cleanup standards.

### 6.2.2 Groundwater to Surface Water and Sediment

Site hydrological studies have confirmed that the groundwater flow direction in the alluvial aquifer is to the north, away from the river, except in the immediate vicinity of the river, where tidal elevation changes cause gradient reversals sufficient to cause temporary southerly flow from the riverbank. The otherwise northerly flow direction is maintained permanently by the nearby CDID #1 pumping stations for flood control purposes, as described in Sections 4.5.3 and 5.2. In addition, the perched zone exists only in the central and northern portions of the Site and does not extend to the Columbia River. These results demonstrate that there is no potential for impacts to be transported to the Columbia River via groundwater, and the pathway to surface water is not considered a complete pathway. Even though there is not a complete pathway for groundwater to

surface water at the Site, sampling results from upgradient wells MW-37 and MW-38 (i.e., closest to the river) were conservatively compared to Ecology's weathered DRO concentrations that are considered protective of aquatic receptors in freshwater, and all results were less than these thresholds, which is 3,000 µg/L for weathered DRO (Ecology 2021c).

### 6.2.3 Groundwater to Air

Volatile contaminants in shallow groundwater and the presence of LNAPL within the top 15 feet bgs within the vicinity of monitoring well MW-09 have the potential to volatilize, rise through the soil column, and discharge into indoor air. Soil vapor points VP-1 and VP-2 were installed approximately 30 feet west of MW-09 and 60 feet west of MW-40, respectively, within the footprint of the former Warehouse 9. These locations are relevant to a potential future exposure pathway because there is a potential for buildings to be constructed in this area of the Site. Additionally, locations VP-1 and VP-2 were installed 7 feet above known soil impacts and are located adjacent to residual saturation level exceedance in soil. Soil vapor data indicate that TPH impacts at the Site do not likely pose a future VI threat using conservative residential screening levels; therefore, the volatile contaminants from LNAPL and shallow groundwater to indoor air pathway is not considered a complete exposure pathway for occupants of any future buildings constructed on the portion of the Site where soil vapor samples were collected.

Additionally, groundwater analytical data within the vicinity of the former U.S. Army Reserve building indicate that TPH and benzene concentrations in monitoring wells MW-11, MW-13, MW-14, MW-20, MW-25, and MW-32 and direct push borings OIP-02, GP-31, and GP-32 are either less than their respective laboratory quantitation limits or less than the vertical separation thresholds shown on Table B-1 of Ecology's VI guidance (Ecology 2022). Therefore, there is no VI risk from groundwater to air to the occupied former U.S. Army Reserve building. However, Figure 6.1 shows this pathway as potentially complete because VI risk will need to be reassessed if occupied buildings are proposed to be built in areas within or immediately adjacent to known groundwater impacts.

## 6.3 ECOLOGICAL SETTING AND TERRESTRIAL ECOLOGICAL EVALUATION

The Site is located in an area surrounded by waterfront industrial and other industrial uses. Ground surfaces in the vicinity are generally paved or surfaced with compacted gravel, and vegetated areas are not present on the Site. Limited undeveloped or vegetated land is present in the vicinity of the Site. Terrestrial wildlife is not typically observed at the Site.

MTCA requires that a TEE be completed after the release of hazardous substances to soil to determine the potential impacts to terrestrial organisms at a site (WAC 173-340-7490). A TEE can be excluded if certain criteria are met (WAC 173-340-7491). However, the Site does not meet the exclusion criteria because there is more than 0.25 acres of contiguous undeveloped land within 500 feet of the Site. Therefore, in accordance with MTCA requirements, a simplified TEE was conducted for the Site (Appendix H). The evaluation found the Site does not pose a substantial potential risk to terrestrial receptors due to its commercial use and the surrounding developed land.

# 7.0 Preliminary Cleanup Levels

This section provides a summary of the approach used to identify the PCULs for COPCs and other chemicals of interest in groundwater and soil determined in the RIWP through evaluation of applicable local, state, and federal laws (ARARs; WAC 173-340-710). In coordination with Ecology, and consistent with the Agreed Order, the RIWP and Interim Data Report compared results to initial screening levels based on MTCA Method A CULs for protection of groundwater to determine potential areas and media of concern. The MTCA Method A framework is the cleanup regulation applicable to the Site, which has been contaminated solely by petroleum releases. The MTCA Method A CULs, where available, are adopted as PCULs. Where MTCA Method A CULs have not been established, MTCA Method B or C CULs and state and federal standards for protection of drinking water quality were considered to determine the most stringent PCULs for screening purposes. PCULs were additionally adjusted for laboratory practical quantitation limits and natural background in accordance with MTCA (WAC 173-340-720(7)(c), WAC 173-340-740(5)(c)).

The following sections identify regulatory criteria considered in the development of PCULs for potentially applicable exposure pathways for each of the impacted media.

## 7.1 GROUNDWATER PRELIMINARY CLEANUP LEVELS

Table 7.1 and the following present the PCULs for groundwater for each of the potentially complete exposure pathways.

- **Protection of Drinking Water Quality.** Groundwater within the alluvial aquifer at the Site is considered potable (Section 6.2.1); therefore, ARARs protective of drinking water quality apply Site-wide. These include MCLs from the National Primary Drinking Water Regulations and MTCA Method A and Method B CULs. The MTCA Method A CULs, where established, are equivalent to the MCLs for all chemicals analyzed. If these criteria are not available, MTCA Method B CULs are selected as the PCUL.

Other pathways evaluated and determined to be incomplete (refer to Section 6.2) include groundwater to sediment and surface water and groundwater to indoor air. However, VI risk would be assessed for future buildings that may proposed to be constructed above known groundwater impacts. A Tier 1 and possibly Tier 2 evaluation would be conducted in accordance with Ecology's VI guidance (Ecology 2022).

## 7.2 SOIL PRELIMINARY CLEANUP LEVELS

Table 7.2 presents the PCULs for soil for each of the potentially complete exposure pathways. The exposure pathways considered potentially complete in developing PCULs for soil and the applicable ARARs are presented as follows:

- **Protection of Human Health Direct Contact.** The Site is in an area zoned for industrial use. Therefore, the PCULs included are based on MTCA Method A CULs for industrial land use or MTCA Method C standard formula table values for industrial land use or where MTCA Method A CULs were not available.

- **Protection of Groundwater Quality.** PCULs that are protective of contaminants leaching from soil to groundwater were based on the MTCA Method A CULs for groundwater protection presented in Table 740-1 (for TPH) or, where MTCA Method A CULs were not established, calculated using the fixed parameter three-phase partitioning model, MTCA Equation 747-1. Soil PCULs were developed to protect drinking water. The basis of the groundwater PCULs used in the calculation is described in Section 7.1.

  Soil-to-groundwater equilibrium calculations performed using the three-phase model can be modified to incorporate Site-specific contaminant leaching and transport variables if available, in accordance with WAC 173-340-708(10)(b)(i) using the MTCA default value of 0.001 for total organic carbon.

Other pathways evaluated and determined to be incomplete (refer to Section 6.1) include soil to indoor air, soil to terrestrial ecological receptors, and soil to sediment. However, VI risk will be assessed for future buildings, within an industrial land use area, that are proposed to be constructed above known soil impacts. A Tier 1 and possibly a Tier 2 evaluation will be conducted in accordance with Ecology's VI guidance (Ecology 2022).

## 7.3 SITE-SPECIFIC TPH CLEANUP LEVELS

As provided for in MTCA WAC 173-340-747, Site-specific TPH MTCA Methods B and C CULs for protection of human health via direct contact were calculated with analytical results from 18 Site soil samples using Ecology's MTCA Workbook Tool (Ecology 2007). Copies of the completed MTCA Methods B and C calculation workbooks are provided in Appendix B.

The soil samples were collected at a range of depths across the Site, and at least one sample was collected from each of the nine AOPCs identified in the RIWP (Figure 3.1; Floyd|Snider 2019a). MTCA Method B CULs ranged from 1,334 to 2,384 mg/kg, and MTCA Method C CULs ranged from 24,278 to 45,743 mg/kg. Because the samples collected were considered representative of the range of potential source areas and petroleum-impacts and mixtures present at the Site, median MTCA Method B and C CULs of 1738 and 29,805.5 mg/kg, respectively, were deemed appropriate for application across the Site. These Site-specific MTCA Method B and Method C CULs are not selected as Site-wide PCULs but will be considered in the development of remedial alternatives for the Site in the FS to ensure that these alternatives adequately protect workers in accordance with MTCA (WAC 173-340-704(4)).

# 8.0 Development of Contaminants of Concern and Proposed Cleanup Standards

This section identifies the proposed COCs in groundwater and soil at the Site from among COPCs and other chemicals of interest for each medium determined in the RIWP. The selected COCs for a Site are intended to represent the full extent of Site contaminants that pose risk to environmental receptors for development of remedial alternatives. COCs are determined by screening Site data against the PCULs developed for each medium, described in Section 7.0. Once COCs are identified, cleanup standards are proposed. Cleanup standards are defined as a CUL combined with a POC where the CUL applies.

## 8.1 DETERMINATION OF CONTAMINANTS OF CONCERN

COCs were developed for groundwater and soil in a stepwise approach. First, chemicals in groundwater were compared to initial selection criteria regarding frequency and magnitude of PCUL exceedances. These selection criteria are established in MTCA to determine compliance with cleanup standards:

- The maximum result exceeds the PCUL by more than 2 times per WAC 173-340-720(9)(e)(i).
- Greater than 10% of results exceed the PCUL per WAC 173-340-720(9)(e)(ii).

After the COCs were identified for groundwater, further evaluation was conducted to select COCs in soil. A summary of the groundwater and soil COC selection process and outcomes is presented in the following sections.

### 8.1.1 Groundwater Contaminants of Concern

This section describes the process for identifying COCs in groundwater by screening groundwater data against the PCULs. Table 8.1 presents Site-wide frequency of exceedance (FOE) information. For each chemical, Table 8.1 presents the PCUL; the number of groundwater results; whether detected results exceeded the PCUL; and for each chemical of interest, the maximum exceedance factor. The most recent groundwater results obtained since 2015 have been included for each monitoring well location. These recent data are reflective of current Site conditions, particularly given the extent of soil interim actions performed at the Site. The chemicals that meet the selection criteria for groundwater presented in Section 8.1 are in Table 8.1.

Based on this evaluation, the chemicals identified as COCs in groundwater are the following:

- GRO
- Total DRO and ORO
- Benzene

### 8.1.2 Soil Contaminants of Concern

This section describes the process for identifying COCs in soil. Soil COCs were determined using a stepwise approach to evaluate their risk to environmental receptors. The potentially complete pathways for soil are leaching to potable groundwater and direct contact. Of these two pathways, the applicable criteria for groundwater protection are more stringent and are therefore considered first.

The PCULs for groundwater protection discussed in Section 7.2 were developed using default assumptions for the leachability of contaminants. These PCULs are a useful tool for understanding the fate and transport of Site contaminants and potential areas of concern for remediation. When determining whether contaminants in soil are of concern for the leaching pathway at a specific site, however, MTCA contains provisions for further site-specific leachability assessment to determine the list of site COCs. Therefore, for determining whether a chemical in soil is a COC for the leaching pathway at the Site, an empirical demonstration was first performed in accordance with WAC 173-340-747(9). Per the MTCA regulation, the empirical demonstration "specifies the procedures and requirements for demonstrating empirically that soil concentrations measured at the site will not cause an exceedance of the applicable groundwater cleanup levels established under WAC 173-340-720*."*

To demonstrate empirically that measured soil concentrations will not cause an exceedance of the applicable groundwater CULs via leaching, the following requirements must be fulfilled per WAC 173-340-740(9)(b):

- The groundwater concentrations are representative of expected leaching conditions—i.e., sufficient time has elapsed since contaminant releases to soil for leaching to occur, and the current leaching pathways through the vadose zone in unpaved areas and within the saturated zone are representative of future Site conditions.
- The measured groundwater concentration is less than or equal to the applicable groundwater cleanup level.

The first requirement for empirical demonstration is fulfilled at the Site, as detailed in prior sections of this report. The groundwater impacts associated with releases from petroleum handling that occurred between the mid-1920s and mid-1990s have been measured consistently during multiple investigations conducted throughout the previous 30 years, with significant variations observed only when concentrations decreased due to remediation activities. Furthermore, the Port intends to maintain the current Site configuration and maritime industrial property use for the indefinite future.

The second requirement is assessed in Section 8.1.1 above. The groundwater COCs identified in Section 8.1.1 on the basis of their frequency and magnitude of exceedances of the PCULs include GRO, total DRO and ORO, and benzene. These groundwater COCs are the contaminants for which the leaching pathway from soil is considered to be potentially complete and are assumed to be COCs for soil.

Under some conditions, contaminants that are found to be COCs in groundwater may no longer be present at concentrations of concern in soil (for instance, if a source has been depleted by leaching). To confirm that the groundwater COCs are additionally soil COCs, therefore, Site soil data for the groundwater COCs were screened against the PCULs in Table 8.2. Table 8.2 presents Site-wide FOE information. For each chemical, Table 8.2 presents the PCUL; the number of soil results; whether detected results exceed the PCUL; and the maximum exceedance factor for each chemical. All soil results representative of current Site conditions (i.e., currently present in situ) have been included in the FOE table; soil samples that have been removed through past excavation activities are not included in the FOE table. The chemicals that meet the COC selection criteria established in MTCA (WAC 173-340-740(7)(c)) and were identified as COCs include the following:

- GRO
- Total DRO and ORO
- Benzene

For all compounds not identified as soil COCs on the basis of empirical demonstration in groundwater, the other potentially complete pathway of direct contact was then considered to assess risk to environmental receptors. For each chemical, Table 8.3 presents the applicable direct contact criterion; the number of soil results; whether detected results exceed the direct contact criterion; and the maximum exceedance factor for each chemical. All soil results representative of current Site conditions (i.e., currently present in situ) have been included in the FOE table; soil samples that have been removed through past excavation activities are not included in the FOE table. The maximum detected concentrations were less than the corresponding criteria for direct contact for all remaining COPCs. Therefore, in accordance with the selection criteria established in MTCA (WAC 173-340-740(7)(c)), no additional chemicals were determined to be COCs due to risk to receptors via direct contact.

## 8.2 GROUNDWATER CLEANUP STANDARDS

Cleanup standards are defined as a CUL combined with a POC where the CUL applies. Groundwater cleanup standards ensure that groundwater leaving the Site is protective of human and ecological receptors in surface water and sediment, and that on-site groundwater is protective of drinking water and ambient air. Proposed cleanup standards have been selected for each of the proposed COCs identified in Section 8.1.1.

### 8.2.1 Point of Compliance

Under MTCA (WAC 173-340-720(8)(b)), the standard POC for groundwater is defined as "throughout the site from the uppermost level of the saturated zone extending vertically to the lowest most depth which could potentially be affected by the site," which implies that groundwater would need to meet CULs throughout the Site.

If it can be demonstrated that it is not practicable to meet groundwater CULs at the standard POC within a reasonable restoration time frame using all practicable methods of treatment in the cleanup, then a conditional POC (CPOC) may be approved by Ecology per WAC 173-340-720(8)(c). If a CPOC is necessary, MTCA requires that a CPOC be set as close to the source area as practicable, not to exceed the property boundary. Because groundwater exceeding CULs may still be present at the edge of the groundwater plume in the off-property area (refer to Section 4.3.7; DRO and ORO concentrations in monitoring wells MW-04 and MW-30 are interpreted to include other organic compounds), conditions for a CPOC are not currently met, and the standard POC will be applied.

There is no exposure to groundwater at the Site through the drinking water pathway, which is expected to be permanently ensured with an environmental covenant restricting groundwater use.

### 8.2.2 Proposed Cleanup Levels

For the groundwater COCs, direct contact and potable groundwater exposure pathways are considered complete for proposed CUL development (refer to Section 6.2). Therefore, the groundwater PCULs in Table 7.1 are numerically equivalent to the proposed CULs, presented in Section 8.4.

## 8.3 SOIL CLEANUP STANDARDS

Soil cleanup standards will ensure that Site soil is protective of direct contact (human health and ecological risk) pathways and leaching (protection of groundwater) pathways.

### 8.3.1 Point of Compliance

The standard POC for soil is pathway-dependent, as defined in WAC 173-340-740(6)(b-d). The standard POC for each potentially active soil exposure pathway, along with specific application at the Site, is summarized as follows:

- **Direct Contact.** The standard POC for all direct contact pathways is the top 15 feet of soil per WAC 173-340-740(6)(d) for human health risk assessment. Exposure pathways at the POC include incidental ingestion and dermal contact with soil and would require ICs and an SMP to be protective of workers conducting maintenance on the rail lines and utilities beneath the property.
- **Leaching to groundwater.** The POC is soil throughout the Site per WAC 173-340-740(6)(b). Compliance will be demonstrated by directly comparing groundwater concentrations to the proposed CULs.
- **Soil vapor.** The standard POC is from the surface to the uppermost groundwater table per WAC 173-340-740(6)(c). The depth to groundwater varies seasonally at the Site, dependent on the presence of perched groundwater and topography. Where perched groundwater is present, it is encountered at depths of approximately 6 to 17 feet bgs. Groundwater in the underlying alluvial aquifer is encountered at depths of

approximately 6 to 25 feet bgs and is typically deeper than approximately 12 feet bgs. Compliance for soil vapor has been demonstrated by soil vapor sampling in an area with the greatest concentrations and thicknesses of TPH impacts, which found that soil vapor concentrations do not exceed applicable regulatory screening levels (Table 4.9). However, VI risk will be assessed if future occupied buildings are proposed within areas of known TPH impacts.

### 8.3.2 Proposed Cleanup Levels

For the soil COCs, the direct contact exposure and leaching pathways are considered complete for proposed CUL development. Therefore, the soil PCULs in Table 7.2 are numerically equivalent to the proposed CULs, presented in Section 8.4.

## 8.4 SUMMARY OF PROPOSED COCS AND CLEANUP STANDARDS

Groundwater and soil proposed COCs and their proposed cleanup standards are summarized in Table 8.4.

**Table 8.4**
**Summary of Proposed Site COCs and Proposed Cleanup Standards**

| Proposed COC | Proposed Cleanup Level [1] | | Point of Compliance |
|---|---|---|---|
| | Value | Basis | |
| **Groundwater** | | | |
| GRO | 800 µg/L | Protection of drinking water | Site-wide |
| Total DRO and ORO | 500 µg/L | Protection of drinking water | Site-wide |
| Benzene | 5.0 µg/L | Protection of drinking water | Site-wide |
| **Soil** | | | |
| GRO | 30 mg/kg | Protection of groundwater [2] | Site-wide |
| Total DRO and ORO | 2,000 mg/kg | Protection of groundwater [2] | Site-wide |
| Benzene | 0.030 mg/kg | Protection of groundwater | Site-wide |

Notes:
1 Proposed CULs are based on MTCA Method A protection of groundwater (Tables 720-1 and 740-1).
2 The CULs for protection of leaching to groundwater and protection of direct contact are equivalent for TPH including GRO and total DRO and ORO. CULs based on leaching for benzene are also protective of the direct contact pathway.

# 9.0 Conceptual Site Model

The preliminary CSM presented in Section 4.0 of the RIWP was refined based on results of the RI data collection described in Section 4.0 of this report. The preliminary CSM used historical information and data to define extents of impacted Site media and outline potential receptors and potentially complete transport and exposure pathways.

This section presents a revised CSM for the Site, including historical sources of proposed COCs and contaminated media, nature and extent of COCs in Site media, and potential receptors and exposure pathways. Figure 9.1 shows the CSM.

## 9.1 ORIGINAL RELEASE MECHANISMS AND PRIMARY CONTAMINATED MEDIA

Based on historical information for the Site, together with prior and current environmental data, COCs whose concentrations exceed PCULs are petroleum-derived and include GRO, total DRO and ORO, and benzene in soil and groundwater. LNAPL has not been measured since approximately 2000, except for the 0.07 to 0.53 feet measured in MW-09 throughout the 2020 and 2021 quarterly groundwater sampling events.

Field investigations and a review of historical information indicate that the primary sources of COCs include the following:

- Former Standard Pipelines
- Former 80,000-barrel AST
- Former Longview Pipeline
- Former fuel loading racks
- Former Calloway UST

An additional lesser source includes the former mechanic's shop UST. The 2020 Phase II activities and GPR results from Golder's 1993 Phase II investigation did not encounter soil impacts related to the former U.S. Army Reserve heating oil UST, and the GPR results did not indicate the presence of any abandoned-in-place USTs adjacent to and west of the former 80,000-barrel AST and former U.S. Army Reserve building.

Available information indicates that the existing petroleum hydrocarbon impacts are from historical releases associated with the storage and transfer of petroleum fuels. The pipelines were used to convey multiple petroleum products including gasoline, diesel, Bunker C fuel, stove oil, and PS300 fuel (Golder 1993a). Based on the GPR survey and field observations beneath the berth, all former pipelines are inferred to be emplaced between approximately 3 and 14 feet bgs throughout the Site, deepest in the southern part of the Site, where they daylight beneath the berths, but sloping downward from south to north (Figure 5.1; Golder 1994). Historical observations indicate that some of the capped and plugged pipelines had leaked beneath the piers (Golder 1994); however, the 2019 pipeline interim action removed all remaining pipelines

extending beyond the bulkhead (Floyd|Snider 2019b), and routine inspections are conducted to ensure that the pathway of surface soil erosion to surface water remains protective. There are currently no continuing sources of petroleum products or other known hazardous substances stored or used at the Site. However, it is unknown if the former Longview Pipeline still contains product but is considered a potential source; although it is likely immobile and currently contained within the pipeline and capped at the ends.

## 9.2 NATURE AND EXTENT OF CONTAMINATED MEDIA

The proposed COCs for the Site based on groundwater and soil data from historical and RI investigations include GRO, total DRO and ORO, and benzene. LNAPL is present at one monitoring well location (MW-09). The sections that follow describe the nature and extent of groundwater and soil impacts using all available in situ data for each of the COCs described in Section 8.1. Figures 9.2 and 9.3 show extents of groundwater COCs at concentrations greater than proposed CULs. Figures 9.4 through 9.6 show maximum concentrations of soil COCs, and Figure 9.7 shows the extent of soil COCs with concentrations that exceed proposed CULs. Table 9.1 presents chemical-specific properties for each COC that may affect fate and transport in the environment, and thus may help inform the selection of remedial technologies.

### 9.2.1 Contaminants of Concern in Groundwater

COCs in groundwater include GRO, total DRO and ORO, and benzene. COCs have been sufficiently delineated for the purpose of the RI, which is to collect sufficient information to evaluate and select remedial alternatives for the Site per WAC 173-340-350(1). Figures 9.2 and 9.3 shows the approximate extents of the groundwater plumes in the perched zone and alluvial aquifer, respectively, with COC concentrations exceeding proposed CULs at the Site. Tables 4.6 and 4.7 provide groundwater analytical results relative to RIWP screening criteria since 2015, and Appendix G includes a summary of historical groundwater analytical data from 1991 to 2013.

#### *9.2.1.1 Total DRO and ORO*

Total DRO and ORO concentrations in groundwater that exceed the proposed CUL of 500 µg/L are found in both the perched zone and alluvial aquifer. Total DRO and ORO concentrations greater than proposed CULs in groundwater are concentrated most heavily in the area beneath the pipelines between the former Calloway Ross Parcel and the former 80,000-barrel AST and fuel loading racks.

**Perched Water-Bearing Zone**

In the perched zone, total DRO and ORO concentrations greater than proposed CULs are present in two separate dissolved-phase plumes, which are separated by a zone of clean perched zone groundwater (Figure 9.2). GRO and benzene are not present at concentrations exceeding their respective proposed CULs within the perched zone.

The northern dissolved-phase plume encompasses the central portion of the rail line near the former fuel loading racks and stretches north and west to MW-02 and MW-04, which are located downgradient and north-northwest of the former Calloway Ross Parcel and former Standard and Longview Pipelines (Figure 9.2). Proposed CUL exceedances have been intermittent over time at these locations. Total DRO and ORO was detected at concentrations exceeding proposed CULs at MW-02 and MW-04 in two of five and one of two recent groundwater sampling events, respectively. In addition, MW-02 and MW-04 have high average dissolved oxygen and total DRO and ORO concentrations, relative to other sample locations. It is likely that a portion of the total DRO and ORO concentrations are detections of organic material in this area (Appendix D). This is supported by the laboratory reports, which indicate that the chromatograms do not match the fuel standards used for instrument calibration and analytical results analyzed with and without silica gel cleanup, which was used between 2001 and 2013. These observations and the intermittent exceedances at MW-02 and MW-04 indicate that these locations are at the edge of the dissolved-phase plume. Groundwater analytical data indicate that the northern dissolved-phase plume within the perched zone is delineated to the northeast east, south, and southwest at monitoring wells MW-16, MW-14, MW-11, and MW-17 and likely does not extend further than MW-02 and MW-04.

The second dissolved-phase plume with total DRO and ORO concentrations greater than proposed CULs in perched zone groundwater includes MW-26 and MW-28 near the divergence of the Standard and Longview Pipelines and extends to the west and downgradient to MW-30 and MW-35. The maximum total DRO and ORO concentration of 6,100 µg/L was detected at MW-28 in August 2020, which is located adjacent to and west of the former Standard and Longview Pipelines along the railroad tracks. Proposed CUL exceedances are relatively low (approximately 1 to less than 3 times the proposed CUL) at the other locations, including MW-30, which is located off the Port property across Port Way. Historical groundwater monitoring results indicate that the hydrocarbons detected at MW-30 by the NWTPH-Dx method may be attributed to naturally occurring organics and/or metabolic byproducts of biodegradation as shown by analytical results after silica gel cleanup, which was used between 2001 and 2013. Analytical results for groundwater samples taken from MW-30 with silica gel cleanup were consistently less than the MTCA A Method CUL (equal to the proposed CUL) during this time (Golder 2000). Groundwater analytical data indicate that the southern dissolved-phase plume in the perched zone is delineated to the east, south, and southwest at monitoring wells MW-18, MS-13, MW-24, and MW-29. Although the plume is not delineated to the west and north, groundwater data and MNA results discussed in Appendix D and in Section 9.2.1.3 indicate that MW-02, MW-04, and MW-30 are close to the edge of the dissolved-phase plume.

It is likely that a portion of the total DRO and ORO concentrations detected in MW-02, MW-04, and MW-30 are detections of organic material and/or metabolic byproducts of biodegradation (e.g., alcohols and organic acids, with possible phenols, aldehydes, ketones). These byproducts have oxygen in their molecules and are not considered hydrocarbons but are included as DRO detections. This is supported by the laboratory reports, which note that the chromatograms for these three locations do not match the fuel standards (diesel and oil) used for instrument calibration. The chromatogram patterns could be a result of a variety of reasons, such as

weathering, biodegradation, or a combination of a mixture of DRO and ORO. However, MW-30 shows neither a decrease of dissolved oxygen, nitrate, and sulfate nor an increase in total alkalinity, manganese, ferrous iron, and methane concentrations (Table 4.8), and groundwater sampling observations at MW-30 have noted the presence of a reddish-brown bacterial growth that is likely associated with organic iron-reducing bacteria. Based on these observations, MNA data, and analytical data analyzed with silica gel cleanup, biodegradation has likely occurred at these three locations and a portion of the detected total DRO and ORO concentrations are metabolic byproducts. These data and observations can be used to conservatively determine that the edge of the dissolved-phase plume is at or does not extend much farther beyond these three monitoring wells.

To summarize, the groundwater plume within the perched zone is considered delineated off-property, as shown on Figure 9.2, and likely does not extend beyond monitoring wells MW-02, MW-04, MW-30, and MW-35 due to the following:

- Relatively low-level and intermittent proposed groundwater CUL exceedances
- Consistent decrease of COC concentrations relative to historical concentrations
- Stability and active natural attenuation within the plumes (Appendix D)
- Presence of a reddish-brown bacterial growth at location MW-30 that is likely associated with iron-reducing bacteria
- Chromatograms for these locations that do not resemble diesel fuel patterns and COC concentrations that are likely naturally occurring organic material and metabolic byproducts at MW-02, MW-04, MW-30, and MW-35, which is supported by MNA data and groundwater results analyzed with silica gel cleanup

However, these conclusions will be confirmed with additional well installation and sampling as a part of predesign data collection prior to submittal of the Engineering Design Report (EDR), as further discussed in Section 15.1.

**Alluvial Aquifer**

In the alluvial aquifer, total DRO and ORO concentrations exceeding proposed CULs are concentrated in three separated dissolved-phase plumes (Figure 9.3). The northern plume is in the northeastern portion of the Site adjacent to the former Standard Pipelines and encompasses MW-06 and MW-39. The total DRO and ORO maximum concentration of 7,300 µg/L was detected at MW-39 in August 2020. The extent of dissolved-phase DRO and ORO impacts is delineated to the north, south, and west at MW-19, OIP-69, and downgradient location MW-01.

The central dissolved-phase plume with total DRO and ORO concentrations exceeding proposed CULs in the alluvial aquifer extends from MW-15 in the northeast adjacent to the former 80,000-barrel AST and Standard Pipelines to the southwest at MW-33, underlying the central rail lines and the pipelines. The dissolved-phase plume extends to the east and west between the former Calloway Ross Parcel and former 80,000-barrel AST (MW-05 and MW-12). The plume is

approximately centered around MW-09, which is the only location on the Site that currently contains measurable LNAPL. The maximum concentration of 3,800 µg/L for total DRO and ORO was detected at MW-40 in November 2020, which is located near the center of the inferred plume and along the pipelines. The central dissolved-phase plume with total DRO and ORO exceedances is delineated at downgradient location MW-31 as well as to the northeast (at T-2), east (at OIP-02, MW-32), and west (at GP-3, and GP-4).

The southern dissolved-phase plume with total DRO and ORO concentrations that exceed proposed CULs is centered around MW-34, located just west and adjacent to the former Standard and Longview Pipelines. The maximum total DRO and ORO concentration at MW-34 is 1,800 µg/L, which was detected in both November 2020 and February 2021. The southern dissolved-phase plume is inferred to be separated from the plume to the north due to multiple boring locations (OIP-46, OIP-64, and GP-3), with soil samples with analytical results less than proposed CULs and OIP borings (OIP-33, OIP-64, OIP-55, and OIP-65) without fluorescent responses collected in this area. The total DRO and ORO groundwater plume is delineated downgradient at GP-3 and GP-4, cross-gradient at location MW-27, and upgradient at locations UST-4 and MW-23.

#### *9.2.1.2 GRO and Benzene*

The extent of groundwater with GRO and benzene concentrations greater than proposed CULs is significantly smaller than the extent of the total DRO and ORO-impacted groundwater, and GRO and benzene exceedances are present only within the alluvial aquifer. The dissolved-phase GRO plume encompasses the dissolved-phase benzene plume, and exceedances of proposed CULs are collocated at MW-10, MW-12, and MW-40 (Figure 9.3). The greatest GRO and benzene concentrations are encountered in the vicinity of the former Calloway UST, beneath the former Standard and Longview Pipelines, and adjacent to the former 80,000-barrel AST. The maximum concentrations of GRO and benzene concentrations were detected at MW-12 in August 2020 at 7,100 and 910 µg/L, respectively.

The dissolved-phase GRO plume within the alluvial aquifer extends from MW-12 in the east to MW-03 and MW-40 in the west and from MW-20 and MW-40 in the south to MW-08 in the north. The dissolved-phase benzene plume extends from MW-40 and MW-10 in the west to MW-12 in the east. Despite the GRO concentrations detected in MW-20, the extent of the GRO impacts in the alluvial aquifer are not expected to extend farther upgradient to the southeast and south due to the lack of a source, groundwater flow direction, and being bounded to the east by OIP-02, GP-31, and MW-32. The GRO and benzene groundwater plume in the alluvial aquifer is considered adequately delineated by results less than proposed CULs at downgradient location MW-31 and cross-gradient locations MW-05, MW-15, MW-32, MW-33, OIP-02, and T-2.

#### *9.2.1.3 Natural Attenuation of Contaminants*

Natural attenuation is the unaided reduction of contaminant concentration and mass by using the natural assimilative capacity of a site groundwater/soil system in situ. As defined in WAC 173-340-200, these in situ processes include natural biodegradation; dispersion; dilution; sorption; volatilization; and chemical or biological stabilization, transformation, or destruction of hazardous substances. When used as part of a cleanup action, natural attenuation is referred to by

the USEPA as MNA to differentiate it from a no action alternative (USEPA 1999). Appendix D provides a summary of these indicators—how metabolic byproducts and electron donors/acceptors can be used to infer the efficacy of natural attenuation processes at a site—and an assessment of the MNA status in both perched zone and alluvial aquifer groundwater.

Site analytical groundwater results (Table 4.8) provide evidence that natural attenuation of groundwater contaminants by various types of biodegradation is occurring in both the perched and alluvial water-bearing zones. In the alluvial aquifer, results show decreased concentrations of dissolved oxygen, nitrate, and sulfate and increased manganese, ferrous iron, methane, and total alkalinity concentrations within the dissolved-phase groundwater plume, relative to unimpacted groundwater. This observation indicates that both aerobic and anaerobic biodegradation are occurring in the alluvial aquifer, particularly in the dissolved-phase plume that surrounds the LNAPL in MW-09. In the perched zone, decreased, but measurable dissolved oxygen concentrations as well as low nitrate and sulfate concentrations within the dissolved-phase plume, relative to impacted groundwater provide evidence for both aerobic and anaerobic biodegradation (i.e., denitrification and sulfate reduction) in groundwater. Strong positive (manganese, ferrous iron, and methane) and negative (dissolved oxygen, nitrate, and sulfate) correlations between these MNA parameters and total DRO and ORO concentrations in both perched zone and alluvial aquifer groundwater provide further evidence that biodegradation is occurring at locations with petroleum-impacted groundwater in the perched zone (Appendix D).

To evaluate the stability of the Site dissolved-phase groundwater plumes, time series plots of total DRO and ORO, GRO, and benzene were constructed for monitoring well locations in both water-bearing zones with available historical groundwater data (Appendix G). In addition, Mann-Kendall analyses using Ecology's natural attenuation data analysis tool package (Ecology 2005) were used to assess the stability of contaminant plumes at individual monitoring well locations. Results indicate that the groundwater plumes in both the perched zone and alluvial aquifer are stable or shrinking.

### 9.2.2 Light Non-Aqueous Phase Liquid

The occurrence of LNAPL on groundwater and analysis of the correlation of LNAPL with soil results for petroleum are described in the following sections. It should be noted that, consistent with the cleanup standards presented in Section 8.4, results for total DRO and ORO are used to analyze correlation between soil concentrations and LNAPL occurrence.

#### *9.2.2.1 Nature and Extent of LNAPL*

Historically, LNAPL has been present in measurable concentrations with thicknesses between 0.01 and 1.34 feet in perched zone monitoring well MW-16 (Figure 9.2) and alluvial aquifer wells MW-03, MW-07, MW-09, MW-19, and MW-20 (Figure 9.3). LNAPL has not been detected in monitoring wells MW-16 and MW-19 since June 1993. Between April 1999 and 2014, absorbent socks were deployed to remove LNAPL in monitoring wells MW-03, MW-07, MW-09, and MW-20. During the 2019 Site-wide groundwater monitoring event, LNAPL was measured only in MW-09, at a thickness of 0.01 feet. Absorbent socks were removed from MW-03, MW-07, MW-09, and MW-20 to assess LNAPL recoverability in these wells.

Since 2019, MW-03, MW-07, and MW-20 remained without measurable LNAPL, and LNAPL thicknesses in MW-09 slowly increased to 0.53 feet in February 2021 (Table 4.10). The depletion in dissolved oxygen, nitrate, and sulfate and increases in manganese and ferrous iron at monitoring well MW-20 indicate that natural attenuation is occurring after the removal of LNAPL using absorbent socks (Appendix D), which is likely occurring at MW-03 and MW-07 as well. Therefore, TPH impacts in soil are no longer present at concentrations for mobile LNAPL to accumulate on the water table at these locations. The slow increase of measurable LNAPL in MW-09 indicates that LNAPL transmissivity within the alluvial aquifer is very low; however, remaining residual LNAPL is likely to continue to accumulate on the water table at MW-09. Because MW-09 is surrounded by alluvial aquifer wells (i.e., MW-07, MW-10, and MW-40) and a perched zone aquifer well (MW-14) that have no measurable LNAPL, the residual LNAPL plume on the Site is inferred to be small in extent, stable, and confined to the portion of the alluvial aquifer underlying MW-09 or likely immobile beyond MW-09 (Figure 9.3). LNAPL extent is considered sufficiently delineated for the purposes of this RI.

### 9.2.3 Contaminants of Concern in Soil

The extents of known total DRO and ORO, GRO, and benzene in soil at concentrations exceeding proposed CULs are shown in Figure 9.7. The extents of soil impacted by total DRO and ORO and by GRO largely overlap, with the exception of some scattered exceedances in the far northern and southern portions of the Site. The soil impacts are largely concentrated in three areas centered along the former Standard and Longview Pipelines as they transect the Site beneath the rail lines from MW-39 in the north to GP-27 in the south. Beneath the rail lines, the affected soil extends laterally to the east and west in three areas: (1) in the vicinity of MW-39 with impacts extending from approximately OIP-69 to OIP-73; (2) in the central portion of the Site near the former fuel loading rack location, where impacts encompass the area between the former Calloway UST and the former 80,000-barrel AST; and (3) in the southern portion of the Site where the former Standard and Longview Pipelines diverge, where impacts are concentrated between MW-34 and MW-24.

In the northernmost area, soil impacted by total DRO and ORO has been identified between 2 and 14 feet bgs at MW-19 and MW-39, with a maximum concentration of 130,000 mg/kg (MW-19). GRO was detected at concentrations greater than the proposed CUL only at MW-39, although historical detection limits for GRO were not available for the soil samples collected at MW-19. Impacted soil in this area is delineated on all sides by analytical results less than proposed CULs at OIP-57, OIP-69, OIP-7, and OIP-73.

The most heavily impacted soil occurs beneath the rail lines within the vicinity of the former fuel loading racks located between the former Calloway UST and the former 80,000-barrel AST and stretches from approximately OIP-56 to OIP-33. The soil impacts, which include total DRO and ORO, GRO, and benzene, are centered around MW-09, which is the only monitoring well with current measurable LNAPL; however, this area includes zones of soil impacts at concentrations greater than preliminary residual saturation levels (Section 4.0). The extent of soil impacted by GRO and by total DRO and ORO stretches eastward into the former 80,000-barrel AST footprint; although this area was excavated to an average depth of 6 feet bgs in 1996, confirmation samples and subsequent RI samples and OIP borings indicate that some impacted material remains at or

below the base of the excavation and beyond the southeastern sidewall near OIP-2 (Floyd|Snider 2021). COC exceedances occur between approximately 1.5 and 20 feet bgs in this area, but exceedances are concentrated between 8 and 17 feet bgs. The maximum detected concentrations for COCs in this area are as follows:

- Total DRO and ORO of 160,000 mg/kg at SCR-2 (0 to 1 foot bgs)
- GRO of 16,000 mg/kg at MW-16 (10 feet bgs)
- Benzene of 12 mg/kg at MW-40 (10.5 to 11 feet bgs)

Soil in this area with total TPH concentrations greater than the Site-specific MTCA Method C CUL for direct contact includes sample locations SCR-1 and SCR-2 (0 to 1 foot bgs) as well as MW-11 (1.5 feet bgs). The extents of total DRO and ORO and GRO concentrations exceeding proposed CULs largely overlap in this area (Figure 9.7), and benzene exceeding proposed CULs was detected in soil from four locations within these extents in a small band just west of the pipelines and MW-09. Saturated zone soil total DRO and ORO that is at or exceeds preliminary residual saturation levels occurs from approximately MW-09 to MW-17, beneath and just west of the rail lines, primarily in a zone between 13 and 18 feet bgs. Based on boring logs and water level measurements, this impacted saturated zone soil is in contact with the upper few feet of the alluvial aquifer. Soil GRO concentrations equal to or exceeding residual saturation levels occur between OIP-47 and MW-16 and are concentrated slightly shallower, between 8 and 12 feet bgs, which is consistent with perched zone water level elevations in these locations. The GRO detections in OIP-49 and OIP-72 were at concentrations of 960 mg/kg and 520 mg/kg, respectively. However, OIP results from OIP-49 and OIP-72 show that these impacts are limited in thickness, less than 1 foot thick, indicating that impacts are pinching out to the east. Therefore, this area is considered delineated on all sides by multiple historical and RI soil analytical results and OIP borings (Figure 9.7).

A zone of clean soil separates the soil impacts centered around MW-09 from the impacts centered around MW-26 in the vicinity of the bend in the former Longview Pipeline and just to the north of the former mechanic's shop and associated USTs. The area includes soil with GRO and total DRO and ORO at concentrations greater than proposed CULs. Maximum COC concentrations include 49,000 mg/kg for total DRO and ORO and 5,600 mg/kg for GRO at OIP-23 and MW-24, respectively. Impacted soil in this area occurs between 12.8 and 24 feet bgs, which is at or below the silt aquitard inferred to separate the perched zone from the alluvial aquifer. Soil exceeds preliminary residual saturation levels for total DRO and ORO between 14 and 20 feet bgs at five boring locations. In addition, soil exceeds the Site-specific total TPH MTCA Method C CUL for direct contact at MW-24 (15.5 feet bgs), MW-26 (18 feet bgs), and OIP-23 (19 to 20 feet bgs). This area is delineated on all sides by analytical results less than proposed CULs at MW-18, OIP-53, OIP-54, UST2, GP-34, and OIP-31.

#### *9.2.3.1 Isolated Soil Contamination*

Outside of the three main areas of impacted soil beneath the railroad tracks, there are several isolated locations where GRO and total DRO and ORO have been detected at concentrations greater than proposed CULs (Figure 9.7). Along the northern Site boundary, sample SCR-7 (0 to 1 foot bgs), collected in 1993, had a total DRO and ORO concentration of 2,700 mg/kg that

exceeded the proposed CUL. South of the former mechanic's shop and USTs, OIP-20 had a thin sand layer (less than 1 foot thick) of impacted soil with a GRO exceedance at 11.5 feet bgs but is considered delineated on all sides. In the southern part of the Site, near the termination of the pipelines and shipping berths, there were multiple limited, non-continuous, low-level exceedances of total cPAHs TEQ and total DRO and ORO in the locations underneath Berths 1 and 2 (P1 through P6), as well as GRO, total DRO and ORO exceedances at GP-18 at 27 feet bgs (Floyd|Snider 2020). However, groundwater data collected at GP-18 show total DRO and ORO detections less than laboratory quantitation limits, which indicate that the total DRO and ORO exceedances in soil at GP-18 at 27 feet bgs do not impact groundwater (Tables 4.2 and 4.6). Additionally, groundwater results in wells MW-37 and MW-38 indicate that the low-level TPH and cPAHs detections in soil beneath the berths do not impact groundwater. Additionally, the residual cPAHs detection beneath the berths are approximately 14 feet above the highest recorded tidal levels. Using the National Oceanic and Atmospheric Administration's (NOAAs) online tool (NOAA 2021), these impacts will not come into contact with the maximum projected sea level rise of 10 feet with high tide flooding (refer to Section 9.4).

## 9.3 CURRENT AND FUTURE POTENTIAL LAND USES

The Site is actively used for marine cargo operations, which include a rail-dependent bulk export facility. Activities and uses in support of those operations include storage of cargo handling equipment, cargo storage, conveyers, rail dump pit, baghouses, ship loader, office, maintenance shop, wastewater pre-treatment plant, transit sheds, and maintenance material storage. Future land use is expected to remain the same.

Ecological receptors are not likely to be impacted by Site use in the future, as indicated by the simplified TEE evaluation (refer to Appendix H). Per the simplified TEE, no further evaluation is necessary.

## 9.4 VULNERABILITY ASSESSMENT

Resilience to climate change impacts is evaluated using the Ecology guidance Adaptation Strategies for Resilient Cleanup Remedies (i.e., climate change guidance; Ecology 2017). The groundwater elevation in the alluvial aquifer at the Site is tidally influenced due to the close proximity the Columbia River; therefore, climate change impacts have a potential to adversely affect the Site. These impacts include the rise in sea level and coastal inundation, high tide flooding, and severe storms. NOAA provides an online analytical tool for doing an initial screening to understand the potential vulnerability of cleanup sites to sea level rise (NOAA 2021). NOAA's Sea Level Riser Viewer shows that the surface elevation of the Site, including the shallow soil impacts beneath the berths, are above a projected sea level rise of 10 feet, which is above projected high tide flooding. In addition, the Site has a low risk to flooding and a low-risk scenario of being impacted by a severe storm (FEMA 2021). Based on this assessment, the remedial alternatives considered (refer to Section 13.0) are not considered vulnerable to projected sea level rise and or flooding.

# 10.0 Remedial Investigation Summary and Conclusions

As discussed in the preceding sections, soil and groundwater beneath the Site have been impacted by incidental releases and leaks from historical sources associated with the storage and transfer of petroleum fuels on the Site, including gasoline, diesel, Bunker C fuel, stove oil, and PS300 fuel. As part of this RI, the Site is considered fully characterized, which was concurred by Ecology (Groven 2021); the horizontal and vertical extent of soil and groundwater impacts have been delineated, and the risks of soil vapor to indoor air and groundwater discharge to surface water have been precluded. The fate and transport of contaminants have been adequately characterized and the CSM has been well-defined for the purpose of development and evaluation of remedial alternatives, in accordance with WAC 173-340-350.

Areas of residual TPH soil impacts, which include DRO, ORO, GRO, and benzene, are present throughout the Site but concentrated primarily on the former Calloway Ross Parcel, along and around the subsurface Standard and Longview Pipelines beneath the rail lines, and near the former 80,000-barrel AST. Within these areas, soil concentrations for GRO and total DRO and ORO greater than preliminary residual saturation levels are also present and primarily along the former pipelines. TPH-impacted soil in the central and northern parts of the Site is concentrated between approximately 8 and 17 feet bgs, which is below the estimated depth of the pipelines (3 to 4 feet bgs). In the southern portion of the Site, TPH-impacted soil is concentrated deeper, between approximately 13 and 24 feet bgs, which corresponds to the area where the pipelines are buried more deeply.

Current groundwater impacts exist in both the perched zone and alluvial aquifer, and measurable LNAPL is present only within the alluvial aquifer at MW-09. The perched zone, which is hydrologically isolated from the alluvial aquifer by a low-permeability silt aquitard at its base, includes two zones of groundwater impacted by total DRO and ORO that are centered around approximately MW-09 and MW-28 and include areas beyond the edge of the Port property at MW-04 and MW-30, respectively. Proposed CUL exceedances are low and intermittent at these locations, which constitute the plume edges. Laboratory and MNA data also suggest that a portion of the DRO concentrations detected at MW-02, MW-04, and MW-30 could be metabolic byproducts of biodegradation, which suggests that the plume is degrading and shrinking. Generally, the dissolved-phase groundwater plumes in the perched zone occur in or downgradient of areas with highly TPH-impacted soil. Dissolved-phase plumes of total DRO and ORO in alluvial aquifer groundwater are present in three main areas underlying the rail tracks, former fuel loading rack area, and the former Standard and Longview Pipelines and are associated with areas of greatest total DRO and ORO concentrations in soil. A smaller dissolved-phase GRO and benzene plume is centered around MW-09 beneath the railroad tracks and is correlated to areas with elevated GRO and benzene soil concentrations, which are located just west of the rail lines.

Overall, both TPH concentrations and measurable LNAPL extents in both perched zone and alluvial aquifer groundwater over the past approximately 40 years have substantially decreased and are continuing to decline, likely due to active biodegradation and natural attenuation

processes. Based on the CSM and available data, pathways of concern include soil leaching to groundwater and direct contact for soil impacts in unpaved areas above the POC of 15 feet bgs throughout the Site.

The nature and extent of contamination at the Site has been sufficiently characterized by the investigations conducted, and the current and potential exposure pathways have been determined for the purposes of assessing and selecting remedial alternatives in the FS. The remaining sections of this report contain the FS, which will define Cleanup Action Areas (CAAs) and evaluate remedial options for the Site to address and interrupt these pathways of concern.

# 11.0 Feasibility Study Introduction and Objectives

The remaining sections of this report comprise the FS, which has been developed in accordance with MTCA (WAC 173-340-351). This FS develops and evaluates remedial action alternatives for the Site and then presents the Preferred Alternative to Ecology for consideration. As part of the FS, the following tasks were conducted:

- Determined remedial action goals and objectives for the Site.
- Evaluated ARARs (i.e., identified applicable local, state, and federal laws and applicable and relevant requirements).
- Defined CAAs based on contamination extents and accessibility.
- Compiled, evaluated, and screened potentially applicable remedial technologies.
- Aggregated and evaluated proposed remedial alternatives that meet MTCA requirements.
- Compared remedial alternatives to the MTCA requirements for a cleanup action per WAC 173-340-351(6).
- Completed a Disproportionate Cost Analysis (DCA) procedure consistent with WAC 173-340-360(5)(c)(iv) to identify the alternative that is permanent to the maximum extent practicable.
- Identified the Preferred Alternative for the Site (Section 15.0) for recommendation to Ecology for consideration in development of the Cleanup Action Plan (CAP) for the Site, and explained how the Preferred Alternative meets RAOs and complies with MTCA and ARARs.

## 11.1 REMEDIAL ACTION OBJECTIVES

The RAOs are Site-specific objectives that can be used to compare the effectiveness of proposed cleanup actions and to ensure compliance with ARARs. The RAOs identified for the Site include the following:

- Protect human health and the environment from contamination that exceeds applicable CULs through compliance with the requirements for cleanup actions as described in WAC 173-340-360(3) including the following:
  - Remove unacceptable human health risk resulting from direct contact with contaminated soil.
  - Reduce, to the extent practicable, concentrations of COCs in soil at the Site that are sources of continuing groundwater contamination.
  - Reduce concentrations of hazardous substances in groundwater at the Site to prevent off-property migration.
- Remove, to the extent practicable, LNAPL accumulations on the water table, per WAC 173-340-360(3)(c)(iii) .

These RAOs will be achieved in a manner that considers current and future site use, in particular, the continuing operations of the Port Terminal and the railway that services Berth 2.

Each remedial alternative proposed in this FS is evaluated for its ability to accomplish the RAOs listed above, as described in the following sections.

## 11.2 APPLICABLE LOCAL, STATE, AND FEDERAL LAWS

The selected remedial alternative must comply with MTCA cleanup regulations (WAC 173-340) and with applicable local, state, and federal laws. Together, these regulations and laws are identified as ARARs. Under WAC 173-340-200 and WAC 173-340-710, the term "applicable requirements" refers to regulatory cleanup standards, standards of control, and other environmental requirements, criteria, or limitations established under state or federal law that specifically address a remedial action, location, COC, or other circumstance at the Site. The "relevant and appropriate" requirements are regulatory requirements or guidance that do not apply to the Site under law but have been determined by Ecology to be appropriate for use at the Site.

ARARs are often categorized as location-specific, action-specific, or chemical-specific, described as follows and summarized in Table 11.1.

- **Location-Specific ARARs** are requirements that are applicable to the specific area where the Site is located and can restrict the performance of activities, including cleanup actions, solely because they occur in specific locations.
- **Action-Specific ARARs** are requirements that are applicable to certain types of activities that occur or technologies that are used during the implementation of cleanup actions. Waste disposal regulations are an example of an action-specific ARAR.
- **Chemical-Specific ARARs** are applicable to the types of contaminants present at the Site. The cleanup of contaminated media must meet the proposed CULs developed under MTCA; these CULs are considered chemical-specific ARARs.

The potentially applicable ARARs for remediation are presented in Table 11.1. Location-specific ARARs would be met through compliance with the applicable local, state, and federal regulations based on the physical location of the Site such as land use regulations for heavy industrial use. Action-specific ARARs would be met through implementation of construction activities in compliance with all applicable construction-related requirements such as regulation for disposal of excavated materials or injection of groundwater treatment reagents. Chemical-specific ARARs will be met through compliance with proposed cleanup standards.

Cleanup actions conducted under an agreed order with Ecology are exempt from the state and local ARAR procedural requirements, such as certain permitting and approval requirements. Cleanup actions must, however, demonstrate compliance with the substantive requirements of those ARARs (WAC 173-340-710(9)). This exemption applies to procedural permitting

requirements under the Washington State Water Pollution Control Act, the Solid Waste Management Act, and the Shoreline Management Act, as well as local laws requiring permitting such as City of Longview municipal codes and regulations. Cleanup actions are not exempt from procedural requirements of federal ARARs.

## 11.3 CLEANUP ACTION AREAS

Remedial actions conducted within the rail lines would impact Port activities, and remedial actions outside the rail lines would likely not interfere with Port activities. Therefore, the Site is divided into two CAAs, the areas outside the active rail lines (CAA-1) and the area within the active rail lines (CAA-2), to enable a better comparison and evaluation of technologies in the FS due to the large size of the Site and the various source areas. A brief description of each CAA is presented in Sections 11.3.1 and 11.3.2.

### 11.3.1 CAA-1 (CAA-1A and CAA-1B)

CAA-1 encompasses the entirety of the Site outside of the active rail lines and is subdivided into areas CAA-1A and CAA-1B. CAA-1A includes the impacted soil and groundwater present north, west, and east of the rail lines within the former Calloway Ross Parcel; in the former Warehouse 9 footprint; and within the vicinity of the former 80,000-barrel AST. CAA-1B includes the City of Longview right-of-way (ROW) and the portions of Washington State Department of Transportation (WSDOT) property in the vicinities of MW-04 and MW-30 that have impacted groundwater. The off-property area is subdivided into CAA-1B because the different site conditions and ownership circumstances call for different approaches to achieving the RAOs. It is expected to be more practicable to remediate the WSDOT and City of Longview ROW while avoiding placing ICs on the properties not owned by the Port. Because all of CAA-1[12] is outside of the active rail lines, implementing remedial actions and technologies in this CAA is more accessible and feasible compared with CAA-2.

COCs in soil and/or groundwater in CAA-1 are present at concentrations exceeding proposed CULs and include GRO, total DRO and ORO, and benzene. CAA-1A also includes two areas of soil that have total DRO and ORO concentrations greater than residual saturation levels (Figure 11.1).

### 11.3.2 CAA-2

CAA-2 constitutes the portion of the Site that is contained within the active rail lines, including the soil and groundwater impacts that lie within the former fuel loading rack area, vicinity of MW-26 and MW-28, former mechanic's shop, and the northern portion of the Standard Pipelines. Per the RAOs in Section 11.1, the rail lines are an important part of the Port operations, and remedial technologies implemented within CAA-2 will need to limit impact to current or future Port operations. A portion of the rail lines within CAA-2 are owned by the Port

[12] When using "CAA-1", the text is referring to both CAA-1A and CAA-1B

and/or BNSF Railway Company, and the Port operates the rail lines that traverse the Site within CAA-2.

COCs in soil and groundwater in CAA-2 are present at concentrations exceeding proposed CULs include GRO, total DRO and ORO, and benzene. Additionally, CAA-2 includes three areas of soil where GRO and/or total DRO and GRO concentrations exceed residual saturation levels in soil and groundwater (Figure 9.7). Measurable LNAPL is present in MW-09.

## 11.4 REMEDIATION LEVELS

This section discusses the use of RELs at the Site. In accordance with WAC 173-340-355 and as defined in WAC 173-340-200, a REL is "a concentration (or other method of identification) of a hazardous substance in soil, water, air, or sediment used to identify where a particular cleanup action component is required as part of a cleanup action at a site." RELs are, by definition, concentrations that exceed CULs and are used when a combination of cleanup action components are necessary to achieve CULs at a POC or CPOC. The use of RELs is consistent with the requirements under MTCA. Specifically, all of the remedial alternatives evaluated meet the minimum requirements under WAC 173-340-360 for selection of a cleanup action, including a determination that the alternatives are protective of human health and the environment. In addition, the results of the DCA (refer to Section 14.3) indicate that a more permanent cleanup action is not practicable, as required under WAC 173-340-360 (3)(b)(i).

RELs are applicable to this Site because implementation of removal- and treatment-based technologies and MNA will be necessary to achieve proposed CULs for groundwater. Specifically, RELs based on residual saturation levels are proposed for soil within CAA-2, where overlapping COCs are present in soil and groundwater, and any remedial activities within CAA-2 will impact Port operations. Remedial actions to attain RELs will be followed by MNA to attain CULs. Therefore, RELs are proposed within CAA-2, and the basis for these proposed RELs is summarized in the following sections.

### 11.4.1 Residual Saturation Levels Development as Remediation Levels within CAA-2

Soil TPH concentrations at or near the perched zone and alluvial aquifer groundwater tables were compared to the occurrence of LNAPL at the Site to determine empirical residual saturation values for use in future Site investigations, actions, or studies, including this RI/FS. The soil contamination remaining in the smear zone (e.g., as residual saturation) acts as a reservoir for continued release of contaminants in groundwater and will continue to do so until the TPH completely dissolves out, volatilizes, biologically degrades, or is remediated. Empirical values of residual saturation were also compared to those values reported in Mercer and Cohen's 1990 study (Mercer and Cohen 1990) and Alaska Department of Environmental Conservation's (ADEC's) *Maximum Allowable Concentration, Residual Saturation, and Free-Product Mobility* (ASCWG 2006).

Two historical soil samples were taken within the screened interval at MW-09 (8 to 18 feet bgs), the only monitoring well location with measurable LNAPL at present. The soil sample collected

at 11 feet bgs had concentrations of 1,400 and 22,000 mg/kg for GRO and total DRO and ORO, respectively. The lower soil sample, collected at 14 feet bgs, had GRO and total DRO and ORO concentrations of 4,700 and 9,800 mg/kg, respectively. Additionally, a saturated soil sample collected from MW-16 contained GRO and total DRO and ORO concentrations of 16,000 and 2,200 mg/kg, respectively. LNAPL has been measured historically at MW-16.

Data from perched zone wells MW-11, MW-14, MW-17, and MW-26 provide empirical demonstrations of elevated soil TPH concentrations within or directly above the saturated zone that have not resulted in LNAPL migration to site groundwater. However, MW-26 has had elevated TPH concentrations in the past near LNAPL levels. Total DRO and ORO soil concentrations at these locations within the saturated zone range from 12,000 to 42,000 mg/kg, and GRO concentrations range from less than laboratory quantitation limits to 6,900 mg/kg. Additionally, analytical results from monitoring wells MW-10, MW-34, and MW-39, screened in the alluvial aquifer, provide empirical data for determination of Site residual saturation levels. Saturated soil samples from these locations contain total DRO and ORO concentrations that range from 4,400 to 18,340 mg/kg and GRO concentrations that range from 280 to 3,900 mg/kg without LNAPL being observed at these locations. Therefore, these data empirically demonstrate that LNAPL is not accumulating on the water table at residual saturation levels of up to 20,000 mg/kg for total DRO and ORO and up to 6,900 mg/kg for GRO.

These values were then compared to studies from ADEC and Mercer and Cohen, which proposed residual saturation levels as functions of soil type and petroleum product. Site soils are identified as primarily a mixture of fine to coarse sand with the two water-bearing zones separated by a silt aquitard, with the perched zone also including some discontinuous silt lenses. Soil parameters were conducted during RI activities, and the grain size analysis confirmed that the perched and alluvial water bearing units were primarily composed of fine to coarse sand, refer to Appendix F of the Interim Data Report (Floyd|Snider 2021). LNAPL samples collected from MW-09 in 1995 indicate that the product encountered in MW-09 consisted of mainly weathered diesel fuel with a small percentage of very weathered gasoline (AGRA 1995). The ADEC recommendations propose residual saturation values of 7,500 mg/kg for GRO and 17,000 mg/kg for middle distillates in fine sand/silt, and 2,800 mg/kg for GRO and 6,500 mg/kg for middle distillates in coarse sand (no values were proposed for fine to medium sand; ASCWG 2006). Mercer and Cohen 1990 study provides residual saturation values of values of 5,625 and 13,333 mg/kg for GRO and middle distillates, respectively, in fine to medium sand. The Mercer and Cohen study also proposes residual saturation values of 3,266 and 7,742 mg/kg GRO and middle distillates, respectively, for medium to coarse sand.

Therefore, preliminary residual saturation levels of 6,900 mg/kg for GRO and 18,000 mg/kg for total DRO and ORO were selected for use at the Site based on empirical data and adjusted based on applicable agency guidance documents. Site soil GRO concentrations at monitoring well locations were observed to reach approximately 6,900 mg/kg without LNAPL accumulating on the water table. A preliminary residual saturation level for GRO of 6,900 mg/kg is more conservative than ADEC's proposed value of 7,500 mg/kg for GRO and less conservative than Ecology's value of 5,625 mg/kg for fine to medium sand. The total DRO and ORO value of

18,000 mg/kg was selected using empirical data from five monitoring well locations and was not adjusted based on guidance documents due to the broad and consistent agreement of LNAPL occurrence and total DRO and ORO data across the Site.

### 11.4.2 Soil Remediation Levels

The basis for the proposed soil RELs within CAA-2 is to limit adverse impacts to Port operations while achieving both short- and long-term cleanup goals. The short-term goal is to eliminate potential mobile LNAPL in areas within CAA-2 that exceed the residual saturation limits. The long-term goal is to achieve compliance with the proposed CULs in groundwater at the downgradient property boundary. The achievement of cleanup action requirements where RELs are used will be evaluated in accordance with a Compliance Monitoring Plan that meets the requirements of WAC 173-340-410. Performance and confirmation monitoring benchmarks will be developed during engineering design of the Preferred Alternative.

#### *11.4.2.1 Total Petroleum Hydrocarbons*

TPH RELs based on residual saturation concentrations are proposed only for CAA-2 and not for CAA-1, which is located outside of the rail lines. A residual saturation value is defined as the concentration at which the petroleum product is not mobile in groundwater. Selection of residual saturation values as RELs is consistent with WAC 173-340-747(3)(g), which states that soil concentrations left on site must not result in the accumulation of non-aqueous phase liquid on or in groundwater. The proposed RELs are 6,900 mg/kg for GRO and 18,000 mg/kg for total DRO and ORO, which were empirically demonstrated to be site-specific residual saturation levels as described in detail in Section 11.4.1. The distribution of GRO and total DRO and ORO in saturated soil at concentrations greater than the REL is shown on Figure 9.7.

#### *11.4.2.2 Benzene*

Benzene impacts in soil are limited to exceedances of proposed CULs for the leaching pathway only; no benzene results were greater than the MTCA Method C direct contact criteria for protection of human health of 2,400 mg/kg. It is anticipated that remediation of GRO in soil, which is the source of benzene, will address benzene in soil and facilitate meeting proposed groundwater CULs over time. Therefore, the REL proposed for benzene is based on soil remediation meeting the GRO soil REL.

### 11.4.3 Groundwater Remediation Levels

Groundwater RELs are not proposed at the Site. Soil RELs described in the preceding sections are intended to be protective of groundwater and, when applied, will facilitate groundwater compliance with the proposed CULs over time in combination with MNA.

The long-term compliance groundwater monitoring program for the Site will include all COCs and assess compliance relative to the proposed groundwater CULs.

# 12.0 Identification and Screening of Remedial Technologies

This section identifies and briefly describes commonly implemented remedial technologies for remediation of the TPH-based impacts present in soil and groundwater at the Site and the application and limitations of each technology.

The general categories of remedial action identified for the Site include the following:

- Passive remediation
- In situ remediation
- Ex situ remediation
- LNAPL removal technologies

Sections 12.1 through 12.4 describe the remedial technologies identified for the four categories above, and Section 12.5 describes the preliminary technology screening performed to eliminate technologies that do not meet the Site RAOs, are not technically feasible, or do not address the types of contamination present. The preliminary screening process is also summarized in Table 12.1.

## 12.1 PASSIVE TECHNOLOGIES

Passive remediation involves not actively treating or removing soil/groundwater from a source area. The approach relies on either (1) stagnation of groundwater flow or existing flow barriers to contain contaminated groundwater or (2) natural groundwater flow to deliver contaminated groundwater to biologically active areas. Passive technologies are described briefly as follows and include no action, ICs, MNA, and surface capping.

**No Action:** No action indicates that no active remedial technology would be implemented. No action provides a reference for comparison of the benefits of other remedial technologies. No action applies to both soil and groundwater.

**Institutional Controls:** ICs are physical, legal, and administrative measures that are implemented to minimize or prevent human exposure to contamination by restricting access to the Site. ICs often involve deed restrictions or covenants, site advisories, use restrictions, or consent decrees and would be implemented at the Site to limit or prohibit activities that may interfere with the integrity of any cleanup action or result in exposures to hazardous substances. ICs are typically implemented in addition to other technologies when those technologies leave COCs or COCs on-site at concentrations greater than CULs. ICs can apply to both soil and groundwater.

**Monitored Natural Attenuation:** MNA involves regular groundwater sampling to monitor the results of one or more naturally occurring physical, chemical, or biological processes that reduce the mass, toxicity, volume, or concentration of contaminants in soil. The implementation of MNA is feasible; however, the restoration time frame for this remedy would have to be further evaluated and MNA parameters closely monitored. MNA applies to groundwater.

**Surface Capping:** Surface capping involves placing a cover over contaminated material, such as contaminated soil. Surface caps isolate and keep contaminated soil in place, while preventing people and wildlife from having contact with contaminants, and may also limit leaching by infiltration. Surface cap materials include asphalt, concrete, aggregate clay, vegetative layers, or a geomembrane. ICs are typically required to maintain the cap. Surface capping applies to both soil and groundwater (by protection of soil to groundwater pathway).

## 12.2 IN SITU TECHNOLOGIES

In situ remediation involves treating in place the soil and groundwater to reduce contaminants to concentrations that comply with established cleanup standards. In situ soil remediation alternatives that could be applicable to the Site include soil vapor extraction (SVE), bioremediation, solidification/stabilization, vitrification, thermal treatment, and chemical oxidant applications. Groundwater remediation alternatives include air sparging (AS), dual-phase extraction (DPE) and multiphase extraction (MPE), enhanced bioremediation (bioventing, biosparging, or enhanced aerobic biodegradation), and chemical oxidant injections. In situ remediation can require several years to reduce the contaminant concentrations to less than MTCA CULs depending on site conditions and the effectiveness of the treatment system. In situ treatment can be a part of a combined remedy to reduce aqueous-phase contaminant concentrations to near compliance and then transition from active remediation to passive remediation (e.g., MNA). In situ treatment technologies are often used and can be effective in treating impacted soil and groundwater that are either inaccessible or left in place due to existing site infrastructure or ongoing operations. The overall result is to reduce the restoration time frame.

**Permeable Reactive Barrier Using Granular Activated Carbon:** A permeable reactive barrier (PRB) is a permanent structure that is constructed to intercept and passively treat impacted groundwater. As groundwater flows through the PRB, it contacts reactive media, such as granular activated carbon (GAC), which treat the impacted groundwater. This passive, in situ treatment system relies on groundwater flow to bring contaminants to the reactive media. PRBs with GAC are applicable to groundwater.

**Air Sparging:** During AS, air is injected through a contaminated aquifer, where it passes horizontally and vertically through channels in the soil column, which removes contaminants by volatilization. This injected air helps to flush the contaminants into the unsaturated zone where a vapor extraction system is usually implemented in conjunction with AS to remove the generated vapor phase contamination. This technology is designed to operate at high flow rates to maintain increased contact between groundwater and soil, reducing concentrations of volatile constituents in petroleum products that are adsorbed to soils and dissolved in groundwater. AS typically targets the lighter range petroleum products, such as GRO, and is less effective for the heavier range fuel types, such as DRO and ORO.

**In Situ Chemical Oxidation Using Direct-Push Drill Rig and/or Vertical Injection Wells:** In situ chemical oxidation (ISCO) involves injecting oxidizing agents, such as ozone; hydrogen peroxide; permanganate; or specialized, advanced reagents, such as Regenesis' RegenOx, PersulfOx, or Advanced Oxygen Release Compound (ORC-A) products, into the subsurface to rapidly destroy

organic chemicals and treat groundwater in place. The volume of injected agent and the rate of chemical injection depend on the subsurface conditions. Injection points may be installed as permanent injection wells or may be injected via temporary borings. The effectiveness of injections depends on site conditions; it is important to consider the heterogeneous nature of site conditions to support an even and effective distribution of the oxidant. When using ISCO, the properties of each product require consideration. For example, PersulfOx has a larger radius of influence and requires fewer injection events than RegenOx; however, PersulfOx may be corrosive to non-stainless steel or polyvinyl chloride (PVC) materials and can be hazardous for utilities if within the radius of influence.

**In Situ Chemical Oxidation Using Horizontal Injection Wells:** Horizontal injection wells can be installed to remediate areas beneath the rail lines and to reduce impact to Port activities. The use of horizontal injection wells is evaluated in select alternatives (Sections 13.3 and 13.4) as a method to address a larger area of impacts beneath the rail lines to reduce the restoration time frame and as a potential implementation method for plume-wide ISCO (Section 13.5). Because of the presence of two water-bearing zones, advancing and installation of horizontal wells beneath the rail lines would require two horizontal wells to be placed every 20 feet: one within the perched zone and a second at the top of the alluvial aquifer. Although feasible, this technology would have a high cost associated with installation of two horizontal wells every 20 feet (based on estimated radius of influence). This technology is applicable to saturated soil and groundwater.

**In Situ Treatment by Bioremediation:** The activity of naturally occurring microorganisms (e.g., fungi, bacteria) is stimulated by adding amendments, such as nitrogen peroxide or ORC-A, to contaminated soils or groundwater to enhance in situ biological degradation (metabolism) of organic contaminants. Nutrients, oxygen, or other amendments may be used to enhance bioremediation and contaminant desorption from subsurface materials, and products such as ORC-A can be placed in excavations during backfilling activities to accelerate aerobic biodegradation. In the presence of sufficient oxygen (aerobic conditions), microorganisms would ultimately convert many organic contaminants to carbon dioxide, water, and microbial cell mass. In the absence of oxygen (anaerobic conditions), many contaminants would be ultimately metabolized to methane. In the absence of a strong groundwater flow gradient and homogenous geology, this technology is constrained to relatively small footprints of contamination. This technology is applicable to soil and groundwater.

**Surfactant Injection and Extraction:** Surfactant injection and extraction is the process of applying or injecting water, or water containing an additive such as Regenesis' PetroCleanze, into soil to enhance contaminant solubility, which can significantly increase the desorption rates of hydrocarbons bound in saturated soil. This process causes contaminants, such as subsurface LNAPL, to leach into the groundwater, which is then extracted and treated. This process can be effective at sites where the majority of the remaining LNAPL is trapped in discontinuous pockets and the ability of LNAPL to travel to the monitoring wells is severely diminished or completely immobile. This technology is applicable to soil.

**Solidification and Stabilization:** Solidification or stabilization of impacted soil physically and chemically immobilizes the contaminants within the soil matrix, thereby reducing or eliminating contaminant mobility. With solidification, the contaminants are either enclosed or bound within the soil matrix via a binding agent such as modified sulfur cement, polyethylene extrusion, or emulsified asphalt. Stabilization involves adding and mixing a chemical amendment with the contaminated soil to make the contaminants immobile through a chemical reaction that forms a new compound that is less toxic than the parent contaminants or through adsorption processes. The feasibility of solidification and stabilization decrease with depth, and implementation of these technologies is not typically feasible for deep impacts (i.e., greater than 15 feet bgs). This technology is applicable to soil.

**Thermal Treatment:** Thermal treatment (which is commonly applied via electrical resistance heating or thermal conduction) is a process that quickly and evenly heats the subsurface to volatilize chemicals with low boiling points (e.g., TPH) by passing electrical current or direct heat through zones of contaminated soil and groundwater. With electrical resistance heating, a current is delivered to the subsurface through a series of closely spaced electrodes. Resistance to the flow of electricity between electrodes via the natural resistance of the soil matrix generates heat in the subsurface. If heated close to the boiling point of water, the heating process volatilizes chemical droplets embedded in soil into a vapor phase. The contaminated vapors, along with steam produced by the boiling of groundwater, are recovered by a subsurface network of vapor recovery wells and condensed and treated. Chemicals in the vapor stream are typically treated using activated carbon or thermal oxidation. Due to the high cost of implementation and significant impact to surface activities, thermal treatment is typically only used in relatively small or inaccessible areas. This technology is applicable to soil and groundwater.

**Soil Vapor Extraction:** SVE is used to treat vadose zone soil through a system in which a vacuum is applied, through extraction wells, to the soil to induce the controlled flow of air. The controlled flow of air removes mostly volatile contaminants from the soil in a vapor stream that is then treated to recover or destroy the contaminants. Implementation of SVE has the potential to cause disturbance to surface activities during installation and maintenance. This technology can be used in conjunction with AS to reduce the contaminant mass. SVE is applicable to soil and facilitates protection of groundwater from vapor-phase migration.

**Vitrification:** In situ vitrification is a solidification and stabilization technology that applies high temperatures via electrical current to soil and any other underlying material to immobilize inorganic contaminants and destroy organic contaminants. The inorganic contaminants are incorporated into a vitrified glass/vitreous mass, and the organic contaminants are destroyed by pyrolysis (i.e., incineration that chemically decomposes organics by heat in the absence of oxygen). The resulting vitreous mass is chemically durable and leach resistant but may affect groundwater flow at a site. The technology is effective to a depth of approximately 20 feet bgs but requires very high electricity loads and is, therefore, typically feasible only in relatively small areas of impacted soil. Vaporization of volatile contaminants via in situ vitrification also requires capture and treatment of the VOCs. Similar to thermal treatment, the contaminated vapors are

condensed and treated through a network of vapor recovery wells. This technology is applicable to soil.

**Immobilization and Biodegradation:** This technology involves the injection of a water-based product, such as the liquid activated carbon product PlumeStop, into the subsurface to inhibit the spreading of contaminant plumes and protect sensitive receptors. Product is typically injected in closely spaced rows of injection points downgradient of a dissolved-phase plume to form a barrier to future contaminant migration. In addition to serving as a barrier, products may be amended with zero-valent iron, which is an electron acceptor that aids in the biodegradation of contaminants that come into contact with the product barrier and persists in the subsurface for multiple years. This technology is applicable to groundwater.

**Sorption and Biodegradation:** This technology is similar to immobilization and biodegradation but involves the injection of a different water-based product, such as Regenesis' PetroFix, into the subsurface. PetroFix, which is an activated carbon-based reagent, removes hydrocarbons from the dissolved phase by adsorbing them to activated carbon particles. It also contains slow-and quick-release electron acceptors that then stimulate biodegradation of the adsorbed hydrocarbons. The product is generally deployed using injections along the downgradient edge of a dissolved-phase plume to form a barrier to prevent contaminant migration. This technology is applicable to groundwater.

## 12.3 EX SITU TECHNOLOGIES

Ex situ remediation includes DPE, MPE, pump and treat, and excavation of contaminated soil for either aboveground treatment or off-site disposal. Aboveground treatment technologies include biopiles, landfarming, and low-temperature thermal desorption. Off-site disposal is primarily applied to soil and consists of contaminated soil excavation and transport to an engineered, permitted landfill. Groundwater generated through pump and treat technologies are typically treated on-site or transported off-site to a facility to be treated.

**Soil Excavation and Landfill Disposal:** Excavation of contaminated soil using standard construction equipment is a common method to achieve remediation goals. For off-site disposal, excavated contaminated soil is transported either by truck or rail to an appropriate licensed landfill. Following soil removal, excavated areas are subjected to confirmation soil sampling prior to backfill, compaction, and site restoration. Excavation may require demolition or relocation of structures, shoring to maintain sidewall stability, and dewatering or drawdown of the groundwater table if excavation is to occur below the groundwater table. Compliance may not occur immediately and may require a short time frame for subsurface conditions to stabilize. This technology is applicable to soil; however, over-excavation into the smear zone will help to reduce dissolved-phase concentrations.

**Dual-Phase/Multiphase Extraction:** During DPE and MPE, generally, a high vacuum system and pumping are used to remove various combinations of contaminated groundwater, LNAPL, and hydrocarbon vapor from the subsurface. Extracted liquids and vapor are treated or collected for disposal. This technology is used primarily in cases where a fuel hydrocarbon lens is floating on

the water table. LNAPL may be removed from subsurface formations by active methods (e.g., pumping) or a passive collection system. Systems may be designed to recover only LNAPL, mixed LNAPL and water, or separate streams of LNAPL and water (i.e., dual pump or dual well systems). DPE/MPE typically results in a significant disruption to existing surface activities during construction and maintenance. This technology typically has high costs associated with perpetual O&M. This technology is applicable to groundwater.

**Pump and Treat:** A pump and treat system involves pumping contaminated groundwater from the subsurface and treating it before it is discharged. Treatment is generally conducted by air stripping or filtration via activated carbon. Groundwater pump and treat can reduce chemical concentrations in saturated soil, but only slowly by increasing the diffusion of soil contamination into groundwater. Extraction system design and treatment depend on the site characteristics and chemical type. Extraction wells may be screened at different levels or intervals to maximize the system effectiveness; however, restoration time frames for pump and treat systems are often very long because pump and treat cannot significantly accelerate the removal of mass from source areas, which are often large enough to leach chemicals into groundwater for long periods of time. Additionally, this technology typically has high costs associated with perpetual O&M and discharge of treated waste. This technology is applicable to groundwater.

## 12.4 LNAPL REMOVAL TECHNOLOGIES

LNAPL removal technologies are focused on removing LNAPL mass from site soil and groundwater using physical or chemical means, and include hand bailing or passive recovery inserts, passive recovery (skimming wells), active recovery (vacuum enhanced), and bioslurping. Soil surfactant injection and extraction, which is described in Section 12.2, is also an applicable LNAPL removal technology.

**Hand Bailing or Passive Recovery Inserts:** Hand bailing or passive recovery inserts are generally utilized when there is little LNAPL remaining at a site. These technologies may be deployed after a more aggressive recovery technology has been implemented. Bailing is performed using either reusable or disposable bailer that is lowered into the well casing to physically remove any remaining LNAPL. Alternatively, absorbent inserts can be deployed in wells with residual LNAPL to absorb any remaining LNAPL that is floating on the surface of the groundwater table. Both technologies can be performed at a range of frequencies, from daily to monthly, but generally have a limited radius of capture. This technology is applicable to soil and groundwater.

**Passive Recovery (Skimming Wells):** Passive recovery techniques, such as skimming wells, are deployed to remove LNAPL as it flows into a recovery well or trench. These technologies are also often deployed when little LNAPL remains at a site. Skimming wells recover LNAPL using a variety of devices, including floating skimmers, pneumatic pumps, mechanical belt/filter canisters, and passive absorbent bailers, with little groundwater recovery. The rate of LNAPL recovery is typically slow and does not remove residual LNAPL in soil. This technology is applicable to groundwater.

**Active Recovery (Vacuum Enhanced):** Vacuum-enhanced recovery applies a vacuum to skimmer wells or induced water table gradient recovery wells to induce a larger potential gradient toward the recovery well through negative pressure, while minimizing the physical movement of the oil-water interface. This technology extracts volatile hydrocarbons from the unsaturated zone and minimizes smearing from the cone of depression. Extracted liquids and vapor are treated and collected for disposal. Active recovery typically includes high O&M costs. This technology is applicable to groundwater.

**Bioslurping:** Bioslurping is the adaptation and application of vacuum-enhanced dewatering technologies to remediate hydrocarbon-contaminated sites. Bioslurping utilizes elements of both bioventing, which involves addition of air to the vadose zone, and LNAPL recovery to address two separate contaminated media. Bioslurping combines elements of these technologies to simultaneously recover LNAPL and bioremediate vadose zone soils. Bioslurping can improve LNAPL recovery efficiency without extracting large quantities of groundwater. Vacuum-enhanced pumping allows LNAPL to be lifted off the water table and released from the capillary fringe. This minimizes changes in the water table elevation, which minimizes the creation of a smear zone. Bioventing of vadose zone soils is achieved by drawing air into the soil as the soil gas is withdrawn via the recovery well. The system is designed to minimize environmental discharge of groundwater and soil gas. This technology is applicable to soil and groundwater.

## 12.5 PRELIMINARY SCREENING OF APPLICABLE TECHNOLOGIES

A preliminary screening of the remedial technologies listed in Sections 12.1, 12.2, 12.3, and 12.4 was completed in accordance with WAC 173-340-351(6)(c). The objective of the screening was to remove technologies from further evaluation if they clearly did not meet the minimum requirements of the RAOs or considerations for Site conditions. The preliminary screening process retains or rejects technologies based on the applicability at the Site given the following:

- The COCs and impacted media
- Effectiveness based on proven success at similar sites
- Applicability of the technology within the Site physical constraints
- The ability of the technology to achieve RAOs

Table 12.1 provides a summary of the general technology benefits and constraints and evaluation relative to these criteria and describes the rationale for why the technology was retained or rejected as a result of the screening process.

Based on this preliminary screening step, the following technologies were rejected from further evaluation for remediation of soil and groundwater:

- No action
- Surface capping
- PRB using GAC

- AS
- Solidification and stabilization
- Thermal treatment
- SVE
- Vitrification
- Immobilization and biodegradation
- DPE/MPE
- Pump and treat
- Hand bailing or passive recovery inserts
- Passive recovery (skimming wells)
- Active recovery (vacuum enhanced)
- Bioslurping

The remaining technologies were retained for further consideration as part of the remedial alternative evaluation in one or both CAAs:

- ICs
- MNA
- ISCO
- In situ treatment by bioremediation
- Surfactant injection and extraction
- Sorption and biodegradation
- Soil excavation and landfill disposal

These technologies may be implemented as stand-alone treatments or in combination with other technologies, as appropriate, depending on subsurface conditions. These retained technologies were evaluated for each CAA and then aggregated into Site-wide alternatives for further evaluation, as described in Section 13.0.

# 13.0 Description of Remedial Alternatives

The retained technologies identified in Section 12.0 have been aggregated into remedial alternatives for soil and groundwater contamination at the Site, as described in the following sections. The alternatives are evaluated in Section 14.0 in accordance with the MTCA procedures for selection of cleanup actions, including a DCA to compare the costs and benefits of the remedial alternatives and identify the alternative that is permanent to the maximum extent practicable.

A summary of each of the five Site-wide alternatives is included in Table 13.1, with a brief description included in the following sections. Assumptions, approximate extents, and the number of injection points within each area and the area's square footage are for cost estimating purposes only. Details for engineering design of soil and groundwater cleanup actions will be included in the CAP. A PDI work plan will be prepared and submitted as a part of predesign data collection prior to submittal of the EDR, once the RI/FS and the Preferred Alternative are finalized and approved.

The five alternatives have been assembled from the retained technologies to meet RAOs and ARARs. They generally range from least to most complex, and they employ combinations of active and passive remedial technologies that either eliminate or manage current and potential future exposure to contaminated media at the Site. The estimated restoration time frames for each alternative include the time anticipated for construction of the cleanup action and subsequent groundwater monitoring until CULs are met for COCs at the downgradient Port property boundary and across the Site. All five alternatives contain the following common components, as described in Section 13.6:

- An inspection of the former Longview Pipeline contents
- Surfactant injections and extraction activities to eliminate the presence of residual LNAPL within MW-09
- Installation of additional monitoring wells along the downgradient northwestern Port property boundary
- Groundwater compliance monitoring including MNA analyses in select wells downgradient, upgradient, and within the source area
- ICs

The need for additional wells will be evaluated and proposed in the PDI work plan. In addition, all five alternatives include treating off-property impacts to avoid placing ICs on properties not owned by the Port (refer to Section 8.2).

## 13.1 ALTERNATIVE 1—LNAPL REMOVAL AND MNA

Alternative 1 is shown on Figure 13.1 and includes the following:

- Surfactant injection and LNAPL extraction activities within the vicinity of MW-09 (CAA-2)

- Installation of additional alluvial and perched monitoring wells along the western, northwestern, and northern Port property boundary (CAA-1A), which will be used to confirm that groundwater is in compliance at the downgradient property boundary.
- Inspection of the former Longview Pipeline contents
- Compliance groundwater monitoring for assessment of MNA in select wells downgradient, upgradient, and within the source area

In addition, ICs would be implemented, such as an environmental covenant and an SMP documenting the actions set in place to protect human health and the environment from a release or threatened release of hazardous substance at the facility at least until the MNA process is completed.

**Restoration Time Frame and Cost:** The predicted restoration time frame to meet groundwater CULs at the western, northwestern, and northern property boundary wells for this alternative is estimated to be approximately 30 years. A Site-wide restoration time frame was not evaluated for this alternative; however, an estimated time frame to meet CULs across the entire Site for this alternative is estimated to be approximately 30 years. This alternative includes eliminating LNAPL from accumulating on the groundwater table, as per MTCA; however, the majority of the hydrocarbon mass will remain and will be addressed by natural attenuation. This approximate time frame is based on the relatively slow rate of attenuation at the downgradient edge of the plume observed in groundwater monitoring over the previous 30 years, and the continued presence of the impacted soil upgradient of the CPOC. The estimated cost for Alternative 1 is $1,600,000 as in Table I.1 of Appendix I. Line-item costs for Alternative 1 are shown in Table I.2.

## 13.2 ALTERNATIVE 2—IN SITU TREATMENT BARRIER AND LNAPL REMOVAL

Alternative 2 is shown on Figure 13.2 and includes the following:

- Installation of a Regenesis' PetroFix in situ treatment barrier in areas outside the rail lines within the former Calloway Ross Parcel and former Warehouse 9 footprint (CAA-1A)
- Off-property ISCO injections in the vicinities of MW-04 and MW-30 (CAA-1B)
- Surfactant injection and LNAPL extraction activities within the vicinity of MW-09 (CAA-2)
- Installation of additional alluvial and perched monitoring wells along the western, northwestern, and northern Port property boundary (CAA-1A)
- Inspection of the former Longview pipeline contents
- Compliance groundwater monitoring for assessment of MNA in select wells downgradient, upgradient, and within the source area

In addition, ICs would be implemented, such as an environmental covenant and an SMP documenting the actions set in place to protect human health and the environment from a

release or threatened release of hazardous substance at the facility at least until the MNA process is completed.

**Groundwater Treatment Barrier (CAA-1A):** The dissolved-phase groundwater plumes would be contained on Port property within CAA-1A by an injection of an activated carbon-based reagent, such as Regenesis' PetroFix or equivalent product, that uses 1- to 2-micrometer activated carbon in a water-based suspension along with added nutrients. The nutrients—either sulfate or sulfite, and nitrate—are to stimulate bioremediation on and around the activated carbon. PetroFix is easily injectable and can last for multiple years as long as there are terminal electron acceptors for contamination biodegradation and for preventing off-property migration of the dissolved-phase perched zone and alluvial aquifer plumes onto WSDOT and City of Longview property. Figure 13.2 shows the approximate location of PetroFix injections. For purposes of this evaluation, it is assumed that the groundwater treatment barrier would be composed of up to 218 injection points with 6-foot spacing within two rows with a length of 650 linear feet, which is a consistent number of injections when compared with other projects with similar lithologies. Additional injections may be needed if groundwater monitoring results indicate that there is contaminant breakthrough of the barrier.

**Off-Property ISCO Injections (CAA-1B):** In an effort to reduce the extent and eliminate the presence of the dissolved-phase hydrocarbons beneath WSDOT property (Figure 9.2), PersulfOx would be injected in the vicinity of MW-04 and MW-30 (Figure 13.2). For this evaluation, it is assumed that approximately 24 injection points, with a 12- to 14-foot spacing, would be advanced to a depth of 20 feet bgs within a 3,850-square-foot area around MW-04, and 14 injection points would be advanced to a depth of 20 feet bgs within a 1,500-square-foot area around MW-30. This depth is approximate and is based on the maximum depths of soil impacts along the western edge of the known soil exceedances and groundwater depths measured at monitoring wells MW-04 and MW-30. Additional targeted injections will be considered if groundwater does not achieve CULs in off-property wells within the estimated restoration time frame, or if groundwater monitoring data do not indicate that the plumes are shrinking in a reasonable time frame.

PersulfOx may be corrosive to non-stainless steel or PVC materials, which can be damaging to utilities. Therefore, care would be taken not to inject PersulfOx at locations within 10 feet laterally or 5 to 10 feet vertically from any utilities.

**Restoration Time Frame and Costs:** This alternative includes eliminating LNAPL from accumulating on the groundwater table, as per MTCA; however, the majority of the hydrocarbon mass will remain beneath the rail lines. This alternative is designed to target the off-property dissolve-phase plume and prevent further off-property migration with a treatment barrier. The restoration time frame to meet CULs in groundwater at the western, northwestern, and northern property boundary is estimated to be approximately 5 to 10 years. This approximate time frame is conservatively based on the time needed for impacted water at the property edge to be replaced by treated water that flows through the barrier. However, long-term O&M costs would be expected to maintain the treatment barrier, including a periodic need (approximately 10-year

intervals) for re-injection of PetroFix barrier to restore electron acceptors. A site-wide restoration time frame was not evaluated for this alternative; however, an estimated time frame to meet CULs across the entire Site for this alternative is estimated to be approximately 30 years. The estimated cost for Alternative 2 is $4,200,000 as in Table I.1 of Appendix I. Line-item costs for Alternative 2 are shown in Table I.3.

### 13.3 ALTERNATIVE 3—TARGETED ISCO INJECTIONS AND LNAPL REMOVAL

Alternative 3 is shown on Figure 13.3 and includes the following:

- Targeted ISCO injections within accessible areas where soil impacts exceed proposed CULs (CAA-1A)
- Targeted ISCO injections along the rail lines within hotspots or where soil concentrations exceed RELs (CAA-2)
- Off-property ISCO injections in the vicinities of MW-04 and MW-30 (CAA-1B)
- Surfactant injection and LNAPL extraction activities within the vicinity of MW-09 (CAA-2)
- Installation of additional perched and alluvial monitoring wells along the western, northwestern, northern Port property boundary (CAA-1A)
- Inspection of the former Longview Pipeline contents
- Compliance groundwater monitoring for assessment of MNA in select wells downgradient, upgradient, and within the source area

Approximately 77% of the impacted soil mass will be treated using targeted ISCO injections in the saturated zone in both the perched and alluvial aquifers. OIP fluorescence data show that the extent of the proposed Alternative 3 treatment area includes the majority of the hydrocarbon mass at the Site (Appendix K). In addition, ICs would be implemented, such as an environmental covenant and an SMP documenting the actions set in place to protect human health and the environment from a release or threatened release of hazardous substance at least until the MNA process is completed. This alternative would address off-property impacts, which avoids placing ICs on properties not owned by the Port. Remaining residual soil impacts outside the treatment area would be located upgradient and would not result in off-property exceedances of CULs because the groundwater plumes in the perched zone and alluvial aquifer are stable or shrinking (refer to Appendix D).

