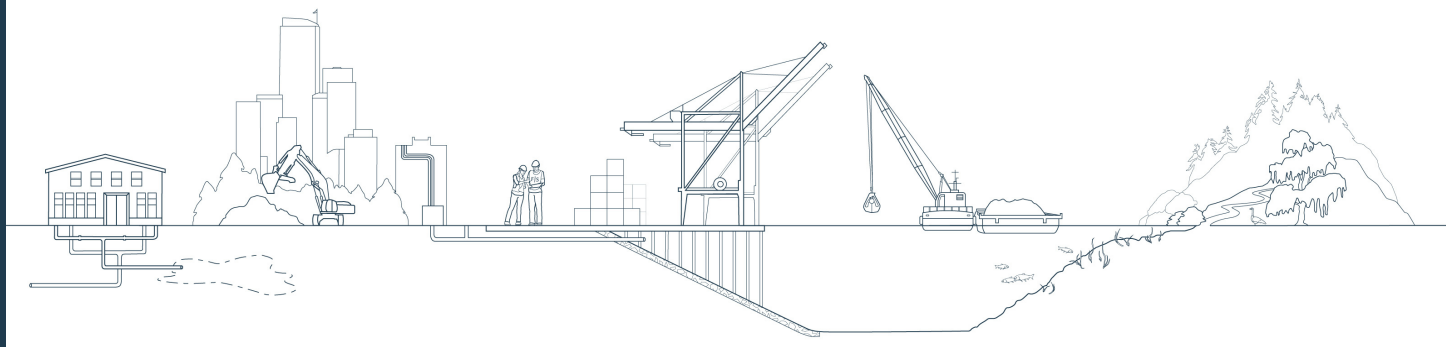
2024 Annual Progress Report for the K Ply Site

K Ply Site

Prepared for
Port of Port Angeles

January 2025



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2024 Annual Progress Report for the K Ply Site

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the Port of Port Angeles
under the supervision of:

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Date: 1/27/2025

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

Abbreviation	Definition
AO	Agreed Order
ATG	Alliance Technical Group (formerly Fremont Analytical, Inc.)
BTEX	Benzene, toluene, ethylbenzene, and xylenes
COC	Contaminant of concern
CPOC	Conditional point of compliance
CUL	Cleanup level
DO	Dissolved oxygen
DRO	Diesel-range organics
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
EIM	Environmental Information Management
FS	Feasibility Study
GRO	Gasoline-range organics
IG	Infiltration gallery
LNAPL	Light non-aqueous phase liquid
µg/L	Micrograms per liter
mg/kg	Milligrams per kilogram
MNA	Monitored natural attenuation
MTA	Marine Trades Area
ORC	Oxygen-releasing compound

Abbreviation	Definition
ORO	Oil-range organics
ORP	Oxidation–reduction potential
PCP	Pentachlorophenol
Port	Port of Port Angeles
RI	Remedial Investigation
SAP/QAPP	Sampling and Analysis Plan/Quality Assurance Project Plan
SDG	Sample delivery group
Site	K Ply Site
SRB	Sulfate-reducing bacteria
TPH	Total petroleum hydrocarbons

1.0 Introduction

This Annual Progress Report has been prepared by Floyd|Snider on behalf of the Port of Port Angeles (Port) to meet the reporting requirements of the 2015 Agreed Order (AO) No. DE 11302 with the Washington State Department of Ecology (Ecology) for the K Ply Site (Site). The Site is located at 439 Marine Drive in Port Angeles, Washington.

The objective of this report is to describe work performed for the monitoring period of January 2024 to December 2024, consistent with the requirements of Section VII, subsection C of the AO.

1.1 SITE BACKGROUND

The Site is located directly west of downtown Port Angeles and historically operated primarily as a plywood manufacturer. Environmental contamination under the former mill building was first documented in the late 1980s with partial cleanup actions undertaken by ITT Rayonier, one of the prior mill owners. The mill was demolished by the Port in 2013, which allowed for a final Site Remedial Investigation (RI)/Feasibility Study (FS; Floyd|Snider 2015a) and cleanup action to be completed. The RI/FS field work was completed in 2014 and documented a broad area of both gasoline- and hydraulic oil-contaminated soil and groundwater under the former mill. The Ecology-selected cleanup remedy was described in the Cleanup Action Report (Ecology 2015) and implemented under the AO for multiple cleanup areas, identified in the Construction Completion Report (Floyd|Snider 2016) as either a “primary” or “minor” cleanup area. This remedial action was implemented between August 2015 and May 2016 and included excavation followed by bioremediation of contaminated soil and groundwater. The final cleanup removed the majority of soil contamination and greatly reduced the source mass of contamination that was causing elevated contaminant concentrations in groundwater in two primary cleanup areas.

1.1.1 Primary Cleanup Areas

The two primary cleanup areas included the following:

- **The Gasoline Area (Areas 5 and 6).** This area extended continuously from the northern to southern boundary of the Site (Figure 1.1). Gasoline was present in soil and groundwater at concentrations greater than Site cleanup levels (CULs) throughout this area. Remediation consisted of excavation of both vadose and smear zone soils to CULs in Area 6 and excavation of vadose zone soils to CULs and smear zone soils to remediation levels in Area 5, followed by application of bio-amendments during backfilling to promote natural attenuation. Residual smear zone soils in Area 5 and a small area of gasoline-range organics (GRO) along the bulkhead in Area 6 (where impacted soil could not be removed without potentially destabilizing the bulkhead) are additionally being addressed through monitored natural attenuation (MNA).
- **The Hydraulic Oil Area (Area 6).** This area is located in the vicinity of the former hydraulic presses. Hydraulic oil was present as a light non-aqueous phase liquid

(LNAPL) pooled on the groundwater surface and also present in soil and groundwater downgradient of the LNAPL zone. Remediation consisted of excavation of both vadose and smear zone soils exceeding CULs followed by application of bio-amendments during backfilling. A portion of the soil in the Hydraulic Oil Area was commingled with contamination from the Gasoline Area.

Per the Ecology-approved remedial design, smear zone soils with gasoline and benzene concentrations in soil greater than the remediation levels of 3,000 milligrams per kilogram (mg/kg) and 10 mg/kg, respectively, were left in place in Area 5. These concentrations in soil within Area 5 were expected to attenuate over time after removal of a majority of source material, and the resulting reduction in upgradient groundwater contaminant concentrations was expected to allow for biodegradation as groundwater flows downgradient through clean backfill soil. The remedial action also included groundwater treatment to stimulate biodegradation of residual petroleum contamination in groundwater following excavation activities.

Groundwater within these primary cleanup areas at the Site was treated via application of bio-amendments in two forms:

- **Cedar Street Plume Bio-Injections**: The RI defined a plume of gasoline and benzene in groundwater emanating from the Gasoline Area and extending under Cedar Street toward the north. This area of dissolved-phase groundwater contamination was treated with an oxygen-releasing compound (ORC) that was injected during the construction phase of the project throughout an approximately 1-acre area between wells PP-15R2 and PP-37R (Figure 1.1). The treated area roughly corresponded to benzene concentrations in the plume greater than 500 micrograms per liter (µg/L). In 2017, after 2 years of post-remediation groundwater monitoring that indicated the aquifer geochemical conditions were highly reducing, a limited area of the benzene plume around wells PP-14R and PP-37/PP-37R was additionally treated with injections of activated carbon amended with magnesium sulfate to promote anaerobic degradation of benzene (Figure 1.1).
- **Groundwater Infiltration Galleries:** Infiltration galleries (IGs) were installed in Areas 5 and 6 prior to backfilling in 2016. These IGs were designed to allow for future application of an ORC or bacteriological nutrients if groundwater monitoring indicates that the groundwater CULs are not being attained at the conditional point of compliance (CPOC). Between 2017 and 2019, targeted treatment with sulfate-rich amendments were applied to the IGs and ground surface of Areas 5 and 6 (refer to Section 1.2.1). In 2018, the IGs were modified by extending IGs 3 and 5 to provide more treatment coverage to the west outside of the excavation footprint and bifurcating IGs 1 through 4 to target treatment applications along the west side of the excavation areas. Figure 1.1 shows the current IG alignment.

The effects of bio-amendment treatment are discussed in Section 2.1.2.4.

1.1.2 Minor Cleanup Areas

Outside of the primary cleanup areas, there were several other minor cleanup areas defined in the RI, including the Stack Area (Area 1), the Hog Fuel Storage Area (Areas 2 and 3), the Pentachlorophenol (PCP) Area (Area 4), and the Log Pond Fill Area. The Stack Area, Hog Fuel Storage Area, and the PCP Area were excavated to address soil impacts. The only minor cleanup area being monitored under the long-term compliance monitoring program is the Log Pond Fill Area, which has residual soil impacts of oil-range organics (ORO) being managed with an environmental covenant and soil management plan. In coordination with Ecology, monitoring wells PP-21 and PP-22, located along the shoreline in the downgradient portion of the Log Pond Fill Area, were added to the long-term compliance monitoring network starting in October 2023. These two monitoring wells will be monitored at a frequency of every 2.5 years to confirm the long-term stability of the Log Pond Fill Area, with the next monitoring event to occur in April 2026.

1.2 SUMMARY OF ADDITIONAL POST-REMEDIATION ACTIVITIES COMPLETED UNDER THE AGREED ORDER

Additional activities to fulfill the AO after the completion of cleanup action construction include supplemental investigations such as the Log Pond Fill Area soil investigation conducted in 2016 (further described in the K Ply 2023 Annual Progress Report; Floyd|Snider 2024), long-term soil monitoring conducted every 5 years, and bioremediation applications to treat groundwater. No soil monitoring activities were conducted in 2024; refer to previous progress reports for additional information on soil monitoring activities.

The need for active bioremediation of groundwater is evaluated annually under an adaptive treatment plan, as described in Section 3.7.4 of the Engineering Design Report (EDR; Floyd|Snider 2015b). The following section summarizes the post-remediation bioremediation treatment completed to date, which is used in conjunction with the 2024 groundwater data discussed in Section 2.1.2, to provide recommendations for future bioremediation treatment options.

1.2.1 In Situ Groundwater Treatment

One year after the initial groundwater treatment applications conducted in 2016 (described in Section 1.1.1), groundwater was assessed to have low to high concentrations of contaminants and low dissolved oxygen (DO) that would not be conducive to aerobic degradation. Groundwater conditions have remained anaerobic to date. Per Table 3.2 in the EDR, additional bio-amendments with sulfate (as electron acceptors) to Site groundwater were injected to support anaerobic degradation of contaminants. In November 2017, two targeted areas around PP-14R and PP-37R were injected with activated carbon amended with magnesium sulfate to control plume migration. In conjunction with these carbon injections, bio-amendment applications consisting of magnesium sulfate and seawater injections into upland IGs began in 2017 and reoccurred every 3 to 6 months until October 2019 to promote anaerobic degradation of benzene under sulfate-reducing conditions. A summary of the bio-amendment applications to date is included in Table 1.1.

Table 1.1
Summary of Bio-Amendments

Date	Bio-Amendment	Location Applied (Figure 1.1)
November 2017	$MgSO_4$ injection, 3,500 pounds (17% solution) with 2,000 gallons chase water per IG	Area 6: IGs 3, 4, and 5
	$MgSO_4$ (400 pounds total) and activated carbon (1,200 pounds total) slurry direct injected via Geoprobe	Vicinity of PP-37R and PP-14R
	Land spread $CaSO_4$, 8,000 pounds	Area 5
April 2018	Land spread $CaSO_4$, 8,000 pounds	Excavation footprint
July 2018	Injected 30,000 gallons of seawater followed by 2,000 gallons chase water per IG	IGs 4 and 5
January 2019	Injected 20,000 gallons of seawater followed by 1,000 gallons chase water per IG	IGs 2, 3, 4, and 5
April 2019		
July 2019		
October 2019		

Abbreviations:
$CaSO_4$ Calcium sulfate
$MgSO_4$ Magnesium sulfate

No bio-amendment applications were made to the Site between 2020 and 2024 to allow the aquifer to recover to a state of equilibrium and to gauge the effectiveness of the bio-amendment process on groundwater conditions. Current groundwater conditions are discussed in Section 2.1, but in general, the groundwater concentrations of contaminants of concern (COCs) have decreased substantially since active remediation was completed in 2016.

1.3 AGREED ORDER ACTIVITIES COMPLETED IN 2024

Activities completed during the 2024 monitoring period presented in this Annual Progress Report include the 20th and 21st rounds of post-remediation groundwater monitoring, which represent 8 years of post-remediation groundwater monitoring data. Groundwater samples were collected in April 2024 and October 2024 from 14 wells in the long-term monitoring network in accordance with the Ecology-approved Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP; Appendix G of the EDR; Floyd|Snider 2015b).

1.4 SITE REDEVELOPMENT ACTIVITIES

In 2024, the Port began construction activities to support redevelopment of the K Ply Site into a Marine Trades Industrial Park. Redevelopment activities are approximately 90% complete and include the following:

- Required backfilling and grading in Areas 5 and 6 was completed with dredge spoils from Terminal 3, which meet the criteria for reuse as shallow grading material as described in the EDR (Floyd|Snider 2015b). Placement of the dredge spoils at the Site

was completed in accordance with the Ecology-approved reuse plan of Terminal 3 dredge material, as documented in the Dredged Material Management memorandum for the separate Terminal 3 project (Floyd|Snider 2020)

- Installing utilities (underground water, sewer, electrical, and stormwater conveyance)
- Installing stormwater treatment

In 2025, the following remaining redevelopment activities will be completed during the dry season:

- Altering the stick-up monitoring well monuments to be flush with the new surface grade
- Additional paving in select areas

As a best management practice, and in conjunction with the 2024 redevelopment activities, the Port requested to decommission upgradient monitoring wells that are not included in the K Ply Site long-term groundwater monitoring plan well network, including MW-8, MW-23, PP-7, and PP-23. Ecology approved decommissioning these wells under the condition that they be sampled for K Ply COCs prior to decommissioning to evaluate current conditions in this area and provide additional data while Ecology evaluates whether any additional upgradient contaminant sources may still exist (Groven 2024).