**Off-Property ISCO Injections Extent (CAA-1B):** In an effort to reduce the extent and eliminate the presence of the dissolved-phase hydrocarbons beneath WSDOT property, PersulfOx would be injected in the vicinity of MW-04 and MW-30 (Figure 13.3). It is assumed that approximately 24 injection points with a 12- to 14-foot spacing would be advanced to a depth of 20 feet bgs within a 3,850-square-foot area around MW-04, and 14 injection points would be advanced to a depth of 20 feet bgs within a 1,500-square-foot area around MW-30. This depth is approximate and is based on the maximum depths of soil impacts along the western edge of the known soil

exceedances and groundwater depths measured at monitoring wells MW-04 and MW-30. Additional targeted injections will be considered if groundwater does not achieve CULs in off-property wells within the estimated restoration time frame, or if groundwater monitoring data do not indicate that the plumes are shrinking in a reasonable time frame.

**Targeted ISCO Injections Outside Rail Lines on Port Property (CAA-1A):** Accessible areas with hydrocarbon impacts in soil greater than the CULs (within the perched and alluvial zones), not located within the active rail lines, would be addressed with ISCO injections. It is assumed that approximately 213 PersulfOx injection points with a 12- to 14-foot spacing would be advanced within accessible areas on the Port property to help destroy organic contaminants found in groundwater and soil through abiotic chemical oxidation reactions. There are few known utilities within CAA-1A; therefore, this area could be addressed with PersulfOx, which would reduce the number of mobilizations needed. In the event of daylighting of the amendments/catalysts being injected due to various factors including the ability of the subsurface conditions to accept the volume being injected within a densely injected area, in-field assessment, decisions, and steps will be detailed in a CAP to address daylighting of amendments. OIP fluorescence data will be used to target soil impacts laterally and vertically within both the alluvial and perched zones across the Site. If groundwater does not achieve TPH CULs along the downgradient property boundary within the restoration time frame, or if groundwater and MNA data do not indicate that the plumes are shrinking in a reasonable time frame, additional targeted in situ treatment may be considered to address remaining areas of groundwater contamination. Contingency actions are summarized in Section 15.2

In CAA-1A, PersulfOx would be injected within the following two areas, based on OIP fluorescence data:

- Within the vicinity of the former Warehouse 9 footprint and former Calloway Ross Parcel at depths between 10 and 22 feet bgs in up to 180 injection points within a 30,000-square-foot area
- In the southern portion the Site and west of MW-26 and MW-28 at depths between 12 and 24 feet bgs in up to 33 injection points within a 5,650-square-foot area

**Targeted ISCO Injections Inside Rail Lines (CAA-2):** The residual saturation levels for GRO and total DRO and ORO are proposed as RELs for soil and groundwater impacts within the rail lines (CAA-2). The smaller extent of remedial activities within CAA-2, using RELs as a guideline and wells that had historical detections of LNAPL, would lessen impact to Port activities but still treat the majority of TPH impacts in soil (approximately 77% of the total mass) and groundwater impacts and reduce the overall hydrocarbon mass within the source area. ISCO amendments would be injected in approximately 202 locations within CAA-2 using PersulfOx and RegenOx, depending on utility locations and depths. As stated previously, PersulfOx has a larger radius of influence with a 12- to 14-foot spacing and requires fewer injection events than RegenOx but may be corrosive to non-stainless steel or PVC materials, which can be hazardous for utilities. PersulfOx injections would consist of one application, and RegenOx locations with a 10- to 14-foot spacing would be injected over three events separated by 2 to 4 weeks. ISCO injections are effective in the saturated zone

and not as effective in the vadose zone. Therefore, ISCO injections are not proposed for the soil impacts that extend to the east of MW-12 and within the vicinity of the former AST because these shallow impacts are within the vadose zone and are less than 1-foot thick (Appendix K). In the event of daylighting of the amendments/catalysts being injected due to various factors including the ability of the subsurface conditions to accept the volume being injected within a densely injected area, in-field assessment, decisions, and steps will be detailed in a CAP to address daylighting of amendments. OIP fluorescence data will be used to target soil impacts laterally and vertically within both the alluvial and perched zones across the Site.

In CAA-2, ISCO amendments would be applied within the following three areas, based on OIP fluorescence data:

- Within the vicinity of MW-19 and MW-39 at depths between 7.5 and 16 feet bgs in up to 36 injection points within a 5,000-square-foot area or the extent practicable
- In the central portion of the Site within the vicinity of the former fuel loading racks and former pipelines at depths between 7 and 20 feet bgs in up to 113 injection points within a 16,000-square-foot area
- Within the vicinity of MW-26 at depths between 12 and 24 feet bgs in up to 71 injection points within a 10,000-square-foot area

The use of horizontal injection wells was evaluated for remediation of hydrocarbon mass beneath the rail lines because it could remediate a larger volume than vertical injection borings could and would limit impact to Port operations. However, given the difficulties of using horizontal wells (refer to Section 12.2), the additional cost associated with layout and design, and the small percentage of hydrocarbon mass that would be treated using horizontal wells, the use of this method would neither be much more effective nor substantially reduce the restoration time frame compared to vertical injection borings. The fluorescence response cross sections included as Appendix K show that the majority of the TPH mass (77%) would be treated by the proposed ISCO injections in Alternative 3. Horizontal borings would provide no unique benefits for Alternative 3 or as a stand-alone alternative and are instead considered a potential implementation method for plume-wide ISCO injections (Alternative 5). If groundwater does not achieve TPH CULs along the downgradient property boundary within the restoration time frame, or if MNA data do not indicate that the plumes are shrinking in a reasonable time frame, additional targeted in situ treatment may be considered to address remaining areas of groundwater contamination. Contingency actions are summarized in Section 15.2.

**Restoration Time Frame and Costs:** The predicted restoration time frame to meet groundwater CULs at the downgradient property boundary for this alternative is estimated to be approximately 5 to 10 years, which is the expected time required for groundwater attenuation following full soil treatment in CAA-1 and partial soil treatment in CAA-2 based on observed declining trends in groundwater concentrations and current ongoing attenuation along the Port property boundary. The site-wide restoration for Alternative 3 will occur less than 10 years to approximately 28 years after remedy implementation is complete. A site-wide restoration time

frame is evaluated in Section 15.4. The estimated cost for Alternative 3 is $4,200,000 as in Table I.1 of Appendix I. Line item costs for Alternative 3 are shown in Table I.4.

## 13.4 ALTERNATIVE 4—LIMITED EXCAVATION, TARGETED ISCO INJECTIONS, AND LNAPL REMOVAL

Alternative 4 is shown on Figure 13.4 and includes the following:

- Excavation of approximately 13,000 cubic yards of impacted soil exceeding proposed CULs (CAA-1A)
- Targeted ISCO injections along the rail lines within hotspots or where soil COC concentrations exceed RELs (CAA-2)
- Off-property ISCO injections in the vicinities of MW-04 and MW-30 (CAA-1B)
- Surfactant injection and LNAPL extraction activities within the vicinity of MW-09
- Installation of additional alluvial and perched monitoring wells along the western, northwestern, and northern Port property boundary (CAA-1A)
- Inspection of the former Longview Pipeline contents
- Compliance groundwater monitoring for assessment of MNA in select wells downgradient, upgradient, and within the source area

Approximately 77% of the impacted soil will be remediated by this alternative using targeted ISCO injections in the saturated zone in both the perched and alluvial aquifers and excavating all impacted soil located downgradient from source areas within CAA-2. In addition, ICs would be implemented, such as an environmental covenant and an SMP documenting the actions set in place to protect human health and the environment from a release or threatened release of hazardous substance at the facility at least until the MNA process is completed. This alternative would remediate off-property impacts and eliminate the need to place ICs on properties not owned by the Port.

**Off-Property ISCO Injections Extent (CAA-1B):** In an effort to reduce the extent and eliminate the presence of the dissolved-phase hydrocarbons beneath WSDOT property, PersulfOx would be injected in the vicinity of MW-04 and MW-30 (Figure 13.4). It is assumed that approximately 24 injection points would be advanced to a depth of 20 feet bgs within a 3,850-square-foot area around MW-04, and 14 injection points would be advanced to a depth of 20 feet bgs within a 1,500-square-foot area around MW-30. This depth is approximate and is based on the maximum depths of soil impacts along the western edge of the known soil exceedances and groundwater depths measured at monitoring wells MW-04 and MW-30. Additional targeted injections will be considered if groundwater does not achieve CULs in off-property wells within the estimated restoration time frame, or if groundwater monitoring data do not indicate that the plumes are shrinking in a reasonable time frame.

**Limited Excavation on Port Property (CAA-1A):** Approximately 13,000 cubic yards of impacted soil would be excavated in two areas outside and to the northwest of the rail lines, within the footprints of the former Calloway Ross Parcel and former Warehouse 9. Soil in these two areas would be excavated from the surface to approximately 23 feet bgs, which is the maximum depth that impacts were identified in these areas. Temporary sheet piles would be installed along the rail lines to the east, and the excavation would be dewatered to achieve the required depth. Clean overburden soil would be stockpiled on-site, sampled, and reused as backfill where appropriate. Excavated impacted soil would be transported off-site to an appropriate disposal/treatment facility, and the excavation would be backfilled with ORC-A pellets to help with ongoing biodegradation processes and a top layer of clean fill material. Water pumped from the excavation would be treated on-site with a temporary water treatment system. If groundwater does not achieve TPH CULs along the downgradient property boundary within the restoration time frame, or if MNA data do not indicate that the plumes are shrinking in a reasonable time frame, additional targeted in situ treatment may be considered to address remaining areas of groundwater contamination. Contingency actions are summarized in Section 15.2

**Targeted ISCO Injections Inside Rail Lines (CAA-2):** The residual saturation levels for GRO and total DRO and ORO are proposed as RELs for soil and groundwater impacts within CAA-2. The smaller extent of remedial activities within CAA-2, using RELs as a guideline and wells that had historical detections of LNAPL to determine remedial extent, would lessen impact to Port activities but still treat the majority of TPH impacts in soil (approximately 77% of the total mass) and groundwater impacts and reduce the overall hydrocarbon mass within the source area. ISCO amendments would be injected in approximately 202 locations within CAA-2 using PersulfOx and RegenOx, depending on utility locations and depths. PersulfOx injections would consist of one application, and RegenOx locations would be injected over three events separated by 2 to 4 weeks. ISCO injections are effective in the saturated zone and not as effective in the vadose zone. Therefore, ISCO injections are not proposed for the soil impacts that extend to the east of MW-12 and within the vicinity of the former AST because these shallow impacts are within the vadose zone and are less than 1-foot thick (Appendix K). In the event of daylighting of the amendments/catalysts being injected due to various factors including the ability of the subsurface conditions to accept the volume being injected within a densely injected area, in-field assessment, decisions, and steps will be detailed in a CAP to address daylighting of amendments.

In CAA-2, ISCO amendments would be applied within the following three areas, based on OIP fluorescence data:

- Within the vicinity of MW-19 and MW-39 at depths between 7.5 and 16 feet bgs in up to 36 injection points within a 5,000-square-foot area or to the extent practicable
- In the central portion of the Site within the vicinity of the former fuel loading racks and former pipelines at depths between 7 and 20 feet bgs in up to 113 injection points within a 16,000-square-foot area
- Within the vicinity of MW-26 at depths between 12 and 24 feet bgs in up to 71 injection points within a 10,000-square-foot area

The use of horizontal injection wells was evaluated for remediation of hydrocarbon mass beneath the rail lines because it could remediate a larger volume than vertical injection borings could and would limit impact to Port operations. However, given the difficulties of using horizontal wells (refer to Section 12.2), the additional cost associated with layout and design, and the small percentage of hydrocarbon mass that would be treated using horizontal wells, the use of this method would neither be much more effective nor substantially reduce the restoration time frame compared to vertical injection borings. The fluorescence response cross sections included as Appendix K show that the majority of the TPH mass (77%) would be treated by the proposed ISCO injections and excavation activities proposed in Alternative 4. Horizontal injection borings would provide no unique benefits for Alternative 4 or as a stand-alone alternative and are instead considered a potential implementation method for plume-wide ISCO injections (Alternative 5). If groundwater does not achieve TPH CULs along the downgradient property boundary within the restoration time frame, or if MNA data do not indicate that the plumes are shrinking in a reasonable time frame, additional targeted in situ treatment may be considered to address remaining areas of groundwater contamination. Contingency actions are summarized in Section 15.2.

**Restoration Time Frame and Costs:** The predicted restoration time frame to meet groundwater CULs at the downgradient property boundary for this alternative is estimated to be approximately 5 to 10 years, which is the expected time required for groundwater attenuation following full soil removal in CAA-1A and partial soil treatment in CAA-2 based on observed declining trends in groundwater concentrations and current ongoing attenuation along the Port property boundary. The site-wide restoration for Alternative 4 is similar to Alternative 3 and will likely occur less than 10 years to approximately 28 years after remedy implementation is complete. A site-wide restoration time frame is evaluated in Section 15.4. The estimated cost for Alternative 4 is $10,200,000 as in Table I.1 of Appendix I. Line-item costs for Alternative 3 are shown in Table I.5.

## 13.5 ALTERNATIVE 5—PLUME-WIDE ISCO INJECTIONS AND LNAPL REMOVAL

Alternative 5 is shown on Figure 13.5 and includes the following:

- ISCO injections throughout the entire extent of groundwater impacts exceeding proposed CULs, including in the vicinity of off-property locations MW-04 and MW-30 (CAA-1B)
- Surfactant injection and LNAPL extraction activities within the vicinity of MW-09
- Installation of additional alluvial and perched monitoring wells along the western, northwestern, and northern Port boundary (CAA-1A)
- Inspection of the former Longview Pipeline contents
- Compliance groundwater monitoring for assessment of MNA in select wells downgradient, upgradient, and within the source area

In addition, ICs would be implemented, such as an environmental covenant and an SMP documenting the actions set in place to protect human health and the environment from a release or threatened release of hazardous substance at the facility at least until the MNA process

is completed. Although Alternative 5 does not fully meet the definition of a permanent cleanup action, it is consistent with WAC 173-340-351(5)(b) because it is the most permanent alternative to the maximum extent practicable and it is not technically feasible to address all contaminated soil beneath all active structures and rail lines. Alternative 5 would address the majority of contaminated saturated soil and groundwater present at the Site.

**Plume-Wide ISCO Injections:** ISCO amendments would be injected in up to approximately 1,370 locations within an approximate total area of 210,000 square feet. Use of PersulfOx and RegenOx at each injection location would depend on utility locations and depths. PersulfOx would be injected at locations farther than 10 feet laterally or 5 feet vertically from any utilities. RegenOx injections would be applied in locations within close vicinity of known utilities. RegenOx is typically injected over a minimum of three events separated by 2 to 4 weeks each to account for matrix back-diffusion, which occurs once groundwater contamination is oxidized, then resolubilized from existing soil contamination. In the event of daylighting of the amendments being injected due to various factors including the ability of the subsurface conditions to accept the volume being injected within a densely injected area, in-field assessment, decisions, and steps will be detailed in a CAP to address daylighting of amendments. OIP fluorescence data will be used to target soil impacts laterally and vertically within both the alluvial and perched zones across the Site. Horizontal borings could be used as a potential implementation method for plume-wide ISCO injection. For the reasons described in Section 12.2, however, this technology is expected to be less technically implementable and to have a higher cost for treatment of the same area as vertical injection borings. If groundwater does not achieve TPH CULs along the downgradient property boundary within the restoration time frame, or if groundwater monitoring and MNA data do not indicate that the plumes are shrinking in a reasonable time frame, additional targeted in situ treatment may be considered to address remaining areas of groundwater contamination. Contingency actions are summarized in Section 15.2.

**Restoration Time Frame and Costs:** The predicted restoration time frame to meet groundwater CULs at the western, northwestern, and northern property boundary is estimated to be approximately 5 to 10 years. This is conservatively based on the time required for groundwater at the downgradient property boundary to reach equilibrium conditions following plume-wide groundwater and soil treatment. The site-wide restoration for Alternative 5 will likely take less time than Alternative 3 because the entire groundwater plume extent will be treated; therefore, it is estimated that site-wide restoration will likely occur less than 10 years to approximately 20 years after remedy implementation is complete. The estimated cost for Alternative 5 is $8,300,000 as in Table I.1 of Appendix I. Line-item costs for Alternative 5 are shown in Table I.6.

## 13.6 REMEDIAL ELEMENTS COMMON TO ALL ALTERNATIVES

### 13.6.1 Former Longview Pipeline Inspection and Potential Source Assessment

In Ecology's July 2019 review of the RIWP, Ecology stated that "it will be important to determine the true extent of remaining product in the pipelines" (Ecology 2019). To meet Ecology's requirements to complete the Site characterization and assess the potential risk of further releases, the former Longview Pipeline would be exposed in an accessible area where it is known

to be at a shallow depth, likely in the northern portion of the Site. This is proposed to determine if there is residual product remaining in the pipeline and to confirm that the remaining residual product, if any, is not mobile. Once the pipeline is exposed, spill response measures would be placed when the pipeline is cut to determine if there is still residual product remaining in pipeline, and its current characteristics, such as viscosity, would be noted. The pipeline would be resealed after observations are recorded. Remediation costs associated with emptying and rinsing the former Longview Pipeline are not included because it has not been determined if there is residual product in the pipeline. If residual product remains in the pipeline, observations will be recorded to assess viscosity and a sample collected for analysis. If the remaining product has a high viscosity, similar to asphalt, no further action is necessary. If residual product is present and is potentially mobile and can impact groundwater, remedial options will be evaluated to determine options for source control. Depending on what is encountered, source control options may include (but not limited to) pumping, rinsing, and capping; excavation and removal; or encapsulation.

The CAP will include a pipeline inspection plan with various detailed scenarios and outcomes based on inspection results. Pipeline inspection details will be included as a part of the pre-design work plan and will be conducted during the pre-design investigation.

### 13.6.2 Surfactant Injections and Extractions

All five alternatives include surfactant injection and extraction activities to eliminate the presence of residual LNAPL. Surfactant injection and extraction activities include the installation of up to four injection/recovery wells within the vicinity of MW-09, which would be used to conduct three surfactant injection events using Regenesis' PetroCleanze, each followed by an extraction event, 1 to 2 weeks after each injection event to have the most effective removal of LNAPL. Surfactant injection is a method used to enhance LNAPL removal from soil by the addition of chemicals that can increase LNAPL recoverability. Surfactants can do this through a number of mechanisms such as changing the interfacial tension between LNAPL and groundwater, decreasing LNAPL viscosity, and desorption of LNAPL entrained in the soil matrix, which ultimately allows for removal by subsequent extraction. Surfactant injection and extraction is designed to be used within a limited area to eliminate LNAPL from accumulating on the groundwater table. Because surfactant can take up the available soil oxygen demand, which is needed to help the biodegradation process, it is not recommended to be applied to a large area. Therefore, the surfactant injection and extraction activities would be designed to remove hydrocarbon mass within a 400-square-foot area focused within the vicinity of MW-09. However, surfactant injections can be performed in additional locations if LNAPL is observed in recently installed wells, such as MW-39 and MW-40, during the predesign period.

### 13.6.3 Installation of Additional Downgradient Monitoring Wells

Additional alluvial and perched monitoring wells would be installed along the northwestern and northern (downgradient) edges of the Port property in each alternative. These wells would be used as CPOC monitoring wells once TPH concentrations in these wells and off-property wells MW-04 and MW-30 are in compliance with proposed CULs.

### 13.6.4 Monitored Natural Attenuation and Groundwater Monitoring

MNA for groundwater is a component of each alternative, and natural attenuation processes would be assumed for groundwater recovery. The goal of MNA is to utilize natural attenuation processes to degrade or destroy Site contaminants to concentrations less than applicable CULs within a reasonable time frame. As discussed in Section 9.2.1.3 and detailed in Appendix D, recent MNA groundwater data indicate that biodegradation of contaminants is occurring in both Site water-bearing zones, and the groundwater plumes in the perched zone and alluvial aquifer are stable or shrinking. Therefore, post-remedy groundwater monitoring would be part of each alternative after remedy implementation. Specific details for compliance groundwater monitoring would be included in a Groundwater Monitoring Plan (GMP) developed as part of a Compliance Monitoring Plan (CMP) for the Site. The GMP would include annual groundwater monitoring and sampling that would be conducted, and select MNA parameters (i.e., dissolved oxygen, nitrate, ferrous iron, sulfate, manganese, total alkalinity, and methane) would be monitored to ensure that biodegradation continues to occur. If monitoring does not indicate that the plumes are shrinking at a reasonable rate, additional active remediation techniques may be needed; details would be addressed in the CMP.

### 13.6.5 Institutional Controls

ICs are expected to be included for the selected remedy for the Site because all alternatives under consideration would leave contamination in place exceeding one or more cleanup standards for soil or groundwater. Specific ICs would include:

- Provisions to restrict the use of both perched zone and alluvial aquifer groundwater until proposed CULs are met.
- Provision to re-evaluated vapor intrusion risk if new or existing buildings are to be constructed or modified for occupancy within the 30-foot lateral and applicable vertical inclusion zones of known soil and groundwater impacts, in accordance with Ecology's VI guidance (Ecology 2022).
- An SMP would be prepared, as part of the CMP, to address the management of potentially contaminated soil, including soil that exceeds the site-specific direct-contact CUL for total TPH, remaining in place in the upper 15 feet bgs that could be encountered during Site redevelopment or O&M of the rail lines and utilities at the Port. The SMP would include field protocols for identification, response actions, communication, removal, temporary storage or stockpiling, transportation, and disposal of Class II or Class III contaminated soil at a subtitle D facility. The SMP will also include any small, isolated soil impacts at the Site, including the low-level residual TPH impacts beneath the berths as shown on Figure 9.7, that may be encountered during routine maintenance activities (refer to Section 9.2.3.1).In addition, routine inspections are conducted beneath the berths to ensure that the soil containing these small isolated TPH impacts is stable and that there is no sloughing or erosion occurring beneath the berths.

# 14.0 Alternatives Evaluation and Disproportionate Cost Analysis

This section evaluates the remedial alternatives developed for the Site in Section 13.0 against MTCA requirements for a cleanup action in accordance with WAC 173-340-360.

## 14.1 REMEDIAL ALTERNATIVE EVALUATION

This section provides a summary of the requirements and criteria that each remedial alternative is evaluated against in accordance with MTCA per WAC 173-340-360(3). Each of the proposed remedial alternatives are screened relative to mandatory MTCA threshold requirements and other MTCA requirements for evaluation described in the following sections. In Section 14.2, the results of a DCA are presented to identify the alternative that is permanent to the maximum extent practicable using DCA evaluation criteria specified in WAC 173-340-360(5)(d). Based on these evaluations, a Preferred Alternative is identified and proposed to Ecology and described in Section 15.0.

### 14.1.1 MTCA Requirements

WAC 173-340-360(3) states that all individual cleanup actions must meet the following requirements and that when multiple technologies are implemented for a single site, the overall cleanup action must also meet the requirements listed as follows:

- **Protect Human Health and the Environment.** Protection of human health and the environment shall be achieved through implementation of the selected remedial alternative.
- **Comply with Cleanup Standards.** Cleanup standards, as defined by MTCA, include CULs for hazardous substances present at the site, the location, or POC where the CULs must be met, and any regulatory requirements that may apply to the site due to the type of action being implemented or the location of the site.
- **Comply with Applicable State and Federal Laws.** WAC 173-340-710 states that cleanup standards shall comply with applicable state and federal laws, as ARARs for the site. ARARs applicable to this Site are detailed in Table 11.1 and consist of chemical-specific ARARs applicable to the contamination types present at the Site, location-specific ARARs that apply to the physical location of the Site, and action-specific ARARs that apply to the construction components of the remedy.
- **Provide for Compliance Monitoring.** MTCA requires that all selected remedial alternatives provide for compliance monitoring as described in WAC 173-340-410. Compliance monitoring consists of three different types of monitoring, including the following:
    - *Protection Monitoring* during construction, operation, and maintenance of the cleanup action to confirm protection of human health and the environment.

- *Performance Monitoring* to confirm compliance with the site CULs immediately following cleanup action to demonstrate compliance with a permit or substantive requirements of other laws.
- *Confirmation Monitoring* to evaluate long-term effectiveness of the cleanup action following attainment of the cleanup standards.

- **Use Permanent Solutions to the Maximum Extent Practicable.** The use of permanent solutions to the maximum extent practicable for a cleanup action is analyzed according to the procedure described in WAC 173-340-360(5). Preference is given to alternatives that implement permanent solutions, defined in MTCA as actions that can meet cleanup standards "without further action being required at the site being cleaned up or any other site involved with the cleanup action, other than the approved disposal of any residue from the treatment of hazardous substances" (WAC 173-340-200). The DCA process is conducted to identify the alternative that uses permanent solutions to the maximum extent practicable.
- **Provide for a Reasonable Restoration Time Frame.** Restoration time frame is defined in MTCA as "the period of time needed to achieve the required cleanup levels at the points of compliance established for the site" (WAC 173-340-200). A cleanup action shall provide for a reasonable restoration time frame. The factors to be considered when determining the reasonable restoration time frame are listed in WAC 173-340-360(4)(c) and include, but are not limited to, the potential risks posed by the site; the practicability of achieving a shorter restoration time frame; long-term effectiveness of the alternative; and the current and expected future use of the site.
- **Consider Public Concerns.** Public involvement must be initiated according to the requirements set forth in WAC 173-340-600. Public concerns are considered at each step in the formal process under MTCA. This RI/FS will be made available for public review and comment, and Ecology's decision on alternative selection will also be presented for public comment in the draft CAP.

### 14.1.2 Evaluation of Requirements

All five proposed alternatives meet the MTCA threshold requirements. The proposed alternatives are evaluated against the MTCA threshold requirements as follows:

- **Protect Human Health and the Environment.** The proposed alternatives provide for protection of human health and the environment through a variety of technologies of contaminated mass removal (e.g., excavation), destruction (e.g., natural attenuation, in situ treatment), and containment (e.g., ICs).
- **Comply with Cleanup Standards.** The proposed alternatives are all capable of achieving the proposed groundwater CULs at the standard POC. Proposed groundwater CULs are anticipated to be met by all alternatives over their respective predicted restoration time frames, with Alternatives 2 through 5 having the shortest restoration time frames and Alternative 1 having the longest restoration time frame.

- **Comply with Applicable State and Federal Laws.** All alternatives address and comply with all state and federal laws relevant and applicable to this project, as described in Section 11.2.
- **Provide for Compliance Monitoring.** All alternatives would include compliance monitoring, which includes protection monitoring, performance monitoring, and confirmation as per WAC 173-340-410. For any alternative selected as the Preferred Alternative, a GMP would be prepared as part of the CMP and would include compliance groundwater monitoring to be conducted following completion of cleanup activities to evaluate compliance with proposed CULs.
- **Use Permanent Solutions to the Maximum Extent Practicable.** The DCA, which is presented in Section 14.2, is used to select the alternative that uses permanent solutions to the maximum extent practicable.
- **Provide for a Reasonable Restoration Time Frame.** Site-specific groundwater conditions have been taken into consideration under WAC 173-340-360(4)(c) to consider the definition of a reasonable restoration time frame and whether it is practicable to achieve a shorter restoration time frame. The primary potential risks to human health and the environment from groundwater are in the potential use of groundwater impacted by TPH constituents (i.e., DRO, GRO, and ORO) for drinking water. ICs would be implemented quickly to restrict Site groundwater usage, and downgradient use would be protected by compliance with CULs at the downgradient property boundary, so that the time frame for compliance at the property boundary is the more relevant time frame for consideration. Additionally, all of the alternatives include leaving at least a small footprint of shallow soil with COC concentrations exceeding proposed soil CULs, and smaller isolated, non-continuous areas of shallow soil impacts exceeding the Site-specific direct-contact screening levels would remain, which would be protected in perpetuity by ICs. Due to the lateral extent of the dissolved-phase plumes in the two water-bearing zones and quantity of residual contaminant mass present in soil, a restoration time frame shorter than 10 years for the entire Site is not practical, even with full-scale treatment. The practicality of reducing this restoration time frame through use of technologies (e.g., horizontal borings) to treat a larger area has been evaluated and found to provide no additional effectiveness and to carry additional cost. Because all alternatives include varying degrees of in situ soil or groundwater treatment, and the plumes of impacted groundwater are stable at the downgradient edge and would be monitored along the downgradient property boundary, the predicted restoration time frames for Site-wide groundwater (including Alternative 1, which is longer than 10 years) are all reasonable. The predicted restoration time frames for groundwater to meet proposed groundwater CULs at the downgradient property boundary for TPH constituents and benzene for each alternative are as follows:
    - Alternative 1: 30 years
    - Alternative 2: 5 to 10 years

- Alternative 3: 5 to 10 years
- Alternative 4: 5 to 10 years
- Alternative 5: 5 to 10 years

A site-wide restoration time frame for the preferred alternative is presented in Section 15.4. Once site-wide CULs have been met for groundwater, all applicable CULs will have been met and the soil to direct contact pathway will be addressed with the implementation of ICs and an SMP.

- **Consider Public Concerns.** Public concerns are addressed by the Ecology-led public comment process for the RI/FS, which includes the DCA for all alternatives.

## 14.2 DISPROPORTIONATE COST ANALYSIS

The MTCA DCA procedure is used to evaluate whether a cleanup action uses permanent solutions to the maximum extent practicable as determined by the level of attainment of specific criteria defined in WAC 173-340-360(5)(d) and listed as follows. As stated in MTCA, the cost of an individual alternative is determined disproportionate "if the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of the other lower cost alternative" (WAC 173-340-360(3)(e)(i)).

Evaluation of disproportionate cost allows comparison of each alternative to the most permanent alternative presented, as determined by attainment of MTCA criteria. This analysis can be qualitative or quantitative. If multiple alternatives possess equivalent benefits, the lower cost alternative will be selected. The seven DCA criteria defined in MTCA (WAC 173-340-360(5)(d)) are summarized as follows:

- **Protectiveness.** Overall protectiveness of human health and the environment, including the degree to which existing risks are reduced, the time required to reduce these risks, and the overall improvement in environmental quality.
- **Permanence.** The degree to which the alternative permanently reduces the toxicity, mobility, or volume of hazardous substances.
- **Effectiveness over the Long Term.** Long-term effectiveness consists of the degree of certainty that the alternative will be successful, the reliability of the alternative during the time that hazardous substances are expected to remain on-site at concentrations greater than CULs, the magnitude of the residual risk with the alternatives in place, and the effectiveness of controls in place to control risk while contaminants remain on-site.
- **Management of Implementation Risks.** Short-term risks consist of the risk to human health and the environment associated with the alternative during construction and implementation and the effectiveness of measures taken to control those risks.
- **Technical and Administrative Implementability.** The ability of the alternative to be implemented is based on whether the alternative is technically possible and meets

administrative and regulatory requirements, and if all necessary services, supplies, and facilities are readily available.

- **Consideration of Public Concerns.** These considerations involve whether the community has concerns regarding the alternative and, if so, to what extent the alternative addresses those concerns.
- **Costs.** The cost to implement the alternative, consisting of construction, net present value of any long-term costs, and agency oversight costs that are recoverable.

As part of the DCA conducted in this FS, each alternative was ranked and assigned a numerical score for each DCA criterion on a scale of 1 to 10, where a score of 10 represents the greatest benefit and a score of 1 represents the least benefit. Each numerical score was then multiplied by a weighting value, and the scores were summed to determine the total alternative benefit score. The weighting values used in this FS are as follows:

- Protectiveness: 30%
- Permanence: 20%
- Effectiveness over the long-term: 20%
- Management of implementation risks: 10%
- Technical and administrative implementability: 10%
- Consideration of public concerns: 10%

The alternatives are evaluated relative to their ability to comply with the criteria listed and are compared to both each other and the criteria. Because some alternatives provide a similar degree of compliance with a given criterion, the associated evaluation statements may be the same or similar. The following sections provide a summary of each of the DCA criteria and discuss the rationale for each alternative's score in relation to the other alternatives. A full description of all aspects evaluated under each criterion for the alternatives is included in Table 14.1. A summary of the scoring for each criterion, including the estimated costs for each alternative, is presented in Table 14.2.

### 14.2.1 Protectiveness

Protectiveness of each alternative was evaluated based on the degree to which existing risks to human health and the environment were reduced, time required to reduce risks and attain cleanup standards, risks resulting from alternative implementation, and improvement in overall environmental quality. Factors contributing to each alternative's score are summarized as follows.

- Alternative 1 is considered the least protective remedy and contains the minimum requirements for a remedial action. This alternative includes eliminating LNAPL from accumulating on the groundwater table, as per MTCA; however, this alternative addresses only a small area (approximately 400 square feet) of the source mass. The

majority of the hydrocarbon mass will remain and will be addressed by natural attenuation; therefore, Alternative 1 has the longest restoration time frame for achievement of proposed groundwater CULs and would achieve the lowest overall improvement in environmental quality. Alternative 1 scored a 2.

- Alternative 2 is considered more protective than Alternative 1 because it includes targeted off-property ISCO injections as well as a barrier to minimize off-property migration of impacted groundwater. However, overall improvement in environmental quality would be low to moderate because it does not include source removal and a substantial amount of residual soil and groundwater exceeding proposed CULs would remain on-site. Alternative 2 scored a 6.
- Alternative 3 is considered more protective than Alternatives 1 and 2 because it includes targeted in situ soil and groundwater remediation in both CAAs to reduce soil and groundwater contaminant mass; has a similar restoration time frame as Alternatives 2, 4, and 5; and has the third-highest improvement in overall environmental quality. Alternative 3 scored a 7.
- Alternative 4 combines in situ treatment and soil removal technologies that would result in the removal of a large quantity of contaminated soil in CAA-1A and CAA-2. Alternative 4 has a similar restoration time frame along the downgradient property boundary as Alternatives 2, 3, and 5 but would more quickly mitigate the off-property migration risk than Alternative 3. Alternative 4 scored an 8.
- Alternative 5 is considered the most protective cleanup action because it would involve the most laterally and vertically extensive in situ groundwater treatment program. The ISCO injections would result in the destruction of the greatest volume of contaminant mass in soil and groundwater exceeding proposed CULs. This alternative also provides a similar restoration time frame for groundwater along the downgradient property boundary as Alternatives 2, 3, and 4; however, Alternative 5 would result in the highest overall improvement in environmental quality and eventually meet CULs in groundwater across the entire Site in a shorter time frame than the other alternatives. Alternative 5 scored a 9.

### 14.2.2 Permanence

Permanence was evaluated based on the degree of reduction of contaminant toxicity, mobility, volume, adequacy of destruction of hazardous substances, reduction or elimination of release sources, degree of irreversibility, and risk of treatment residuals. The technologies proposed in all five alternatives include irreversible destruction and contaminant reduction mechanisms and do not result in any treatment residuals. Factors contributing to each alternative's score are summarized as follows.

- Alternative 1 is the least permanent solution. It includes residual LNAPL removal within a 400 square foot area around MW-09; however, it would provide the lowest reduction in contaminant volume compared to other alternatives, and it relies on

natural biodegradation and ICs, which are a less certain contaminant reduction mechanism than destruction or removal of contaminants. Alternative 1 scored a 1.

- Alternative 2 is considered more permanent than Alternative 1 because it includes targeted off-property ISCO injections to reduce off-property groundwater contaminant mass and a treatment barrier. However, the treatment barrier is expected to last only between 5 and 10 years before replacement, and the alternative would leave in place a substantial of contaminant mass in the CAAs. Alternative 2 scored a 4.
- Alternative 3 is considered more permanent than Alternatives 1 and 2 because it includes targeted in situ soil and groundwater remediation in both CAAs to reduce soil and groundwater contaminant mass. Alternative 3 scored a 7.
- Alternative 4 is considered marginally more permanent to Alternative 3 because although it would result in the removal of a slightly higher quantity of soil exceeding proposed CULs, vadose zone impacts exceeding proposed CULs would remain in CAA-1A. Alternative 4 scored an 8.
- Alternative 5 would treat the greatest area of soil and groundwater exceeding proposed CULs, resulting in the greatest destruction and reduction of contaminant mass. Although Alternative 5 does not meet the definition of a permanent cleanup action, it is consistent with WAC 173-340-351(5)(b) because it is the most permanent alternative to the maximum extent practicable, and it is not technically feasible to address all contaminated soil beneath all active structures and rail lines, even if horizontal borings were to be used. Alternative 5 would provide the greatest reduction in contaminant volume compared to the other alternatives. Alternative 5 scored a 9.

### 14.2.3 Effectiveness Over the Long-Term

Long-term effectiveness was evaluated based on the degree of certainty of success, reliability while contaminants remain on-site, magnitude of residual risk, and effectiveness of controls to manage residual risk. All alternatives address residual risks associated with leaving varying amounts of soil and groundwater exceeding proposed CULs in place with ICs, including an CMP and SMP. Factors contributing to each alternative's score are summarized as follows.

- Alternative 1 relies primarily on MNA but also includes source treatment as a component of the LNAPL removal. Alternative 1 would be least effective at achieving Site-wide proposed groundwater CULs and would not address off-property migration risk. Alternative 1 scored a 1.
- Alternative 2 provides a higher degree of certainty of success than Alternative 1 and would be more reliable in reducing risk associated with off-property migration. However, there is a low certainty of maintaining groundwater CULs at the downgradient property boundary after 10 years without additional barrier injections, because most of the source area would not be actively treated. Alternative 2 scored a 4.

- Alternative 3 employs focused in situ soil and groundwater treatment to reduce contaminant mass in both CAAs and would be more effective at achieving groundwater CULs site-wide and at the downgradient property boundary than Alternatives 1 and 2, which would not treat any residual hydrocarbon mass in CAA-2. Alternative 3 scored an 8.
- Alternative 4 is considered to have a slightly higher degree of certainty of success eliminating off-property migration risk than Alternative 3 because it would permanently remove a significant amount of soil exceeding proposed CULs within CAA-1A; however, the overall long-term effectiveness would be the same as Alternative 3 because the treatment is similar for impacts within CAA-2. Alternative 4 scored a 9.
- Alternative 5 has the highest certainty of success to achieve soil and groundwater CULs option because it would treat the greatest area of soil and groundwater exceeding proposed CULs, resulting in the greatest destruction and reduction of contaminant mass. Alternative 5 would not be as immediately effective in CAA-1 when compared to excavation of impacted soil but would treat the largest area of impacts exceeding CULs; therefore, Alternative 5 scored a 10.

### 14.2.4 Management of Short-Term Risks

Short-term risk management was evaluated based on the risk to human health and the environment associated with remedy implementation and the effectiveness of controls to manage the short-term risk. All five alternatives include managing the risks associated with approximately 6,000 gallons of contaminated fluids, which will be extracted during surfactant injection and extraction in the MW-09 vicinity. Factors contributing to each alternative's score are summarized as follows.

- Alternative 1 is the least invasive alternative that does not include excavation or an extensive in situ injection program, only surfactant injection and extraction to remove LNAPL. Thus, it has the lowest potential for worker or public contact with contaminated media. Alternative 1 scored a 9.
- Alternative 2 includes injections associated with the groundwater barrier and off-property contamination, which have relatively low to moderate short-term risk to workers and the public. Alternative 2 scored a 7.
- Alternative 3 includes a similar scope of work as Alternative 2 but with a higher total number of injections. Alternative 3 scored a 7.
- Alternative 4 includes a large excavation, requiring shoring, dewatering, and a significant number of truck trips associated with handling and disposal of contaminated soil, which would have a negative balance of environmental impact due to $CO_2$ emissions. Alternative 4 also includes a significant number of injections. Alternative 4 scored a 5.

- Alternative 5 scored a 6 because it includes the largest scope of in situ treatment, including the most injection points, some of which would be in the City of Longview ROW. Similar short-term risks would apply if horizontal borings were to be used, given the number and density of the horizontal borings that would be needed.

### 14.2.5 Technical and Administrative Implementability

Technical and administrative implementability was evaluated based on technical possibility and complexity of the remedy; availability of off-site services, facilities, and materials; regulatory and administrative requirements; ease of site access for remedy implementation; monitoring requirements; and integration with existing Site operations. All five alternatives include an in situ injection component, which involves obtaining underground injection control (UIC) permits and selecting a qualified contractor, many of which exist in the area. All five alternatives also include routine groundwater monitoring as part of a CMP. Factors contributing to each alternative's score are summarized as follows.

- Alternative 1 is the smallest in scale, includes the fewest number of technologies, and would be the least disruptive to Site operations. However, proposed off-property ICs may not be accepted by the property owners, and the alternative could impact future development activities on Port, WSDOT, or City of Longview property. Alternative 1 scored a 5.
- Alternative 2 is larger in scale than Alternative 1 but still relatively small in scale and complexity and would not impede current/future property use on WSDOT or City of Longview property. Alternative 2 scored an 8.
- Alternative 3 is roughly the same in scale and technical complexity to Alternative 2. Although injections inside the rail lines have the potential to cause minimal disruption to Site operations, it is assumed that these would be performed during times when the rail lines are not active. Alternative 3 scored an 8.
- Alternative 4 is equal in scale to Alternative 3; however, it includes the greatest number of technologies and has the highest degree of technical complexity. Alternative 4 scored a 4.
- Alternative 5 is the largest in scale and has potential to cause the highest disruption in Site operations due to the number of proposed injection locations and days within CAA-2. Potential use of horizontal injection wells would be technically and administratively difficult to implement because of the required density of horizontal wells and concerns about boring beneath active rail lines. Alternative 5 scored a 6.

### 14.2.6 Consideration of Public Concerns

Public concerns will be reviewed following the public comment period and will be addressed as part of the final remedial alternative selection and design. All alternatives were scored prior to public comment because it is anticipated that the public perception will not be the same for each

alternative. Factors that could contribute to different public perception of the alternatives are summarized as follows.

- Alternative 1 may cause public concern because it has the longest restoration time frame, would leave the most impacted soil and groundwater in place, would not address off-property migration risk, and may be of concern to adjacent property owners, as well as members of the public. Alternative 1 scored a 2.
- Alternative 2 would not disrupt off-property businesses and would have minimal impact on traffic. However, the alternative would not destroy/remove most source area impacts, which may be of concern to adjacent property owners, as well as members of the public. Alternative 2 scored a 5.
- Alternative 3 would likely cause less public concern than Alternatives 1 and 2 because it has a shorter restoration time frame than Alternative 1 and would destroy/remove more source area impacts than Alternative 2. Although coordination of cleanup actions with rail activities is expected during implementation, this alternative has potential to cause some disruption of Port activities. Alternative 3 scored a 7.
- Alternative 4 may have less public concern than Alternative 1 and 2 but may have a greater public concern than Alternative 3 due to significant number of truck trips associated with handling and disposal of contaminated soil, which would have a negative balance of environmental impact due to $CO_2$ emissions. Implementation of Alternative 4 has the potential to cause disruptions of Port activities consistent with Alternative 3. Alternative 4 scored a 6.
- Alternative 5 may elicit public concern due to the possible short-term disruptions to Port operations as well as proposed injections in the City of Longview ROW that may involve short-duration traffic lane closures. This would also be expected to apply if horizontal injection wells were used. Because Alternative 5 includes a greater number of injections in the active rail line, the potential for disruptions to Port operations is greater than both Alternatives 3 and 4. However, Alternative 5 would also result in the greatest degree of contaminant reduction, which would satisfy public concerns about Site impacts. Lane closures would not be expected to impact nearby businesses. Alternative 5 scored a 7.

### 14.2.7 Cost

Costs were estimated for each alternative and include costs for construction and permitting, long-term operations, maintenance, monitoring, and agency oversight. In addition, all costs include sales tax, a 25% contingency on direct construction costs, and a 20% contingency on indirect construction costs. Estimated costs for each alternative are summarized in Table 14.1 and presented in detail in Appendix I. The costs and benefit per unit cost ratio[13] for each alternative are shown on Table 14.2 and are as follows:

[13] Benefit per unit cost ratio calculated by dividing the total weighted benefit score by the estimated total alternative cost; for this calculation, cost was standardized by dividing by 1 million. Higher value indicates the most benefit per unit cost.

- Alternative 1: $1,600,000 and 1.63
- Alternative 2: $4,200,000 and 1.29
- Alternative 3: $4,200,000 and 1.74
- Alternative 4: $10,200,000 and 0.72
- Alternative 5: $8,300,000 and 1.01

## 14.3 REMEDIAL ALTERNATIVES EVALUATION SUMMARY

Based on the evaluation presented in Tables 14.1 and 14.2 and in the previous sections, Alternative 3 is proposed as the Preferred Alternative for recommendation to Ecology. Section 15.0 describes the Preferred Alternative in greater detail.

# 15.0 Preferred Remedial Alternative

## 15.1 DESCRIPTION OF THE PREFERRED REMEDIAL ALTERNATIVE

Alternative 3 provides the greatest degree of benefit for the associated cost out of the five alternatives discussed in Section 14.0 and is proposed as the Preferred Alternative for the Site (Figure 13.3). Alternative 3 includes the following components:

- Targeted ISCO injections within accessible areas where soil impacts exceed proposed CULs (CAA-1A)
- Targeted ISCO injections along the rail lines where soil concentrations exceed RELs (CAA-2)
- Off-property ISCO injections in the vicinities of MW-04 and MW-30 (CAA-1B)
- Surfactant injection and LNAPL extraction activities within the vicinity of MW-09
- Installation of additional alluvial and perched monitoring wells along the downgradient western, northwestern, and northern Port property boundary (CAA-1A)
- Inspection of the former Longview Pipeline contents
- Compliance groundwater monitoring for assessment of MNA, which includes an evaluation of groundwater and MNA data to determine if the plume is stable and shrinking within a reasonable time frame and if additional contingency injections are required
- ICs on the Port property including the following provisions:
    - Restrictions on the use of both perched zone and alluvial aquifer groundwater
    - Implementation of an SMP to address remaining, small, isolated soil impacts that can be encountered during redevelopment activities or O&M of the rail lines and utilities
    - Re-evaluate VI risk for new buildings or modified buildings to be used for occupancy that are proposed within the lateral and vertical inclusion zones, as per Ecology's VI guidance
- Potential ICs on adjacent properties if determined necessary after cleanup actions have been performed

Together, these technologies would remove contaminant mass in soil and groundwater through destruction and LNAPL recovery. The Preferred Alternative is a comprehensive final remedy for the Site that is compliant with all the applicable remedy selection requirements under MTCA. This alternative has a restoration time frame between 10 and approximately 28 years for the standard POC, with the majority of the Site in compliance in less than 10 years. It would provide the greatest environmental benefit for the associated cost based on the DCA presented in Section 14.0 and Tables 14.1 and 14.2.

### 15.1.1 Surfactant Injections and Extractions

The Preferred Alternative includes surfactant injections and extractions, which are designed to eliminate the presence of residual LNAPL, which currently exists in MW-09. In addition to decreasing the LNAPL viscosity, which renders it more recoverable, adding surfactant increases desorption potential of LNAPL from the soil matrix. Surfactant injection and extraction activities include the installation of up to four 4-inch-diameter injection/recovery wells within a 400-square-foot vicinity of MW-09. Existing wells MW-09 and MW-10 would be used in combination with these injection/recovery wells to conduct three injection and extraction events using PetroCleanze. It is assumed that each injection event would consist of injecting approximately 281 gallons of surfactant at each of the six locations, followed by an extraction event that would remove approximately 2,000 gallons of groundwater from all six locations. Extraction events would occur approximately 1 to 2 weeks after each injection event to achieve the most effective removal of LNAPL. Subsequent injection events would occur immediately after extraction. Extraction events would be coordinated around Port operations and rail line usage and may require temporary closure of some rail operation. Additional surfactant and extraction activities may be required, if residual LNAPL is accumulating on the water table in any Site monitoring well, refer to Section 15.2.

Extracted groundwater would be containerized and transported to an appropriate disposal or treatment facility in the area.

### 15.1.2 In Situ Soil and Groundwater Treatment

ISCO injections would be the primary method of contaminant destruction used in the Preferred Alternative. ISCO injections would focus on remediating impacted soil and groundwater in CAA-1 and CAA-2, as well as groundwater impacts on WSDOT property, located across Port Way. To maximize the effectiveness and vertical extent of in situ soil and groundwater treatment, ISCO injections would be implemented in the wet season (i.e., October through March) when seasonal groundwater levels are high. In the event of daylighting of the ISCO amendments being injected due to various factors including the ability of the subsurface conditions to accept the volume being injected within a densely injected area, in-field assessment, decisions, and steps will be detailed in a CAP to address daylighting of amendments.

**Off-Property ISCO Injections (CAA-1B):** To reduce the extent and eliminate the presence of the dissolved-phase hydrocarbons beneath the WSDOT property, PersulfOx would be injected in the vicinity of MW-04 and MW-30, where recent groundwater monitoring results have exceeded proposed CULs for TPH constituents (Figure 13.3). Up to 38 injection points would be advanced to a depth of 20 feet bgs on the WSDOT property: 24 injection points within a 3,850-square-foot area around MW-04 and 14 injection points within a 1,500-square-foot area around MW-30. The proposed spacing between injection points is between 12 and 14 feet, and the target injection intervals is 10 to 20 feet. Because injections are not expected to be within 10 feet of utility lines, PersulfOx is the preferred product in this area because one application is expected to result in the reduction of groundwater contaminant concentrations to less than proposed CULs. Additional targeted injections will be considered if groundwater does not achieve CULs in

off-property wells within the estimated restoration time frame, or if groundwater monitoring data do not indicate that the plumes are shrinking in a reasonable time frame.

**ISCO Injections Outside Rail Lines on Port Property (CAA-1A):** Accessible areas in CAA-1A with hydrocarbon impacts in soil greater than the proposed CULs would be targeted by ISCO injections. Up to 213 PersulfOx injection points would be advanced in accessible areas to destroy TPH contaminants found in groundwater and soil through abiotic chemical oxidation reaction. There are few known utilities within CAA-1A; therefore, impacts in this area could be addressed with PersulfOx, which is expected to reduce soil and groundwater contaminant concentrations to less than proposed CULs after one application. Figure 13.3 shows the extent of PersulfOx injection locations within CAA-1A, which would be focused in two areas: a 30,000-square-foot area encompassing part of the former Calloway Ross Parcel and former Warehouse 9 footprint (180 injection points) and a 5,650-square-foot area to the south (33 injection points). The proposed spacing between injection points is between 12 and 14 feet, and the target injection intervals is 10 to 20 feet. OIP fluorescence data will be used to target soil impacts laterally and vertically within both the alluvial and perched zones within CAA-1A.

If groundwater does not achieve TPH CULs along the downgradient property boundary within the restoration time frame, or if MNA data do not indicate that the plumes are shrinking in a reasonable time frame, additional targeted in situ treatment may be considered to address remaining areas of groundwater contamination. Once groundwater CULs have been met, continued monitoring will be conducted on select wells to ensure that remaining residual TPH impacts in CAA-2 are not recontaminating groundwater within CAA-1A in a way that may affect compliance with TPH CULs along the downgradient property boundary. If groundwater data, post-remedial implementation, indicate that the TPH groundwater plume is expanding and migrating off-property, additional injections will be conducted. Locations for additional injections will be determined using the most recent groundwater data at that time, which could include, but not limited to, injections within CAA-2 or remaining source areas. Contingency actions are summarized in Section 15.2.

**ISCO Injections Inside Rail Lines (CAA-2):** ISCO treatment in CAA-2 is focused on areas of GRO and total DRO and ORO that exceed proposed RELs for soil. The targeted treatment (as opposed to treating all soil exceeding proposed CULs) would lessen the impact to Port activities and still treat a large volume of soil and groundwater impacts to reduce the overall hydrocarbon mass within the source area. ISCO injection events would be coordinated around Port operations in CAA-2 to the greatest degree possible but may require occasional, temporary closure of some rail lines. ISCO amendments would be injected in up to 202 locations within CAA-2 using a combination of PersulfOx and RegenOx, depending on utility locations and depths. Figure 13.3 shows the three target treatment areas: 5,000-square-foot area surrounding MW-39 (up to 36 injection points or to the extent practicable), 16,000-square-foot area near MW-40 (113 injection points), and a 10,000-square-foot area centered on MW-26 (71 injection points). ISCO injections are effective in the saturated zone and not as effective in the vadose zone. Therefore, ISCO injections are not proposed for the soil impacts that extend to the east of MW-12 and within the

vicinity of the former AST because these shallow impacts are within the vadose zone and are less than 1-foot thick (Appendix K).

PersulfOx has a larger radius of influence and requires fewer injection events than RegenOx, and thus it is the preferred product for ISCO in this area. However, because PersulfOx is corrosive to non-stainless steel or PVC materials (i.e., utilities), which are known to exist in this area, treatment with RegenOx would be necessary in some locations. Areas of PersulfOx and RegenOx treatment would be clearly demarcated through extensive utility locating, which would include a GPR survey, and coordination with Port staff prior to remedy implementation. Injection point spacing would be between 12 and 14 feet and 10 and 14 feet for PersulfOx and RegenOx injection locations, respectively. PersulfOx treatments would consist of one application, and RegenOx locations would be injected over three events separated by 2 to 4 weeks. OIP fluorescence data will be used to target soil impacts laterally and vertically within both the alluvial and perched zones within CAA-2. If groundwater does not achieve TPH CULs along the downgradient property boundary within the restoration time frame, or if MNA data do not indicate that the plumes are shrinking in a reasonable time frame, additional targeted in situ treatment may be considered to address remaining areas of groundwater contamination. The locations of additional targeted injections will be determined using the most recent groundwater data at that time.

### 15.1.3 Installation of Additional On-Property Downgradient Monitoring Wells

The Preferred Alternative includes the installation of at least two additional 2-inch-diameter monitoring wells along the downgradient northwestern and northern edges of the Port property (just east of Port Way), likely equally spaced between existing wells MW-05 and MW-35. The additional monitoring wells would be part of the compliance monitoring network (refer to Section 15.3). The number of wells and installation details will be proposed in a PDI work plan, prior to submittal of the EDR.

### 15.1.4 Former Longview Pipeline Inspection

As requested by Ecology in their 2019 RIWP review (Ecology 2019), the Preferred Alternative includes a limited inspection of the former Longview Pipeline to determine presence/absence of residual product. This inspection will be done prior to remedial implementation activities during the PDI activities. The limited inspection would involve excavating approximately 125 cubic feet (5-foot by 5-foot by 5-foot excavation) of surface soil overlying the pipeline in the northern portion of the Site, where the pipeline is known to lie at a shallow depth of approximately 5 feet bgs. Once the pipeline is exposed, spill response measures and air monitoring would be put into place in and around the excavation. The top of the pipeline would be cut open using either a small drill bit or a saw and, using this hole, the interior of the pipeline would be inspected for residual product. If residual product exists within the pipeline, observations, including approximate volume, color, odor, viscosity, and any other notable characteristics, would be recorded. Following the inspection, the pipeline would be resealed. Excavated soil would be stockpiled and tested for Site COCs and, pending analytical results, will be used to backfill the excavation if results indicate concentrations less than their respective MTCA CULs. The results of the inspection would be used to confirm that potential residual product is not mobile or not

present, or that contingency action is needed, which would include a cost benefit analysis. Details of the pipeline inspection work plan will be included as part of the PDI. The selection of contingency action, if determined that one is required, for Longview Pipeline will be subject to Ecology's approval. The remedial action for Longview Pipeline, if needed, will allow the site to complete the actions approved by Ecology, as part of the CAP, without extending the restoration time frame.

### 15.1.5 Monitoring Natural Attenuation and Groundwater Monitoring

MNA for groundwater is a component of the Preferred Alternative after the destruction of the soil source contamination, and natural attenuation processes are assumed for groundwater recovery. As discussed in Section 9.2.1.3 and detailed in Appendix D, recent MNA groundwater data suggest that biodegradation of contaminants is occurring in Site groundwater, and the groundwater plumes in both the perched zone and alluvial aquifer are stable or shrinking. As part of MNA, groundwater monitoring would be conducted in select wells throughout the plume, downgradient and upgradient of in situ source treatment, following remedy implementation. Specific wells that will be sampled for MNA parameters will be provided in the CMP and subject to Ecology's approval. Select MNA parameters, including dissolved oxygen, nitrate, ferrous iron, sulfate, manganese, total alkalinity, and methane, would be monitored to ensure that biodegradation is ongoing.

### 15.1.6 Institutional Controls

ICs are legal and administrative controls intended to minimize the potential for human exposure to contamination or protect the integrity of the implemented remedy. ICs, such as an environmental covenant, would be included as part of the Preferred Alternative for the Site where contaminants in soil and groundwater are left in place exceeding the cleanup standards. ICs would include restrictions on the use of both perched zone and alluvial aquifer groundwater until proposed CULs are met across the Site. Additionally, although ISCO injections target all saturated soil with TPH concentrations greater than proposed CULs in CAA-1A, there would be shallow, limited small areas of soil within the vadose zone in CAA-2 with residual impacts exceeding direct-contact CULs for total TPH. To address management of possible exposure to these residual soil impacts during Site redevelopment or rail and utility line O&M, an SMP would be prepared as part of the CMP.

## 15.2 CONTINGENCY ACTIONS

Contingency actions may be considered if groundwater does not achieve CULs within the estimated restoration time frame. If groundwater does not achieve TPH CULs in downgradient off-property or along the downgradient property boundary within the restoration time frame, or if MNA data do not indicate the plumes are shrinking in a reasonable time frame, additional targeted in situ treatment may be considered to address remaining areas of groundwater contamination. Post remedial implementation groundwater results will be evaluated to determine if and where additional injections would be appropriate, refer to Section 15.1.2. Additional surfactant and extraction activities may be required, if residual LNAPL is still

accumulating on the water table in MW-09 after three injection/extraction events. Costs for one contingency PersulfOx injection event, targeting approximately 5,000 square feet along the downgradient property boundary, were assumed for evaluation purposes and included in alternative costs. More detailed information regarding the triggers for contingency actions and scope of such actions would be presented in the CMP.

Contingency actions may also be considered in the event that residual product is encountered within the Longview Pipeline that is determined to be mobile enough to result in a potential release to the environment.

## 15.3 COMPLIANCE MONITORING

The CMP will describe long-term post-construction groundwater monitoring and adaptive management to ensure the long-term protectiveness of the Preferred Alternative. Compliance monitoring consists of protection monitoring, performance monitoring, and confirmation monitoring in accordance with WAC 173-340-410. Protection monitoring is conducted to confirm that human health and the environment are adequately protected during construction and the operation and maintenance period of a cleanup action. Performance monitoring is conducted to confirm that the cleanup action has attained cleanup standards and, if appropriate, remediation levels or other performance standards. Confirmation monitoring is conducted to confirm the long-term effectiveness of the cleanup action once cleanup standards and, if appropriate, remediation levels or other performance standards have been attained. Details will be provided within the cleanup action plan.

Groundwater compliance will be determined based on a comparison of groundwater data to Site CULs. Following completion of remedial activities, groundwater compliance monitoring will be conducted on an annual basis for the first 10 years or until concentrations are less than Site CULs, and then compliance monitoring will be conducted on a semiannual basis during the wet and dry season. Once Site-wide concentrations meet CULs during semiannual monitoring, groundwater monitoring will be conducted on a quarterly basis to meet MTCA regulations of four consecutive quarters.

Based on current conditions, the standard POC for groundwater will be applied. However, under future conditions, the northwestern and northern Port property boundary could serve as a CPOC once impacted dissolved-phase hydrocarbons in groundwater at off-property and on-property downgradient perimeter wells attenuate to concentrations less than proposed CULs (refer to Section 8.2.1).

## 15.4 RESTORATION TIME FRAME

Surfactant injections and extractions and ISCO injections would help destroy a large portion of the hydrocarbon mass at the Site (approximately 77%) within 1 to 2 years, which would help promote natural attenuation and reduce the restoration time frame to meet groundwater CULs when compared to relying on MNA as a stand-alone alternative. Additional treatment to further reduce the restoration time frame was evaluated but was not found to be effective. Treatment

of a larger area of CAA-2 than proposed in Alternative 3, including use of horizontal injection wells, would not materially shorten the restoration time frame as evaluated using the factors provided under WAC 173-340-360(4)(c). Because Alternative 3 targets the most concentrated source areas, the remaining hydrocarbon mass that would be left in place would be relatively thin and spread out. A sharp decline in groundwater concentrations is expected within 6 months of the last round of injections. Surfactant injections and extractions are expected to remove LNAPL from the MW-09 vicinity within approximately 6 to 8 weeks after the first round of surfactant injections. As described in Section 15.1.6, ICs would be implemented to manage future exposures while contamination remains.

The restoration time frame for soil and groundwater site-wide was evaluated based on the estimated rate of biodegradation for site conditions following in situ treatment (refer to Appendix D). Based on this evaluation, the site-wide restoration will occur less than 10 years to approximately 28 years after remedy implementation is complete. The restoration time frame estimate found that the majority of the currently impacted area, including near the western, northwestern, and northern property boundary, would attain CULs within approximately 2 to 5 years following implementation. It is estimated that a relatively small area of the Site where residual soil mass would remain would take the longest to attenuate, up to approximately 28 years.

## 15.5 SUMMARY OF ESTIMATED REMEDY COSTS

Estimated remedial costs for the Preferred Alternative are presented in Table I.4 of Appendix I. The costs associated with remedy implementation consist of capital construction costs, compliance monitoring and closure costs following remedy completion, and agency oversight that would include periodic reviews of the constructed remedy. The estimated costs for remedy construction are as follows:

- Construction capital costs that include remedy implementation and construction as well as permitting are estimated to be approximately $1,567,000.
- Construction indirect costs that include construction project management, agency oversight, engineering design/reporting, planning, and field management and oversight are estimated to be $551,000.
- Compliance groundwater monitoring and closure net present value costs were estimated based on annual monitoring and reporting costs for 30 years after remedy implementation, cost to negotiate ICs, well abandonment, and draft and final closure reports. One event of contingency PersulfOx injections to address any residual proposed CUL groundwater exceedances at the downgradient property boundary was also included in the estimate. The compliance groundwater monitoring costs were estimated to be $1,278,000.

The total project cost for the Preferred Alternative, which includes a 25% contingency on direct construction costs, 20% contingency on indirect construction costs, and 10% sales tax, is estimated to be $4,200,000.

## 15.6 COMPLIANCE WITH MTCA

The Preferred Alternative meets the minimum requirements for selection of a cleanup action under MTCA (WAC 173-340-360(3)(a)) because it is protective of human health and the environment, complies with cleanup standards, complies with applicable state and federal laws, provides for compliance monitoring. The Preferred Alternative also meets other MTCA requirements (WAC 173-340-360(3)(b-d)) for selection of a cleanup action, including using permanent solutions to the maximum extent practicable, providing for a reasonable restoration time frame, and consideration of public concerns.

The Preferred Alternative also meets the requirements of expectations for cleanup actions under MTCA (WAC 173-340-370(7)) where natural attenuation can be appropriate for sites where source control has been conducted to the maximum extent practicable; where leaving contaminants on-site during the restoration time frame does not pose an unacceptable threat to human health or the environment; where there is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate; and where appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.

## 15.7 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Compliance with ARARs is a minimum requirement for cleanup actions. ARARs are divided into location-specific, action-specific, and chemical-specific, and are summarized in Table 11.1. The applicability of the ARARs to the Preferred Alternative, and how the Preferred Alternative will meet the ARARs, are described as follows.

**Location-Specific ARARs:** The location-specific ARARs are not applicable to the Preferred Alternative, which does not include removal of soil or other ground-disturbing activities or demolition of structures.

**Action-Specific ARARs:** The action-specific ARARs potentially applicable to the Preferred Alternative include the ARARs governing noise that may be generated during injection (i.e., the Noise Control Act of 1974), the Washington State UIC Program, City of Longview codes regarding ROW and hydrant water use, and Occupational Safety and Health Act (OSHA) regulations applicable to Site workers involved in cleanup implementation. Compliance with the UIC Program would be achieved by obtaining the appropriate UIC permit from Ecology. Injection work in ROWs would be performed in accordance with City of Longview standards, and a hydrant permit, if needed for injection of water-based reagents, would be obtained from the City of Longview. A Health and Safety Plan detailing hazards and necessary controls associated with cleanup action implementation would be prepared for Site workers to meet OSHA requirements.

**Chemical-Specific ARARs:** The chemical-specific ARARs are all applicable to the Preferred Alternative and would be met through compliance with proposed CULs.

As stated in Section 11.4, remedial actions conducted under an agreed order with Ecology are exempt from state and local ARAR procedural requirements; however, the Preferred Alternative would be implemented in compliance with the substantive requirements of the appliable state and local requirements.

## 15.8 COMPLIANCE WITH REMEDIAL ACTION OBJECTIVES

The Preferred Alternative achieves the RAOs through the following actions:

- Protect human health and the environment from Site impacts that exceed proposed CULs by greatly reducing the hydrocarbon mass in soil and groundwater through ISCO injections and management of exposure pathways (i.e., ICs to prevent groundwater withdrawal until proposed CULs are met and an SMP to manage areas with residual soil concentrations greater than direct-contact CULs). Treating all soil that exceeds proposed CULs in CAA-1 (as well as downgradient off-property groundwater) will significantly reduce off-property migration risk.
- Protect human health and the environment from Site impacts and reduce the restoration time frame by actively treating source areas of soil in CAA-2 (active rail lines) that exceed RELs with ISCO injections. ISCO injections are minimally disruptive and, with proper coordination with the Port and its tenants, can be deployed in CAA-2 when the rail lines are not active, so no rail lines are closed. Additionally, ISCO treatment of all impacted soil and groundwater in CAA-1A would not impact future redevelopment activities on Port property.
- Remove LNAPL accumulations from Site media by implementing surfactant injections and extractions in the MW-09 vicinity and targeting areas of soil GRO and total DRO and ORO concentrations greater than residual saturation levels with ISCO injections.
- Develop and implement an CMP with a provision for compliance groundwater monitoring to evaluate the effectiveness of the Preferred Alternative and to determine that CULs are met at the downgradient property boundary and throughout the Site.

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# Remedial Investigation/Feasibility Study

Port of Longview TPH Site

## Tables

# Table 4.1
# RIWP Screening Levels

| Exposure Pathway for Soil | |
|---|---|
| **Analyte** | **Unrestricted Land Use (MTCA Method A)** |
| Gasoline-range organics | 30 mg/kg |
| Diesel-range organics | 2,000 mg/kg |
| Oil-range organics | 2,000 mg/kg |
| cPAHs | 0.1 mg/kg |
| Benzene | 0.03 mg/kg |
| Toluene | 7 mg/kg |
| Ethylbenzene | 6 mg/kg |
| Total xylenes | 9 mg/kg |
| **Exposure Pathway for Groundwater** | |
| **Analyte** | **MTCA Method A Protection of Drinking Water [(1)]** |
| Gasoline-range organics | 800 µg/L |
| Diesel-range organics | 500 µg/L |
| Oil-range organics | 500 µg/L |
| cPAHs | 0.1 µg/L |
| Benzene | 5 µg/L |
| Toluene | 1,000 µg/L |
| Ethylbenzene | 700 µg/L |
| Total xylenes | 1,000 µg/L |
| **Exposure Pathway for Indoor Air** | |
| **Analyte** | **Sub-Slab MTCA Method B Soil Gas Screening Level [(2)]** |
| Total TPH [(3,4)] | 4,700 µg/m³ |
| Benzene | 11 µg/m³ |
| Ethylbenzene | 15,000 µg/$m^3$ |
| Methyl tert-butyl ether | 320 µg/$m^3$ |
| Naphthalene | 2.5 µg/$m^3$ |
| Toluene | 7,600 µg/$m^3$ |
| Total Xylenes | 1,500 µg/$m^3$ |

Notes:

-- Not applicable.

1 Site-specific cleanup levels may be developed from EPH/VPH data.

2 Screening levels acquired from the July 2022 CLARC Spreadsheet and Ecology 2022.

3 Total TPH concentrations are compared to Indoor Air Cleanup Levels listed on Ecology's CLARC worksheet and in Appendix E of Ecology 2022.

4 A MTCA Method C screening for total TPH has not been established by Ecology.

Abbreviations:

CLARC Cleanup Levels and Risk Calculation
cPAH Carcinogenic polycyclic aromatic hydrocarbon
Ecology Washington State Department of Ecology
EPH Extractable petroleum hydrocarbons
µg/$m^3$ Micrograms per cubic meter
µg/L Micrograms per liter
mg/kg Milligrams per kilogram
MTCA Model Toxics Control Act
RIWP Remedial Investigation Work Plan
TPH Total petroleum hydrocarbons
VPH Volatile petroleum hydrocarbons

# Table 4.2
## RI Soil Analytical Results: TPH and BTEX

| Analyte Class | | | | Total Petroleum Hydrocarbons (TPH) | | | | | Benzene, Toluene, Ethylbenzene, and Xylene Compounds | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Analyte | | | | Gasoline-Range Organics | Diesel-Range Organics | Oil-Range Organics | Total DRO and ORO | TPH [2] | Benzene | Toluene | Ethylbenzene | Xylene (meta & para) | Xylene (ortho) | Xylene (total) |
| Screening Level [1] | | | | 30 | 2,000 | 2,000 | 2,000 | -- | 0.030 | 7.0 | 6.0 | -- | -- | 9.0 |
| MTCA Method C | | | | -- | -- | -- | 35,647 [3] | -- | 2,400 | 280,000 | 350,000 | 700,000 | 700,000 | 700,000 |
| Unit | | | | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg |
| Location Name | Sample Name | Date | Depth Range (ft bgs) | | | | | | | | | | | |
| **2015 Data Gaps Investigation** | | | | | | | | | | | | | | |
| GP-1 | GP-1-19.5-20 | 9/15/2015 | 19.5–20 | 18 | 280 | 250 | 280 | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | GP-1-21-21.5 | 9/15/2015 | 21–21.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-2 | GP-2-16-16.5 | 9/15/2015 | 16–16.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-3 | GP-3-2-3 | 9/15/2015 | 2–3 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | GP-3-16-16.5 | 9/15/2015 | 16–16.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-4 | GP-4-21-21.5 | 9/15/2015 | 21–21.5 | 20 U | 50 U | 470 | 470 | | | | | | | |
| GP-6 | GP-6-16-17 | 9/15/2015 | 16–17 | 20 U | 50 U | 140 JQ | 140 JQ | | | | | | | |
| GP-7 | GP-7-25.5-26 | 9/15/2015 | 25.5–26 | 20 U | 50 U | 470 | 470 | | | | | | | |
| GP-8 | GP-8-25.5-26 | 9/15/2015 | 25.5–26 | 20 U | 50 U | 720 | 720 | | | | | | | |
| GP-9 | GP-9-27.5-28 | 9/16/2015 | 27.5–28 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-10 | GP-10-28-28.5 | 9/16/2015 | 28–28.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-11 | GP-11-27-27.5 | 9/16/2015 | 27–27.5 | 20 U | 120 JM | 530 | 650 | | | | | | | |
| GP-12 | GP-12-26-26.5 | 9/16/2015 | 26–26.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-13 | GP-13-26.5-27 | 9/16/2015 | 26.5–27 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-14 | GP-14-26-26.5 | 9/16/2015 | 26–26.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-15 | GP-15-27-27.5 | 9/16/2015 | 27–27.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-16 | GP-16-27.5-28 | 9/16/2015 | 27.5–28 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-18 | GP-18-27-28 | 9/16/2015 | 27–28 | **71** | **4,400** | **5,600** | **10,000** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | GP-18-29-30 | 9/16/2015 | 29–30 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-5 | GP-5-19-19.5 | 9/17/2015 | 19–19.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-17 | GP-17-26-26.5 | 9/17/2015 | 26–26.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-19 | GP-19-23.5-24 | 9/17/2015 | 23.5–24 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-20 | GP-20-24-25 | 9/17/2015 | 24–25 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-21 | GP-21-21-21.5 | 9/17/2015 | 21–21.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | GP-21-25.5-26 | 9/17/2015 | 25.5–26 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-22 | GP-22-29-29.5 | 9/17/2015 | 29–29.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-23 | GP-23-10.5-11 | 9/17/2015 | 10.5–11 | 20 U | 50 U | 510 | 510 | | | | | | | |
| | GP-23-27-27.5 | 9/17/2015 | 27–27.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-24 | GP-24-20-20.5 | 9/17/2015 | 20–20.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-25 | GP-25-20-20.5 | 9/17/2015 | 20–20.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-26 | GP-26-14-14.5 | 9/18/2015 | 14–14.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | GP-26-19-19.5 | 9/18/2015 | 19–19.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-27 | GP-27-14-14.5 | 9/18/2015 | 14–14.5 | 30 | **11,000** | **11,000** | **22,000** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | GP-27-17-18 | 9/18/2015 | 17–18 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-29 | GP-29-25-25.5 | 9/18/2015 | 25–25.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | GP-29-27-27.5 | 9/18/2015 | 27–27.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-30 | GP-30-16-16.5 | 9/18/2015 | 16–16.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | GP-30-19.5-20 | 9/18/2015 | 19.5–20 | 20 U | 50 U | 250 U | 250 U | | | | | | | |

## Table 4.2
## RI Soil Analytical Results: TPH and BTEX

| | | | Analyte Class | Total Petroleum Hydrocarbons (TPH) | | | | | Benzene, Toluene, Ethylbenzene, and Xylene Compounds | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Analyte | Gasoline-Range Organics | Diesel-Range Organics | Oil-Range Organics | Total DRO and ORO | TPH [2] | Benzene | Toluene | Ethylbenzene | Xylene (meta & para) | Xylene (ortho) | Xylene (total) |
| | | | Screening Level [1] | 30 | 2,000 | 2,000 | 2,000 | -- | 0.030 | 7.0 | 6.0 | -- | -- | 9.0 |
| | | | MTCA Method C | -- | -- | -- | 35,647 [3] | -- | 2,400 | 280,000 | 350,000 | 700,000 | 700,000 | 700,000 |
| | | | Unit | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg |
| Location Name | Sample Name | Date | Depth Range (ft bgs) | | | | | | | | | | | |
| **Former 80,000-Barrel AST** | | | | | | | | | | | | | | |
| TP-2 | TP-2-7 | 11/23/1992 | 7–7 | 650 | 13,000 | 1,200 | 14,000 | | | | | | | |
| TP-3 | TP-3-8 | 11/23/1992 | 8–8 | 1,800 | 660 | 540 | 1,200 | | | | | | | |
| | TP-3-11 | 11/23/1992 | 11–11 | ND U [4] | 150 | ND U [4] | 150 | | | | | | | |
| TP-6 | TP-6-11 | 11/23/1992 | 11–11 | 1,200 | 130 | 160 | 290 | | | | | | | |
| MW-21 | MW-21-14 | 5/21/1993 | 14–14 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | |
| | MW-21-16.8 | 5/21/1993 | 16.8–16.8 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | |
| | MW-21-17 | 5/21/1993 | 17–17 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | |
| T-1 | T-1-9 | 8/30/1995 | 9–9 | | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | T-1-20 | 8/30/1995 | 20–20 | | 78 | ND U [4] | 78 | | | | | | | |
| T-2 | T-2-19 | 8/30/1995 | 19–19 | | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| UBV1 | UBV1 | 6/5/1996 | 3–3 | | | | | 25 U | | | | | | |
| UBV2 | UBV2 | 6/5/1996 | 4–4 | | | | | 25 U | | | | | | |
| UBV3 | UBV3 | 6/5/1996 | 3–3 | | | | | 25 U | | | | | | |
| UBV4 | UBV4 | 6/5/1996 | 6–6 | | | | | 50 U | | | | | | |
| UBV5 | UBV5 | 6/5/1996 | 7.5–7.5 | | | | | 50 U | | | | | | |
| UBV6 | UBV6 | 6/10/1996 | 6–6 | | | | | 25 U | | | | | | |
| UBV7 | UBV7 | 6/10/1996 | 6–6 | | | | | 92 | | | | | | |
| UBV8 | UBV8 | 6/10/1996 | 6–6 | | | | | 50 U | | | | | | |
| UBV9 | UBV9 | 6/11/1996 | 6–6 | | | | | 8,300 | | | | | | |
| UBV10 | UBV10 | 6/11/1996 | 4–4 | | | | | 25 U | | | | | | |
| UBV11 | UBV11 | 6/11/1996 | 3–3 | | | | | 25 U | | | | | | |
| UBV12 | UBV12 | 6/11/1996 | 6–6 | | | | | 28 | | | | | | |
| MW-32 | MW-32-10-11.5 | 6/24/1998 | 10–11.5 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-32-20-21.5 | 6/24/1998 | 20–21.5 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| OIP-02 | OIP-02-5-5.5 | 3/11/2020 | 5–5.5 | 20 U | 1,900 [5] | 3,400 | 5,300 | | | | | | | |
| | OIP-02-14-15 | 3/11/2020 | 14–15 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-04 | OIP-04-4-5 | 3/10/2020 | 4–5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | OIP-04-15-16 | 3/10/2020 | 15–16 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| **Former Calloway Ross Parcel** | | | | | | | | | | | | | | |
| MW-03 | PL-MW3-9-10.5 | 5/1/1991 | 9–10.5 | 10 U | 1,700 | 10 U | 1,700 | | | | | | | |
| SB-1 | PL-SB1-5.5-7 | 5/1/1991 | 5.5–7 | ***100 U*** | 4,800 | 100 U | 4,800 | | | | | | | |
| | PL-SB1-7-8.5 | 5/1/1991 | 7–8.5 | ***100 U*** | 2,300 | 100 U | 2,300 | | | | | | | |
| SB-2 | PL-SB2-2.5-4 | 5/1/1991 | 2.5–4 | 10 U | 10 U | 220 | 220 | | | | | | | |
| | PL-SB2-6-7.5 | 5/1/1991 | 6–7.5 | 540 | 7,800 | 100 U | 7,800 | | | | | | | |
| | PL-SB5-6-7.5 | 5/1/1991 | 6–7.5 | 590 | 7,200 | 100 U | 7,200 | | | | | | | |
| | PL-SB2-7.5-9 | 5/1/1991 | 7.5–9 | 1,500 | 13,000 | 100 U | 13,000 | | | | | | | |
| SB-3 | PL-SB3-10-11.5 | 5/1/1991 | 10–11.5 | 10 U | 450 | 10 U | 450 | | | | | | | |
| SB-4 | PL-SB4-7-8.5' | 5/2/1991 | 7–8.5 | ***100 U*** | 11,000 | 100 U | 11,000 | | | | | | | |
| SB-5 | PL-SB5-10-11.5' | 5/2/1991 | 10–11.5 | 10 U | 10 U | 10 U | 10 U | | | | | | | |
| | PL-SB8-10-11.5' | 5/2/1991 | 10–11.5 | ND U [4] | 43 | 110 | 150 | | | | | | | |
| SB-6 | PL-SB6-11.5-13' | 5/2/1991 | 11.5–13 | 10 U | 10 U | 10 U | 10 U | | | | | | | |
| SB-7 | PL-SB7-7.5-9 | 5/2/1991 | 7.5–9 | 25 | 54 | 10 U | 54 | | | | | | | |
| SB-8 | PL-SB8-9-10.5' | 5/2/1991 | 9–10.5 | 10 U | 10 U | 10 U | 10 U | | | | | | | |

## Table 4.2
## RI Soil Analytical Results: TPH and BTEX

| | | | Analyte Class | Total Petroleum Hydrocarbons (TPH) | | | | | Benzene, Toluene, Ethylbenzene, and Xylene Compounds | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Analyte | Gasoline-Range Organics | Diesel-Range Organics | Oil-Range Organics | Total DRO and ORO | TPH [2] | Benzene | Toluene | Ethylbenzene | Xylene (meta & para) | Xylene (ortho) | Xylene (total) |
| | | | Screening Level [1] | 30 | 2,000 | 2,000 | 2,000 | -- | 0.030 | 7.0 | 6.0 | -- | -- | 9.0 |
| | | | MTCA Method C | -- | -- | -- | 35,647 [3] | -- | 2,400 | 280,000 | 350,000 | 700,000 | 700,000 | 700,000 |
| | | | Unit | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg |
| Location Name | Sample Name | Date | Depth Range (ft bgs) | | | | | | | | | | | |
| **Former Calloway Ross Parcel (cont.)** | | | | | | | | | | | | | | |
| MW-05 | PL-MW5-11-12.5' | 5/3/1991 | 11–12.5 | 10 U | 10 U | 10 U | 10 U | | | | | | | |
| SB-9 | PL-SB9-9-10.5' | 5/3/1991 | 9–10.5 | 10 U | 10 U | 10 U | 10 U | | | | | | | |
| MW-08 | MW-8-10 | 12/8/1992 | 10–10 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-8-16 | 12/8/1992 | 16–16 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-8-24 | 12/8/1992 | 24–24 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-10 | MW-10-2 | 12/7/1992 | 2–2 | 10 | 110 | 140 | 250 | | | | | | | |
| | MW-10-8 | 12/7/1992 | 8–8 | **1,800** | 660 | 540 | 1,200 | | | | | | | |
| | MW-10-9 | 12/7/1992 | 9–9 | **1,000** | **4,900** | 310 | **5,200** | | | | | | | |
| | MW-10-11 | 12/7/1992 | 11–11 | ND U [4] | 150 | ND U [4] | 150 | | | | | | | |
| | MW-10-14 | 12/7/1992 | 14–14 | **3,900** | **4,100** | 300 | **4,400** | | | | | | | |
| | MW-10-24 | 12/7/1992 | 24–24 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| SCR-1 | SCR-1 | 3/22/1993 | 0–1 | ND U [4] | **60,000** | **3,500** | **64,000** | | | | | | | |
| SCR-2 | SCR-2 | 3/22/1993 | 0–1 | ND U [4] | **14,000** | **150,000** | **160,000** | | | | | | | |
| SCR-3 | SCR-3 | 3/22/1993 | 0–1 | ND U [4] | **5,300** | **21,000** | **26,000** | | | | | | | |
| SCR-7 | SCR-7 | 3/22/1993 | 0–1 | ND U [4] | 300 | **2,400** | **2,700** | | | | | | | |
| SCR-10 | SCR-10 | 3/22/1993 | 0–1 | ND U [4] | 220 | 1,400 | 1,700 | | | | | | | |
| UAV2 | UAV 2 | 6/1/1996 | 4–4 | | | | | 25 U | | | | | | |
| UAV3 | UAV 3 | 6/1/1996 | 3–3 | | | | | 25 U | | | | | | |
| OIP-08 | OIP08-19-20-112219 | 11/22/2019 | 19–20 | **4,900** | **12,000** | 1,000 [5] | **13,000** | | **1.1** | 0.74 | **27** | 3.2 | 0.25 U | 3.2 |
| OIP-66 | OIP66-12-12.5-1112219 | 11/22/2019 | 12–12.5 | **1,500** | 760 | 250 U | 760 | | 0.030 U | 0.050 U | 0.12 | 0.10 U | 0.050 U | 0.10 U |
| | OIP166-12-12.5D | 11/22/2019 | 12–12.5 | **2,000** | 490 | 250 U | 490 | | 0.030 U | 0.050 U | 0.25 | 0.10 U | 0.050 U | 0.10 U |
| OIP-68 | OIP-68-10-11 | 3/11/2020 | 10–11 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | OIP-68-10-11D | 3/11/2020 | 10–11 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | OIP-68-13.5-14 | 3/11/2020 | 13.5–14 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-36 | GP-36-13-14 | 3/12/2020 | 13–14 | **4,100** | **3,500** | 250 U | **3,500** | | **0.25** | 0.27 | 4.7 | 1.5 | 0.050 U | 1.5 |
| | GP-36-16-17 | 3/12/2020 | 16–17 | **950** | **15,000** | 970 [5] | **16,000** | | **0.61** | 0.47 | **7.6** | 2.5 | 0.056 | 2.6 |
| | GP-36-22-23 | 3/12/2020 | 22–23 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-37 | GP-37-12-14 | 3/12/2020 | 12–14 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | GP-37-12-14D | 3/12/2020 | 12–14 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-67 | OIP-67-7-8 | 3/12/2020 | 7–8 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | OIP-67-11-12 | 3/12/2020 | 11–12 | **1,500** | **4,300** | 310 [5] | **4,600** | | 0.030 U | 0.050 U | 0.062 | 0.10 U | 0.050 U | 0.10 U |
| | OIP-67-14.5-15 | 3/12/2020 | 14.5–15 | **2,200** | **2,100** | 250 U | **2,100** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | OIP-67-18-19 | 3/12/2020 | 18–19 | 20 U | 50 U | 250 U | 250 U | | | | | | | |

## Table 4.2
## RI Soil Analytical Results: TPH and BTEX

| | | | Analyte Class | Total Petroleum Hydrocarbons (TPH) | | | | | Benzene, Toluene, Ethylbenzene, and Xylene Compounds | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Analyte | Gasoline-Range Organics | Diesel-Range Organics | Oil-Range Organics | Total DRO and ORO | TPH [2] | Benzene | Toluene | Ethylbenzene | Xylene (meta & para) | Xylene (ortho) | Xylene (total) |
| | | | Screening Level [1] | 30 | 2,000 | 2,000 | 2,000 | -- | 0.030 | 7.0 | 6.0 | -- | -- | 9.0 |
| | | | MTCA Method C | -- | -- | -- | 35,647 [3] | -- | 2,400 | 280,000 | 350,000 | 700,000 | 700,000 | 700,000 |
| | | | Unit | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg |
| Location Name | Sample Name | Date | Depth Range (ft bgs) | | | | | | | | | | | |
| **Former Fuel Loading Racks** | | | | | | | | | | | | | | |
| MW-09 | MW-9-2 | 12/2/1992 | 2–2 | 16 | 1,500 | **4,600** | **6,100** | | | | | | | |
| | MW-9-7 | 12/2/1992 | 7–7 | **650** | **13,000** | 1,200 | **14,000** | | | | | | | |
| | MW-9-10 | 12/2/1992 | 10–10 | ND U [4] | 180 | 270 | 450 | | | | | | | |
| | MW-9-11 | 12/2/1992 | 11–11 | **1,400** | **19,000** | 2,600 | **22,000** | | | | | | | |
| | MW-9-14 | 12/2/1992 | 14–14 | **4,700** | **9,000** | 830 | **9,800** | | | | | | | |
| | MW-9-19.5 | 12/2/1992 | 19.5–19.5 | ND U [4] | 550 | ND U [4] | 550 | | | | | | | |
| MW-11 | MW-11-1.5 | 12/3/1992 | 1.5–1.5 | **450** | **26,000** | **34,000** | **60,000** | | | | | | | |
| | MW-11-9 | 12/3/1992 | 9–9 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-11-11 | 12/3/1992 | 11–11 | ND U [4] | **17,000** | 830 | **18,000** | | | | | | | |
| | MW-11-15 | 12/3/1992 | 15–15 | ND U [4] | **16,000** | 700 | **17,000** | | | | | | | |
| | MW-11-19 | 12/3/1992 | 19–19 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-11-20 | 12/3/1992 | 20–20 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-12 | MW-12-6 | 12/4/1992 | 6–6 | **510** | 120 | ND U [4] | 120 | | | | | | | |
| | MW-12-14 | 12/4/1992 | 14–14 | **4,900** | 1,800 | 180 | 2,000 | | | | | | | |
| | MW-12-19 | 12/4/1992 | 19–19 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-12-22 | 12/4/1992 | 22–22 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| IB-2 | IB-2-20 | 12/4/1992 | 20–20 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-07 | MW-7-9 | 12/7/1992 | 9–9 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-7-16 | 12/7/1992 | 16–16 | **490** | 370 | ND U [4] | 370 | | | | | | | |
| | MW-7-24 | 12/7/1992 | 24–24 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-14 | MW-14-8 | 5/17/1993 | 8–8 | **6,900** | **13,000** | 410 | **13,000** | | | | | | | |
| | MW-14-11 | 5/17/1993 | 11–11 | **6,000** | **12,000** | ND U [4] | **12,000** | | | | | | | |
| MW-15 | MW-15-10 | 5/18/1993 | 10–10 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-15-13.5 | 5/18/1993 | 13.5–13.5 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-15-16.5 | 5/18/1993 | 16.5–16.5 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-16 | MW-16-10 | 5/18/1993 | 10–10 | **16,000** | 1,900 | 290 | **2,200** | | | | | | | |
| | MW-16-13.5 | 5/18/1993 | 13.5–13.5 | ND U [4] | **9,400** | ND U [4] | **9,400** | | | | | | | |
| | MW-16-18 | 5/18/1993 | 18–18 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-17 | MW-17-11 | 5/19/1993 | 11–11 | ND U [4] | **2,300** | ND U [4] | **2,300** | | | | | | | |
| | MW-17-13.5 | 5/19/1993 | 13.5–13.5 | ND U [4] | **20,000** | 970 | **21,000** | | | | | | | |
| | MW-17-19.7 | 5/19/1993 | 19.7–19.7 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-20 | MW-20-11.5 | 5/20/1993 | 11.5–11.5 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-20-18-19 | 5/20/1993 | 18–19 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-20-19 | 5/20/1993 | 19–19 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-13 | MW-13-1 | 5/26/1993 | 1–1 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-25 | MW-25-9.5 | 3/2/1994 | 9.5–9.5 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| OIP-42 | OIP42-17-17.5-112119 | 11/21/2019 | 17–17.5 | **3,600** | **17,000** | 1,500 [5] | **19,000** | | **2.4** | 0.99 | **41** | 4.1 | 0.50 U | 4.1 |
| MW-33 | MW-33-12-12.5 | 3/9/2020 | 12–12.5 | **230** | **15,000** | 600 [5] | **16,000** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | MW-33-19.5-20 | 3/9/2020 | 19.5–20 | 5.0 U | 50 U | 250 U | 250 U | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | MW-33-22.5-23 | 3/9/2020 | 22.5–23 | 20 U | 50 U | 250 U | 250 U | | | | | | | |