During the April 2024 compliance monitoring event, monitoring well MW-8, located southwest of the K Ply Site, was sampled and resulted in non-detect concentrations of GRO, ORO, and BTEX. Diesel-range organics (DRO) at MW-8 was detected at 207 µg/L, less than the Site CUL of 500 µg/L. The laboratory noted that the detected concentrations were likely a result of weathered unresolved petroleum compounds or organic material. MW-8 was originally installed for the Marine Trades Area (MTA) Site but is no longer used for either the MTA or K Ply monitoring programs and will be decommissioned in 2025. Analytical results from MW-8 were submitted to Ecology's Environmental Information Management (EIM) database in December 2024.

During the April 2024 compliance monitoring event, the monitoring well PP-7 was found to have LNAPL, and therefore, a groundwater sample was not collected from this well. Soil and groundwater sampling conducted during the RI between K Ply and the Peninsula Fuels property indicated there was a zone of GRO and DRO contamination on the southern half of the Peninsula Fuels property that was distinct from the GRO contamination associated with the K Ply Site (Floyd|Snider 2015a). The LNAPL observed in PP-7 appeared to be consistent with elevated total petroleum hydrocarbons (TPH) concentrations in soil and groundwater on the upgradient-adjacent Peninsula Fuels property, which is currently owned and being redeveloped by Platypus Marine, Inc. The property is enrolled in Ecology's Voluntary Cleanup Program (VCP project number: SW1425). Ecology requested that this well not be decommissioned.

Neither MW-23 nor PP-23 were found, Ecology determined that these monitoring wells were likely decommissioned ahead of redevelopment of the upgradient former Peninsula Fuels property. Ecology informed the Port that it will coordinate the well decommissioning documentation with the property owner.

2.0 Groundwater Compliance Monitoring

Groundwater monitoring is conducted per the schedule identified in the AO to ensure that residual soil contamination does not pose a risk to the surface water in Port Angeles Harbor via leaching of contaminants to groundwater and migration of contaminated groundwater to surface water. This section presents the groundwater monitoring results from the April 2024 and October 2024 monitoring events. Except where deviations are noted, the field methods used were conducted in accordance with the SAP/QAPP (Appendix G of the EDR; Floyd|Snider 2015b). The groundwater data from these monitoring events were loaded to Ecology's EIM database in October 2024 and December 2024. Notification of acceptance of the data into the EIM database has not yet been received for either data set.

The following sections present the results of monitoring for Site groundwater COCs compared to CULs. The Site groundwater COCs are GRO, DRO, ORO, and benzene.

2.1 SEMIANNUAL GROUNDWATER COMPLIANCE MONITORING RESULTS

The list of long-term monitoring wells includes 4 CPOC wells (PP-17, PP-18R2, PP-19, and PP-34) and 10 performance monitoring wells (PP-13R, PP-14R, PP-15R2, PP-27, PP-29, PP-30, PP-32, PP-33, PP-36, and PP-37R) within the larger excavation areas (Areas 5 and 6) of the Site. Monitoring well locations are shown in Figure 1.1. Groundwater samples were collected from the 14 wells within Areas 5 and 6 on April 17 and April 18, 2024, and October 10, 2024, using standard low-flow sampling methods. Purge water was collected and placed in a 55-gallon drum stored on-site for profiling and off-site disposal in accordance with applicable laws by Clean Harbors as industrial wastewater. All compliance monitoring samples were analyzed according to the Ecology-approved plans. All samples were analyzed for GRO; DRO; ORO; and benzene, toluene, ethylbenzene, and xylenes (BTEX). Additionally, select samples were analyzed for MNA parameters including sulfate, nitrate, iron, and manganese.

Water quality parameters, including specific conductivity, pH, DO, oxidation–reduction potential (ORP), temperature, and turbidity, were field monitored during sampling of all wells using a YSI Pro DSS water quality meter and a LaMotte turbidity meter. Field parameters are presented in Table 2.1. Elevated pH ranging between 8.01 and 11.94 measured at certain locations (PP-13R, PP-14R, PP-17, PP-27, PP-30, PP-34, and PP-36) are a result of the crushed concrete backfill placed throughout the excavation area, which is expected to neutralize over time. In general, groundwater at the Site has anaerobic/reducing geochemical qualities, such as low DO and negative ORP. There are some seasonal variations in DO and ORP measurements that are likely influenced by tides and stormwater infiltration.

2.1.1 Data Quality

As described in the SAP/QAPP (Appendix G of the EDR; Floyd|Snider 2015b), a Compliance Screening (Stage 2A) data quality review was performed on TPH, volatile organic compounds, and sulfate data resulting from laboratory analysis. The analytical data were reviewed and validated

using guidance and quality control criteria documented in the RI/FS Work Plan SAP/QAPP (Floyd|Snider 2013), the National Functional Guidelines for Organic Superfund Methods Data Review (USEPA 2020a), and the National Functional Guidelines for Inorganic Superfund Methods Data Review (USEPA 2020b).

A total of 15 groundwater samples and 1 field duplicate from the April 2024 groundwater sampling event were submitted to Fremont Analytical in Seattle, Washington, under one sample delivery group (SDG): 2404343. A total of 14 groundwater samples, 1 field duplicate, and 1 trip blank from the October 2024 groundwater sampling event were submitted to Alliance Technical Group (ATG; formerly Fremont Analytical) in Seattle, Washington, under SDG 2410263. All SDGs were submitted for chemical analysis by NWTPH-Dx with and without silica-gel cleanup, NWTPH-Gx, USEPA 8260D, and USEPA 300.0. Select samples from SDG 2404343 were also submitted for metals analysis by USEPA 6020B.

Based on each data quality review, all data are determined to be of acceptable quality for use as reported or qualified.

2.1.2 Groundwater Analytical Results within Areas 5 and 6

Analytical results for the 2024 post-remediation groundwater compliance monitoring are presented in Table 2.2 and on Figures 2.1 through 2.6. The 2024 groundwater results are discussed separately by contaminant group: GRO, DRO, ORO, and benzene. For reference, the cumulative post-remediation groundwater monitoring results from 2016 to 2024 are presented in Table A.1[1] for all COCs and Table A.2 for all monitored geochemical parameters (Appendix A).

2.1.2.1 Gasoline-Range Organics

The most recent GRO concentrations in groundwater at Site wells from April and October 2024 are presented in Figures 2.1a and 2.1b, respectively. Figure 2.2 graphically presents all post-remediation GRO concentrations in CPOC wells since 2016.

GRO concentrations in groundwater at the CPOC have generally decreased or remained stable since the 2023 sampling events. For both 2024 monitoring events, GRO concentrations in and around the CPOC were less than the CUL of 800 µg/L, with concentrations ranging from non-detect (at a reporting limit of 50.0 µg/L) to 249 µg/L, at all four CPOC wells (PP-17, PP-18R2, PP-19, and PP-34) and PP-37R immediately upgradient of the CPOC.

GRO concentrations in other site monitoring wells are less than the CUL of 800 µg/L except at PP-15R2, PP-27, and PP-36. GRO concentrations at performance wells PP-15R2, PP-27, and PP-36 ranged between 828 µg/L and 3,660 µg/L and are generally stable with some seasonal variability. These performance wells are located in Area 5, where residually contaminated soil with

[1] In October 2021, the laboratory shifted the reporting of DRO and ORO concentrations based on carbon chains to quantification based on the chromatographic pattern and the conceptual site model of residual diesel fuel in soil. ORO concentrations reported in 2016 through April 2021 (Table A.1) are more consistent with a weathered diesel product rather than heavy oil (ORO).

concentrations greater than CULs (but less than remediation levels of 3,000 mg/kg) was left in place in the smear zone, so some groundwater exceedances are anticipated. However, the site-wide GRO concentrations continue to slowly decline relative to pre-remediation concentrations, and the GRO CUL is being achieved at the other performance wells and at the CPOC, indicating that attenuation is occurring as anticipated.

2.1.2.2 Diesel-Range Organics

The most recent DRO concentrations in groundwater at Site wells from April and October 2024 are presented in Figures 2.3a and 2.3b, respectively. Figure 2.4 graphically presents all post-remediation DRO concentrations in CPOC wells since 2016 (quantified by the laboratory as ORO between 2016 and April 2021 and quantified as DRO beginning in October 2021).

DRO concentrations in groundwater continue to be relatively stable with seasonal variability observed since remediation was completed in 2016. DRO concentrations measured in groundwater from CPOC well PP-19 continued to be less than the Site CUL of 500 µg/L. Groundwater samples from the other three CPOC wells (PP-17, PP-18R2, and PP-34) consistently demonstrate exceedances of DRO with concentrations measured in 2024 ranging from 529 µg/L to 1,810 µg/L, or approximately 1.1 to 3.6 times the Site CUL. Additionally, DRO exceedances in upgradient performance monitoring wells range from 571 µg/L to 3,860 µg/L.

The use of silica gel cleanup on these samples site-wide results in a significant decrease in DRO concentrations, with an average decrease of 76% for all 2024 results. Silica gel cleanup on the CPOC well samples resulted in DRO concentrations less than the CUL at all four CPOC wells during both monitoring events (refer to Table 2.2). Upgradient performance monitoring wells PP-15R2 and PP-36 were the only two locations where DRO concentrations remained greater than the CUL with silica gel cleanup. DRO concentrations with silica gel cleanup at these locations ranged from 737 µg/L to 906 µg/L. ATI additionally noted that these detections were biased high due to overlap with gasoline-range organics.

The DRO concentrations with silica gel cleanup are a line of evidence that despite stable DRO concentrations, diesel-range compounds are degrading, and continued exceedances of DRO represent a mix of weathered diesel, fuel metabolites, and naturally occurring organics in the aquifer.

2.1.2.3 Oil-Range Organics

ORO concentrations resulting from hydraulic oil in groundwater comply with the Site CUL of 500 µg/L at the CPOC and all upgradient performance monitoring wells. In both April and October 2024, ORO was not detected in any monitoring well. This is consistent with previous results and the RI findings that ORO was not detected in most groundwater samples from the southern portion of the former mill building (Area 5) or in the northern portion of the former mill building and bulkhead (Area 6; Floyd|Snider 2015a). Because ORO was not detected in any monitoring wells in 2023, there is no figure depicting ORO results in groundwater.

2.1.2.4 Benzene

The most recent benzene concentrations in groundwater at Site wells from April and October 2024 are presented in Figures 2.5a and 2.5b, respectively. Figure 2.6 graphically presents all post-remediation benzene concentrations in CPOC wells since 2016.

The 2024 benzene concentrations measured in all four CPOC wells (PP-17, PP-18R2, PP-19, and PP-34) are all less than the site-specific CUL of 51 µg/L and have been less than the CUL during the past 4 years of monitoring. Benzene concentrations in groundwater across the Site have steadily decreased since 2016, and the overall plume footprint continues to shrink with some seasonal variability. The only 2024 benzene exceedances were measured at upgradient site monitoring well PP-15R2, with concentrations of 187 and 239 µg/L in April and October, respectively. However, these concentrations at PP-15R2 have decreased by about 80% since their respective measurements in 2023. Upgradient wells are expected to continue to have benzene results that exceed the CUL due to residual source mass in soil in Area 5 that is contributing to elevated groundwater concentrations. Benzene concentrations at the CPOC have remained less than the CUL since 2020, demonstrating that upgradient exceedances are successfully attenuating before reaching the CPOC and cleanup standards are being met.

In the 2023 Annual Progress Report, benzene concentrations at PP-13R, PP-14R, and PP-37R near the downgradient edge of the benzene plume were noted to be elevated (refer to Table A.1), indicating a potential rebound downgradient of the in situ treatment areas. Because of this increase, additional groundwater analyses were conducted in 2024 to re-baseline geochemical conditions of the aquifer and to evaluate the benzene degradation mechanism and bacterial (gene assay) population present near the center of the groundwater benzene plume. The results are presented in a memorandum prepared by Tersus Environmental presented in Appendix B. The gene assay confirmed the presence of sulfate-reducing bacteria (SRB) genes in both PP-14R and PP-15R2, which confirms microbial activity is conducting anaerobic biodegradation at the Site under sulfate-reducing conditions. The anion/metals results are included in Table 2.2 and indicate that electron acceptors, such as sulfate, are present to support anerobic degradation of benzene. Because the elevated concentrations of benzene observed in 2023 were not duplicated in 2024, the temporary increases observed in 2023 are attributed to redevelopment of the upgradient Peninsula Fuels property where ground-disturbing activities and stormwater infiltration likely temporarily remobilized some residual contamination particularly of benzene, which is generally the most mobile portion of petroleum mixtures.

3.0 Groundwater Monitoring Conclusions and Recommendations

The groundwater monitoring results presented in this report confirm the overall effectiveness of remediation in reducing groundwater contamination to meet CULs at the CPOC. The COC concentrations in groundwater are generally stable or decreasing with a few non-exceedance, localized increases upgradient of the CPOC described in this section. The results support the following summary conclusions:

- Post-remediation groundwater COC concentrations are gradually declining across the Site with some seasonal variability.
- Despite some seasonal variability and temporary ground-disturbing activities upgradient in 2023 that temporarily remobilized upgradient COCs, the site-wide data indicate that the GRO and benzene groundwater plumes continue to shrink, with at least 3 consecutive years of data resulting in concentrations less than the Site CULs at the CPOC.
- Hydraulic oil as ORO is not detected and remains in compliance with CULs at the CPOC.
- Weathered diesel as DRO concentrations (and historically quantified with overlap between DRO and ORO) in groundwater have remained generally stable with exceedances of approximately 1.1 to 3.6 times the CUL at the CPOC. DRO results after silica gel cleanup at the CPOC were less than the CUL for the past three monitoring events with results non-detect at PP-18R2 and PP-19. The DRO concentrations with silica gel cleanup are a compelling line of evidence that despite stable DRO concentrations, diesel-range compounds are degrading, and continued exceedances of DRO represent a mix of weathered diesel, fuel metabolites, and naturally occurring organics in the aquifer. Per Ecology's Guidance for Silica Gel Cleanup in Washington State (Ecology 2023), the DRO concentrations with silica gel cleanup are relevant for compliance evaluation because the source of DRO is weathered and there is evidence of natural attenuation.
- Groundwater monitoring is proposed to continue on a semiannual basis for groundwater COCs within the Area 5 and 6 monitoring well network. Groundwater samples with detectable concentrations of DRO will continue to be analyzed with and without silica gel cleanup during the 2025 monitoring events.
- The localized increases of benzene at PP-13R, PP-14R, and PP-37R in 2023 were not duplicated in 2024. SRB populations and the presence of sulfate confirm conditions are satisfactory for anaerobic degradation of benzene. Monitoring of COCs will continue on a semiannual basis, and the need for additional in situ treatment will be evaluated adaptively per the EDR in the next annual report based on the apparent trends observed during 2025.