## Table 4.2
## RI Soil Analytical Results: TPH and BTEX

| | | | Analyte Class | Total Petroleum Hydrocarbons (TPH) | | | | | Benzene, Toluene, Ethylbenzene, and Xylene Compounds | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Analyte | Gasoline-Range Organics | Diesel-Range Organics | Oil-Range Organics | Total DRO and ORO | TPH [2] | Benzene | Toluene | Ethylbenzene | Xylene (meta & para) | Xylene (ortho) | Xylene (total) |
| | | | Screening Level [1] | 30 | 2,000 | 2,000 | 2,000 | -- | 0.030 | 7.0 | 6.0 | -- | -- | 9.0 |
| | | | MTCA Method C | -- | -- | -- | 35,647 [3] | -- | 2,400 | 280,000 | 350,000 | 700,000 | 700,000 | 700,000 |
| | | | Unit | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg |
| Location Name | Sample Name | Date | Depth Range (ft bgs) | | | | | | | | | | | |
| **Former Fuel Loading Racks (cont.)** | | | | | | | | | | | | | | |
| MW-40 | MW-40-1.0-1.5 | 3/9/2020 | 1–1.5 | 20 U | 200 [5] | **2,400** | **2,600** | | | | | | | |
| | MW-40-10.5-11 | 3/9/2020 | 10.5–11 | **2,000** | **18,000** | **7,900** [5] | **26,000** | | **12** | **7.4** | 5.4 | | | **15** |
| | MW-40-17 | 3/9/2020 | 17–17 | **170** | **2,400** | 250 U | **2,400** | | **0.33** | 0.050 U | 0.14 | 0.13 | 0.050 U | 0.13 |
| | MW-40-17D | 3/9/2020 | 17–17 | **1,700** | **2,100** | 320 [5] | **2,400** | | **0.088** | 0.050 U | 0.19 | 0.12 | 0.050 U | 0.12 |
| | MW-40-24-24.5 | 3/9/2020 | 24–24.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-47 | OIP-47-2-3 | 3/9/2020 | 2–3 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | OIP-47-11-12 | 3/9/2020 | 11–12 | **5,700** | 210 [5] | 250 U | 210 | | 0.030 U | 0.12 | **27** | 1.9 | 0.30 | 2.2 |
| | OIP-47-17 | 3/9/2020 | 17–17 | **49** | 360 | 250 U | 360 | | 0.030 U | 0.089 | **7.0** | 1.6 | 0.15 | 1.8 |
| | OIP-47-25 | 3/9/2020 | 25–25 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-49 | OIP-49-10 | 3/9/2020 | 10–10 | 22 | 50 U | 360 | 360 | | 0.020 U | 0.16 | 0.020 U | | | 0.41 |
| | OIP-49-17 | 3/9/2020 | 17–17 | **960** | 50 U | 250 U | 250 U | | 0.020 UJ | 0.020 UJ | **14 J** | | | **14 J** |
| GP-35 | GP-35-7-8 | 3/10/2020 | 7–8 | 20 U | 590 | 250 U | 590 | | | | | | | |
| | GP-35-16-17 | 3/10/2020 | 16–17 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-39 | OIP-39-15-15.5 | 3/10/2020 | 15–15.5 | 5.0 U | 50 U | 250 U | 250 U | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | OIP-39-16.5-17 | 3/10/2020 | 16.5–17 | 7.3 | 50 U | 250 U | 250 U | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | OIP-39-21-22 | 3/10/2020 | 21–22 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-46 | OIP-46-10-11 | 3/10/2020 | 10–11 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | OIP-46-14 | 3/10/2020 | 14–14 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-72 | OIP-72-10-11 | 3/11/2020 | 10–11 | **520** | 50 U | 250 U | 250 U | | 0.020 UJ | 0.020 UJ | 6.1 J | | | 7.0 J |
| | OIP-72-16-17 | 3/11/2020 | 16–17 | **270** | 50 U | 250 U | 250 U | | 0.020 U | 0.020 U | 2.1 | | | 2.3 |
| OIP-15 | OIP-15-15-16 | 3/12/2020 | 15–16 | **35** | **2,300** | 370 [5] | **2,700** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | OIP-15-20-21 | 3/12/2020 | 20–21 | 5.0 U | 50 U | 250 U | 250 U | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | OIP-15-23-24 | 3/12/2020 | 23–24 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-64 | OIP-64-14-15 | 3/12/2020 | 14–15 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| **Former Mechanic's Shop** | | | | | | | | | | | | | | |
| UST1 | UST1-722-24 | 7/22/1993 | 24–24 | 20 U | 50 U | 100 U | 100 U | | | | | | | |
| UST2 | UST2-723-15 | 7/23/1993 | 15–15 | 20 U | 50 U | 100 U | 100 U | | | | | | | |
| UST3 | UST3-723-14.5 | 7/23/1993 | 14.5–14.5 | 20 U | 50 U | 100 U | 100 U | | | | | | | |
| UST4 | UST4-726-10 | 7/26/1993 | 10–10 | 20 U | 50 U | 100 U | 100 U | | | | | | | |
| UST5 | UST5-9 | 6/3/1994 | 9–9 | **790** | 170 | 200 | 370 | | | | | | | |
| | UST5-13 | 6/3/1994 | 13–13 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | UST5-18 | 6/3/1994 | 18–18 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| GP-34 | GP-34-14-15 | 3/9/2020 | 14–15 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-38 | GP-38-11-11.5 | 3/13/2020 | 11–11.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-18 | OIP-18-19-19.5 | 3/13/2020 | 19–19.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-19 | OIP-19-19-20 | 3/13/2020 | 19–20 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-20 | OIP-20-11-11.5 | 3/13/2020 | 11–11.5 | **630** | 440 [5] | 250 U | 440 | | 0.030 U | 0.050 U | 0.11 | 0.11 | 0.050 U | 0.11 |
| | OIP-20-19-19.5 | 3/13/2020 | 19–19.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-21 | OIP-21-18-19 | 3/13/2020 | 18–19 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| **Former U.S. Army Reserve Heating Oil UST** | | | | | | | | | | | | | | |
| GP-31 | GP-31-14-15 | 3/11/2020 | 14–15 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| GP-32 | GP-32-17.5-18.5 | 3/11/2020 | 17.5–18.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |

## Table 4.2
## RI Soil Analytical Results: TPH and BTEX

| | | | Analyte Class | Total Petroleum Hydrocarbons (TPH) | | | | | Benzene, Toluene, Ethylbenzene, and Xylene Compounds | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Analyte | Gasoline-Range Organics | Diesel-Range Organics | Oil-Range Organics | Total DRO and ORO | TPH [2] | Benzene | Toluene | Ethylbenzene | Xylene (meta & para) | Xylene (ortho) | Xylene (total) |
| | | | Screening Level [1] | 30 | 2,000 | 2,000 | 2,000 | -- | 0.030 | 7.0 | 6.0 | -- | -- | 9.0 |
| | | | MTCA Method C | -- | -- | -- | 35,647 [3] | -- | 2,400 | 280,000 | 350,000 | 700,000 | 700,000 | 700,000 |
| | | | Unit | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg |
| Location Name | Sample Name | Date | Depth Range (ft bgs) | | | | | | | | | | | |
| **Monitoring Wells MW-26 and MW-28** | | | | | | | | | | | | | | |
| MW-18 | MW-18-17 | 5/19/1993 | 17–17 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-18-17-DUP | 5/19/1993 | 17–17 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-24 | MW-24-15.5 | 3/3/1994 | 15.5–15.5 | **5,600** | **43,000** | 360 | **43,000** | | | | | | | |
| | MW-24-15.5-DUP | 3/3/1994 | 15.5–15.5 | | **47,000** | | **47,000** [6] | | | | | | | |
| | MW-24-20 | 3/3/1994 | 20–20 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-24-22.2 | 3/3/1994 | 22.2–22.2 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-26 | MW-26-12.8 | 3/3/1994 | 12.8–12.8 | **2,300** | **17,000** | 94 | **17,000** | | | | | | | |
| | MW-26-12.8-DUP | 3/3/1994 | 12.8–12.8 | **1,900** | **15,000** | 93 | **15,000** | | | | | | | |
| | MW-26-18 | 3/3/1994 | 18–18 | **2,100** | **42,000** | | **42,000** [6] | | | | | | | |
| | MW-26-37.5 | 3/3/1994 | 37.5–37.5 | ND U [4] | 5.4 | | 5.4 [6] | | | | | | | |
| MW-27 | MW-27-18.2 | 3/21/1994 | 18.2–18.2 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-28 | MW-28-14.6 | 3/22/1994 | 14.6–14.6 | **760** | **8,400** | | **8,400** [6] | | | | | | | |
| | MW-28-14.6-DUP | 3/22/1994 | 14.6–14.6 | **830** | **8,700** | | **8,700** [6] | | | | | | | |
| | MW-28-27.7 | 3/22/1994 | 27.7–27.7 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-28-29.5 | 3/22/1994 | 28–29.5 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-29 | MW-29-10 | 6/3/1994 | 10–10 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-29-20 | 6/3/1994 | 20–20 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-29-24 | 6/3/1994 | 24–24 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| OIP-30 | OIP30-20-21-111919 | 11/19/2019 | 20–21 | **61** | **11,000** | **12,000** | **23,000** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.063 | 0.063 |
| GP-33 | GP-33-14-14.5 | 3/9/2020 | 14–14.5 | **170** | 830 [5] | **3,800** | **4,630** | | 0.020 U | 0.11 | 0.58 | | | 1.7 |
| | GP-33-19.5-20 | 3/9/2020 | 19.5–20 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | GP-33-24-25 | 3/9/2020 | 24–25 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | GP-33-28-29 | 3/9/2020 | 28–29 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-52 | OIP52-19-19.5-112219 | 11/22/2019 | 19–19.5 | **86** | 530 | 250 U | 530 | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | OIP52-22-22.5-112219 | 11/22/2019 | 22–22.5 | **260** | **2,200** | 250 U | **2,200** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| OIP-53 | OIP53-22-22.5-112219 | 11/22/2019 | 22–22.5 | 5.0 U | 50 U | 250 U | 250 U | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| OIP-31 | OIP-31-17 | 3/9/2020 | 17–17 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | OIP-31-20 | 3/9/2020 | 20–20 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| MW-34 | MW-34-15-15.5 | 3/10/2020 | 15–15.5 | **760** | **23,000** | 540 [5] | **24,000** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | MW-34-20-20.5 | 3/10/2020 | 20–20.5 | **280** | **17,000** | 480 [5] | **17,000** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | MW-34-24-24.5 | 3/10/2020 | 24–24.5 | **46** | 300 | 250 U | 300 | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | MW-34-28-28.5 | 3/10/2020 | 28–28.5 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-23 | OIP-23-14-15 | 3/10/2020 | 14–15 | **420** | **13,000** | 250 U | **13,000** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | OIP-23-19-20 | 3/10/2020 | 19–20 | **790** | **48,000** | 1,300 [5] | **49,000** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.081 | 0.081 |
| | OIP-23-23-24 | 3/10/2020 | 23–24 | **200** | **5,700** | 250 U | **5,700** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | OIP-23-29.5-30 | 3/10/2020 | 29.5–30 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-54 | OIP-54-15-16 | 3/11/2020 | 15–16 | 20 U | 50 U | 660 | 660 | | | | | | | |

# Table 4.2
## RI Soil Analytical Results: TPH and BTEX

| Analyte Class | | | | Total Petroleum Hydrocarbons (TPH) | | | | | Benzene, Toluene, Ethylbenzene, and Xylene Compounds | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Analyte | | | | Gasoline-Range Organics | Diesel-Range Organics | Oil-Range Organics | Total DRO and ORO | TPH [2] | Benzene | Toluene | Ethylbenzene | Xylene (meta & para) | Xylene (ortho) | Xylene (total) |
| Screening Level [1] | | | | 30 | 2,000 | 2,000 | 2,000 | -- | 0.030 | 7.0 | 6.0 | -- | -- | 9.0 |
| MTCA Method C | | | | -- | -- | -- | 35,647 [3] | -- | 2,400 | 280,000 | 350,000 | 700,000 | 700,000 | 700,000 |
| Unit | | | | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg |
| Location Name | Sample Name | Date | Depth Range (ft bgs) | | | | | | | | | | | |
| **Northern Portion of the Former Standard Pipelines** | | | | | | | | | | | | | | |
| MW-06 | MW-6-14 | 12/9/1992 | 14–14 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-6-19 | 12/9/1992 | 19–19 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-19 | MW-19-2-4 | 5/18/1993 | 2–4 | ND U [4] | 3,700 | 12,000 | 16,000 | | | | | | | |
| | MW-19-4-8 | 5/18/1993 | 4–8 | ND U [4] | 72,000 | 58,000 | 130,000 | | | | | | | |
| OIP-57 | OIP-57-14 | 3/10/2020 | 14–14 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-70 | OIP-70-8 | 3/10/2020 | 8–8 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | OIP-70-12-14 | 3/10/2020 | 12–14 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-69 | OIP-69-11-12 | 3/11/2020 | 11–12 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | OIP-69-14.5-15 | 3/11/2020 | 14.5–15 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| MW-39 | MW-39-2-4 | 3/12/2020 | 2–4 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | MW-39-8-9 | 3/12/2020 | 8–9 | 150 | 4,400 | 250 U | 4,400 | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | MW-39-13-14 | 3/12/2020 | 13–14 | 990 | 18,000 | 340 [5] | 18,000 | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | MW-39-18.5-20 | 3/12/2020 | 18.5–20 | 5.0 U | 50 U | 250 U | 250 U | | 0.030 U | 0.050 UJ | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| OIP-73 | OIP-73-13-14 | 3/12/2020 | 13–14 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | OIP-73-13-14D | 3/12/2020 | 13–14 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | OIP-73-9-10 | 3/12/2020 | 9–10 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| **Perimeter Monitoring Wells** | | | | | | | | | | | | | | |
| MW-22 | MW-22-27.5 | 3/1/1994 | 27.5–27.5 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-23 | MW-23-26.5 | 3/2/1994 | 26.5–26.5 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-30 | MW-30-16-16.5 | 6/24/1998 | 16–16.5 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-30-25-26.5 | 6/24/1998 | 25–26.5 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-31 | MW-31-10-11 | 6/24/1998 | 10–11 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| | MW-31-20-21.5 | 6/24/1998 | 20–21.5 | ND U [4] | ND U [4] | ND U [4] | ND U [4] | | | | | | | |
| MW-35 | MW-35-15.5-16 | 3/10/2020 | 15.5–16 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| MW-36 | MW-36-25.5-26 | 3/11/2020 | 25.5–26 | 20 U | 50 U | 250 U | 250 U | | | | | | | |

## Table 4.2
## RI Soil Analytical Results: TPH and BTEX

| Analyte Class | | | | Total Petroleum Hydrocarbons (TPH) | | | | | Benzene, Toluene, Ethylbenzene, and Xylene Compounds | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Analyte | | | | Gasoline-Range Organics | Diesel-Range Organics | Oil-Range Organics | Total DRO and ORO | TPH [2] | Benzene | Toluene | Ethylbenzene | Xylene (meta & para) | Xylene (ortho) | Xylene (total) |
| Screening Level [1] | | | | 30 | 2,000 | 2,000 | 2,000 | -- | 0.030 | 7.0 | 6.0 | -- | -- | 9.0 |
| MTCA Method C | | | | -- | -- | -- | 35,647 [3] | -- | 2,400 | 280,000 | 350,000 | 700,000 | 700,000 | 700,000 |
| Unit | | | | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg |
| Location Name | Sample Name | Date | Depth Range (ft bgs) | | | | | | | | | | | |
| **Southern Pipelines and Berths** | | | | | | | | | | | | | | |
| P-1 | P-1 | 4/1/1994 | 0–1 | | **4,400** | 600 | **5,000** | | | | | | | |
| P-2 | P-2 | 4/1/1994 | 0–1 | | **8,300** | **5,400** | **14,000** | | | | | | | |
| MW-38 | MW-38-23.5-24 | 3/11/2020 | 23.5–24 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| MW-37 | MW-37-27.5-28 | 3/12/2020 | 27.5–28 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| | MW-37-27.5-28D | 3/12/2020 | 27.5–28 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| P3 | P3-0-0.5 | 3/12/2020 | 0–0.5 | 25 U | 620 [5] | **4,200** | **4,800** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| P4 | P4-0-0.5 | 3/12/2020 | 0–0.5 | 25 U | 300 [5] | 1,900 | **2,200** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| P5 | P5-0-0.5 | 3/12/2020 | 0–0.5 | 25 U | 860 | 1,200 | **2,100** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| P6 | P6-0.5-1.0 | 3/12/2020 | 0.5–1 | 25 U | 580 | **2,300** | **2,900** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| | P6-0.5-1.0D | 3/12/2020 | 0.5–1 | 25 U | 560 | **2,100** | **2,700** | | 0.030 U | 0.050 U | 0.050 U | 0.10 U | 0.050 U | 0.10 U |
| OIP-05 | OIP-05-27-28 | 3/13/2020 | 27–28 | 20 U | 50 U | 250 U | 250 U | | | | | | | |
| OIP-06 | OIP-06-27-28 | 3/13/2020 | 27–28 | 20 U | 50 U | 250 U | 250 U | | | | | | | |

Notes:

Blank cells are intentional.

All results rounded to two significant figures.

**BOLD RED** Result exceeds screening level and is detected.

***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.

1 Remedial investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.

2 TPH by WTPH 418.8.

3 MTCA Method C criteria calculated using site data.

4 Historical data that did not provide reporting limits. Result reported as ND.

5 The laboratory indicated that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.

6 Total DRO and ORO sum calculated with only DRO; ORO analysis unavailable.

Abbreviations:

AST Aboveground storage tank
bgs Below ground surface
DRO Diesel-range organics
ft Feet
mg/kg Milligrams per kilogram
MTCA Model Toxics Control Act
ND Not detected
ORO Oil-range organics
UST Underground storage tank

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JM Concentration is estimated due to poor match to standard.
JQ Concentration is an estimated value reported less than the associated quantitation limit but greater than the method detection limit.
U Analyte is not detected at the associated reporting limit.
UJ Analyte is not detected at the associated reporting limit, which is an estimate.

# Table 4.3
## RI Soil Analytical Results: VOCs and PAHs

| | | | Location Area | 2015 Data Gaps Investigation | | Former Calloway Ross Parcel | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Location Name | GP-1 | GP-27 | OIP-08 | OIP-66 | | OIP-68 | GP-36 | |
| | | | Sample Name | GP-1-19.5-20 | GP-27-14-14.5 | OIP08-19-20-112219 | OIP66-12-12.5-1112219 | OIP166-12-12.5D | OIP-68-14-14.5 | GP-36-13-14 | GP-36-16-17 |
| | | | Sample Date | 9/15/2015 | 9/18/2015 | 11/22/2019 | 11/22/2019 | 11/22/2019 | 3/11/2020 | 3/12/2020 | 3/12/2020 |
| | | | Depth Range (ft bgs) | 19.5–20 | 14–14.5 | 19–20 | 12–12.5 | 12–12.5 | 14–14.5 | 13–14 | 16–17 |
| **Analyte** | **Screening Level [1]** | **MTCA Method C** | **Unit** | | | | | | | | |
| **Conventionals** | | | | | | | | | | | |
| Total organic carbon | -- | -- | % | | | | | | 0.16 | | |
| **Metals** | | | | | | | | | | | |
| Lead | -- | 1,000 | mg/kg | 1.8 | 5.1 | | 3.0 | 3.8 | | 2.7 | 3.8 |
| **Semivolatile Organic Compounds** | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | 130 | mg/kg | 0.0076 U | **0.95** | 0.042 | 0.038 U | 0.038 U | | 0.038 | 0.045 |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | 130 | mg/kg | 0 U [2] | **0.95** | 0.0073 | 0 U [2] | 0 U [2] | | 0.00064 | 0.010 |
| 1-Methylnaphthalene | -- | -- | mg/kg | 0.010 U | 15 | 32 | 1.7 | 1.4 | | | |
| 2-Methylnaphthalene | -- | -- | mg/kg | 0.010 U | 7.2 | 27 | 1.9 | 1.6 | | | |
| Acenaphthene | -- | 210,000 | mg/kg | 0.010 U | 1.6 | 1.0 | 0.053 | 0.050 U | | | |
| Acenaphthylene | -- | -- | mg/kg | 0.010 U | 0.10 U | 0.050 U | 0.050 U | 0.050 U | | | |
| Anthracene | -- | 1,100,000 | mg/kg | 0.010 U | 2.6 | 0.050 U | 0.050 U | 0.050 U | | | |
| Benzo(a)anthracene | -- | -- | mg/kg | 0.010 U | 2.0 | 0.057 | 0.050 U | 0.050 U | | 0.050 U | 0.091 |
| Benzo(a)pyrene | -- | 130 | mg/kg | 0.010 U | 0.65 | 0.050 U | 0.050 U | 0.050 U | | 0.050 U | 0.050 U |
| Benzo(b)fluoranthene | -- | -- | mg/kg | 0.010 U | 0.35 | 0.050 U | 0.050 U | 0.050 U | | 0.050 U | 0.050 U |
| Benzo(g,h,i)perylene | -- | -- | mg/kg | 0.010 U | 0.19 | 0.050 U | 0.050 U | 0.050 U | | | |
| Benzo(k)fluoranthene | -- | -- | mg/kg | 0.010 U | 0.10 U | 0.050 U | 0.050 U | 0.050 U | | 0.050 U | 0.050 U |
| Chrysene | -- | -- | mg/kg | 0.010 U | 3.8 | 0.16 | 0.050 U | 0.050 U | | 0.064 | 0.11 |
| Dibenzo(a,h)anthracene | -- | -- | mg/kg | 0.010 U | 0.16 | 0.050 U | 0.050 U | 0.050 U | | 0.050 U | 0.050 U |
| Fluoranthene | -- | 140,000 | mg/kg | 0.010 U | 0.94 | 0.16 | 0.050 U | 0.050 U | | | |
| Fluorene | -- | 140,000 | mg/kg | 0.036 | 2.9 | 6.8 | 0.28 | 0.24 | | | |
| Indeno(1,2,3-c,d)pyrene | -- | -- | mg/kg | 0.010 U | 0.10 U | 0.050 U | 0.050 U | 0.050 U | | 0.050 U | 0.050 U |
| Naphthalene | -- | 70,000 | mg/kg | 0.010 U | 0.10 U | 0.050 U | 0.050 U | 0.050 U | | 1.1 | 2.0 |
| Phenanthrene | -- | -- | mg/kg | 0.076 | 10 | 8.8 | 0.32 | 0.30 | | | |
| Pyrene | -- | 110,000 | mg/kg | 0.010 U | 4.3 | 0.43 | 0.050 U | 0.050 U | | | |
| **Volatile Organic Compounds** | | | | | | | | | | | |
| 1,2-Dibromoethane | -- | 66 | mg/kg | 0.050 U | 0.050 U | 0.25 U | 0.050 U | | | 0.050 U | 0.050 U |
| 1,2-Dichloroethane | -- | 1,400 | mg/kg | 0.050 U | 0.050 U | 0.25 U | 0.050 U | | | 0.050 U | 0.050 U |
| Methyl-tert-butyl ether | -- | 73,000 | mg/kg | 0.050 U | 0.050 U | 0.25 U | 0.050 U | | | 0.050 U | 0.050 U |
| n-Hexane | -- | 210,000 | mg/kg | 0.25 U | 0.25 U | 23 | 1.1 | | | 18 | 32 |

Notes:

Blank cells are intentional.
All results rounded to two significant figures.
-- Not established.
**BOLD RED** Result exceeds screening level.
***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.
1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.
2 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

bgs Below ground surface
cPAH Carcinogenic polycyclic aromatic hydrocarbon
ft Feet
mg/kg Milligrams per kilogram
MTCA Model Toxics Control Act
TEQ Toxic equivalent

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
U Analyte is not detected at the associated reporting limit.
UJ Analyte is not detected at the associated reporting limit, which is an estimate.

# Table 4.3
## RI Soil Analytical Results: VOCs and PAHs

| Location Area | | | | Former Calloway Ross Parcel (cont.) | | Former Fuel Loading Rack Area | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | | OIP-67 | | OIP-42 | MW-33 | | MW-40 | | OIP-47 | |
| Sample Name | | | | OIP-67-11-12 | OIP-67-14.5-15 | OIP42-17-17.5-112119 | MW-33-12-12.5 | MW-33-19.5-20 | MW-40-17 | MW-40-17D | OIP-47-11-12 | OIP-47-17 |
| Sample Date | | | | 3/12/2020 | 3/12/2020 | 11/21/2019 | 3/9/2020 | 3/9/2020 | 3/9/2020 | 3/9/2020 | 3/9/2020 | 3/9/2020 |
| Depth Range (ft bgs) | | | | 12-Nov | 14.5–15 | 17–17.5 | 12–12.5 | 19.5–20 | 17–17 | 17–17 | 11–12 | 17–17 |
| **Analyte** | **Screening Level [1]** | **MTCA Method C** | **Unit** | | | | | | | | | |
| **Conventionals** | | | | | | | | | | | | |
| Total organic carbon | -- | -- | % | | | | | | | | | |
| **Metals** | | | | | | | | | | | | |
| Lead | -- | 1,000 | mg/kg | 5.0 | 1.6 | | 1.1 | 3.6 | 2.1 | 1.5 | 3.3 | 2.6 |
| **Semivolatile Organic Compounds** | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | 130 | mg/kg | 0.048 | 0.038 U | 0.052 | 0.039 | 0.0076 U | 0.038 | 0.038 | 0.0076 U | 0.0076 U |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | 130 | mg/kg | 0.015 | 0 U [2] | 0.017 | 0.0010 | 0 U [2] | 0.00068 | 0.00088 | 0 U [2] | 0 U [2] |
| 1-Methylnaphthalene | -- | -- | mg/kg | | | 38 | | | | | | |
| 2-Methylnaphthalene | -- | -- | mg/kg | | | 27 | | | | | | |
| Acenaphthene | -- | 210,000 | mg/kg | | | 1.3 | | | | | | |
| Acenaphthylene | -- | -- | mg/kg | | | 0.050 U | | | | | | |
| Anthracene | -- | 1,100,000 | mg/kg | | | 0.050 U | | | | | | |
| Benzo(a)anthracene | -- | -- | mg/kg | 0.080 | 0.050 U | 0.13 | 0.050 U | 0.010 U | 0.050 U | 0.050 U | 0.010 U | 0.010 U |
| Benzo(a)pyrene | -- | 130 | mg/kg | 0.050 U | 0.050 U | 0.050 U | 0.050 U | 0.010 U | 0.050 U | 0.050 U | 0.010 U | 0.010 U |
| Benzo(b)fluoranthene | -- | -- | mg/kg | 0.063 | 0.050 U | 0.050 U | 0.050 U | 0.010 U | 0.050 U | 0.050 U | 0.010 U | 0.010 U |
| Benzo(g,h,i)perylene | -- | -- | mg/kg | | | 0.050 U | | | | | | |
| Benzo(k)fluoranthene | -- | -- | mg/kg | 0.050 U | 0.050 U | 0.050 U | 0.050 U | 0.010 U | 0.050 U | 0.050 U | 0.010 U | 0.010 U |
| Chrysene | -- | -- | mg/kg | 0.093 | 0.050 U | 0.40 | 0.10 | 0.010 U | 0.068 | 0.088 | 0.010 U | 0.010 U |
| Dibenzo(a,h)anthracene | -- | -- | mg/kg | 0.050 U | 0.050 U | 0.050 U | 0.050 U | 0.010 U | 0.050 U | 0.050 U | 0.010 U | 0.010 U |
| Fluoranthene | -- | 140,000 | mg/kg | | | 0.24 | | | | | | |
| Fluorene | -- | 140,000 | mg/kg | | | 8.0 | | | | | | |
| Indeno(1,2,3-c,d)pyrene | -- | -- | mg/kg | 0.050 U | 0.050 U | 0.050 U | 0.050 U | 0.010 U | 0.050 U | 0.050 U | 0.010 U | 0.010 U |
| Naphthalene | -- | 70,000 | mg/kg | | 0.15 | 0.050 U | | | | | | 6.3 |
| Phenanthrene | -- | -- | mg/kg | | | 11 | | | | | | |
| Pyrene | -- | 110,000 | mg/kg | | | 0.71 | | | | | | |
| **Volatile Organic Compounds** | | | | | | | | | | | | |
| 1,2-Dibromoethane | -- | 66 | mg/kg | 0.050 U | 0.050 U | 0.50 U | 0.050 U | 0.050 U | | | 0.050 U | 0.050 U |
| 1,2-Dichloroethane | -- | 1,400 | mg/kg | 0.050 U | 0.050 U | 0.50 U | 0.050 U | 0.050 U | | | 0.050 U | 0.050 U |
| Methyl-tert-butyl ether | -- | 73,000 | mg/kg | 0.050 U | 0.050 U | 0.50 U | 0.050 U | 0.050 U | | | 0.050 U | 0.050 U |
| n-Hexane | -- | 210,000 | mg/kg | 0.32 | 1.0 | 45 | 0.25 U | 0.25 U | | | 3.6 | 1.3 |

Notes:

Blank cells are intentional.

All results rounded to two significant figures.

-- Not established.

**BOLD RED** Result exceeds screening level.

***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.

1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.

2 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

bgs Below ground surface

cPAH Carcinogenic polycyclic aromatic hydrocarbon

ft Feet

mg/kg Milligrams per kilogram

MTCA Model Toxics Control Act

TEQ Toxic equivalent

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.

U Analyte is not detected at the associated reporting limit.

UJ Analyte is not detected at the associated reporting limit, which is an estimate.

# Table 4.3
## RI Soil Analytical Results: VOCs and PAHs

| Location Area | | | | Former Fuel Loading Rack Area (cont.) | | | | | Former Mechanic's Shop | Monitoring Wells MW-26 and MW-28 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | | OIP-39 | | OIP-46 | OIP-15 | | OIP-20 | OIP-30 | OIP-52 |
| Sample Name | | | | OIP-39-15-15.5 | OIP-39-16.5-17 | OIP-46-8 | OIP-15-15-16 | OIP-15-20-21 | OIP-20-11-11.5 | OIP30-20-21-111919 | OIP52-19-19.5-112219 |
| Sample Date | | | | 3/10/2020 | 3/10/2020 | 3/10/2020 | 3/12/2020 | 3/12/2020 | 3/13/2020 | 11/19/2019 | 11/22/2019 |
| Depth Range (ft bgs) | | | | 15–15.5 | 16.5–17 | 8–8 | 15–16 | 20–21 | 11–11.5 | 20–21 | 19–19.5 |
| **Analyte** | **Screening Level [1]** | **MTCA Method C** | **Unit** | | | | | | | | |
| **Conventionals** | | | | | | | | | | | |
| Total organic carbon | -- | -- | % | | | 0.075 U | | | | | |
| **Metals** | | | | | | | | | | | |
| Lead | -- | 1,000 | mg/kg | | 1.2 | | 1.1 | 1.9 | 8.2 | | 1.0 U |
| **Semivolatile Organic Compounds** | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | 130 | mg/kg | 0.0076 U | 0.0076 U | | 0.038 U | 0.0076 U | 0.0076 U | **0.54** | 0.0076 U |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | 130 | mg/kg | 0 U [2] | 0 U [2] | | 0 U [2] | 0 U [2] | 0 U [2] | **0.53** | 0 U [2] |
| 1-Methylnaphthalene | -- | -- | mg/kg | | | | | | | 13 | 0.55 |
| 2-Methylnaphthalene | -- | -- | mg/kg | | | | | | | 15 | 0.010 U |
| Acenaphthene | -- | 210,000 | mg/kg | | | | | | | 0.94 | 0.077 |
| Acenaphthylene | -- | -- | mg/kg | | | | | | | 0.10 U | 0.010 U |
| Anthracene | -- | 1,100,000 | mg/kg | | | | | | | 2.1 | 0.010 U |
| Benzo(a)anthracene | -- | -- | mg/kg | 0.010 U | 0.010 U | | 0.050 U | 0.010 U | 0.010 U | 0.81 | 0.010 U |
| Benzo(a)pyrene | -- | 130 | mg/kg | 0.010 U | 0.010 U | | 0.050 U | 0.010 U | 0.010 U | 0.40 | 0.010 U |
| Benzo(b)fluoranthene | -- | -- | mg/kg | 0.010 U | 0.010 U | | 0.050 U | 0.010 U | 0.010 U | 0.24 | 0.010 U |
| Benzo(g,h,i)perylene | -- | -- | mg/kg | | | | | | | 0.11 | 0.010 U |
| Benzo(k)fluoranthene | -- | -- | mg/kg | 0.010 U | 0.010 U | | 0.050 U | 0.010 U | 0.010 U | 0.10 U | 0.010 U |
| Chrysene | -- | -- | mg/kg | 0.010 U | 0.010 U | | 0.050 U | 0.010 U | 0.010 U | 2.0 | 0.010 U |
| Dibenzo(a,h)anthracene | -- | -- | mg/kg | 0.010 U | 0.010 U | | 0.050 U | 0.010 U | 0.010 U | 0.10 U | 0.010 U |
| Fluoranthene | -- | 140,000 | mg/kg | | | | | | | 0.58 | 0.011 |
| Fluorene | -- | 140,000 | mg/kg | | | | | | | 4.3 | 0.57 |
| Indeno(1,2,3-c,d)pyrene | -- | -- | mg/kg | 0.010 U | 0.010 U | | 0.050 U | 0.010 U | 0.010 U | 0.10 U | 0.010 U |
| Naphthalene | -- | 70,000 | mg/kg | | | | | 0.050 U | 1.5 | 0.10 U | 0.010 U |
| Phenanthrene | -- | -- | mg/kg | | | | | | | 8.4 | 0.87 |
| Pyrene | -- | 110,000 | mg/kg | | | | | | | 3.4 | 0.026 |
| **Volatile Organic Compounds** | | | | | | | | | | | |
| 1,2-Dibromoethane | -- | 66 | mg/kg | | 0.050 U | | 0.050 U | 0.050 U | 0.050 U | 0.050 U | |
| 1,2-Dichloroethane | -- | 1,400 | mg/kg | | 0.050 U | | 0.050 U | 0.050 U | 0.050 U | 0.050 U | |
| Methyl-tert-butyl ether | -- | 73,000 | mg/kg | | 0.050 U | | 0.050 U | | 0.050 U | 0.050 U | |
| n-Hexane | -- | 210,000 | mg/kg | | 0.25 U | | 0.25 U | 0.25 U | 0.25 U | 0.25 U | |

Notes:

Blank cells are intentional.

All results rounded to two significant figures.

-- Not established.

**BOLD RED** Result exceeds screening level.

***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.

1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.

2 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

bgs Below ground surface

cPAH Carcinogenic polycyclic aromatic hydrocarbon

ft Feet

mg/kg Milligrams per kilogram

MTCA Model Toxics Control Act

TEQ Toxic equivalent

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.

U Analyte is not detected at the associated reporting limit.

UJ Analyte is not detected at the associated reporting limit, which is an estimate.

# Table 4.3
## RI Soil Analytical Results: VOCs and PAHs

| Location Area | | | | Monitoring Wells MW-26 and MW-28 (cont.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | | OIP-52 (cont.) | OIP-53 | MW-34 | | | OIP-23 | | | OIP-54 |
| Sample Name | | | | OIP52-22-22.5-112219 | OIP53-22-22.5-112219 | MW-34-15-15.5 | MW-34-20-20.5 | MW-34-24-24.5 | OIP-23-14-15 | OIP-23-19-20 | OIP-23-23-24 | OIP-54-18-19 |
| Sample Date | | | | 11/22/2019 | 11/22/2019 | 3/10/2020 | 3/10/2020 | 3/10/2020 | 3/10/2020 | 3/10/2020 | 3/10/2020 | 3/11/2020 |
| Depth Range (ft bgs) | | | | 22–22.5 | 22–22.5 | 15–15.5 | 20–20.5 | 24–24.5 | 14–15 | 19–20 | 23–24 | 18–19 |
| **Analyte** | **Screening Level [1]** | **MTCA Method C** | **Unit** | | | | | | | | | |
| **Conventionals** | | | | | | | | | | | | |
| Total organic carbon | -- | -- | % | | 0.075 U | | | | | | | 0.075 U |
| **Metals** | | | | | | | | | | | | |
| Lead | -- | 1,000 | mg/kg | 1.2 | 1.0 U | 1.1 | 1.3 | 1.0 U | | | | |
| **Semivolatile Organic Compounds** | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | 130 | mg/kg | 0.0076 | 0.0076 U | 0.039 | 0.038 | 0.0076 U | 0.038 | 0.053 | 0.038 U | |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | 130 | mg/kg | 0.00010 | 0 U [2] | 0.0014 | 0.00072 | 0 U [2] | 0.00058 | 0.018 | 0 U [2] | |
| 1-Methylnaphthalene | -- | -- | mg/kg | 8.1 | 0.010 U | | | | | | | |
| 2-Methylnaphthalene | -- | -- | mg/kg | 0.010 U | 0.010 U | | | | | | | |
| Acenaphthene | -- | 210,000 | mg/kg | 0.39 | 0.010 U | | | | | | | |
| Acenaphthylene | -- | -- | mg/kg | 0.010 U | 0.010 U | | | | | | | |
| Anthracene | -- | 1,100,000 | mg/kg | 0.010 U | 0.010 U | | | | | | | |
| Benzo(a)anthracene | -- | -- | mg/kg | 0.010 U | 0.010 U | 0.050 U | 0.050 U | 0.010 U | 0.050 U | 0.16 | 0.050 U | |
| Benzo(a)pyrene | -- | 130 | mg/kg | 0.010 U | 0.010 U | 0.050 U | 0.050 U | 0.010 U | 0.050 U | 0.050 U | 0.050 U | |
| Benzo(b)fluoranthene | -- | -- | mg/kg | 0.010 U | 0.010 U | 0.050 U | 0.050 U | 0.010 U | 0.050 U | 0.050 U | 0.050 U | |
| Benzo(g,h,i)perylene | -- | -- | mg/kg | 0.010 U | 0.010 U | | | | | | | |
| Benzo(k)fluoranthene | -- | -- | mg/kg | 0.010 U | 0.010 U | 0.050 U | 0.050 U | 0.010 U | 0.050 U | 0.050 U | 0.050 U | |
| Chrysene | -- | -- | mg/kg | 0.010 | 0.010 U | 0.14 | 0.072 | 0.010 U | 0.058 | 0.23 | 0.050 U | |
| Dibenzo(a,h)anthracene | -- | -- | mg/kg | 0.010 U | 0.010 U | 0.050 U | 0.050 U | 0.010 U | 0.050 U | 0.050 U | 0.050 U | |
| Fluoranthene | -- | 140,000 | mg/kg | 0.045 | 0.010 U | | | | | | | |
| Fluorene | -- | 140,000 | mg/kg | 3.5 | 0.010 U | | | | | | | |
| Indeno(1,2,3-c,d)pyrene | -- | -- | mg/kg | 0.010 U | 0.010 U | 0.050 U | 0.050 U | 0.010 U | 0.050 U | 0.050 U | 0.050 U | |
| Naphthalene | -- | 70,000 | mg/kg | 0.010 U | 0.010 U | | | | | | | |
| Phenanthrene | -- | -- | mg/kg | 4.0 | 0.010 U | | | | | | | |
| Pyrene | -- | 110,000 | mg/kg | 0.10 | 0.010 U | | | | | | | |
| **Volatile Organic Compounds** | | | | | | | | | | | | |
| 1,2-Dibromoethane | -- | 66 | mg/kg | | | | | | 0.050 U | 0.050 U | 0.050 U | |
| 1,2-Dichloroethane | -- | 1,400 | mg/kg | | | | | | 0.050 U | 0.050 U | 0.050 U | |
| Methyl-tert-butyl ether | -- | 73,000 | mg/kg | | | | | | 0.050 U | 0.050 U | 0.050 U | |
| n-Hexane | -- | 210,000 | mg/kg | | | | | | 0.25 U | 0.42 | 0.25 U | |

Notes:

Blank cells are intentional.

All results rounded to two significant figures.

-- Not established.

**BOLD RED** Result exceeds screening level.

***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.

1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.

2 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

bgs Below ground surface

cPAH Carcinogenic polycyclic aromatic hydrocarbon

ft Feet

mg/kg Milligrams per kilogram

MTCA Model Toxics Control Act

TEQ Toxic equivalent

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.

U Analyte is not detected at the associated reporting limit.

UJ Analyte is not detected at the associated reporting limit, which is an estimate.

# Table 4.3
## RI Soil Analytical Results: VOCs and PAHs

| | | | Location Area | Northern Portion of the Former Standard Pipelines | | | | Southern Pipelines and Berths | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Location Name | OIP-69 | MW-39 | | | GP-18 | P3 | P4 | P5 | P6 | |
| | | | Sample Name | OIP-69-14.5-15 | MW-39-8-9 | MW-39-13-14 | MW-39-18.5-20 | GP-18-27-28 | P3-0-0.5 | P4-0-0.5 | P5-0-0.5 | P6-0.5-1.0 | P6-0.5-1.0D |
| | | | Sample Date | 3/11/2020 | 3/12/2020 | 3/12/2020 | 3/12/2020 | 9/16/2015 | 3/12/2020 | 3/12/2020 | 3/12/2020 | 3/12/2020 | 3/12/2020 |
| | | | Depth Range (ft bgs) | 14.5–15 | 8–9 | 13–14 | 18.5–20 | 27–28 | 0–0.5 | 0–0.5 | 0–0.5 | 0.5–1 | 0.5–1 |
| **Analyte** | **Screening Level [1]** | **MTCA Method C** | **Unit** | | | | | | | | | | |
| **Conventionals** | | | | | | | | | | | | | |
| Total organic carbon | -- | -- | % | 0.075 U | | | | | | | | | |
| **Metals** | | | | | | | | | | | | | |
| Lead | -- | 1,000 | mg/kg | | | | | 8.9 | | | | | |
| **Semivolatile Organic Compounds** | | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | 130 | mg/kg | | 0.0077 J | 0.038 | 0.0076 U | **0.50** | **2.3** | **0.51** | ***0.76 U*** | ***0.76 U*** | ***7.1 U*** |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | 130 | mg/kg | | 0.00023 J | 0.00071 | 0 U [2] | **0.20** | **2.3** | **0.51** | 0 U [2] | 0 U [2] | 0 U [2] |
| 1-Methylnaphthalene | -- | -- | mg/kg | | | | | 10 | | | | | |
| 2-Methylnaphthalene | -- | -- | mg/kg | | | | | 0.50 U | | | | | |
| Acenaphthene | -- | 210,000 | mg/kg | | | | | 1.1 | | | | | |
| Acenaphthylene | -- | -- | mg/kg | | | | | 0.50 U | | | | | |
| Anthracene | -- | 1,100,000 | mg/kg | | | | | 1.6 | | | | | |
| Benzo(a)anthracene | -- | -- | mg/kg | | 0.010 U | 0.050 U | 0.010 U | 0.86 | 1.8 | 0.46 | 1.0 U | 1.0 U | 1.0 U |
| Benzo(a)pyrene | -- | 130 | mg/kg | | 0.010 U | 0.050 U | 0.010 U | 0.50 U | 1.5 | 0.35 | 1.0 U | 1.0 U | 10 U |
| Benzo(b)fluoranthene | -- | -- | mg/kg | | 0.010 U | 0.050 U | 0.010 U | 0.50 U | 3.5 | 0.66 | 1.0 U | 1.0 U | 10 U |
| Benzo(g,h,i)perylene | -- | -- | mg/kg | | | | | 0.50 U | | | | | |
| Benzo(k)fluoranthene | -- | -- | mg/kg | | 0.010 U | 0.050 U | 0.010 U | 0.50 U | 1.0 | 0.22 | 1.0 U | 1.0 U | 10 U |
| Chrysene | -- | -- | mg/kg | | 0.023 | 0.071 | 0.010 U | 1.5 | 3.1 | 0.63 | 1.0 U | 1.0 U | 1.0 U |
| Dibenzo(a,h)anthracene | -- | -- | mg/kg | | 0.010 UJ | 0.050 U | 0.010 U | 0.50 U | 1.0 U | 0.10 U | 1.0 U | 1.0 U | 10 U |
| Fluoranthene | -- | 140,000 | mg/kg | | | | | 0.50 U | | | | | |
| Fluorene | -- | 140,000 | mg/kg | | | | | 2.5 | | | | | |
| Indeno(1,2,3-c,d)pyrene | -- | -- | mg/kg | | 0.010 U | 0.050 U | 0.010 U | 0.50 U | 1.3 | 0.19 | 1.0 U | 1.0 U | 10 U |
| Naphthalene | -- | 70,000 | mg/kg | | | | | 0.50 U | | | | | |
| Phenanthrene | -- | -- | mg/kg | | | | | 3.6 | | | | | |
| Pyrene | -- | 110,000 | mg/kg | | | | | 2.4 | | | | | |
| **Volatile Organic Compounds** | | | | | | | | | | | | | |
| 1,2-Dibromoethane | -- | 66 | mg/kg | | | 0.050 U | | 0.050 U | | | | | |
| 1,2-Dichloroethane | -- | 1,400 | mg/kg | | | 0.050 U | | 0.050 U | | | | | |
| Methyl-tert-butyl ether | -- | 73,000 | mg/kg | | | 0.050 U | | 0.050 U | | | | | |
| n-Hexane | -- | 210,000 | mg/kg | | | 0.25 U | | 0.25 U | | | | | |

Notes:

Blank cells are intentional.

All results rounded to two significant figures.

-- Not established.

**BOLD RED** Result exceeds screening level.

***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.

1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.

2 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

bgs Below ground surface

cPAH Carcinogenic polycyclic aromatic hydrocarbon

ft Feet

mg/kg Milligrams per kilogram

MTCA Model Toxics Control Act

TEQ Toxic equivalent

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.

U Analyte is not detected at the associated reporting limit.

UJ Analyte is not detected at the associated reporting limit, which is an estimate.

## Table 4.4
## RI Soil Analytical Results: EPH and VPH

| Location Area | | Former Calloway Ross Parcel | | | | | | | Former Fuel Loading Rack Area | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | GP-1 | OIP-08 | OIP-66 | GP-36 | | OIP-67 | | OIP-42 | MW-33 | | OIP-47 | |
| Sample Name | | GP-1-19.5-20 | OIP08-19-20-112219 | OIP66-12-12.5-1112219 | GP-36-13-14 | GP-36-16-17 | OIP-67-11-12 | OIP-67-14.5-15 | OIP42-17-17.5-112119 | MW-33-12-12.5 | MW-33-19.5-20 | OIP-47-11-12 | OIP-47-17 |
| Sample Date | | 9/15/2015 | 11/22/2019 | 11/22/2019 | 3/12/2020 | 3/12/2020 | 3/12/2020 | 3/12/2020 | 11/21/2019 | 3/9/2020 | 3/9/2020 | 3/9/2020 | 3/9/2020 |
| Depth Range (ft bgs) | | 19.5–20 | 19–20 | 12–12.5 | 13–14 | 16–17 | 11–12 | 14.5–15 | 17–17.5 | 12–12.5 | 19.5–20 | 11–12 | 17–17 |
| Analyte | Unit | | | | | | | | | | | | |
| **Petroleum Fractionation Data** | | | | | | | | | | | | | |
| EPH Aliphatic C8-C10 | mg/kg | 6.0 UJ | 820 J | 240 J | 170 J | 440 J | 320 J | 42 J | 920 J | 110 J | 30 UJ | 27 UJ | 32 J |
| EPH Aliphatic C10-C12 | mg/kg | 6.0 UJ | 1,100 | 200 | 350 | 820 | 580 | 62 J | 1,300 | 690 | 15 U | 17 | 19 |
| EPH Aliphatic C12-C16 | mg/kg | 18 J | 3,300 | 270 | 1,200 | 2,400 | 1,500 | 210 J | 4,100 | 3,300 | 20 | 13 U | 15 U |
| EPH Aliphatic C16-C21 | mg/kg | 26 J | 2,800 | 200 | 1,200 | 2,300 | 1,500 | 230 J | 3,500 | 3,000 | 15 U | 13 U | 15 U |
| EPH Aliphatic C21-C34 | mg/kg | 6.0 UJ | 870 | 45 | 250 J | 520 J | 330 J | 22 J | 990 | 720 J | 15 U | 13 U | 15 U |
| EPH Aromatic C8-C10 | mg/kg | 6.0 U | 80 J | 13 UJ | 13 UJ | 22 J | 12 UJ | 12 UJ | 110 J | 13 UJ | 15 UJ | 13 UJ | 15 UJ |
| EPH Aromatic C10-C12 | mg/kg | 6.0 U | 290 | 69 | 120 | 240 | 180 | 14 J | 400 | 110 | 15 U | 16 | 28 |
| EPH Aromatic C12-C16 | mg/kg | 6.0 U | 890 | 96 | 450 | 880 | 610 | 57 J | 1,300 | 850 | 15 U | 16 | 15 U |
| EPH Aromatic C16-C21 | mg/kg | 19 | 2,000 | 180 | 970 | 1,800 | 1,200 | 190 J | 2,600 | 2,400 | 15 U | 13 U | 18 |
| EPH Aromatic C21-C34 | mg/kg | 6.0 U | 390 | 93 | 170 | 400 | 250 | 19 J | 500 | 490 | 15 U | 13 U | 27 |
| VPH Aliphatic C5-C6 | mg/kg | 2.2 U | 16 U | 1.3 U | 62 U | 63 | 35 U | 5.4 J | 280 | 7.7 | 1.5 U | 270 | 8.5 |
| VPH Aliphatic C6-C8 | mg/kg | 2.2 U | 270 | 36 | 89 U | 400 | 250 | 120 J | 600 | 12 | 2.1 U | 830 | 110 |
| VPH Aliphatic C8-C10 | mg/kg | 2.2 U | 290 | 35 | 50 U | 170 | 540 | 150 J | 120 | 40 | 1.2 U | 330 | 100 |
| VPH Aliphatic C10-C12 | mg/kg | 2.2 U | 620 | 60 | 53 U | 240 | 800 | 230 J | 220 | 210 | 1.3 U | 470 | 110 |
| VPH Aromatic C8-C10 | mg/kg | 7.8 | 430 | 57 | 110 U | 190 | 510 | 120 J | 200 | 53 J | 2.5 U | 330 | 130 J |
| VPH Aromatic C10-C12 | mg/kg | 3.9 J | 1,400 | 200 | 79 | 560 | 1,900 J | 440 J | 540 | 760 | 14 | 1,100 | 360 |
| VPH Aromatic C12-C13 | mg/kg | 7.1 | 2,200 | 170 | 610 | 820 | 4,300 J | 780 J | 560 | 2,200 J | 20 J | 1,200 | 420 |

Notes:

All results rounded to two significant figures.

Fractional range does not have screening level or cleanup level criteria.

Abbreviations:

bgs Below ground surface
EPH Extractable petroleum hydrocarbons
ft Feet
mg/kg Milligrams per kilogram
VPH Volatile petroleum hydrocarbons

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JQ Concentration is an estimated value reported less than the associated quantitation limit but greater than the method detection limit.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

## Table 4.4
## RI Soil Analytical Results: EPH and VPH

| Location Area | | Former Fuel Loading Rack Area (cont.) | | | Former Mechanic's Shop | | Monitoring Wells MW-26 and MW-28 | | | | Northern Portion of the Former Standard Pipelines | Southern Pipelines and Berths |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | OIP-39 | OIP-15 | | GP-27 | OIP-20 | OIP-30 | OIP-23 | | | MW-39 | GP-18 |
| Sample Name | | OIP-39-16.5-17 | OIP-15-15-16 | OIP-15-20-21 | GP-27-14-14.5 | OIP-20-11-11.5 | OIP30-20-21-111919 | OIP-23-14-15 | OIP-23-19-20 | OIP-23-23-24 | MW-39-13-14 | GP-18-27-28 |
| Sample Date | | 3/10/2020 | 3/12/2020 | 3/12/2020 | 9/18/2015 | 3/13/2020 | 11/19/2019 | 3/10/2020 | 3/10/2020 | 3/10/2020 | 3/12/2020 | 9/16/2015 |
| Depth Range (ft bgs) | | 16.5–17 | 15–16 | 20–21 | 14–14.5 | 11–11.5 | 20–21 | 14–15 | 19–20 | 23–24 | 13–14 | 27–28 |
| **Analyte** | **Unit** | | | | | | | | | | | |
| **Petroleum Fractionation Data** | | | | | | | | | | | | |
| EPH Aliphatic C8-C10 | mg/kg | 37 J | 23 UJ | 26 UJ | 9.4 | 71 J | 33 J | 140 J | 620 J | 70 J | 200 J | 7.7 |
| EPH Aliphatic C10-C12 | mg/kg | 12 U | 150 | 13 U | 150 JQ | 64 | 150 | 630 | 2,800 | 300 | 890 | 75 JQ |
| EPH Aliphatic C12-C16 | mg/kg | 12 U | 1,100 | 13 U | 950 | 32 | 1,300 | 2,900 | 12,000 | 1,600 | 4,300 | 370 JQ |
| EPH Aliphatic C16-C21 | mg/kg | 12 U | 1,100 | 13 U | 1,100 | 14 U | 1,700 | 3,100 | 11,000 | 1,800 | 4,600 | 390 JQ |
| EPH Aliphatic C21-C34 | mg/kg | 12 U | 310 J | 13 U | 880 | 14 U | 2,000 | 470 J | 1,600 J | 260 J | 630 J | 370 JQ |
| EPH Aromatic C8-C10 | mg/kg | 12 UJ | 11 UJ | 13 UJ | 6.8 U | 14 UJ | 16 J | 13 UJ | 44 J | 12 UJ | 10 UJ | 5.9 U |
| EPH Aromatic C10-C12 | mg/kg | 12 U | 11 U | 13 U | 49 | 130 | 56 | 98 | 480 | 49 | 130 | 28 |
| EPH Aromatic C12-C16 | mg/kg | 12 U | 120 | 13 U | 580 JQ | 110 | 560 | 910 | 3,600 | 490 | 1,000 | 330 JQ |
| EPH Aromatic C16-C21 | mg/kg | 12 U | 740 | 13 U | 1,900 | 20 | 1,700 | 2,700 | 9,500 | 1,500 | 3,300 | 1,000 |
| EPH Aromatic C21-C34 | mg/kg | 12 U | 270 | 13 U | 1,300 | 20 | 2,300 | 320 | 910 | 160 | 410 | 920 |
| VPH Aliphatic C5-C6 | mg/kg | 1.3 U | 1.1 U | 1.8 U | 2.3 U | 1.7 U | 1.6 U | 17 U | 16 U | 27 U | 15 U | 2.6 U |
| VPH Aliphatic C6-C8 | mg/kg | 2.1 | 1.6 U | 2.5 U | 2.3 U | 26 | 6.2 | 24 U | 39 | 38 U | 33 | 2.6 U |
| VPH Aliphatic C8-C10 | mg/kg | 1.0 U | 0.88 U | 1.4 U | 2.3 U | 56 | 9.5 | 35 | 65 | 22 U | 57 | 2.6 U |
| VPH Aliphatic C10-C12 | mg/kg | 1.1 U | 13 | 1.5 U | 7.7 | 120 | 39 | 110 | 310 | 84 | 260 | 12 |
| VPH Aromatic C8-C10 | mg/kg | 2.2 U | 1.9 U | 3.1 U | 11 | 51 | 18 | 34 J | 110 J | 46 U | 63 | 8.1 |
| VPH Aromatic C10-C12 | mg/kg | 0.85 | 31 | 0.61 U | 29 J | 270 | 44 | 470 | 1,000 | 320 | 520 | 23 J |
| VPH Aromatic C12-C13 | mg/kg | 5.2 U | 200 | 7.1 U | 56 | 280 | 140 | 900 J | 4,000 | 1,700 J | 2,700 J | 48 |

Notes:

All results rounded to two significant figures.

Fractional range does not have screening level or cleanup level criteria.

Abbreviations:

bgs Below ground surface
EPH Extractable petroleum hydrocarbons
ft Feet
mg/kg Milligrams per kilogram
VPH Volatile petroleum hydrocarbons

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JQ Concentration is an estimated value reported below the associated quantitation limit but above the MDL.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

## Table 4.5
## OIP Fluorescence Percentage and Thickness

| OIP Location | Maximum Fluorescence Response (%) | Depth of Maximum Detection (ft bgs) | Thickness (ft) | Approximate Depth Range of Maximum Percentage (ft bgs) | Soil Analytical Data in mg/kg [1] | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | GRO (30) | DRO (2,000) | ORO (2,000) | Sample Depth (ft bgs) |
| OIP-02 | 1.4 | 2.65 | 0.25 | 2.5–2.75 | -- | 1,900 | **3,400** | 5 |
| OIP-04 | 0.5 | 1 | 0.1 | 0.9–1.0 | -- | -- | -- | 4 |
| OIP-05 | 0 | -- | -- | -- | -- | -- | -- | 27 |
| OIP-06 | 0 | -- | -- | -- | -- | -- | -- | 27 |
| OIP-08 | 89.1 | 21.75 | 8.85 | 13.6–22.45 | **4,900** | **12,000** | 1,000 | 19 |
| OIP-09 [2] | 64 | 17.65 | 0.65 | 17.6–18.25 | 18 | 280 | -- | 19.5 |
| OIP-15 | 100 | 15 | 2 | 14.5–15.3; 20.6–21.6 | **35** | **2,300** | 370 | 15 |
| | | | | | -- | -- | -- | 20 |
| OIP-18 | 0 | -- | -- | -- | -- | -- | -- | 19 |
| OIP-19 | 0 | -- | -- | -- | -- | -- | -- | 19 |
| OIP-20 | 71.4 | 11.3 | 0.25 | 11.2–11.45 | **630** | 440 | -- | 11 |
| OIP-21 | 0 | -- | -- | -- | -- | -- | -- | 18 |
| OIP-23 | 100 | 12.7 | 12 | 11.8–23.8 | **420** | **13,000** | -- | 14 |
| | | | | | **790** | **48,000** | 1,300 | 19 |
| | | | | | **200** | **5,700** | -- | 23 |
| | | | | | -- | -- | -- | 29.5 |
| OIP-30 | 74.1 | 18.35 | 0.8 | 18–18.8 | **61** | **11,000** | **12,000** | 20 |
| OIP-31 | 0 | -- | -- | -- | -- | -- | -- | 17 |
| | | | | | -- | -- | -- | 20 |
| OIP-39 | 83.5 | 16.85 | 1 | 15–15.3; 16.5–17.3 | 7.3 | -- | -- | 16.5 |
| OIP-42 | 89.9 | 16.15 | 3.3 | 15.8–19.1 | **3,600** | **17,000** | 1,500 | 17 |
| OIP-46 | 14.9 | 12.05 | 0.25 | 12–12.25 | -- | -- | -- | 10 |
| OIP-47 | 90.2 | 11.7 | 6.4 | 10.1–12.0; 15.5–19 | **5,700** | 210 | -- | 11 |
| | | | | | **49** | 360 | -- | 17 |
| | | | | | -- | -- | -- | 25 |
| OIP-49 | 77.4 | 18.1 | 0.8 | 10.7–11.2; 18–18.3 | 22 | -- | 360 | 10 |
| | | | | | **960** | -- | -- | 17 |
| OIP-52 | 99.7 | 19.4 | 3 | 13.5–15.5; 19.4–20; 22–22.4 | **86** | 530 | -- | 19 |
| | | | | | **260** | **2,200** | -- | 22 |
| OIP-53 | 0 | -- | -- | -- | -- | -- | -- | 22 |
| OIP-54 | 0 | -- | -- | -- | -- | -- | 660 | 15 |
| OIP-57 | 3.7 | 0.5 | 0.5 | 0.2–0.7 | -- | -- | -- | 14 |
| OIP-64 | 0 | -- | -- | -- | -- | -- | -- | 14 |
| OIP-66 | 77.8 | 12.05 | 0.3 | 11.9–12.2 | **2,000** | 760 | -- | 12 |
| OIP-67 | 79.9 | 12.8 | 7.8 | 7.4–15.2 | -- | -- | -- | 7 |
| | | | | | **1,500** | **4,300** | -- | 11 |
| | | | | | **2,200** | **2,100** | -- | 14.5 |
| | | | | | -- | -- | -- | 18 |
| OIP-68 | 0 | -- | -- | -- | -- | -- | -- | 10 |
| | | | | | -- | -- | -- | 13.5 |
| OIP-69 | 0 | -- | -- | -- | -- | -- | -- | 11 |
| | | | | | -- | -- | -- | 14.5 |
| OIP-70 | 0 | -- | -- | -- | -- | -- | -- | 8 |
| | | | | | -- | -- | -- | 12 |
| OIP-72 | 84.7 | 10.2 | 0.8 | 10–10.8 | **520** | -- | -- | 10 |
| | | | | | **270** | -- | -- | 16 |
| OIP-73 | 55 | 0.3 | 0.1 | 0.05 | -- | -- | -- | 9 |
| | | | | | -- | -- | -- | 13 |

Notes:

-- Not applicable or not detected at or greater than laboratory detection limit.

**BOLD RED** Concentration exceeds respective MTCA Method A screening levels for soil; MTCA Method A is used only as a screening level and to compare concentrations with fluorescence response.

1 This table is used to show correlation between fluorescence response and select soil analytical data; refer to Tables 4.1 through 4.3 for details and complete soil laboratory results. Screening levels are presented in parentheses.

2 Fluorescence response results are compared to GP-01 soil analytical results due to their collocation.

Abbreviations:

bgs Below ground surface
DRO Diesel-range organics
ft Feet
GRO Gasoline-range organics
mg/kg Milligrams per kilogram
MTCA Model Toxics Control Act
OIP Optical image profiler
ORO Oil-range organics

# Table 4.6
## RI Groundwater Analytical Results: TPH, BTEX, and PAHs

| | | | Location Area | 2015 Data Gaps Investigation | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Location Name | GP-1 | GP-2 | GP-3 | GP-4 | GP-6 | GP-7 | GP-8 | GP-13 | GP-14 | GP-15 | GP-16 | GP-17 | GP-20 | GP-21 | GP-28 |
| | | | Sample Name | GP-1-GW | GP-2-GW | GP-3-GW | GP-4-GW | GP-6-GW | GP-7-GW | GP-8-GW | GP-13-GW | GP-14-GW | GP-15-GW | GP-16-GW | GP-17-GW | GP-20-GW | GP-21-GW | GP-28-GW |
| | | | Sample Date | 9/15/2015 | 9/15/2015 | 9/15/2015 | 9/15/2015 | 9/15/2015 | 9/15/2015 | 9/15/2015 | 9/16/2015 | 9/16/2015 | 9/16/2015 | 9/16/2015 | 9/17/2015 | 9/17/2015 | 9/17/2015 | 9/18/2015 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | | | | |
| **Total Petroleum Hydrocarbons by NWTPH-Gx and NWTPH-Dx** | | | | | | | | | | | | | | | | | | |
| Gasoline-range organics | 800 | µg/L | | 290 | 310 | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U |
| Diesel-range organics | 500 | µg/L | | **820 JM** | **1,100 JM** | 50 U | 110 JM | **600 JM** | 50 U | 50 U | 180 JM | 100 JM | 50 U | 50 U | 68 JM | 50 U | 50 U | 50 U |
| Oil-range organics | 500 | µg/L | | 250 U | 250 U | 250 U | 250 U | 290 JM | 250 U | 250 U | 250 U | 250 U | 250 U | 250 U | 250 U | 250 U | 250 U | 250 U |
| Total DRO and ORO | 500 | µg/L | | **820** | **1,100** | 250 U | 110 | **900** | 250 U | 250 U | 180 | 100 | 250 U | 250 U | 68 | 250 U | 250 U | 250 U |
| **Total Petroleum Hydrocarbons by NWTPH-Dx Sg** | | | | | | | | | | | | | | | | | | |
| Diesel-range organics | 500 | µg/L | | | | | | | | | | | | | | | | |
| Oil-range organics | 500 | µg/L | | | | | | | | | | | | | | | | |
| Total DRO and ORO | 500 | µg/L | | | | | | | | | | | | | | | | |
| **BTEX Compounds by USEPA 8021B/8260D** | | | | | | | | | | | | | | | | | | |
| Benzene | 5.0 | µg/L | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Ethylbenzene | 700 | µg/L | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Toluene | 1,000 | µg/L | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.1 | 1.0 U | 1.0 U | 1.1 | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (meta & para) | -- | µg/L | | | | | | | | | | | | | | | | |
| Xylene (ortho) | -- | µg/L | | | | | | | | | | | | | | | | |
| Xylene (total) | 1,000 | µg/L | | 3.0 U | 3.0 U | 3.0 U | 3.0 U | 3.0 U | 3.0 U | 3.0 U | 3.0 U | 3.0 U | 3.0 U | 3.0 U | 3.0 U | 3.0 U | 3.0 U | 3.0 U |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | µg/L | | | | | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | µg/L | | | | | | | | | | | | | | | | |
| Total HPAH | -- | µg/L | | | | | | | | | | | | | | | | |
| Total LPAH | -- | µg/L | | | | | | | | | | | | | | | | |
| Total PAH | -- | µg/L | | | | | | | | | | | | | | | | |
| 1-Methylnaphthalene | -- | µg/L | | | | | | | | | | | | | | | | |
| 2-Methylnaphthalene | -- | µg/L | | | | | | | | | | | | | | | | |
| Acenaphthene | -- | µg/L | | | | | | | | | | | | | | | | |
| Acenaphthylene | -- | µg/L | | | | | | | | | | | | | | | | |
| Anthracene | -- | µg/L | | | | | | | | | | | | | | | | |
| Benzo(a)anthracene | -- | µg/L | | | | | | | | | | | | | | | | |
| Benzo(a)pyrene | -- | µg/L | | | | | | | | | | | | | | | | |
| Benzo(b)fluoranthene | -- | µg/L | | | | | | | | | | | | | | | | |
| Benzo(g,h,i)perylene | -- | µg/L | | | | | | | | | | | | | | | | |
| Benzo(k)fluoranthene | -- | µg/L | | | | | | | | | | | | | | | | |
| Chrysene | -- | µg/L | | | | | | | | | | | | | | | | |
| Dibenzo(a,h)anthracene | -- | µg/L | | | | | | | | | | | | | | | | |
| Fluoranthene | -- | µg/L | | | | | | | | | | | | | | | | |
| Fluorene | -- | µg/L | | | | | | | | | | | | | | | | |
| Hexachlorobutadiene | -- | µg/L | | | | | | | | | | | | | | | | |
| Indeno(1,2,3-c,d)pyrene | -- | µg/L | | | | | | | | | | | | | | | | |
| Naphthalene | -- | µg/L | | | | | | | | | | | | | | | | |
| Phenanthrene | -- | µg/L | | | | | | | | | | | | | | | | |
| Pyrene | -- | µg/L | | | | | | | | | | | | | | | | |

Notes:

Blank cells are intentional.
All results rounded to two significant figures.
Some wells were not samples each quarter due to accessibility, insufficient volume of groundwater, or presence of LNAPL, or were removed from the sampling program after the August 2020 sampling event. For additional details, refer to Section 4.3.
-- Not established.
**BOLD RED** Result exceeds screening level.
***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.
1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.
2 The laboratory noted that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.
3 Xylene (total) result is a calculated value.
4 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

AST Aboveground storage tank
BTEX Benzene, toluene, ethylbenzene, and xylenes
cPAH Carcinogenic polycyclic aromatic hydrocarbon
HPAH High molecular weight polycyclic aromatic hydrocarbon
LNAPL Light non-aqueous phase liquid
LPAH Low molecular weight polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
PAH Polycyclic aromatic hydrocarbon
TEQ Toxic equivalent
UST Underground storage tank

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JM Concentration is estimated due to poor match to standard.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

# Table 4.6
## RI Groundwater Analytical Results: TPH, BTEX, and PAHs

| Location Area | | | Former 80,000-Barrel AST | | | | | | | | | Former Calloway Ross Parcel | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | OIP-02 | | OIP-04 | MW-32 | | | T-2 | | | OIP-67 | OIP-68 | MW-02 | |
| Sample Name | | | OIP-02-GW-14.5-19.5 | OIP-02-GW-14.5-19.5D | OIP-04-GW-15-20 | MW-32-022819 | MW-32-050720 | MW-32-081120 | T-2-081120 | T-2-110220 | T-2-022321 | OIP-67-GW-14-19 | OIP-68-GW-13-18 | MW-02-022719 | MW-02-050620 |
| Sample Date | | | 3/11/2020 | 3/11/2020 | 3/10/2020 | 2/28/2019 | 5/7/2020 | 8/11/2020 | 8/11/2020 | 11/2/2020 | 2/23/2021 | 3/12/2020 | 3/11/2020 | 2/27/2019 | 5/6/2020 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | |
| **Total Petroleum Hydrocarbons by NWTPH-Gx and NWTPH-Dx** | | | | | | | | | | | | | | | |
| Gasoline-range organics | 800 | µg/L | 100 U | 100 U | 130 | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | **3,200** | **860** | 100 U | 100 U |
| Diesel-range organics | 500 | µg/L | 110 [2] | 94 [2] | **660** [2] | 60 U | 50 U | 50 U | 50 U | 50 U | 54 [2] | **2,000** | **900** [2] | 60 U | 310 [2] |
| Oil-range organics | 500 | µg/L | 250 U | 250 U | **870** [2] | 300 U | 250 U | 250 U | 250 U | 250 U | 250 U | 250 U | 290 [2] | 300 U | 250 U |
| Total DRO and ORO | 500 | µg/L | 110 [2] | 94 [2] | **1,500** [2] | 300 U | 250 U | 250 U | 250 U | 250 U | 54 [2] | **2,000** | **1,200** [2] | 300 U | 310 [2] |
| **Total Petroleum Hydrocarbons by NWTPH-Dx Sg** | | | | | | | | | | | | | | | |
| Diesel-range organics | 500 | µg/L | | | | 60 U | | | | | | | | 60 U | |
| Oil-range organics | 500 | µg/L | | | | 300 U | | | | | | | | 300 U | |
| Total DRO and ORO | 500 | µg/L | | | | 300 U | | | | | | | | 300 U | |
| **BTEX Compounds by USEPA 8021B/8260D** | | | | | | | | | | | | | | | |
| Benzene | 5.0 | µg/L | 0.35 U | 0.35 U | 0.35 U | 1.0 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 1.3 | 0.35 U | 1.0 U | 0.35 U |
| Ethylbenzene | 700 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.3 | 1.0 U | 1.0 U | 1.0 U |
| Toluene | 1,000 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 2.3 | 1.0 U | 1.0 U | 1.0 U |
| Xylene (meta & para) | -- | µg/L | 2.0 U | 2.0 U | 2.0 U | | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.2 | 2.0 U | | 2.0 U |
| Xylene (ortho) | -- | µg/L | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U |
| Xylene (total) | 10,000 | µg/L | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.2 [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | µg/L | 0.030 U | 0.030 U | 0.030 U | | 0.030 U | 0.0302 U | 0.0302 U | | | 0.030 UJ | 0.030 U | | 0.030 U |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | µg/L | 0 U [4] | 0 U [4] | 0 U [4] | | 0 U [4] | 0 U [4] | 0 U [4] | | | 0 UJ [4] | 0 U [4] | | 0 U [4] |
| Total HPAH | -- | µg/L | | | | | 0.040 U | | | | | | | | 0.040 U |
| Total LPAH | -- | µg/L | | | | | 0.40 UJ | | | | | | | | 0.40 UJ |
| Total PAH | -- | µg/L | | | | | 0.40 UJ | | | | | | | | 0.40 UJ |
| 1-Methylnaphthalene | -- | µg/L | | | | | 0.40 U | | | | | | | | 0.40 U |
| 2-Methylnaphthalene | -- | µg/L | | | | | 0.40 U | | | | | | | | 0.40 U |
| Acenaphthene | -- | µg/L | | | | | 0.040 U | | | | | | | | 0.040 U |
| Acenaphthylene | -- | µg/L | | | | | 0.040 U | | | | | | | | 0.040 U |
| Anthracene | -- | µg/L | | | | | 0.040 U | | | | | | | | 0.040 U |
| Benzo(a)anthracene | -- | µg/L | 0.040 U | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | 0.040 U |
| Benzo(a)pyrene | -- | µg/L | 0.040 U | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | 0.040 U | | | 0.040 UJ | 0.040 U | | 0.040 U |
| Benzo(b)fluoranthene | -- | µg/L | 0.040 U | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | 0.040 U |
| Benzo(g,h,i)perylene | -- | µg/L | | | | | 0.040 U | | | | | | | | 0.040 U |
| Benzo(k)fluoranthene | -- | µg/L | 0.040 U | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | 0.040 U |
| Chrysene | -- | µg/L | 0.040 U | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | 0.040 U |
| Dibenzo(a,h)anthracene | -- | µg/L | 0.040 U | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | 0.040 U | | | 0.040 UJ | 0.040 U | | 0.040 U |
| Fluoranthene | -- | µg/L | | | | | 0.040 U | | | | | | | | 0.040 U |
| Fluorene | -- | µg/L | | | | | 0.040 UJ | | | | | | | | 0.040 UJ |
| Hexachlorobutadiene | -- | µg/L | | | | | | | 1.0 U | | | | | | |
| Indeno(1,2,3-c,d)pyrene | -- | µg/L | 0.040 U | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | 0.040 U |
| Naphthalene | -- | µg/L | 1.0 U | 1.0 U | 1.0 U | | 0.40 U | | 1.0 U | | | 1.0 U | 1.0 U | | 0.40 U |
| Phenanthrene | -- | µg/L | | | | | 0.060 U | | | | | | | | 0.060 U |
| Pyrene | -- | µg/L | | | | | 0.040 U | | | | | | | | 0.040 U |

Notes:

Blank cells are intentional.
All results rounded to two significant figures.
Some wells were not samples each quarter due to accessibility, insufficient volume of groundwater, or presence of LNAPL, or were removed from the sampling program after the August 2020 sampling event. For additional details, refer to Section 4.3.
-- Not established.
**BOLD RED** Result exceeds screening level.
***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.
1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.
2 The laboratory noted that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.
3 Xylene (total) result is a calculated value.
4 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

AST Aboveground storage tank
BTEX Benzene, toluene, ethylbenzene, and xylenes
cPAH Carcinogenic polycyclic aromatic hydrocarbon
HPAH High molecular weight polycyclic aromatic hydrocarbon
LNAPL Light non-aqueous phase liquid
LPAH Low molecular weight polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
PAH Polycyclic aromatic hydrocarbon
TEQ Toxic equivalent
UST Underground storage tank

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JM Concentration is estimated due to poor match to standard.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

# Table 4.6
## RI Groundwater Analytical Results: TPH, BTEX, and PAHs

| Location Area | | | Former Calloway Ross Parcel (cont.) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | MW-02 (cont.) | | | MW-03 | | | | | | MW-05 | | MW-08 | | | |
| Sample Name | | | MW-02-081020 | MW-02-110220 | MW-02-022321 | MW-03-022719 | MW-03-050620 | MW-03-081020 | MW-03-110220 | MW-03-022321 | MW-103-022321 | MW-05-022719 | MW-05-022421 | MW-08-050620 | MW-08-081020 | MW-08-110220 | MW-08-022321 |
| Sample Date | | | 8/10/2020 | 11/2/2020 | 2/23/2021 | 2/27/2019 | 5/6/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 | 2/23/2021 | 2/27/2019 | 2/24/2021 | 5/6/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | | | |
| **Total Petroleum Hydrocarbons by NWTPH-Gx and NWTPH-Dx** | | | | | | | | | | | | | | | | | |
| Gasoline-range organics | 800 | µg/L | 100 U | 100 U | 100 U | **960** | 260 | 570 | 370 | **950** | **870** | 100 U | 100 U | **2,300** | **3,000** | **2,500** | **2,900** |
| Diesel-range organics | 500 | µg/L | **640** [2] | **630** [2] | 110 [2] | **1,700** [2] | **1,500** [2] | **1,100** [2] | **1,000** [2] | **1,200** [2] | **1,200** [2] | 82 [2] | **790** [2] | **2,100** [2] | **2,400** [2] | **2,100** [2] | **2,200** [2] |
| Oil-range organics | 500 | µg/L | 330 [2] | 460 [2] | 250 U | 450 [2] | **590** [2] | 410 [2] | **620** [2] | **550** [2] | **550** [2] | 300 U | **520** [2] | 280 [2] | 370 [2] | 370 [2] | 480 [2] |
| Total DRO and ORO | 500 | µg/L | **970** [2] | **1,100** [2] | 110 [2] | **2,200** [2] | **2,100** [2] | **1,500** [2] | **1,600** [2] | **1,800** [2] | **1,800** [2] | 82 [2] | **1,300** [2] | **2,400** [2] | **2,800** [2] | **2,500** [2] | **2,700** [2] |
| **Total Petroleum Hydrocarbons by NWTPH-Dx Sg** | | | | | | | | | | | | | | | | | |
| Diesel-range organics | 500 | µg/L | | | | 73 [2] | | | | | | 60 U | | | | | |
| Oil-range organics | 500 | µg/L | | | | 300 U | | | | | | 300 U | | | | | |
| Total DRO and ORO | 500 | µg/L | | | | 73 [2] | | | | | | 300 U | | | | | |
| **BTEX Compounds by USEPA 8021B/8260D** | | | | | | | | | | | | | | | | | |
| Benzene | 5.0 | µg/L | 0.35 U | 0.35 U | 0.35 U | **13** | 1.1 | 1.2 | 1.0 | 0.88 | 0.89 | 1.0 U | 0.35 U | 1.1 | 1.0 | 1.1 | 1.1 |
| Ethylbenzene | 700 | µg/L | 1.0 U | 1.0 U | 1.0 U | 5.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Toluene | 1,000 | µg/L | 1.0 U | 1.0 U | 1.0 U | 5.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 2.0 | 1.8 | 1.9 | 1.9 |
| Xylene (meta & para) | -- | µg/L | 2.0 U | 2.0 U | 2.0 U | | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | | 2.0 U | 2.7 | 3.2 | 2.6 | 2.3 |
| Xylene (ortho) | -- | µg/L | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (total) | 10,000 | µg/L | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 15 U | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] | 2.7 [3] | 3.2 [3] | 2.6 [3] | 2.3 [3] |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | µg/L | 0.030 U | | | | 0.030 U | 0.030 U | | | | | | 0.030 U | 0.038 U | | |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | µg/L | 0 U [4] | | | | 0 U [4] | 0 U [4] | | | | | | 0 U [4] | 0 U [4] | | |
| Total HPAH | -- | µg/L | | | | | 0.040 U | | | | | | | 0.040 U | | | |
| Total LPAH | -- | µg/L | | | | | 0.40 UJ | | | | | | | 2.2 J | | | |
| Total PAH | -- | µg/L | | | | | 0.40 UJ | | | | | | | 2.2 J | | | |
| 1-Methylnaphthalene | -- | µg/L | | | | | 0.40 U | | | | | | | 20 | | | |
| 2-Methylnaphthalene | -- | µg/L | | | | | 0.40 U | | | | | | | 0.40 U | | | |
| Acenaphthene | -- | µg/L | | | | | 0.040 U | | | | | | | 0.46 | | | |
| Acenaphthylene | -- | µg/L | | | | | 0.040 U | | | | | | | 0.040 U | | | |
| Anthracene | -- | µg/L | | | | | 0.040 U | | | | | | | 0.040 U | | | |
| Benzo(a)anthracene | -- | µg/L | 0.040 U | | | | 0.040 U | 0.040 U | | | | | | 0.040 U | 0.050 U | | |
| Benzo(a)pyrene | -- | µg/L | 0.040 U | | | | 0.040 U | 0.040 U | | | | | | 0.040 U | 0.050 U | | |
| Benzo(b)fluoranthene | -- | µg/L | 0.040 U | | | | 0.040 U | 0.040 U | | | | | | 0.040 U | 0.050 U | | |
| Benzo(g,h,i)perylene | -- | µg/L | | | | | 0.040 U | | | | | | | 0.040 U | | | |
| Benzo(k)fluoranthene | -- | µg/L | 0.040 U | | | | 0.040 U | 0.040 U | | | | | | 0.040 U | 0.050 U | | |
| Chrysene | -- | µg/L | 0.040 U | | | | 0.040 U | 0.040 U | | | | | | 0.040 U | 0.050 U | | |
| Dibenzo(a,h)anthracene | -- | µg/L | 0.040 U | | | | 0.040 U | 0.040 U | | | | | | 0.040 U | 0.050 U | | |
| Fluoranthene | -- | µg/L | | | | | 0.040 U | | | | | | | 0.040 U | | | |
| Fluorene | -- | µg/L | | | | | 0.040 UJ | | | | | | | 1.5 J | | | |
| Hexachlorobutadiene | -- | µg/L | | | | | | | | | | | | | | | |
| Indeno(1,2,3-c,d)pyrene | -- | µg/L | 0.040 U | | | | 0.040 U | 0.040 U | | | | | | 0.040 U | 0.050 U | | |
| Naphthalene | -- | µg/L | | | | | 0.40 U | 1.0 U | | | | | | 0.40 U | | | |
| Phenanthrene | -- | µg/L | | | | | 0.060 U | | | | | | | 0.28 | | | |
| Pyrene | -- | µg/L | | | | | 0.040 U | | | | | | | 0.040 U | | | |

Notes:

Blank cells are intentional.
All results rounded to two significant figures.
Some wells were not samples each quarter due to accessibility, insufficient volume of groundwater, or presence of LNAPL, or were removed from the sampling program after the August 2020 sampling event. For additional details, refer to Section 4.3.
-- Not established.
**BOLD RED** Result exceeds screening level.
***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.
1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.
2 The laboratory noted that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.
3 Xylene (total) result is a calculated value.
4 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

AST Aboveground storage tank
BTEX Benzene, toluene, ethylbenzene, and xylenes
cPAH Carcinogenic polycyclic aromatic hydrocarbon
HPAH High molecular weight polycyclic aromatic hydrocarbon
LNAPL Light non-aqueous phase liquid
LPAH Low molecular weight polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
PAH Polycyclic aromatic hydrocarbon
TEQ Toxic equivalent
UST Underground storage tank

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JM Concentration is estimated due to poor match to standard.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

# Table 4.6
## RI Groundwater Analytical Results: TPH, BTEX, and PAHs

| | | | Location Area | Former Calloway Ross Parcel (cont.) | | | | | Former Fuel Loading Rack Area | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Location Name | MW-10 | | | | | OIP-15 | MW-07 | | | | | | MW-11 | |
| | | | Sample Name | MW-10-022719 | MW-10-050620 | MW-10-081020 | MW-10-110220 | MW-10-022321 | OIP-15-GW-14-19 | MW-07-022719 | MW-07-050620 | MW-07-081120 | MW-107-081120 | MW-07-110220 | MW-07-022421 | MW-11-022819 | MW-11-050720 |
| | | | Sample Date | 2/27/2019 | 5/6/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 | 3/12/2020 | 2/27/2019 | 5/6/2020 | 8/11/2020 | 8/11/2020 | 11/2/2020 | 2/24/2021 | 2/28/2019 | 5/7/2020 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | | | |
| **Total Petroleum Hydrocarbons by NWTPH-Gx and NWTPH-Dx** | | | | | | | | | | | | | | | | | |
| Gasoline-range organics | 800 | µg/L | 100 U | 450 | **4,100** | **5,300** | **5,800** | 380 | **1,100** | 560 | **1,200** | **1,300** | 700 | 490 | 100 U | 100 U |
| Diesel-range organics | 500 | µg/L | 60 U | 340 [2] | **1,400** [2] | **1,900** [2] | **1,600** [2] | **1,300** | **780** [2] | **820** | **1,200** | **1,200** | **750** | **590** | 60 U | 66 [2] |
| Oil-range organics | 500 | µg/L | 300 U | 250 U | 250 U | 250 U | 250 U | 380 [2] | 300 U | 250 U | 250 U | 250 U | 250 U | 250 U | 300 U | 250 U |
| Total DRO and ORO | 500 | µg/L | 300 U | 340 [2] | **1,400** [2] | **1,900** [2] | **1,600** [2] | **1,700** [2] | **780** [2] | **820** | **1,200** | **1,200** | **750** | **590** | 300 U | 66 [2] |
| **Total Petroleum Hydrocarbons by NWTPH-Dx Sg** | | | | | | | | | | | | | | | | | |
| Diesel-range organics | 500 | µg/L | 60 U | | | | | | 340 [2] | | | | | | 60 U | |
| Oil-range organics | 500 | µg/L | 300 U | | | | | | 300 U | | | | | | 300 U | |
| Total DRO and ORO | 500 | µg/L | 300 U | | | | | | 340 [2] | | | | | | 300 U | |
| **BTEX Compounds by USEPA 8021B/8260D** | | | | | | | | | | | | | | | | | |
| Benzene | 5.0 | µg/L | 1.1 | **42** | **120** | **170** | **180** | 0.35 U | 2.0 | 0.45 | 0.56 | 0.58 | 0.35 U | 0.35 U | 1.0 U | 0.35 U |
| Ethylbenzene | 700 | µg/L | 1.0 U | 7.6 | 60 | 83 | 68 | 1.0 U | 2.2 | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Toluene | 1,000 | µg/L | 1.0 U | 5.0 | 19 | 28 | 31 | 1.0 U | 9.2 | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (meta & para) | -- | µg/L | | 2.5 | 20 | 38 | 45 | 2.0 U | | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | | 2.0 U |
| Xylene (ortho) | -- | µg/L | | 1.0 U | 1.0 U | 1.0 U | 1.1 | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U |
| Xylene (total) | 10,000 | µg/L | 3.0 U | 2.5 [3] | 20 [3] | 38 [3] | 46 [3] | 2.0 U [3] | 6.0 | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | µg/L | | 0.030 U | 0.030 U | | | 0.030 U | | 0.030 U | 0.030 U | 0.030 U | | | | 0.030 U |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | µg/L | | 0 U [4] | 0 U [4] | | | 0 U [4] | | 0 U [4] | 0 U [4] | 0 U [4] | | | | 0 U [4] |
| Total HPAH | -- | µg/L | | 0.040 U | | | | | | 0.040 U | | | | | | 0.040 U |
| Total LPAH | -- | µg/L | | 0.075 J | | | | | | 0.40 UJ | | | | | | 0.40 UJ |
| Total PAH | -- | µg/L | | 0.075 J | | | | | | 0.40 UJ | | | | | | 0.40 UJ |
| 1-Methylnaphthalene | -- | µg/L | | 2.1 | | | | | | 0.40 U | | | | | | 0.40 U |
| 2-Methylnaphthalene | -- | µg/L | | 0.40 U | | | | | | 0.40 U | | | | | | 0.40 U |
| Acenaphthene | -- | µg/L | | 0.040 U | | | | | | 0.040 U | | | | | | 0.040 U |
| Acenaphthylene | -- | µg/L | | 0.040 U | | | | | | 0.040 U | | | | | | 0.040 U |
| Anthracene | -- | µg/L | | 0.040 U | | | | | | 0.040 U | | | | | | 0.040 U |
| Benzo(a)anthracene | -- | µg/L | | 0.040 U | 0.040 U | | | 0.040 U | | 0.040 U | 0.040 U | 0.040 U | | | | 0.040 U |
| Benzo(a)pyrene | -- | µg/L | | 0.040 U | 0.040 U | | | 0.040 U | | 0.040 U | 0.040 U | 0.040 U | | | | 0.040 U |
| Benzo(b)fluoranthene | -- | µg/L | | 0.040 U | 0.040 U | | | 0.040 U | | 0.040 U | 0.040 U | 0.040 U | | | | 0.040 U |
| Benzo(g,h,i)perylene | -- | µg/L | | 0.040 U | | | | | | 0.040 U | | | | | | 0.040 U |
| Benzo(k)fluoranthene | -- | µg/L | | 0.040 U | 0.040 U | | | 0.040 U | | 0.040 U | 0.040 U | 0.040 U | | | | 0.040 U |
| Chrysene | -- | µg/L | | 0.040 U | 0.040 U | | | 0.040 U | | 0.040 U | 0.040 U | 0.040 U | | | | 0.040 U |
| Dibenzo(a,h)anthracene | -- | µg/L | | 0.040 U | 0.040 U | | | 0.040 U | | 0.040 U | 0.040 U | 0.040 U | | | | 0.040 U |
| Fluoranthene | -- | µg/L | | 0.040 U | | | | | | 0.040 U | | | | | | 0.040 U |
| Fluorene | -- | µg/L | | 0.075 J | | | | | | 0.040 UJ | | | | | | 0.040 UJ |
| Hexachlorobutadiene | -- | µg/L | | 1.0 U | 1.0 U | | | | | | | | | | | |
| Indeno(1,2,3-c,d)pyrene | -- | µg/L | | 0.040 U | 0.040 U | | | 0.040 U | | 0.040 U | 0.040 U | 0.040 U | | | | 0.040 U |
| Naphthalene | -- | µg/L | | 0.40 U | 1.0 U | | | 1.0 U | | 0.40 U | 1.0 U | 1.0 U | | | | 0.40 U |
| Phenanthrene | -- | µg/L | | 0.060 U | | | | | | 0.060 U | | | | | | 0.060 U |
| Pyrene | -- | µg/L | | 0.040 U | | | | | | 0.040 U | | | | | | 0.040 U |

Notes:

Blank cells are intentional.
All results rounded to two significant figures.
Some wells were not samples each quarter due to accessibility, insufficient volume of groundwater, or presence of LNAPL, or were removed from the sampling program after the August 2020 sampling event. For additional details, refer to Section 4.3.
-- Not established.
**BOLD RED** Result exceeds screening level.
***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.
1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.
2 The laboratory noted that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.
3 Xylene (total) result is a calculated value.
4 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

AST Aboveground storage tank
BTEX Benzene, toluene, ethylbenzene, and xylenes
cPAH Carcinogenic polycyclic aromatic hydrocarbon
HPAH High molecular weight polycyclic aromatic hydrocarbon
LNAPL Light non-aqueous phase liquid
LPAH Low molecular weight polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
PAH Polycyclic aromatic hydrocarbon
TEQ Toxic equivalent
UST Underground storage tank