3.1 OTHER AGREED ORDER REPORTING REQUIREMENTS

Information on other AO reporting requirements include the following:

- Summary of deviations from the approved work plan: At Ecology's request, a groundwater sample was collected from MW-8 in April 2024 prior to planned decommissioning of this monitoring well. MW-8 is not in the Site long-term monitoring plan and has no specified monitoring purpose for the K Ply Site.
- Summary of contacts with representatives of the local community; public interest groups; press; and federal, state, or tribal governments related to the Site cleanup: None.
- Changes in key personnel: None.

3.2 UPCOMING WORK

AO work activities planned during the next work period, ending in December 2025, include the following:

- Groundwater monitoring, which will continue on the Ecology-approved semiannual schedule in spring (April or May) and fall (October or November) 2025.
- Preparation of the 2025 annual groundwater monitoring report to be submitted in January 2026.

Additional Site activities anticipated to occur in 2025 include the following:

- Decommissioning MW-8, as approved by Ecology.
- Additional paving of select areas and altering the stick-up monitoring well monuments to be flush with the new surface grade, as approved by Ecology.

All monitoring well modifications will be completed by a licensed driller per WAC 173-160-420(8).

Design of the K Ply redevelopment plans are not yet final; however, a vapor intrusion assessment is required prior to construction of any buildings per Section VII of the AO. As redevelopment plans are finalized, a vapor intrusion assessment work plan will be coordinated with Ecology for approval. Following any required assessment, the Port will work with Ecology to assess the data for further action.

4.0 References

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2024 Annual Progress Report for the K Ply Site

K Ply Site

Tables

Table 2.1
2024 Groundwater Field Parameters

Field Parameter [1]			Depth to Water	Groundwater Elevation	Specific Conductivity	pH	Dissolved Oxygen	ORP	Temperature	Turbidity
Units			Feet bTOC	Feet NAVD 88	µS/cm	--	mg/L	mV	°C	NTU
Location	Measured Date	Screened Interval (feet bgs)								
PP-13R	4/17/2024	7–17	9.50	5.24	694	9.20	0	-63.6	11.9	3.99
	10/10/2024		9.92	4.82	448	9.83	0.26	-49.5	15.6	3.57
PP-14R	4/17/2024	7–17	10.14	5.43	519	9.08	0.0	-71.1	11.2	0.00
	10/10/2024		10.89	4.68	581	8.01	0.23	-66.1	16.4	0.49
PP-15R2	4/17/2024	7–17	9.74	5.67	758	7.44	0	-150.9	11.7	1.49
	10/10/2024		9.42	5.99	563	7.34	0.23	-112.3	15.6	1.06
PP-17	4/17/2024	5–15	11.37	4.95	774	10.52	0.35	-296.6	12.1	2.37
	10/10/2024		11.55	4.77	656	10.51	0.37	-248.9	15.6	1.56
PP-18R2	4/17/2024	10–20	12.37	4.27	1,368	7.68	0.93	-158.1	11.8	7.27 [2]
	10/10/2024		11.76	4.88	1,112	6.98	0.41	-48.6	13.6	1.52
PP-19	4/17/2024	5–15	11.13	4.51	6,028	7.77	1.25	134.9	12.0	2.94 [2]
	10/10/2024		11.22	4.42	4,167	7.44	0.75	125.8	16.0	0.67
PP-27	4/17/2024	7–17	9.93	5.53	1,080	11.23	0.42	-284.9	11.8	34.5 [2]
	10/10/2024		9.27	6.19	594	10.02	0.28	-233.7	15.3	2.43
PP-29	4/17/2024	7–17	10.35	5.61	869	7.43	0.74	-160.7	12.1	18.2 [2]
	10/10/2024		9.56	6.40	750	6.96	0.33	-98.4	15.5	1.10
PP-30	4/17/2024	7–17	10.28	5.22	867	11.49	0.30	-289.8	12.0	NM [2]
	10/10/2024		10.59	4.91	387	11.44	0.22	-46.6	15.9	1.15
PP-32	4/18/2024	8–18	9.95	5.10	1,649	7.26	0	-108.5	13.0	2.70
	10/10/2024		10.40	4.65	872	7.70	0.19	-153.4	15.8	1.89
PP-33	4/17/2024	7–17	10.10	5.52	1,180	7.33	1.06	-86.5	11.5	0.41
	10/10/2024		9.58	6.04	588	7.24	0.23	-112.3	14.3	1.16
PP-34	4/17/2024	10–20	12.04	4.82	1,937	11.92	0.36	-247.6	12.3	4.56 [2]
	10/10/2024		12.01	4.85	1,606	11.94	0.37	-241.2	15.8	1.59
PP-36	4/18/2024	10–20	10.37	5.72	351	9.80	0.36	-286.8	11.3	9.88 [2]
	10/10/2024		9.89	6.20	408	8.75	0.41	-203.6	14.4	0.94
PP-37R	4/17/2024	10–20	10.67	4.99	1,293	7.42	0	-99.8	12.2	4.42
	10/10/2024		10.96	4.70	1,005	7.09	0.36	-164.9	15.5	3.19

Notes:

1 Field parameters collected with YSI Pro DSS water quality meter and LaMotte 2020t/we turbidity meter.

2 Sample visibly clear. Turbidity measurement likely biased high from instrument drift.

Abbreviations:

bgs Below ground surface
bTOC Below top of casing
°C Degrees Celsius
µS/cm Microsiemens per centimeter
mg/L Milligrams per liter
mV Millivolts
NAVD 88 North American Vertical Datum of 1988
NM Not measured
NTU Nephelometric turbidity units
ORP Oxidation–reduction potential

Table 2.2
2024 Groundwater Analytical Results

Analyte Class		Total Petroleum Hydrocarbons					Benzene, Toluene, Ethylbenzene, and Xylenes				Monitored Natural Attenuation Parameters			
Analyte		Gasoline-Range Organics	Diesel-Range Organics	Diesel-Range Organics (Silica Gel)	Oil-Range Organics	Oil-Range Organics (Silica Gel)	Benzene	Ethylbenzene	Toluene	Xylene (total)	Total Iron	Total Manganese	Nitrate	Sulfate
Cleanup Level		800	500	500	500	500	51	--	--	--	--	--	--	--
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L
Location	Sample Date													
Conditional Point of Compliance Monitoring Wells														
PP-17	4/17/2024	249	**1,550** (1)	94.7 U	142 U	94.7 U	27.7	5.00 U	5.00 U	10.0 U	--	--	--	--
	10/10/2024	171	**1,030** (1,2)	183 (1,2)	143 U	143 U	20.9	1.20	0.518	2.23	--	--	--	98.9
PP-18R2	4/17/2024	99.1 (3)	**831** (1)	95.2 U	143 U	95.2 U	0.340	0.500 U	0.500 U	1.00 U	--	--	--	--
	10/10/2024 (4)	50.0 U	**529** (1)	93.5 U	140 U	140 U	0.314	0.500 U	0.500 U	1.00 U	--	--	--	140
PP-19	4/17/2024	50.0 U	327 (1)	93.9 U	141 U	93.9 U	0.200 U	0.500 U	0.500 U	1.00 U	--	--	--	--
	10/10/2024	50.0 U	324 (1)	101 U	151 U	151 U	0.200 U	0.500 U	0.500 U	1.00 U	--	--	--	--
PP-34	4/17/2024	155 (3)	**1,810 J** (1,2)	94.5 U	142 U	94.5 U	1.19	3.94	0.500 U	3.05	--	--	--	--
	10/10/2024	180	**1,590** (1,2)	328 (1,2)	142 U	142 U	2.44	8.41	0.619	7.21	--	--	--	40.0
Other Site Monitoring Wells														
PP-13R	4/17/2024	50.0 U	**586** (1)	94.9 U	142 U	94.9 U	2.50	5.00 U	5.00 U	10.0 U	--	--	--	--
	10/10/2024	50.0 U	418 (1)	95.6 U	143 U	143 U	4.18	0.500 U	0.500 U	1.00 U	--	--	--	112
PP-14R	4/17/2024	50.0 U	**614** (1)	94.1 U	141 U	94.1 U	7.45	5.00 U	5.00 U	10.0 U	30.0 U	11.0	0.200 U	139
	10/10/2024	50.0 U	**694** (1)	97.7 U	147 U	147 U	5.57	0.500 U	0.500 U	1.00 U	--	--	--	207
PP-15R2	4/17/2024	**3,660** (3)	**3,860 J** (1,2)	**891** (2)	144 U	96.2 U	**187**	136	6.98	18.4	446	239	1.00 U	18.2
	10/10/2024	**2,200**	**2,290** (1,2)	**737** (2)	147 U	147 U	**239**	10.0 U	10.0 U	20.0 U	--	--	--	3.66
PP-27	4/17/2024	**1,220** (3)	**2,760 J** (1,2)	438 (2)	144 U	95.8 U	50.2	46.4	5.00 U	24.2	--	--	--	--
	10/10/2024	**828**	**1,290** (1,2)	425 (2)	144 U	144 U	24.8	35.0	2.14	14.8	--	--	--	--
PP-29	4/17/2024	500 U	**780** (1)	94.6 U	142 U	94.6 U	2.00 U	5.00 U	5.00 U	10.0 U	--	--	--	--
	10/10/2024	50.0 U	**583** (1)	204 (1)	141 U	141 U	0.200 U	0.500 U	0.500 U	1.00 U	--	--	--	--
PP-30	4/17/2024	401 (3)	**1,480 J** (1,2)	194 (2)	143 U	95.6 U	21.7	3.10	0.789	3.01	--	--	--	--
	10/10/2024	347	**1,350** (1,2)	297 (1,2)	145 U	145 U	12.3	3.10	0.703	3.34	--	--	--	--
PP-32	4/18/2024	50.0 U	337 (1)	94.5 U	142 U	94.5 U	3.85	0.500 U	0.500 U	1.00 U	--	--	--	--
	10/10/2024	50.0 U	363 (1,2)	93.9 U	141 U	141 U	5.15	0.500 U	0.500 U	1.00 U	--	--	--	--
PP-33	4/17/2024 (4)	50.0 U	**902** (1)	94.7 U	142 U	94.7 U	1.22	0.500 U	0.500 U	1.00 U	--	--	--	--
	10/10/2024	50.0 U	**571** (1)	94.7 U	142 U	142 U	0.200 U	0.500 U	0.500 U	1.00 U	--	--	--	--
PP-36	4/18/2024	**2,640** (3)	**1,270 J** (1,2)	**906** (2)	144 U	96.1 U	25.4	28.1	5.00 U	10.0 U	--	--	--	--
	10/10/2024	**1,820**	**878** (1,2)	**759** (2)	143 U	143 U	16.3	13.9	0.507	2.27	--	--	--	--
PP-37R	4/17/2024	50.0 U	488 (1)	94.3 U	141 U	94.3 U	0.200 U	0.500 U	0.500 U	1.00 U	506	48.8	1.00 U	12.5
	10/10/2024	50.3	421 (1)	93.6 U	140 U	140 U	23.1	0.500 U	0.500 U	1.00 U	--	--	--	6.17

Notes:

-- Not analyzed or not available.

RED/BOLD Detected concentration that exceeds criterion.

1 Laboratory noted that the chromatographic pattern indicates an unresolved complex mixture, which may be weathered and/or organic material.

2 Laboratory noted that the detection is biased high by overlap with gasoline-range material.

3 Laboratory noted that the detection is due to non-petroleum compounds.

4 A field duplicate was collected. The greatest detected value is reported; in cases where both results were not detected, the lowest reporting limit is given.

Abbreviations:

µg/L Micrograms per liter

mg/L Milligrams per liter

Qualifiers:

J Concentration is estimated but acceptable for most uses.

U Analyte is not detected at the associated reporting limit.