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JM Concentration is estimated due to poor match to standard.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

# Table 4.6
## RI Groundwater Analytical Results: TPH, BTEX, and PAHs

| Location Area | | | Former Fuel Loading Rack Area (cont.) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | MW-12 | | | | | MW-13 | | | MW-14 | | | | | MW-15 | |
| Sample Name | | | MW-12-022719 | MW-12-050720 | MW-12-081120 | MW-12-110320 | MW-12-022321 | MW-13-022819 | MW-13-050720 | MW-13-081020 | MW-14-022719 | MW-14-050720 | MW-14-081120 | MW-14-110220 | MW-14-022421 | MW-15-022719 | MW-15-050720 |
| Sample Date | | | 2/27/2019 | 5/7/2020 | 8/11/2020 | 11/3/2020 | 2/23/2021 | 2/28/2019 | 5/7/2020 | 8/10/2020 | 2/27/2019 | 5/7/2020 | 8/11/2020 | 11/2/2020 | 2/24/2021 | 2/27/2019 | 5/7/2020 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | | | |
| **Total Petroleum Hydrocarbons by NWTPH-Gx and NWTPH-Dx** | | | | | | | | | | | | | | | | | |
| Gasoline-range organics | 800 | µg/L | 600 | 470 | **7,100** | **5,500** | **4,900** | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 140 |
| Diesel-range organics | 500 | µg/L | 490 [2] | 130 [2] | **2,100** | **1,900** [2] | **1,100** [2] | 60 U | 50 U | 60 [2] | 150 [2] | 120 [2] | 230 [2] | 80 [2] | 50 U | 78 [2] | **510** [2] |
| Oil-range organics | 500 | µg/L | 300 U | 250 U | 250 U | 250 U | 250 U | 300 U | 250 U | 250 U | 300 U | 250 U | 250 U | 250 U | 250 U | 300 U | 250 U |
| Total DRO and ORO | 500 | µg/L | 490 [2] | 130 [2] | **2,100** [2] | **1,900** [2] | **1,100** [2] | 300 U | 250 U | 60 [2] | 150 [2] | 120 [2] | 230 [2] | 80 [2] | 250 U | 78 [2] | **510** [2] |
| **Total Petroleum Hydrocarbons by NWTPH-Dx Sg** | | | | | | | | | | | | | | | | | |
| Diesel-range organics | 500 | µg/L | 100 [2] | | | | | 60 U | | | 81 | | | | | 60 U | |
| Oil-range organics | 500 | µg/L | 300 U | | | | | 300 U | | | 300 U | | | | | 300 U | |
| Total DRO and ORO | 500 | µg/L | 100 [2] | | | | | 300 U | | | 81 | | | | | 300 U | |
| **BTEX Compounds by USEPA 8021B/8260D** | | | | | | | | | | | | | | | | | |
| Benzene | 5.0 | µg/L | **61** | **81** | **910** | **620** | **180** | 1.0 U | 0.35 U | 0.35 U | 1.0 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 1.0 U | 0.35 U |
| Ethylbenzene | 700 | µg/L | 3.5 | 2.0 | 46 | 39 | 36 | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Toluene | 1,000 | µg/L | 6.4 | 2.8 | 42 | 39 | 23 | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (meta & para) | -- | µg/L | | 3.6 | 57 | 62 | 38 | | 2.0 U | 2.0 U | | 2.0 U | 2.0 U | 2.0 U | 2.0 U | | 2.0 U |
| Xylene (ortho) | -- | µg/L | | 1.0 U | 1.3 | 1.4 | 1.0 | | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U |
| Xylene (total) | 10,000 | µg/L | 6.2 | 3.6 [3] | 58 [3] | 63 [3] | 39 [3] | 3.0 U | 2.0 U [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | µg/L | | 0.030 U | 0.030 U | | | | 0.030 U | 0.030 U | | 0.030 U | 0.030 U | | | | 0.030 U |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | µg/L | | 0 U [4] | 0 U [4] | | | | 0 U [4] | 0 U [4] | | 0 U [4] | 0 U [4] | | | | 0 U [4] |
| Total HPAH | -- | µg/L | | 0.040 U | | | | | 0.040 U | | | 0.040 U | | | | | 0.040 U |
| Total LPAH | -- | µg/L | | 0.40 UJ | | | | | 0.40 UJ | | | 0.40 UJ | | | | | 0.66 J |
| Total PAH | -- | µg/L | | 0.40 UJ | | | | | 0.40 UJ | | | 0.40 UJ | | | | | 0.66 J |
| 1-Methylnaphthalene | -- | µg/L | | 0.40 U | | | | | 0.40 U | | | 0.40 U | | | | | 0.40 U |
| 2-Methylnaphthalene | -- | µg/L | | 0.40 U | | | | | 0.40 U | | | 0.40 U | | | | | 0.40 U |
| Acenaphthene | -- | µg/L | | 0.040 U | | | | | 0.040 U | | | 0.040 U | | | | | 0.38 |
| Acenaphthylene | -- | µg/L | | 0.040 U | | | | | 0.040 U | | | 0.040 U | | | | | 0.040 U |
| Anthracene | -- | µg/L | | 0.040 U | | | | | 0.040 U | | | 0.040 U | | | | | 0.040 U |
| Benzo(a)anthracene | -- | µg/L | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U |
| Benzo(a)pyrene | -- | µg/L | | 0.040 UJ | 0.040 U | | | | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U |
| Benzo(b)fluoranthene | -- | µg/L | | 0.040 UJ | 0.040 U | | | | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U |
| Benzo(g,h,i)perylene | -- | µg/L | | 0.040 UJ | | | | | 0.040 U | | | 0.040 U | | | | | 0.040 U |
| Benzo(k)fluoranthene | -- | µg/L | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U |
| Chrysene | -- | µg/L | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U |
| Dibenzo(a,h)anthracene | -- | µg/L | | 0.040 UJ | 0.040 U | | | | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U |
| Fluoranthene | -- | µg/L | | 0.040 U | | | | | 0.040 U | | | 0.040 U | | | | | 0.040 U |
| Fluorene | -- | µg/L | | 0.040 UJ | | | | | 0.040 UJ | | | 0.040 UJ | | | | | 0.19 J |
| Hexachlorobutadiene | -- | µg/L | | 1.0 U | 1.0 U | | | | | | | | | | | | |
| Indeno(1,2,3-c,d)pyrene | -- | µg/L | | 0.040 UJ | 0.040 U | | | | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U |
| Naphthalene | -- | µg/L | | 0.40 U | 1.0 U | | | | 0.40 U | | | 0.40 U | | | | | 0.40 U |
| Phenanthrene | -- | µg/L | | 0.060 U | | | | | 0.060 U | | | 0.060 U | | | | | 0.087 |
| Pyrene | -- | µg/L | | 0.040 U | | | | | 0.040 U | | | 0.040 U | | | | | 0.040 U |

Notes:

Blank cells are intentional.
All results rounded to two significant figures.
Some wells were not samples each quarter due to accessibility, insufficient volume of groundwater, or presence of LNAPL, or were removed from the sampling program after the August 2020 sampling event. For additional details, refer to Section 4.3.
-- Not established.
**BOLD RED** Result exceeds screening level.
***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.
1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.
2 The laboratory noted that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.
3 Xylene (total) result is a calculated value.
4 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

AST Aboveground storage tank
BTEX Benzene, toluene, ethylbenzene, and xylenes
cPAH Carcinogenic polycyclic aromatic hydrocarbon
HPAH High molecular weight polycyclic aromatic hydrocarbon
LNAPL Light non-aqueous phase liquid
LPAH Low molecular weight polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
PAH Polycyclic aromatic hydrocarbon
TEQ Toxic equivalent
UST Underground storage tank

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JM Concentration is estimated due to poor match to standard.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

# Table 4.6
## RI Groundwater Analytical Results: TPH, BTEX, and PAHs

| Location Area | | | Former Fuel Loading Rack Area (cont.) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | MW-15 (cont.) | | | MW-16 | | MW-17 | | | | | MW-20 | | | MW-25 | |
| Sample Name | | | MW-15-081020 | MW-15-110220 | MW-15-022321 | MW-16-022719 | MW-16-050720 | MW-17-022819 | MW-17-050720 | MW-17-081120 | MW-17-110320 | MW-17-022421 | MW-20-022819 | MW-20-050720 | MW-20-022321 | MW-25-022819 | MW-25-050720 |
| Sample Date | | | 8/10/2020 | 11/2/2020 | 2/23/2021 | 2/27/2019 | 5/7/2020 | 2/28/2019 | 5/7/2020 | 8/11/2020 | 11/3/2020 | 2/24/2021 | 2/28/2019 | 5/7/2020 | 2/23/2021 | 2/28/2019 | 5/7/2020 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | | | |
| **Total Petroleum Hydrocarbons by NWTPH-Gx and NWTPH-Dx** | | | | | | | | | | | | | | | | | |
| Gasoline-range organics | 800 | µg/L | 120 | 180 | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | **1,500** | **2,800** | **2,600** | 100 U | 100 U |
| Diesel-range organics | 500 | µg/L | 300 [2] | 430 [2] | 54 [2] | 60 U | 84 [2] | 60 U | 67 [2] | 62 [2] | 50 U | 53 [2] | **970** [2] | **1,000** [2] | **1,000** [2] | 60 U | 50 U |
| Oil-range organics | 500 | µg/L | 250 U | 250 U | 250 U | 300 U | 250 U | 300 U | 250 U | 250 U | 250 U | 250 U | 360 [2] | 290 [2] | 490 [2] | 300 U | 250 U |
| Total DRO and ORO | 500 | µg/L | 300 | 430 [2] | 54 [2] | 300 U | 84 [2] | 300 U | 67 | 62 | 250 U | 53 [2] | **1,300** [2] | **1,300** [2] | **1,500** [2] | 300 U | 250 U |
| **Total Petroleum Hydrocarbons by NWTPH-Dx Sg** | | | | | | | | | | | | | | | | | |
| Diesel-range organics | 500 | µg/L | | | | 60 U | | 65 U | | | | | 370 [2] | | | 60 U | |
| Oil-range organics | 500 | µg/L | | | | 300 U | | 320 U | | | | | 300 U | | | 300 U | |
| Total DRO and ORO | 500 | µg/L | | | | 300 U | | 320 U | | | | | 370 [2] | | | 300 U | |
| **BTEX Compounds by USEPA 8021B/8260D** | | | | | | | | | | | | | | | | | |
| Benzene | 5.0 | µg/L | 0.35 U | 0.35 U | 0.35 U | 1.0 U | 0.35 U | 1.0 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 1.7 | 1.6 | 0.86 | 1.0 U | 0.35 U |
| Ethylbenzene | 700 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 7.0 | 5.5 | 4.3 | 1.0 U | 1.0 U |
| Toluene | 1,000 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 3.7 | 1.8 | 1.0 U | 1.0 U |
| Xylene (meta & para) | -- | µg/L | 2.0 U | 2.0 U | 2.0 U | | 2.0 U | | 2.0 U | 2.0 U | 2.0 U | 2.0 U | | 4.3 | 2.0 U | | 2.0 U |
| Xylene (ortho) | -- | µg/L | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | | 1.0 U |
| Xylene (total) | 10,000 | µg/L | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] | 3.0 U | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 9.1 | 4.3 [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | µg/L | 0.030 U | | | | 0.030 U | | 0.030 U | 0.030 U | | | | 0.030 U | | | 0.030 U |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | µg/L | 0 U [4] | | | | 0 U [4] | | 0 U [4] | 0 U [4] | | | | 0 U [4] | | | 0 U [4] |
| Total HPAH | -- | µg/L | | | | | 0.040 U | | 0.040 U | | | | | 0.040 U | | | 0.040 U |
| Total LPAH | -- | µg/L | | | | | 0.40 UJ | | 0.40 UJ | | | | | 0.40 UJ | | | 0.40 UJ |
| Total PAH | -- | µg/L | | | | | 0.40 UJ | | 0.40 UJ | | | | | 0.40 UJ | | | 0.40 UJ |
| 1-Methylnaphthalene | -- | µg/L | | | | | 0.40 U | | 0.40 U | | | | | 7.4 | | | 0.40 U |
| 2-Methylnaphthalene | -- | µg/L | | | | | 0.40 U | | 0.40 U | | | | | 0.40 U | | | 0.40 U |
| Acenaphthene | -- | µg/L | | | | | 0.040 U | | 0.040 U | | | | | 0.040 U | | | 0.040 U |
| Acenaphthylene | -- | µg/L | | | | | 0.040 U | | 0.040 U | | | | | 0.040 U | | | 0.040 U |
| Anthracene | -- | µg/L | | | | | 0.040 U | | 0.040 U | | | | | 0.040 U | | | 0.040 U |
| Benzo(a)anthracene | -- | µg/L | 0.040 U | | | | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U | | | 0.040 U |
| Benzo(a)pyrene | -- | µg/L | 0.040 U | | | | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U | | | 0.040 U |
| Benzo(b)fluoranthene | -- | µg/L | 0.040 U | | | | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U | | | 0.040 U |
| Benzo(g,h,i)perylene | -- | µg/L | | | | | 0.040 U | | 0.040 U | | | | | 0.040 U | | | 0.040 U |
| Benzo(k)fluoranthene | -- | µg/L | 0.040 U | | | | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U | | | 0.040 U |
| Chrysene | -- | µg/L | 0.040 U | | | | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U | | | 0.040 U |
| Dibenzo(a,h)anthracene | -- | µg/L | 0.040 U | | | | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U | | | 0.040 U |
| Fluoranthene | -- | µg/L | | | | | 0.040 U | | 0.040 U | | | | | 0.040 U | | | 0.040 U |
| Fluorene | -- | µg/L | | | | | 0.040 UJ | | 0.040 UJ | | | | | 0.040 UJ | | | 0.040 UJ |
| Hexachlorobutadiene | -- | µg/L | | | | | | | | | | | | | | | |
| Indeno(1,2,3-c,d)pyrene | -- | µg/L | 0.040 U | | | | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U | | | 0.040 U |
| Naphthalene | -- | µg/L | | | | | 0.40 U | | 0.40 U | | | | | 0.40 U | | | 0.40 U |
| Phenanthrene | -- | µg/L | | | | | 0.060 U | | 0.060 U | | | | | 0.060 U | | | 0.060 U |
| Pyrene | -- | µg/L | | | | | 0.040 U | | 0.040 U | | | | | 0.040 U | | | 0.040 U |

Notes:

Blank cells are intentional.
All results rounded to two significant figures.
Some wells were not samples each quarter due to accessibility, insufficient volume of groundwater, or presence of LNAPL, or were removed from the sampling program after the August 2020 sampling event. For additional details, refer to Section 4.3.
-- Not established.
**BOLD RED** Result exceeds screening level.
***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.
1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.
2 The laboratory noted that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.
3 Xylene (total) result is a calculated value.
4 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

AST Aboveground storage tank
BTEX Benzene, toluene, ethylbenzene, and xylenes
cPAH Carcinogenic polycyclic aromatic hydrocarbon
HPAH High molecular weight polycyclic aromatic hydrocarbon
LNAPL Light non-aqueous phase liquid
LPAH Low molecular weight polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
PAH Polycyclic aromatic hydrocarbon
TEQ Toxic equivalent
UST Underground storage tank

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JM Concentration is estimated due to poor match to standard.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

# Table 4.6
## RI Groundwater Analytical Results: TPH, BTEX, and PAHs

| | | | Location Area | Former Fuel Loading Rack Area (cont.) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Location Name | MW-25 (cont.) | | | MW-33 | | | | | | MW-40 | | | |
| | | | Sample Name | MW-25-081120 | MW-25-110320 | MW-25-022321 | MW-33-050620 | MW-133-050620 | MW-33-081120 | MW-33-110220 | MW-133-110220 | MW-33-022421 | MW-40-050620 | MW-40-081120 | MW-40-110220 | MW-40-022421 |
| | | | Sample Date | 8/11/2020 | 11/3/2020 | 2/23/2021 | 5/6/2020 | 5/6/2020 | 8/11/2020 | 11/2/2020 | 11/2/2020 | 2/24/2021 | 5/6/2020 | 8/11/2020 | 11/2/2020 | 2/24/2021 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | | |
| **Total Petroleum Hydrocarbons by NWTPH-Gx and NWTPH-Dx** | | | | | | | | | | | | | | | | |
| Gasoline-range organics | 800 | µg/L | 100 U | 100 U | 100 U | 160 | 130 | 150 | 170 | 170 | 190 | **1,100** | **2,000** | **1,600** | **2,300** |
| Diesel-range organics | 500 | µg/L | 50 U | 50 U | 50 U | **1,100** | **850** | **930** | **890** [2] | **890** [2] | **830** [2] | **2,900** [2] | **3,400** | **3,400** | **2,500** |
| Oil-range organics | 500 | µg/L | 250 U | 250 U | 250 U | 250 U | 250 U | 250 U | 250 U | 250 U | 220 U | 320 [2] | 330 [2] | 400 [2] | 290 [2] |
| Total DRO and ORO | 500 | µg/L | 250 U | 250 U | 250 U | **1,100** | **850** | **930** | **890** [2] | **890** [2] | **830** [2] | **3,200** [2] | **3,700** [2] | **3,800** [2] | **2,800** [2] |
| **Total Petroleum Hydrocarbons by NWTPH-Dx Sg** | | | | | | | | | | | | | | | | |
| Diesel-range organics | 500 | µg/L | | | | | | | | | | | | | | |
| Oil-range organics | 500 | µg/L | | | | | | | | | | | | | | |
| Total DRO and ORO | 500 | µg/L | | | | | | | | | | | | | | |
| **BTEX Compounds by USEPA 8021B/8260D** | | | | | | | | | | | | | | | | |
| Benzene | 5.0 | µg/L | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | **430** | **310** | **300** | **200** |
| Ethylbenzene | 700 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 7.4 | 1.1 | 3.9 | 2.6 |
| Toluene | 1,000 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 11 | 6.3 | 9.6 | 9.7 |
| Xylene (meta & para) | -- | µg/L | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 4.2 | 2.0 | 4.5 | 4.5 |
| Xylene (ortho) | -- | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (total) | 10,000 | µg/L | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 4.2 [3] | 2.0 U [3] | 4.5 [3] | 4.5 [3] |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | µg/L | 0.030 U | | | 0.030 U | 0.030 U | 0.030 U | | | | 0.030 U | 0.030 U | | |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | µg/L | 0 U [4] | | | 0 U [4] | 0 U [4] | 0 U [4] | | | | 0 U [4] | 0 U [4] | | |
| Total HPAH | -- | µg/L | | | | 0.040 U | 0.040 U | | | | | 0.040 U | | | |
| Total LPAH | -- | µg/L | | | | 1.5 J | 1.6 J | | | | | 8.5 J | | | |
| Total PAH | -- | µg/L | | | | 1.5 J | 1.6 J | | | | | 8.5 J | | | |
| 1-Methylnaphthalene | -- | µg/L | | | | 0.40 U | 0.40 U | | | | | 53 | | | |
| 2-Methylnaphthalene | -- | µg/L | | | | 0.40 U | 0.40 U | | | | | 3.8 | | | |
| Acenaphthene | -- | µg/L | | | | 0.34 | 0.36 | | | | | 1.2 | | | |
| Acenaphthylene | -- | µg/L | | | | 0.040 U | 0.040 U | | | | | 0.040 U | | | |
| Anthracene | -- | µg/L | | | | 0.040 U | 0.040 U | | | | | 0.040 U | | | |
| Benzo(a)anthracene | -- | µg/L | 0.040 U | | | 0.040 U | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | |
| Benzo(a)pyrene | -- | µg/L | 0.040 U | | | 0.040 U | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | |
| Benzo(b)fluoranthene | -- | µg/L | 0.040 U | | | 0.040 U | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | |
| Benzo(g,h,i)perylene | -- | µg/L | | | | 0.040 U | 0.040 U | | | | | 0.040 U | | | |
| Benzo(k)fluoranthene | -- | µg/L | 0.040 U | | | 0.040 U | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | |
| Chrysene | -- | µg/L | 0.040 U | | | 0.040 U | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | |
| Dibenzo(a,h)anthracene | -- | µg/L | 0.040 U | | | 0.040 U | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | |
| Fluoranthene | -- | µg/L | | | | 0.040 U | 0.040 U | | | | | 0.040 U | | | |
| Fluorene | -- | µg/L | | | | 0.70 J | 0.74 J | | | | | 5.2 J | | | |
| Hexachlorobutadiene | -- | µg/L | | | | | | | | | | 1.0 U | 1.0 U | | |
| Indeno(1,2,3-c,d)pyrene | -- | µg/L | 0.040 U | | | 0.040 U | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | |
| Naphthalene | -- | µg/L | | | | 0.40 U | 0.40 U | | | | | 0.40 U | 1.0 U | | |
| Phenanthrene | -- | µg/L | | | | 0.44 | 0.47 | | | | | 2.1 | | | |
| Pyrene | -- | µg/L | | | | 0.040 U | 0.040 U | | | | | 0.040 U | | | |

Notes:

Blank cells are intentional.
All results rounded to two significant figures.
Some wells were not samples each quarter due to accessibility, insufficient volume of groundwater, or presence of LNAPL, or were removed from the sampling program after the August 2020 sampling event. For additional details, refer to Section 4.3.
-- Not established.
**BOLD RED** Result exceeds screening level.
***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.
1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.
2 The laboratory noted that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.
3 Xylene (total) result is a calculated value.
4 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

AST Aboveground storage tank
BTEX Benzene, toluene, ethylbenzene, and xylenes
cPAH Carcinogenic polycyclic aromatic hydrocarbon
HPAH High molecular weight polycyclic aromatic hydrocarbon
LNAPL Light non-aqueous phase liquid
LPAH Low molecular weight polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
PAH Polycyclic aromatic hydrocarbon
TEQ Toxic equivalent
UST Underground storage tank

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JM Concentration is estimated due to poor match to standard.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

# Table 4.6
## RI Groundwater Analytical Results: TPH, BTEX, and PAHs

| Location Area | | | Former Mechanic's Shop | | | | | | | | Former U.S. Army Reserve Heating Oil UST | | Monitoring Wells MW-26 and MW-28 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | GP-34 | UST-4 | | | | | | | GP-31 | GP-32 | MW-18 | | |
| Sample Name | | | GP-34-GW-14-19 | UST-4-022819 | UST-104-022819 | UST-4-050620 | UST-4-081020 | UST-4-110220 | UST-104-110220 | UST-4-022321 | GP-31-GW-13.5-18.5 | GP-32-GW-14-19 | MW-18-022819 | MW-18-050720 | MW-18-081120 |
| Sample Date | | | 3/9/2020 | 2/28/2019 | 2/28/2019 | 5/6/2020 | 8/10/2020 | 11/2/2020 | 11/2/2020 | 2/23/2021 | 3/11/2020 | 3/11/2020 | 2/28/2019 | 5/7/2020 | 8/11/2020 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | |
| **Total Petroleum Hydrocarbons by NWTPH-Gx and NWTPH-Dx** | | | | | | | | | | | | | | | |
| Gasoline-range organics | 800 | µg/L | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U |
| Diesel-range organics | 500 | µg/L | 330 [2] | 140 [2] | 140 [2] | 230 [2] | 57 [2] | 50 U | 50 U | 87 [2] | 55 [2] | 150 [2] | 60 U | 50 U | 50 U |
| Oil-range organics | 500 | µg/L | 250 U | 300 U | 300 U | 320 [2] | 250 U | 250 U | 250 U | 290 [2] | 250 U | 250 U | 300 U | 250 U | 250 U |
| Total DRO and ORO | 500 | µg/L | 330 | 140 | 140 | **550** [2] | 57 [2] | 250 U | 250 U | 380 [2] | 55 [2] | 150 [2] | 300 U | 250 U | 250 U |
| **Total Petroleum Hydrocarbons by NWTPH-Dx Sg** | | | | | | | | | | | | | | | |
| Diesel-range organics | 500 | µg/L | | 60 U | 60 U | | | | | | | | 60 U | | |
| Oil-range organics | 500 | µg/L | | 300 U | 300 U | | | | | | | | 300 U | | |
| Total DRO and ORO | 500 | µg/L | | 300 U | 300 U | | | | | | | | 300 U | | |
| **BTEX Compounds by USEPA 8021B/8260D** | | | | | | | | | | | | | | | |
| Benzene | 5.0 | µg/L | 0.35 U | 1.0 U | 1.0 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 1.0 U | 0.35 U | 0.35 U |
| Ethylbenzene | 700 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Toluene | 1,000 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (meta & para) | -- | µg/L | 2.0 U | | | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | | 2.0 U | 2.0 U |
| Xylene (ortho) | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U |
| Xylene (total) | 10,000 | µg/L | 2.0 U [3] | 3.0 U | 3.0 U | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] | 2.0 U [3] |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | µg/L | 0.030 U | | | 0.030 U | 0.030 U | | | | 0.030 U | 0.030 U | | 0.030 U | 0.030 U |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | µg/L | 0 U [4] | | | 0 U [4] | 0 U [4] | | | | 0 U [4] | 0 U [4] | | 0 U [4] | 0 U [4] |
| Total HPAH | -- | µg/L | | | | 0.040 U | | | | | | | | 0.040 U | |
| Total LPAH | -- | µg/L | | | | 0.40 UJ | | | | | | | | 0.40 UJ | |
| Total PAH | -- | µg/L | | | | 0.40 UJ | | | | | | | | 0.40 UJ | |
| 1-Methylnaphthalene | -- | µg/L | | | | 0.40 U | | | | | | | | 0.40 U | |
| 2-Methylnaphthalene | -- | µg/L | | | | 0.40 U | | | | | | | | 0.40 U | |
| Acenaphthene | -- | µg/L | | | | 0.040 U | | | | | | | | 0.040 U | |
| Acenaphthylene | -- | µg/L | | | | 0.040 U | | | | | | | | 0.040 U | |
| Anthracene | -- | µg/L | | | | 0.040 U | | | | | | | | 0.040 U | |
| Benzo(a)anthracene | -- | µg/L | 0.040 U | | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | 0.040 U | 0.040 U |
| Benzo(a)pyrene | -- | µg/L | 0.040 U | | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | 0.040 U | 0.040 U |
| Benzo(b)fluoranthene | -- | µg/L | 0.040 U | | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | 0.040 U | 0.040 U |
| Benzo(g,h,i)perylene | -- | µg/L | | | | 0.040 U | | | | | | | | 0.040 U | |
| Benzo(k)fluoranthene | -- | µg/L | 0.040 U | | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | 0.040 U | 0.040 U |
| Chrysene | -- | µg/L | 0.040 U | | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | 0.040 U | 0.040 U |
| Dibenzo(a,h)anthracene | -- | µg/L | 0.040 U | | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | 0.040 U | 0.040 U |
| Fluoranthene | -- | µg/L | | | | 0.040 U | | | | | | | | 0.040 U | |
| Fluorene | -- | µg/L | | | | 0.040 UJ | | | | | | | | 0.040 UJ | |
| Hexachlorobutadiene | -- | µg/L | | | | | | | | | | | | | |
| Indeno(1,2,3-c,d)pyrene | -- | µg/L | 0.040 U | | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | 0.040 U | 0.040 U |
| Naphthalene | -- | µg/L | 1.0 U | | | 0.40 U | 1.0 U | | | | | | | 0.40 U | |
| Phenanthrene | -- | µg/L | | | | 0.060 U | | | | | | | | 0.060 U | |
| Pyrene | -- | µg/L | | | | 0.040 U | | | | | | | | 0.040 U | |

Notes:

Blank cells are intentional.
All results rounded to two significant figures.
Some wells were not samples each quarter due to accessibility, insufficient volume of groundwater, or presence of LNAPL, or were removed from the sampling program after the August 2020 sampling event. For additional details, refer to Section 4.3.
-- Not established.
**BOLD RED** Result exceeds screening level.
***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.
1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.
2 The laboratory noted that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.
3 Xylene (total) result is a calculated value.
4 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

AST Aboveground storage tank
BTEX Benzene, toluene, ethylbenzene, and xylenes
cPAH Carcinogenic polycyclic aromatic hydrocarbon
HPAH High molecular weight polycyclic aromatic hydrocarbon
LNAPL Light non-aqueous phase liquid
LPAH Low molecular weight polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
PAH Polycyclic aromatic hydrocarbon
TEQ Toxic equivalent
UST Underground storage tank

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JM Concentration is estimated due to poor match to standard.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

# Table 4.6
## RI Groundwater Analytical Results: TPH, BTEX, and PAHs

| Location Area | | | Monitoring Wells MW-26 and MW-28 (cont.) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | MW-18 (cont.) | | MW-24 | | | | | MW-26 | | | | | MW-27 | |
| Sample Name | | | MW-18-110320 | MW-18-022421 | MW-24-022819 | MW-24-050720 | MW-24-081120 | MW-24-110320 | MW-24-022321 | MW-26-022819 | MW-26-050720 | MW-26-081020 | MW-26-110220 | MW-26-022321 | MW-27-022819 | MW-27-050720 |
| Sample Date | | | 11/3/2020 | 2/24/2021 | 2/28/2019 | 5/7/2020 | 8/11/2020 | 11/3/2020 | 2/23/2021 | 2/28/2019 | 5/7/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 | 2/28/2019 | 5/7/2020 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | | |
| **Total Petroleum Hydrocarbons by NWTPH-Gx and NWTPH-Dx** | | | | | | | | | | | | | | | | |
| Gasoline-range organics | 800 | µg/L | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U |
| Diesel-range organics | 500 | µg/L | 50 U | 50 U | 60 U | 50 U | 50 U | 50 U | 50 U | 140 [2] | **670 [2]** | **610 [2]** | **570 [2]** | 50 U | 60 U | 150 [2] |
| Oil-range organics | 500 | µg/L | 250 U | 250 U | 300 U | 250 U | 250 U | 250 U | 250 U | 300 U | 250 U | 250 U | 250 U | 250 U | 300 U | 250 U |
| Total DRO and ORO | 500 | µg/L | 250 U | 250 U | 300 U | 250 U | 250 U | 250 U | 250 U | 140 [2] | **670 [2]** | **610 [2]** | **570 [2]** | 250 U | 300 U | 150 [2] |
| **Total Petroleum Hydrocarbons by NWTPH-Dx Sg** | | | | | | | | | | | | | | | | |
| Diesel-range organics | 500 | µg/L | | | 60 U | | | | | 60 U | | | | | 60 U | |
| Oil-range organics | 500 | µg/L | | | 300 U | | | | | 300 U | | | | | 300 U | |
| Total DRO and ORO | 500 | µg/L | | | 300 U | | | | | 300 U | | | | | 300 U | |
| **BTEX Compounds by USEPA 8021B/8260D** | | | | | | | | | | | | | | | | |
| Benzene | 5.0 | µg/L | 0.35 U | 0.35 U | 1.0 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 1.0 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 1.0 U | 0.35 U |
| Ethylbenzene | 700 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Toluene | 1,000 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (meta & para) | -- | µg/L | 2.0 U | 2.0 U | | 2.0 U | 2.0 U | 2.0 U | 2.0 U | | 2.0 U | 2.0 U | 2.0 U | 2.0 U | | 2.0 U |
| Xylene (ortho) | -- | µg/L | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U |
| Xylene (total) | 10,000 | µg/L | 2.0 U [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | µg/L | | | | 0.030 U | 0.030 U | | | | 0.030 U | 0.0302 U | | | | 0.030 U |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | µg/L | | | | 0 U [4] | 0 U [4] | | | | 0 U [4] | 0 U [4] | | | | 0 U [4] |
| Total HPAH | -- | µg/L | | | | 0.040 U | | | | | 0.040 U | | | | | 0.040 U |
| Total LPAH | -- | µg/L | | | | 0.40 UJ | | | | | 0.40 UJ | | | | | 0.40 UJ |
| Total PAH | -- | µg/L | | | | 0.40 UJ | | | | | 0.40 UJ | | | | | 0.40 UJ |
| 1-Methylnaphthalene | -- | µg/L | | | | 0.40 U | | | | | 0.40 U | | | | | 0.40 U |
| 2-Methylnaphthalene | -- | µg/L | | | | 0.40 U | | | | | 0.40 U | | | | | 0.40 U |
| Acenaphthene | -- | µg/L | | | | 0.040 U | | | | | 0.040 U | | | | | 0.040 U |
| Acenaphthylene | -- | µg/L | | | | 0.040 U | | | | | 0.040 U | | | | | 0.040 U |
| Anthracene | -- | µg/L | | | | 0.040 U | | | | | 0.040 U | | | | | 0.040 U |
| Benzo(a)anthracene | -- | µg/L | | | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | | | 0.040 U |
| Benzo(a)pyrene | -- | µg/L | | | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | | | 0.040 U |
| Benzo(b)fluoranthene | -- | µg/L | | | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | | | 0.040 U |
| Benzo(g,h,i)perylene | -- | µg/L | | | | 0.040 U | | | | | 0.040 U | | | | | 0.040 U |
| Benzo(k)fluoranthene | -- | µg/L | | | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | | | 0.040 U |
| Chrysene | -- | µg/L | | | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | | | 0.040 U |
| Dibenzo(a,h)anthracene | -- | µg/L | | | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | | | 0.040 U |
| Fluoranthene | -- | µg/L | | | | 0.040 U | | | | | 0.040 U | | | | | 0.040 U |
| Fluorene | -- | µg/L | | | | 0.040 UJ | | | | | 0.040 UJ | | | | | 0.040 UJ |
| Hexachlorobutadiene | -- | µg/L | | | | | | | | | | | | | | |
| Indeno(1,2,3-c,d)pyrene | -- | µg/L | | | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | | | 0.040 U |
| Naphthalene | -- | µg/L | | | | 0.40 U | | | | | 0.40 U | | | | | 0.40 U |
| Phenanthrene | -- | µg/L | | | | 0.060 U | | | | | 0.060 U | | | | | 0.060 U |
| Pyrene | -- | µg/L | | | | 0.040 U | | | | | 0.040 U | | | | | 0.040 U |

Notes:

Blank cells are intentional.
All results rounded to two significant figures.
Some wells were not samples each quarter due to accessibility, insufficient volume of groundwater, or presence of LNAPL, or were removed from the sampling program after the August 2020 sampling event. For additional details, refer to Section 4.3.
-- Not established.
**BOLD RED** Result exceeds screening level.
***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.
1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.
2 The laboratory noted that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.
3 Xylene (total) result is a calculated value.
4 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

AST Aboveground storage tank
BTEX Benzene, toluene, ethylbenzene, and xylenes
cPAH Carcinogenic polycyclic aromatic hydrocarbon
HPAH High molecular weight polycyclic aromatic hydrocarbon
LNAPL Light non-aqueous phase liquid
LPAH Low molecular weight polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
PAH Polycyclic aromatic hydrocarbon
TEQ Toxic equivalent
UST Underground storage tank

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JM Concentration is estimated due to poor match to standard.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

# Table 4.6
## RI Groundwater Analytical Results: TPH, BTEX, and PAHs

| Location Area | | | Monitoring Wells MW-26 and MW-28 (cont.) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | MW-27 (cont.) | | MW-28 | | | MW-29 | | | | | MW-34 | | | |
| Sample Name | | | MW-127-050720 | MW-27-081020 | MW-28-022819 | MW-28-081120 | MW-28-022421 | MW-29-022819 | MW-29-050620 | MW-29-081120 | MW-29-110320 | MW-29-022421 | MW-34-050620 | MW-34-081020 | MW-34-110220 | MW-34-022421 |
| Sample Date | | | 5/7/2020 | 8/10/2020 | 2/28/2019 | 8/11/2020 | 2/24/2021 | 2/28/2019 | 5/6/2020 | 8/11/2020 | 11/3/2020 | 2/24/2021 | 5/6/2020 | 8/10/2020 | 11/2/2020 | 2/24/2021 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | | |
| **Total Petroleum Hydrocarbons by NWTPH-Gx and NWTPH-Dx** | | | | | | | | | | | | | | | | |
| Gasoline-range organics | 800 | µg/L | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 130 | 110 | 100 U |
| Diesel-range organics | 500 | µg/L | 190 [2] | 110 [2] | **5,500 [2]** | **5,200 [2]** | **1,200 [2]** | 60 U | 54 [2] | 50 U | 50 U | 50 U | **1,300 [2]** | **1,500 [2]** | **1,300 [2]** | **1,500 [2]** |
| Oil-range organics | 500 | µg/L | 250 U | 250 U | **1,600 [2]** | **890 [2]** | **680 [2]** | 300 U | 250 U | 250 U | 250 U | 250 U | 250 U | 290 [2] | 310 [2] | 310 [2] |
| Total DRO and ORO | 500 | µg/L | 190 [2] | 110 [2] | **7,100 [2]** | **6,100 [2]** | **1,900 [2]** | 300 U | 54 [2] | 250 U | 250 U | 250 U | **1,300 [2]** | **1,800 [2]** | **1,600 [2]** | **1,800 [2]** |
| **Total Petroleum Hydrocarbons by NWTPH-Dx Sg** | | | | | | | | | | | | | | | | |
| Diesel-range organics | 500 | µg/L | | | **610** | | | 60 U | | | | | | | | |
| Oil-range organics | 500 | µg/L | | | 300 U | | | 300 U | | | | | | | | |
| Total DRO and ORO | 500 | µg/L | | | **610** | | | 300 U | | | | | | | | |
| **BTEX Compounds by USEPA 8021B/8260D** | | | | | | | | | | | | | | | | |
| Benzene | 5.0 | µg/L | 0.35 U | 0.35 U | 1.0 U | 0.35 U | 0.35 U | 1.0 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U |
| Ethylbenzene | 700 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Toluene | 1,000 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (meta & para) | -- | µg/L | 2.0 U | 2.0 U | | 2.0 U | 2.0 U | | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U |
| Xylene (ortho) | -- | µg/L | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (total) | 10,000 | µg/L | 2.0 U [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | µg/L | 0.030 U | 0.030 U | | 0.030 U | | | 0.030 U | 0.030 U | | | 0.030 U | 0.030 U | | |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | µg/L | 0 U [4] | 0 U [4] | | 0 U [4] | | | 0 U [4] | 0 U [4] | | | 0 U [4] | 0 U [4] | | |
| Total HPAH | -- | µg/L | 0.040 U | | | | | | 0.040 U | | | | 0.040 U | | | |
| Total LPAH | -- | µg/L | 0.40 UJ | | | | | | 0.40 UJ | | | | 0.24 J | | | |
| Total PAH | -- | µg/L | 0.40 UJ | | | | | | 0.40 UJ | | | | 0.24 J | | | |
| 1-Methylnaphthalene | -- | µg/L | 0.40 U | | | | | | 0.40 U | | | | 0.40 U | | | |
| 2-Methylnaphthalene | -- | µg/L | 0.40 U | | | | | | 0.40 U | | | | 0.40 U | | | |
| Acenaphthene | -- | µg/L | 0.040 U | | | | | | 0.040 U | | | | 0.095 | | | |
| Acenaphthylene | -- | µg/L | 0.040 U | | | | | | 0.040 U | | | | 0.040 U | | | |
| Anthracene | -- | µg/L | 0.040 U | | | | | | 0.040 U | | | | 0.040 U | | | |
| Benzo(a)anthracene | -- | µg/L | 0.040 U | 0.040 U | | 0.040 U | | | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | |
| Benzo(a)pyrene | -- | µg/L | 0.040 U | 0.040 U | | 0.040 U | | | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | |
| Benzo(b)fluoranthene | -- | µg/L | 0.040 U | 0.040 U | | 0.040 U | | | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | |
| Benzo(g,h,i)perylene | -- | µg/L | 0.040 U | | | | | | 0.040 U | | | | 0.040 U | | | |
| Benzo(k)fluoranthene | -- | µg/L | 0.040 U | 0.040 U | | 0.040 U | | | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | |
| Chrysene | -- | µg/L | 0.040 U | 0.040 U | | 0.040 U | | | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | |
| Dibenzo(a,h)anthracene | -- | µg/L | 0.040 U | 0.040 U | | 0.040 U | | | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | |
| Fluoranthene | -- | µg/L | 0.040 U | | | | | | 0.040 U | | | | 0.040 U | | | |
| Fluorene | -- | µg/L | 0.040 UJ | | | | | | 0.040 UJ | | | | 0.14 J | | | |
| Hexachlorobutadiene | -- | µg/L | | | | 1.0 U | | | | | | | 1.0 U | 1.0 U | | |
| Indeno(1,2,3-c,d)pyrene | -- | µg/L | 0.040 U | 0.040 U | | 0.040 U | | | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | |
| Naphthalene | -- | µg/L | 0.40 U | | | 1.0 U | | | 0.40 U | | | | 0.40 U | 1.0 U | | |
| Phenanthrene | -- | µg/L | 0.060 U | | | | | | 0.060 U | | | | 0.060 U | | | |
| Pyrene | -- | µg/L | 0.040 U | | | | | | 0.040 U | | | | 0.040 U | | | |

Notes:

Blank cells are intentional.
All results rounded to two significant figures.
Some wells were not samples each quarter due to accessibility, insufficient volume of groundwater, or presence of LNAPL, or were removed from the sampling program after the August 2020 sampling event. For additional details, refer to Section 4.3.
-- Not established.
**BOLD RED** Result exceeds screening level.
***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.
1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.
2 The laboratory noted that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.
3 Xylene (total) result is a calculated value.
4 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

AST Aboveground storage tank
BTEX Benzene, toluene, ethylbenzene, and xylenes
cPAH Carcinogenic polycyclic aromatic hydrocarbon
HPAH High molecular weight polycyclic aromatic hydrocarbon
LNAPL Light non-aqueous phase liquid
LPAH Low molecular weight polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
PAH Polycyclic aromatic hydrocarbon
TEQ Toxic equivalent
UST Underground storage tank

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JM Concentration is estimated due to poor match to standard.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

# Table 4.6
## RI Groundwater Analytical Results: TPH, BTEX, and PAHs

| Location Area | | | Northern Portion of the Former Standard Pipelines | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | OIP-69 | OIP-70 | MW-06 | | | | | MW-19 | | | MW-39 | | | |
| Sample Name | | | OIP-69-GW-12-17 | OIP-70-GW-10-15 | MW-06-022719 | MW-06-050620 | MW-06-081020 | MW-06-110220 | MW-06-022321 | MW-19-022719 | MW-19-050720 | MW-19-081020 | MW-39-050720 | MW-39-081020 | MW-39-110220 | MW-39-022321 |
| Sample Date | | | 3/11/2020 | 3/10/2020 | 2/27/2019 | 5/6/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 | 2/27/2019 | 5/7/2020 | 8/10/2020 | 5/7/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | | |
| **Total Petroleum Hydrocarbons by NWTPH-Gx and NWTPH-Dx** | | | | | | | | | | | | | | | | |
| Gasoline-range organics | 800 | µg/L | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 380 | 510 | 370 | 500 |
| Diesel-range organics | 500 | µg/L | 140 | 220 [2] | **800 [2]** | **780 [2]** | **1,900 [2]** | **1,300 [2]** | **630 [2]** | 67 [2] | 50 U | 76 [2] | **5,700** | **6,500 [2]** | **5,500 [2]** | **4,800 [2]** |
| Oil-range organics | 500 | µg/L | 250 U | 250 U | 300 U | 250 U | 360 [2] | 400 [2] | 250 U | 300 U | 250 U | 250 U | **950 [2]** | **790 [2]** | **1,200 [2]** | **800 [2]** |
| Total DRO and ORO | 500 | µg/L | 140 | 220 [2] | **800 [2]** | **780 [2]** | **2,300 [2]** | **1,700 [2]** | **630 [2]** | 67 [2] | 250 U | 76 [2] | **6,700 [2]** | **7,300 [2]** | **6,700 [2]** | **5,600 [2]** |
| **Total Petroleum Hydrocarbons by NWTPH-Dx Sg** | | | | | | | | | | | | | | | | |
| Diesel-range organics | 500 | µg/L | | | 140 | | | | | 60 U | | | | | | |
| Oil-range organics | 500 | µg/L | | | 300 U | | | | | 300 U | | | | | | |
| Total DRO and ORO | 500 | µg/L | | | 140 | | | | | 300 U | | | | | | |
| **BTEX Compounds by USEPA 8021B/8260D** | | | | | | | | | | | | | | | | |
| Benzene | 5.0 | µg/L | 0.35 U | 0.35 U | 1.0 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 1.0 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U |
| Ethylbenzene | 700 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Toluene | 1,000 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (meta & para) | -- | µg/L | 2.0 U | 2.0 U | | 2.0 U | 2.0 U | 2.0 U | 2.0 U | | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U |
| Xylene (ortho) | -- | µg/L | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (total) | 10,000 | µg/L | 2.0 U [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | µg/L | 0.030 U | 0.030 U | | 0.030 U | 0.030 U | | | | 0.030 U | 0.030 U | 0.030 U | 0.030 U | | |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | µg/L | 0 U [4] | 0 U [4] | | 0 U [4] | 0 U [4] | | | | 0 U [4] | 0 U [4] | 0 U [4] | 0 U [4] | | |
| Total HPAH | -- | µg/L | | | | 0.040 U | | | | | 0.040 U | | 0.040 U | | | |
| Total LPAH | -- | µg/L | | | | 0.80 J | | | | | 0.40 UJ | | 10 J | | | |
| Total PAH | -- | µg/L | | | | 0.80 J | | | | | 0.40 UJ | | 10 J | | | |
| 1-Methylnaphthalene | -- | µg/L | | | | 0.40 U | | | | | 0.40 U | | 11 | | | |
| 2-Methylnaphthalene | -- | µg/L | | | | 0.40 U | | | | | 0.40 U | | 0.40 U | | | |
| Acenaphthene | -- | µg/L | | | | 0.15 | | | | | 0.040 U | | 1.7 | | | |
| Acenaphthylene | -- | µg/L | | | | 0.040 U | | | | | 0.040 U | | 0.040 U | | | |
| Anthracene | -- | µg/L | | | | 0.040 U | | | | | 0.040 U | | 0.040 U | | | |
| Benzo(a)anthracene | -- | µg/L | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | 0.040 U | 0.040 U | | |
| Benzo(a)pyrene | -- | µg/L | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | 0.040 U | 0.040 U | | |
| Benzo(b)fluoranthene | -- | µg/L | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | 0.040 U | 0.040 U | | |
| Benzo(g,h,i)perylene | -- | µg/L | | | | 0.040 U | | | | | 0.040 U | | 0.040 U | | | |
| Benzo(k)fluoranthene | -- | µg/L | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | 0.040 U | 0.040 U | | |
| Chrysene | -- | µg/L | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | 0.040 U | 0.040 U | | |
| Dibenzo(a,h)anthracene | -- | µg/L | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | 0.040 U | 0.040 U | | |
| Fluoranthene | -- | µg/L | | | | 0.040 U | | | | | 0.040 U | | 0.040 U | | | |
| Fluorene | -- | µg/L | | | | 0.65 J | | | | | 0.040 UJ | | 7.2 J | | | |
| Hexachlorobutadiene | -- | µg/L | | | | | | | | | 1.0 U | 1.0 U | | 1.0 U | | |
| Indeno(1,2,3-c,d)pyrene | -- | µg/L | 0.040 U | 0.040 U | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | 0.040 U | 0.040 U | | |
| Naphthalene | -- | µg/L | 1.0 U | 1.0 U | | 0.40 U | | | | | 0.40 U | 1.0 U | 0.40 U | 1.0 U | | |
| Phenanthrene | -- | µg/L | | | | 0.060 U | | | | | 0.060 U | | 1.5 | | | |
| Pyrene | -- | µg/L | | | | 0.040 U | | | | | 0.040 U | | 0.040 U | | | |

Notes:

Blank cells are intentional.
All results rounded to two significant figures.
Some wells were not samples each quarter due to accessibility, insufficient volume of groundwater, or presence of LNAPL, or were removed from the sampling program after the August 2020 sampling event. For additional details, refer to Section 4.3.
-- Not established.
**BOLD RED** Result exceeds screening level.
***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.
1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.
2 The laboratory noted that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.
3 Xylene (total) result is a calculated value.
4 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

AST Aboveground storage tank
BTEX Benzene, toluene, ethylbenzene, and xylenes
cPAH Carcinogenic polycyclic aromatic hydrocarbon
HPAH High molecular weight polycyclic aromatic hydrocarbon
LNAPL Light non-aqueous phase liquid
LPAH Low molecular weight polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
PAH Polycyclic aromatic hydrocarbon
TEQ Toxic equivalent
UST Underground storage tank

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JM Concentration is estimated due to poor match to standard.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

# Table 4.6
## RI Groundwater Analytical Results: TPH, BTEX, and PAHs

| Location Area | | | Perimeter Monitoring Wells | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | MW-01 | | | MW-04 | | MW-22 | | | | | MW-23 | | | |
| Sample Name | | | MW-01-022719 | MW-01-050620 | MW-01-081020 | MW-04-022819 | MW-04-022421 | MW-22-022819 | MW-22-050720 | MW-22-081120 | MW-22-110320 | MW-22-022421 | MW-23-091415 | MW-23-022819 | MW-23-050620 | MW-23-081120 |
| Sample Date | | | 2/27/2019 | 5/6/2020 | 8/10/2020 | 2/28/2019 | 2/24/2021 | 2/28/2019 | 5/7/2020 | 8/11/2020 | 11/3/2020 | 2/24/2021 | 9/14/2015 | 2/28/2019 | 5/6/2020 | 8/11/2020 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | | |
| **Total Petroleum Hydrocarbons by NWTPH-Gx and NWTPH-Dx** | | | | | | | | | | | | | | | | |
| Gasoline-range organics | 800 | µg/L | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U |
| Diesel-range organics | 500 | µg/L | 60 U | 50 U | 50 U | 60 U | **520** [2] | 60 U | 50 U | 50 U | 50 U | 50 U | 50 U | 60 U | 50 U | 50 U |
| Oil-range organics | 500 | µg/L | 300 U | 250 U | 250 U | 300 U | 440 [2] | 300 U | 250 U | 250 U | 250 U | 250 U | 250 U | 300 U | 250 U | 250 U |
| Total DRO and ORO | 500 | µg/L | 300 U | 250 U | 250 U | 300 U | **960** [2] | 300 U | 250 U | 250 U | 250 U | 250 U | 250 U | 300 U | 250 U | 250 U |
| **Total Petroleum Hydrocarbons by NWTPH-Dx Sg** | | | | | | | | | | | | | | | | |
| Diesel-range organics | 500 | µg/L | 60 U | | | 60 U | | 60 U | | | | | | 60 U | | |
| Oil-range organics | 500 | µg/L | 300 U | | | 300 U | | 300 U | | | | | | 300 U | | |
| Total DRO and ORO | 500 | µg/L | 300 U | | | 300 U | | 300 U | | | | | | 300 U | | |
| **BTEX Compounds by USEPA 8021B/8260D** | | | | | | | | | | | | | | | | |
| Benzene | 5.0 | µg/L | 1.0 U | 0.35 U | 0.35 U | 1.0 U | 0.35 U | 1.0 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 1.0 U | 1.0 U | 0.35 U | 0.35 U |
| Ethylbenzene | 700 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Toluene | 1,000 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (meta & para) | -- | µg/L | | 2.0 U | 2.0 U | | 2.0 U | | 2.0 U | 2.0 U | 2.0 U | 2.0 U | | | 2.0 U | 2.0 U |
| Xylene (ortho) | -- | µg/L | | 1.0 U | 1.0 U | | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | | 1.0 U | 1.0 U |
| Xylene (total) | 10,000 | µg/L | 3.0 U | 2.0 U [3] | 2.0 U [3] | 3.0 U | 2.0 U [3] | 3.0 U | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 3.0 U | 3.0 U | 2.0 U [3] | 2.0 U [3] |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | µg/L | | 0.030 U | 0.030 U | | | | 0.030 U | 0.030 U | | | | | 0.030 U | 0.030 U |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | µg/L | | 0 U [4] | 0 U [4] | | | | 0 U [4] | 0 U [4] | | | | | 0 U [4] | 0 U [4] |
| Total HPAH | -- | µg/L | | 0.040 U | | | | | 0.040 U | | | | | | 0.040 U | |
| Total LPAH | -- | µg/L | | 0.40 UJ | | | | | 0.40 UJ | | | | | | 0.40 UJ | |
| Total PAH | -- | µg/L | | 0.40 UJ | | | | | 0.40 UJ | | | | | | 0.40 UJ | |
| 1-Methylnaphthalene | -- | µg/L | | 0.40 U | | | | | 0.40 U | | | | | | 0.40 U | |
| 2-Methylnaphthalene | -- | µg/L | | 0.40 U | | | | | 0.40 U | | | | | | 0.40 U | |
| Acenaphthene | -- | µg/L | | 0.040 U | | | | | 0.040 U | | | | | | 0.040 U | |
| Acenaphthylene | -- | µg/L | | 0.040 U | | | | | 0.040 U | | | | | | 0.040 U | |
| Anthracene | -- | µg/L | | 0.040 U | | | | | 0.040 U | | | | | | 0.040 U | |
| Benzo(a)anthracene | -- | µg/L | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | | | | 0.040 U | 0.040 U |
| Benzo(a)pyrene | -- | µg/L | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | | | | 0.040 U | 0.040 U |
| Benzo(b)fluoranthene | -- | µg/L | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | | | | 0.040 U | 0.040 U |
| Benzo(g,h,i)perylene | -- | µg/L | | 0.040 U | | | | | 0.040 U | | | | | | 0.040 U | |
| Benzo(k)fluoranthene | -- | µg/L | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | | | | 0.040 U | 0.040 U |
| Chrysene | -- | µg/L | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | | | | 0.040 U | 0.040 U |
| Dibenzo(a,h)anthracene | -- | µg/L | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | | | | 0.040 U | 0.040 U |
| Fluoranthene | -- | µg/L | | 0.040 U | | | | | 0.040 U | | | | | | 0.040 U | |
| Fluorene | -- | µg/L | | 0.040 UJ | | | | | 0.040 UJ | | | | | | 0.040 UJ | |
| Hexachlorobutadiene | -- | µg/L | | | | | | | | | | | | | 1.0 U | 1.0 U |
| Indeno(1,2,3-c,d)pyrene | -- | µg/L | | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | | | | | 0.040 U | 0.040 U |
| Naphthalene | -- | µg/L | | 0.40 U | | | | | 0.40 U | | | | | | 0.40 U | 1.0 U |
| Phenanthrene | -- | µg/L | | 0.060 U | | | | | 0.060 U | | | | | | 0.060 U | |
| Pyrene | -- | µg/L | | 0.040 U | | | | | 0.040 U | | | | | | 0.040 U | |

Notes:

Blank cells are intentional.
All results rounded to two significant figures.
Some wells were not samples each quarter due to accessibility, insufficient volume of groundwater, or presence of LNAPL, or were removed from the sampling program after the August 2020 sampling event. For additional details, refer to Section 4.3.
-- Not established.
**BOLD RED** Result exceeds screening level.
***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.
1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.
2 The laboratory noted that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.
3 Xylene (total) result is a calculated value.
4 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

AST Aboveground storage tank
BTEX Benzene, toluene, ethylbenzene, and xylenes
cPAH Carcinogenic polycyclic aromatic hydrocarbon
HPAH High molecular weight polycyclic aromatic hydrocarbon
LNAPL Light non-aqueous phase liquid
LPAH Low molecular weight polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
PAH Polycyclic aromatic hydrocarbon
TEQ Toxic equivalent
UST Underground storage tank

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JM Concentration is estimated due to poor match to standard.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

# Table 4.6
## RI Groundwater Analytical Results: TPH, BTEX, and PAHs

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Location Area | Perimeter Monitoring Wells (cont.) | | | | | | | | | | |
| | | Location Name | MW-23 (cont.) | | MW-30 | | | MW-31 | | | | | |
| | | Sample Name | MW-23-110320 | MW-23-022421 | MW-30-081120 | MW-30-110220 | MW-30-022421 | MW-31-022719 | MW-131-022719 | MW-31-050620 | MW-31-081020 | MW-31-110220 | MW-31-022321 |
| | | Sample Date | 11/3/2020 | 2/24/2021 | 8/11/2020 | 11/2/2020 | 2/24/2021 | 2/27/2019 | 2/27/2019 | 5/6/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | |
| **Total Petroleum Hydrocarbons by NWTPH-Gx and NWTPH-Dx** | | | | | | | | | | | | | |
| Gasoline-range organics | 800 | µg/L | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U |
| Diesel-range organics | 500 | µg/L | 50 U | 50 U | **1,100 [2]** | **1,600 [2]** | **940 [2]** | 60 U | 60 U | 50 U | 50 U | 50 U | 50 U |
| Oil-range organics | 500 | µg/L | 250 U | 250 U | 480 [2] | **920 [2]** | **550 [2]** | 300 U | 300 U | 250 U | 250 U | 250 U | 250 U |
| Total DRO and ORO | 500 | µg/L | 250 U | 250 U | **1,600 [2]** | **2,500 [2]** | **1,500 [2]** | 300 U | 300 U | 250 U | 250 U | 250 U | 250 U |
| **Total Petroleum Hydrocarbons by NWTPH-Dx Sg** | | | | | | | | | | | | | |
| Diesel-range organics | 500 | µg/L | | | | | | 60 U | 60 U | | | | |
| Oil-range organics | 500 | µg/L | | | | | | 300 U | 300 U | | | | |
| Total DRO and ORO | 500 | µg/L | | | | | | 300 U | 300 U | | | | |
| **BTEX Compounds by USEPA 8021B/8260D** | | | | | | | | | | | | | |
| Benzene | 5.0 | µg/L | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 1.0 U | 1.0 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U |
| Ethylbenzene | 700 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Toluene | 1,000 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (meta & para) | -- | µg/L | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | | | 2.0 U | 2.0 U | 2.0 U | 2.0 U |
| Xylene (ortho) | -- | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (total) | 10,000 | µg/L | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 3.0 U | 3.0 U | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | µg/L | | | 0.030 U | | | | | 0.030 U | 0.030 U | | |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | µg/L | | | 0 U [4] | | | | | 0 U [4] | 0 U [4] | | |
| Total HPAH | -- | µg/L | | | | | | | | 0.040 U | | | |
| Total LPAH | -- | µg/L | | | | | | | | 0.40 UJ | | | |
| Total PAH | -- | µg/L | | | | | | | | 0.40 UJ | | | |
| 1-Methylnaphthalene | -- | µg/L | | | | | | | | 0.40 U | | | |
| 2-Methylnaphthalene | -- | µg/L | | | | | | | | 0.40 U | | | |
| Acenaphthene | -- | µg/L | | | | | | | | 0.040 U | | | |
| Acenaphthylene | -- | µg/L | | | | | | | | 0.040 U | | | |
| Anthracene | -- | µg/L | | | | | | | | 0.040 U | | | |
| Benzo(a)anthracene | -- | µg/L | | | 0.040 U | | | | | 0.040 U | 0.040 U | | |
| Benzo(a)pyrene | -- | µg/L | | | 0.040 U | | | | | 0.040 U | 0.040 U | | |
| Benzo(b)fluoranthene | -- | µg/L | | | 0.040 U | | | | | 0.040 U | 0.040 U | | |
| Benzo(g,h,i)perylene | -- | µg/L | | | | | | | | 0.040 U | | | |
| Benzo(k)fluoranthene | -- | µg/L | | | 0.040 U | | | | | 0.040 U | 0.040 U | | |
| Chrysene | -- | µg/L | | | 0.040 U | | | | | 0.040 U | 0.040 U | | |
| Dibenzo(a,h)anthracene | -- | µg/L | | | 0.040 U | | | | | 0.040 U | 0.040 U | | |
| Fluoranthene | -- | µg/L | | | | | | | | 0.040 U | | | |
| Fluorene | -- | µg/L | | | | | | | | 0.040 UJ | | | |
| Hexachlorobutadiene | -- | µg/L | | | | | | | | | | | |
| Indeno(1,2,3-c,d)pyrene | -- | µg/L | | | 0.040 U | | | | | 0.040 U | 0.040 U | | |
| Naphthalene | -- | µg/L | | | | | | | | 0.40 U | | | |
| Phenanthrene | -- | µg/L | | | | | | | | 0.060 U | | | |
| Pyrene | -- | µg/L | | | | | | | | 0.040 U | | | |

Notes:

Blank cells are intentional.
All results rounded to two significant figures.
Some wells were not samples each quarter due to accessibility, insufficient volume of groundwater, or presence of LNAPL, or were removed from the sampling program after the August 2020 sampling event. For additional details, refer to Section 4.3.
-- Not established.
**BOLD RED** Result exceeds screening level.
***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.
1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.
2 The laboratory noted that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.
3 Xylene (total) result is a calculated value.
4 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

AST Aboveground storage tank
BTEX Benzene, toluene, ethylbenzene, and xylenes
cPAH Carcinogenic polycyclic aromatic hydrocarbon
HPAH High molecular weight polycyclic aromatic hydrocarbon
LNAPL Light non-aqueous phase liquid
LPAH Low molecular weight polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
PAH Polycyclic aromatic hydrocarbon
TEQ Toxic equivalent
UST Underground storage tank

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JM Concentration is estimated due to poor match to standard.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

# Table 4.6
## RI Groundwater Analytical Results: TPH, BTEX, and PAHs

| Location Area | | | Perimeter Monitoring Wells (cont.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | MW-35 | | | | | MW-36 | | | | |
| Sample Name | | | MW-35-050620 | MW-35-081020 | MW-35-110320 | MW-35-022421 | MW-135-022421 | MW-36-050620 | MW-36-081020 | MW-136-081020 | MW-36-110220 | MW-36-022321 |
| Sample Date | | | 5/6/2020 | 8/10/2020 | 11/3/2020 | 2/24/2021 | 2/24/2021 | 5/6/2020 | 8/10/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | |
| **Total Petroleum Hydrocarbons by NWTPH-Gx and NWTPH-Dx** | | | | | | | | | | | | |
| Gasoline-range organics | 800 | µg/L | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U | 100 U |
| Diesel-range organics | 500 | µg/L | **630** [2] | **670** [2] | **620** [2] | 470 [2] | **520** [2] | 50 U | 50 U | 50 U | 50 U | 50 U |
| Oil-range organics | 500 | µg/L | 250 U | 260 [2] | 330 [2] | 250 U | 270 [2] | 250 U | 250 U | 250 U | 250 U | 250 U |
| Total DRO and ORO | 500 | µg/L | **630** [2] | **930** [2] | **950** [2] | 470 | **790** [2] | 250 U | 250 U | 250 U | 250 U | 250 U |
| **Total Petroleum Hydrocarbons by NWTPH-Dx Sg** | | | | | | | | | | | | |
| Diesel-range organics | 500 | µg/L | | | | | | | | | | |
| Oil-range organics | 500 | µg/L | | | | | | | | | | |
| Total DRO and ORO | 500 | µg/L | | | | | | | | | | |
| **BTEX Compounds by USEPA 8021B/8260D** | | | | | | | | | | | | |
| Benzene | 5.0 | µg/L | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U |
| Ethylbenzene | 700 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Toluene | 1,000 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (meta & para) | -- | µg/L | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U | 2.0 U |
| Xylene (ortho) | -- | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (total) | 10,000 | µg/L | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | µg/L | 0.030 U | 0.030 U | | | | 0.030 U | 0.030 U | 0.030 U | | |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | µg/L | 0 U [4] | 0 U [4] | | | | 0 U [4] | 0 U [4] | 0 U [4] | | |
| Total HPAH | -- | µg/L | 0.040 U | | | | | 0.040 U | | | | |
| Total LPAH | -- | µg/L | 0.40 UJ | | | | | 0.40 UJ | | | | |
| Total PAH | -- | µg/L | 0.40 UJ | | | | | 0.40 UJ | | | | |
| 1-Methylnaphthalene | -- | µg/L | 0.40 U | | | | | 0.40 U | | | | |
| 2-Methylnaphthalene | -- | µg/L | 0.40 U | | | | | 0.40 U | | | | |
| Acenaphthene | -- | µg/L | 0.040 U | | | | | 0.040 U | | | | |
| Acenaphthylene | -- | µg/L | 0.040 U | | | | | 0.040 U | | | | |
| Anthracene | -- | µg/L | 0.040 U | | | | | 0.040 U | | | | |
| Benzo(a)anthracene | -- | µg/L | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | 0.040 U | | |
| Benzo(a)pyrene | -- | µg/L | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | 0.040 U | | |
| Benzo(b)fluoranthene | -- | µg/L | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | 0.040 U | | |
| Benzo(g,h,i)perylene | -- | µg/L | 0.040 U | | | | | 0.040 U | | | | |
| Benzo(k)fluoranthene | -- | µg/L | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | 0.040 U | | |
| Chrysene | -- | µg/L | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | 0.040 U | | |
| Dibenzo(a,h)anthracene | -- | µg/L | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | 0.040 U | | |
| Fluoranthene | -- | µg/L | 0.040 U | | | | | 0.040 U | | | | |
| Fluorene | -- | µg/L | 0.040 UJ | | | | | 0.040 UJ | | | | |
| Hexachlorobutadiene | -- | µg/L | 1.0 U | 1.0 U | | | | | | | | |
| Indeno(1,2,3-c,d)pyrene | -- | µg/L | 0.040 U | 0.040 U | | | | 0.040 U | 0.040 U | 0.040 U | | |
| Naphthalene | -- | µg/L | 0.40 U | 1.0 U | | | | 0.40 U | | | | |
| Phenanthrene | -- | µg/L | 0.060 U | | | | | 0.060 U | | | | |
| Pyrene | -- | µg/L | 0.040 U | | | | | 0.040 U | | | | |

Notes:

Blank cells are intentional.
All results rounded to two significant figures.
Some wells were not samples each quarter due to accessibility, insufficient volume of groundwater, or presence of LNAPL, or were removed from the sampling program after the August 2020 sampling event. For additional details, refer to Section 4.3.
-- Not established.
**BOLD RED** Result exceeds screening level.
***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.
1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.
2 The laboratory noted that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.
3 Xylene (total) result is a calculated value.
4 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

AST Aboveground storage tank
BTEX Benzene, toluene, ethylbenzene, and xylenes
cPAH Carcinogenic polycyclic aromatic hydrocarbon
HPAH High molecular weight polycyclic aromatic hydrocarbon
LNAPL Light non-aqueous phase liquid
LPAH Low molecular weight polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
PAH Polycyclic aromatic hydrocarbon
TEQ Toxic equivalent
UST Underground storage tank

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JM Concentration is estimated due to poor match to standard.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

# Table 4.6
## RI Groundwater Analytical Results: TPH, BTEX, and PAHs

| | | Location Area | Southern Pipelines and Berths | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Location Name | OIP-06 | GP-18 | MW-37 | | | | MW-38 | | | |
| | | Sample Name | OIP-06-GW-25-30 | GP-18-GW | MW-37-050720 | MW-37-081020 | MW-37-110220 | MW-37-022321 | MW-38-050720 | MW-38-081020 | MW-38-110220 | MW-38-022321 |
| | | Sample Date | 3/13/2020 | 9/18/2015 | 5/7/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 | 5/7/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | |
| **Total Petroleum Hydrocarbons by NWTPH-Gx and NWTPH-Dx** | | | | | | | | | | | | |
| Gasoline-range organics | 800 | µg/L | 100 U | 100 U | 100 U | 120 | 100 U | 260 | 100 U | 100 U | 100 U | 100 U |
| Diesel-range organics | 500 | µg/L | 200 [2] | 50 U | 210 [2] | 50 U | 160 [2] | 63 [2] | 74 [2] | 57 [2] | 50 U | 50 U |
| Oil-range organics | 500 | µg/L | 250 U | 250 U | 250 U | 250 UJ | 250 U | 250 U | 250 U | 250 U | 250 U | 250 U |
| Total DRO and ORO | 500 | µg/L | 200 [2] | 250 U | 210 [2] | 250 UJ | 160 [2] | 63 [2] | 74 [2] | 57 [2] | 250 U | 250 U |
| **Total Petroleum Hydrocarbons by NWTPH-Dx Sg** | | | | | | | | | | | | |
| Diesel-range organics | 500 | µg/L | | | | | | | | | | |
| Oil-range organics | 500 | µg/L | | | | | | | | | | |
| Total DRO and ORO | 500 | µg/L | | | | | | | | | | |
| **BTEX Compounds by USEPA 8021B/8260D** | | | | | | | | | | | | |
| Benzene | 5.0 | µg/L | 0.35 U | 1.0 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U | 0.35 U |
| Ethylbenzene | 700 | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 3.7 | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Toluene | 1,000 | µg/L | 1.0 U | 1.0 U | 1.0 U | 2.5 | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (meta & para) | -- | µg/L | 2.0 U | | 2.0 U | 2.0 U | 2.0 U | 2.7 | 2.0 U | 2.0 U | 2.0 U | 2.0 U |
| Xylene (ortho) | -- | µg/L | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Xylene (total) | 10,000 | µg/L | 2.0 U [3] | 3.0 U | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.7 [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] | 2.0 U [3] |
| **Semivolatile Organic Compounds (SVOCs)** | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-HalfND) | 0.10 | µg/L | 0.030 U | | 0.030 | 0.030 U | | | 0.030 U | 0.030 U | | |
| cPAHs (MTCA TEQ-ZeroND) | 0.10 | µg/L | 0 U [4] | | 0.00045 | 0 U [4] | | | 0 U [4] | 0 U [4] | | |
| Total HPAH | -- | µg/L | | | 0.198 | | | | 0.040 U | | | |
| Total LPAH | -- | µg/L | | | 0.89 J | | | | 0.40 UJ | | | |
| Total PAH | -- | µg/L | | | 1.1 J | | | | 0.40 UJ | | | |
| 1-Methylnaphthalene | -- | µg/L | | | 0.40 U | | | | 0.40 U | | | |
| 2-Methylnaphthalene | -- | µg/L | | | 0.40 U | | | | 0.40 U | | | |
| Acenaphthene | -- | µg/L | | | 0.82 | | | | 0.040 U | | | |
| Acenaphthylene | -- | µg/L | | | 0.040 U | | | | 0.040 U | | | |
| Anthracene | -- | µg/L | | | 0.040 U | | | | 0.040 U | | | |
| Benzo(a)anthracene | -- | µg/L | 0.040 U | | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | |
| Benzo(a)pyrene | -- | µg/L | 0.040 U | | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | |
| Benzo(b)fluoranthene | -- | µg/L | 0.040 U | | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | |
| Benzo(g,h,i)perylene | -- | µg/L | | | 0.040 U | | | | 0.040 U | | | |
| Benzo(k)fluoranthene | -- | µg/L | 0.040 U | | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | |
| Chrysene | -- | µg/L | 0.040 U | | 0.045 | 0.040 U | | | 0.040 U | 0.040 U | | |
| Dibenzo(a,h)anthracene | -- | µg/L | 0.040 U | | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | |
| Fluoranthene | -- | µg/L | | | 0.043 | | | | 0.040 U | | | |
| Fluorene | -- | µg/L | | | 0.073 J | | | | 0.040 UJ | | | |
| Hexachlorobutadiene | -- | µg/L | | | | | | | | | | |
| Indeno(1,2,3-c,d)pyrene | -- | µg/L | 0.040 U | | 0.040 U | 0.040 U | | | 0.040 U | 0.040 U | | |
| Naphthalene | -- | µg/L | 1.0 U | | 0.40 U | | | | 0.40 U | | | |
| Phenanthrene | -- | µg/L | | | 0.060 U | | | | 0.060 U | | | |
| Pyrene | -- | µg/L | | | 0.11 | | | | 0.040 U | | | |

Notes:

Blank cells are intentional.
All results rounded to two significant figures.
Some wells were not samples each quarter due to accessibility, insufficient volume of groundwater, or presence of LNAPL, or were removed from the sampling program after the August 2020 sampling event. For additional details, refer to Section 4.3.
-- Not established.
**BOLD RED** Result exceeds screening level.
***Bold Italics*** Analyte not detected; reporting limit exceeds screening level.
1 Remedial Investigation screening criteria established in the Remedial Investigation Work Plan (Floyd|Snider 2019a) and discussed in Section 4.1.
2 The laboratory noted that the sample chromatographic pattern does not resemble the fuel standard used for quantitation.
3 Xylene (total) result is a calculated value.
4 None of the cPAH compounds were detected at reporting limits; therefore, the TEQ result was 0.

Abbreviations:

AST Aboveground storage tank
BTEX Benzene, toluene, ethylbenzene, and xylenes
cPAH Carcinogenic polycyclic aromatic hydrocarbon
HPAH High molecular weight polycyclic aromatic hydrocarbon
LNAPL Light non-aqueous phase liquid
LPAH Low molecular weight polycyclic aromatic hydrocarbon
µg/L Micrograms per liter
PAH Polycyclic aromatic hydrocarbon
TEQ Toxic equivalent
UST Underground storage tank

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
JM Concentration is estimated due to poor match to standard.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

# Table 4.7
## RI Groundwater Analytical Results: VOCs

| Location Area | | | Former 80,000-Barrel AST | Former Calloway Ross Parcel | | | | Former Fuel Loading Rack Area | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | T-2 | MW-03 | | MW-10 | | MW-07 | | | MW-12 | | MW-40 | |
| Sample Name | | | T-2-081120 | MW-03-050620 | MW-03-081020 | MW-10-050620 | MW-10-081020 | MW-07-050620 | MW-07-081120 | MW-107-081120 | MW-12-050720 | MW-12-081120 | MW-40-050620 | MW-40-081120 |
| Sample Date | | | 8/11/2020 | 5/6/2020 | 8/10/2020 | 5/6/2020 | 8/10/2020 | 5/6/2020 | 8/11/2020 | 8/11/2020 | 5/7/2020 | 8/11/2020 | 5/6/2020 | 8/11/2020 |
| Analyte | Screening Level [1] | Unit | | | | | | | | | | | | |
| **Volatile Organic Compounds by USEPA 8260D** | | | | | | | | | | | | | | |
| 1,1-Dichloroethane | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,1-Dichloroethene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,1-Dichloropropene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,1,1-Trichloroethane | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,1,1,2-Tetrachloroethane | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,1,2-Trichloroethane | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,1,2,2-Tetrachloroethane | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,2-Dibromo-3-chloropropane | -- | µg/L | 10 U | | | 10 U | 10 U | | | | 10 U | 10 U | 10 U | 10 U |
| 1,2-Dibromoethane [2] | -- | µg/L | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U |
| 1,2-Dibromoethane | -- | µg/L | 1.0 U | | | | 1.0 U | | | 1.0 U | | 1.0 U | | 1.0 U |
| 1,2-Dichlorobenzene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,2-Dichloroethane | -- | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,2-Dichloropropane | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,2,3-Trichlorobenzene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,2,3-Trichloropropane | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,2,4-Trichlorobenzene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,2,4-Trimethylbenzene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 | 1.0 U | 1.0 U |
| 1,3-Dichlorobenzene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,3-Dichloropropane | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,3-Dichloropropane | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,3,5-Trimethylbenzene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 3.3 | 1.0 U | 1.0 U |
| 1,4-Dichlorobenzene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 2-Chlorotoluene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 2-Hexanone | -- | µg/L | 10 U | | | 10 U | 10 U | | | | 10 U | 10 U | 10 U | 10 U |
| 2,2-Dichloropropane | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 4-Chlorotoluene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Acetone | -- | µg/L | 50 U | | | 50 U | 50 U | | | | 50 U | 50 U | 50 U | 50 U |
| Bromobenzene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Bromodichloromethane | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Bromoform | -- | µg/L | 5.0 U | | | 5.0 U | 5.0 U | | | | 5.0 U | 5.0 U | 5.0 U | 5.0 U |
| Bromomethane | -- | µg/L | 5.0 U | | | 5.0 U | 5.0 U | | | | 5.0 U | 5.0 U | 5.0 U | 5.0 U |
| Carbon tetrachloride | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Chlorobenzene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Chloroethane | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Chloroform | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Chloromethane | -- | µg/L | 10 U | | | 10 U | 10 U | | | | 10 U | 10 U | 10 U | 10 U |
| cis-1,2-Dichloroethene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| cis-1,3-Dichloropropene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Cymene | -- | µg/L | 1.0 U | | | 1.0 U | 1.1 | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Dibromochloromethane | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Dibromomethane | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Dichlorodifluoromethane | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Methyl ethyl ketone | -- | µg/L | 20 U | | | 20 U | 20 U | | | | 20 U | 20 U | 20 U | 20 U |
| Methylene chloride | -- | µg/L | 5.0 U | | | 5.0 U | 5.0 U | | | | 5.0 U | 5.0 U | 5.0 U | 5.0 U |
| Methyl-tert-butyl ether | -- | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| n-Hexane | -- | µg/L | 5.0 U | | | 3.7 | 49 | | | | 10 | 190 | 22 | 10 |
| n-Propylbenzene | -- | µg/L | 1.0 U | | | 9.1 | 64 | | | | 3.7 | 82 | 19 | 5.0 |
| sec-Butylbenzene | -- | µg/L | 1.0 U | | | 1.0 U | 3.2 | | | | 1.0 U | 3.5 | 2.9 | 1.2 |
| Styrene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |

## Table 4.7
## RI Groundwater Analytical Results: VOCs

| Location Area | | | Former 80,000-Barrel AST | Former Calloway Ross Parcel | | | | Former Fuel Loading Rack Area | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | T-2 | MW-03 | | MW-10 | | MW-07 | | | MW-12 | | MW-40 | |
| Sample Name | | | T-2-081120 | MW-03-050620 | MW-03-081020 | MW-10-050620 | MW-10-081020 | MW-07-050620 | MW-07-081120 | MW-107-081120 | MW-12-050720 | MW-12-081120 | MW-40-050620 | MW-40-081120 |
| Sample Date | | | 8/11/2020 | 5/6/2020 | 8/10/2020 | 5/6/2020 | 8/10/2020 | 5/6/2020 | 8/11/2020 | 8/11/2020 | 5/7/2020 | 8/11/2020 | 5/6/2020 | 8/11/2020 |
| Analyte | Screening Level [1] | Unit | | | | | | | | | | | | |
| **Volatile Organic Compounds by USEPA 8260D (cont.)** | | | | | | | | | | | | | | |
| tert-Butylbenzene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Tetrachloroethene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| trans-1,2-Dichloroethene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| trans-1,3-Dichloropropene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Trichloroethene | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Trichlorofluoromethane | -- | µg/L | 1.0 U | | | 1.0 U | 1.0 U | | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Vinyl chloride | -- | µg/L | 0.20 U | | | 0.20 U | 0.20 U | | | | 0.20 U | 0.20 U | 0.20 U | 0.20 U |

Notes:

Blank cells are intentional.

All results rounded to two significant figures.

-- Not established.

1 These volatile organic compounds were analyzed per the Remedial Investigation Work Plan (Floyd|Snider 2019a), but no screening criteria have been developed for this site.

2 1,2-Dibromoethane analyzed by USEPA Method 8011M.

Abbreviations:

AST Aboveground storage tank

µg/L Micrograms per liter

USEPA U.S. Environmental Protection Agency

Qualifier:

U Analyte was not detected at the given reporting limit.

# Table 4.7
## RI Groundwater Analytical Results: VOCs

| Location Area | | | Former Mechanic's Shop | | Monitoring Wells MW-26 and MW-28 | | | Northern Portion of the Former Standard Pipelines | | | | Perimeter Monitoring Wells | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | UST4 | | MW-28 | MW-34 | | MW-19 | | MW-39 | | MW-23 | | MW-35 | |
| Sample Name | | | UST-4-050620 | UST-4-081020 | MW-28-081120 | MW-34-050620 | MW-34-081020 | MW-19-050720 | MW-19-081020 | MW-39-050720 | MW-39-081020 | MW-23-050620 | MW-23-081120 | MW-35-050620 | MW-35-081020 |
| Sample Date | | | 5/6/2020 | 8/10/2020 | 8/11/2020 | 5/6/2020 | 8/10/2020 | 5/7/2020 | 8/10/2020 | 5/7/2020 | 8/10/2020 | 5/6/2020 | 8/11/2020 | 5/6/2020 | 8/10/2020 |
| Analyte | Screening Level [1] | Unit | | | | | | | | | | | | | |
| **Volatile Organic Compounds by USEPA 8260D** | | | | | | | | | | | | | | | |
| 1,1-Dichloroethane | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,1-Dichloroethene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,1-Dichloropropene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,1,1-Trichloroethane | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,1,1,2-Tetrachloroethane | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,1,2-Trichloroethane | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,1,2,2-Tetrachloroethane | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,2-Dibromo-3-chloropropane | -- | µg/L | | | 10 U | 10 U | 10 U | 10 U | 10 U | | 10 U | 10 U | 10 U | 10 U | 10 U |
| 1,2-Dibromoethane [2] | -- | µg/L | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U | 0.010 U |
| 1,2-Dibromoethane | -- | µg/L | | | 1.0 U | | 1.0 U | | 1.0 U | | 1.0 U | | 1.0 U | | 1.0 U |
| 1,2-Dichlorobenzene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,2-Dichloroethane | -- | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,2-Dichloropropane | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,2,3-Trichlorobenzene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,2,3-Trichloropropane | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,2,4-Trichlorobenzene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,2,4-Trimethylbenzene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,3-Dichlorobenzene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,3-Dichloropropane | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,3,5-Trimethylbenzene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 1,4-Dichlorobenzene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 2-Chlorotoluene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 2-Hexanone | -- | µg/L | | | 10 U | 10 U | 10 U | 10 U | 10 U | | 10 U | 10 U | 10 U | 10 U | 10 U |
| 2,2-Dichloropropane | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| 4-Chlorotoluene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Acetone | -- | µg/L | | | 50 U | 50 U | 50 U | 50 U | 50 U | | 50 U | 50 U | 50 U | 50 U | 50 U |
| Bromobenzene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Bromodichloromethane | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Bromoform | -- | µg/L | | | 5.0 U | 5.0 U | 5.0 U | 5.0 U | 5.0 U | | 5.0 U | 5.0 U | 5.0 U | 5.0 U | 5.0 U |
| Bromomethane | -- | µg/L | | | 5.0 U | 5.0 U | 5.0 U | 5.0 U | 5.0 U | | 5.0 U | 5.0 U | 5.0 U | 5.0 U | 5.0 U |
| Carbon tetrachloride | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Chlorobenzene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Chloroethane | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Chloroform | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Chloromethane | -- | µg/L | | | 10 U | 10 U | 10 U | 10 U | 10 U | | 10 U | 10 U | 10 U | 10 U | 10 U |
| cis-1,2-Dichloroethene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| cis-1,3-Dichloropropene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Cymene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Dibromochloromethane | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Dibromomethane | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Dichlorodifluoromethane | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Methyl ethyl ketone | -- | µg/L | | | 20 U | 20 U | 20 U | 20 U | 20 U | | 20 U | 20 U | 20 U | 20 U | 20 U |
| Methylene chloride | -- | µg/L | | | 5.0 U | 5.0 U | 5.0 U | 5.0 U | 5.0 U | | 5.0 U | 5.0 U | 5.0 U | 5.0 U | 5.0 U |
| Methyl-tert-butyl ether | -- | µg/L | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| n-Hexane | -- | µg/L | | | 5.0 U | 1.0 U | 5.0 U | 1.0 U | 5.0 U | 1.0 U | 5.0 U | 1.0 U | 5.0 U | 1.0 U | 5.0 U |
| n-Propylbenzene | -- | µg/L | | | 1.0 U | 1.0 U | 1.2 | 1.0 U | 1.0 U | | 9.4 | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| sec-Butylbenzene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 2.3 | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Styrene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |

## Table 4.7
## RI Groundwater Analytical Results: VOCs

| Location Area | | | Former Mechanic's Shop | | Monitoring Wells MW-26 and MW-28 | | | Northern Portion of the Former Standard Pipelines | | | | Perimeter Monitoring Wells | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | UST4 | | MW-28 | MW-34 | | MW-19 | | MW-39 | | MW-23 | | MW-35 | |
| Sample Name | | | UST-4-050620 | UST-4-081020 | MW-28-081120 | MW-34-050620 | MW-34-081020 | MW-19-050720 | MW-19-081020 | MW-39-050720 | MW-39-081020 | MW-23-050620 | MW-23-081120 | MW-35-050620 | MW-35-081020 |
| Sample Date | | | 5/6/2020 | 8/10/2020 | 8/11/2020 | 5/6/2020 | 8/10/2020 | 5/7/2020 | 8/10/2020 | 5/7/2020 | 8/10/2020 | 5/6/2020 | 8/11/2020 | 5/6/2020 | 8/10/2020 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | |
| **Volatile Organic Compounds by USEPA 8260D (cont.)** | | | | | | | | | | | | | | | |
| tert-Butylbenzene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Tetrachloroethene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| trans-1,2-Dichloroethene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| trans-1,3-Dichloropropene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Trichloroethene | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Trichlorofluoromethane | -- | µg/L | | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U | | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 1.0 U |
| Vinyl chloride | -- | µg/L | | | 0.20 U | 0.20 U | 0.20 U | 0.20 U | 0.20 U | | 0.20 U | 0.20 U | 0.20 U | 0.20 U | 0.20 U |

Notes:

Blank cells are intentional.

All results rounded to two significant figures.

-- Not established.

1 These volatile organic compounds were analyzed per the Remedial Investigation Work Plan (Floyd|Snider 2019a), but no screening criteria have been developed for this site.

2 1,2-Dibromoethane analyzed by USEPA Method 8011M.

Abbreviations:

AST Aboveground storage tank

µg/L Micrograms per liter

USEPA U.S. Environmental Protection Agency

Qualifier:

U Analyte was not detected at the given reporting limit.

# Table 4.8
## RI Groundwater Analytical Results: Monitored Natural Attenuation Parameters and Metals

| | | Location Area | Former 80,000-Barrel AST | | | | | Former Calloway Ross Parcel | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Location Name | MW-32 | | T-2 | | | MW-02 | | | | MW-03 | |
| | | Sample Name | MW-32-050720 | MW-32-081120 | T-2-081120 | T-2-110220 | T-2-022321 | MW-02-050620 | MW-02-081020 | MW-02-110220 | MW-02-022321 | MW-03-050620 | MW-03-081020 |
| | | Sample Date | 5/7/2020 | 8/11/2020 | 8/11/2020 | 11/2/2020 | 2/23/2021 | 5/6/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 | 5/6/2020 | 8/10/2020 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | |
| **Conventionals** | | | | | | | | | | | | | |
| Ferrous iron | -- | mg/L | | | | | | | | | | | |
| Nitrate (as nitrogen) | -- | mg/L | | | | | | | | | | | |
| Sulfate | -- | mg/L | | | | | | | | | | | |
| Alkalinity (as $CaCO_3$) | -- | mg/L | | | | | | | | | | | |
| Biochemical oxygen demand | -- | mg/L | | | | | | | | | | | |
| Chemical oxygen demand | -- | mg/L | | | | | | | | | | | |
| **Field Parameters** | | | | | | | | | | | | | |
| Conductivity | -- | µS/cm | 351.7 | 403 | 333 | 383.7 | 256 | 544 | 481.5 | 640 | 229.4 | 400 | 276.3 |
| Dissolved oxygen | -- | mg/L | 0.63 | 0.50 | 2.63 | 0.45 | 1.03 | 6.58 | 1.49 | 1.18 | 8.47 | 0.14 | 0.2 |
| ORP | -- | mV | -119 | -113 | -65.5 | -24.2 | -76.1 | 84.2 | 119.2 | 74.6 | 195.9 | -175.6 | -16.5 |
| pH | -- | pH | 6.26 | 6.5 | 6.47 | 6.41 | 6.75 | 6.29 | 6.28 | 6.18 | 6.68 | 6.36 | 6.32 |
| Temperature | -- | °C | 13.6 | 16.1 | 14.4 | 14.3 | 12.6 | 13.6 | 16.6 | 16.9 | 12.9 | 14.7 | 16.7 |
| Turbidity | -- | NTU | 9.07 | 5.8 | 22.3 | 0.65 | 17.6 | 8.9 | 4.22 | 1.12 | 2.51 | 3.3 | 6.95 |
| **Dissolved Gases** | | | | | | | | | | | | | |
| Methane | -- | mg/L | | | | | | | | | | | |
| **Total Metals** | | | | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | | | 1.0 U | 1.0 U |
| **Dissolved Metals** | | | | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | | | 1.0 U | |
| Manganese | -- | µg/L | | | | | | | | | | | |

Notes:

Blank cells are intentional.

All laboratory results rounded to two significant figures. Field parameters are not rounded.

-- Not established.

1 MTCA Method A cleanup levels are used as screening levels for total and dissolved lead.

Abbreviations:

AST Aboveground storage tank

°C Degrees Celsius

µg/L Micrograms per liter

µS/cm Microsiemens per centimeter

mg/L Milligrams per liter

MTCA Model Toxics Control Act

mV Millivolts

NTU Nephelometric turbidity units

ORP Oxidation-reduction potential

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.

U Analyte was not detected at the given reporting limit.

UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

## Table 4.8
## RI Groundwater Analytical Results: Monitored Natural Attenuation Parameters and Metals

| | | Location Area | Former Calloway Ross Parcel (cont.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Location Name | MW-03 (cont.) | | MW-05 | MW-08 | | | | MW-10 | | | |
| | | Sample Name | MW-03-110220 | MW-03-022321 | MW-05-022421 | MW-08-050620 | MW-08-081020 | MW-08-110220 | MW-08-022321 | MW-10-050620 | MW-10-081020 | MW-10-110220 | MW-10-022321 |
| | | Sample Date | 11/2/2020 | 2/23/2021 | 2/24/2021 | 5/6/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 | 5/6/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | |
| **Conventionals** | | | | | | | | | | | | | |
| Ferrous iron | -- | mg/L | | | | | | | | 1.1 | 3.0 | 2.5 | 3.0 |
| Nitrate (as nitrogen) | -- | mg/L | | | | | | | | 0.10 UJ | 0.20 U | 0.20 UJ | 0.20 U |
| Sulfate | -- | mg/L | | | | | | | | 0.78 | 0.60 U | 0.60 U | 1.2 U |
| Alkalinity (as $CaCO_3$) | -- | mg/L | | | | | | | | 43 | 120 | 130 | 150 |
| Biochemical oxygen demand | -- | mg/L | | | | | | | | | | | |
| Chemical oxygen demand | -- | mg/L | | | | | | | | | | | |
| **Field Parameters** | | | | | | | | | | | | | |
| Conductivity | -- | µS/cm | 357 | 251 | 409 | 543 | 571 | 648 | 534 | 145.4 | 426.4 | 570 | 480 |
| Dissolved oxygen | -- | mg/L | 0.15 | 1.19 | 3.93 | 0.080 | 0.21 | 0.26 | 0.8 | 0.42 | 0.24 | 0.18 | 1.18 |
| ORP | -- | mV | -95.8 | -54.3 | 79.5 | -87.9 | -85 | -157 | 177.7 | 52.8 | -6.5 | -146 | -119 |
| pH | -- | pH | 6.31 | 6.6 | 7.9 | 6.51 | 6.47 | 6.43 | 6.55 | 5.83 | 6.34 | 6.47 | 6.72 |
| Temperature | -- | °C | 14.9 | 13.6 | 12.4 | 13.9 | 15.9 | 15.1 | 13.4 | 13.6 | 15.1 | 14.1 | 13.7 |
| Turbidity | -- | ntu | 0.86 | 0.95 | 45.6 | 11.17 | 7.36 | 1.87 | 7.23 | 35.44 | 4.15 | 1.1 | 0.98 |
| **Dissolved Gases** | | | | | | | | | | | | | |
| Methane | -- | mg/L | | | | | | | | 1.6 | 2.4 | 4.4 | 3.3 |
| **Total Metals** | | | | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | 1.0 U | 1.0 U | | |
| **Dissolved Metals** | | | | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | 1.0 U | | | |
| Manganese | -- | µg/L | | | | | | | | 660 | 2,300 | 2,300 | 2,500 |

Notes:

Blank cells are intentional.
All laboratory results rounded to two significant figures. Field parameters are not rounded.
-- Not established.
1 MTCA Method A cleanup levels are used as screening levels for total and dissolved lead.

Abbreviations:

AST Aboveground storage tank
°C Degrees Celsius
µg/L Micrograms per liter
µS/cm Microsiemens per centimeter
mg/L Milligrams per liter
MTCA Model Toxics Control Act
mV Millivolts
NTU Nephelometric turbidity units
ORP Oxidation-reduction potential

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

## Table 4.8
## RI Groundwater Analytical Results: Monitored Natural Attenuation Parameters and Metals

| Location Area | | | Former Fuel Loading Rack Area | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | MW-07 | | | | | MW-11 | MW-12 | | | | MW-13 | |
| Sample Name | | | MW-07-050620 | MW-07-081120 | MW-107-081120 | MW-07-110220 | MW-07-022421 | MW-11-050720 | MW-12-050720 | MW-12-081120 | MW-12-110320 | MW-12-022321 | MW-13-050720 | MW-13-081020 |
| Sample Date | | | 5/6/2020 | 8/11/2020 | 8/11/2020 | 11/2/2020 | 2/24/2021 | 5/7/2020 | 5/7/2020 | 8/11/2020 | 11/3/2020 | 2/23/2021 | 5/7/2020 | 8/10/2020 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | |
| **Conventionals** | | | | | | | | | | | | | | |
| Ferrous iron | -- | mg/L | | | | | | | 2.62 | 2.5 | 4.0 | 2.5 | | |
| Nitrate (as nitrogen) | -- | mg/L | | | | | | | 0.92 | 0.10 U | 0.10 U | 0.10 U | | |
| Sulfate | -- | mg/L | | | | | | | 0.50 | 0.31 | 0.36 | 0.60 U | | |
| Alkalinity (as $CaCO_3$) | -- | mg/L | | | | | | | 54 | 200 | 190 | 190 | | |
| Biochemical oxygen demand | -- | mg/L | | | | | | | | | | | | |
| Chemical oxygen demand | -- | mg/L | | | | | | | | | | | | |
| **Field Parameters** | | | | | | | | | | | | | | |
| Conductivity | -- | µS/cm | 452.4 | 494.4 | | 429.1 | 333.1 | 535 | 129.5 | 554 | 515 | 503.1 | 568 | 533 |
| Dissolved oxygen | -- | mg/L | 3.08 | 0.030 | | 1.19 | 0.59 | 8.66 | 2.69 | 0.020 | 1.17 | 0.44 | 3.36 | 0.53 |
| ORP | -- | mV | -0.3 | -128 | | -94.7 | 213.8 | 61.6 | 8.02 | -109 | -136.5 | -117.2 | -40.2 | -128 |
| pH | -- | pH | 6.52 | 6.69 | | 6.21 | 6.53 | 6.9 | 6.38 | 6.45 | 6.4 | 6.44 | 6.88 | 6.66 |
| Temperature | -- | °C | 14.4 | 14.1 | | 14.4 | 12.6 | 14.6 | 14.5 | 14.6 | 13.3 | 12.6 | 14.5 | 16.4 |
| Turbidity | -- | ntu | 45 | 0.60 | | 0.65 | 2.41 | 39.8 | 6.28 | 9.0 | 0.68 | 1.25 | 27 | 4.28 |
| **Dissolved Gases** | | | | | | | | | | | | | | |
| Methane | -- | mg/L | | | | | | | 0.061 | 4.6 | 11 | 7.1 | | |
| **Total Metals** | | | | | | | | | | | | | | |
| Lead | 15 | µg/L | 1.0 U | 1.0 U | 1.0 U | | | | | | | | | |
| **Dissolved Metals** | | | | | | | | | | | | | | |
| Lead | 15 | µg/L | 1.0 U | | | | | | | | | | | |
| Manganese | -- | µg/L | | | | | | | 23 | 1,800 | 20 | 1,900 | | |

Notes:

Blank cells are intentional.

All laboratory results rounded to two significant figures. Field parameters are not rounded.

-- Not established.

1 MTCA Method A cleanup levels are used as screening levels for total and dissolved lead.

Abbreviations:

AST Aboveground storage tank
°C Degrees Celsius
µg/L Micrograms per liter
µS/cm Microsiemens per centimeter
mg/L Milligrams per liter
MTCA Model Toxics Control Act
mV Millivolts
NTU Nephelometric turbidity units
ORP Oxidation-reduction potential

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

## Table 4.8
## RI Groundwater Analytical Results: Monitored Natural Attenuation Parameters and Metals

| Location Area | | | Former Fuel Loading Rack Area (cont.) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | MW-14 | | | | MW-15 | | | | MW-16 | MW-17 | | | |
| Sample Name | | | MW-14-050720 | MW-14-081120 | MW-14-110220 | MW-14-022421 | MW-15-050720 | MW-15-081020 | MW-15-110220 | MW-15-022321 | MW-16-050720 | MW-17-050720 | MW-17-081120 | MW-17-110320 | MW-17-022421 |
| Sample Date | | | 5/7/2020 | 8/11/2020 | 11/2/2020 | 2/24/2021 | 5/7/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 | 5/7/2020 | 5/7/2020 | 8/11/2020 | 11/3/2020 | 2/24/2021 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | |
| **Conventionals** | | | | | | | | | | | | | | | |
| Ferrous iron | -- | mg/L | 0.02 | | 0.5 U | 0.5 U | | | | | | 0.05 | 0.5 U | 0.5 U | 0.5 U |
| Nitrate (as nitrogen) | -- | mg/L | 3.0 J | 0.10 | 3.6 J | 2.8 | | | | | | 0.88 | 0.27 | 2.0 | 2.0 |
| Sulfate | -- | mg/L | 7.3 | 2.4 | 29 | 1.6 | | | | | | 3.3 | 2.0 | 9.4 | 5.9 |
| Alkalinity (as $CaCO_3$) | -- | mg/L | 210 | 220 | 220 | 180 | | | | | | 210 | 170 | 93 | 170 |
| Biochemical oxygen demand | -- | mg/L | | | | | | | | | | | | | |
| Chemical oxygen demand | -- | mg/L | | | | | | | | | | | | | |
| **Field Parameters** | | | | | | | | | | | | | | | |
| Conductivity | -- | µS/cm | 334.3 | 0.426 | 501 | 301.5 | 434.5 | 643 | 546 | 570 | 286.9 | 429 | 296.3 | 253.3 | 350.6 |
| Dissolved oxygen | -- | mg/L | 2.16 | 0.56 | 1.73 | 2.02 | 0.35 | 0.03 | 1.13 | 1.27 | 2.78 | 8.55 | 5.38 | 6.99 | 7.1 |
| ORP | -- | mV | 78.1 | 30.5 | 0.2 | 188.2 | -96.6 | -132.5 | -133.5 | -113.6 | 68.9 | 161.3 | 108 | 89.8 | 117.8 |
| pH | -- | pH | 6.63 | 6.56 | 6.34 | 6.41 | 6.24 | 6.59 | 6.4 | 6.69 | 6.44 | 6.25 | 6.91 | 6.89 | 6.62 |
| Temperature | -- | °C | 15.3 | 18 | 16 | 10.9 | 15.2 | 14.8 | 14.9 | 12.8 | 14.11 | 14.5 | 14.5 | 14.7 | 12 |
| Turbidity | -- | ntu | 25.4 | 12.4 | 7.08 | 3.15 | 9.64 | 5.2 | 63.32 | 2 | 3.12 | 6.8 | 8.7 | 12.29 | 1.65 |
| **Dissolved Gases** | | | | | | | | | | | | | | | |
| Methane | -- | mg/L | 0.0086 U | 1.6 | 0.0086 U | 0.007 | | | | | | 0.0086 U | 0.19 | 0.0086 U | 0.0081 |
| **Total Metals** | | | | | | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | | | | | | |
| **Dissolved Metals** | | | | | | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | | | | | | |
| Manganese | -- | µg/L | 6 | 88 | 19 | 1.9 | | | | | | 2.5 | 2.7 | 2.5 | 2.5 |

Notes:

Blank cells are intentional.

All laboratory results rounded to two significant figures. Field parameters are not rounded.

-- Not established.

1 MTCA Method A cleanup levels are used as screening levels for total and dissolved lead.

Abbreviations:

AST Aboveground storage tank
°C Degrees Celsius
µg/L Micrograms per liter
µS/cm Microsiemens per centimeter
mg/L Milligrams per liter
MTCA Model Toxics Control Act
mV Millivolts
NTU Nephelometric turbidity units
ORP Oxidation-reduction potential

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

## Table 4.8
## RI Groundwater Analytical Results: Monitored Natural Attenuation Parameters and Metals

| | | Location Area | Former Fuel Loading Rack Area (cont.) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Location Name | MW-20 | | MW-25 | | | | MW-33 | | | | MW-40 | | | |
| | | Sample Name | MW-20-050720 | MW-20-022321 | MW-25-050720 | MW-25-081120 | MW-25-110320 | MW-25-022321 | MW-33-050620 | MW-33-081120 | MW-33-110220 | MW-33-022421 | MW-40-050620 | MW-40-081120 | MW-40-110220 | MW-40-022421 |
| | | Sample Date | 5/7/2020 | 2/23/2021 | 5/7/2020 | 8/11/2020 | 11/3/2020 | 2/23/2021 | 5/6/2020 | 8/11/2020 | 11/2/2020 | 2/24/2021 | 5/6/2020 | 8/11/2020 | 11/2/2020 | 2/24/2021 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | | |
| **Conventionals** | | | | | | | | | | | | | | | | |
| Ferrous iron | -- | mg/L | 4.8 | 2.5 | 3.11 | 4.5 | 2.5 | 3.5 | | | | | | | | |
| Nitrate (as nitrogen) | -- | mg/L | 0.20 U | 0.10 U | 0.10 U | 0.11 | 1.0 U | 0.10 U | | | | | | | | |
| Sulfate | -- | mg/L | 0.69 | 0.60 U | 4.1 | 0.34 | 0.35 | 4.5 | | | | | | | | |
| Alkalinity (as $CaCO_3$) | -- | mg/L | 430 | 430 | 78 | 190 | 190 | 280 | | | | | | | | |
| Biochemical oxygen demand | -- | mg/L | 45 | | | | | | | | | | 11 J | | | |
| Chemical oxygen demand | -- | mg/L | 69 | | | | | | | | | | 46 | | | |
| **Field Parameters** | | | | | | | | | | | | | | | | |
| Conductivity | -- | µS/cm | 802 | 914 | 301.9 | 398 | 434.9 | 416 | 474.6 | 298.6 | 397.3 | 432 | 407 | 279.1 | 415 | 263 |
| Dissolved oxygen | -- | mg/L | 2.23 | 0.54 | 0.08 | 0.67 | 1.08 | 0.49 | 2.74 | 0.4 | 0.66 | 0.28 | 0.21 | 5.6 | 0.41 | 0.55 |
| ORP | -- | mV | -124 | -135.5 | -70.9 | -102 | -135.9 | -84.5 | -53.8 | 88.4 | -101.8 | -108.6 | -156 | 104.3 | -152 | 182 |
| pH | -- | pH | 6.76 | 6.69 | 6.52 | 6.47 | 6.45 | 6.33 | 6.46 | 6.3 | 6.48 | 6.48 | 6.54 | 6.37 | 6.54 | 6.65 |
| Temperature | -- | °C | 16.6 | 12.2 | 12.4 | 15.8 | 16.2 | 10.8 | 14.8 | 14.2 | 14 | 13 | 14 | 14.8 | 14.3 | 12.3 |
| Turbidity | -- | ntu | 43.4 | 2.34 | 7.3 | 3.9 | 1.7 | 1.09 | 72.5 | 19.33 | 3.57 | 1.17 | 3.7 | 5.89 | 2.01 | 0.98 |
| **Dissolved Gases** | | | | | | | | | | | | | | | | |
| Methane | -- | mg/L | 5.9 J | 9.2 | 2.1 | 4.6 | 7.3 | 5.1 | | | | | | | | |
| **Total Metals** | | | | | | | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | | | | | | | |
| **Dissolved Metals** | | | | | | | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | | | | | | | |
| Manganese | -- | µg/L | 3,000 | 2,800 | 720 | 1,400 | 2,000 | 1,000 | | | | | | | | |

Notes:

Blank cells are intentional.

All laboratory results rounded to two significant figures. Field parameters are not rounded.

-- Not established.

1 MTCA Method A cleanup levels are used as screening levels for total and dissolved lead.

Abbreviations:

AST Aboveground storage tank
°C Degrees Celsius
µg/L Micrograms per liter
µS/cm Microsiemens per centimeter
mg/L Milligrams per liter
MTCA Model Toxics Control Act
mV Millivolts
NTU Nephelometric turbidity units
ORP Oxidation-reduction potential

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

## Table 4.8
## RI Groundwater Analytical Results: Monitored Natural Attenuation Parameters and Metals

| | | Location Area | Former Mechanic's Shop | | | | Monitoring Wells MW-26 and MW-28 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Location Name | UST4 | | | | MW-18 | | | | MW-24 | | | | MW-26 | |
| | | Sample Name | UST-4-050620 | UST-4-081020 | UST-4-110220 | UST-4-022321 | MW-18-050720 | MW-18-081120 | MW-18-110320 | MW-18-022421 | MW-24-022321 | MW-24-050720 | MW-24-081120 | MW-24-110320 | MW-26-050720 | MW-26-081020 |
| | | Sample Date | 5/6/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 | 5/7/2020 | 8/11/2020 | 11/3/2020 | 2/24/2021 | 2/23/2021 | 5/7/2020 | 8/11/2020 | 11/3/2020 | 5/7/2020 | 8/10/2020 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | | |
| **Conventionals** | | | | | | | | | | | | | | | | |
| Ferrous iron | -- | mg/L | | | | | 0.15 | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.0 U | 0.5 U | 0.5 U | | |
| Nitrate (as nitrogen) | -- | mg/L | | | | | 0.96 | 0.54 | 1.6 | 2.8 | 1.3 | 0.88 | 0.95 | 2.3 | | |
| Sulfate | -- | mg/L | | | | | 4.0 | 3.8 | 7.5 | 6.8 | 5.9 | 5.2 | 4.8 | 7.6 | | |
| Alkalinity (as $CaCO_3$) | -- | mg/L | | | | | 88 | 110 | 69 | 62 | 89 | 110 | 130 | 120 | | |
| Biochemical oxygen demand | -- | mg/L | | | | | | | | | | | | | | |
| Chemical oxygen demand | -- | mg/L | | | | | | | | | | | | | | |
| **Field Parameters** | | | | | | | | | | | | | | | | |
| Conductivity | -- | µS/cm | 277.5 | 211 | 267.9 | 220 | 194 | 198.2 | 161.1 | 209.4 | 166 | 188 | 247.9 | 275 | 195.1 | 218.5 |
| Dissolved oxygen | -- | mg/L | 8.13 | 4.48 | 3.57 | 6.26 | 9.63 | 2.13 | 7.93 | 8.68 | 7.43 | 5.89 | 7.11 | 6.2 | 1.57 | 7.29 |
| ORP | -- | mV | 94.7 | 127 | 99.7 | 35.1 | 114 | 63.8 | 78.1 | 124 | 75.2 | 109 | 113.9 | 65.5 | -28.3 | -67.7 |
| pH | -- | pH | 5.9 | 6.05 | 6.02 | 6.13 | 6.8 | 6.51 | 6.69 | 6.73 | 6.78 | 6.92 | 6.8 | 6.91 | 6.29 | 6.52 |
| Temperature | -- | °C | 14.8 | 17.5 | 15.8 | 13.9 | 13.7 | 14.6 | 14.1 | 11.6 | 12.1 | 13.1 | 14 | 13.5 | 13.2 | 22.2 |
| Turbidity | -- | ntu | 19.1 | 15.3 | 1.4 | 2.42 | 5.5 | 6.69 | 1.21 | 0.79 | 11.5 | 17.2 | 39.87 | 2.72 | 28.01 | 20.87 |
| **Dissolved Gases** | | | | | | | | | | | | | | | | |
| Methane | -- | mg/L | | | | | 0.0086 U | 0.025 | 0.019 | 0.0068 U | 0.0068 U | 0.016 | 0.0086 U | 0.0086 U | | |
| **Total Metals** | | | | | | | | | | | | | | | | |
| Lead | 15 | µg/L | 1.0 U | 1.0 U | | | | | | | | | | | | |
| **Dissolved Metals** | | | | | | | | | | | | | | | | |
| Lead | 15 | µg/L | 1.0 U | | | | | | | | | | | | | |
| Manganese | -- | µg/L | | | | | 3.5 | 100 | 12 | 1.8 U | 2.9 | 9.1 | 6.4 | 3.1 | | |

Notes:

Blank cells are intentional.

All laboratory results rounded to two significant figures. Field parameters are not rounded.

-- Not established.

1 MTCA Method A cleanup levels are used as screening levels for total and dissolved lead.

Abbreviations:

AST Aboveground storage tank

°C Degrees Celsius

µg/L Micrograms per liter

µS/cm Microsiemens per centimeter

mg/L Milligrams per liter

MTCA Model Toxics Control Act

mV Millivolts

NTU Nephelometric turbidity units

ORP Oxidation-reduction potential

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.

U Analyte was not detected at the given reporting limit.

UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

## Table 4.8
## RI Groundwater Analytical Results: Monitored Natural Attenuation Parameters and Metals

| Location Area | | | Monitoring Wells MW-26 and MW-28 (cont.) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | MW-26 (cont.) | | MW-27 | | MW-28 | | MW-29 | | | | MW-34 | | | |
| Sample Name | | | MW-26-110220 | MW-26-022321 | MW-27-050720 | MW-27-081020 | MW-28-081120 | MW-28-022421 | MW-29-050620 | MW-29-081120 | MW-29-110320 | MW-29-022421 | MW-34-050620 | MW-34-081020 | MW-34-110220 | MW-34-022421 |
| Sample Date | | | 11/2/2020 | 2/23/2021 | 5/7/2020 | 8/10/2020 | 8/11/2020 | 2/24/2021 | 5/6/2020 | 8/11/2020 | 11/3/2020 | 2/24/2021 | 5/6/2020 | 8/10/2020 | 11/2/2020 | 2/24/2021 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | | |
| **Conventionals** | | | | | | | | | | | | | | | | |
| Ferrous iron | -- | mg/L | | | | | | 0.5 U | 0.0 U | 0.5 U | 0.5 U | 0.5 U | | | | |
| Nitrate (as nitrogen) | -- | mg/L | | | | | | 1.4 | 2.4 J | 2.2 | 2.1 | 0.87 | | | | |
| Sulfate | -- | mg/L | | | | | | 4.2 | 9.9 | 14 | 13 | 1.3 | | | | |
| Alkalinity (as $CaCO_3$) | -- | mg/L | | | | | | 41 | 47 | 49 | 64 | 45 | | | | |
| Biochemical oxygen demand | -- | mg/L | | | | | | | | | | | | | | |
| Chemical oxygen demand | -- | mg/L | | | | | | | | | | | | | | |
| **Field Parameters** | | | | | | | | | | | | | | | | |
| Conductivity | -- | µS/cm | 259.6 | 137 | 531 | 445 | 203.4 | 114 | 120.6 | 167 | 210 | 92 | 267.8 | 1,906 | 2,706 | 856 |
| Dissolved oxygen | -- | mg/L | 0.59 | 7.31 | 3.12 | 0.73 | 1.57 | 1.5 | 4.12 | 2.78 | 1.39 | 6.29 | 0.46 | 0.56 | 0.45 | 1.31 |
| ORP | -- | mV | -4.8 | 51.5 | 21.6 | -37.8 | 2.8 | 175.4 | 120.3 | 63.7 | 42.7 | 51.2 | -56.2 | -25.5 | -8.7 | -31.5 |
| pH | -- | pH | 6.39 | 6.08 | 6.48 | 6.31 | 6.2 | 5.5 | 6.17 | 6.35 | 6.35 | 6.32 | 5.79 | 5.88 | 5.9 | 6.51 |
| Temperature | -- | °C | 16 | 12.3 | 13.9 | 16.3 | 17.5 | 12 | 14.2 | 14.1 | 14.3 | 12.4 | 15.3 | 17.3 | 14.9 | 14.5 |
| Turbidity | -- | ntu | 12.8 | 3.87 | 22.2 | 18.24 | 17.02 | 10.36 | 0.17 | 3.69 | 0.72 | 3.94 | 4.77 | 3.3 | 2.19 | 4.48 |
| **Dissolved Gases** | | | | | | | | | | | | | | | | |
| Methane | -- | mg/L | | | | | | 0.052 | 0.0097 | 0.017 | 0.0086 U | 0.0068 U | | | | |
| **Total Metals** | | | | | | | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | | | | | | | |
| **Dissolved Metals** | | | | | | | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | | | | | | | |
| Manganese | -- | µg/L | | | | | | 10 | 2.0 U | 2.0 U | 2.5 | 1.8 U | | | | |

Notes:

Blank cells are intentional.

All laboratory results rounded to two significant figures. Field parameters are not rounded.

-- Not established.

1 MTCA Method A cleanup levels are used as screening levels for total and dissolved lead.

Abbreviations:

AST Aboveground storage tank
°C Degrees Celsius
µg/L Micrograms per liter
µS/cm Microsiemens per centimeter
mg/L Milligrams per liter
MTCA Model Toxics Control Act
mV Millivolts
NTU Nephelometric turbidity units
ORP Oxidation-reduction potential

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
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UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

## Table 4.8
## RI Groundwater Analytical Results: Monitored Natural Attenuation Parameters and Metals

| Location Area | | | Northern Portion of the Former Standard Pipelines | | | | | | | | | | Perimeter Monitoring Wells | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | MW-06 | | | | MW-19 | | MW-39 | | | | MW-01 | | MW-04 |
| Sample Name | | | MW-06-050620 | MW-06-081020 | MW-06-110220 | MW-06-022321 | MW-19-050720 | MW-19-081020 | MW-39-050720 | MW-39-081020 | MW-39-110220 | MW-39-022321 | MW-01-050620 | MW-01-081020 | MW-04-022421 |
| Sample Date | | | 5/6/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 | 5/7/2020 | 8/10/2020 | 5/7/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 | 5/6/2020 | 8/10/2020 | 2/24/2021 |
| **Analyte** | **Screening Level [(1)]** | **Unit** | | | | | | | | | | | | | |
| **Conventionals** | | | | | | | | | | | | | | | |
| Ferrous iron | -- | mg/L | | | | | 0.02 | 0.5 U | | | | | | | |
| Nitrate (as nitrogen) | -- | mg/L | | | | | 5.3 J | 7.7 J | | | | | | | |
| Sulfate | -- | mg/L | | | | | 10 | 16 | | | | | | | |
| Alkalinity (as $CaCO_3$) | -- | mg/L | | | | | 110 | 93 | | | | | | | |
| Biochemical oxygen demand | -- | mg/L | | | | | | | | | | | | | |
| Chemical oxygen demand | -- | mg/L | | | | | | | | | | | | | |
| **Field Parameters** | | | | | | | | | | | | | | | |
| Conductivity | -- | µS/cm | 185 | 239.4 | 285.7 | 252.6 | 273.8 | 422.8 | 522 | 562 | 482.7 | 613.5 | 225 | 274.6 | 477 |
| Dissolved oxygen | -- | mg/L | 0.15 | 0.1 | 1.13 | 0.61 | 3.34 | 0.97 | 2.93 | 0.01 | 1.13 | 2.53 | 3.76 | -0.03 | 7.7 |
| ORP | -- | mV | -86.4 | -116.1 | -104.6 | -111.4 | 71.1 | 126.4 | -7.9 | -144.4 | -120.4 | -129.5 | -39.8 | -93.2 | 55.4 |
| pH | -- | pH | 6.61 | 6.55 | 6.19 | 6.42 | 5.98 | 6.13 | 6.45 | 6.51 | 6.19 | 6.41 | 6.4 | 6.51 | 11.26 |
| Temperature | -- | °C | 13.1 | 16.3 | 15.5 | 13.4 | 14.6 | 15.4 | 16 | 16.1 | 14.7 | 13.5 | 13 | 15.1 | 11.5 |
| Turbidity | -- | ntu | 10.65 | 2.4 | 0.61 | 2.57 | 3.8 | 0 | 5.8 | -0.4 | 1 | 0.81 | 5.7 | -2.0 | 2.67 |
| **Dissolved Gases** | | | | | | | | | | | | | | | |
| Methane | -- | mg/L | | | | | 0.0086 U | 0.0086 U | | | | | | | |
| **Total Metals** | | | | | | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | | | | | | |
| **Dissolved Metals** | | | | | | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | | | | | | |
| Manganese | -- | µg/L | | | | | 2.0 U | 2.0 U | | | | | | | |

Notes:

Blank cells are intentional.

All laboratory results rounded to two significant figures. Field parameters are not rounded.

-- Not established.

1 MTCA Method A cleanup levels are used as screening levels for total and dissolved lead.

Abbreviations:

AST Aboveground storage tank
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Qualifiers:

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## Table 4.8
## RI Groundwater Analytical Results: Monitored Natural Attenuation Parameters and Metals

| | | Location Area | Perimeter Monitoring Wells (cont.) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Location Name | MW-22 | | | | | MW-23 | | | | | MW-30 | | |
| | | Sample Name | MW-22-050720 | MW-22-081120 | MW-122-081120 | MW-22-110320 | MW-22-022421 | MW-23-050620 | MW-23-081120 | MW-23-110320 | MW-123-110320 | MW-23-022421 | MW-30-081120 | MW-30-110220 | MW-30-022421 |
| | | Sample Date | 5/7/2020 | 8/11/2020 | 8/11/2020 | 11/3/2020 | 2/24/2021 | 5/6/2020 | 8/11/2020 | 11/3/2020 | 11/3/2020 | 2/24/2021 | 8/11/2020 | 11/2/2020 | 2/24/2021 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | |
| **Conventionals** | | | | | | | | | | | | | | | |
| Ferrous iron | -- | mg/L | 5.26 | 4.0 | | 1.5 | 3.5 | 9.64 | 2.5 | 4 | | 4.5 | 0.5 U | 0.5 U | 0.5 U |
| Nitrate (as nitrogen) | -- | mg/L | 0.11 | 0.10 U | 0.10 U | 1.0 U | 0.10 U | 0.20 UJ | 0.40 U | 1.0 U | 1.0 U | 1.0 U | 42 J | 58 J | 24 |
| Sulfate | -- | mg/L | 0.3 U | 0.31 | 0.30 | 0.33 | 2.3 | 3.3 | 7.3 | 14 | 14 | 14 | 130 | 230 | 97 |
| Alkalinity (as $CaCO_3$) | -- | mg/L | 150 | 150 | 150 | 160 | 130 | 100 | 93 | 88 | 100 | 83 | 140 | 150 | 140 |
| Biochemical oxygen demand | -- | mg/L | | | | | | | | | | | | | |
| Chemical oxygen demand | -- | mg/L | | | | | | | | | | | | | |
| **Field Parameters** | | | | | | | | | | | | | | | |
| Conductivity | -- | µS/cm | 284.2 | 266 | | 302 | 205 | 633 | 712 | 1,154 | | 720 | 1,167 | 1,872 | 700 |
| Dissolved oxygen | -- | mg/L | 2.74 | 0.51 | | 0.53 | 0.38 | 0.15 | 0.29 | 1.24 | | 1.45 | 2.49 | 2.1 | 3.85 |
| ORP | -- | mV | 27.3 | -49.6 | | 14.1 | 15 | -99.1 | -385 | -98.9 | | 11.2 | 127.3 | 35.6 | 54 |
| pH | -- | pH | 6.23 | 6.38 | | 6.48 | 6.38 | 6.5 | 6.44 | 6.15 | | 6.31 | 6.28 | 6.37 | 6.84 |
| Temperature | -- | °C | 14.8 | 15.4 | | 14.5 | 13.6 | 15.5 | 15.5 | 13.4 | | 13.7 | 15.5 | 15.7 | 13.2 |
| Turbidity | -- | ntu | 9.9 | 6 | | 0.71 | 0.43 | 4.14 | 3.35 | 1.57 | | 1.23 | 4.2 | 0.27 | 0.35 |
| **Dissolved Gases** | | | | | | | | | | | | | | | |
| Methane | -- | mg/L | 0.98 | 4.0 | 2.8 | 3.0 | 2.6 | 0.77 | 0.75 | 0.46 | 0.35 | 0.94 | 0.0086 U | 0.0086 U | 0.0068 U |
| **Total Metals** | | | | | | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | | | | | | |
| **Dissolved Metals** | | | | | | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | | | | | | |
| Manganese | -- | µg/L | 790 | 1,100 | 1,100 | 1,100 | 870 | 2,100 | 2,600 | 3,700 | 4,000 | 1,600 | 130 | 490 | 180 |

Notes:

Blank cells are intentional.

All laboratory results rounded to two significant figures. Field parameters are not rounded.

-- Not established.

1 MTCA Method A cleanup levels are used as screening levels for total and dissolved lead.

Abbreviations:

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°C Degrees Celsius
µg/L Micrograms per liter
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## Table 4.8
## RI Groundwater Analytical Results: Monitored Natural Attenuation Parameters and Metals

| Location Area | | | Perimeter Monitoring Wells (cont.) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location Name | | | MW-31 | | | | MW-35 | | | | | MW-36 | | | |
| Sample Name | | | MW-31-050620 | MW-31-081020 | MW-31-110220 | MW-31-022321 | MW-35-050620 | MW-35-081020 | MW-35-110220 | MW-35-022421 | MW-135-022421 | MW-36-050620 | MW-36-081020 | MW-36-110220 | MW-36-022321 |
| Sample Date | | | 5/6/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 | 5/6/2020 | 8/10/2020 | 11/2/2020 | 2/24/2021 | 2/24/2021 | 5/6/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | | | | | | |
| **Conventionals** | | | | | | | | | | | | | | | |
| Ferrous iron | -- | mg/L | 0.0 U | 0.5 U | 0.5 U | 0.5 U | | 0.5 U | 0.5 U | 0.5 U | | | | | |
| Nitrate (as nitrogen) | -- | mg/L | 5.6 J | 4.4 | 1.5 J | 5.1 | | 13 J | 5.3 J | 9.3 | 9.3 | | | | |
| Sulfate | -- | mg/L | 17 | 18 | 16 | 13 | | 8.3 | 6.7 | 15 | 16 | | | | |
| Alkalinity (as $CaCO_3$) | -- | mg/L | 230 | 200 | 210 | 190 | | 78 | 88 | 86 | 89 | | | | |
| Biochemical oxygen demand | -- | mg/L | | | | | | | | | | | | | |
| Chemical oxygen demand | -- | mg/L | | | | | | | | | | | | | |
| **Field Parameters** | | | | | | | | | | | | | | | |
| Conductivity | -- | µS/cm | 375.8 | 386 | 458 | 319 | 364.8 | 433 | 338.9 | 403.4 | | 270 | 232 | 266 | 191 |
| Dissolved oxygen | -- | mg/L | 3.53 | 6.09 | 1.46 | 2.9 | 0.13 | 1.05 | 0.43 | 1.35 | | 0.24 | 1.29 | 0.49 | 6.22 |
| ORP | -- | mV | 124.1 | 127.3 | 42.9 | 187 | 120 | 74.9 | 49.8 | 138.2 | | 100 | 61.1 | 42.8 | 15.6 |
| pH | -- | pH | 6.53 | 6.42 | 6.44 | 6.53 | 6.55 | 6.44 | 6.6 | 6.67 | | 6.42 | 6.26 | 6.1 | 6.45 |
| Temperature | -- | °C | 14.3 | 16 | 14.8 | 13.6 | 13.2 | 18.4 | 15 | 13.3 | | 15.5 | 17.1 | 15.9 | 14.2 |
| Turbidity | -- | ntu | 6.03 | 6 | 15.6 | 5.34 | 7.7 | 9.6 | 1.02 | 1.43 | | 10.7 | 9.3 | 3.0 | 52.4 |
| **Dissolved Gases** | | | | | | | | | | | | | | | |
| Methane | -- | mg/L | 0.0086 U | 0.0086 U | 0.022 | 0.043 | | 0.013 | 0.017 | 0.0068 U | 0.0068 U | | | | |
| **Total Metals** | | | | | | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | | | | | | |
| **Dissolved Metals** | | | | | | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | | | | | | |
| Manganese | -- | µg/L | 2.0 U | 2.0 U | 2.1 | 9.2 | | 26 | 6.4 | 9.1 | 9.1 | | | | |

Notes:

Blank cells are intentional.

All laboratory results rounded to two significant figures. Field parameters are not rounded.

-- Not established.

1 MTCA Method A cleanup levels are used as screening levels for total and dissolved lead.

Abbreviations:

AST Aboveground storage tank

°C Degrees Celsius

µg/L Micrograms per liter

µS/cm Microsiemens per centimeter

mg/L Milligrams per liter

MTCA Model Toxics Control Act

mV Millivolts

NTU Nephelometric turbidity units

ORP Oxidation-reduction potential

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.

U Analyte was not detected at the given reporting limit.

UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

## Table 4.8
## RI Groundwater Analytical Results: Monitored Natural Attenuation Parameters and Metals

| | | Location Area | Southern Pipelines and Berths | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Location Name | MW-37 | | | | MW-38 | | | |
| | | Sample Name | MW-37-050720 | MW-37-081020 | MW-37-110220 | MW-37-022321 | MW-38-050720 | MW-38-081020 | MW-38-110220 | MW-38-022321 |
| | | Sample Date | 5/7/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 | 5/7/2020 | 8/10/2020 | 11/2/2020 | 2/23/2021 |
| **Analyte** | **Screening Level [1]** | **Unit** | | | | | | | | |
| **Conventionals** | | | | | | | | | | |
| Ferrous iron | -- | mg/L | | | | | | | | |
| Nitrate (as nitrogen) | -- | mg/L | | | | | | | | |
| Sulfate | -- | mg/L | | | | | | | | |
| Alkalinity (as $CaCO_3$) | -- | mg/L | | | | | | | | |
| Biochemical oxygen demand | -- | mg/L | | | | | | | | |
| Chemical oxygen demand | -- | mg/L | | | | | | | | |
| **Field Parameters** | | | | | | | | | | |
| Conductivity | -- | µS/cm | 1,799 | 1,267 | 1,509 | 890 | 466.3 | 381 | 487 | 338 |
| Dissolved oxygen | -- | mg/L | 0.12 | 0.4 | 1.78 | 0.20 | 3.49 | 0.43 | 0.49 | 0.29 |
| ORP | -- | mV | -130.8 | -110.5 | -57.1 | -1.8 | -6.5 | -83.6 | -47.5 | -37.7 |
| pH | -- | pH | 6.84 | 6.83 | 6.42 | 6.89 | 6.3 | 6.61 | 6.33 | 6.49 |
| Temperature | -- | °C | 14.6 | 18.5 | 15.4 | 12.9 | 14.6 | 17.2 | 15.7 | 14.7 |
| Turbidity | -- | ntu | 8.7 | 87.3 | 2.54 | 1.74 | 230.1 | 104 | 92.1 | 3.58 |
| **Dissolved Gases** | | | | | | | | | | |
| Methane | -- | mg/L | | | | | | | | |
| **Total Metals** | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | |
| **Dissolved Metals** | | | | | | | | | | |
| Lead | 15 | µg/L | | | | | | | | |
| Manganese | -- | µg/L | | | | | | | | |

Notes:

Blank cells are intentional.

All laboratory results rounded to two significant figures. Field parameters are not rounded.

-- Not established.

1 MTCA Method A cleanup levels are used as screening levels for total and dissolved lead.

Abbreviations:

AST Aboveground storage tank
°C Degrees Celsius
µg/L Micrograms per liter
µS/cm Microsiemens per centimeter
mg/L Milligrams per liter
MTCA Model Toxics Control Act
mV Millivolts
NTU Nephelometric turbidity units
ORP Oxidation-reduction potential

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.
U Analyte was not detected at the given reporting limit.
UJ Analyte was not detected, concentration given is the reporting limit, which is considered to be an estimate.

# Table 4.9
## RI Soil Vapor Analytical Results

| | | Location Area | Former Calloway Ross Parcel | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Location Name | VP-1 | | | | VP-2 | |
| | | Sample Name | SVP-01-050820 | SVP-101-050820 | SVP-1-110320 | SVP-101-110320 | SVP-02-050820 | SVP-2-110320 |
| | | Sample Date | 5/8/2020 | 5/8/2020 | 11/3/2020 | 11/3/2020 | 5/8/2020 | 11/3/2020 |
| Analyte | MTCA Sub-slab Method B Screening Level | Unit | | | | | | |
| **Conventionals** | | | | | | | | |
| Helium | -- | % | 0.60 U | 0.60 U | | | 0.60 U | |
| Isopropyl alcohol | -- | µg/m³ | | | 28 U | 27 U | | 330 J |
| **Total Petroleum Hydrocarbons (TPH)** | | | | | | | | |
| TPH | 4,700 | µg/m³ | 180 | 160 | | | 450 | |
| **Air Phase Hydrocarbons** | | | | | | | | |
| C5-C8 Aliphatics | -- | µg/m³ | 90 U | 96 U | 130 U | 120 U | 100 | 210 |
| C9-C10 Aromatics | -- | µg/m³ | 75 U | 80 U | 82 | 86 | 77 U | 82 U |
| C9-C12 Aliphatics | -- | µg/m³ | 180 | 160 | 480 | 480 | 350 | 310 |
| **Volatile Organic Compounds** | | | | | | | | |
| Benzene | 11 | µg/m³ | 0.96 U | 1.0 U | 1.0 U | 0.99 U | 0.99 U | 1.1 U |
| Toluene | 7,600 | µg/m³ | 57 U | 60 U | 60 U | 58 U | 58 U | 62 U |
| Ethylbenzene | 15,000 | µg/m³ | 1.3 U | 1.4 U | 1.7 | 1.4 | 1.3 U | 9.0 |
| Xylene (total) | 1,500 | µg/m³ | 2.6 U | 2.8 U | 10 | 8.2 | 5.6 | 56 |
| **Polycyclic Aromatic Hydrocabons** | | | | | | | | |
| Naphthalene | 2.5 | µg/m³ | 0.79 U | 0.84 U | 0.84 U | 0.81 U | 0.81 U | 0.86 U |

Notes:

Blank cells are intentional.

All results rounded to two significant figures.

-- Not available.

Abbreviations:

µg/m³ Micrograms per cubic meter

MTCA Model Toxics Control Act

Qualifiers:

J Analyte was detected, concentration is considered to be an estimate.

U Analyte was not detected at the given reporting limit.

## Table 4.10
## Monitoring Well Groundwater Elevations

| Well | Aquifer | Screened Interval (ft bgs) | TOC Elevation (ft NAVD 88) | Date | Time | Depth to Water (ft bgs) | Depth to LNAPL (ft bgs) | Groundwater Elevation (ft NAVD 88) |
|---|---|---|---|---|---|---|---|---|
| MW-01 | Alluvial Aquifer | 6.3–16.3 | 17.96 | 5/6/2020 | 11:34 | 11.17 | -- | 6.79 |
| | | | | 8/10/2020 | 10:08 | 11.70 | -- | 6.26 |
| | | | | 11/2/2020 | 9:45 | 12.06 | -- | 5.90 |
| | | | | 2/23/2021 | 9:57 | 9.74 | -- | 8.22 |
| MW-02 | Perched | 6.2–12.4 | 22.71 | 5/6/2020 | 10:59 | 9.76 | -- | 12.95 |
| | | | | 8/10/2020 | 10:19 | 10.17 | -- | 12.54 |
| | | | | 11/2/2020 | 10:19 | 10.18 | -- | 12.53 |
| | | | | 2/23/2021 | 9:36 | 8.50 | -- | 14.21 |
| MW-03 | Alluvial Aquifer | 8.4–18.4 | 20.93 | 5/6/2020 | 10:48 | 13.39 | -- | 7.54 |
| | | | | 8/10/2020 | 10:15 | 14.18 | -- | 6.75 |
| | | | | 11/2/2020 | 11:41 | 14.65 | -- | 6.28 |
| | | | | 2/23/2021 | 9:26 | 12.28 | -- | 8.65 |
| MW-04 [1] | Perched | 7.4–17.4 | 24.22 | 5/6/2020 | -- | -- | -- | -- |
| | | | | 8/10/2020 | 9:30 | 17.12 | -- | 7.10 |
| | | | | 11/2/2020 | 9:37 | 17.24 | -- | 6.98 |
| | | | | 2/23/2021 | 9:30 | 10.52 | -- | 13.70 |
| MW-05 | Alluvial Aquifer | 12.5–22.5 | 22.69 | 5/6/2020 | 11:11 | 14.96 | -- | 7.73 |
| | | | | 8/10/2020 | 10:21 | 15.90 | -- | 6.79 |
| | | | | 11/2/2020 | 11:47 | 16.36 | -- | 6.33 |
| | | | | 2/23/2021 | 9:30 | 13.74 | -- | 8.95 |
| MW-06 | Alluvial Aquifer | 16–21 | 17.48 | 5/6/2020 | 11:45 | 10.62 | -- | 6.86 |
| | | | | 8/10/2020 | 10:15 | 11.35 | -- | 6.13 |
| | | | | 11/2/2020 | 10:59 | 11.64 | -- | 5.84 |
| | | | | 2/23/2021 | 10:26 | 9.35 | -- | 8.13 |
| MW-07 | Alluvial Aquifer | 18–23 | 22.21 | 5/6/2020 | 11:57 | 14.82 | -- | 7.39 |
| | | | | 8/10/2020 | 10:40 | 15.60 | -- | 6.61 |
| | | | | 11/2/2020 | -- | -- | -- | -- |
| | | | | 2/23/2021 | 11:05 | 13.57 | -- | 8.64 |
| MW-08 | Alluvial Aquifer | 18–23 | 20.61 | 5/6/2020 | 10:25 | 13.19 | -- | 7.42 |
| | | | | 8/10/2020 | 10:08 | 13.93 | -- | 6.68 |
| | | | | 11/2/2020 | 11:36 | 14.42 | -- | 6.19 |
| | | | | 2/23/2021 | 9:22 | 12.05 | -- | 8.56 |
| MW-09 | Alluvial Aquifer [2] | 8–18 | 23.36 | 5/6/2020 | 14:30 | 16.19 | 16.05 | 7.28 |
| | | | | 8/11/2020 | 10:05 | 16.96 | 16.85 | 6.49 |
| | | | | 11/2/2020 | 10:47 | 17.02 | 16.95 | 6.40 |
| | | | | 2/23/2021 | 11:02 | 14.98 | 14.45 | 8.81 |
| MW-10 | Alluvial Aquifer | 18–23 | 22.89 | 5/6/2020 | 10:36 | 15.38 | -- | 7.51 |
| | | | | 8/10/2020 | 10:11 | 16.21 | -- | 6.68 |
| | | | | 11/2/2020 | 11:49 | 16.30 | -- | 6.59 |
| | | | | 2/23/2021 | 9:46 | 14.43 | -- | 8.46 |
| MW-11 | Perched | 6.7–16.7 | 25.07 | 5/07/2020 [4] | 12:37 | 12.39 | -- | 12.68 |
| | | | | 8/10/2020 | 10:55 | 15.43 | -- | 9.64 |
| | | | | 11/2/2020 | 10:27 | 14.84 | -- | 10.23 |
| | | | | 2/23/2021 | 10:43 | 6.45 | -- | 18.62 |
| MW-12 | Alluvial Aquifer | 22–27 | 21.16 | 5/07/2020 [4] | 13:58 | 13.60 | -- | 7.56 |
| | | | | 8/11/2020 [5] | 12:28 | 14.60 | -- | 6.56 |
| | | | | 11/2/2020 | 10:41 | 14.95 | -- | 6.21 |
| | | | | 2/23/2021 | 10:45 | 12.52 | -- | 8.64 |
| MW-13 | Perched | 13–18 | 25.09 | 5/07/2020 [4] | 11:01 | 11.03 | -- | 14.06 |
| | | | | 8/10/2020 | 11:06 | 11.46 | -- | 13.63 |
| | | | | 11/2/2020 | 10:21 | 10.99 | -- | 14.10 |
| | | | | 2/23/2021 | 10:22 | 9.05 | -- | 16.04 |
| MW-14 | Perched | 7–12 | 23.77 | 5/07/2020 [4] | 13:44 | 6.43 | -- | 17.34 |
| | | | | 8/10/2020 | 10:42 | 8.51 | -- | 15.26 |
| | | | | 11/2/2020 | 10:43 | 6.83 | -- | 16.94 |
| | | | | 2/23/2021 | 10:57 | 4.65 | -- | 19.12 |
| MW-15 | Alluvial Aquifer | 8.5–18.5 | 21.75 | 5/07/2020 [4] | 12:40 | 14.11 | -- | 7.64 |
| | | | | 8/10/2020 | 10:25 | 15.00 | -- | 6.75 |
| | | | | 11/2/2020 | 10:56 | 15.50 | -- | 6.25 |
| | | | | 2/23/2021 | 10:40 | 12.99 | -- | 8.76 |
| MW-16 | Perched | 4.5–14.5 | 22.06 | 5/07/2020 [4] | 11:30 | 9.92 | -- | 12.14 |
| | | | | 8/10/2020 | 10:31 | 12.41 | -- | 9.65 |
| | | | | 11/2/2020 | 10:55 | 10.84 | -- | 11.22 |
| | | | | 2/23/2021 | 11:00 | 5.40 | -- | 16.66 |
| MW-17 | Perched | 7.5–17.5 | 25.24 | 5/07/2020 [4] | 9:48 | 10.07 | -- | 15.17 |
| | | | | 8/10/2020 | 11:12 | 12.62 | -- | 12.62 |
| | | | | 11/2/2020 | 11:28 | 9.13 | -- | 16.11 |
| | | | | 2/23/2021 | 10:20 | 6.80 | -- | 18.44 |
| MW-18 | Perched | 8–18 | 26.56 | 5/07/2020 [4] | 12:37 | 12.50 | -- | 14.06 |
| | | | | 8/10/2020 | 11:40 | 13.40 | -- | 13.16 |
| | | | | 11/2/2020 | 10:17 | 12.69 | -- | 13.87 |
| | | | | 2/23/2021 | 10:33 | 9.80 | -- | 16.76 |

## Table 4.10
## Monitoring Well Groundwater Elevations

| Well | Aquifer | Screened Interval (ft bgs) | TOC Elevation (ft NAVD 88) | Date | Time | Depth to Water (ft bgs) | Depth to LNAPL (ft bgs) | Groundwater Elevation (ft NAVD 88) |
|---|---|---|---|---|---|---|---|---|
| MW-19 | Alluvial Aquifer | 13.5–18.5 | 20.20 | 5/7/2020 (4) | 13:55 | 13.30 | -- | 6.90 |
| | | | | 8/10/2020 | 10:14 | 13.95 | -- | 6.25 |
| | | | | 11/2/2020 | 11:12 | 14.35 | -- | 5.85 |
| | | | | 2/23/2021 | 10:37 | 12.09 | -- | 8.11 |
| MW-20 | Alluvial Aquifer | 11.5–21.5 | 23.34 | 5/07/2020 (4) | 12:13 | 15.55 | -- | 7.79 |
| | | | | 8/11/2020 (5) | 10:00 | 16.78 | -- | 6.56 |
| | | | | 11/2/2020 | 10:33 | 17.10 | -- | 6.24 |
| | | | | 2/23/2021 | 10:57 | 14.74 | -- | 8.60 |
| MW-22 | Alluvial Aquifer | 20.2–30.2 | 31.40 | 5/6/2020 | 9:28 | 23.04 | -- | 8.36 |
| | | | | 8/10/2020 | 11:07 | 24.76 | -- | 6.64 |
| | | | | 11/2/2020 | 9:54 | 24.97 | -- | 6.43 |
| | | | | 2/23/2021 | 9:55 | 22.83 | -- | 8.57 |
| MW-23 | Alluvial Aquifer | 22.4–32.4 | 31.43 | 5/6/2020 | 8:53 | 22.93 | -- | 8.50 |
| | | | | 8/10/2020 | 10:43 | 24.72 | -- | 6.71 |
| | | | | 11/2/2020 | 9:43 | 24.95 | -- | 6.48 |
| | | | | 2/23/2021 | 9:46 | 22.90 | -- | 8.53 |
| MW-24 | Perched | 9.6–19.6 | 27.89 | 5/6/2020 | 10:02 | 12.58 | -- | 15.31 |
| | | | | 8/10/2020 | 11:36 | 13.31 | -- | 14.58 |
| | | | | 11/2/2020 | 10:04 | 12.51 | -- | 15.38 |
| | | | | 2/23/2021 | 10:10 | 10.90 | -- | 16.99 |
| MW-25 | Perched (3) | 7.8–17.8 | 21.45 | 5/07/2020 (4) | 10:45 | 8.02 | -- | 13.43 |
| | | | | 8/11/2020 (5) | 11:31 | 9.68 | -- | 11.77 |
| | | | | 11/2/2020 | 10:36 | 10.45 | -- | 11.00 |
| | | | | 2/23/2021 | 10:50 | 6.40 | -- | 15.05 |
| MW-26 | Perched | 9.4–19.4 | 27.14 | 5/6/2020 | 10:13 | 12.89 | -- | 14.25 |
| | | | | 8/10/2020 | 11:20 | 13.08 | -- | 14.06 |
| | | | | 11/2/2020 | 10:06 | 13.10 | -- | 14.04 |
| | | | | 2/23/2021 | 10:12 | 10.48 | -- | 16.66 |
| MW-27 | Alluvial Aquifer | 18–28 | 25.90 | 5/07/2020 (4) | 10:01 | 18.10 | -- | 7.80 |
| | | | | 8/10/2020 | 11:27 | 18.50 | -- | 7.40 |
| | | | | 11/2/2020 | 10:13 | 19.85 | -- | 6.05 |
| | | | | 2/23/2021 | 10:36 | 17.40 | -- | 8.50 |
| MW-28 | Perched | 9.8–19.8 | 27.36 | 5/07/2020 (4) | 15:50 | 17.91 | -- | 9.45 |
| | | | | 8/10/2020 | 11:35 | 13.60 | -- | 13.76 |
| | | | | 11/2/2020 | 10:10 | 18.45 | -- | 8.91 |
| | | | | 2/23/2021 | 10:15 | 11.75 | -- | 15.61 |
| MW-29 | Perched (3) | 15–27.7 | 29.77 | 5/6/2020 | 15:05 | 15.82 | -- | 13.95 |
| | | | | 8/10/2020 | 11:31 | 16.20 | -- | 13.57 |
| | | | | 11/2/2020 | 10:49 | 16.46 | -- | 13.31 |
| | | | | 2/23/2021 | 10:08 | 14.30 | -- | 15.47 |
| MW-30 (1) | Perched (3) | 9–26 | 26.32 | 5/6/2020 | -- | -- | -- | -- |
| | | | | 8/10/2020 | 8:45 | 16.80 | -- | 9.52 |
| | | | | 11/2/2020 | 9:34 | 17.32 | -- | 9.00 |
| | | | | 2/23/2021 | 9:25 | 13.75 | -- | 12.57 |
| MW-31 | Alluvial Aquifer | 9–19 | 19.89 | 5/6/2020 | 11:22 | 13.09 | -- | 6.80 |
| | | | | 8/10/2020 | 10:02 | 13.72 | -- | 6.17 |
| | | | | 11/2/2020 | 10:16 | 14.15 | -- | 5.74 |
| | | | | 2/23/2021 | 9:48 | 11.87 | -- | 8.02 |
| MW-32 | Alluvial Aquifer | 8–18 | 21.17 | 5/6/2020 | 12:08 | 13.38 | -- | 7.79 |
| | | | | 8/10/2020 | 09:45 | 14.31 | -- | 6.86 |
| | | | | 11/2/2020 | 11:25 | 14.76 | -- | 6.41 |
| | | | | 2/23/2021 | 10:12 | 12.06 | -- | 9.11 |
| MW-33 | Alluvial Aquifer | 18–28 | 25.91 | 5/6/2020 | 15:08 | 18.32 | -- | 7.59 |
| | | | | 8/10/2020 | 11:15 | 19.25 | -- | 6.66 |
| | | | | 11/2/2020 | 11:05 | 19.61 | -- | 6.30 |
| | | | | 2/23/2021 | 10:18 | 17.30 | -- | 8.61 |
| MW-34 | Alluvial Aquifer | 22–32 | 26.67 | 5/6/2020 | 8:30 | 18.74 | -- | 7.93 |
| | | | | 8/10/2020 | 10:21 | 20.27 | -- | 6.40 |
| | | | | 11/2/2020 | 9:25 | 20.55 | -- | 6.12 |
| | | | | 2/23/2021 | 9:15 | 18.45 | -- | 8.22 |
| MW-35 | Perched (3) | 16–26 | 26.95 | 5/6/2020 | 8:41 | 14.20 | -- | 12.75 |
| | | | | 8/10/2020 | 10:36 | 15.08 | -- | 11.87 |
| | | | | 11/2/2020 | 9:27 | 16.24 | -- | 10.71 |
| | | | | 2/23/2021 | 9:20 | 14.71 | -- | 12.24 |
| MW-36 | Alluvial Aquifer | 25–35 | 31.59 | 5/6/2020 | 9:39 | 23.50 | -- | 8.09 |
| | | | | 8/10/2020 | 11:13 | 25.05 | -- | 6.54 |
| | | | | 11/2/2020 | 9:57 | 25.34 | -- | 6.25 |
| | | | | 2/23/2021 | 10:00 | 23.08 | -- | 8.51 |
| MW-37 | Alluvial Aquifer | 25–35 | 31.13 | 5/6/2020 | 9:05 | 22.54 | -- | 8.59 |
| | | | | 8/10/2020 | 10:59 | 23.91 | -- | 7.22 |
| | | | | 11/2/2020 | 9:47 | 24.42 | -- | 6.71 |
| | | | | 2/23/2021 | 9:50 | 22.52 | -- | 8.61 |

## Table 4.10
## Monitoring Well Groundwater Elevations

| Well | Aquifer | Screened Interval (ft bgs) | TOC Elevation (ft NAVD 88) | Date | Time | Depth to Water (ft bgs) | Depth to LNAPL (ft bgs) | Groundwater Elevation (ft NAVD 88) |
|---|---|---|---|---|---|---|---|---|
| MW-38 | Alluvial Aquifer | 25–35 | 31.09 | 5/6/2020 | 09:16 | 22.32 | -- | 8.77 |
| | | | | 8/10/2020 | 11:03 | 24.09 | -- | 7.00 |
| | | | | 11/2/2020 | 9:51 | 24.48 | -- | 6.61 |
| | | | | 2/23/2021 | 9:53 | 22.74 | -- | 8.35 |
| MW-39 | Alluvial Aquifer | 8–18 | 18.95 | 5/07/2020 [4] | 13:18 | 12.08 | -- | 6.87 |
| | | | | 8/10/2020 | 10:30 | 12.80 | -- | 6.15 |
| | | | | 11/2/2020 | 11:09 | 13.16 | -- | 5.79 |
| | | | | 2/23/2021 | 10:32 | 10.85 | -- | 8.10 |
| MW-40 | Alluvial Aquifer | 16–26 | 24.65 | 5/6/2020 | 14:14 | 17.05 | -- | 7.60 |
| | | | | 8/10/2020 | 10:55 | 18.07 | -- | 6.58 |
| | | | | 11/2/2020 | 10:29 | 18.71 | -- | 5.94 |
| | | | | 2/23/2021 | 10:48 | 16.40 | -- | 8.25 |
| UST-4 [6] | Perched | 14.3–24.3 | 31.68 | 5/6/2020 | 9:51 | 17.34 | -- | 14.34 |
| | | | | 8/10/2020 | 11:19 | 17.67 | -- | 14.01 |
| | | | | 11/2/2020 | 10:00 | 18.03 | -- | 13.65 |
| | | | | 2/23/2021 | 10:05 | 16.31 | -- | 15.37 |
| T-2 [1] | Alluvial Aquifer | 9.8–19.8 [7] | 19.30 | 5/6/2020 | -- | -- | -- | -- |
| | | | | 8/10/2020 | 10:00 | 12.91 | -- | 6.39 |
| | | | | 11/2/2020 | 11:28 | 13.20 | -- | 6.10 |
| | | | | 2/23/2021 | 10:16 | 10.82 | -- | 8.48 |

Notes:

-- Not applicable.
1 Well not accessible or known during the May 2020 sampling event.
2 A portion of the well screen extends through both the perched zone and alluvial aquifer. Groundwater elevations appear to be in equilibrium with the alluvial aquifer, but may also be affected by pressure in the overlying perched zone.
3 The well screen extends through both the perched zone and alluvial aquifer. Groundwater elevations appear to be in equilibrium with the perched aquifer, but may also be affected by the pressure in the underlying alluvial aquifer.
4 Well not accessible on first day of depth to water measurements.
5 Groundwater elevation not used in contour figures due to depth to water measurement collected on a different day.
6 Groundwater elevation not used in contour figures.
7 Well log not available; screened interval is based on total depth and consistency with Site wells.

Abbreviations:

bgs Below ground surface
ft Feet
LNAPL Light non-aqueous phase liquid
NAVD 88 North American Vertical Datum of 1988
TOC Top of casing

## Table 7.1
## Groundwater Preliminary Cleanup Levels

| Analyte | CAS No. | Protection of Drinking Water | | | | Adjustment Factors [1] | Preliminary CUL [2] |
|---|---|---|---|---|---|---|---|
| | | MTCA Method A Cleanup Levels | MTCA Method B Cleanup Levels | Federal MCL Goal (Non-cancer) | Washington State MCL | Practical Quantitation Limit | |
| **Metals (µg/L) [3]** | | | | | | | |
| Lead | 7439-92-1 | 15 | -- | -- | 15 | 1.0 | 15 |
| **Total Petroleum Hydrocarbons (µg/L)** | | | | | | | |
| Gasoline-range organics [4] | GRO | 800 | -- | -- | -- | 100 | 800 |
| Diesel-range organics | DRO | 500 | -- | -- | -- | 50 | 500 |
| Oil-range organics | ORO | 500 | -- | -- | -- | 250 | 500 |
| Total DRO and ORO | DRO+ORO | 500 | -- | -- | -- | 250 | 500 |
| **Volatile Organic Compounds (µg/L)** | | | | | | | |
| 1,1-Dichloroethane | 75-34-3 | -- | 7.7 | -- | -- | 1.0 | 7.7 |
| 1,1-Dichloroethene | 75-35-4 | -- | 400 | 7.0 | 7.0 | 1.0 | 7.0 |
| 1,1,1-Trichloroethane | 71-55-6 | 200 | 16,000 | 200 | 200 | 1.0 | 200 |
| 1,1,1,2-Tetrachloroethane | 630-20-6 | -- | 1.7 | -- | -- | 1.0 | 1.7 |
| 1,1,2-Trichloroethane | 79-00-5 | -- | 0.77 | 3.00 | 5.00 | 1.0 | 3.0 |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | -- | 0.22 | -- | -- | 1.0 | 1.0 |
| 1,2-Dibromo-3-chloropropane | 96-12-8 | -- | 0.06 | -- | 0.20 | 10 | 10 |
| 1,2-Dibromoethane | 106-93-4 | 0.010 | 0.02 | -- | 0.050 | 0.010 | 0.010 |
| 1,2-Dichloroethane | 107-06-2 | 5.0 | 0.48 | -- | 5.0 | 1.0 | 5.0 |
| 1,2-Dichloropropane | 78-87-5 | -- | 1.20 | -- | 5.0 | 1.0 | 5.0 |
| 1,2,3-Trichloropropane | 96-18-4 | -- | 0.0015 | -- | -- | 1.0 | 1.0 |
| 1,2,4-Trichlorobenzene | 120-82-1 | -- | 1.5 | 70 | 70 | 1.0 | 70 |
| 1,2,4-Trimethylbenzene | 95-63-6 | -- | 80 | -- | -- | 1.0 | 80 |
| 1,3,5-Trimethylbenzene | 108-67-8 | -- | 80 | -- | -- | 1.0 | 80 |
| 1,4-Dichlorobenzene | 106-46-7 | -- | 8.1 | 75 | 75 | 1.0 | 75 |
| 2-Chlorotoluene | 95-49-8 | -- | 160 | -- | -- | 1.0 | 160 |
| 2-Hexanone | 591-78-6 | -- | 40 | -- | -- | 10 | 40 |
| Acetone | 67-64-1 | -- | 7,200 | -- | -- | 50 | 7,200 |
| Benzene | 71-43-2 | 5.0 | 0.80 | -- | 5.0 | 0.35 | 5.0 |
| Bromobenzene | 108-86-1 | -- | 64 | -- | -- | 1.0 | 64 |
| Bromodichloromethane | 75-27-4 | -- | 0.71 | -- | 80 | 1.0 | 80 |
| Bromoform | 75-25-2 | -- | 5.5 | -- | 80 | 5.0 | 80 |
| Bromomethane | 74-83-9 | -- | 11 | -- | -- | 5.0 | 11 |
| Carbon tetrachloride | 56-23-5 | -- | 0.63 | -- | 5.0 | 1.0 | 5.0 |
| Chlorobenzene | 108-90-7 | -- | 160 | 100 | 100 | 1.0 | 100 |
| Chloroform | 67-66-3 | -- | 1.4 | 70 | 80 | 1.0 | 70 |
| cis-1,2-Dichloroethene | 156-59-2 | -- | 16 | 70 | 70 | 1.0 | 70 |
| cis-1,3-Dichloropropene | 10061-01-5 | -- | 0.44 | -- | -- | 1.0 | 1.0 |
| Dibromochloromethane | 124-48-1 | -- | 0.52 | 60 | 80 | 1.0 | 60 |
| Dibromomethane | 74-95-3 | -- | 80 | -- | -- | 1.0 | 80 |
| Dichlorodifluoromethane | 75-71-8 | -- | 1,600 | -- | -- | 1.0 | 1,600 |
| Ethylbenzene | 100-41-4 | 700 | 800 | 700 | 700 | 1.0 | 700 |
| Isopropylbenzene | 98-82-8 | -- | 800 | -- | -- | 1.0 | 800 |
| Xylene (meta & para) | 108-38-3 | -- | 1,600 | -- | -- | 2.0 | 1,600 |
| Methyl ethyl ketone | 78-93-3 | -- | 4,800 | -- | -- | 20 | 4,800 |
| Methyl isobutyl ketone | 108-10-1 | -- | 640 | -- | -- | 10 | 640 |
| Methyl-tert-butyl ether | 1634-04-4 | 20 | 24 | -- | -- | 1.0 | 24 |
| Methylene chloride | 75-09-2 | 5.0 | 22 | -- | 5 | 5.0 | 5.0 |
| n-Propylbenzene | 103-65-1 | -- | 800 | -- | -- | 1.0 | 800 |
| Xylene (ortho) | 95-47-6 | -- | 1600 | -- | -- | 2.0 | 1,600 |
| Styrene | 100-42-5 | -- | 1600 | 100 | 100 | 1.0 | 100 |
| tert-Butylbenzene | 98-06-6 | -- | 800 | -- | -- | 1.0 | 800 |
| Tetrachloroethene | 127-18-4 | 5.0 | 21 | -- | 5.00 | 1.0 | 5.0 |
| Toluene | 108-88-3 | 1,000 | 640 | 1,000 | 1,000 | 1.0 | 1,000 |
| Xylenes (total) | 1330-20-7 | 1,000 | 1,600 | 10,000 | 10,000 | 2.0 | 1,000 |
| trans-1,2-Dichloroethene | 156-60-5 | -- | 160 | 100 | 100 | 1.0 | 100 |
| trans-1,3-Dichloropropene | 10061-02-6 | -- | 0.44 | -- | -- | 1.0 | 1.0 |
| Trichloroethene | 79-01-6 | 5.0 | 0.54 | -- | 5.00 | 1.0 | 5.0 |
| Trichlorofluoromethane | 75-69-4 | -- | 2,400 | -- | -- | 1.0 | 2,400 |
| Vinyl chloride | 75-01-4 | 0.20 | 0.029 | -- | 2.00 | 0.20 | 0.20 |

## Table 7.1
## Groundwater Preliminary Cleanup Levels

| Analyte | CAS No. | Protection of Drinking Water | | | | Adjustment Factors [1] | Preliminary CUL [2] |
|---|---|---|---|---|---|---|---|
| | | MTCA Method A Cleanup Levels | MTCA Method B Cleanup Levels | Federal MCL Goal (Non-cancer) | Washington State MCL | Practical Quantitation Limit | |
| **Semivolatile Organic Compounds (µg/L)** | | | | | | | |
| cPAH TEQ | BaPEq (U=0) | 0.10 | 0.023 | -- | 0.20 | 0.30 | 0.10 |
| Acenaphthene | 128-39-2 | -- | 960 | -- | -- | 0.04 | 960 |
| Acenaphthylene | 117-81-7 | -- | 6.3 | -- | 6.0 | 0.04 | 6.0 |
| Anthracene | 101-55-3 | -- | 4,800 | -- | -- | 0.04 | 4,800 |
| Benzo(a)pyrene | 50-32-8 | 0.10 | 0.023 | -- | 0.20 | 0.04 | 0.10 |
| Fluoranthene | 206-44-0 | -- | 640 | -- | -- | 0.04 | 640 |
| Fluorene | 86-73-7 | -- | 640 | -- | -- | 0.04 | 640 |
| Hexachlorobutadiene | 87-68-3 | -- | 0.56 | -- | -- | 1.00 | 0.56 |
| Naphthalene[5] | 91-20-3 | 160 | -- | -- | -- | 0.04 | 160 |
| Pyrene | 129-00-0 | -- | 480 | -- | -- | 0.04 | 480 |

Notes:

Criteria have been rounded to two significant digits.

-- Not available.

Preliminary CUL is based on the PQL provided by Friedman & Bruya, Inc., and Fremont Analytical, Inc.

1 Proposal of natural background concentrations for other chemicals may be appropriate per WAC 173-340-709.

2 The preliminary CUL is the minimum of MTCA Method A or the MCLs, or the MTCA Method B CUL if MTCA Method A and MCLs are not available, adjusted for the PQL in accordance with WAC 173-340-705(6), as appropriate.

3 Metals criteria may apply to either the dissolved metals fraction or total metals fraction.

4 MTCA Method A criteria for gasoline-range organics has assumed that benzene is present.

5 The MTCA Method A CUL defined in Table 720-1 applies to the summed concentrations of naphthalene, 1-methylnaphthalene and 2-methylnaphthalene.

Abbreviations:

CAS Chemical Abstracts Service
cPAH Carcinogenic polycyclic aromatic hydrocarbon
CUL Cleanup level
DRO Diesel-range organics
MCL Maximum contaminant level
µg/L Micrograms per liter
MTCA Model Toxics Control Act
ORO Oil-range organics
PQL Practical quantitation limit
TEQ Toxic equivalent
WAC Washington Administrative Code

## Table 7.2
## Soil Preliminary Cleanup Levels

| Analyte | CAS No. | Protection of Direct Contact | Protection of Groundwater Leaching | Adjustment Factors | | Most Stringent Risk-Based Criteria | Preliminary CUL [5] |
|---|---|---|---|---|---|---|---|
| | | MTCA Method C Cleanup Levels—Direct Contact [1] | Protect Drinking Water via Groundwater [2] | Washington State Natural Background [3] | Practical Quantitation Limit [4] | | |
| **Metals (mg/kg)** | | | | | | | |
| Lead | 7439-92-1 | 1,000 | 250 | 24 | 1.00 | 250 | 250 |
| **Total Petroleum Hydrocarbons (mg/kg)** | | | | | | | |
| Gasoline-range organics [6] | GRO | 30 | 30 | -- | 20 | 30 | 30 |
| Diesel-range organics | DRO | 2,000 | 2,000 | -- | 50 | 2,000 | 2,000 |
| Oil-range organics | ORO | 2,000 | 2,000 | -- | 250 | 2,000 | 2,000 |
| Total DRO and ORO | DRO+ORO | 2,000 | 2,000 | -- | 250 | 2,000 | 2,000 |
| **Volatile Organic Compounds (mg/kg)** | | | | | | | |
| 1,2-Dibromoethane | 106-93-4 | 66 | 0.0050 | -- | 0.050 | 0.0050 | 0.050 |
| 1,2-Dichloroethane | 107-06-2 | 1,400 | -- | -- | 0.050 | 1,400 | 1,400 |
| Benzene | 71-43-2 | 2,400 | 0.030 | -- | 0.030 | 0.030 | 0.030 |
| Ethylbenzene | 100-41-4 | 350,000 | 6.0 | -- | 0.050 | 6.0 | 6.0 |
| Xylene (meta & para) | 108-38-3 | 700,000 | -- | -- | 0.050 | 700,000 | 700,000 |
| Toluene | 108-88-3 | 280,000 | 7.0 | -- | 0.050 | 7.0 | 7.0 |
| Xylenes (total) | 1330-20-7 | 700,000 | 9.0 | -- | 0.10 | 9.0 | 9.0 |
| **Semivolatile Organic Compounds—PAHs (mg/kg)** | | | | | | | |
| cPAH TEQ | BaPEq (U=0) | 130 | 0.10 | -- | 0.0076 | 0.10 | 0.10 |
| Naphthalene [7] | 91-20-3 | 70,000 | 5.0 | -- | 0.010 | 0.10 | 5.0 |
| Benzo(a)pyrene | 50-32-8 | 130 | 0.10 | -- | 0.010 | 0.10 | 0.10 |

Notes:

Criteria have been rounded to two significant digits.

-- Not available.

Preliminary CUL is based on the PQL provided by Friedman & Bruya, Inc., and Fremont Analytical, Inc.

1 MTCA Method A has been used where MTCA Method B/C is not available (applies to lead and total petroleum hydrocarbons).

2 The preliminary CUL for protection of drinking water is the MTCA Method A CUL presented in WAC Table 740-1, which is calculated accrdoing to the procedures in WAC 173-340-747.

3 Values from *Natural Background Soil Metals Concentrations in Washington State* (Ecology 1994) are used for the metals.

4 PQL values from Friedman & Bruya, Inc., and Fremont Analytical, Inc., of Seattle, Washington.

5 The preliminary CUL for each chemical is based on the lowest of the protection of industrial (MTCA Method C) direct contact and leaching ARAR, adjusted for background and the PQL in accordance with WAC 173-340-705(6), as appropriate.

6 MTCA Method A criteria for gasoline-range organics has assumed that benzene is present.

7 The MTCA Method A CUL defined in Table 740-1 applies to the summed concentrations of naphthalene, 1-methylnaphthalene and 2-methylnaphthalene.

Abbreviations:

ARAR Applicable or Relevant and Appropriate Requirement
CAS Chemical Abstracts Service
cPAH Carcinogenic polycyclic aromatic hydrocarbon
CUL Cleanup level
DRO Diesel-range organics
MCL Maximum contaminant level
mg/kg Milligrams per kilogram
MTCA Model Toxics Control Act
ORO Oil-range organics
PAH Polcyclic aromatic hydrocarbon
PQL Practical quantitation limit
TEQ Toxic equivalent
WAC Washington Administrative Code

**Table 8.1**
**Groundwater Frequency of Exceedance**

| Analyte | CAS No. | PCUL | PCUL Basis [1] | Unit | Number of Results | Number of Detections | Number of Detected Results Exceeding PCUL | Percentage of Detected Results Exceeding PCUL | Maximum Detected Value | Location of Maximum Detected Value | Sample Date | Exceedance Factor | Retained as COC? [2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Metals** | | | | | | | | | | | | | |
| Lead | 7439-92-1 | 15 | MTCA A/MCL | µg/L | 12 | None | None | None | None | None | None | None | No |
| **Total Petroleum Hydrocarbons** | | | | | | | | | | | | | |
| Gasoline-range organics | GRO | 800 | MTCA A | µg/L | 189 | 51 | 23 | 45% | 7,100 | MW-12 | 8/11/2020 | 8.9 | Yes; >10% of results exceed and the maximum exceedance factor is >2. |
| Diesel-range organics | DRO | 500 | MTCA A | µg/L | 218 | 123 | 69 | 56% | 6,500 | MW-39 | 8/10/2020 | 13 | NA [3] |
| Oil-range organics | ORO | 500 | MTCA A | µg/L | 218 | 43 | 14 | 33% | 1,600 | MW-28 | 2/28/2019 | 3.2 | NA [3] |
| Total DRO and ORO | DRO+ORO | 500 | MTCA A | µg/L | 218 | 123 | 70 | 57% | 7,300 | MW-39 | 8/10/2020 | 15 | Yes; >10% of results exceed and the maximum exceedance factor is >2. |
| **Volatile Organic Compounds** | | | | | | | | | | | | | |
| 1,1-Dichloroethane | 75-34-3 | 7.7 | MTCA B | µg/L | 17 | None | None | None | None | None | None | None | No |
| 1,1-Dichloroethene | 75-35-4 | 7.0 | MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| 1,1,1-Trichloroethane | 71-55-6 | 3.0 | MTCA A/MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| 1,1,1,2-Tetrachloroethane | 630-20-6 | 1.7 | MTCA B | µg/L | 17 | None | None | None | None | None | None | None | No |
| 1,1,2-Trichloroethane | 79-00-5 | 5.0 | MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | 1.0 | PQL | µg/L | 17 | None | None | None | None | None | None | None | No [2] |
| 1,2-Dibromo-3-chloropropane | 96-12-8 | 10 | PQL | µg/L | 17 | None | None | None | None | None | None | None | No [2] |
| 1,2-Dibromoethane | 106-93-4 | 0.010 | MTCA A | µg/L | 34 | None | None | None | None | None | None | None | No |
| 1,2-Dichloroethane | 107-06-2 | 5.0 | MTCA A/MCL | µg/L | 24 | None | None | None | None | None | None | None | No |
| 1,2-Dichloropropane | 78-87-5 | 5.0 | MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| 1,2,3-Trichloropropane | 96-18-4 | 1.0 | PQL | µg/L | 17 | None | None | None | None | None | None | None | No [2] |
| 1,2,4-Trichlorobenzene | 120-82-1 | 70 | MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| 1,2,4-Trimethylbenzene | 95-63-6 | 80 | MTCA B | µg/L | 17 | 1 | None | None | 1 | MW-12 | 8/11/2020 | None | No |
| 1,3,5-Trimethylbenzene | 108-67-8 | 80 | MTCA B | µg/L | 17 | 1 | None | None | 3.3 | MW-12 | 8/11/2020 | None | No |
| 1,4-Dichlorobenzene | 106-46-7 | 75 | MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| 2-Chlorotoluene | 95-49-8 | 160 | MTCA B | µg/L | 17 | None | None | None | None | None | None | None | No |
| 2-Hexanone | 591-78-6 | 40 | MTCA B | µg/L | 17 | None | None | None | None | None | None | None | No |
| Acetone | 67-64-1 | 7,200 | MTCA B | µg/L | 17 | None | None | None | None | None | None | None | No |
| Benzene | 71-43-2 | 5.0 | MTCA A/MCL | µg/L | 189 | 30 | 14 | 47% | 910 | MW-12 | 8/11/2020 | 180 | Yes; >10% of results exceed and the maximum exceedance factor is >2. |
| Bromobenzene | 108-86-1 | 64 | MTCA B | µg/L | 17 | None | None | None | None | None | None | None | No |
| Bromodichloromethane | 75-27-4 | 80 | MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| Bromoform | 75-25-2 | 80 | MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| Bromomethane | 74-83-9 | 11 | MTCA B | µg/L | 17 | None | None | None | None | None | None | None | No |
| Carbon tetrachloride | 56-23-5 | 5.0 | MCL | µg/L | 17 | None | None | None | None | None | None | None | No |

**Table 8.1**
**Groundwater Frequency of Exceedance**

| Analyte | CAS No. | PCUL | PCUL Basis [1] | Unit | Number of Results | Number of Detections | Number of Detected Results Exceeding PCUL | Percentage of Detected Results Exceeding PCUL | Maximum Detected Value | Location of Maximum Detected Value | Sample Date | Exceedance Factor | Retained as COC? [2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Volatile Organic Compounds (cont.)** | | | | | | | | | | | | | |
| Chlorobenzene | 108-90-7 | 7.0 | MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| Chloroform | 67-66-3 | 80 | MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| cis-1,2-Dichloroethene | 156-59-2 | 70 | MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| cis-1,3-Dichloropropene | 10061-01-5 | 1.0 | PQL | µg/L | 17 | None | None | None | None | None | None | None | No [2] |
| Dibromochloromethane | 124-48-1 | 6.0 | MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| Dibromomethane | 74-95-3 | 80 | MTCA B | µg/L | 17 | None | None | None | None | None | None | None | No |
| Dichlorodifluoromethane | 75-71-8 | 1,600 | MTCA B | µg/L | 17 | None | None | None | None | None | None | None | No |
| Ethylbenzene | 100-41-4 | 700 | MTCA A/MCL | µg/L | 189 | 19 | None | None | 83 | MW-10 | 11/2/2020 | None | No |
| Isopropylbenzene | 98-82-8 | 800 | MTCA B | µg/L | 17 | 9 | None | None | 34 | MW-12 | 8/11/2020 | None | No |
| Xylene (meta & para) | 108-38-3/106-42-3 | 1,600 | MTCA B | µg/L | 143 | 19 | None | None | 62 | MW-12 | 11/3/2020 | None | No |
| Methyl ethyl ketone | 78-93-3 | 4,800 | MTCA B | µg/L | 17 | None | None | None | None | None | None | None | No |
| Methyl isobutyl ketone | 108-10-1 | 640 | MTCA B | µg/L | 17 | None | None | None | None | None | None | None | No |
| Methyl-tert-butyl ether | 1634-04-4 | 24 | MTCA A | µg/L | 24 | None | None | None | None | None | None | None | No |
| Methylene chloride | 75-09-2 | 5.0 | MTCA A/MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| n-Propylbenzene | 103-65-1 | 800 | MTCA B | µg/L | 17 | 8 | None | None | 82 | MW-12 | 8/11/2020 | None | No |
| Xylene (ortho) | 95-47-6 | 1,600 | MTCA B | µg/L | 143 | 4 | None | None | 1.4 | MW-12 | 11/3/2020 | None | No |
| sec-Butylbenzene | 135-98-8 | 800 | MTCA B | µg/L | 17 | 5 | None | None | 3.5 | MW-12 | 8/11/2020 | None | No |
| Styrene | 100-42-5 | 100 | MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| tert-Butylbenzene | 98-06-6 | 800 | MTCA B | µg/L | 17 | None | None | None | None | None | None | None | No |
| Tetrachloroethene | 127-18-4 | 5.0 | MTCA A/MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| Toluene | 108-88-3 | 1,000 | MTCA A/MCL | µg/L | 189 | 24 | None | None | 42 | MW-12 | 8/11/2020 | None | No |
| Xylene (total) | 1330-20-7 | 1,000 | MTCA A | µg/L | 189 | 22 | None | None | 63 | MW-12 | 11/3/2020 | None | No |
| trans-1,2-Dichloroethene | 156-60-5 | 100 | MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| trans-1,3-Dichloropropene | 10061-02-6 | 1.0 | PQL | µg/L | 17 | None | None | None | None | None | None | None | No [2] |
| Trichloroethene | 79-01-6 | 5.0 | MTCA A/MCL | µg/L | 17 | None | None | None | None | None | None | None | No |
| Trichlorofluoromethane | 75-69-4 | 2,400 | MTCA B | µg/L | 17 | None | None | None | None | None | None | None | No |
| Vinyl chloride | 75-01-4 | 0.20 | MTCA A | µg/L | 17 | None | None | None | None | None | None | None | No |
| **Semivolatile Organic Compounds** | | | | | | | | | | | | | |
| cPAHs (MTCA TEQ-ZeroND) | BaPEq (U=0) | 0.10 | MTCA A | µg/L | 81 | 1 | None | None | 0.00045 | MW-37 | 5/7/2020 | None | No |
| cPAHs (MTCA TEQ-HalfND) | BaPEq (U=1/2) | 0.10 | MTCA A | µg/L | 81 | 1 | None | None | 0.03 | MW-37 | 5/7/2020 | None | No |
| 1-Methylnaphthalene | 90-12-0 | 1.5 | MTCA B | µg/L | 35 | 5 | 5 | 100% | 53 | MW-40 | 5/6/2020 | 35 | Yes; >10% of results exceed and the maximum exceedance factor is >2. |
| 2-Methylnaphthalene | 91-57-6 | 32 | MTCA B | µg/L | 35 | 1 | None | None | 3.8 | MW-40 | 5/6/2020 | None | No |
| Acenaphthene | 83-32-9 | 960 | MTCA B | µg/L | 35 | 8 | None | None | 1.7 | MW-39 | 5/7/2020 | None | No |
| Acenaphthylene | 208-96-8 | 6.0 | MCL | µg/L | 35 | None | None | None | None | None | None | None | No |
| Anthracene | 120-12-7 | 4,800 | MTCA B | µg/L | 35 | None | None | None | None | None | None | None | No |
| Benzo(a)pyrene | 50-32-8 | 0.10 | MTCA A | µg/L | 81 | None | None | None | None | None | None | None | No |
| Fluoranthene | 206-44-0 | 640 | MTCA B | µg/L | 35 | 1 | None | None | 0.043 | MW-37 | 5/7/2020 | None | No |

## Table 8.1
## Groundwater Frequency of Exceedance

| Analyte | CAS No. | PCUL | PCUL Basis [1] | Unit | Number of Results | Number of Detections | Number of Detected Results Exceeding PCUL | Percentage of Detected Results Exceeding PCUL | Maximum Detected Value | Location of Maximum Detected Value | Sample Date | Exceedance Factor | Retained as COC? [2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semivolatile Organic Compounds (cont.)** | | | | | | | | | | | | | |
| Fluorene | 86-73-7 | 640 | MTCA B | µg/L | 35 | 9 | None | None | 7.2 | MW-39 | 5/7/2020 | None | No |
| Hexachlorobutadiene | 87-68-3 | 0.56 | MTCA B | µg/L | 17 | None | None | None | None | None | None | None | No |
| Naphthalene | 91-20-3 | 160 | MTCA A [4] | µg/L | 57 | 5 | None | None | 56.8 | MW-40 | 5/6/2020 | None | No |
| Pyrene | 129-00-0 | 480 | MTCA B | µg/L | 35 | 1 | None | None | 0.11 | MW-37 | 5/7/2020 | None | No |

Notes:

Only analytes with applicable PCULs are shown. Field duplicate samples are not included in the total number of results.
PCULs and results are presented in µg/L. PCULs, results, and exceedance factors are rounded to two significant figures.
Analyte retained as a COC.

1 All regulatory criteria used to determine PCULs are for protection of drinking water, which is the only groundwater pathway determined to be potentially complete at the Site.
2 Five volatile organic compounds that were not detected at any locations have PCULs that were adjusted upward to the PQL because the PQL was greater than the available risk-based criteria. Each of these chemicals, however, can be eliminated from further consideration as a COC because none of these chemicals are suspected of being present at the Site based on Site history and other knowledge, per WAC 173-340-720(9)(f)(v).
3 The PCUL is also applicable to the summed DRO and ORO fractions, which is retained as a preliminary COC.
4 The PCUL applies to the summed concentrations of naphthalene, 1-methylnaphthalene and 2-methylnaphthalene. If methylnaphthalenes were not analyzed, the result for napthalene is compared to the PCUL.

Abbreviations:

CAS Chemical Abstracts Service
COC Contaminant of concern
cPAH Carcinogenic polycyclic aromatic hydrocarbon
DRO Diesel-range organics
MCL Maximum contaminant level
µg/L Micrograms per liter
MTCA Model Toxics Control Act
NA Not applicable
ORO Oil-range organics
PCUL Preliminary cleanup level
PQL Practical quantitation limit
TEQ Toxic equivalent

## Table 8.2
## Soil Frequency of Exceedance for Groundwater COCs

| Analyte | CAS No. | PCUL | PCUL Basis | Number of Results | Number of Detections | Number of Detected Results Exceeding PCUL | Percentage of Detected Results Exceeding PCUL | Maximum Detected Value | Location of Maximum Detected Value | Sample Date | Sample Depth (ft bgs) | Exceedance Factor | Retained as COC? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Petroleum Hydrocarbons** | | | | | | | | | | | | | |
| Gasoline-range organics | GRO | 30 | MTCA A Groundwater Protection | 245 | 64 | 55 | 86% | 16,000 | MW-16 | 5/18/1993 | 10–10 | 530 | Yes; >10% of the results exceed, the maximum exceedance factor is >2, and it is retained as a COC in groundwater. |
| Diesel-range organics | DRO | 2,000 | MTCA A Groundwater Protection | 251 | 99 | 60 | 61% | 72,000 | MW-19 | 5/18/1993 | 4–8 | 36 | NA [(1)] |
| Oil-range organics | ORO | 2,000 | MTCA A Groundwater Protection | 247 | 71 | 27 | 38% | 150,000 | SCR-2 | 3/22/1993 | 0–1 | 75 | NA [(1)] |
| Total DRO and ORO | DRO+ORO | 2,000 | MTCA A Groundwater Protection | 251 | 107 | 71 | 66% | 160,000 | SCR-2 | 3/22/1993 | 0–1 | 80 | Yes; >10% of the results exceed, the maximum exceedance factor is >2, and it is retained as a COC in groundwater. |
| **Volatile Organic Compounds** | | | | | | | | | | | | | |
| Benzene | 71-43-2 | 0.03 | MTCA A Groundwater Protection | 43 | 6 | 6 | 100% | 12 | MW-40 | 3/9/2020 | 10.5–11 | 400 | Yes; >10% of the results exceed, the maximum exceedance factor is >2, and it is retained as a COC in groundwater. |

Notes:

Only analytes with applicable PCULs are shown. Field duplicates are not included in the total number of results.

PCULs and results are presented in mg/kg. PCULs, results, and exceedance factors are rounded to two significant figures.

Analyte retained as a COC.

1 The PCUL is also applicable to the summed DRO and ORO fractions, which is retained as a COC.

Abbreviations:

bgs Below ground surface
CAS Chemical Abstracts Service
COC Contaminant of concern
DRO Diesel-range organics
ft Feet
GRO Gasoline-range organics
mg/kg Milligrams per kilogram
MTCA Model Toxics Control Act
NA Not applicable
ORO Oil-range organics
PCUL Preliminary cleanup level

## Table 8.3
## Soil Frequency of Exceedance for Other COPCs

| Analyte | CAS No. | Direct Contact Criterion | Direct Contact Criterion Basis | Number of Results | Number of Detections | Number of Detected Results Exceeding PCUL | Percentage of Detected Results Exceeding PCUL | Maximum Detected Value | Location of Maximum Detected Value | Sample Date | Sample Depth (ft bgs) | Exceedance Factor | Retained as COC? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Metals** | | | | | | | | | | | | | |
| Lead | 7439-92-1 | 1,000 | MTCA A Industrial | 23 | 20 | None | None | 8.9 | GP-18 | 9/16/2015 | 27–28 | None | No |
| **Volatile Organic Compounds** | | | | | | | | | | | | | |
| 1,2-Dibromoethane | 106-93-4 | 66 | MTCA C | 23 | None | None | None | None | None | None | None | None | No |
| 1,2-Dichloroethane | 107-06-2 | 1,400 | MTCA C | 23 | None | None | None | None | None | None | None | None | No |
| Ethylbenzene | 100-41-4 | 350,000 | MTCA C | 43 | 15 | None | None | 41 | OIP-42 | 11/21/2019 | 17–17.5 | None | No |
| Xylene (meta & para) | 108-38-3/106-42-3 | 700,000 | MTCA C | 37 | 8 | None | None | 4.1 | OIP-42 | 11/21/2019 | 17–17.5 | None | No |
| Toluene | 108-88-3 | 280,000 | MTCA C | 43 | 9 | None | None | 7.4 | MW-40 | 3/9/2020 | 10.5–11 | None | No |
| Xylene (total) | 1330-20-7 | 700,000 | MTCA C | 43 | 16 | None | None | 15 | MW-40 | 3/9/2020 | 10.5–11 | None | No |
| **Semivolatile Organic Compounds** | | | | | | | | | | | | | |
| 1-methylnaphthalene | 90-12-0 | 4,500 | MTCA C [(1)] | 10 | 8 | None | None | 38 | OIP-42 | 11/21/2019 | 17–17.5 | None | No |
| 2-methylnaphthalene | 91-57-6 | 14,000 | MTCA C [(1)] | 10 | 5 | None | None | 27 | OIP-42 | 11/21/2019 | 17–17.5 | None | No |
| cPAHs (MTCA TEQ-ZeroND) | BaPEq (U=0) | 130 | MTCA C | 37 | 19 | None | None | 2.3 | P3 | 3/12/2020 | 0–0.5 | None | No |
| cPAHs (MTCA TEQ-HalfND) | BaPEq (U=1/2) | 130 | MTCA C | 37 | 19 | None | None | 2.3 | P3 | 3/12/2020 | 0–0.5 | None | No |
| Benzo(a)pyrene | 50-32-8 | 130 | MTCA C | 37 | 4 | None | None | 1.5 | P3 | 3/12/2020 | 0–0.5 | None | No |
| Naphthalene | 91-20-3 | 70,000 | MTCA C [(1)] | 16 | 5 | None | None | 6.3 | OIP-47 | 3/9/2020 | 17 | None | No |

Notes:

Only analytes with applicable direct contact criteria are shown. Field duplicates are not included in the total number of results.