2024 Annual Progress Report for the K Ply Site

K Ply Site

Figures

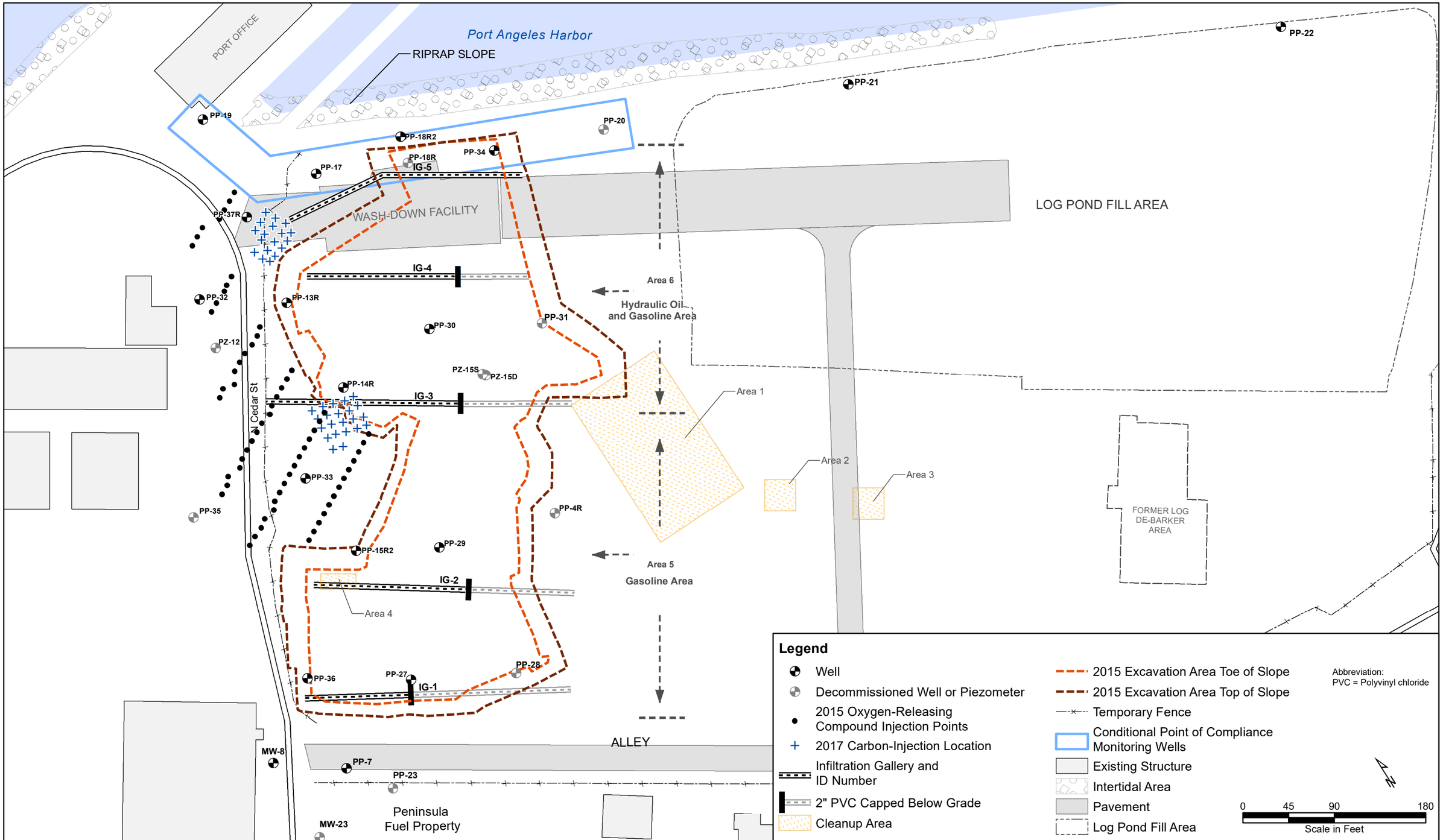

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Figure 1.1
Site Features

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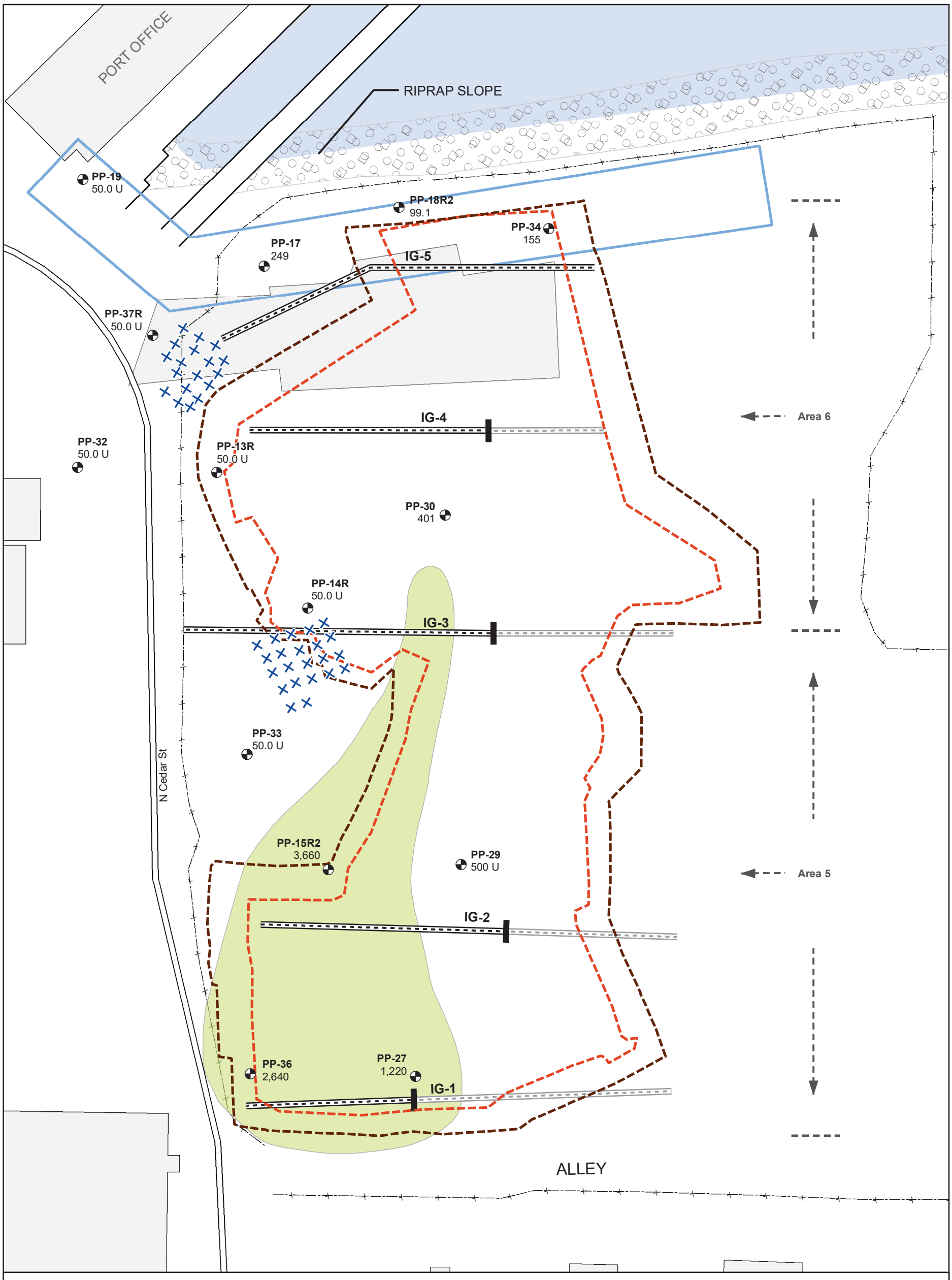
1/23/2025



Legend

- Well
- Carbon-Injection Location
- Infiltration Gallery and ID Number
- 2" PVC Capped Below Grade

Extent of GRO in Groundwater (µg/L)

- >800
- 2015 Excavation Area Toe of Slope
- 2015 Excavation Area Top of Slope
- Conditional Point of Compliance Monitoring Wells
- Temporary Fence
- Existing Structure
- Intertidal Area

Notes:
- All results reported in µg/L.
- Cleanup level is 800 µg/L.
- If duplicate collected, greater concentration reported.
- Results rounded to three significant figures.

Abbreviations:
GRO = Gasoline-range organics
µg/L = Micrograms per liter
PVC = Polyvinyl chloride

Qualifier:
U = Analyte is not detected at the associated reporting limit.

0 30 60 120
Scale in Feet

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Figure 2.1a
April 2024 GRO Concentrations in Groundwater