Criteria and results are presented in mg/kg. Criteria, results, and exceedance factors are rounded to two significant figures.

1 Summed naphthalene criteria presented in Table 7.2 apply to the leaching pathway; applicable direct contact criteria are compared separately to results for naphthalene, 1-methylnaphthalene, and 2-methylnaphthale.

Abbreviations:

bgs Below ground surface
CAS Chemical Abstracts Service
COC Contaminant of concern
COPC Contaminant of potential concern
cPAH Carcinogenic polycyclic aromatic hydrocarbon
ft Feet
mg/kg Milligrams per kilogram
MTCA Model Toxics Control Act
PCUL Preliminary cleanup level
TEQ Toxic equivalent

## Table 9.1
## Chemical-Specific Properties for Site COCs

| Contaminant of Concern | CAS No. | Boiling Point (°C) | Form at 20 °C | Vapor Pressure (atm) | Volatile | Solubility at 20 °C (mg/L) | Henry's Law at 13 °C (atm-$m^3$/mol) | Partitioning Coefficient ($K_{oc}$) ($cm^3$/g) | Mobility in Water |
|---|---|---|---|---|---|---|---|---|---|
| **Total Petroleum Hydrocarbons** | | | | | | | | | |
| Gasoline-range organics | GRO | 50–200 (1) | liquid | 0.4–0.9 (1) | moderate | Insoluble (2) | 0.00033–0.00048 at 20 °C (2) | Log 1.8-4.6 (2) | high |
| Diesel-range organics | DRO | 282–338 (3) | liquid | 0.003–0.035 (3) | moderate | 5 (3) | 0.000059–0.000074 at 20 °C (3) | Log 3.0-6.7 (3) | moderate |
| Oil-range organics | ORO | 101–588 (3) | liquid | 0.003–0.035 (3) | moderate | 5 (3) | 0.000059–0.000074 at 20 °C (3) | Log 3.0-6.7 (3) | low |
| **Volatile Organic Compounds** | | | | | | | | | |
| Benzene | 71-43-2 | 80 (4) | liquid | 0.1 (4) | moderate | 1,750 (5) | 0.133 (5) | 62 (5) | high |

Notes:

1 Chemical and physical properties data for gasoline from the IARC Working Group on the Evaluation of Carcinogenic Risk to Humans' 1989 *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, No. 45* (https://www.ncbi.nlm.nih.gov/books/NBK531262/).

2 From the Agency for Toxic Substances & Disease Registry's Toxic Substances Portal page for Gasoline, Automotive (https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=83).

3 From the Agency for Toxic Substances & Disease Registry's Toxic Substances Portal page for Fuel Oils/Kerosene (https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=91).

4 From NIOSH pocket guide to Chemical Hazards, distributed and published by Centers for Disease Control and Prevention, DHHS (NIOSH) Publication No. 97-140.

5 From Cleanup Levels and Risk Calculation worksheet (https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Contamination-clean-up-tools/CLARC/Data-tables).

Abbreviations:

| | |
|---|---|
| atm | Atmospheres |
| CAS | Chemical Abstracts Service |
| $cm^3$/g | Cubic centimeters per gram |
| °C | Degrees Celsius |
| DHHS | Department of Health and Human Services |
| IARC | International Agency for Research on Cancer |
| $K_{oc}$ | Soil organic carbon–water partitioning coefficient |
| $m^3$/mol | Cubic meters per mole |
| mg/L | Milligrams per liter |
| NIOSH | National Institute for Occupational Safety and Health |

**Table 11.1**
**Potential Applicable or Relevant and Appropriate Requirements**

| Standard, Requirement, or Limitation [1] | Description |
|---|---|
| **Location-Specific ARARs [2]** | |
| Washington Shoreline Management Act (RCW 90.58; WAC 173-14) | The Washington Shoreline Management Act, authorized under the federal Coastal Zone Management Act, establishes requirements for substantial development occurring within the waters of Washington or within 200 feet of a shoreline. |
| Longview Shorelines Master Program (17.60 LMC) | Implements the requirements imposed on the City of Longview by the Washington Shoreline Management Act (RCW 90.58) and ensures that development under the program will not cause a net loss of ecological functions. Applies to areas with 200 feet of a water body regulated by the program. |
| Longview Critical Areas Regulations (17.10 LMC) | This chapter establishes regulations pertaining to the development within or adjacent to critical areas, which include areas that provide a variety of biological and physical functions that benefit the City of Longview and its residents, including water quality protection, fish and wildlife habitat, and food chain support. |
| Endangered Species Act (16 USC 1531 et seq.; 50 CFR 17, 225, and 402)<br>Migratory Bird Treaty Act (16 USC 742a-j and 40 CFR 10.13) | These statutes regulate the incidental take of migratory birds (such as Canada geese) and other endangered species by facility operations and construction activities. |
| Native American Graves Protection and Repatriation Act (25 USC 3001 through 3013; 43 CFR 10)<br>Washington's Indian Graves and Records Law (RCW 27.44) | These statutes prohibit the destruction or removal of Native American cultural items and require written notification of inadvertent discovery to the appropriate agencies and Native American tribe. These programs are applicable to the remedial action if cultural items are found. The activities must cease in the area of the discovery; a reasonable effort must be made to protect the items discovered; and notice must be provided. |
| Archaeological Resources Protection Act (16 USC 470aa et seq.; 43 CFR 7) | This program sets forth requirements that are triggered when archaeological resources are discovered. These requirements only apply if archaeological items are discovered during implementation of the selected remedy. |
| National Historic Preservation Act (16 USC 470 et seq.; 36 CFR parts 60, 63, and 800) | This program sets forth a national policy of historic preservation and provides a process that must be followed to ensure that impacts of actions on archaeological, historic, and other cultural resources are protected. |
| **Action-Specific ARARs [3]** | |
| State Environmental Policy Act (RCW 43.21C, WAC 197-11) | Establishes the state's policy for protection and preservation of the natural environment. Applies to cleanup actions conducted under MTCA. |
| Resource Conservation and Recovery Act (42 USC 6921-6949a; 40 CFR Part 268, Subtitles C and D) | Establishes requirements for the identification, handling, and disposal of hazardous and nonhazardous waste. |
| Dangerous Waste Regulations (RCW 70.105; WAC 173-303) | Establishes regulations that are the state equivalent of RCRA requirements for determining whether a solid waste is a state dangerous waste. This regulation also provides requirements for the management of dangerous wastes. |
| Solid Waste Disposal Act (42 USC Sec. 6901-6992; 40 CFR 257-258)<br>Federal Land Disposal Requirements (40 CFR 268) | Protects health and the environment and promotes conservation of valuable material and energy resources. The Solid Waste Disposal Act establishes a framework for regulation of solid waste disposal. Federal land disposal requirements promulgated under the authority of the Solid Waste Disposal Act set minimum safety requirements for landfills including limitations on storage and land disposal for hazardous substances. |
| Department of Transportation Hazardous Materials Regulations (49 CFR 172) | Regulates the safe and secure transportation of hazardous materials, including documentation and handling requirements for shipping. |
| Washington Minimum Functional Standards for Solid Waste Handling (WAC 173-304) | Sets minimum functional standards for the proper handling of all solid waste materials originating from residences, commercial, agricultural, and industrial operations, as well as other sources. |
| Washington Solid Waste Handling Standards (RCW 70.95 and WAC 173-350) | Establishes minimum standards for handling and disposal of solid waste. Solid waste includes wastes that are likely to be generated as a result of site remediation, including contaminated soils, construction and demolition wastes, and garbage. |
| Washington Water Pollution Control Law (RCW 90.48; WAC 173-216, WAC 173-220)<br>National Pollution Discharge Elimination System (CWA Part 402) | Washington has been delegated authority to issue NPDES permits. CWA Section 301, 302, and 303 require states to adopt water quality standards and implement a NPDES permitting process. The Washington Water Pollution Control Law and regulations address this requirement. |
| Noise Control Act of 1974 (RCW 70.107, WAC 173-60) | Establishes maximum noise levels. |
| Washington State Underground Injection Control Program (WAC 173-218) | Washington is authorized under CWA Sections 144 through 147 to administer a statewide Underground Injection Control program to protect groundwater by regulating the discharge of fluid from injection wells including temporary injection points. |
| Occupational Safety and Health Act 29 USC 651 (29 CFR 1910) | Applies to onsite workers involved in cleanup implementation. |
| City of Longview Streets and Sidewalks Code (12.30 LMC) | The City of Longview code regulates construction use and permitting in the right of way. |

**Table 11.1**
**Potential Applicable or Relevant and Appropriate Requirements**

| Standard, Requirement, or Limitation [1] | Description |
|---|---|
| **Action-Specific ARARs [3] (cont.)** | |
| City of Longview Construction Codes for Grading (17.10.060 LMC) | Required for the excavation or addition of material within an Environmentally Critical Area. |
| National Electrical Code (NFPA 70) and the Seattle Electric Code Supplement for Class 1 Division 2 Environments. | Establishes restrictions and guidelines for temporary and/or permanent electrical installations. |
| City of Longview Water Utilities Code (15.10 LMC) | Establishes rules for hydrant water use. |
| City of Longview Sewage Disposal Code (15.26 LMC) | Regulates discharge of liquid waste to the wastewater (sanitary sewer) system. |
| Federal, State, and Local Air Quality Protection Programs<br>State Implementation of Ambient Air Quality Standards<br>NWAPA Ambient and Emission Standards<br>Regional Standards for Fugitive Dust Emissions<br>Toxic Air Pollutants | Regulations promulgated under the federal Clean Air Act (42 USC 7401) and the Washington State Clean Air Act (RCW 70.94) govern the release of airborne contaminants from point and nonpoint sources. Local air pollution control authorities such as PSCAA have also set forth regulations for implementing these air quality requirements. These requirements may be applicable to the Site for the purposes of demolition or dust control. PSCAA requires notification prior to demolition of any building with asbestos-containing material. Both PSCAA (under Regulation III) and WAC 173-460 establish ambient source impact levels for arsenic. |
| **Chemical-Specific ARARs [4]** | |
| Model Toxics Control Act (WAC 173-340) | Establishes Washington administrative processes and standards to identify, investigate, and clean up facilities where hazardous substances are located. |
| Drinking Water Standards—State MCLs (WAC 246-290-310) | Establishes standards for contaminant levels in drinking water for water system purveyors. |
| Water Quality Standards for Groundwaters of the State of Washington (WAC 173-200) | Implements the Water Pollution Control Act and the Water Resources Act of 1971 (90.54 RCW). |
| National Recommended Water Quality Standards (40 CFR 131)<br>Washington Maximum Contaminant Levels (WAC 246-290-310) | These water quality standards define the water quality goals of the water body by designating the use or uses to be made of the water and by setting criteria necessary to protect the uses. States adopt water quality standards from 40 CFR 131 to protect public health or welfare, enhance the quality of water, and serve the purposes of the CWA. Washington water quality standards (MCLs) are presented in WAC. |

Notes:

1 Projects conducted under a consent decree are exempt from the procedural requirements of most state and local permits (RCW 70.105D.090); however, the remedial actions must still comply with the substantive requirements of the exempt permits. Therefore, for exempt permits, the statutory review timelines do not apply; actual timelines will be based on negotiations with the jurisdiction or agency, which should result in an expedited review timeline.
2 Location-specific ARARs are requirements that are applicable to the specific area where the Site is located, and can restrict the performance of activities, including cleanup actions, solely because they occur in specific locations.
3 Action-specific ARARs are requirements that are applicable to certain types of activities that occur or technologies that are used during the implementation of cleanup actions.
4 Chemical-specific ARARs are applicable to the types of contaminants present at the Site. The cleanup of contaminated media at the Site must meet the CULs developed under MTCA; these CULs are considered chemical-specific ARARs.

Abbreviations:

| | |
|---|---|
| ARAR | Applicable or Relevant and Appropriate Requirement |
| CFR | Code of Federal Regulations |
| CUL | Cleanup level |
| CWA | Clean Water Act |
| MCL | Maximum Contaminant Level |
| MTCA | Model Toxics Control Act |
| NPDES | National Pollutant Discharge Elimination System |
| NWAPA | Northwest Air Pollution Authority |
| PSCAA | Puget Sound Clean Air Agency |
| RCRA | Resource Conservation and Recovery Act |
| RCW | Revised Code of Washington |
| USC | U.S. Code |
| WAC | Washington Administrative Code |

**Table 12.1**
**Preliminary Screening of Remedial Technologies**

| Remedial Technology | Applicable Media | General Technology Benefits | General Technology Constraints | Consideration of Site Physical Conditions and RAOs | Rationale for Retaining or Rejecting Technology |
|---|---|---|---|---|---|
| **Passive Technologies** | | | | | |
| No Action | • Soil<br>• Groundwater | • No cost to implement.<br>• No long-term monitoring cost.<br>• Does not cause significant impacts to site operations. | • Does not reduce or remove chemical concentrations.<br>• Does not protect human health and the environment.<br>• Does not meet cleanup goals in a reasonable restoration time frame. | • Not impacted by physical conditions at the Site.<br>• Does not contribute to achievement of RAOs.<br>• Does not contribute to achievement of RAOs (e.g., LNAPL removal) when not used in combination with other remedial technologies. | The No Action technology does not address any of the Site COCs in soil or groundwater or achieve RAOs.<br>**No Action is Rejected** from further evaluation. |
| Institutional Controls | • Soil<br>• Groundwater | • Low cost to implement.<br>• Protective of direct contact pathway through controls.<br>• Technology has proven success at sites with similar conditions. | • Does not reduce or remove chemical concentrations.<br>• Must be used in combination with other technologies.<br>• Limits future site use through restrictive covenants or administrative measures. | • Can be implemented in conjunction with site development plans for building or paving.<br>• Not limited by site physical conditions.<br>• Contributes to achievement of RAOs when used in combination with other technologies.<br>• Does not contribute to achievement of RAOs (i.e., LNAPL removal) when not used in combination with other remedial technologies. | Institutional controls are applicable to all COCs and all media, achieve RAOs when used in combination with other technologies, and can be implemented given Site conditions.<br>**Institutional Controls are Retained** for further evaluation. |
| Monitored Natural Attenuation | • Groundwater | • Low cost associated with implementation.<br>• Does not cause impacts to site operations.<br>• Technology does have proven success at sites with similar conditions. | • Long-term monitoring required in perpetuity.<br>• Does not control chemical migration. | • Is not limited by site physical conditions and can be implemented under any future use conditions.<br>• Does not contribute to achievement of RAOs (e.g., LNAPL removal) when not used in combination with other remedial technologies. | Monitored natural attenuation would be applicable to achieving RAOs for naturally degrading COCs in groundwater when used in combination with other technologies.<br>**Monitored Natural Attenuation is Retained** for further evaluation. |
| Surface Capping | • Soil<br>• Groundwater (by protection of soil to groundwater pathway) | • Contains contaminated soil below the ground surface, provides barrier from contact pathways, and may reduce or prevent infiltration that would cause leaching. | • Chemicals remain in place and are not removed or destroyed.<br>• Surface cap maintenance and inspections required in perpetuity. | • Current Site uses, such as rail lines, prevent surface capping from being utilized in some areas of contaminated soil.<br>• Implementing a surface cap in areas outside of the rail tracks may impede future development.<br>• Does not contribute to achievement of RAOs (i.e., LNAPL removal) when not used in combination with other remedial technologies. | Although surface capping may help achieve RAOs when used in combination with other technologies, the technology is not feasible to implement within the rail and could potentially restrict future development/land use in areas outside of the rail tracks.<br>**Surface Capping is Rejected** for further evaluation. |

**Table 12.1**
**Preliminary Screening of Remedial Technologies**

| Remedial Technology | Applicable Media | General Technology Benefits | General Technology Constraints | Consideration of Site Physical Conditions and RAOs | Rationale for Retaining or Rejecting Technology |
|---|---|---|---|---|---|
| **In Situ Technologies** | | | | | |
| Permeable Reactive Barrier Using Granular Activated Carbon | • Groundwater | • Passively treats contaminated groundwater as it passes through the PRB area.<br>• Can be straightforward to implement, except at significant depths (i.e., greater than 15 feet).<br>• Is relatively feasible to implement at shallow depths and does not cause significant disruption to site operations. | • A PRB can become "clogged" by migration of fines in groundwater and can be costly to maintain.<br>• Depending on the concentrations in groundwater, the PRB may require replacement once the reaction capacity of the material in the barrier is reached, or the pores become clogged. This concern is even greater for multiple COCs and the required media to address their migration. | • Site COCs are generally not mobile, and groundwater contamination does not extend off-site, such as the Columbia River, or to sensitive receptors.<br>• Installation of PRB around perimeter would be cost prohibitive considering the general lack of mobility of COCs. | The relative stability and containment of the plume to the Site limits the potential effectiveness of a PRB in achieving RAOs. It would provide marginal if any benefit compared to the capital construction and long-term maintenance costs.<br>**Permeable Reactive Barrier Using Granulated Activated Carbon is Rejected** from further evaluation. |
| Air Sparging | • Soil<br>• Groundwater | • Proven effective technology for small, impacted areas with elevated VOC and GRO concentrations.<br>• Readily available equipment and easily implemented.<br>• Requires no removal, treatment, storage, or discharge of groundwater. | • Limited effectiveness for DRO, ORO, and heavier fuel types.<br>• Effectiveness depends on site-specific factors, including limited soil heterogeneity. | • Air sparging will likely be ineffective for impacts within the perched water-bearing zone due to the interbedded silt and sand layers.<br>• Less effective for DRO, which is the most extensive COC at the Site.<br>• Does not contribute to achievement of RAOs (i.e., LNAPL removal) when not used in combination with other remedial technologies. | Air sparging would have limited effectiveness in achieving RAOs due to Site hydrologic conditions and the nature of Site contamination.<br>**Air Sparging is Rejected** from further evaluation. |
| In Situ Chemical Oxidation | • Soil<br>• Groundwater | • Technology reduces contaminant concentrations and mass in place.<br>• Oxidizing agents include ozone, hydrogen peroxide, PersulfOx, RegenOx, or an oxygen-release compound. | • Effectiveness limited by subsurface conditions and site heterogeneity because injected solutions can follow preferential pathways.<br>• Sometimes requires multiple rounds of injection.<br>• Contaminant rebound may be observed when source concentrations and volume are elevated and insufficient source treatment has occurred. | • Technology does not cause significant impacts to Site activities if conducted when there are no rail activities.<br>• Large portions of the Site have not yet been developed and are currently accessible. This technology would be more challenging within developed site conditions.<br>• Can be used in combination with other remedial technologies.<br>• Some oxidizing agents can corrode utility lines or potentially corrode the ductile iron pipelines. | In situ groundwater and soil treatment by ISCO is applicable to TPH in soil and groundwater, is implementable given Site conditions, poses minimal impacts to Port operations when compared to other technologies, and achieves RAOs.<br>**In Situ Chemical Oxidation is Retained** for further evaluation. |

**Table 12.1**
**Preliminary Screening of Remedial Technologies**

| Remedial Technology | Applicable Media | General Technology Benefits | General Technology Constraints | Consideration of Site Physical Conditions and RAOs | Rationale for Retaining or Rejecting Technology |
|---|---|---|---|---|---|
| **In Situ Technologies (cont.)** | | | | | |
| In Situ Treatment by Bioremediation | • Soil<br>• Groundwater | • The activity of naturally occurring microorganisms is stimulated by adding water-based solutions to enhance the biological degradation of organic contaminants. | • Effectiveness is highly dependent on geochemical conditions, and success is highly dependent on the ability to deliver the substrate to the affected areas.<br>• Groundwater gradient and fine-grained interbeds would limit effectiveness. Radius of influence for each area of injection expected to be localized. | • The extensive dissolved-phase plume within the perched water-bearing zone and deeper alluvial aquifer would make this technology challenging to achieve RAOs. | In situ groundwater treatment by bioremediation is applicable to TPH in soil and groundwater, is implementable given Site conditions, and achieves RAOs.<br>**In Situ Treatment by Bioremediation is Retained** for further evaluation. |
| Surfactant Soil Flushing [(1)] | • Soil | • Can be implemented with minimal disturbance to surface activities. | • Requires injection of large volumes of water and surfactant to release soil contamination into groundwater.<br>• High risk associated with capturing all downgradient groundwater/surfactant to ensure chemicals are not mobilized when transported downgradient.<br>• Installation of recovery wells required for extraction.<br>• Significant impact to existing surface activities, so applicable only in specific small locations. | • Surfactant injection and extraction will likely be ineffective for impacts within the perched water-bearing zone due to the low yield and inability to recover the required volume of mixed water and surfactant.<br>• Can be used in combination with other remedial technologies. | Surfactant soil flushing would be applicable to achieving RAOs when used in combination with other technologies.<br>**Surfactant Soil Flushing is Retained** for further evaluation. |
| Solidification and Stabilization | • Soil | • Technology reduces the mobility of soil contamination through physical or chemical immobilization.<br>• Toxicity of individual COCs may be reduced through chemical reaction processes (stabilization only).<br>• Controls contaminant migration or leaching to groundwater. | • Feasibility of implementation decreases with depth below ground surface.<br>• Chemicals remain in place and are immobilized, but not removed (solidification).<br>• Significant impact to existing surface activities, so applicable only in specific small locations. | • Could be difficult to implement due to the large footprint of contamination.<br>• Can be implemented when there is a break in rail activities. | Due to the extensive footprint of impacts, solidification and stabilization would not be cost effective and not address Site groundwater impacts.<br>**Solidification and Stabilization is Rejected** for further evaluation. |

**Table 12.1**
**Preliminary Screening of Remedial Technologies**

| Remedial Technology | Applicable Media | General Technology Benefits | General Technology Constraints | Consideration of Site Physical Conditions and RAOs | Rationale for Retaining or Rejecting Technology |
|---|---|---|---|---|---|
| **In Situ Technologies (cont.)** | | | | | |
| Thermal Treatment | • Soil<br>• Groundwater | • Can be implemented in a short time frame.<br>• Can be implemented at greater depths than other technologies.<br>• Treats both soil and groundwater contamination simultaneously.<br>• No long-term maintenance required. | • High cost associated with implementation.<br>• Requires large loads of on-site power.<br>• Requires substantial surface infrastructure for operation.<br>• Requires intensive O&M during short-term operation (usually 1 to 2 years).<br>• Significant impact to existing surface activities, so applicable only in specific small locations. | • Technology not limited by site physical conditions and can be implemented in coordination with future use conditions.<br>• Would be difficult to implement due to the large site footprint and rail activities.<br>• Potential issue with mobilization of Bunker C pipeline contents.<br>• Tidal fluctuations may cause excessive heat loss. | Thermal treatment is energy intensive and disruptive and would not be cost effective to treat the small source area of contamination and the large groundwater plume.<br>**Thermal Treatment is Rejected** from further evaluation. |
| Soil Vapor Extraction | • Soil | • System can be easily turned on and off to optimize performance and cost.<br>• Facilitates protection of groundwater from vapor-phase contaminant migration. | • Limited to treatment of vadose zone soil and volatile contaminants.<br>• Relatively expensive to install and maintain.<br>• Does not address groundwater contamination for Site COCs.<br>• Technology does not have proven success at sites with similar conditions.<br>• Potential disturbance to surface activities. | • Does not address contamination in the saturated zone or LNAPL.<br>• Accessibility and widespread nature of soil contamination are additional obstacles.<br>• Tight spacing of wells anticipated due to geology.<br>• Multiple systems would be required across the Site. | Soil vapor extraction would not address the large footprint of saturated zone soil and groundwater impacts at the Site.<br>**Soil Vapor Extraction is Rejected** from further evaluation. |
| Vitrification | • Soil | • Completely immobilizes inorganic contaminants and destroys organic contaminants by high temperatures.<br>• Effective to depths of up to 20 feet bgs.<br>• Resulting glass/vitreous mass prevents contamination from leaching to groundwater. | • Requires heating the ground to very high temperatures, which is costly.<br>• Resulting glass/vitreous mass would affect Site groundwater flow.<br>• Does not treat deep contamination (greater than 20 feet bgs).<br>• Vaporized contamination requires capture and treatment. | • No significant inorganic issues at the Site. Not an appropriate tool if inorganic contamination is not a concern.<br>• Would be difficult to implement due to the large site footprint.<br>• Might not be effective for any product remaining in the former Longview Pipeline. | Vitrification is not applicable to Site contaminants, which are organic, and thus would not achieve RAOs.<br>**Vitrification is Rejected** from further evaluation. |

**Table 12.1**
**Preliminary Screening of Remedial Technologies**

| Remedial Technology | Applicable Media | General Technology Benefits | General Technology Constraints | Consideration of Site Physical Conditions and RAOs | Rationale for Retaining or Rejecting Technology |
|---|---|---|---|---|---|
| **In Situ Technologies (cont.)** | | | | | |
| Immobilization and Biodegradation | • Groundwater | • Used to prevent further migration of contaminants.<br>• Removes hydrocarbons from the dissolved phase by adsorbing them onto activated carbon matrix. Once immobile, contaminants degrade via biodegradation. | • Can be expensive compared to other in situ chemical oxidation technologies.<br>• Can be difficult to implement in certain geological conditions. | • Could be easily implemented within the rail lines during periods of no activity.<br>• Can be used in combination with other remedial technologies.<br>• High amounts of LNAPL could both overwhelm sorption sites on the PlumeStop carbon and the rates of anaerobic degradation.<br>• Low permeability soils and low yield in the water-bearing zone for this Site will likely result in this technology being less effective. | Immobilization and biodegradation (PlumeStop) would be applicable to achieving RAOs when used in combination with other technologies. However, another similar technology, sorption and biodegradation using PetroFix, is a better fit for Site conditions, and PlumeStop does not offer any marginal benefit.<br>**Immobilization and Biodegradation is Rejected** from future evaluation. |
| Sorption and Biodegradation | • Groundwater | • Used to prevent further migration of contaminants.<br>• Removes hydrocarbons from the dissolved phase by adsorbing them onto activated carbon particles and contains electron acceptors, which stimulate biodegradation. | • Is not as effective with carbon ranges higher than C34 and is effective for component in the higher end carbon ranges that are soluble and mobile.<br>• Can be difficult to implement in certain geological conditions. | • Could be easily implemented within the rail lines during periods of no activity.<br>• Can be used in combination with other remedial technologies.<br>• High amounts of LNAPL could overwhelm sorption sites on the PetroFix carbon and decrease the rates of biodegradation.<br>• Contains more carbon than PlumeStop but with a decreased radius of influence.<br>• Low permeability soils in the perched water-bearing zone could be an issue. | Sorption and biodegradation using PetroFix would be applicable to achieving RAOs when used in combination with other technologies.<br>**Sorption and Biodegradation is Retained** for future evaluation. |

**Table 12.1**
**Preliminary Screening of Remedial Technologies**

| Remedial Technology | Applicable Media | General Technology Benefits | General Technology Constraints | Consideration of Site Physical Conditions and RAOs | Rationale for Retaining or Rejecting Technology |
|---|---|---|---|---|---|
| **Ex Situ Technologies** | | | | | |
| Soil Excavation and Landfill Disposal | • Soil<br>• Groundwater | • Results in immediate removal of chemicals from a site, reducing mass in a short time frame.<br>• Effectively removes all COCs in excavation area.<br>• Removal of soil contamination in areas of impacted groundwater removes the ongoing source of contaminants to groundwater.<br>• Does not require long-term monitoring and maintenance. | • Can be expensive to implement because of landfill disposal costs.<br>• Significant impacts to surface activities.<br>• Technology is limited by contaminant depth and active rail lines.<br>• In accessible areas, excavation depths can extend down to depths up to 23 feet bgs; therefore, shoring will likely be required for stability if open cuts cannot be made.<br>• Dewatering may be required for excavations extending below the groundwater table, which generates liquid waste streams that would require treatment and disposal. | • Excavation would be limited to select areas outside of the rail lines (not feasible in the areas in and around the rail lines).<br>• Landfarming might be an option in lieu of off-site landfill disposal.<br>• Does not contribute to achievement of RAOs (i.e., LNAPL removal) when not used in combination with other remedial technologies. | Source removal addresses all COCs, is implementable given Site conditions, and achieves RAOs when combined with other remedial technologies for downgradient groundwater.<br>**Soil Excavation and Landfill Disposal is Retained** for further evaluation. |
| Dual-Phase/ Multiphase Extraction | • Groundwater | • Effective at treating vadose and smear zone where LNAPL often accumulates. | • Expensive O&M costs.<br>• Significant impact to existing surface activities. | • Likely difficult to implement and conduct O&M within rail lines. | The lateral and vertical extents of groundwater impacts at the Site limit the effectiveness of dual-phase/multiphase extraction. It would provide marginal if any benefit compared to the capital and long-term O&M costs.<br>**Dual-Phase/Multiphase Extraction is Rejected** from further evaluation. |

**Table 12.1**
**Preliminary Screening of Remedial Technologies**

| Remedial Technology | Applicable Media | General Technology Benefits | General Technology Constraints | Consideration of Site Physical Conditions and RAOs | Rationale for Retaining or Rejecting Technology |
|---|---|---|---|---|---|
| **Ex Situ Technologies (cont.)** | | | | | |
| Pump and Treat | • Groundwater | • Removes dissolved-phase chemicals from groundwater.<br>• Typically causes minimal impact to site operations. | • Does not treat soil source contamination and generally unsuccessful at meeting groundwater cleanup levels when soil source remains.<br>• High groundwater pumping rates may be required resulting in high volumes of groundwater for treatment and disposal.<br>• Significant cost associated with treatment and discharge of treated waste stream.<br>• Long-term O&M required for extraction system in perpetuity. | • Permeable subsurface conditions in the alluvial aquifer would likely result in excessive water volumes requiring treatment and disposal in perpetuity.<br>• Difficult to implement within rail lines but could be installed along the western boundary of rails.<br>• Generally low mobility of COCs and stagnant plume do not support the need for implementation of this technology. | Pump and treat could eventually achieve RAOs but would not be cost effective over time and would result in a longer restoration time frame than other groundwater treatment technologies.<br>**Pump and Treat is Rejected** from further evaluation. |
| **LNAPL Removal Technologies** | | | | | |
| Hand Bailing or Passive Recovery Inserts | • Soil<br>• Groundwater | • Can be implemented with minimal disturbance to surface activities.<br>• Relatively low-cost to implement and maintain. | • The limited capture area of this technology is not an efficient recovery method for persistent LNAPL and would leave in place substantial product in soils. | • Implemented in the past at this Site with little effect but can be easily implemented because it does not interfere with Site operations. | Hand bailing or passive recovery inserts would be applicable to achieving RAOs; however, historical bailing activities were not as effective and surfactant soil flushing would likely be more effective.<br>**Hand Bailing or Passive Recovery Inserts is Rejected** for further evaluation. |
| Passive Recovery (Skimming Wells) | • Groundwater | • Skimming wells recover product using a variety of means with little groundwater recovery. | • Rate of recovery is slow, and this technology would leave in place substantial residual product in soils. | • Can be easily implemented.<br>• Would likely leave residual product in soils.<br>• O&M cost is relatively inexpensive compared to other active remediation technologies. | Passive recovery (skimming wells) would be applicable to achieving RAOs; however, soil flushing with surfactants will likely be more effective in removing residual LNAPL present in the soil.<br>**Passive Recovery is Rejected** for further evaluation. |

**Table 12.1**
**Preliminary Screening of Remedial Technologies**

| Remedial Technology | Applicable Media | General Technology Benefits | General Technology Constraints | Consideration of Site Physical Conditions and RAOs | Rationale for Retaining or Rejecting Technology |
|---|---|---|---|---|---|
| **LNAPL Removal Technologies (cont.)** | | | | | |
| Active Recovery (Vacuum Enhanced) | • Groundwater | • Applies a vacuum to induce a larger potential gradient toward recovery wells through negative pressure.<br>• Minimizes the physical movement of the oil–water interface.<br>• Extracts volatile hydrocarbons (liquid and vapor) from the unsaturated zone. | • Expensive O&M costs. | • Difficult to implement and conduct O&M within rail lines.<br>• Would likely leave residual product in soils. | Active recovery would be applicable to achieving RAOs when used in combination with other technologies. However, considering the Site conditions, this expensive technology would offer no benefit over surfactant soil flushing, which is a more cost-effective LNAPL removal technology.<br>**Active recovery is Rejected** from further evaluation. |
| Bioslurping | • Soil<br>• Groundwater | • Allows for removal of product with minimal depression of the water table.<br>• Vapor recovery remediates residual product in the unsaturated zone and enhances bioremediation. | • Expensive O&M costs. | • Difficult to implement and conduct O&M within rail lines.<br>• Would likely leave residual product in soils. | Bioslurping would be applicable to achieving RAOs when used in combination with other technologies. However, considering the Site conditions, this expensive technology would offer no benefit over surfactant soil flushing, which is a more cost-effective LNAPL removal technology.<br>**Bioslurping is Rejected** from further evaluation. |

Notes:

Shading indicates technology rejected from further consideration for remedial alternative development.

1 Soil flushing also retained as an LNAPL removal technology.

Abbreviations:

| | |
|---|---|
| bgs | Below ground level |
| COC | Contaminant of concern |
| DRO | Diesel-range organics |
| GRO | Gasoline-range organics |
| ISCO | In situ chemical oxidation |
| LNAPL | Light non-aqueous phase liquid |
| ORO | Oil-range organics |
| O&M | Operations and maintenance |
| PRB | Permeable reactive barrier |
| RAO | Remedial action objective |
| VOC | Volatile organic compound |
| TPH | Total petroleum hydrocarbons |

## Table 13.1
## Summary of Remedial Alternatives

| Preliminary Alternatives | Summary Description | Conceptual Components | Benefits | Issues/Considerations | Sustainability | Estimated Total Alternative Cost (1) |
|---|---|---|---|---|---|---|
| Alternative 1 - LNAPL Removal and MNA | - Surfactant injection and LNAPL extraction activities in MW-09<br>- Installation of additional downgradient wells along the western, northwestern, and northern Port property boundary<br>- Inspection of the former Longview Pipeline contents<br>- Long-term groundwater monitoring and MNA<br>- Institutional Controls and SMP | - Surfactant injection and extraction activities including installation of additional 4-inch-diameter recovery wells within the vicinity of MW-09, which would be used during injections and extraction activities<br>- Surfactant and water extraction, soil handling/disposal<br>- Institutional controls indefinitely (or until MNA) including an SMP<br>- MNA monitoring - indefinite | - Low cost, low disturbance from minimal active construction.<br>- Surfactant injection and extraction would help eliminate residual LNAPL in soil and groundwater. | - Requires ICs on Port, City of Longview, and WSDOT properties; ICs on City of Longview and WSDOT properties may not be acceptable to those entities.<br>- Does not address the majority of the soil source contamination present in CAA-2.<br>- Indefinite long-term monitoring.<br>- There might be public and tribal concerns with off-property migration. | - Small negative balance of environmental impact due to carbon dioxide emissions from implementation. The small carbon footprint due to raw material consumption (fuels and electricity) and greenhouse gas emissions (heavy equipment) is more sustainable than the other alternatives. | Low.<br>$1,600,000 |
| Alternative 2 - In Situ Treatment Barrier and LNAPL Removal | - Installation of in situ treatment barrier with PetroFix<br>- Off-property ISCO injections in the vicinities of MW-04 and MW-30<br>- Surfactant injection and LNAPL extraction activities in MW-09<br>- Installation of additionaldowngradient wells along the western, northwestern, and northern Port property boundary<br>- Inspection of the former Longview Pipeline contents<br>- Long-term groundwater monitoring and MNA<br>- Institutional Controls and SMP | - Installation of a PetroFix barrier in area outside the rail lines within the footprint of the former Calloway Ross Parcel and former Warehouse 9 footprint<br>- Surfactant injection and extraction activities including installation of additional 4-inch-diameter recovery wells within the vicinity of MW-09, which would be used during injections and extraction activities<br>- In situ injections to address off-property downgradient plume on WSDOT property<br>- Institutional controls indefinitely (or until MNA) including an SMP<br>- MNA and compliance monitoring | - Prevents off-property migration onto WSDOT and City of Longview property.<br>- PetroFix expected to last from 5 to 10 years as long as there are terminal electron acceptors.<br>- Surfactant injection and extraction would help reduce hydrocarbon mass and eliminate LNAPL.<br>- Low disturbance to rail activities. | - Containment remedy that would not address source areas in CAA-1 and CAA-2, resulting in indefinite restoration time frame<br>- Long-term O&M costs to maintain treatment barrier to meet CULs at at the downgradient Port property boundary, which includes a potential for re-injection of PetroFix barrier to restore electron acceptors | - Small negative balance of environmental impact due to carbon dioxide emissions from implementation. The small carbon footprint due to raw material consumption (fuels and electricity) and greenhouse gas emissions (heavy equipment) is more sustainable than Alternatives 3 through 5. | Low to Moderate implementation cost, with greater long-term O&M cost than other options.<br>$4,200,000 |
| Alternative 3 - Targeted ISCO Injections and LNAPL Removal | - Targeted ISCO injections within accessible areas where soil COC concentrations exceed proposed CULs (CAA-1)<br>- Targeted ISCO injections along the rail lines within hotspots or where soil COC concentrations exceed RELs (CAA-2)<br>- Off-property ISCO injections in the vicinities of MW-04 and MW-30<br>- Surfactant injection and LNAPL extraction activities in MW-09<br>- Installation of additional downgradient wells along the western, northwestern, and northern Port property boundary<br>- Inspection of the former Longview Pipeline contents<br>- Long-term groundwater monitoring and MNA<br>- Institutional Controls and SMP | - Accessible areas outside the rail lines: In situ injections within extent of MTCA Method A soil exceedances to protect groundwater; PersulfOx injections within alluvial aquifer and RegenOx in perched water-bearing zone<br>- Within the rail lines: Focused PersulfOx injections within alluvial aquifer and RegenOx in perched water-bearing zone<br>- In situ RegenOx injections to address off-property downgradient plume on WSDOT property<br>- LNAPL removal via surfactant injections and extractions within the vicinity of MW-09<br>- Institutional controls including an SMP<br>- Performance monitoring and long-term monitoring | - Would prevent off-property migration to City of Longview and WSDOT properties.<br>- Would more quickly achieve CULs in accessible areas than Alternative 1 and 2 and allow the Port to develop and lease the areas outside of the rail lines.<br>- Least invasive injection alternative, would use RELs for remediating soil exceeding residual saturation levels within rail lines to reduce impact to Port activities.<br>- Lower expected cost than aggressive injections and excavation. | - Would not address impacts less than residual saturation levels within the rail lines resulting in long restoration time frame for Site-wide impacts; however, the restoration time frame to meet groundwater CULs at the downgradient Port property boundary is 5 to 10 years.<br>- Some uncertainty concerning whether the injections would reach all intended areas.<br>- Access constraints, disruption to rail activities (approximately a total of up to 30 days of injection activities in the rail lines) but less impact than Alternative 5.<br>- May require supplemental injections to meet remedial action goals. | - Small negative balance of environmental impact due to carbon dioxide emissions from implementation. The small carbon footprint due to raw material consumption (fuels and electricity) and greenhouse gas emissions (heavy equipment) is not as sustainable as Alternatives 1 and 2 but is more sustainable than Alternative 4. | Moderate.<br>$4,200,000 |

## Table 13.1
## Summary of Remedial Alternatives

| Preliminary Alternatives | Summary Description | Conceptual Components | Benefits | Issues/Considerations | Sustainability | Estimated Total Alternative Cost (1) |
|---|---|---|---|---|---|---|
| Alternative 4 - Limited Excavation, Targeted ISCO Injections, and LNAPL Removal | - Excavation of approximately 13,000 cubic yards of impacted soil exceeding proposed CULs (CAA-1)<br>- Targeted ISCO injections along the rail lines within hotspots or where soil concentrations exceed RELs (CAA-2)<br>- Off-property ISCO injections in the vicinities of MW-04 and MW-30<br>- Surfactant injection and LNAPL extraction activities in MW-09<br>- Installation of additional downgradient wells along the western, northwestern, and northern Port property boundary<br>- Inspection of the former Longview Pipeline contents<br>- Long-term groundwater monitoring and MNA<br>- Institutional Controls and SMP | -Excavation of approximately 13,000 cubic yards of impacted soil in areas outside the rail lines within the footprint of the former Calloway Ross Parcel and former Warehouse 9 footprint; impacts present to depths up to 23 feet bgs; ORC-A applied in excavation<br>- PersulfOx injections within hotspots beneath rail lines in alluvial aquifer and RegenOx within hotspots beneath rail lines in perched water-bearing zone<br>- Surfactant injection and extraction activities including installation of additional 4-inch-diameter recovery wells within the vicinity of MW-09, which would be used during injections and extraction activities<br>- In situ injections to address off-property downgradient plume on WSDOT property<br>- Insitutional controls including an SMP<br>- Performance monitoring and long-term monitoring | - Would prevent off-property migration to City of Longview and WSDOT properties more quickly than all other alternatives<br>- Moderate disruption during injection activities<br>- More effective than excavation alone within accessible areas<br>- Would more quickly achieve CULs in accessible areas than Alternatives 1, 2 and 3, and would allow the Port to develop and lease the areas outside of the rail lines<br>- Would use RELs for remediate soil exceeding residual saturation levels within rail lines to reduce impact to Port activities<br>- Lower cost than a full Site-wide excavation<br>- Has a potential to more quickly meet groundwater CULs at the downgradient Port property boundary than Alternative 3, but similar restoration time frame within the rail lines as Alternative 3. | - Would not address impacts less than residual saturation levels within the rail lines, resulting in long restoration time frame for Site-wide impacts; however, the restoration time frame to meet groundwater CULs at the downgradient Port property boundary is 5 to 10 years.<br>- Access constraints and disruption to rail lines (approximately a total of up to 30 days of injection activities in the rail lines) but less impact than Alternative 5<br>- Some uncertainty concerning if the injections would reach all intended areas<br>- Excavation depths would require extensive, high-cost shoring to protect rail lines and expected to require geotechnical evaluation.<br>- Dewatering may be needed to dewater perched water-bearing zone and reach required depths. | - There is a negative balance of environmental impact due to carbon dioxide emissions from numerous trucks hauling impacted soil and clean backfill to and from the Site. The increase in the carbon footprint due to raw material consumption (fuels and electricity) and greenhouse gas emissions (heavy equipment) is not as sustainable as the other alternatives. | High.<br>$10,200,000 |
| Alternative 5 - Plume-Wide ISCO Injections and LNAPL Removal | - ISCO injections throughout the entire extent of groundwater impacts exceeding proposed CULs, including in the vicinity of off-property locations MW-04 and MW-30<br>- Surfactant injection and LNAPL extraction activities in MW-09<br>- Installation of additional downgradient wells along the western, northwestern, and northern Port property boundary<br>- Inspection of the former Longview Pipeline contents<br>- Long-term groundwater monitoring and MNA<br>- Institutional Controls and SMP | -Installation of additional 4-inch-diameter wells within the vicinity of MW-09 to assist with surfactant injection and extraction<br>-PersulfOx injections in alluvial aquifer and RegenOx in the perched water-bearing zone within the entire extent of groundwater impacts; both with close injection point spacing to maximize contaminant destruction<br>- Horizontal injection wells as potential alternative implementation option<br>- In situ injections to address off-property downgradient plume on WSDOT property<br>- Insitutional controls including an SMP<br>- Performance and compliance monitoring | - Would prevent off-property migration to City of Longview and WSDOT properties<br>- More cleanup certainty by addressing the entire dissolved-phase plumes within the perched water-bearing zone and alluvial aquifer<br>- Quicker compliance throughout plume, which would allow the Port to redevelop portions of the Site<br>- Most permanent option that will treat all soil to meet leaching pathway CULs | - Access constraints, disruption to rail activities<br>- Potential use of horizontal wells would involve technical and administrative difficulties and concerns about boring beneath active rail lines<br>- High cost to treat entire dissolve-phase plumes and soil impacts exceeding most conservative screening levels<br>- Some uncertainty concerning if the injections would reach all intended areas<br>- May require supplemental injections to meet remedial action goals within the estimated restoration time frame at downgradient Port property boundary, but this is less of a concern when compared to Alternative 3 | - Small negative balance of environmental impact due to carbon dioxide emissions from implementation. The small carbon footprint due to raw material consumption (fuels and electricity) and greenhouse gas emissions (heavy equipment) is not as sustainable as Alternatives 1 and 2 but is more sustainable than Alternative 4. | Moderate to high.<br>$8,300,000 |

Description of Regenesis In Situ Technologies:

PetroCleanze PetroCleanze is a customized formulation of the widely used RegenOx ISCO technology. This two-part reagent contains purposefully enhanced, detergent-like properties which significantly increase the desorption rates of hydrocarbons bound in saturated soils. Once the hydrocarbons are liberated into the dissolved phase, they are more readily available for removal using a range of enhanced recovery techniques. PetroCleanze is designed to increase the viability and efficiency of enhanced recovery techniques such as dual-phase extraction, vacuum-enhanced extraction, and pump and treat systems.

PetroFix PetroFix is an activated carbon-based reagent that uses 1- to 2-micrometer activated carbon in a water-based suspension along with added nutrients. The nutrients—either sulfate or sulfite, and nitrate—are to stimulate bioremediation on and around the activated carbon. PetroFix is easily injectable and can last for multiple years as a long as there are terminal electron acceptors for contamination biodegradation.

PersulfOx PersulfOx is an advanced ISCO reagent that destroys organic contaminants found in groundwater and soil through abiotic chemical oxidation reactions. It is an all-in-one product with a built-in catalyst that activates the sodium persulfate component and generates contaminant-destroying free radicals without the costly and potentially hazardous addition of a separate activator. The patented catalyst enhances the oxidative destruction of both petroleum hydrocarbons and chlorinated contaminants in the subsurface.

RegenOx RegenOx is a calcium percarbonate-based reagent that is engineered to be safe near utilities. The downside to RegenOx is its short-lived and highly reactive nature. RegenOx is typically injected over a minimum of three events separated by 2 to 4 weeks each. Oxygen ($O_2$) is often rapidly produced when RegenOx contacts organic matter or contamination. Should the suggested volume not be possible, the percentage of the RegenOx mixture may be increased or point spacing may be tightened. RegenOx is a metal- and utility-safe product.

Note:

1 Detailed cost estimate information for each alternative is provided in Appendix I.

Abbreviations:

bgs Below ground surface
CUL Cleanup level
ft Feet
GW Groundwater
ISCO In situ chemcial oxidation
LNAPL Light non-aqueous phase liquid
LTM Long-term monitoring
MNA Monitored natural attenuation
MTCA Model Toxic Controls Act
O&M Operations and maintenance
ORC Oxygen release compound
REL Remediation Levels
ROW Right-of-way
SMP Soil Management Plan
sq. ft. Square feet
WSDOT Washington State Department of Transportation

**Table 14.1**
**Disproportionate Cost Analysis Alternative Evaluation**

| Criteria | Alternative 1<br>LNAPL Removal and MNA | Alternative 2<br>In Situ Treatment Barrier and LNAPL Removal | Alternative 3<br>Targeted ISCO Injections and LNAPL Removal | Alternative 4<br>Limited Excavation, Targeted ISCO Injections, and LNAPL Removal | Alternative 5<br>Plume-wide ISCO Injections and LNAPL Removal |
|---|---|---|---|---|---|
| **Alternative Description** | Alternative 1 consists of the following:<br>• PetroCleanze surfactant injections and extractions, including installation of additional 4-inch-diameter injection/recovery wells within the vicinity of MW-09, which will be used during injections and extraction activities.<br>• Former Longview Pipeline inspection<br>• Installation of additional monitoring wells along the western downgradient boundary<br>• Long-term MNA<br>Once the dissolved-phase plumes are no longer present off-property, compliance groundwater monitoring would be implemented along the northwestern and northern edge of the Port property to verify plume status and to ensure no off-property migration of contamination. Groundwater monitoring would include MNA to verify natural attenuation of groundwater, which is expected to eventually achieve groundwater CULs at the downgradient property boundary in a restoration time frame of approximately 30 years.<br>ICs would be required indefinitely to address remaining soil and groundwater contamination on- and off-property (or until MNA). A soil management plan would be prepared to address the management of potentially contaminated soil remaining in place in the upper 15 feet bgs that could be encountered during Site redevelopment or O&M of the rail lines and utilities at the Port. | Alternative 2 consists of the following:<br>• Installation of a PetroFix barrier in CAA-1 within the footprint of the former Calloway Ross Parcel and former Warehouse 9 footprint.<br>• In situ PersulfOx injections to address the off-property downgradient groundwater plume on WSDOT property.<br>• PetroCleanze surfactant injection and extraction activities include installation of additional 4-inch-diameter injection/recovery wells within the vicinity of MW-09, which will be used during injections and extraction activities.<br>• Former Longview Pipeline inspection<br>• Installation of additional monitoring wells along the western downgradient boundary<br>• Long-term MNA<br>Compliance groundwater monitoring would be implemented to verify plume status and to ensure no off-property migration of contamination onto the City of Longview and WSDOT properties. Groundwater CULs at the downgradient property boundary are expected to be met in a restoration time frame of approximately 5 to 10 years.<br>ICs would be required indefinitely to address remaining soil and groundwater contamination on Port property. A soil management plan would be prepared to address the management of potentially contaminated soil remaining in place in the upper 15 feet bgs that could be encountered during Site redevelopment or O&M of the rail lines and utilities at the Port. | Alternative 3 consists of the following:<br>• Accessible areas outside the rail lines (CAA-1): In situ PersulfOx and RegenOx injections within extent of MTCA Method A soil exceedances to protect groundwater.<br>• Within the rail lines (CAA-2): Focused PersulfOx and RegenOx injections in both water-bearing zones in areas where soil concentrations exceed RELs.<br>• In situ PersulfOx injections to address off-property downgradient groundwater plume on WSDOT property.<br>• PetroCleanze surfactant injection and extraction activities include installation of additional 4-inch-diameter recovery wells within the vicinity of MW-09, which will be used during injections and extraction activities.<br>• Former Longview Pipeline inspection<br>• Installation of additional monitoring wells along the western downgradient boundary<br>• Long-term MNA<br>Performance monitoring would be implemented to verify the efficacy of in situ injections, and long-term monitoring would be implemented to verify plume status. Groundwater CULs at the downgradient property boundary are expected to be met in a restoration time frame of approximately 5 to 10 years.<br>ICs would be required indefinitely to address remaining soil contamination on Port property. A soil management plan would be prepared to address the management of potentially contaminated soil remaining in place in the upper 15 feet bgs that could be encountered during Site redevelopment or O&M of the rail lines and utilities at the Port. | Alternative 4 consists of the following:<br>• Excavation of approximately 13,000 cubic yards of impacted soil in areas outside the rail lines within the footprint of the former Calloway Ross Parcel and former Warehouse 9 footprint (CAA-1). ORC-A applied in base of excavation. Excavated soil would be transported off-site for disposal.<br>• PersulfOx and RegenOx injections in both water-bearing zones in areas where soil concentrations exceed RELs within the rail lines (CAA-2).<br>• In situ PersulfOx injections to address off-property downgradient groundwater plume on WSDOT property.<br>• PetroCleanze surfactant injection and extraction activities include installation of additional 4-inch-diameter recovery wells within the vicinity of MW-09, which will be used during injections and extraction activities.<br>• Former Longview Pipeline inspection<br>• Installation of additional monitoring wells along the western downgradient boundary<br>• Long-term MNA<br>Performance monitoring would be implemented to verify the efficacy of in situ injections, and long-term monitoring would be implemented to verify plume status. Groundwater CULs at the downgradient property boundary are expected to be met in a restoration time frame of approximately 5 to 10 years.<br>ICs would be required indefinitely to address remaining soil contamination on Port property. A soil management plan would be prepared to address the management of potentially contaminated soil remaining in place in the upper 15 feet bgs that could be encountered during Site redevelopment or O&M of the rail lines and utilities at the Port. | Alternative 5 consists of the following:<br>• PersulfOx and RegenOx injections within the entire extent of the groundwater plumes in both water-bearing zones.<br>• PetroCleanze surfactant injection and extraction activities include installation of additional 4-inch-diameter recovery wells within the vicinity of MW-09, which will be used during injections and extraction activities.<br>• Former Longview Pipeline inspection<br>• Installation of additional monitoring wells along the western downgradient boundary<br>• Long-term MNA<br>Performance monitoring would be implemented to verify the efficacy of in situ injections, and long-term monitoring would be implemented to verify plume status. Groundwater CULs at the downgradient property boundary are expected to be met in a restoration time frame of approximately 5 to 10 years.<br>ICs would be required indefinitely to address remaining vadose zone soil contamination. A soil management plan would be prepared to address the management of potentially contaminated soil remaining in place in the upper 15 feet bgs that could be encountered during Site redevelopment or O&M of the rail lines and utilities at the Port. |

**Table 14.1**
**Disproportionate Cost Analysis Alternative Evaluation**

| Criteria | Alternative 1<br>LNAPL Removal and MNA | Alternative 2<br>In Situ Treatment Barrier and LNAPL Removal | Alternative 3<br>Targeted ISCO Injections and LNAPL Removal | Alternative 4<br>Limited Excavation, Targeted ISCO Injections, and LNAPL Removal | Alternative 5<br>Plume-wide ISCO Injections and LNAPL Removal |
|---|---|---|---|---|---|
| **Overall Protectiveness**<br>• Degree to which existing risks to human health and the environment are reduced<br>• Time required to reduce risks and attain cleanup standards<br>• On-site and off-site risks resulting from alternative implementation<br>• Improvement in overall environmental quality<br><br>**Protectiveness Benefit Scoring by Alternative**<br><br> | • Risks associated with LNAPL present in the MW-09 vicinity would be removed with surfactant injections/extractions. Risks from contaminated groundwater rely on long-term effectiveness of natural attenuation and ICs on Port, City of Longview, and WSDOT properties. Risks associated with contaminated soil would be managed by ICs on Port property, as well as a soil management plan.<br>• There are few current risks from on-site soil and groundwater. However, risk reduction is less than other alternatives, which include ISCO treatment and soil excavation.<br>• The time frame for achievement of groundwater CULs at the downgradient property boundary is anticipated to be approximately 30 years.<br>• On-site risks during LNAPL removal and routine monitoring would be managed by proper H&S protocols and site security. Surfactant injections/extractions within the active rail lines would require planning to target time windows without rail traffic. The off-site risks associated with contaminated material transport and disposal are negligible and would be managed using licensed operators and permitted disposal facilities.<br>• Alternative 1 achieves the lowest improvement in overall environmental quality because TPH contamination will remain in soil and groundwater for the longest amount of time after remedy implementation. This alternative has a significantly longer restoration time frame relative to Alternatives 2, 3, 4, and 5 because it does not include contaminated soil removal or active treatment of the downgradient portions of the groundwater plume. | • Risks associated with LNAPL present in the MW-09 vicinity would be removed with surfactant injections/extractions. Risks from contaminated groundwater on Port property would be gradually reduced through natural attenuation, ICs, and a downgradient PetroFix barrier to prevent off-property migration. Risks from contaminated groundwater on the City of Longview and WSDOT property would be reduced by ISCO injections. Contaminated soil would be managed by ICs on Port property, as well as a soil management plan.<br>• Risk reduction and overall protectiveness are slightly higher than Alternative 1 because this alternative includes a barrier to prevent off-property migration and actively treats off-property impacts.<br>• The time frame for achievement of groundwater CULs at the downgradient property boundary is anticipated to be 5 to 10 years. Groundwater impacts on the City of Longview and WSDOT properties are expected to attenuate to concentrations less than CULs within 5 to 10 years of ISCO injections.<br>• On-site risks during construction would be managed by proper H&S protocols and site security. Surfactant injections/extractions within the active rail lines would require planning to target time windows without rail traffic. The off-site risks associated with contaminated material transport and disposal are negligible and would be managed using licensed operators and permitted disposal facilities.<br>• Alternative 2 achieves the fourth-highest improvement in overall environmental quality because the majority of TPH contamination will remain in soil and groundwater for an indefinite amount of time following remedy implementation. Alternative 2 is considered more protective than Alternative 1 because it includes targeted off-property in situ treatment and a PetroFix barrier to prevent off-property migration of contaminated groundwater. | • Risks associated with LNAPL present in the MW-09 vicinity would be removed with surfactant injections/extractions. Risks from contaminated groundwater on Port property would be moderately reduced through ISCO injections in areas with soil exceeding CULs outside the rail lines and areas with soil exceeding RELs inside the rail lines. Risks from contaminated groundwater on the City of Longview and WSDOT properties would be eliminated by ISCO injections on and off Port property. Risks associated with remaining contaminated soil beneath the Port property would be managed by ICs and a soil management plan.<br>• Risk reduction and overall protectiveness are higher than both Alternatives 1 and 2 because Alternative 3 actively treats the source area (destruction vs. reliance on downgradient barrier and ICs).<br>• The time frame for achievement of groundwater CULs at the downgradient property boundary is anticipated to be 5 to 10 years.<br>• On-site risks during construction would be managed by proper H&S protocols and site security. This alternative would require significant planning to work around active rail lines. There are no other added on-site risks. The off-site risks associated with contaminated material transport would be limited to incidental investigation-derived waste and extracted impacted groundwater because no soil excavation is proposed.<br>• Alternative 3 achieves the third-highest improvement in overall environmental quality because it actively treats the soil source area and is expected to fully achieve CULs in groundwater. This alternative has a similar anticipated restoration time frame for achievement of groundwater CULs at the downgradient property boundary as Alternative 2, but also leaves contaminated soil on the Site indefinitely. | • Risks associated with LNAPL present in the MW-09 vicinity would be removed with surfactant injections/extractions. Risks from contaminated groundwater on Port property would be moderately to strongly reduced through an excavation with added ORC-A in areas with soil exceeding CULs outside the rail lines and ISCO injections in areas with soil exceeding RELs inside the rail lines. Risks from contaminated groundwater on the City of Longview and WSDOT properties would be eliminated by excavation of impacted soil and ISCO injections. Risks associated with remaining contaminated soil beneath the Port property would be managed by ICs and a soil management plan.<br>• Risk reduction and overall protectiveness are similar to Alternative 3 because this alternative includes an excavation component to remove source area material. The removal of soil from beneath the property would significantly reduce off-property migration of contamination.<br>• The time frame for achievement of groundwater CULs at the downgradient property boundary is anticipated to be 5 to 10 years.<br>• On-site risks during construction would be managed by proper H&S protocols and site security. This alternative would require significant planning to work around active rail lines. The excavation would also require extensive shoring and potentially a geotechnical evaluation to protect active rail lines. Dewatering may also be required. The off-site risks are associated with contaminated material transport of soil and groundwater waste.<br>• Alternative 4 achieves the second-highest improvement in overall environmental quality because it permanently removes a large volume of impacted soil outside the rail lines and is expected to fully achieve CULs in groundwater through ISCO injections. This alternative has a similar anticipated restoration time frame for achievement of the groundwater CULs at the downgradient property boundary as Alternatives 2 and 3. However, this alternative would have the highest carbon footprint due to the transportation of impacted soil for disposal and imported backfill material. | • Risks associated with LNAPL present in the MW-09 vicinity would be removed with surfactant injections/extractions. In situ treatment throughout the entirety of the Site groundwater plumes would significantly reduce risks from contaminated soil and groundwater. Risks associated with remaining contaminated soil in the vadose zone would be managed by ICs and a soil management plan.<br>• Risk reduction and overall protectiveness are marginally higher than Alternative 4 because this alternative includes plume-wide injections, which would assist biodegradation of the largest extent and volume of the impacted soil and groundwater extents at the Site (destruction vs. reliance on containment and ICs).<br>• The time frame for achievement of groundwater CULs at the downgradient property boundary is anticipated to be 5 to 10 years. Although the ISCO injections will help attain soil CULs in the saturated zone, there will likely be residual soil impacts in the vadose zone.<br>• On-site risks during construction would be managed by proper H&S protocols and site security. This alternative would require significant planning to work around active rail lines. There are no other added on-site risks. The off-site risks associated with impacted material transport would be limited to incidental investigation-derived waste and extracted impacted groundwater because no soil excavation is proposed.<br>• Alternative 5 achieves the highest improvement in overall environmental quality because it addresses the largest extent of impacts exceeding CULs and the least amount of residual soil with CUL exceedances would be left on site. This alternative has a similar anticipated restoration time frame for achievement of the groundwater CULs at the downgradient property boundary as Alternatives 2, 3, and 4. |

**Table 14.1**
**Disproportionate Cost Analysis Alternative Evaluation**

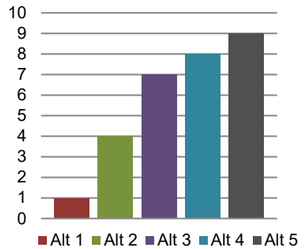
| Criteria | Alternative 1<br>LNAPL Removal and MNA | Alternative 2<br>In Situ Treatment Barrier and LNAPL Removal | Alternative 3<br>Targeted ISCO Injections and LNAPL Removal | Alternative 4<br>Limited Excavation, Targeted ISCO Injections, and LNAPL Removal | Alternative 5<br>Plume-wide ISCO Injections and LNAPL Removal |
|---|---|---|---|---|---|
| **Permanence**<br>• Degree of reduction of contaminant toxicity, mobility, and volume<br>• Adequacy of destruction of hazardous substances<br>• Reduction or elimination of substance release, and source of release<br>• Degree of irreversibility of waste treatment processes<br>• Volume and characteristics of generated treatment residuals<br><br>**Permanence Benefit Scoring by Alternative**<br>  <br> | • Alternative 1 is the least permanent alternative and provides a low reduction in contaminant volume compared to other alternatives because most of the impacts would be addressed by natural attenuation. Off-property migration of contaminants would not be addressed.<br>• Remaining soil impacts would be controlled by ICs on WSDOT, City of Longview, and Port properties, as well as a soil management plan for any site redevelopment or O&M activities in those areas.<br>• Attenuation via breakdown of contaminants is irreversible. LNAPL removal and surfactant extraction is also irreversible.<br>• There are no treatment residuals associated with implementation of this technology. | • Alternative 2 provides low reduction in contaminant volume compared to Alternatives 3, 4, and 5.<br>• Installation of a PetroFix barrier northwest of the rail lines in CAA-1 would prevent downgradient contamination migration, but not actively reduce source area contaminant volume. In situ PersulfOx injections would reduce groundwater impacts on WSDOT property.<br>• Remaining soil impacts would be controlled by ICs on Port property as well as by a soil management plan for any site redevelopment or O&M activities in areas with remaining impacts.<br>• The PetroFix barrier is expected to last between 5 and 10 years or as long as there are terminal electron acceptors present. In situ biodegradation and LNAPL removal and surfactant extraction are both irreversible.<br>• ISCO injections can increase dissolved iron and sulfate concentrations in groundwater for a short period of time. Sulfate and iron will be monitored after injections and compared to GWQS criteria of 250 mg/L and 0.30 mg/L, respectively (WAC 173-200-040). There are no other treatment residuals associated with implementation of this technology. | • Alternative 3 provides a moderate reduction in contaminant volume compared to other alternatives.<br>• Impacted soil and groundwater in CAA-1 (including the City of Longview and WSDOT properties) would be reduced using ISCO injections and biodegradation. In situ treatment in areas with soil concentrations greater than RELs in CAA-2 would reduce hydrocarbon mass in the source area to concentrations that would eventually be protective of groundwater over the restoration time frame.<br>• Remaining soil impacts within the Port property would be controlled by ICs, as well as by a soil management plan for any site redevelopment or O&M activities in areas with remaining impacts.<br>• In situ biodegradation, LNAPL removal, and surfactant extraction are irreversible. However, this alternative may require supplemental injections to meet remediation goals.<br>• ISCO injections can increase dissolved iron and sulfate concentrations in groundwater for a short period of time. Sulfate and iron will be monitored after injections and compared to GWQS criteria of 250 mg/L and 0.30 mg/L, respectively (WAC 173-200-040). There are no other treatment residuals associated with implementation of this technology. | • Alternative 4 provides a moderate to high reduction in contaminant volume compared to other alternatives. This alternative ranks slightly higher than Alternative 3 because the excavation will remove vadose zone impacts in CAA-1.<br>• Impacted soil and groundwater in CAA-1 (including the City of Longview and WSDOT properties) would be removed by excavation and in situ treatment. In situ treatment in areas with soil concentrations greater than RELs in CAA-2 would reduce hydrocarbon mass in the source area to concentrations that would eventually be protective of groundwater over the restoration time frame.<br>• Remaining soil impacts within the Port property would be controlled by ICs, as well as by a soil management plan for any site redevelopment or O&M activities in areas with remaining impacts.<br>• Excavation and off-site disposal of impacted soil, in situ biodegradation, and LNAPL removal/surfactant extraction are all irreversible. ORC-A pellets applied to the base of the excavation would help with ongoing attenuation of groundwater impacts and serve as a barrier to prevent contamination from migrating off-site.<br>• ISCO injections can increase dissolved iron and sulfate concentrations in groundwater for a short period of time. Sulfate and iron will be monitored after injections and compared to GWQS criteria of 250 mg/L and 0.30 mg/L, respectively (WAC 173-200-040). There are no other treatment residuals associated with implementation of this technology. | • Although Alternative 5 does not fully meet the definition of a permanent cleanup action, it is consistent with WAC 173-340-350(8)(c)(ii)(B)(II) because it is the most permanent alternative to the maximum extent practicable and it is not technically feasible to address all contaminated soil beneath all active structures and rail lines, even if horizontal injection wells are used. Alternative 5 provides the greatest reduction in contaminant volume compared to other alternatives.<br>• Plume-wide in situ treatment would address Site soil and groundwater impacts in CAA-1 and CAA-2 and prevent off-property migration.<br>• Remaining vadose zone soil impacts within the Port property would be controlled by ICs, as well as by a soil management plan for any site redevelopment or O&M activities in areas with remaining impacts.<br>• In situ biodegradation, LNAPL removal, and surfactant extraction are irreversible. However, this alternative may require supplemental injections to meet remediation goals.<br>• ISCO injections can increase dissolved iron and sulfate concentrations in groundwater for a short period of time. Sulfate and iron will be monitored after injections and compared to GWQS criteria of 250 mg/L and 0.30 mg/L, respectively (WAC 173-200-040). There are no other treatment residuals associated with implementation of this technology. |

**Table 14.1**
**Disproportionate Cost Analysis Alternative Evaluation**

| Criteria | Alternative 1<br>LNAPL Removal and MNA | Alternative 2<br>In Situ Treatment Barrier and LNAPL Removal | Alternative 3<br>Targeted ISCO Injections and LNAPL Removal | Alternative 4<br>Limited Excavation, Targeted ISCO Injections, and LNAPL Removal | Alternative 5<br>Plume-wide ISCO Injections and LNAPL Removal |
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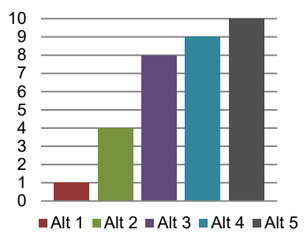
| **Effectiveness over the Long-Term**<br>• Degree of certainty of alternative success<br>• Reliability while contaminants on-site remain greater than CULs<br>• Magnitude of residual risk<br>• Effectiveness of controls implemented to manage residual risk<br><br>**Effectiveness over the Long-Term Benefit Scoring by Alternative**<br>  <br> | • Alternative 1 provides a low degree of certainty of success to meet RAOs and achieve groundwater CULs at the downgradient property boundary within a 30-year restoration time frame.<br>• Degree of certainty for success to remediate groundwater Site-wide is low because the majority of the TPH plumes would not be targeted by active treatment. Natural attenuation of contaminants is ongoing in Site groundwater, but at a slow rate.<br>• Residual risk from contaminated soil and groundwater on Port property would be managed by ICs and a soil management plan. The Port is expected to own the property in perpetuity, ensuring the long-term success of these controls. However, the ownership future of the WSDOT property is uncertain, and placing an IC on the City of Longview and WSDOT properties to restrict groundwater usage may not be feasible or acceptable to those entities.<br>• Off-property exposure risk to groundwater contamination during the restoration time frame would be monitored by routine groundwater monitoring events until in compliance with CULs. | • Alternative 2 provides a moderate degree of certainty of success to meet RAOs and achieve groundwater CULs at the downgradient property boundary within a 5- to 10-year restoration time frame.<br>• Degree of certainty for success to meet groundwater CULs at the downgradient property boundary is moderate. Although off-property groundwater impacts would be remediated through ISCO injections, the majority of the TPH plumes would not be targeted by active treatment. Initially, the off-property migration risk would be mitigated by the downgradient PetroFix barrier, but the barrier would likely have to be replaced after 5 to 10 years to ensure groundwater CULs continue to be met at the Port property boundary.<br>• Residual risk from contaminated soil and groundwater on Port property would be managed by ICs and a soil management plan. The Port is expected to own the property in perpetuity, ensuring the long-term success of these controls. A PetroFix barrier would also protect downgradient migration of impacted groundwater.<br>• Off-property exposure risk to groundwater contamination during the restoration time frame would be monitored by routine groundwater monitoring events until in compliance with CULs. | • Alternative 3 provides a moderate to high degree of certainty of success to meet RAOs and achieve groundwater CULs at the downgradient property boundary within a 5- to 10-year restoration time frame.<br>• In situ treatment is an effective and reasonably common technology to implement and would remove TPH impacts in groundwater and saturated soil.<br>• Degree of certainty for success to meet groundwater CULs at the Port property boundary is moderate to high because this alternative does not include soil removal; however, ISCO injections would be implemented in areas within CAA-2 where soil concentrations exceed RELs and in CAA-1 where soil concentrations exceed MTCA Method A CULs. Off-property groundwater impacts would also be addressed by ISCO injections.<br>• Residual risk from contaminated soil and groundwater on Port property would be managed by ICs and a soil management plan. The Port is expected to own the property in perpetuity, ensuring the long-term success of these controls.<br>• Off-property exposure risk to groundwater contamination during the restoration time frame would be monitored by routine groundwater monitoring events until in compliance with CULs. | • Alternative 4 provides a high degree of certainty of success to meet RAOs and achieve groundwater CULs at the downgradient property boundary within a 5- to 10-year restoration time frame.<br>• In situ treatment is an effective and standard technology to implement and would remove TPH impacts in groundwater and saturated soil. Excavation is an effective and common technology that would fully remove contaminants in soil.<br>• Degree of certainty for success to meet groundwater CULs at the Port property boundary is moderate to high because of soil removal in CAA-1 and ISCO injections in CAA-2 would significantly reduce the TPH mass in Site soils exceeding RELs.<br>• Residual risk from contaminated soil and groundwater on Port property would be managed by ICs and a soil management plan. The Port is expected to own the property in perpetuity, ensuring the long-term success of these controls.<br>• Off-property exposure risk to groundwater contamination during the restoration time frame would be monitored by routine groundwater monitoring events until in compliance with CULs. | • Alternative 5 provides a high degree of certainty of success to meet RAOs and achieve groundwater CULs at the downgradient property boundary within a 5- to 10-year restoration time frame.<br>• In situ treatment is an effective and standard technology to implement and would remove TPH impacts in groundwater and saturated soil.<br>• Degree of certainty for success to meet groundwater CULs at the Port property boundary is high because of extensive plume-wide in situ treatment. This alternative also has a high degree of certainty for success in remediating saturated zone soil concentrations, which could contribute to Site-wide achievement of groundwater CULs.<br>• Residual risk from contaminated soil and groundwater on Port property would be managed by ICs and a soil management plan. The Port is expected to own the property in perpetuity, ensuring the long-term success of these controls.<br>• Off-property exposure risk to groundwater contamination during the restoration time frame would be monitored by routine groundwater monitoring events until in compliance with CULs. |

**Table 14.1**
**Disproportionate Cost Analysis Alternative Evaluation**

| Criteria | Alternative 1<br>LNAPL Removal and MNA | Alternative 2<br>In Situ Treatment Barrier and LNAPL Removal | Alternative 3<br>Targeted ISCO Injections and LNAPL Removal | Alternative 4<br>Limited Excavation, Targeted ISCO Injections, and LNAPL Removal | Alternative 5<br>Plume-wide ISCO Injections and LNAPL Removal |
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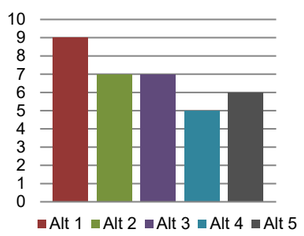
| **Short-Term Risk Management**<br>• Risk to human health and the environment associated with alternative construction<br>• The effectiveness of controls in place to manage short-term risks<br><br>**Short-Term Risk Management Benefit Scoring by Alternative**<br>  <br> | • Alternative 1 has a low short-term risk to human health and the environment during implementation. There are residual risks to human health and the environment posed by surfactant injection/extraction, and transport of contaminated fluid.<br>• There is a low risk to site workers during handling of liquid PetroCleanze surfactant and groundwater monitoring activities. There is a low risk associated with the handling and transportation for disposal of the impacted soil from drill cuttings during the installation of the injection/recovery wells within the vicinity of MW-09.<br>• Approximately 6,000 gallons of contaminated fluids containing product and dissolved-phase hydrocarbons will be generated during surfactant extraction events and managed on-site.<br>• Site activities would require appropriate PPE, BMPs, site controls to restrict site access, rail traffic control, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk. | • Alternative 2 has a low to moderate short-term risk to human health and the environment during implementation. Short term risk is slightly higher than Alternative 1 due to the addition of low risks associated with the ISCO injections. There are residual risks to human health and the environment posed by surfactant injection/extraction, and transport of contaminated fluid. These risks would be managed by proper BMPs, worker H&S protocols, and site security.<br>• There is a low risk to site workers during handling of PetroCleanze, PersulfOx, RegenOx, and PetroFix injection substrates and groundwater monitoring activities. There is a low risk associated with the handling and transportation for disposal of the impacted soil from drill cuttings during the installation of the injection/recovery wells within the vicinity of MW-09.<br>• There is a low risk that ISCO injections can potentially increase dissolved iron and sulfate concentrations in groundwater for a short period of time.<br>• Approximately 6,000 gallons of contaminated fluids containing product and dissolved-phase hydrocarbons will be generated during surfactant extraction events and managed on-site.<br>• ISCO injections will occur in primarily vacant and inactive areas of the Port and WSDOT properties. However, access to all locations is not controlled, and there is a small possibility of encountering traffic or WSDOT and Port employees in these locations. Additional controls to restrict Site access, including exclusion zones and traffic cones, would be implemented in applicable areas.<br>• Site activities would require appropriate PPE, BMPs, site controls to restrict site access, rail traffic control, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk. | • Alternative 3 has a low to moderate short-term risk to human health and the environment during implementation. Short-term risk is slightly higher than Alternative 2 due to the addition of injection points. There are residual risks to human health and the environment posed by surfactant injection/extraction, and disposal/transport of contaminated fluid.<br>• There is a low risk to site workers during handling of PetroCleanze, PersulfOx, and RegenOx injection substrates and groundwater monitoring activities. There is a low risk associated with the handling and transportation for disposal of the impacted soil from drill cuttings during the installation of the injection/recovery wells within the vicinity of MW-09.<br>• There is a low risk that ISCO injections can potentially increase dissolved iron and sulfate concentrations in groundwater for a short period of time.<br>• Approximately 6,000 gallons of contaminated fluids containing product and dissolved phase hydrocarbons will be generated during surfactant extraction events and managed on-site.<br>• ISCO injections within CAA-2 will occur during periods when the lines are inactive to minimize risk to on-site workers.<br>• Site activities would require appropriate PPE, BMPs, site controls to restrict site access, coordination with railyard, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk. | • Alternative 4 has a moderate to high short-term risk to human health and the environment during implementation, which is the highest of all the alternatives. There are residual risks to human health and the environment posed by surfactant injection/extraction, and disposal/transport of contaminated fluid.<br>• Handling and disposal of contaminated soil would require a significant number of truck trips to haul contaminated soil off-site that would increase traffic risks and would have a larger carbon footprint. There is also some risk for public exposure with this alternative due to increased traffic associated with contaminated soil transportation from the site for disposal over public roadways; however, the excavated soil would be managed by licensed professionals at a permitted landfill.<br>• There is a low risk to site workers during handling of PetroCleanze, PersulfOx, and RegenOx injection substrates and groundwater monitoring activities. There is a low risk associated with the handling and transportation for disposal of the impacted soil from drill cuttings during the installation of the injection/recovery wells within the vicinity of MW-09.<br>• There is a low risk that ISCO injections can potentially increase dissolved iron and sulfate concentrations in groundwater for a short period of time.<br>• Approximately 6,000 gallons of contaminated fluids containing product and dissolved-phase hydrocarbons will be generated during surfactant extraction events and managed on-site.<br>• ISCO injections within CAA-2 will occur during periods when the lines are inactive to minimize risk to on-site workers.<br>• Site activities would require appropriate PPE, BMPs, site controls to restrict site access, coordination with railyard, and appropriate training requirements for management of risk. The large excavation would also require extensive shoring and potentially a geotechnical evaluation. These controls are highly effective and anticipated to adequately manage short-term risk. | • Alternative 5 has a moderate short-term risk to human health and the environment during implementation. There are residual risks to human health and the environment posed by surfactant injection/extraction, and disposal/transport of contaminated fluid.<br>• There is a low risk to site workers during handling of PetroCleanze, PersulfOx, and RegenOx injection substrates and groundwater monitoring activities. There is a low risk associated with the handling and transportation for disposal of the impacted soil from drill cuttings during the installation of the injection/recovery wells within the vicinity of MW-09.<br>• There is a low risk that ISCO injections can potentially increase dissolved iron and sulfate concentrations in groundwater for a short period of time.<br>• Approximately 6,000 gallons of contaminated fluids containing product and dissolved-phase hydrocarbons will be generated during surfactant extraction events and managed on-site.<br>• ISCO injections within CAA-2 will occur during periods when the lines are inactive to minimize risk to on-site workers. Injections within the City of Longview ROW pose risks to workers and the public due to working in the roadway and may also increase the risk of traffic collisions due to detours. Alternative 5 is the only alternative that would require work in the ROW. Similar short-term risks would apply if horizontal injection wells were used, given the number and density of borings.<br>• Site activities would require appropriate PPE, BMPs, site controls to restrict site access, coordination with railyard, traffic control, and appropriate training requirements for management of risk. These controls are highly effective and anticipated to adequately manage short-term risk. |

**Table 14.1**
**Disproportionate Cost Analysis Alternative Evaluation**

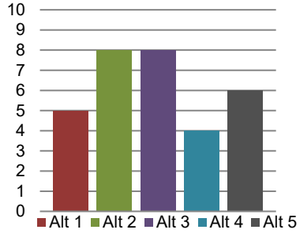
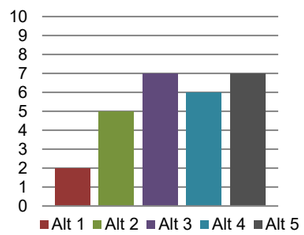
| Criteria | Alternative 1<br>LNAPL Removal and MNA | Alternative 2<br>In Situ Treatment Barrier and LNAPL Removal | Alternative 3<br>Targeted ISCO Injections and LNAPL Removal | Alternative 4<br>Limited Excavation, Targeted ISCO Injections, and LNAPL Removal | Alternative 5<br>Plume-wide ISCO Injections and LNAPL Removal |
|---|---|---|---|---|---|
| **Technical and Administrative Implementability**<br>• Technical possibility<br>• Availability of off-site facilities, services, and materials<br>• Administrative and regulatory requirements<br>• Schedule, size, and complexity of construction<br>• Monitoring requirements<br>• Site access for construction, operations, and monitoring<br>• Integration with existing site operations or other current and potential future remedial action<br><br>**Technical and Administrative Implementability Benefit Scoring by Alternative**<br>  <br> | • Alternative 1 is the smallest in scale. Surfactant injections and extractions is a somewhat specialized construction element; however, many licensed drillers in the region are qualified to safely perform this work. This surfactant injections/extractions associated with this alternative can be implemented in a single construction season.<br>• All necessary off-site facilities, materials, and services are available within the region.<br>• UIC permits would need to be obtained prior to injection activities.<br>• Monitoring requirements include performance monitoring during injection and extraction and MNA groundwater monitoring following implementation.<br>• ICs and a soil management plan would be developed for contamination remaining on Port property. ICs would need to be placed on WSDOT and City of Longview properties to restrict groundwater use. This might not be feasible or accepted by the property owners, which would make this more technically challenging.<br>• This alternative would not impede current property use or preclude potential future remedial action. However, this alternative could impact future redevelopment activities on the Port, WSDOT, or City of Longview properties if excavation or dewatering is required. | • Alternative 2 is the second smallest in scale. In situ injection is a somewhat specialized construction element; however, many licensed drillers in the region are qualified to safely perform this work. This alternative can be implemented in a single construction season.<br>• All necessary off-site facilities, materials, and services are available within the region.<br>• UIC permits would need to be obtained prior to injection activities.<br>• An access agreement with WSDOT would be required to perform injection activities on WSDOT property.<br>• Monitoring requirements include performance monitoring during injection and extraction and long-term groundwater monitoring following implementation.<br>• ICs and a soil management plan would be developed for contamination remaining on Port property.<br>• This alternative would not impede current or future property use or preclude potential future remedial action. However, this alternative could impact future redevelopment activities on the Port property if excavation or dewatering is required. | • Alternative 3 is the second largest in scale. In situ injection is a somewhat specialized construction element; however, many licensed drillers in the region are qualified to safely perform this work. This alternative can be implemented in a single construction season but would require coordination with Port activities along the rail lines.<br>• All necessary off-site facilities, materials, and services are available within the region.<br>• UIC permits would need to be obtained prior to injection activities.<br>• An access agreement with WSDOT would be required to perform injection activities on their property.<br>• Monitoring requirements include performance monitoring during injection and extraction activities and long-term groundwater monitoring following implementation.<br>• ICs and a soil management plan would be developed for remaining contamination on Port property.<br>• This alternative has the potential to cause minimal disruption to existing Site operations but would not impede current property as heavy industrial use. This alternative would not preclude potential future management of impacted soil during Port operations. | • Alternative 4 incorporates the greatest number of technologies and has the highest degree of technical complexity. Excavation with shoring and dewatering is a technically challenging, yet common technology that can be safely implemented by contractors in the region. In situ injection is a somewhat specialized construction element; however, many licensed drillers in the region are qualified to safely perform this work. This alternative can be implemented in a single construction season but would require a significant amount of planning for the excavation activities would require and coordination with Port activities along the rail lines.<br>• All necessary off-site facilities, materials, and services are available within the region.<br>• UIC permits would need to be obtained prior to injection activities.<br>• An access agreement with WSDOT would be required to performed injection activities on their property.<br>• Monitoring requirements include protection monitoring for workers during construction; performance monitoring during injection and extraction activities; and long-term groundwater monitoring following implementation.<br>• ICs and a soil management plan would be developed for contamination remaining on Port property.<br>• This alternative has the potential to cause short-term disruption to existing Site operations but would not impede current property use. This alternative would not preclude potential future management of impacted soil during Port operations. | • Alternative 5 is the largest in scale. In situ injection is a somewhat specialized construction element; however, many licensed drillers in the region are qualified to safely perform this work. This alternative can be implemented in a single construction season but would require a significant amount of coordination with Port activities along the rail lines. Use of horizontal injection wells would involve technical and administrative challenges because of the number and density of wells and boring beneath active rail lines.<br>• All necessary off-site facilities, materials, and services are available within the region.<br>• UIC permits would need to be obtained prior to injection activities.<br>• Access agreements with WSDOT and the City of Longview would be required to perform injection activities on their properties.<br>• Monitoring requirements include performance monitoring during injection and extraction activities; and long-term groundwater monitoring following implementation.<br>• ICs and a soil management plan would be developed for contamination remaining on Port property.<br>• Alternative 5 involves work in the City ROW and may require single lane closures of an arterial roadway for some portions of remedy implementation. Minimal lane closures will not affect surrounding businesses or private property.<br>• This alternative has the potential to cause short-term disruption to existing Site operations due to extensive injections in active rail lines but would not impede current property use. This alternative would not preclude potential future management of impacted soil during Port operations. |

**Table 14.1**
**Disproportionate Cost Analysis Alternative Evaluation**

| Criteria | Alternative 1<br>LNAPL Removal and MNA | Alternative 2<br>In Situ Treatment Barrier and LNAPL Removal | Alternative 3<br>Targeted ISCO Injections and LNAPL Removal | Alternative 4<br>Limited Excavation, Targeted ISCO Injections, and LNAPL Removal | Alternative 5<br>Plume-wide ISCO Injections and LNAPL Removal |
|---|---|---|---|---|---|
| **Consideration of Public Concerns**<br>• Whether the community has concerns<br>• Degree to which the alternative addresses those concerns<br>**Consideration of Public Concerns Benefit Scoring by Alternative**<br>  <br> | • Disturbance to Port operations and traffic impacts are also expected to be of concern to the Port and the public. Alternative 1 does not impact Port operations and does not require lane closures on arterial roads.<br>• Alternative 1 is expected to elicit the highest amount of public concern because it does not include source area removal or treatment.<br>• Public concerns will be reviewed following the public comment period and will be addressed as part of the final remedial alternative selection and design. | • Alternative 2 addresses potential public concerns regarding contaminated groundwater impacts to private and City of Longview properties with targeted groundwater treatment of off-property impacts and a PetroFix barrier to minimize the risk of off-site migration of contamination.<br>• Alternative 2 does not impact Port operations and does not require lane closures on arterial roads.<br>• Public concerns will be reviewed following the public comment period and will be addressed as part of the final remedial alternative selection and design. | • Alternative 3 addresses potential public concerns regarding contaminated groundwater impacts to private and City of Longview properties with targeted groundwater treatment of off-property impacts.<br>• Possible minor disturbances to Port operations are expected to be of concern to the Port and the public. Alternative 3 does not require lane closures or traffic controls.<br>• Public concerns will be reviewed following the public comment period and will be addressed as part of the final remedial alternative selection and design. | • Alternative 4 addresses potential public concerns regarding contaminated groundwater impacts to private and City of Longview properties with targeted groundwater treatment of off-property impacts.<br>• Possible disturbances to Port operations are expected to be of concern to the Port and the public. Alternative 4 does not require lane closures or traffic controls. However, Alternative 4 may elicit public concern due to the significant number of truck trips (and CO2 emissions) associated with the handling and disposal of contaminated soil.<br>• Public concerns will be reviewed following the public comment period and will be addressed as part of the final remedial alternative selection and design. | • Alternative 5 addresses potential public concerns regarding contaminated groundwater impacts to private and City of Longview properties with targeted groundwater treatment of off-property impacts and extensive source treatment on Port property.<br>• Disturbances to Port operations are expected to be of concern to the Port and the public. Alternative 5 involves work in the City of Longview ROW and may require single lane closures of an arterial roadway for some portions of remedy implementation. This would also be expected to apply if horizontal injection wells were used. Lane closures are not anticipated to impact nearby businesses.<br>• Public concerns will be reviewed following the public comment period and will be addressed as part of the final remedial alternative selection and design. |
| **Cost** [(1)]<br>• Cost of construction and permitting<br>• Long-term monitoring and closure costs, including maintenance/contingency injections<br>• Sales tax and 25% contingency on direct construction costs and 20% contingency on indirect construction costs<br>• Agency oversight costs | • Total cost: $1,600,000 | • Total cost: $4,200,000<br>• Includes two maintenance injection events | • Total cost: $4,200,000<br>• Includes one contingency injection event | • Total cost: $10,200,000 | • Total cost: $8,300,000<br>• Includes one contingency injection event |

Note:
1 Long-term monitoring costs are adjusted for Net Present Value using a discount rate of 5%.

Abbreviations:

| | | | | | |
|---|---|---|---|---|---|
| bgs | Below ground surface | ISCO | In situ chemical oxidation | Port | Port of Longview |
| BMP | Best management practice | LNAPL | Light non-aqueous phase liquid | PPE | Personal protective equipment |
| CAA | Cleanup Action Area | mg/L | Milligrams per liter | RAO | Remedial action objective |
| CUL | Cleanup level | MNA | Monitored Natural Attenuation | TPH | Total petroleum hydrocarbons |
| GWQS | Groundwater Quality Standards | MTCA | Model Toxics Control Act | UIC | Underground Injection Control |
| H&S | Health and safety | O&M | Operations & Maintenance | WAC | Washington Administrative Code |
| IC | Institutional control | ORC-A | Advanced oxygen release compound | WSDOT | Washington Department of Transportation |

**Table 14.2**
**Disproportionate Cost Analysis Summary**

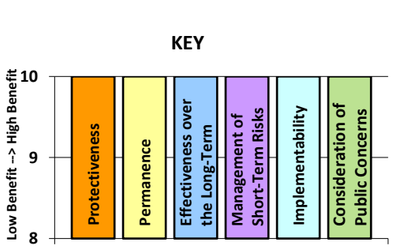
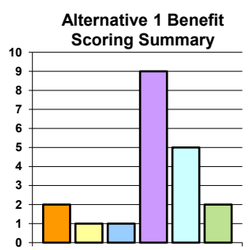
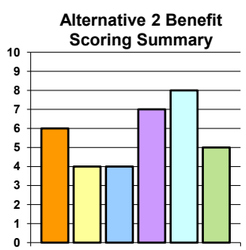
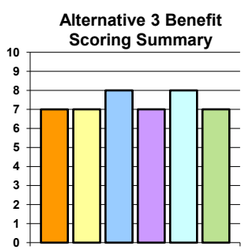
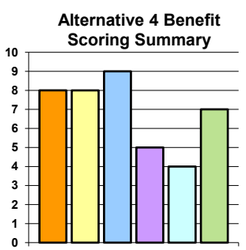
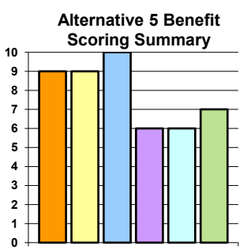
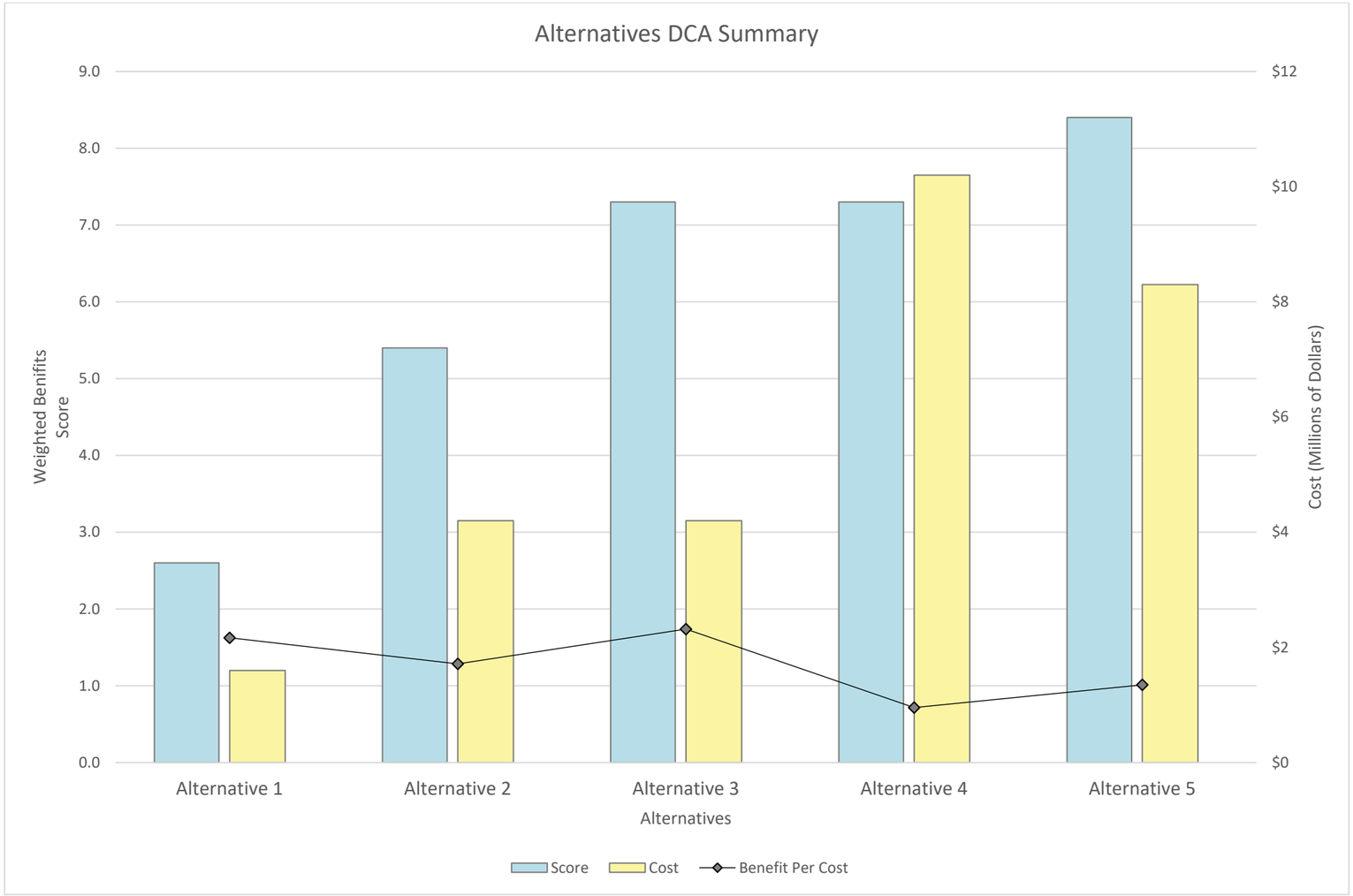
| Alternative | Alternative 1<br>LNAPL Removal and MNA | Alternative 2<br>In Situ Treatment Barrier and LNAPL Removal | Alternative 3<br>Targeted ISCO Injections and LNAPL Removal | Alternative 4<br>Limited Excavation, Targeted ISCO Injections, and LNAPL Removal | Alternative 5<br>Plume-wide ISCO Injections and LNAPL Removal |
|---|---|---|---|---|---|
| **Alternative Description** | Alternative 1 includes:<br>(1) LNAPL removal in MW-09 vicinity<br>(2) Former Longview Pipeline inspection<br>(3) Installation of additional downgradient monitoring wells<br>(4) Long-term monitoring and MNA<br>(5) ICs and SMP | Alternative 2 includes:<br>(1) LNAPL removal in MW-09 vicinity<br>(2) Former Longview Pipeline inspection<br>(3) Installation of additional downgradient monitoring wells<br>(4) In situ PetroFix barrier along northwestern and northern Site boundary (CAA-1) to prevent downgradient migration of groundwater plume<br>(5) ISCO groundwater treatment by injection of PersulfOx to address the downgradient groundwater plume on WSDOT property<br>(6) Long-term monitoring and MNA<br>(7) ICs and SMP | Alternative 3 includes:<br>(1) LNAPL removal in MW-09 vicinity<br>(2) Former Longview Pipeline inspection<br>(3) Installation of additional downgradient monitoring wells<br>(4) Focused ISCO treatment by PersulfOx and RegenOx in CAA-2 (hot spots at concentrations greater than RELs) and CAA-1 (areas with soil concentrations greater than MTCA Method A) of the rail tracks to remediate contaminated soil and groundwater<br>(5) ISCO groundwater treatment by injection of PersulfOx to address the downgradient groundwater plume on WSDOT property<br>(6) Long-term monitoring and MNA<br>(7) ICs and SMP | Alternative 4 includes:<br>(1) LNAPL removal in MW-09 vicinity<br>(2) Former Longview Pipeline inspection<br>(3) Installation of additional downgradient monitoring wells<br>(4) Excavation of soil with concentrations greater than MTCA Method A in CAA-1 (approximately 13,000 cubic yards)<br>(5) ISCO treatment by PersulfOx and RegenOx in CAA-2 where soil concentrations exceed RELs<br>(6) ISCO groundwater treatment by injection of PersulfOx to address the downgradient groundwater plume on WSDOT property<br>(7) Long-term monitoring and MNA<br>(8) ICs and SMP | Alternative 5 includes:<br>(1) LNAPL removal in MW-09 vicinity<br>(2) Former Longview Pipeline inspection<br>(3) Installation of additional downgradient monitoring wells<br>(4) Plume-wide injections of PersulfOx and RegenOx in areas of soil and groundwater proposed CUL exceedances in CAA-1, CAA-2, and off-property<br>(5) Long-term monitoring and MNA<br>(6) ICs and SMP |
|  |  |  |  |  |  |
| Complies with MTCA Threshold Requirements | Yes | Yes | Yes | Yes | Yes |
| Restoration Time Frame (to achieve proposed CULs in groundwater at the Port property boundary) | 30 years | 5 to 10 years | 5 to 10 years | 5 to 10 years | 5 to 10 years |
| Protectiveness (30%) | 2 | 6 | 7 | 8 | 9 |
| Permanence (20%) | 1 | 4 | 7 | 8 | 9 |
| Effectiveness over the Long Term (20%) | 1 | 4 | 8 | 9 | 10 |
| Management of Short-Term Risks (10%) | 9 | 7 | 7 | 5 | 6 |
| Technical and Administrative Implementability (10%) | 5 | 8 | 8 | 4 | 6 |
| Consideration of Public Concerns (10%) [1] | 2 | 5 | 7 | 6 | 7 |
| **Total Weighted Benefit Score (Relative Benefit Ranking)** | **2.6** | **5.4** | **7.3** | **7.3** | **8.4** |
| Estimated Total Alternative Cost [2] | $1.6 million | $4.2 million | $4.2 million | $10.2 million | $8.3 million |
| **Benefit per Unit Cost Ratio [3]** | **1.63** | **1.29** | **1.74** | **0.72** | **1.01** |
| Costs Disproportionate to Incremental Benefits | No | No | No | No | No |
| **Overall Alternative Ranking** | **2** | **3** | **1** | **5** | **4** |

**Table 14.2**
**Disproportionate Cost Analysis Summary**




Notes:

1 Scores for Consideration of Public Concerns are pending public comment but expected to remain similar to initial rankings.
2 Specific cost estimate information is provided in Appendix I.
3 Benefit per Unit Cost Ratio calculated by dividing the Total Weighted Benefit Score by the Estimated Total Alternative Cost; for this calculation, cost was standardized by dividing by 1 million. Higher value indicates the most benefit per unit cost.

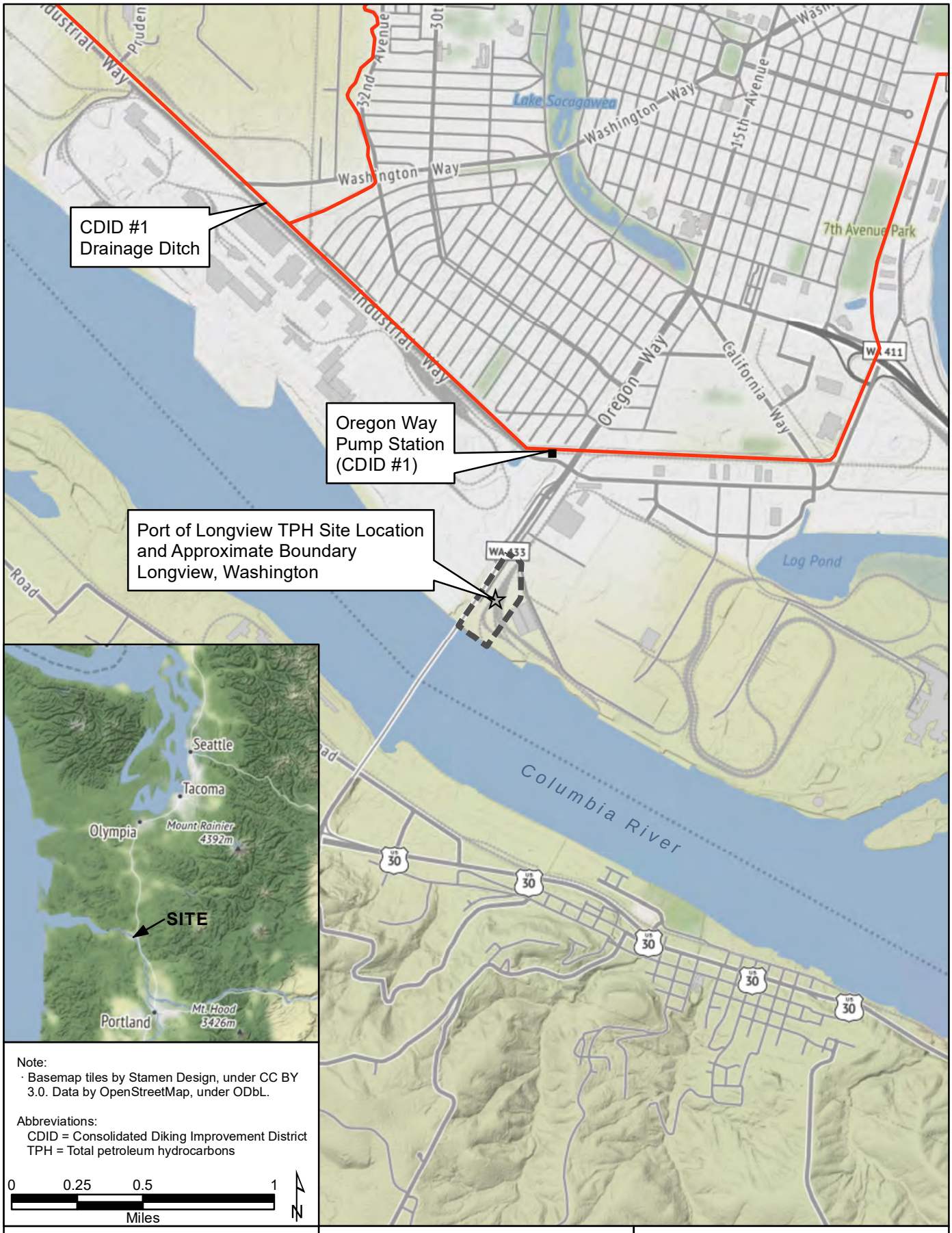
Abbreviations:

CAA Cleanup Action Area
CUL Cleanup level
DCA Disproportionate cost analysis
IC Institutional control
LNAPL Light non aqueous phase liquid
MNA Monitored natural attenuation
MTCA Model Toxics Control Act
REL Remediation level
SMP Soil Management Plan
WSDOT Washington State Department of Transportation

# Remedial Investigation/Feasibility Study

Port of Longview TPH Site

## Figures




Note:
· Basemap tiles by Stamen Design, under CC BY 3.0. Data by OpenStreetMap, under ODbL.

Abbreviations:
CDID = Consolidated Diking Improvement District
TPH = Total petroleum hydrocarbons

0 0.25 0.5 1
Miles

N

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**Longview, Washington**

Figure 1.1
Vicinity Map

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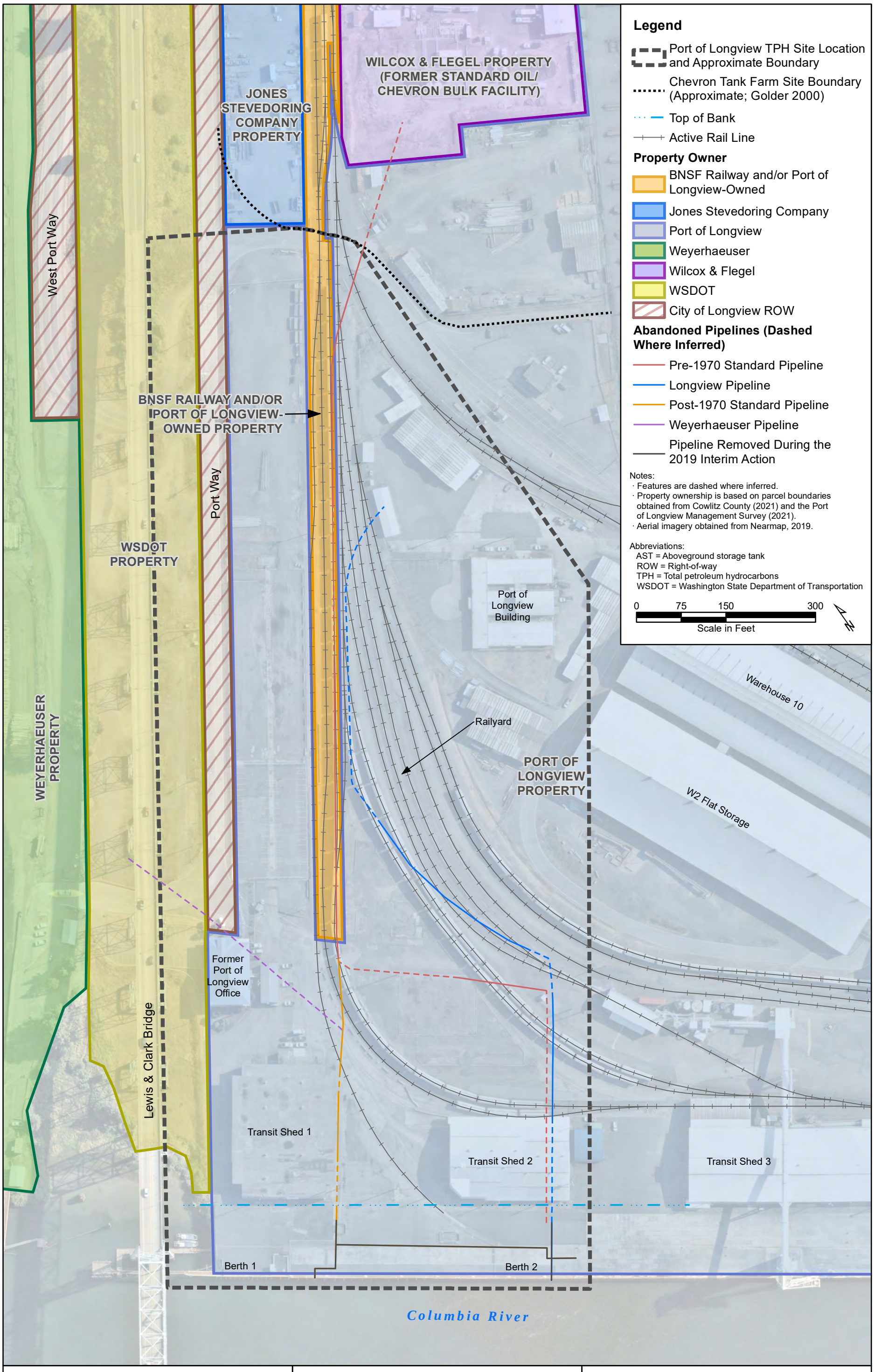


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**Longview, Washington**

Figure 1.2
Site Map and Vicinity Property Ownership

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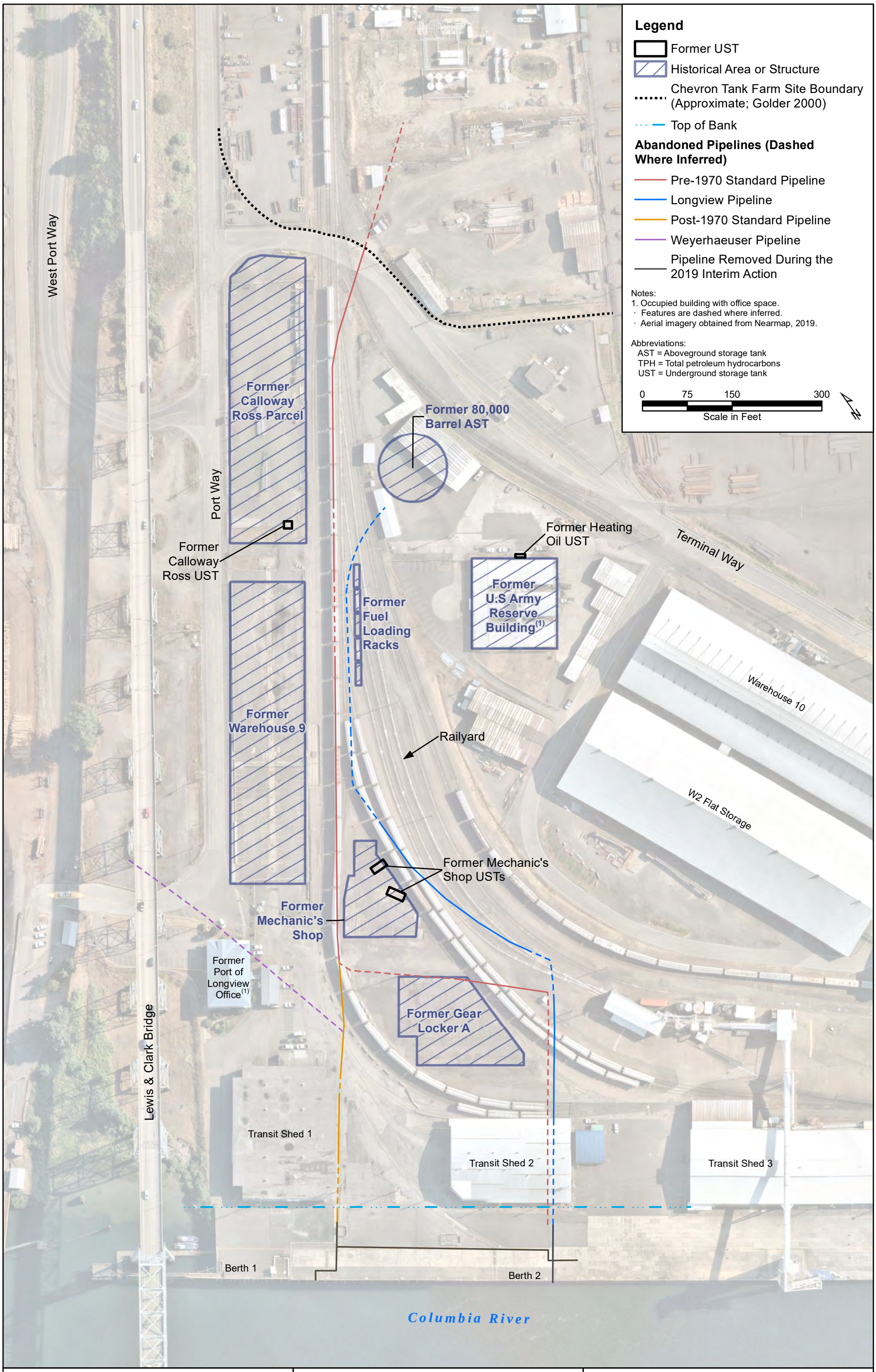
6/11/2023

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**Port of Longview TPH Site**
**Longview, Washington**

Figure 2.1
Historical Site Features

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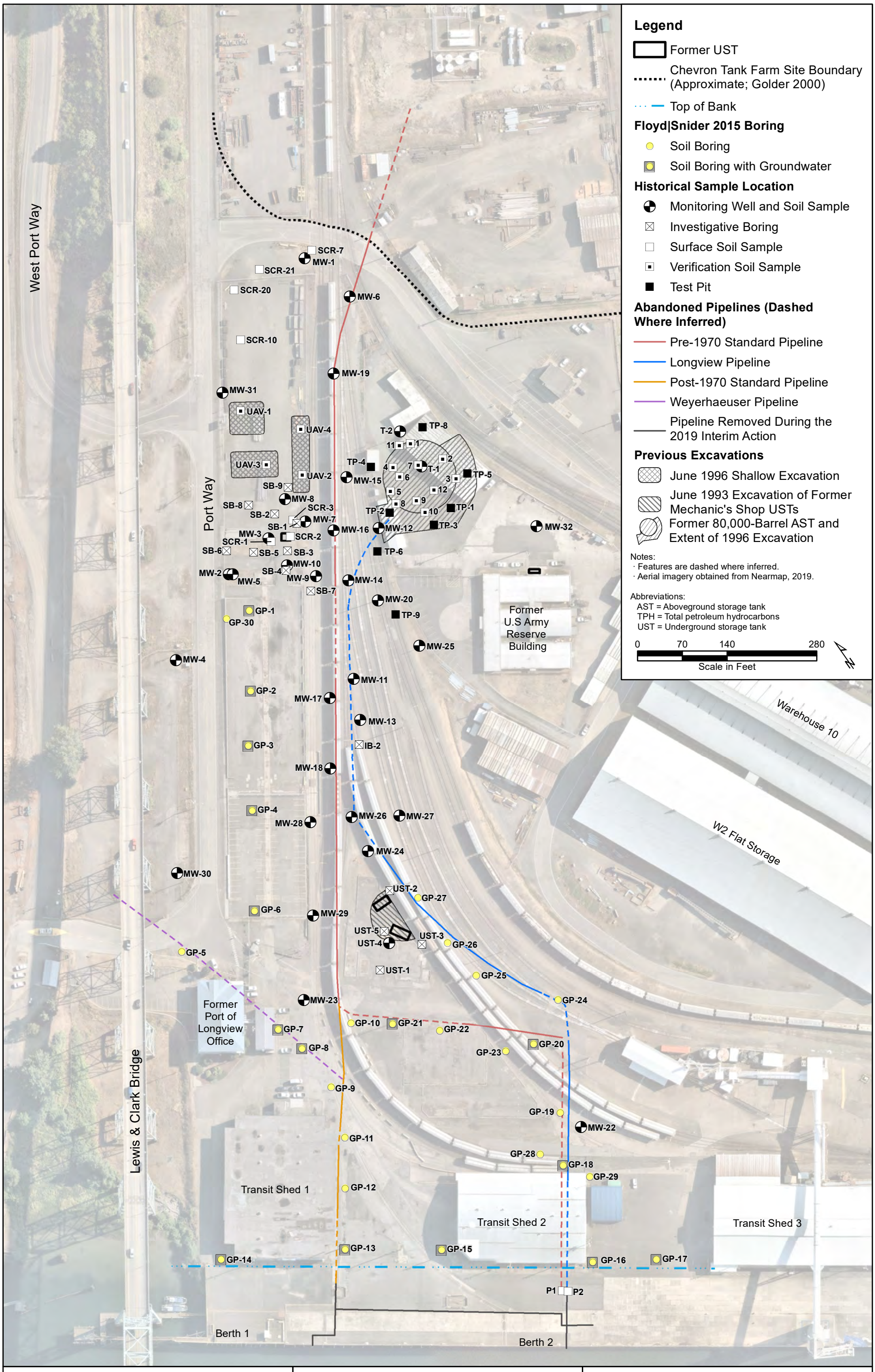


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**Longview, Washington**

Figure 2.2
Historical and 2015 Sample Locations

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6/11/2023

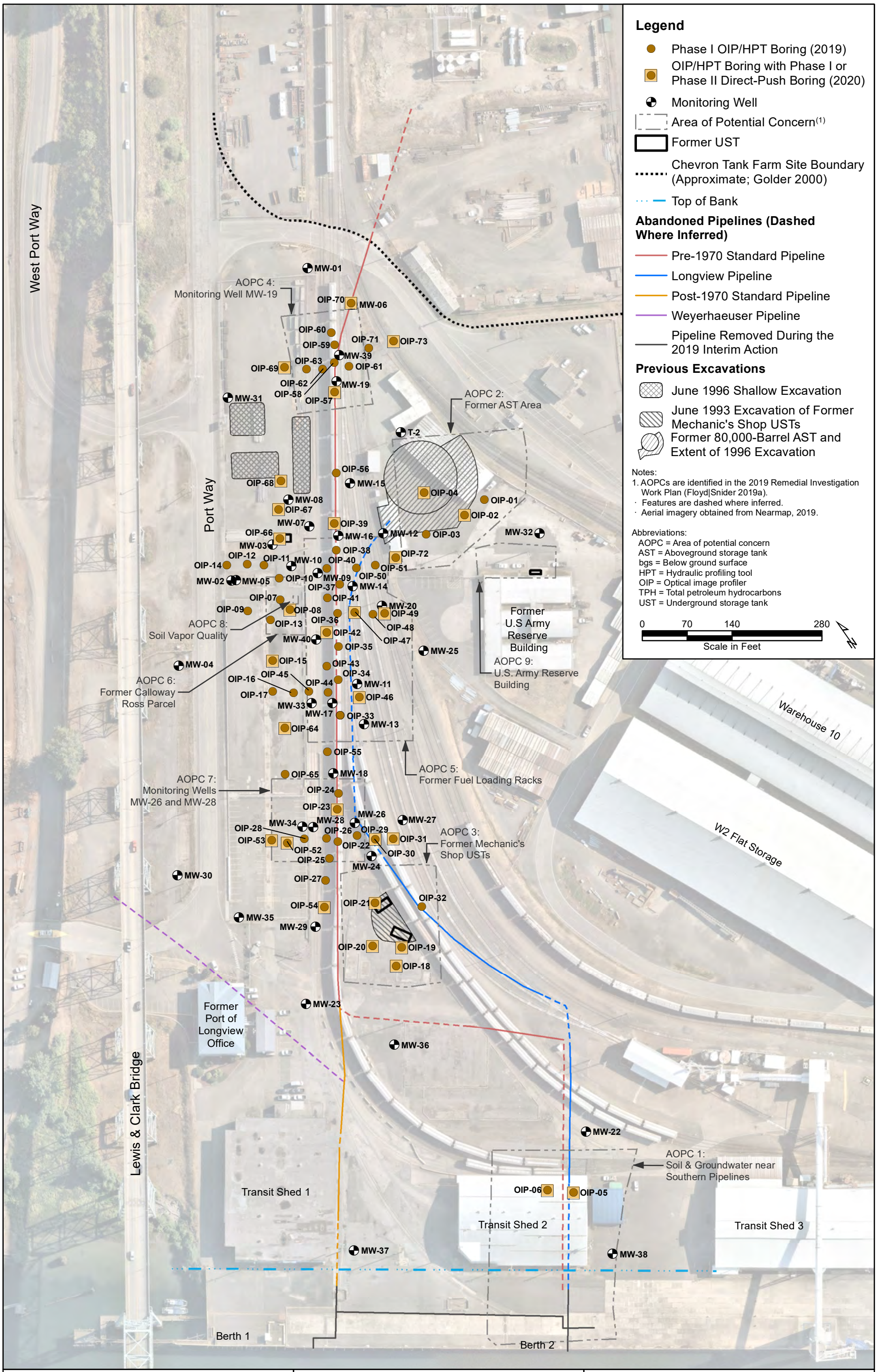


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Figure 3.1
Phase I OIP/HPT Boring Locations

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6/11/2023

## Legend

- 2015 Floyd|Snider Direct Push Location
- Phase I and Phase II Direct Push Location (2020)
- Vapor Pin (2020)
- Monitoring Well
- A — A' Cross-Section Location
- Former UST
- Chevron Tank Farm Site Boundary (Approximate; Golder 2000)
- Top of Bank

**Abandoned Pipelines (Dashed Where Inferred)**

- Pre-1970 Standard Pipeline
- Longview Pipeline
- Post-1970 Standard Pipeline
- Weyerhaeuser Pipeline
- Pipeline Removed During the 2019 Interim Action

**Previous Excavations**

- June 1996 Shallow Excavation
- June 1993 Excavation of Former Mechanic's Shop USTs
- Former 80,000-Barrel AST and Extent of 1996 Excavation

Notes:
· Features are dashed where inferred.
· Aerial imagery obtained from Nearmap, 2019.

Abbreviations:
AOPC = Area of potential concern
AST = Aboveground storage tank
bgs = Below ground surface
RI = Remedial investigation
TPH = Total petroleum hydrocarbons
UST = Underground storage tank

0 70 140 280
Scale in Feet

West Port Way
Port Way
Lewis & Clark Bridge
NORTHERN PORTION OF THE STANDARD PIPELINES
FORMER CALLOWAY ROSS PARCEL
FORMER 80,000 BARREL AST
FORMER FUEL RACK LOADING AREA
FORMER MECHANIC'S SHOP
SOUTHERN PIPELINES AND BERTHS
Former U.S Army Reserve Building
Former Port of Longview Office
Transit Shed 1
Transit Shed 2
Transit Shed 3
Warehouse 10
W2 Flat Storage
Berth 1
Berth 2
A
A'
B
B'
C
C'
MW-01 MW-02 MW-03 MW-04 MW-05 MW-06 MW-07 MW-08 MW-09 MW-10 MW-11 MW-12 MW-13 MW-14 MW-15 MW-16 MW-17 MW-18 MW-19 MW-20 MW-22 MW-23 MW-24 MW-25 MW-26 MW-27 MW-28 MW-29 MW-30 MW-31 MW-32 MW-33 MW-34 MW-35 MW-36 MW-37 MW-38 MW-39 MW-40
OIP-02 OIP-04 OIP-05 OIP-06 OIP-08 OIP-15 OIP-19 OIP-20 OIP-21 OIP-23 OIP-30 OIP-31 OIP-39 OIP-42 OIP-46 OIP-47 OIP-49 OIP-52 OIP-53 OIP-54 OIP-57 OIP-64 OIP-67 OIP-68 OIP-69 OIP-70 OIP-72 OIP-73
GP-1 GP-2 GP-3 GP-4 GP-5 GP-6 GP-7 GP-8 GP-9 GP-10 GP-11 GP-12 GP-13 GP-14 GP-15 GP-16 GP-17 GP-18 GP-19 GP-20 GP-21 GP-22 GP-23 GP-24 GP-25 GP-26 GP-27 GP-28 GP-29 GP-30 GP-31 GP-32 GP-33 GP-34 GP-35 GP-36 GP-37 GP-38
T-2
VP-1 VP-2
P3 P4 P5 P6

| | | |
|---|---|---|
| FLOYD \| SNIDER strategy • science • engineering | **Remedial Investigation/Feasibility Study Port of Longview TPH Site Longview, Washington** | Figure 3.2 RI Soil Sample and Monitoring Well Locations |

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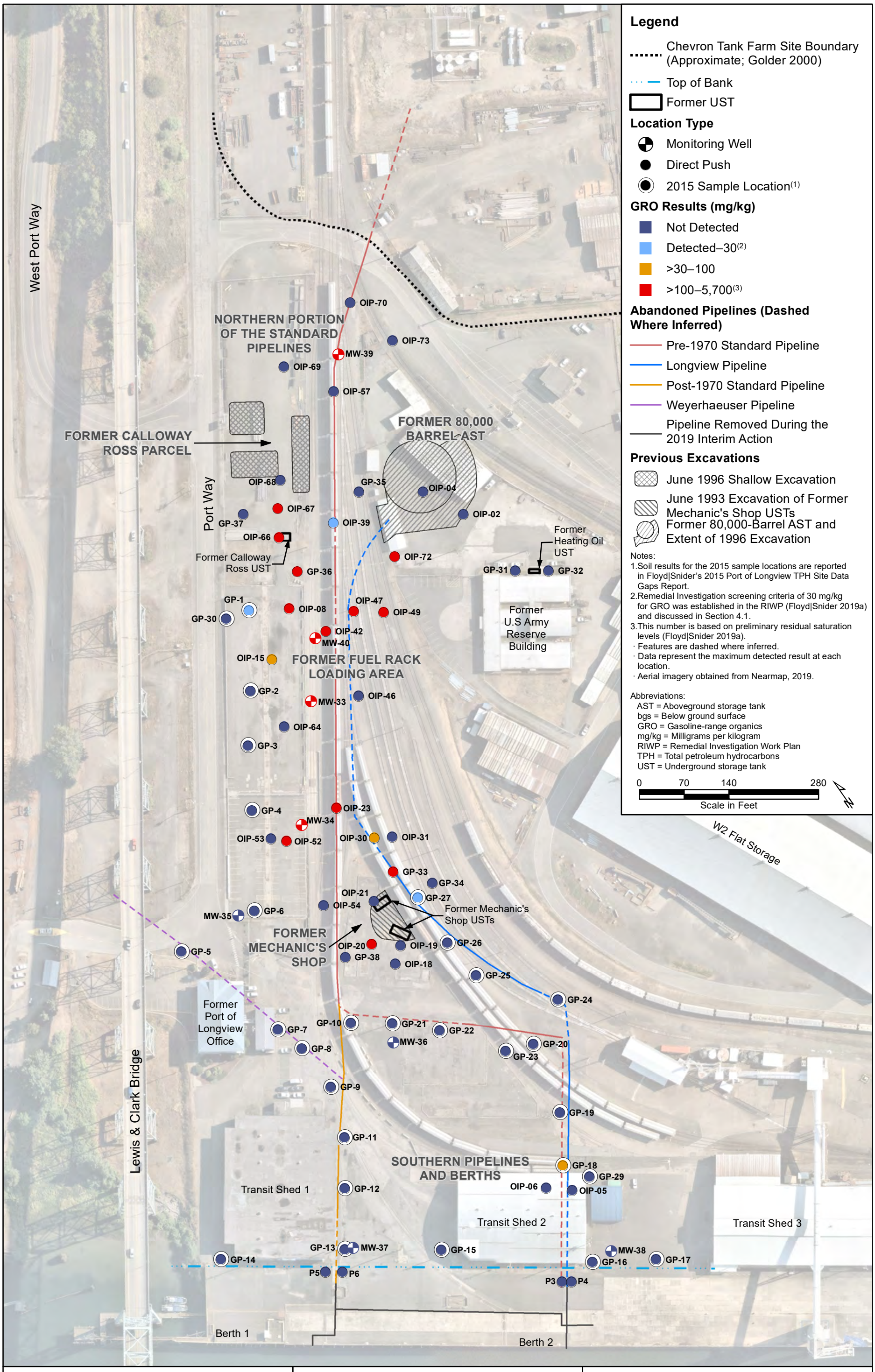
6/11/2023




## Legend

- Chevron Tank Farm Site Boundary (Approximate; Golder 2000)
- Top of Bank
- Former UST

**Location Type**

- Monitoring Well
- Direct Push
- 2015 Sample Location(1)

**GRO Results (mg/kg)**

- Not Detected
- Detected–30(2)
- >30–100
- >100–5,700(3)

**Abandoned Pipelines (Dashed Where Inferred)**

- Pre-1970 Standard Pipeline
- Longview Pipeline
- Post-1970 Standard Pipeline
- Weyerhaeuser Pipeline
- Pipeline Removed During the 2019 Interim Action

**Previous Excavations**

- June 1996 Shallow Excavation
- June 1993 Excavation of Former Mechanic's Shop USTs
- Former 80,000-Barrel AST and Extent of 1996 Excavation

Notes:

1. Soil results for the 2015 sample locations are reported in Floyd|Snider's 2015 Port of Longview TPH Site Data Gaps Report.
2. Remedial Investigation screening criteria of 30 mg/kg for GRO was established in the RIWP (Floyd|Snider 2019a) and discussed in Section 4.1.
3. This number is based on preliminary residual saturation levels (Floyd|Snider 2019a).

· Features are dashed where inferred.
· Data represent the maximum detected result at each location.
· Aerial imagery obtained from Nearmap, 2019.

Abbreviations:
AST = Aboveground storage tank
bgs = Below ground surface
GRO = Gasoline-range organics
mg/kg = Milligrams per kilogram
RIWP = Remedial Investigation Work Plan
TPH = Total petroleum hydrocarbons
UST = Underground storage tank

0 70 140 280
Scale in Feet

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Figure 4.1
Concentrations of Gasoline-Range Organics in Soil

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6/11/2023

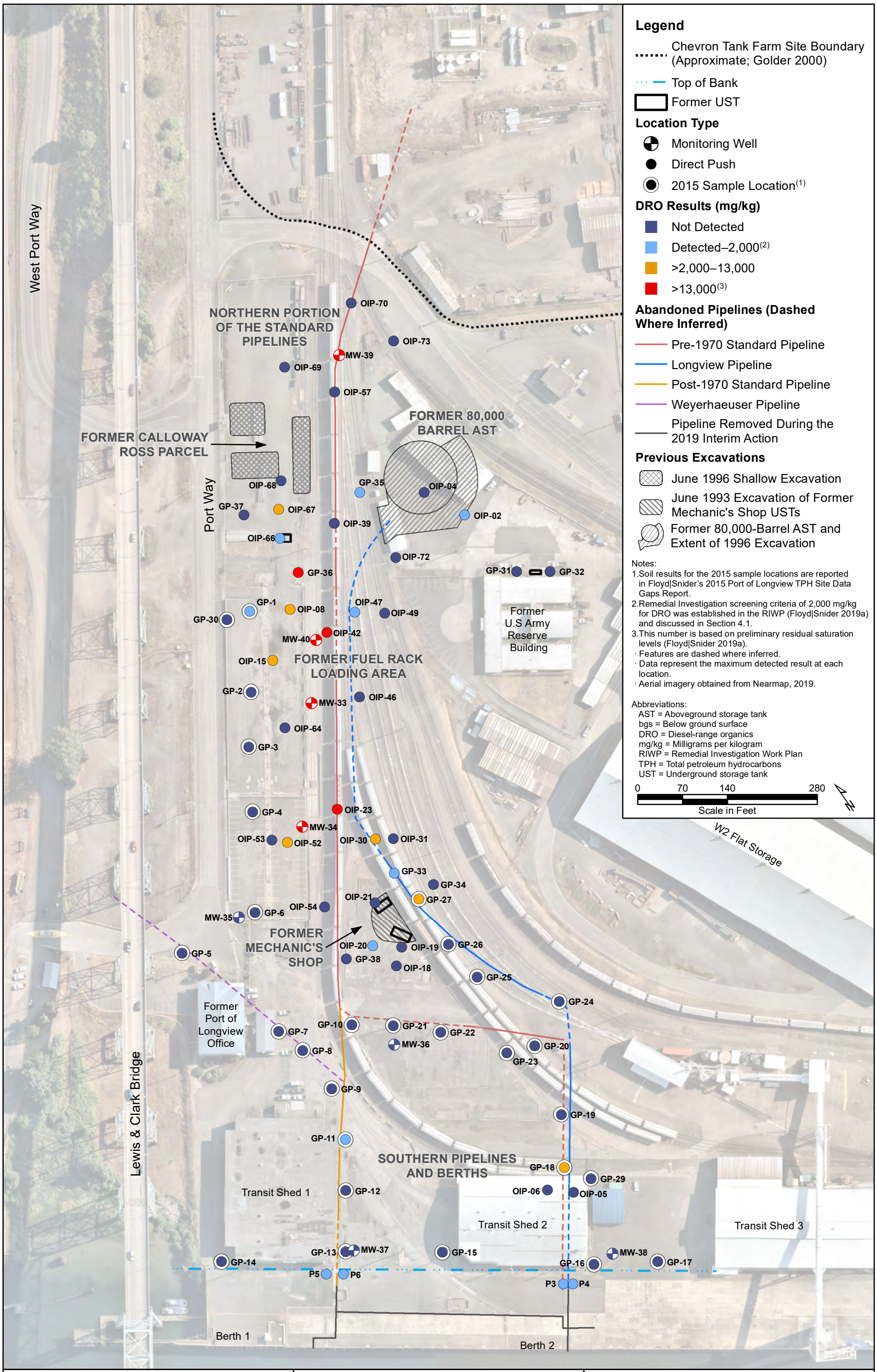


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Figure 4.2
Concentrations of Diesel-Range Organics in Soil

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6/12/2023

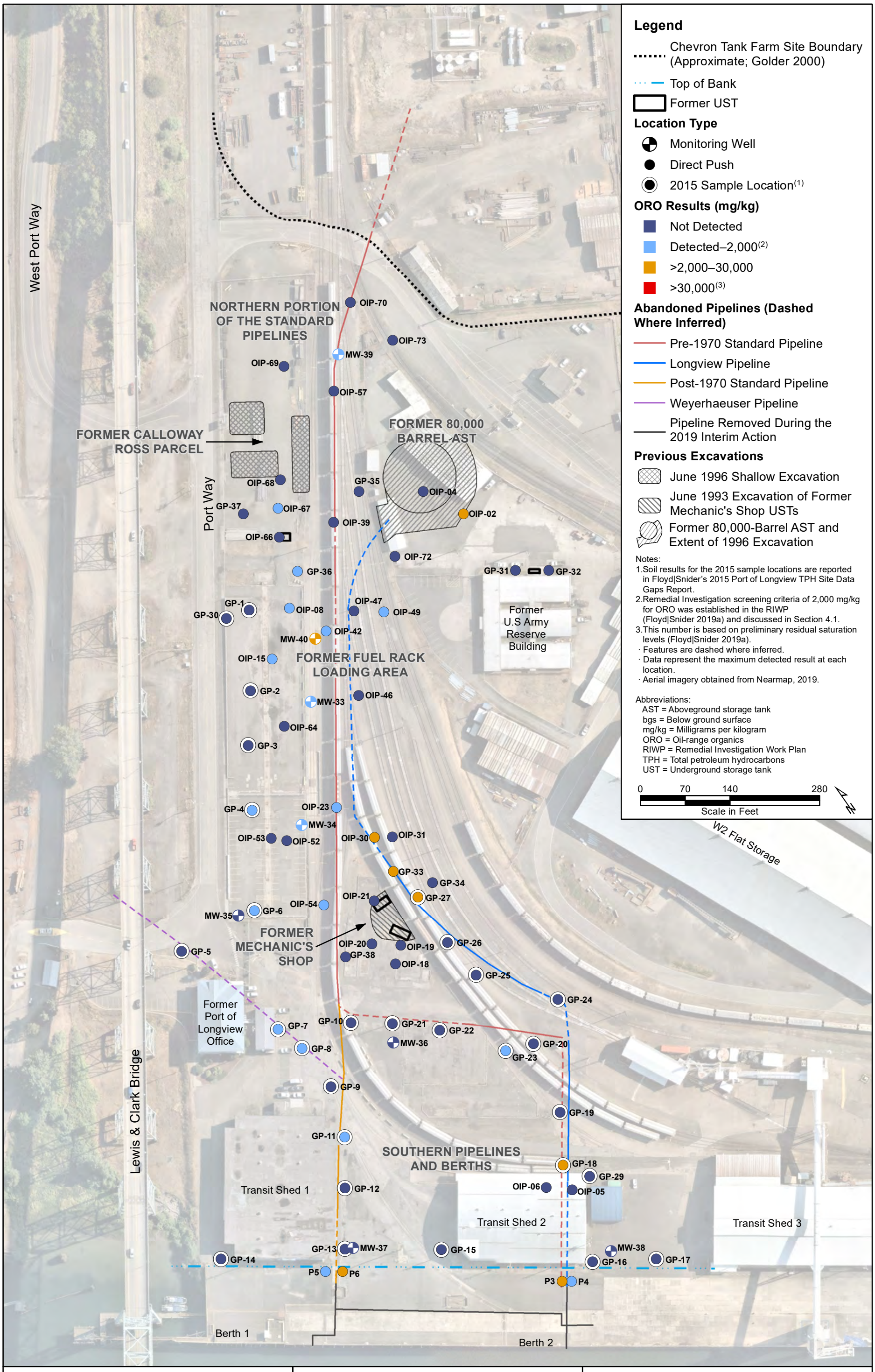


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Figure 4.3
Concentrations of Oil-Range Organics in Soil

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6/12/2023

## Legend

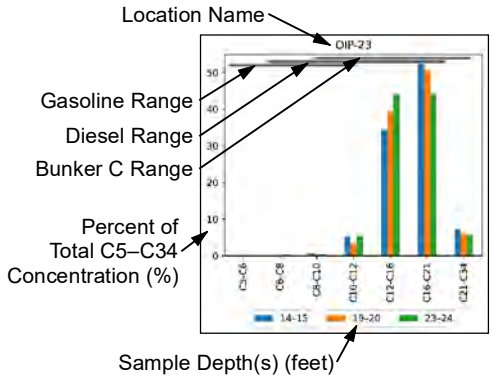
- Geoprobe Location
- Monitoring Well
- Chevron Tank Farm Site Boundary (Approximate; Golder 2000)
- Top of Bank
- Former UST

**Abandoned Pipelines (Dashed Where Inferred)**

- Pre-1970 Standard Pipeline
- Longview Pipeline
- Post-1970 Standard Pipeline
- Weyerhaeuser Pipeline
- Pipeline Removed During the 2019 Interim Action

**Previous Excavations**

- June 1996 Shallow Excavation
- June 1993 Excavation of Former Mechanic's Shop USTs
- Former 80,000-Barrel AST and Extent of 1996 Excavation




Notes:
- Full size EPH/VPH plots for each location are presented in Appendix C.
- Features are dashed where inferred.
- Aerial imagery obtained from Nearmap, 2019.

Abbreviations:
AST = Aboveground storage tank
bgs = Below ground surface
EPH = Extractable petroleum hydrocarbons
TPH = Total petroleum hydrocarbons
UST = Underground storage tank
VPH = Volatile petroleum hydrocarbons

0 62.5 125 250
Scale in Feet

NORTHERN PORTION OF THE STANDARD PIPELINES
FORMER CALLOWAY ROSS PARCEL
FORMER 80,000 BARREL AST
Former U.S Army Reserve Building
FORMER FUEL RACK LOADING AREA
FORMER MECHANIC'S SHOP
SOUTHERN PIPELINES AND BERTHS
Port Way
Lewis & Clark Bridge
W2 Flat Storage
Transit Shed 1
Transit Shed 2
Transit Shed 3
MW-39
OIP-67
OIP-39
OIP-66
GP-36
GP-1
OIP-08
OIP-47
OIP-42
OIP-15
MW-33
OIP-23
OIP-30
GP-27
OIP-20
GP-18

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Figure 4.4
Soil EPH/VPH Results

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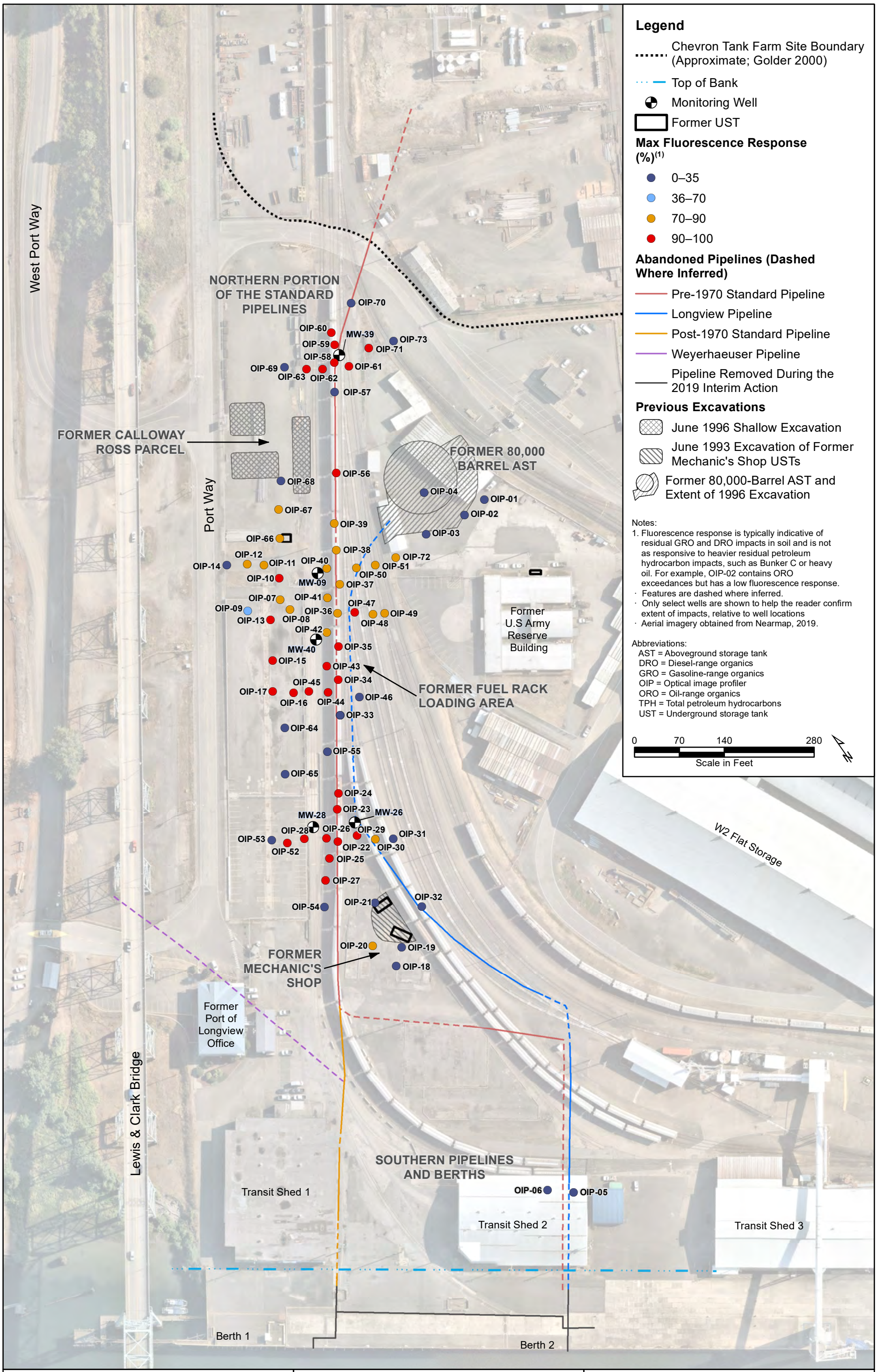
6/11/2023

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**Longview, Washington**

Figure 4.5
OIP Fluorescence Response

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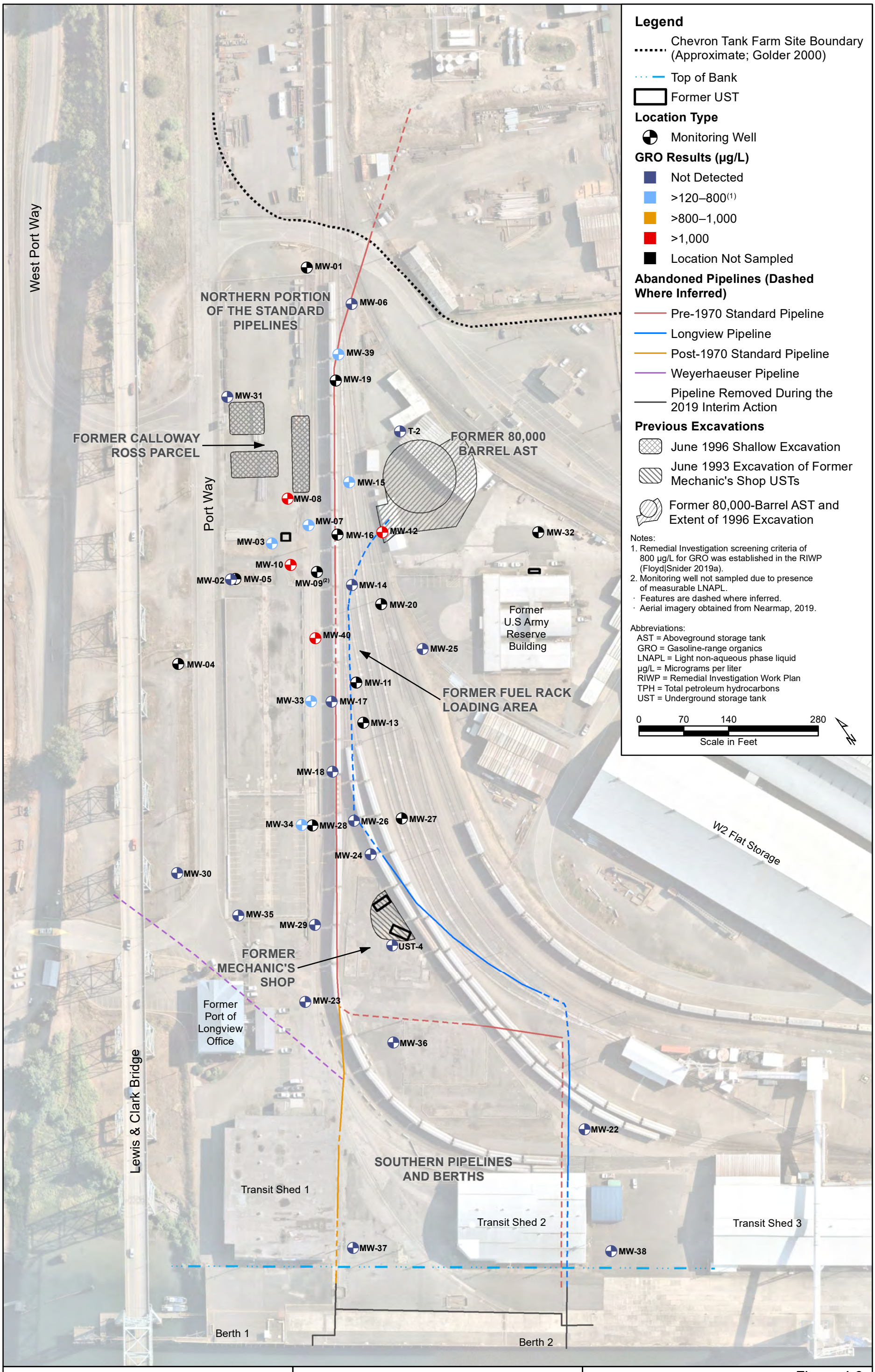


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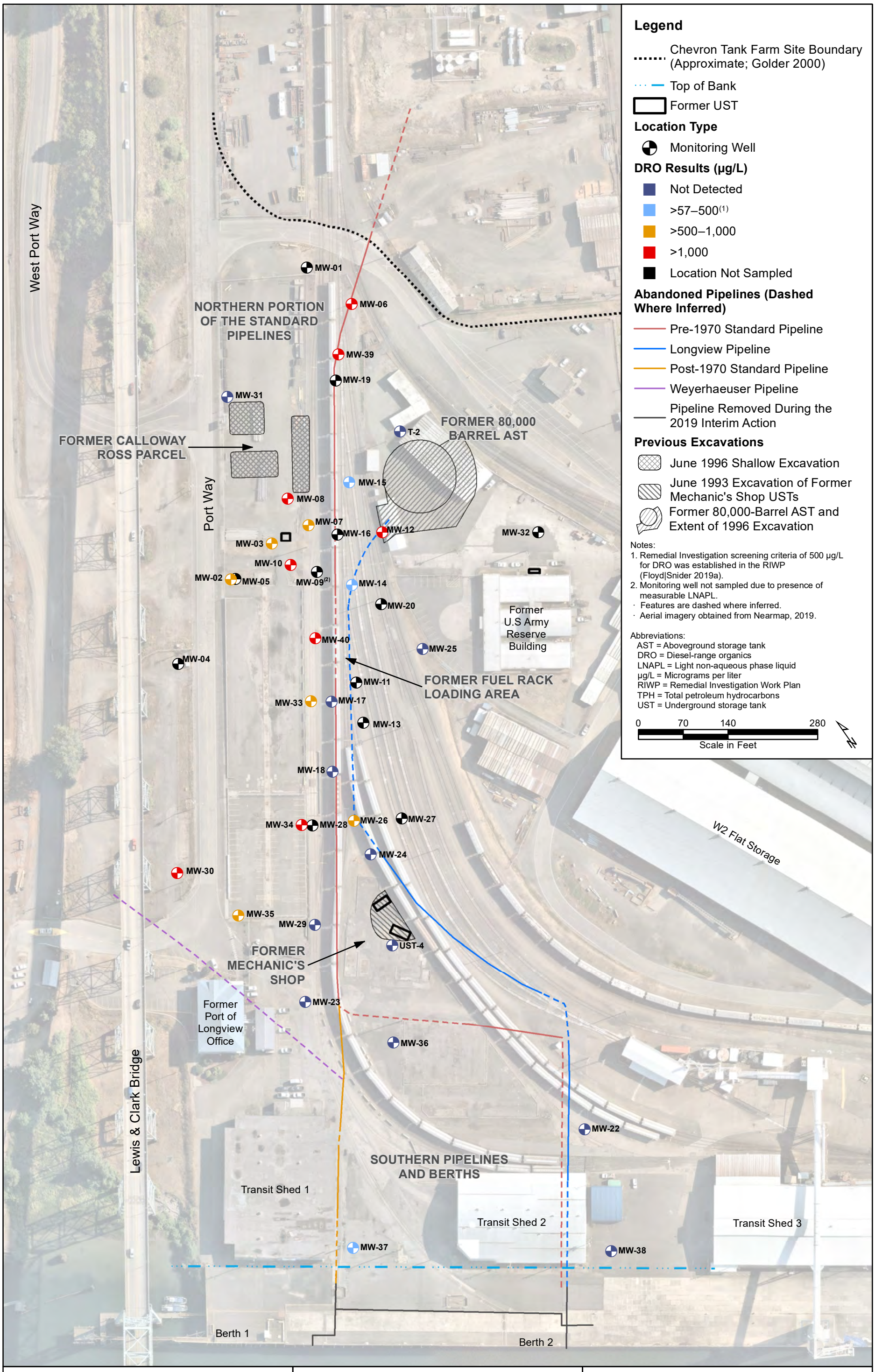
Figure 4.6
November 2020 Concentrations of Gasoline-Range Organics in Groundwater

I:\GIS\Projects\POL-TPH\MXD\RIFS\Figure 4.6 November 2020 Concentrations of Gasoline-Range Organics in Groundwater.mxd
6/11/2023

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**Longview, Washington**

Figure 4.7
November 2020 Concentrations of Diesel-Range Organics in Groundwater

I:\GIS\Projects\POL-TPH\MXD\RIFS\Figure 4.7 November 2020 Concentrations of Diesel-Range Organics in Groundwater.mxd
6/11/2023

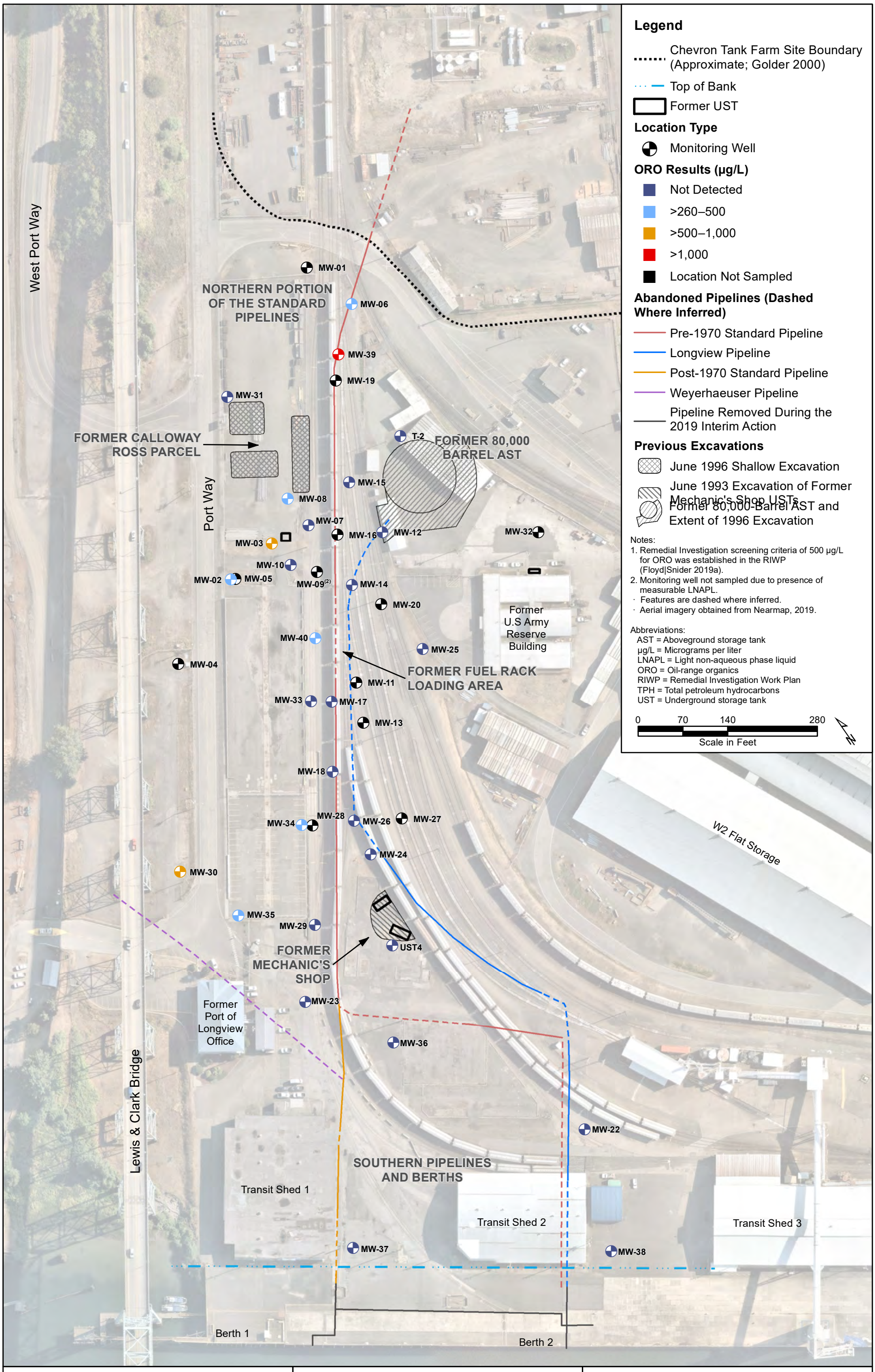


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Figure 4.8
November 2020 Concentrations of Oil-Range Organics in Groundwater

I:\GIS\Projects\POL-TPH\MXD\RIFS\Figure 4.8 November 2020 Concentrations of Oil-Range Organics in Groundwater.mxd
6/11/2023

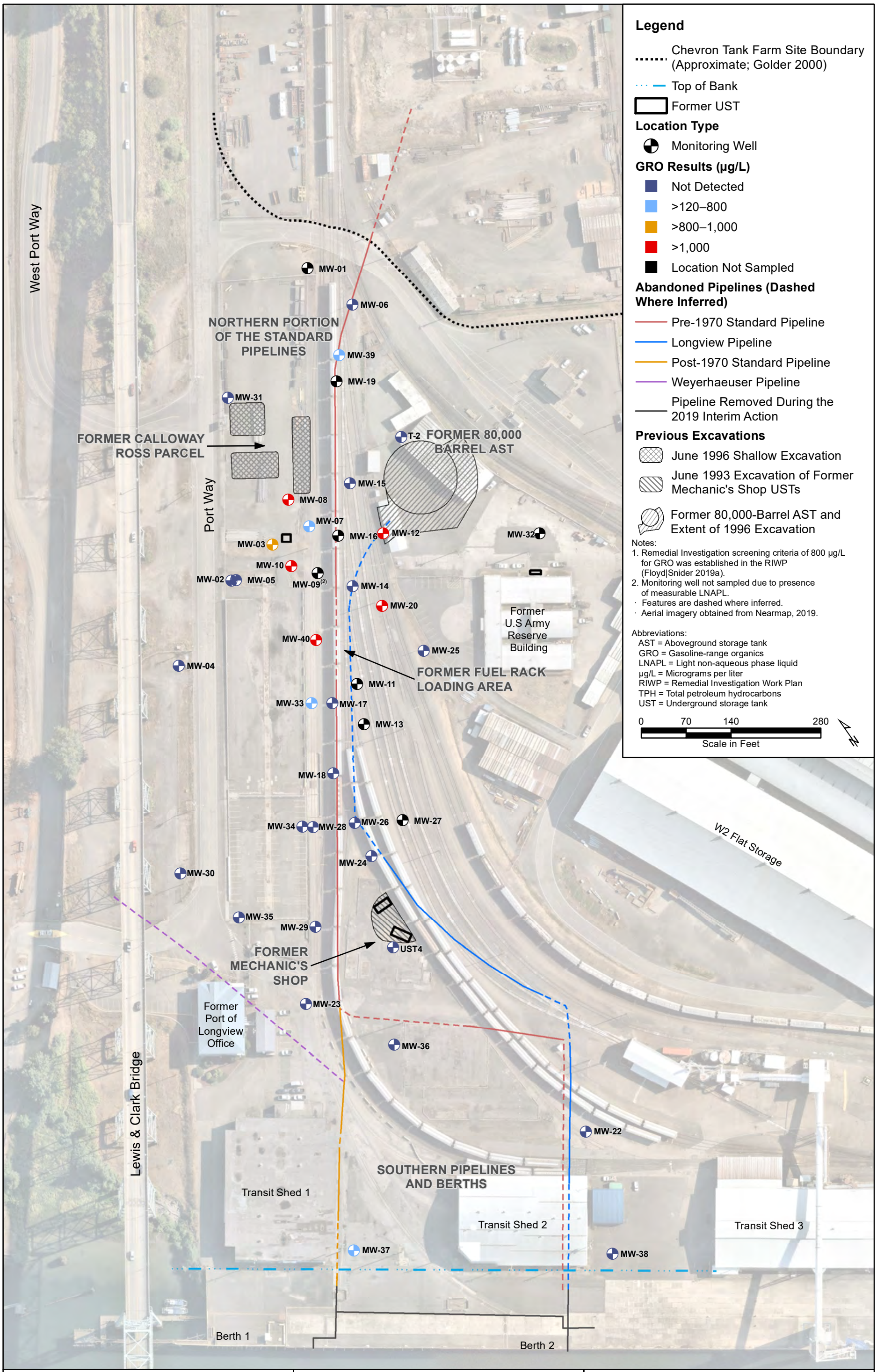


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Figure 4.9
February 2021 Concentrations of Gasoline-Range Organics in Groundwater

I:\GIS\Projects\POL-TPH\MXD\RIFS\Figure 4.9 February 2021 Concentrations of Gasoline-Range Organics in Groundwater.mxd
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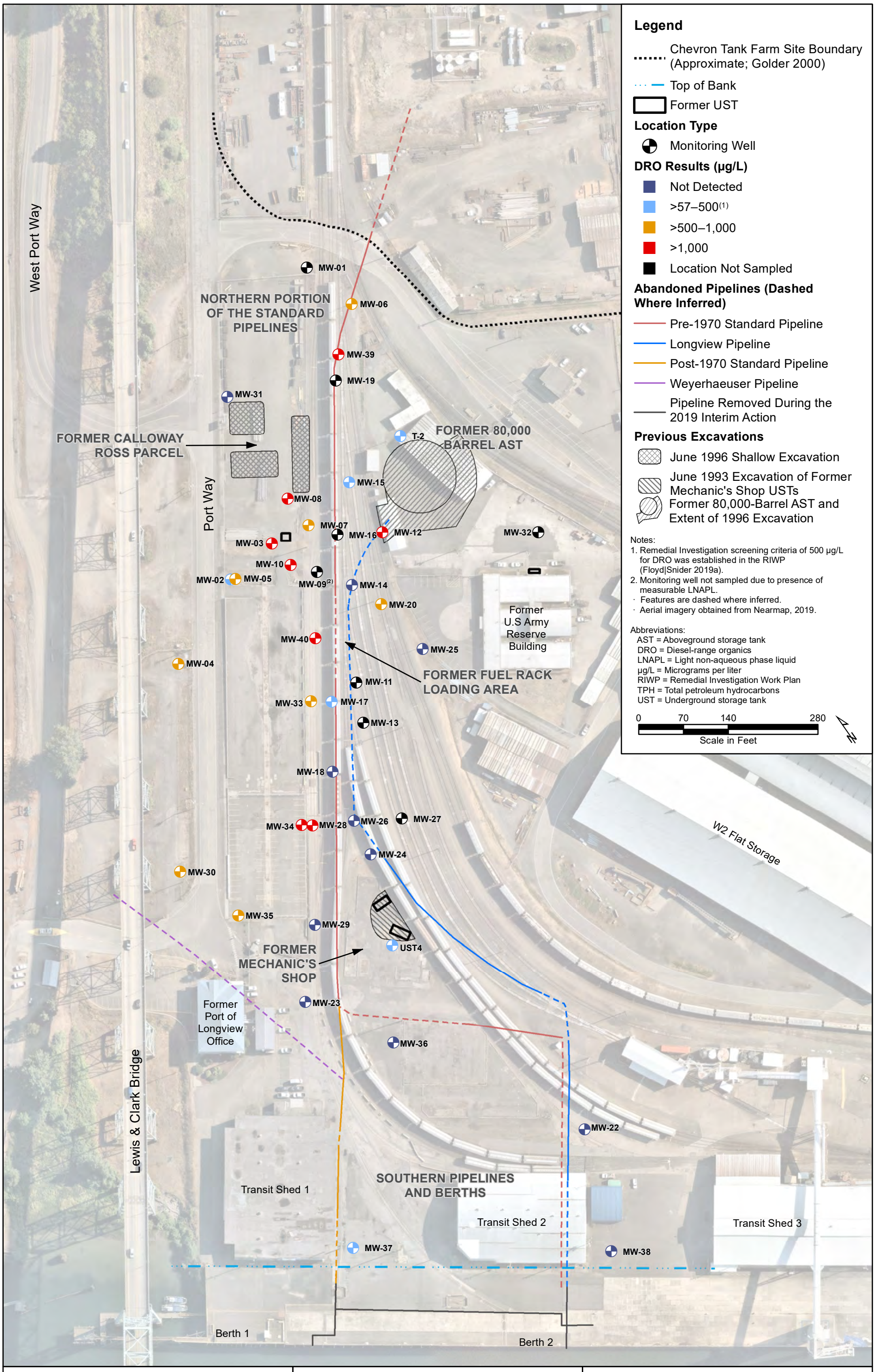


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Figure 4.10
February 2021 Concentrations of Diesel-Range Organics in Groundwater

I:\GIS\Projects\POL-TPH\MXD\RIFS\Figure 4.10 February 2021 Concentrations of Diesel-Range Organics in Groundwater.mxd
6/11/2023

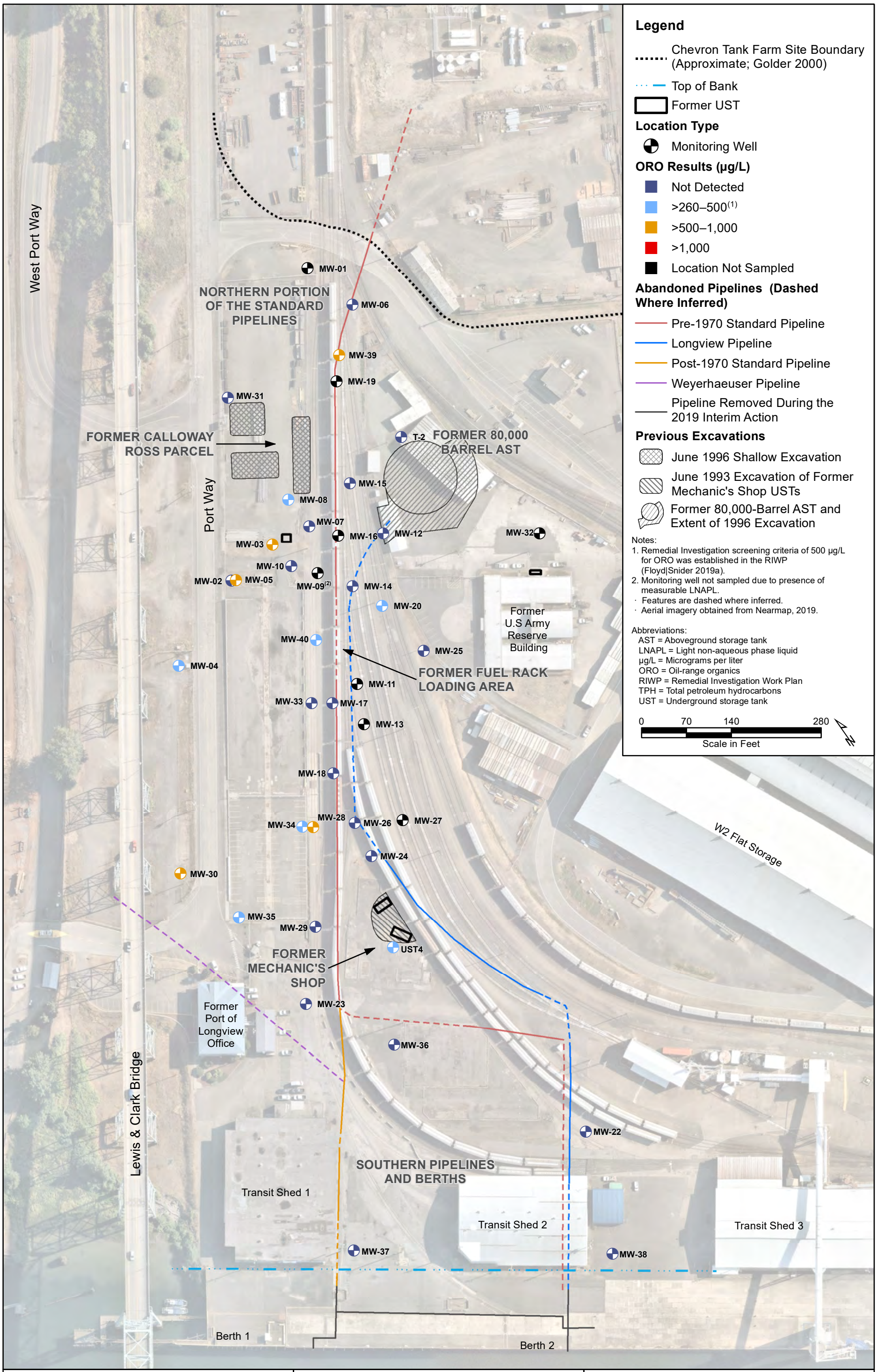


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Figure 4.11
February 2021 Concentrations of Oil-Range Organics in Groundwater

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6/12/2023

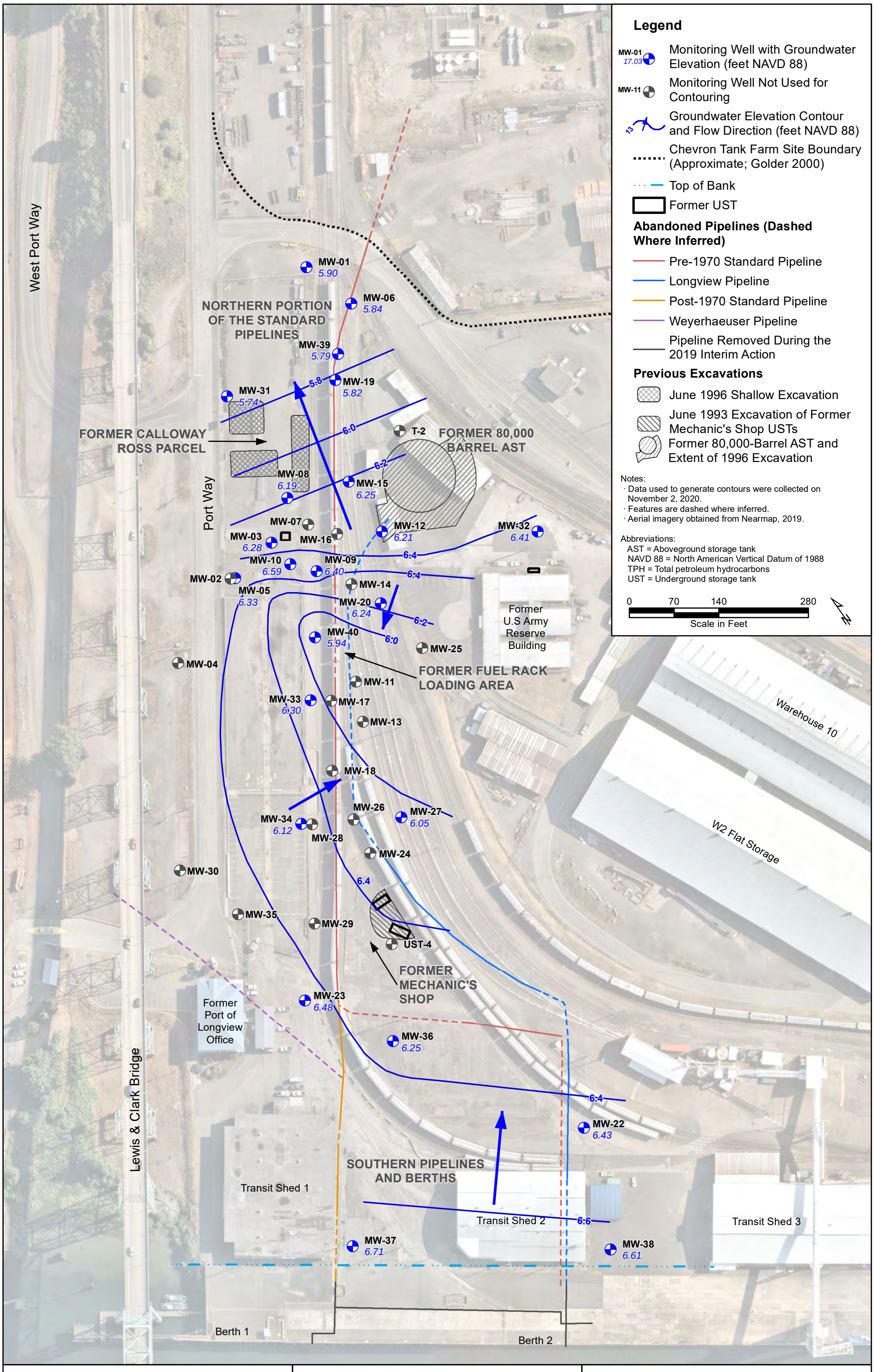


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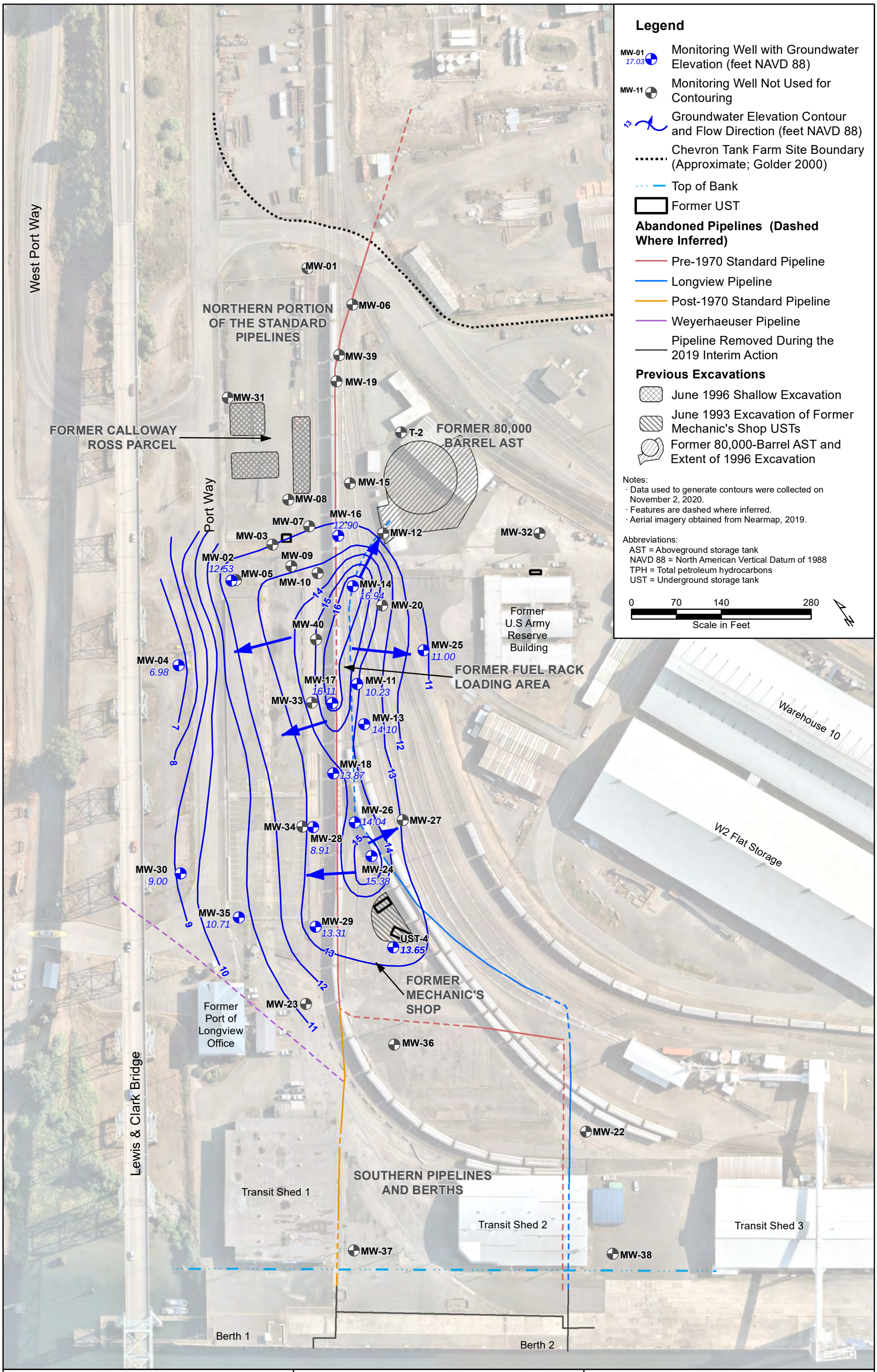
Figure 4.12
November 2020 Groundwater Contours—Alluvial Aquifer

I:\GIS\Projects\POL-TPH\MXD\RIFS\Figure 4.12 Nov 2020 Groundwater Contours - Alluvial Aquifer.mxd
6/11/2023




| | | |
|---|---|---|
| FLOYD \| SNIDER strategy • science • engineering | **Remedial Investigation/Feasibility Study Port of Longview TPH Site Longview, Washington** | Figure 4.13 November 2020 Groundwater Contours—Perched Water-Bearing Zone |

I:\GIS\Projects\POL-TPH\MXD\RIFS\Figure 4.13 Nov 2020 Groundwater Contours - Perched Water-Bearing Zone.mxd
6/11/2023

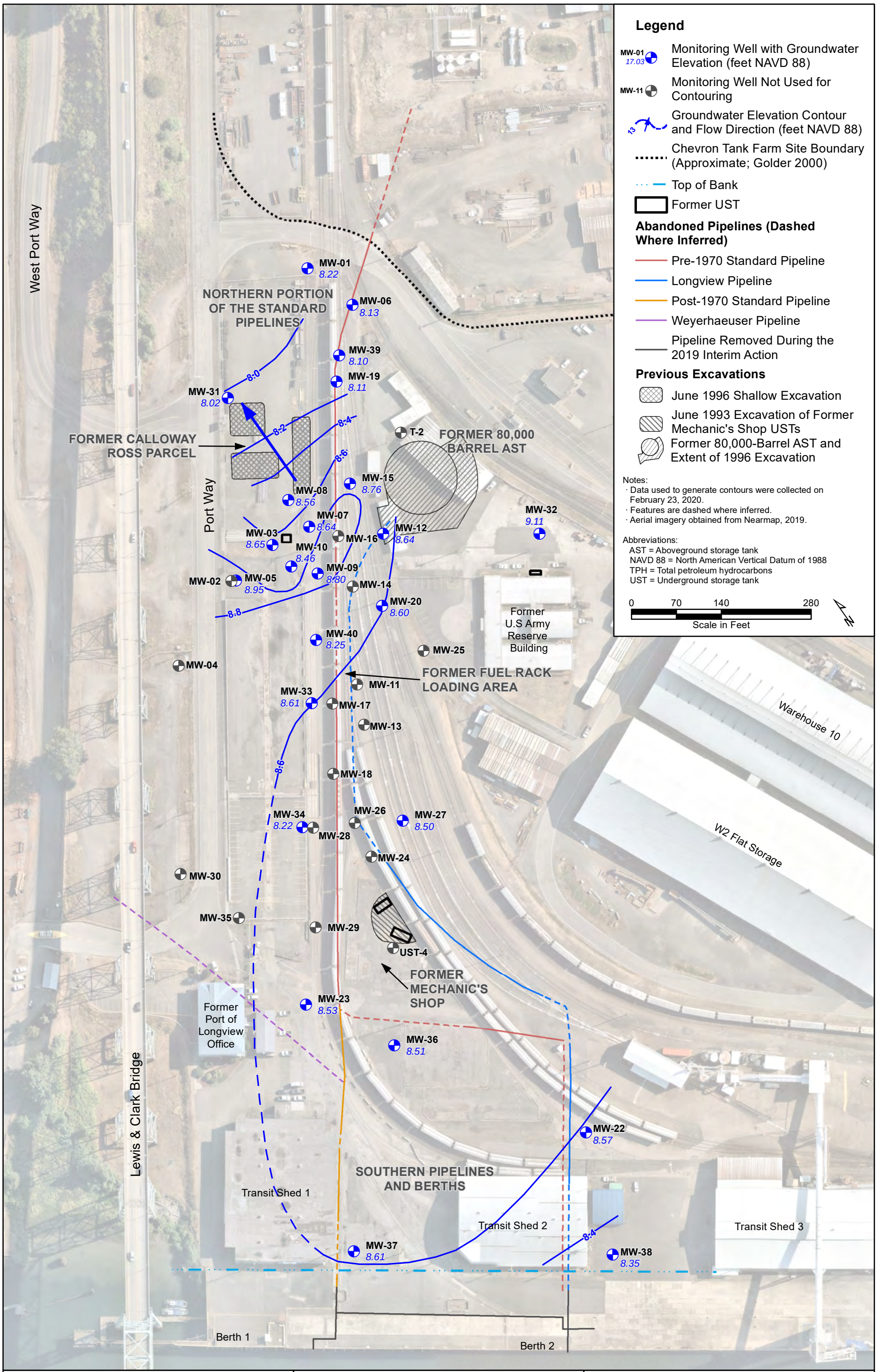



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Figure 4.14
February 2021 Groundwater Contours—
Alluvial Aquifer

I:\GIS\Projects\POL-TPH\MXD\RIFS\Figure 4.14 Feb 2021 Groundwater Contours - Alluvial Aquifer.mxd
6/11/2023

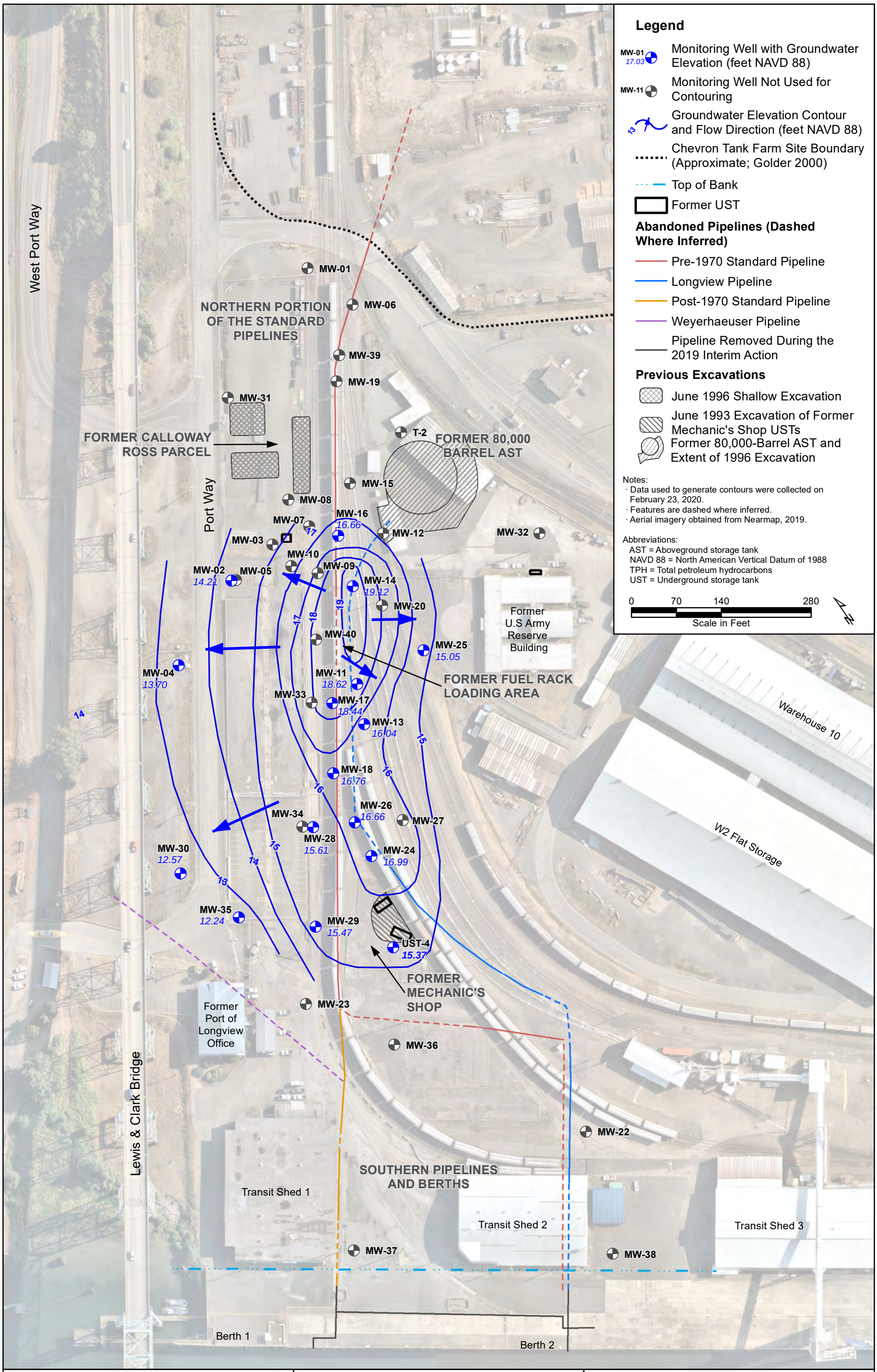


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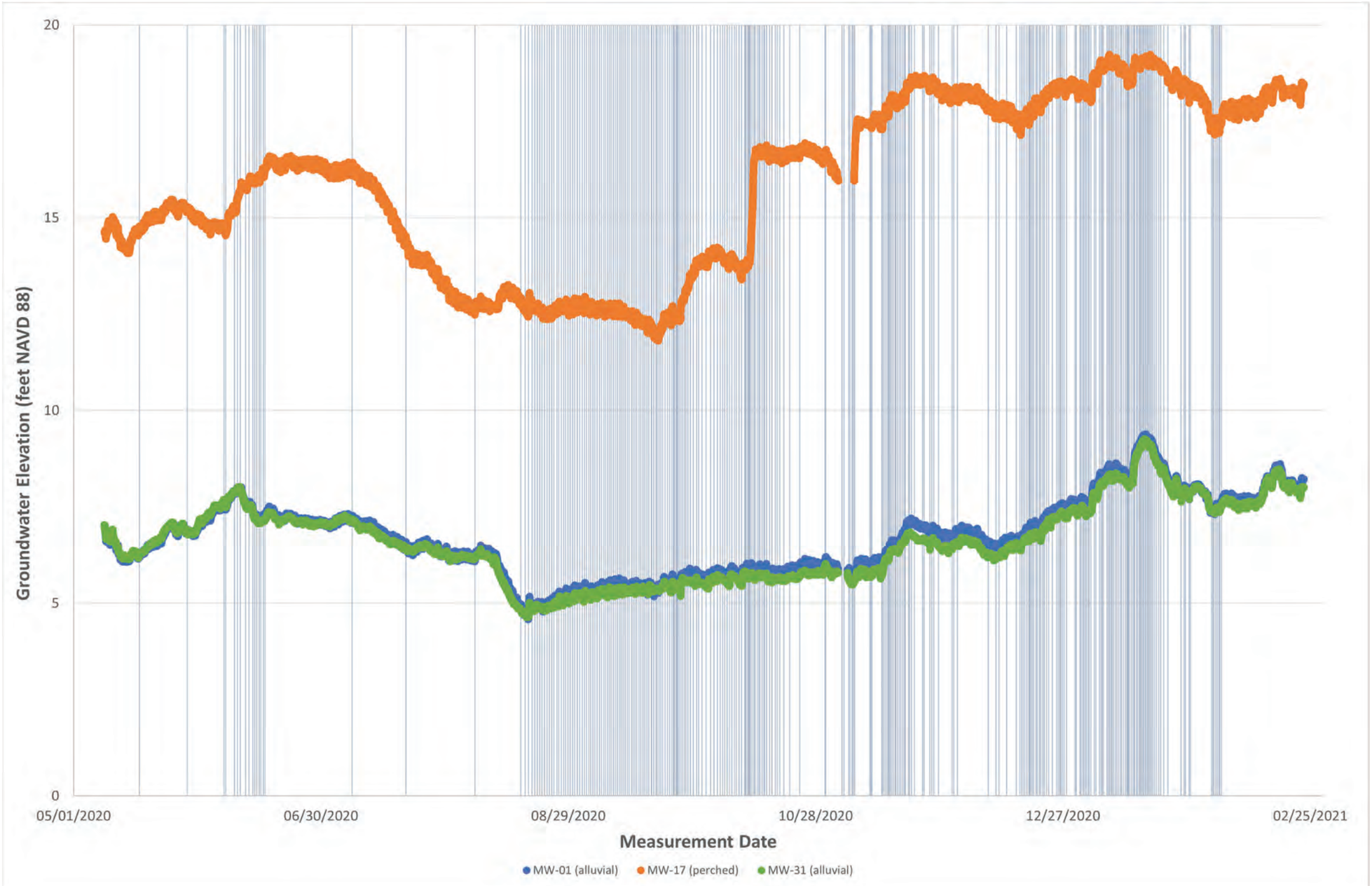
Figure 4.15
February 2021 Groundwater Contours—
Perched Water-Bearing Zone

I:\GIS\Projects\POL-TPH\MXD\RIFS\Figure 4.15 Feb 2021 Groundwater Contours - Perched Water-Bearing Zone.mxd
6/11/2023




Notes:
- Vertical blue lines represent activations of one or both pumps at the CDID #1 Oregon Way pumping station between May 1, 2020, and February 4, 2021.
- Oregon Way pump activation data obtained from CDID #1 on February 4, 2021.

Abbreviations:
CDID = Consolidated Diking Improvement District
NAVD 88 = North American Vertical Datum of 1988

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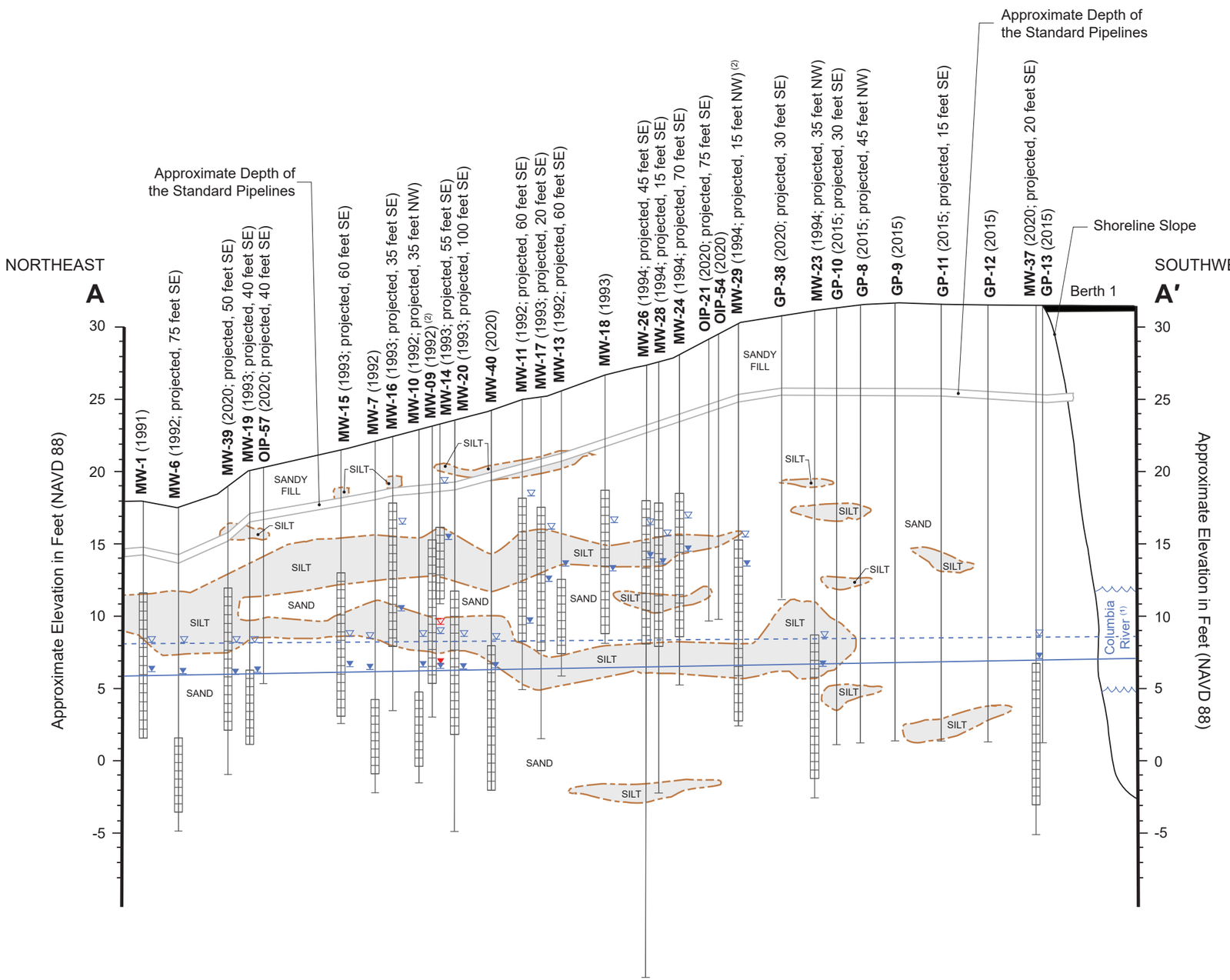
Figure 4.16
2020–2021 Groundwater Elevations and Oregon Way Pumping Activations

6/21/2021




## Legend

- MW-02 (1992) — Year Installed and Distance and Direction of Offset Boring
- Groundwater measured February 23, 2021
- Groundwater measured August 10 or 11, 2020
- Well Screen Interval
- LNAPL observed during February 2021 sampling event
- LNAPL observed during August 2020 sampling event
- Approximate alluvial aquifer groundwater elevation measured on February 23, 2021
- Approximate alluvial aquifer groundwater elevation measured on August 10 and 11, 2020
- Contact boundary between lithologies
- SANDY FILL — Heterogeneous mixture of sand, silt, and gravel materials likely emplaced on the ground surface and graded. Commonly observed fill materials at the Site include railroad ballast, spall, and other types of crushed rock.
- SAND — Fine to coarse SAND with little to some silt and trace to few gravel. This lithology can include thin layers of sandy gravel, silt, silty sand, and silty gravel.
- SILT — SILT with low to high plasticity and little to some sand and varying amounts of clay. This lithology can also include thin layers of interbedded sand, silty sand, and clay.

Notes:

1 The Columbia River Stage has an approximate highest tide of 12 feet NAVD 88 and approximate lowest tide of 4.9 feet NAVD 88. Elevations represent the average of average monthly highest and lowest tide elevations from 2002 to 2021 at Station 9440422.

2 The well screen extends through both the perched zone and alluvial aquifer. MW-09 and MW-29 groundwater elevations appear to be in equilibrium with the alluvial and perched, respectively, water bearing zones (Table 4.10).

- Cross-section location shown on Figure 3.2.
- Cross-section incorporates lithology from boring logs (Appendix J) and Hydraulic Profiling Tool (HPT) logs (Appendix A of the Interim Data Report, included as Appendix A). In locations where conflicting subsurface information exists, continuous soil data from direct push, sonic, and/or HPT logs are preferentially depicted.
- Only calculated groundwater elevations using manual water level measurements are shown.

Abbreviations:
LNAPL = Light non-aqueous phase liquid, NAVD 88 = North American Vertical Datum of 1988, TPH = Total petroleum hydrocarbons

Horizontal Scale in Feet
0’ 50’ 100’ 200’
0’ 2’ 4’ 8’
Vertical Scale in Feet
Vertical Exaggeration = 25x

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Figure 5.1
Cross-Section A-A′

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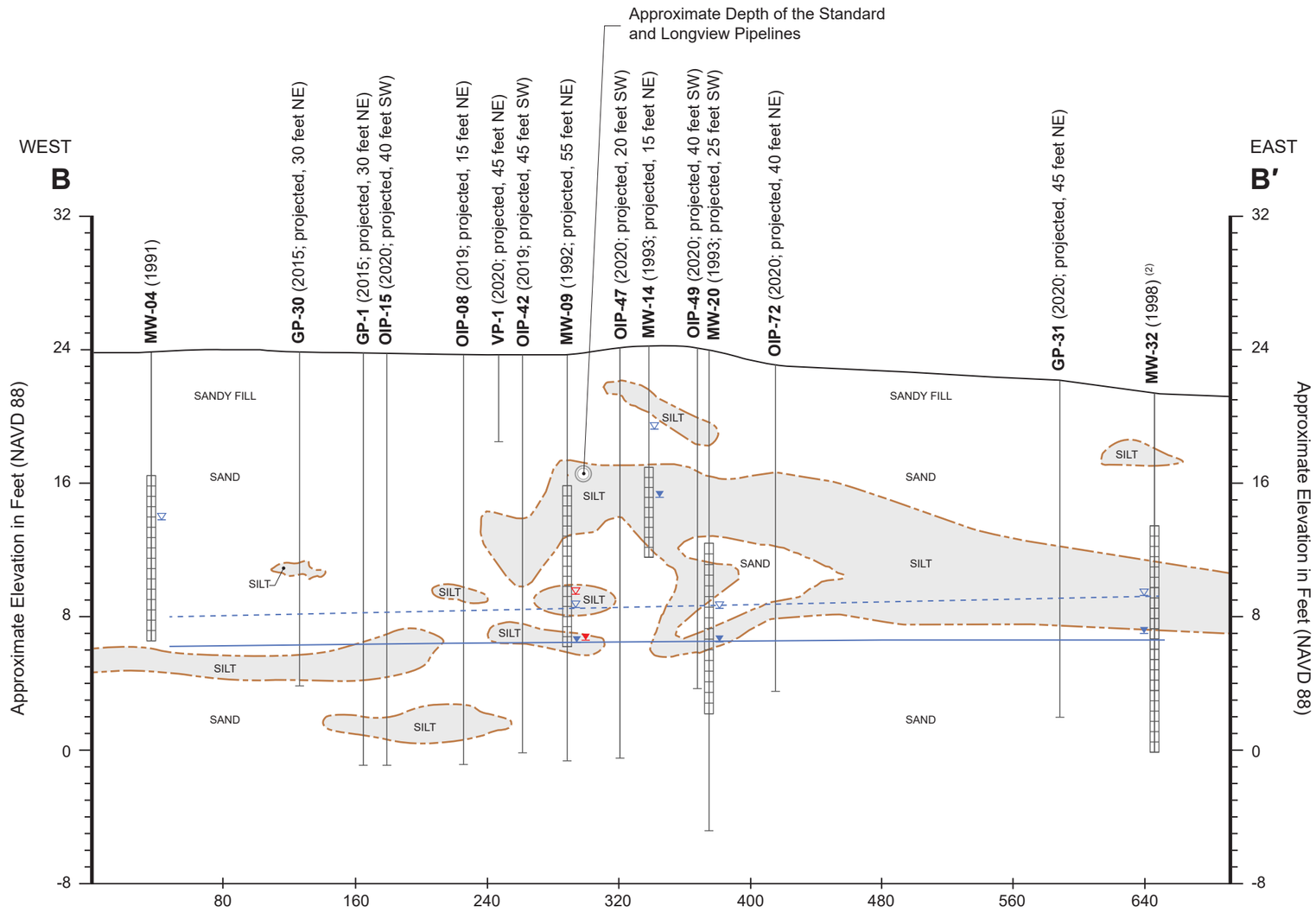
12/12/2022




## Legend

- Year Installed and Distance and Direction of Offset Boring (e.g., MW-20 (1993))
- Groundwater measured February 23, 2021
- Groundwater measured August 10 or 11, 2020
- Well Screen Interval
- LNAPL observed during February 2021 sampling event
- LNAPL observed during August 2020 sampling event
- Approximate alluvial aquifer groundwater elevation measured on February 23, 2021 (1)
- Approximate alluvial aquifer groundwater elevation measured on August 10 and 11, 2020 (1)
- Contact boundary between lithologies

SANDY FILL — Heterogeneous mixture of sand, silt, and gravel materials likely emplaced on the ground surface and graded. Commonly observed fill materials at the Site include railroad ballast, spall, and other types of crushed rock.

SAND — Fine to coarse SAND with little to some silt and trace to few gravel. This lithology can include thin layers of sandy gravel, silt, silty sand, and silty gravel.

SILT — SILT with low to high plasticity and little to some sand and varying amounts of clay. This lithology can also include thin layers of interbedded sand, silty sand, and clay.

Notes:

1 Groundwater elevations west of MW-09 are inferred based on subsurface geology and water level elevations from nearby monitoring wells.

2 The well screen extends through both the perched zone and alluvial aquifer. MW-32 groundwater elevations appear to be in equilibrium with the perched water bearing zone (Table 4.10).

- Cross-section location shown on Figure 3.2.
- Cross-section incorporates lithology from boring logs (Appendix J) and Hydraulic Profiling Tool (HPT) logs (Appendix A of the Interim Data Report, included as Appendix A). In locations where conflicting subsurface information exists, continuous soil data from direct push, sonic, and/or HPT logs are preferentially depicted.
- Only calculated groundwater elevations using manual water level measurements are shown.

Abbreviations:
LNAPL = Light non-aqueous phase liquid, NAVD 88 = North American Vertical Datum of 1988, TPH = Total petroleum hydrocarbons

Horizontal Scale in Feet
0’ 20’ 40’ 80’
0’ 2’ 4’ 8’
Vertical Scale in Feet
Vertical Exaggeration = 10x

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Figure 5.2
Cross-Section B-B′

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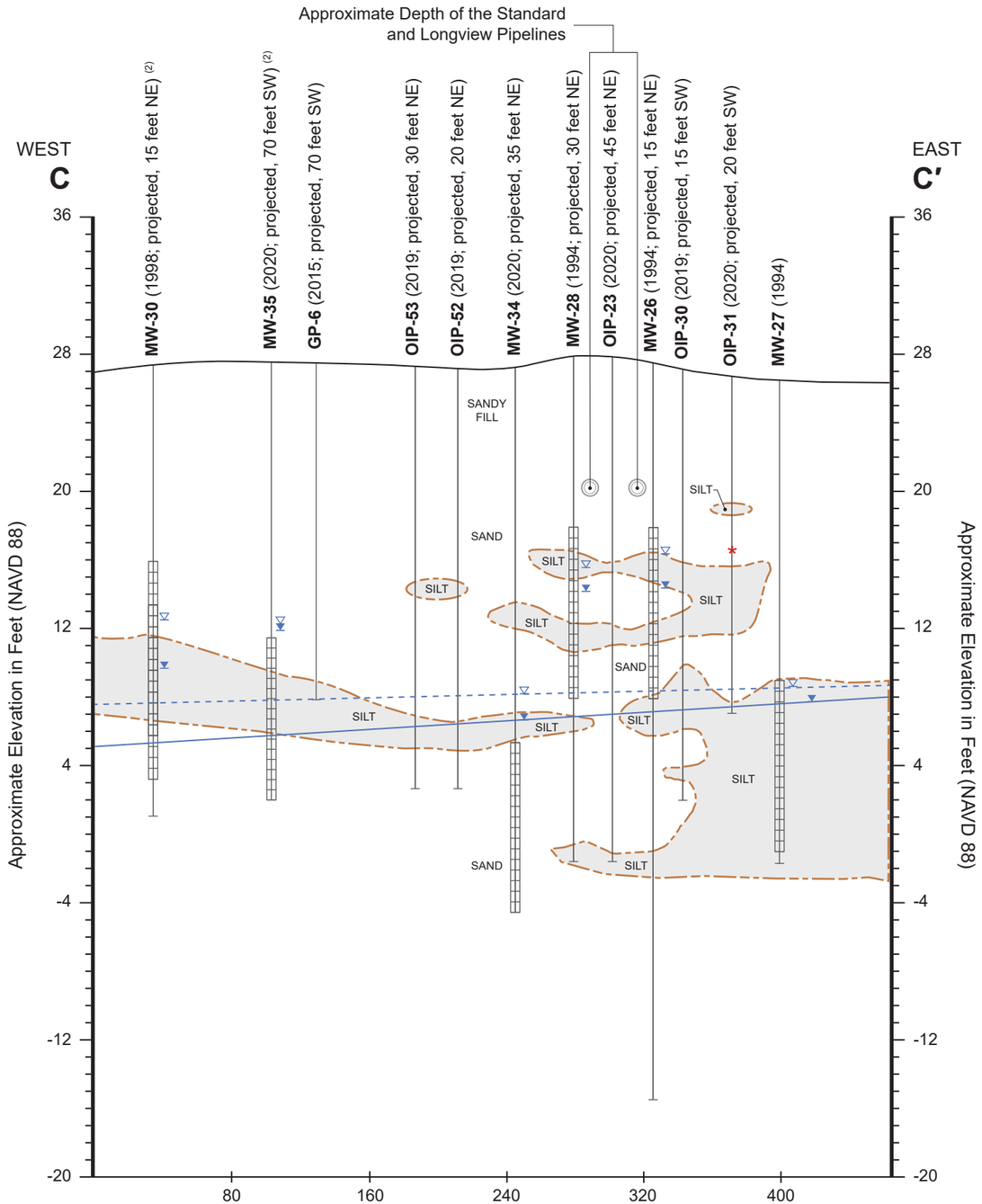
12/12/2022




## Legend

- MW-27 (1994) — Year Installed and Distance and Direction of Offset Boring
- Groundwater measured February 23, 2021
- Groundwater measured August 10 or 11, 2020
- Well Screen Interval
- LNAPL observed during February 2021 sampling event
- LNAPL observed during August 2020 sampling event
- Approximate alluvial aquifer groundwater elevation measured on February 23, 2021 (1)
- Approximate alluvial aquifer groundwater elevation measured on August 10 and 11, 2020 (1)
- Contact boundary between lithologies
- SANDY FILL — Heterogeneous mixture of sand, silt, and gravel materials likely emplaced on the ground surface and graded. Commonly observed fill materials at the Site include railroad ballast, spall, and other types of crushed rock.
- SAND — Fine to coarse SAND with little to some silt and trace to few gravel. This lithology can include thin layers of sandy gravel, silt, silty sand, and silty gravel.
- SILT — SILT with low to high plasticity and little to some sand and varying amounts of clay. This lithology can also include thin layers of interbedded sand, silty sand, and clay.

Notes:

1 Groundwater elevations west of MW-34 are inferred based on subsurface geology and water level elevations from nearby monitoring wells.

2 The well screen extends through both the perched zone and alluvial aquifer. MW-30 and MW-35 groundwater elevations appear to be in equilibrium with the perched water bearing zone (Table 4.10).

- Cross-section location shown on Figure 3.2.
- Cross-section incorporates lithology from boring logs (Appendix J) and Hydraulic Profiling Tool (HPT) logs (Appendix A of the Interim Data Report, included as Appendix A). In locations where conflicting subsurface information exists, continuous soil data from direct push, sonic, and/or HPT logs are preferentially depicted.
- Only calculated groundwater elevations using manual water level measurements are shown.

Abbreviations:
LNAPL = Light non-aqueous phase liquid, NAVD 88 = North American Vertical Datum of 1988, TPH = Total petroleum hydrocarbons

Horizontal Scale in Feet
0’ 20’ 40’ 80’
0’ 2’ 4’ 8’
Vertical Scale in Feet
Vertical Exaggeration = 10x

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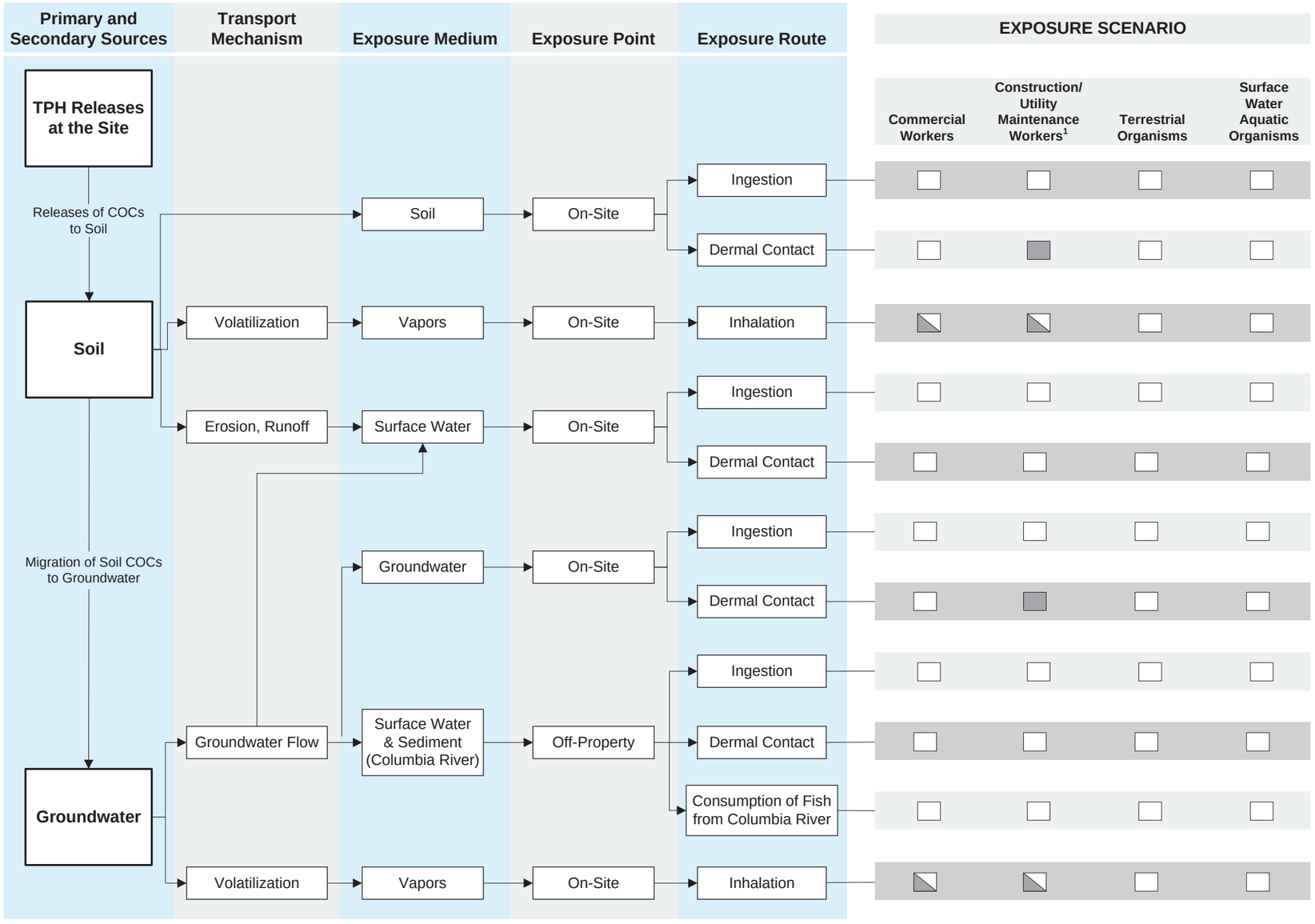
Figure 5.3
Cross-Section C-C′

I:\GIS\Projects\POL-TPH\AI\RIFS\Figure 5.3 Cross-Section C-C'.ai
12/12/2022




**These exposure scenarios are reasonable maximum exposure scenarios. Therefore, these scenarios are considered protective of other similar exposure scenarios. All potential receptors are on-site, unless otherwise noted.**

1 Shallow soil contamination is limited to areas adjacent to or within the rail lines with a potential for workers conducting utility repairs or rail maintenance to come into direct contact with impacted soil at concentrations exceeding the site-specific direct contact Model Toxics Control Act Method C cleanup level. This will be addressed with a soil management plan as a component of the remedial action.

**Legend**

- Complete Exposure Pathway
- Potentially Complete Exposure Pathway
- Incomplete Exposure Pathway

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Figure 6.1
Conceptual Site Model of
Potential Exposure Scenarios and Receptors

10/27/2022

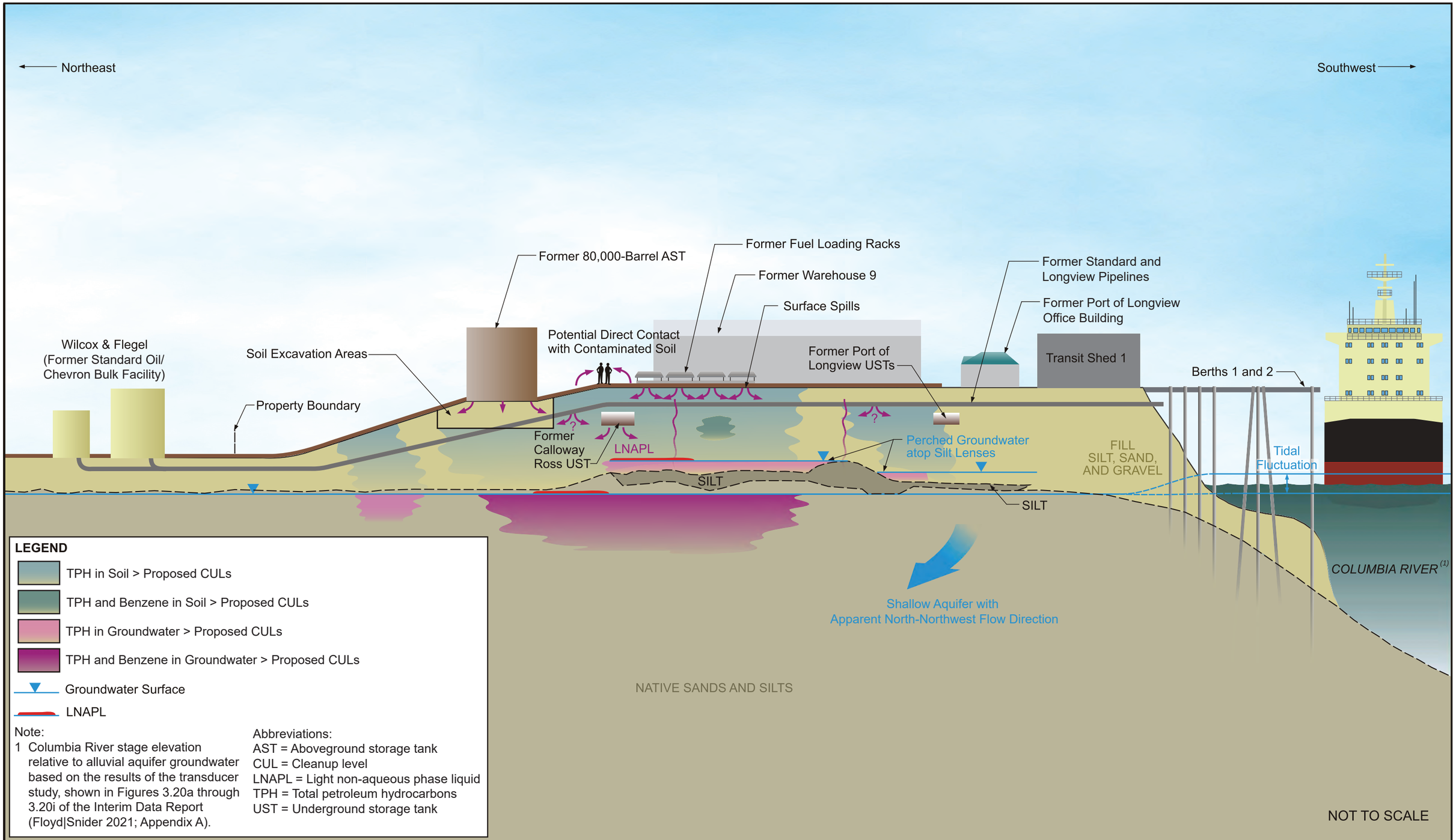


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Figure 9.1
Conceptual Site Model

I:\GIS\Projects\POL-TPH\AI\RIFS\Figure 9.1 Conceptual Site Model.ai
09/02/2021

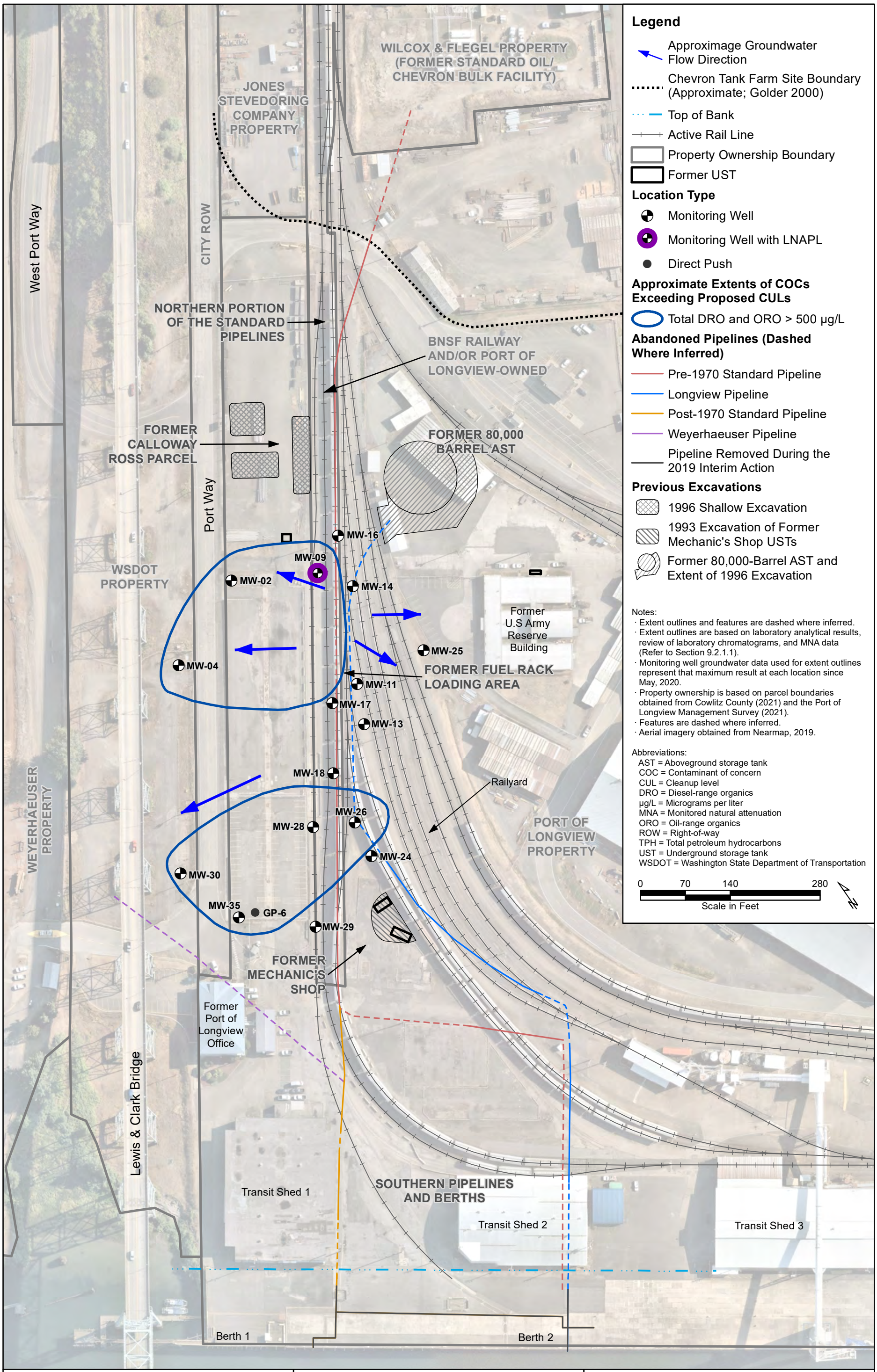


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Figure 9.2
Extent of COCs in Perched Zone Groundwater Exceeding Proposed CULs

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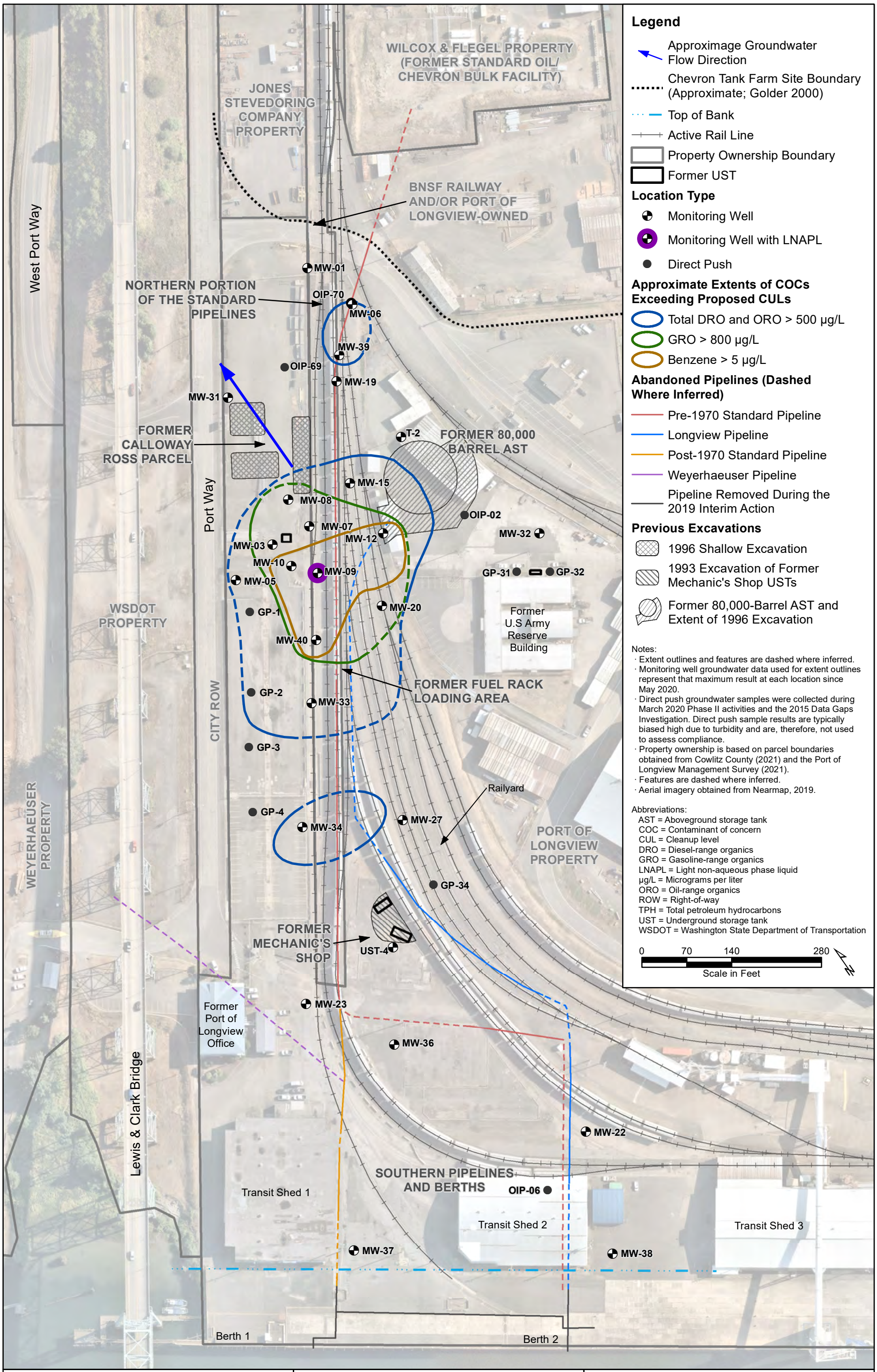
6/11/2023




**Legend**

- Approximage Groundwater Flow Direction
- Chevron Tank Farm Site Boundary (Approximate; Golder 2000)
- Top of Bank
- Active Rail Line
- Property Ownership Boundary
- Former UST

**Location Type**

- Monitoring Well
- Monitoring Well with LNAPL
- Direct Push

**Approximate Extents of COCs Exceeding Proposed CULs**

- Total DRO and ORO > 500 µg/L
- GRO > 800 µg/L
- Benzene > 5 µg/L

**Abandoned Pipelines (Dashed Where Inferred)**

- Pre-1970 Standard Pipeline
- Longview Pipeline
- Post-1970 Standard Pipeline
- Weyerhaeuser Pipeline
- Pipeline Removed During the 2019 Interim Action

**Previous Excavations**

- 1996 Shallow Excavation
- 1993 Excavation of Former Mechanic's Shop USTs
- Former 80,000-Barrel AST and Extent of 1996 Excavation

Notes:

- Extent outlines and features are dashed where inferred.
- Monitoring well groundwater data used for extent outlines represent that maximum result at each location since May 2020.
- Direct push groundwater samples were collected during March 2020 Phase II activities and the 2015 Data Gaps Investigation. Direct push sample results are typically biased high due to turbidity and are, therefore, not used to assess compliance.
- Property ownership is based on parcel boundaries obtained from Cowlitz County (2021) and the Port of Longview Management Survey (2021).
- Features are dashed where inferred.
- Aerial imagery obtained from Nearmap, 2019.

Abbreviations:

AST = Aboveground storage tank
COC = Contaminant of concern
CUL = Cleanup level
DRO = Diesel-range organics
GRO = Gasoline-range organics
LNAPL = Light non-aqueous phase liquid
µg/L = Micrograms per liter
ORO = Oil-range organics
ROW = Right-of-way
TPH = Total petroleum hydrocarbons
UST = Underground storage tank
WSDOT = Washington State Department of Transportation

0 70 140 280
Scale in Feet

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**Longview, Washington**

Figure 9.3
Extent of COCs in Alluvial Aquifer Groundwater Exceeding Proposed CULs

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6/12/2023

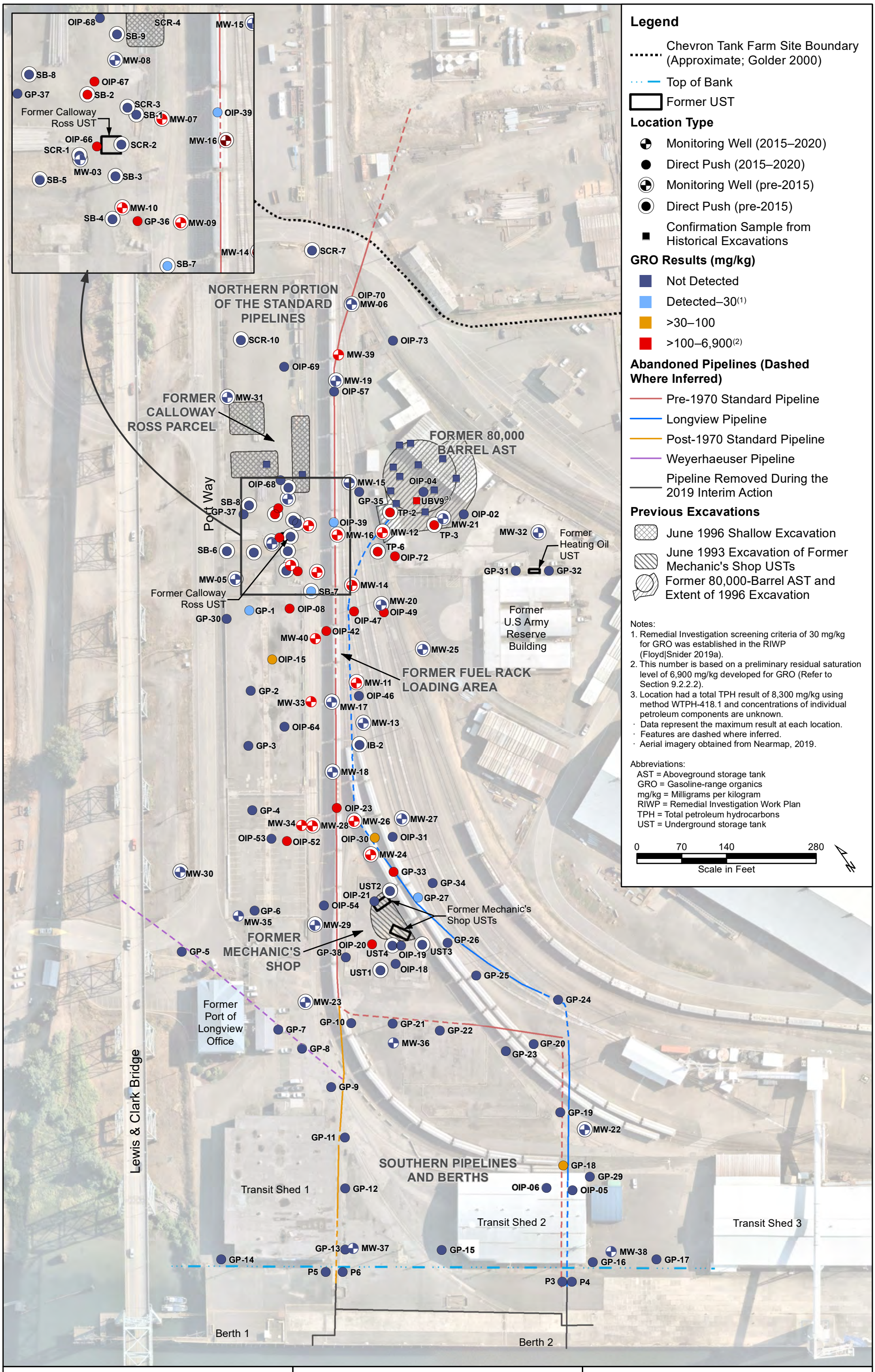


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Figure 9.4
Maximum Concentrations of Gasoline-Range Organics in Soil

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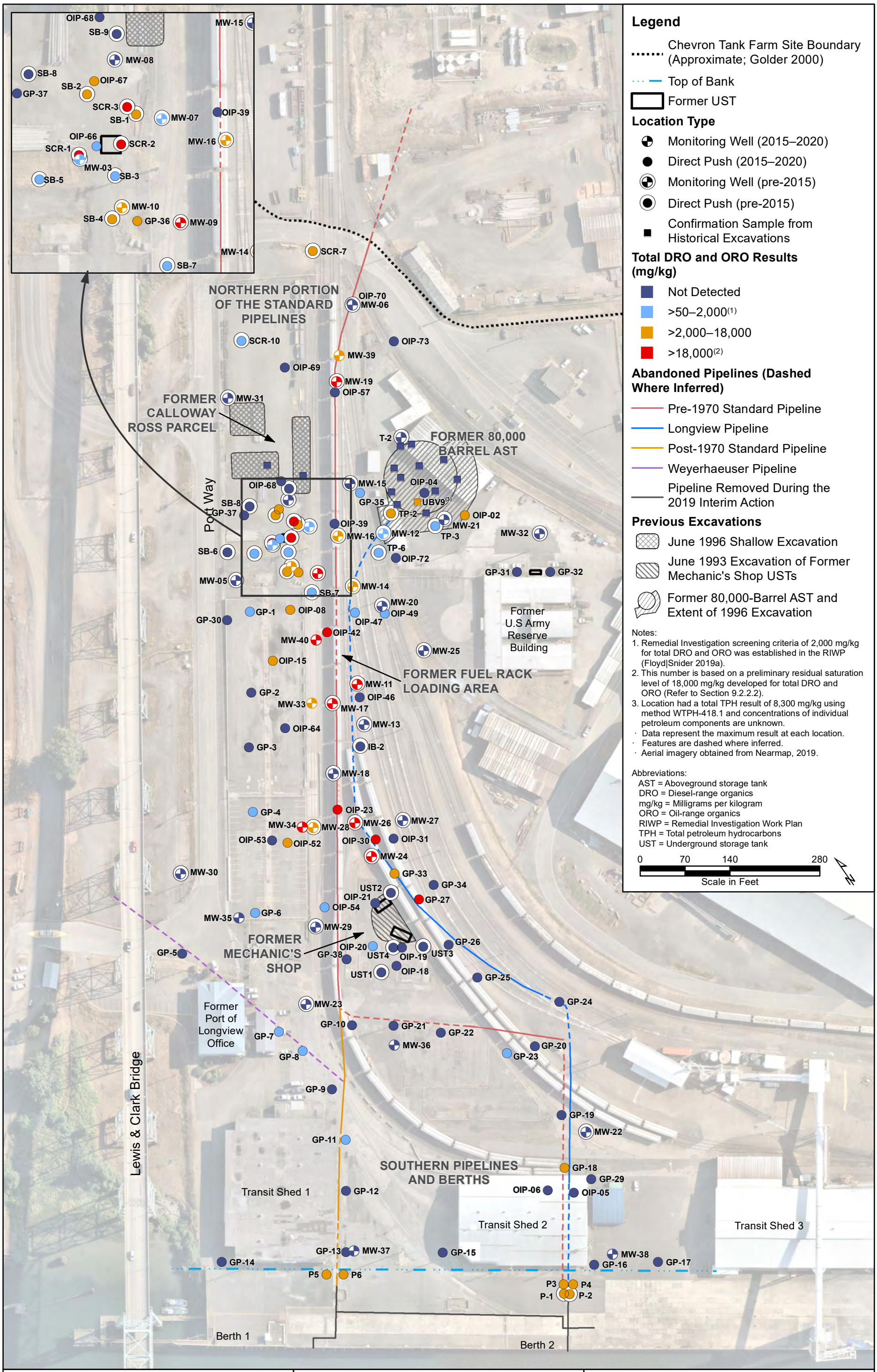
6/11/2023




## Legend

- Chevron Tank Farm Site Boundary (Approximate; Golder 2000)
- Top of Bank
- Former UST

**Location Type**

- Monitoring Well (2015–2020)
- Direct Push (2015–2020)
- Monitoring Well (pre-2015)
- Direct Push (pre-2015)
- Confirmation Sample from Historical Excavations

**Total DRO and ORO Results (mg/kg)**

- Not Detected
- >50–2,000(1)
- >2,000–18,000
- >18,000(2)

**Abandoned Pipelines (Dashed Where Inferred)**

- Pre-1970 Standard Pipeline
- Longview Pipeline
- Post-1970 Standard Pipeline
- Weyerhaeuser Pipeline
- Pipeline Removed During the 2019 Interim Action

**Previous Excavations**

- June 1996 Shallow Excavation
- June 1993 Excavation of Former Mechanic's Shop USTs
- Former 80,000-Barrel AST and Extent of 1996 Excavation

Notes:
1. Remedial Investigation screening criteria of 2,000 mg/kg for total DRO and ORO was established in the RIWP (Floyd|Snider 2019a).
2. This number is based on a preliminary residual saturation level of 18,000 mg/kg developed for total DRO and ORO (Refer to Section 9.2.2.2).
3. Location had a total TPH result of 8,300 mg/kg using method WTPH-418.1 and concentrations of individual petroleum components are unknown.

· Data represent the maximum result at each location.
· Features are dashed where inferred.
· Aerial imagery obtained from Nearmap, 2019.

Abbreviations:
AST = Aboveground storage tank
DRO = Diesel-range organics
mg/kg = Milligrams per kilogram
ORO = Oil-range organics
RIWP = Remedial Investigation Work Plan
TPH = Total petroleum hydrocarbons
UST = Underground storage tank

0 70 140 280
Scale in Feet

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Figure 9.5
Maximum Concentrations of Total DRO and ORO in Soil

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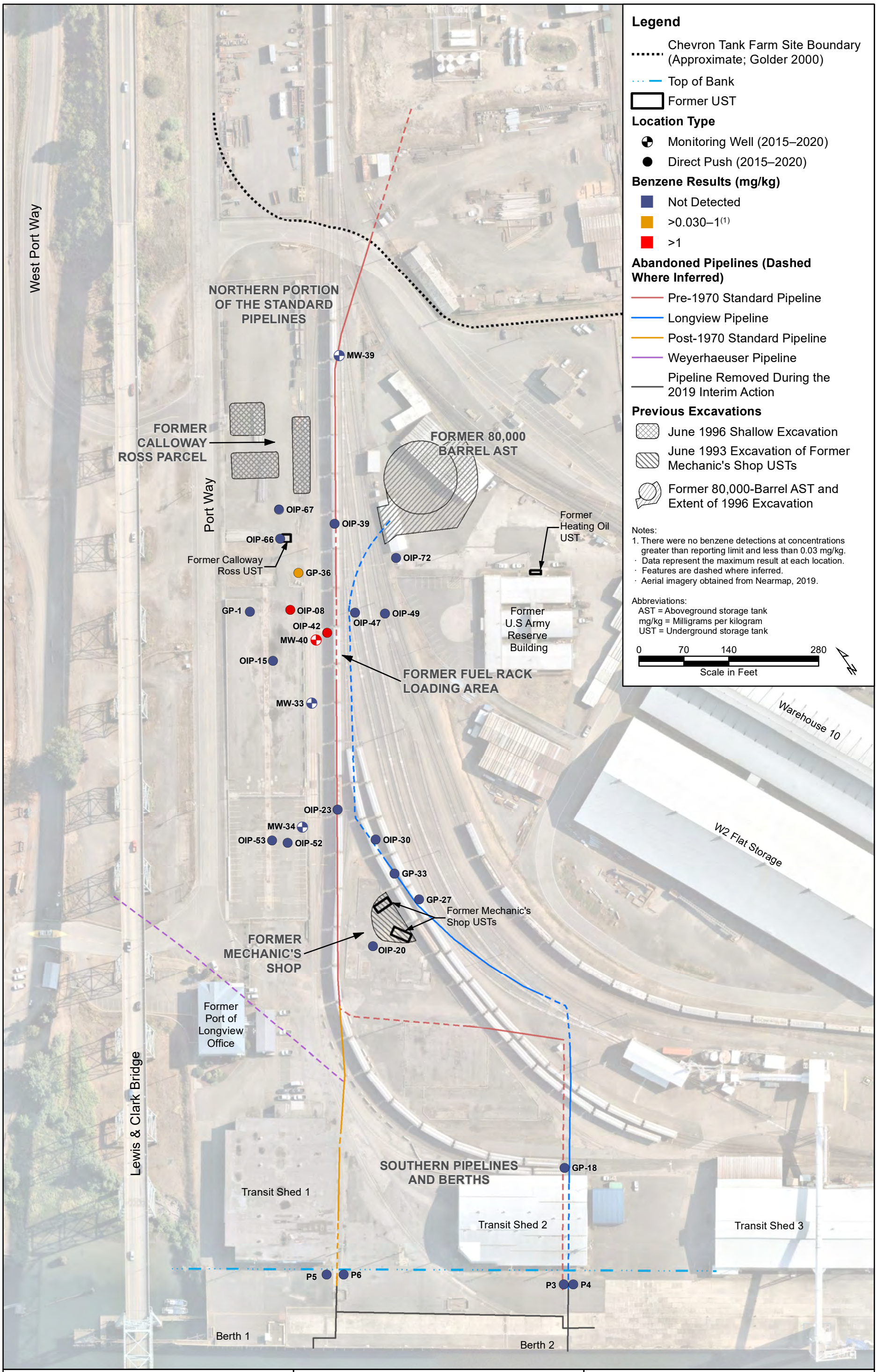
6/11/2023

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**Longview, Washington**

Figure 9.6
Maximum Concentrations of Benzene in Soil

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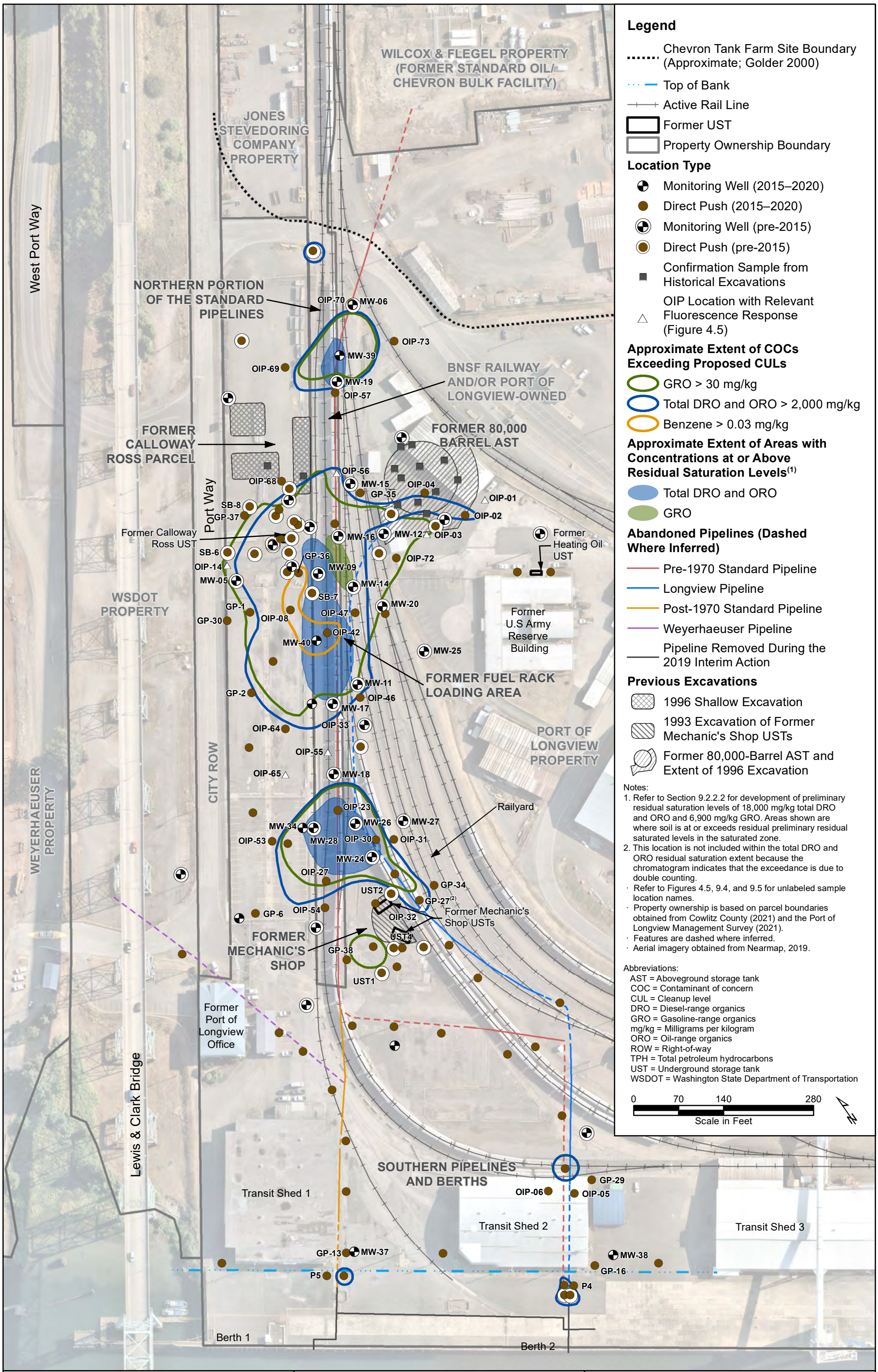
6/11/2023




## Legend

- Chevron Tank Farm Site Boundary (Approximate; Golder 2000)
- Top of Bank
- Active Rail Line
- Former UST
- Property Ownership Boundary

**Location Type**

- Monitoring Well (2015–2020)
- Direct Push (2015–2020)
- Monitoring Well (pre-2015)
- Direct Push (pre-2015)
- Confirmation Sample from Historical Excavations
- OIP Location with Relevant Fluorescence Response (Figure 4.5)

**Approximate Extent of COCs Exceeding Proposed CULs**

- GRO > 30 mg/kg
- Total DRO and ORO > 2,000 mg/kg
- Benzene > 0.03 mg/kg

**Approximate Extent of Areas with Concentrations at or Above Residual Saturation Levels(1)**

- Total DRO and ORO
- GRO

**Abandoned Pipelines (Dashed Where Inferred)**

- Pre-1970 Standard Pipeline
- Longview Pipeline
- Post-1970 Standard Pipeline
- Weyerhaeuser Pipeline
- Pipeline Removed During the 2019 Interim Action

**Previous Excavations**

- 1996 Shallow Excavation
- 1993 Excavation of Former Mechanic's Shop USTs
- Former 80,000-Barrel AST and Extent of 1996 Excavation

Notes:
1. Refer to Section 9.2.2.2 for development of preliminary residual saturation levels of 18,000 mg/kg total DRO and ORO and 6,900 mg/kg GRO. Areas shown are where soil is at or exceeds residual preliminary residual saturated levels in the saturated zone.
2. This location is not included within the total DRO and ORO residual saturation extent because the chromatogram indicates that the exceedance is due to double counting.

- Refer to Figures 4.5, 9.4, and 9.5 for unlabeled sample location names.
- Property ownership is based on parcel boundaries obtained from Cowlitz County (2021) and the Port of Longview Management Survey (2021).
- Features are dashed where inferred.
- Aerial imagery obtained from Nearmap, 2019.

Abbreviations:
AST = Aboveground storage tank
COC = Contaminant of concern
CUL = Cleanup level
DRO = Diesel-range organics
GRO = Gasoline-range organics
mg/kg = Milligrams per kilogram
ORO = Oil-range organics
ROW = Right-of-way
TPH = Total petroleum hydrocarbons
UST = Underground storage tank
WSDOT = Washington State Department of Transportation

0 70 140 280
Scale in Feet

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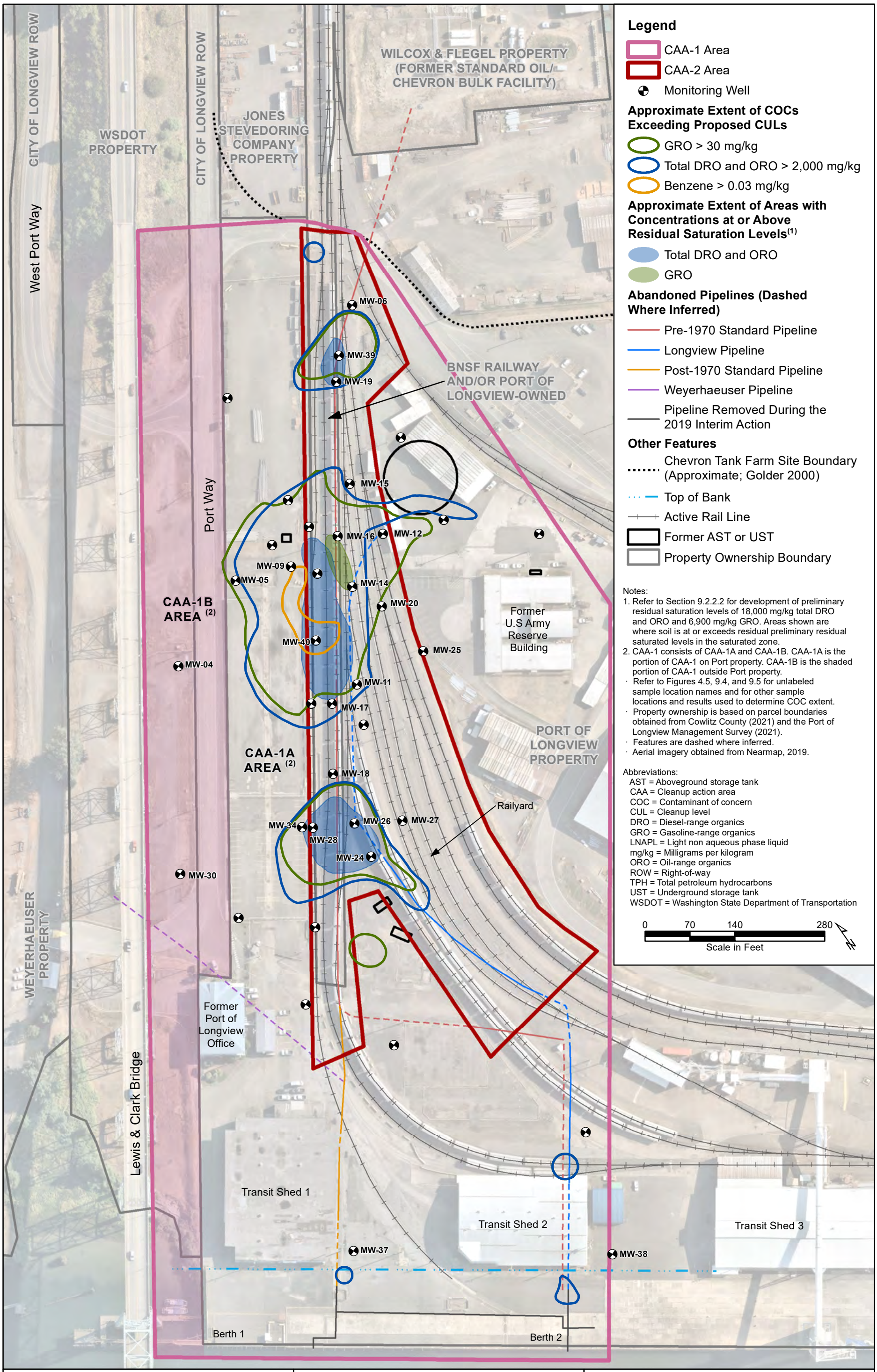
**Port of Longview TPH Site**
**Longview, Washington**

Figure 9.7
Extent of COCs in Soil Exceeding Proposed CULs

I:\GIS\Projects\POL-TPH\MXD\RIFS\Figure 9.7 Extent of COCs in Soil Exceeding PCULs.mxd
6/11/2023




## Legend

- CAA-1 Area
- CAA-2 Area
- Monitoring Well

**Approximate Extent of COCs Exceeding Proposed CULs**

- GRO > 30 mg/kg
- Total DRO and ORO > 2,000 mg/kg
- Benzene > 0.03 mg/kg

**Approximate Extent of Areas with Concentrations at or Above Residual Saturation Levels(1)**

- Total DRO and ORO
- GRO

**Abandoned Pipelines (Dashed Where Inferred)**

- Pre-1970 Standard Pipeline
- Longview Pipeline
- Post-1970 Standard Pipeline
- Weyerhaeuser Pipeline
- Pipeline Removed During the 2019 Interim Action

**Other Features**

- Chevron Tank Farm Site Boundary (Approximate; Golder 2000)
- Top of Bank
- Active Rail Line
- Former AST or UST
- Property Ownership Boundary

Notes:
1. Refer to Section 9.2.2.2 for development of preliminary residual saturation levels of 18,000 mg/kg total DRO and ORO and 6,900 mg/kg GRO. Areas shown are where soil is at or exceeds residual preliminary residual saturated levels in the saturated zone.
2. CAA-1 consists of CAA-1A and CAA-1B. CAA-1A is the portion of CAA-1 on Port property. CAA-1B is the shaded portion of CAA-1 outside Port property.

- Refer to Figures 4.5, 9.4, and 9.5 for unlabeled sample location names and for other sample locations and results used to determine COC extent.
- Property ownership is based on parcel boundaries obtained from Cowlitz County (2021) and the Port of Longview Management Survey (2021).
- Features are dashed where inferred.
- Aerial imagery obtained from Nearmap, 2019.

Abbreviations:
AST = Aboveground storage tank
CAA = Cleanup action area
COC = Contaminant of concern
CUL = Cleanup level
DRO = Diesel-range organics
GRO = Gasoline-range organics
LNAPL = Light non aqueous phase liquid
mg/kg = Milligrams per kilogram
ORO = Oil-range organics
ROW = Right-of-way
TPH = Total petroleum hydrocarbons
UST = Underground storage tank
WSDOT = Washington State Department of Transportation

0 70 140 280
Scale in Feet

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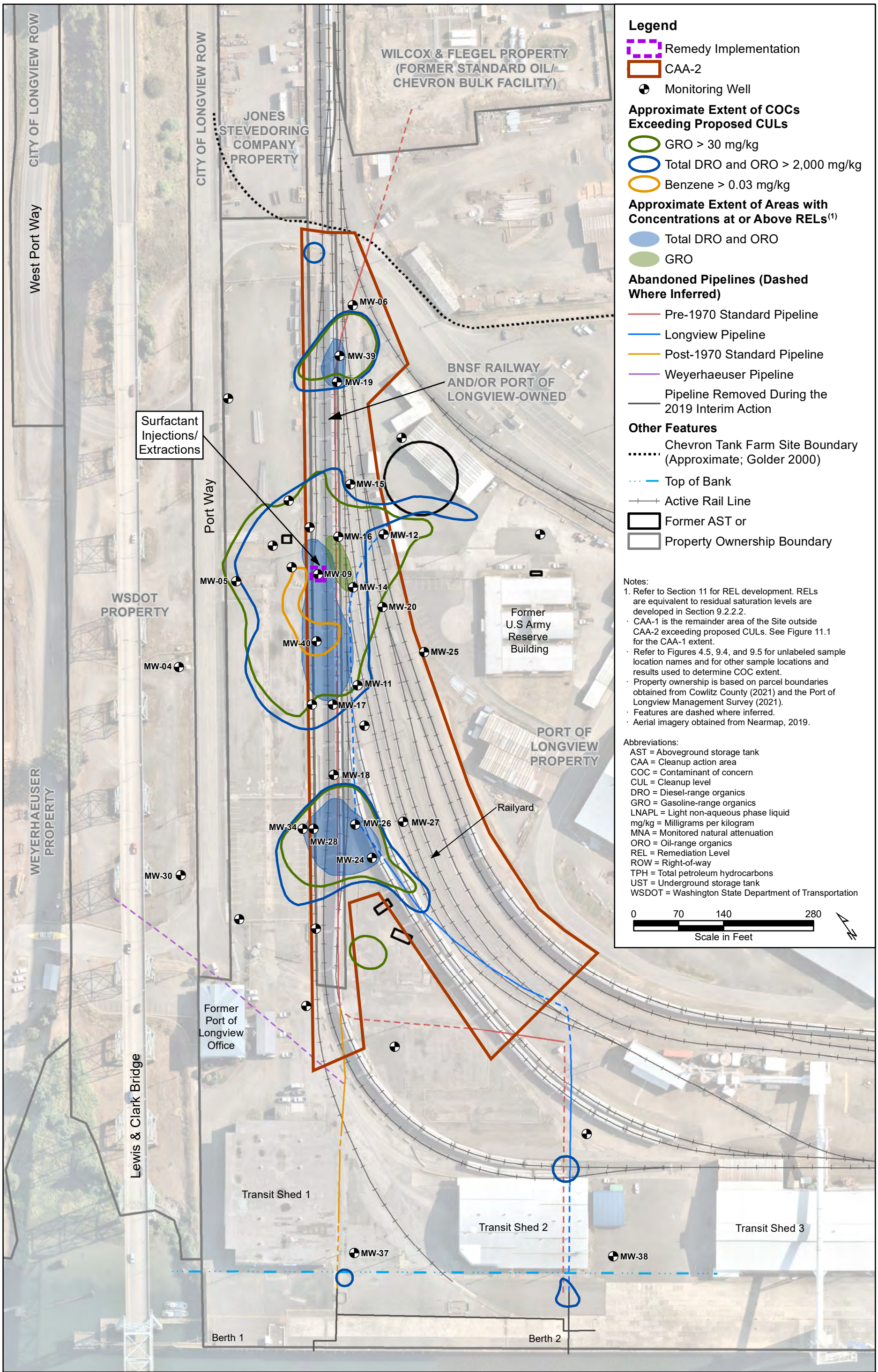
Figure 11.1
Cleanup Action Areas

I:\GIS\Projects\POL-TPH\MXD\RIFS\Figure 11.1 Cleanup Action Areas.mxd
8/7/2023

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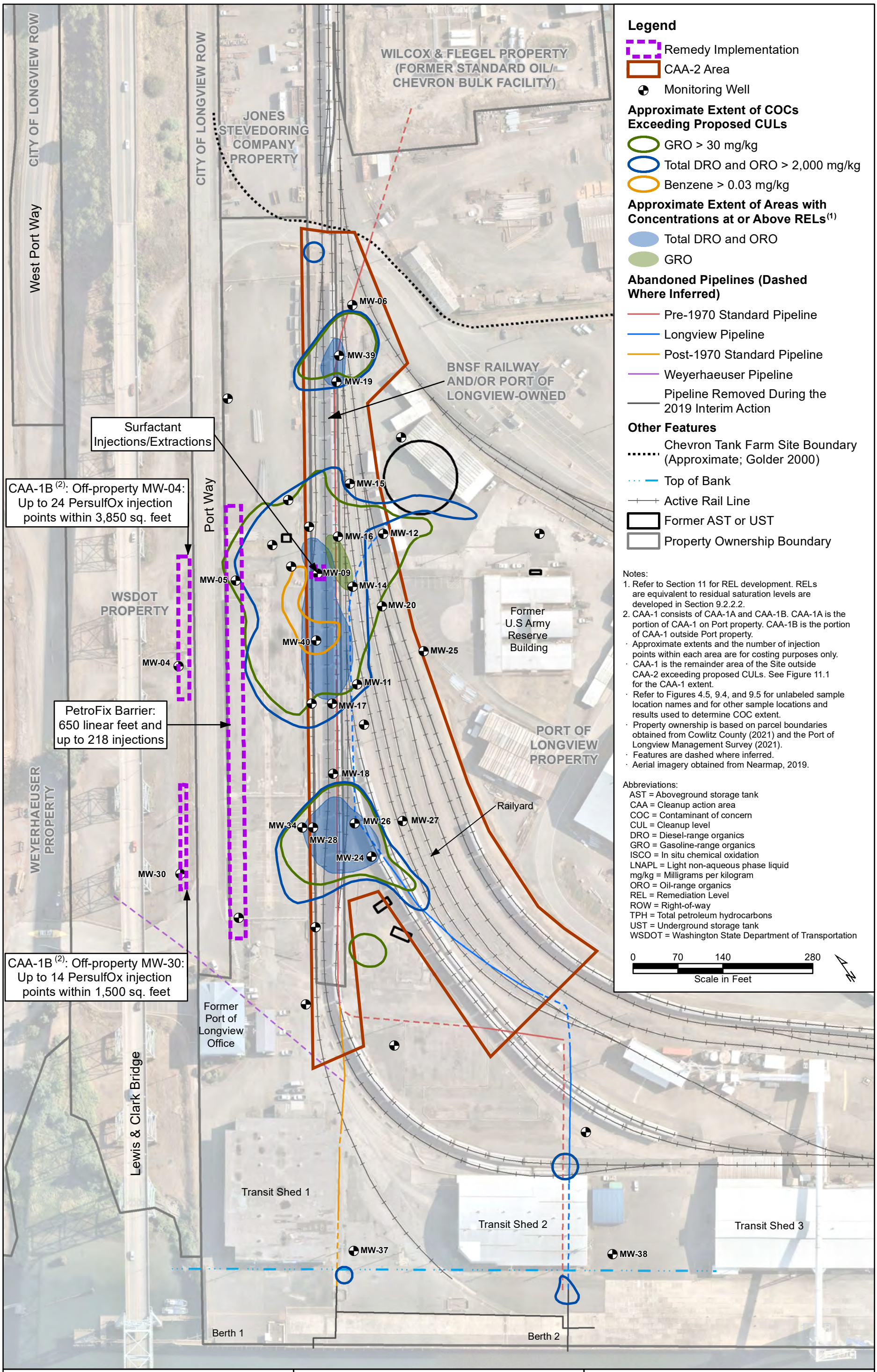
**Longview, Washington**

Figure 13.1
Alternative 1—
LNAPL Removal and MNA

I:\GIS\Projects\POL-TPH\MXD\RIFS\Figure 13.1 Alternative 1 - LNAPL Removal and MNA.mxd
6/11/2023

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**Longview, Washington**

Figure 13.2
Alternative 2—
In Situ Treatment Barrier and
LNAPL Removal

I:\GIS\Projects\POL-TPH\MXD\RIFS\Figure 13.2 Alternative 2 - In Situ Treatment Barrier and LNAPL Removal.mxd
8/7/2023

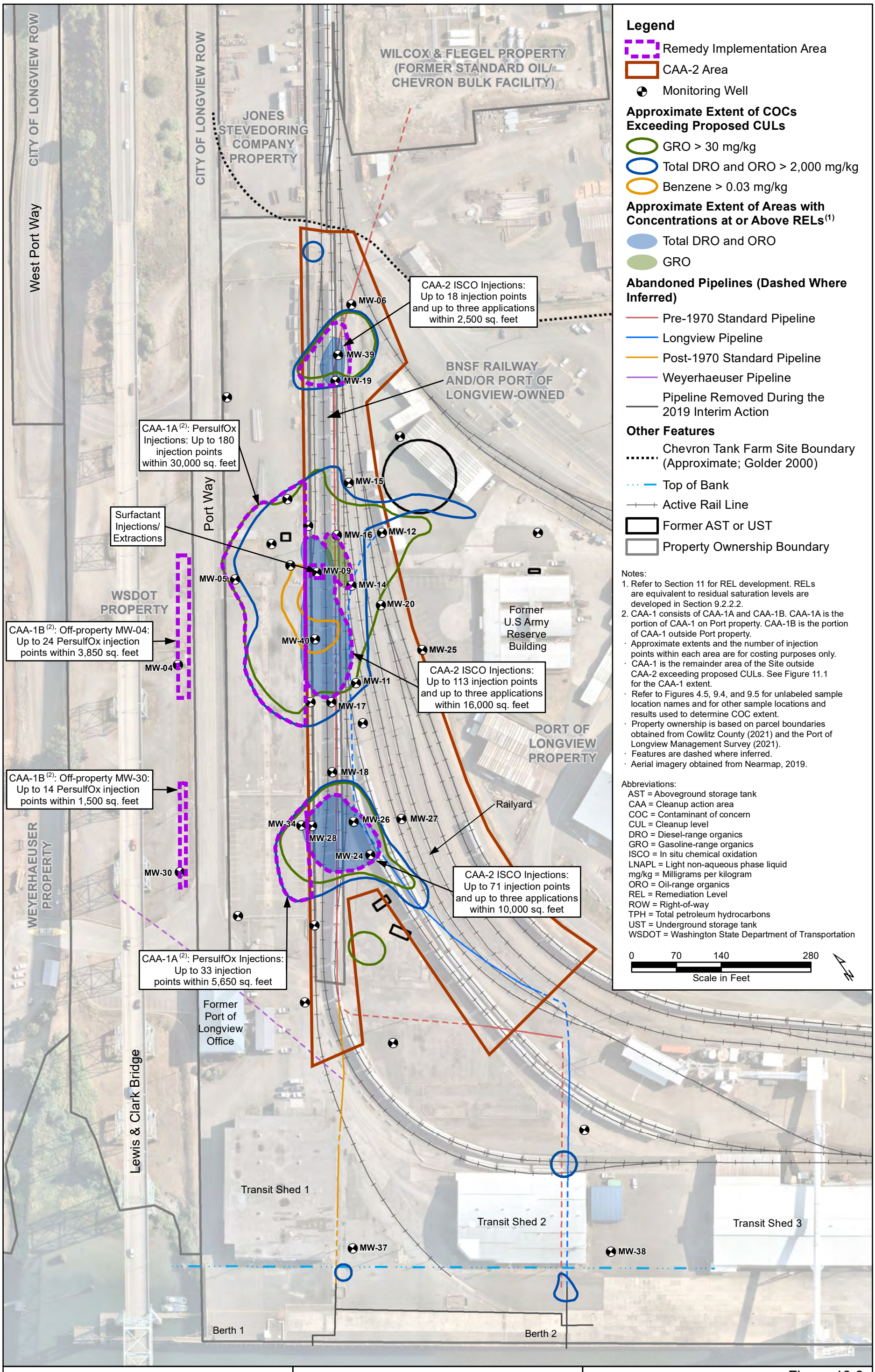


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Figure 13.3
Alternative 3—
Targeted ISCO Injections and
LNAPL Removal

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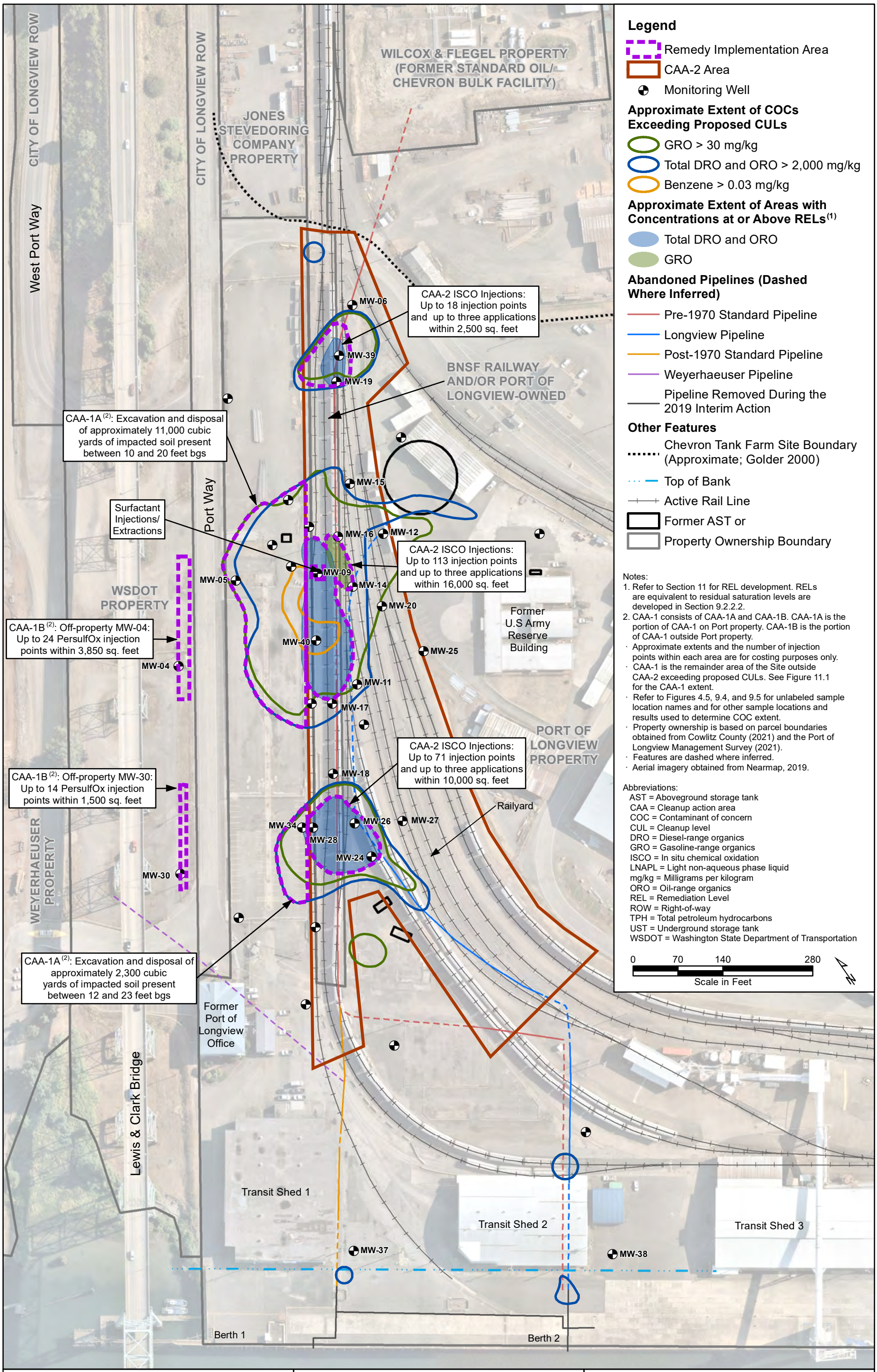
8/7/2023

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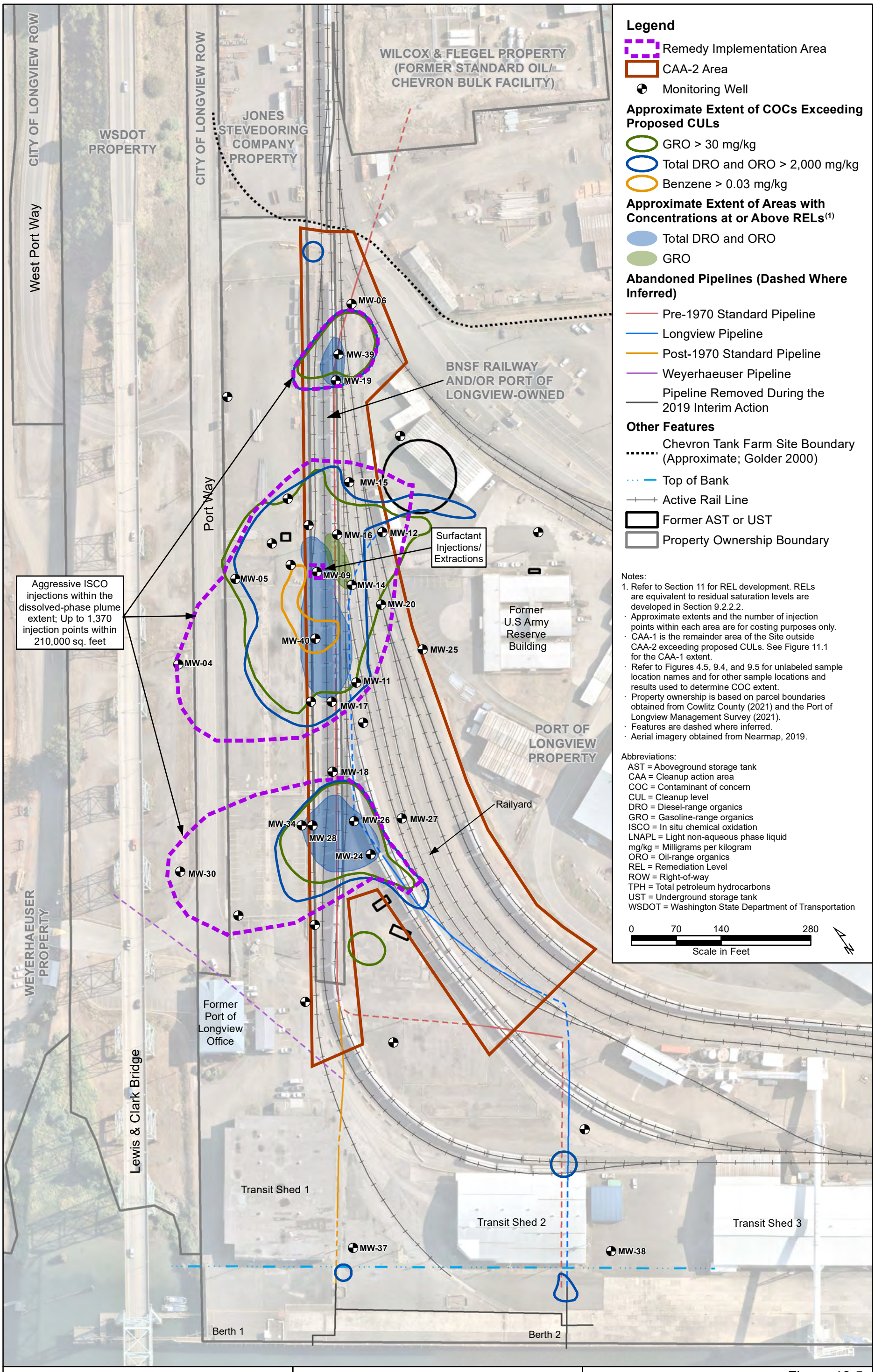
**Longview, Washington**

Figure 13.4
Alternative 4—
Limited Excavation, Targeted ISCO Injections, and LNAPL Removal

I:\GIS\Projects\POL-TPH\MXD\RIFS\Figure 13.4 Alternative 4 - Limited Excavation, Targeted ISCO Injections, and LNAPL Removal.mxd
8/7/2023




## Legend

- Remedy Implementation Area
- CAA-2 Area
- Monitoring Well

**Approximate Extent of COCs Exceeding Proposed CULs**

- GRO > 30 mg/kg
- Total DRO and ORO > 2,000 mg/kg
- Benzene > 0.03 mg/kg

**Approximate Extent of Areas with Concentrations at or Above RELs(1)**

- Total DRO and ORO
- GRO

**Abandoned Pipelines (Dashed Where Inferred)**

- Pre-1970 Standard Pipeline
- Longview Pipeline
- Post-1970 Standard Pipeline
- Weyerhaeuser Pipeline
- Pipeline Removed During the 2019 Interim Action

**Other Features**

- Chevron Tank Farm Site Boundary (Approximate; Golder 2000)
- Top of Bank
- Active Rail Line
- Former AST or UST
- Property Ownership Boundary

Notes:

1. Refer to Section 11 for REL development. RELs are equivalent to residual saturation levels are developed in Section 9.2.2.2.

- Approximate extents and the number of injection points within each area are for costing purposes only.
- CAA-1 is the remainder area of the Site outside CAA-2 exceeding proposed CULs. See Figure 11.1 for the CAA-1 extent.
- Refer to Figures 4.5, 9.4, and 9.5 for unlabeled sample location names and for other sample locations and results used to determine COC extent.
- Property ownership is based on parcel boundaries obtained from Cowlitz County (2021) and the Port of Longview Management Survey (2021).
- Features are dashed where inferred.
- Aerial imagery obtained from Nearmap, 2019.

Abbreviations:

AST = Aboveground storage tank
CAA = Cleanup action area
COC = Contaminant of concern
CUL = Cleanup level
DRO = Diesel-range organics
GRO = Gasoline-range organics
ISCO = In situ chemical oxidation
LNAPL = Light non-aqueous phase liquid
mg/kg = Milligrams per kilogram
ORO = Oil-range organics
REL = Remediation Level
ROW = Right-of-way
TPH = Total petroleum hydrocarbons
UST = Underground storage tank
WSDOT = Washington State Department of Transportation

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Scale in Feet

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**Port of Longview TPH Site**
**Longview, Washington**

Figure 13.5
Alternative 5—
Plume-wide ISCO Injections and
LNAPL Removal

I:\GIS\Projects\POL-TPH\MXD\RIFS\Figure 13.5 Alternative 5 - Plume-wide ISCO Injections and LNAPL Removal.mxd
6/11/2023