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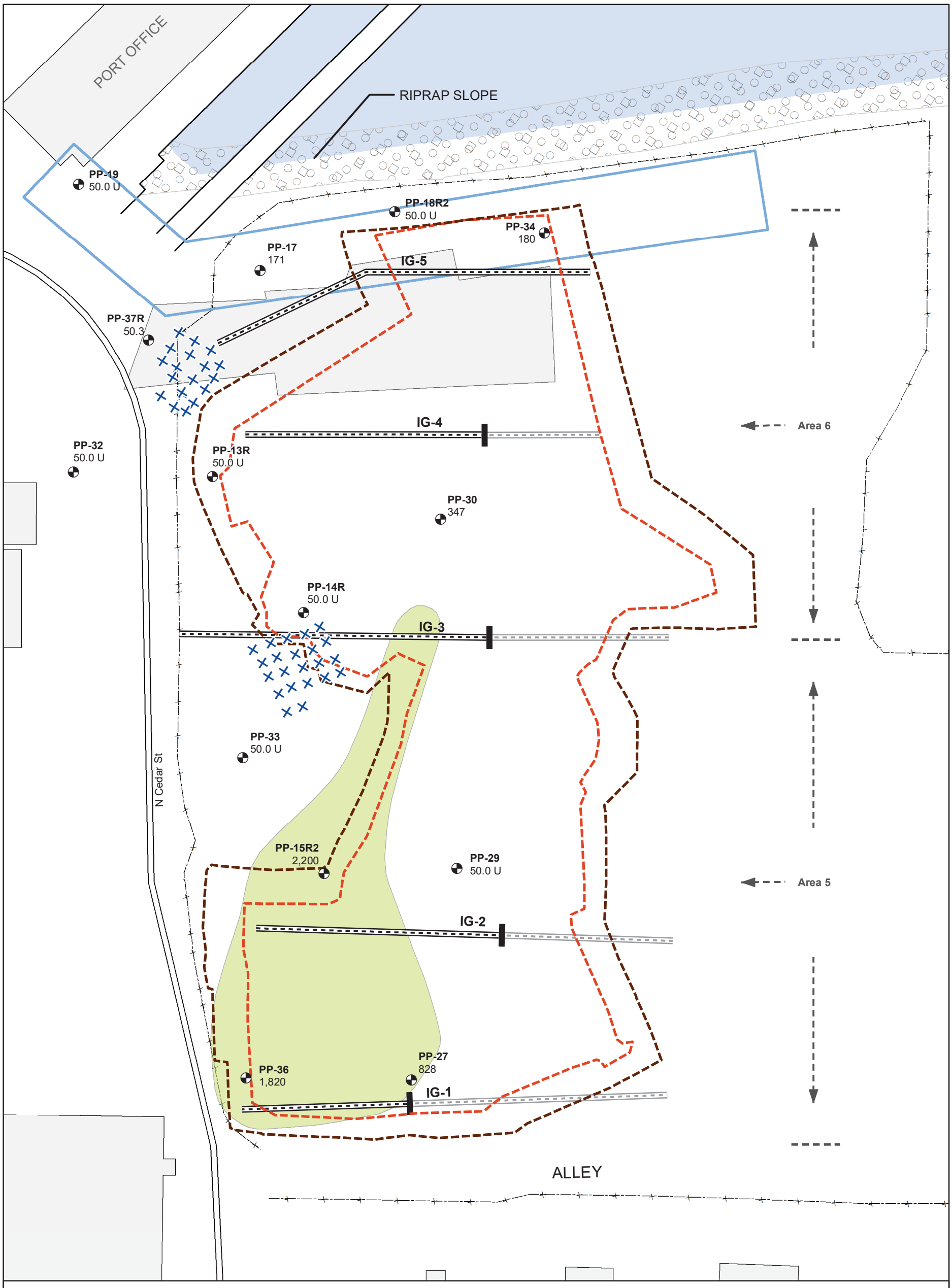
1/9/2025



Legend

- Well
- Carbon-Injection Location
- Infiltration Gallery and ID Number
- 2" PVC Capped Below Grade

Extent of GRO in Groundwater (µg/L)

- >800
- 2015 Excavation Area Toe of Slope
- 2015 Excavation Area Top of Slope
- Conditional Point of Compliance Monitoring Wells
- Temporary Fence
- Existing Structure
- Intertidal Area

Notes:
- All results reported in µg/L.
- Cleanup level is 800 µg/L.
- If duplicate collected, greater concentration reported.
- Results rounded to three significant figures.

Abbreviations:
GRO = Gasoline-range organics
µg/L = Micrograms per liter
PVC = Polyvinyl chloride

Qualifier:
U = Analyte is not detected at the associated reporting limit.

0 30 60 120
Scale in Feet

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Figure 2.1b
October 2024 GRO Concentrations in Groundwater

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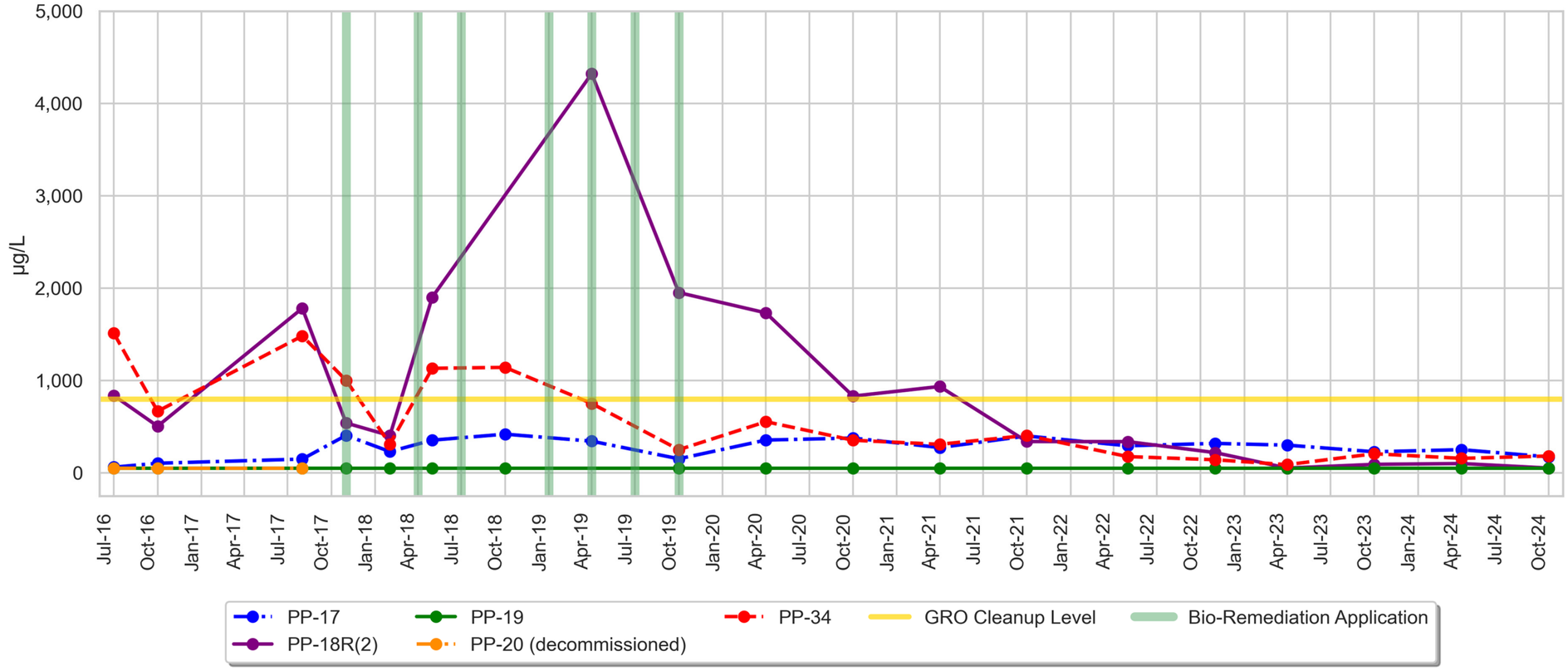
1/9/2025



Abbreviations:
CPOC = Conditional point of compliance
GRO = Gasoline-range organics
µg/L = Micrograms per liter

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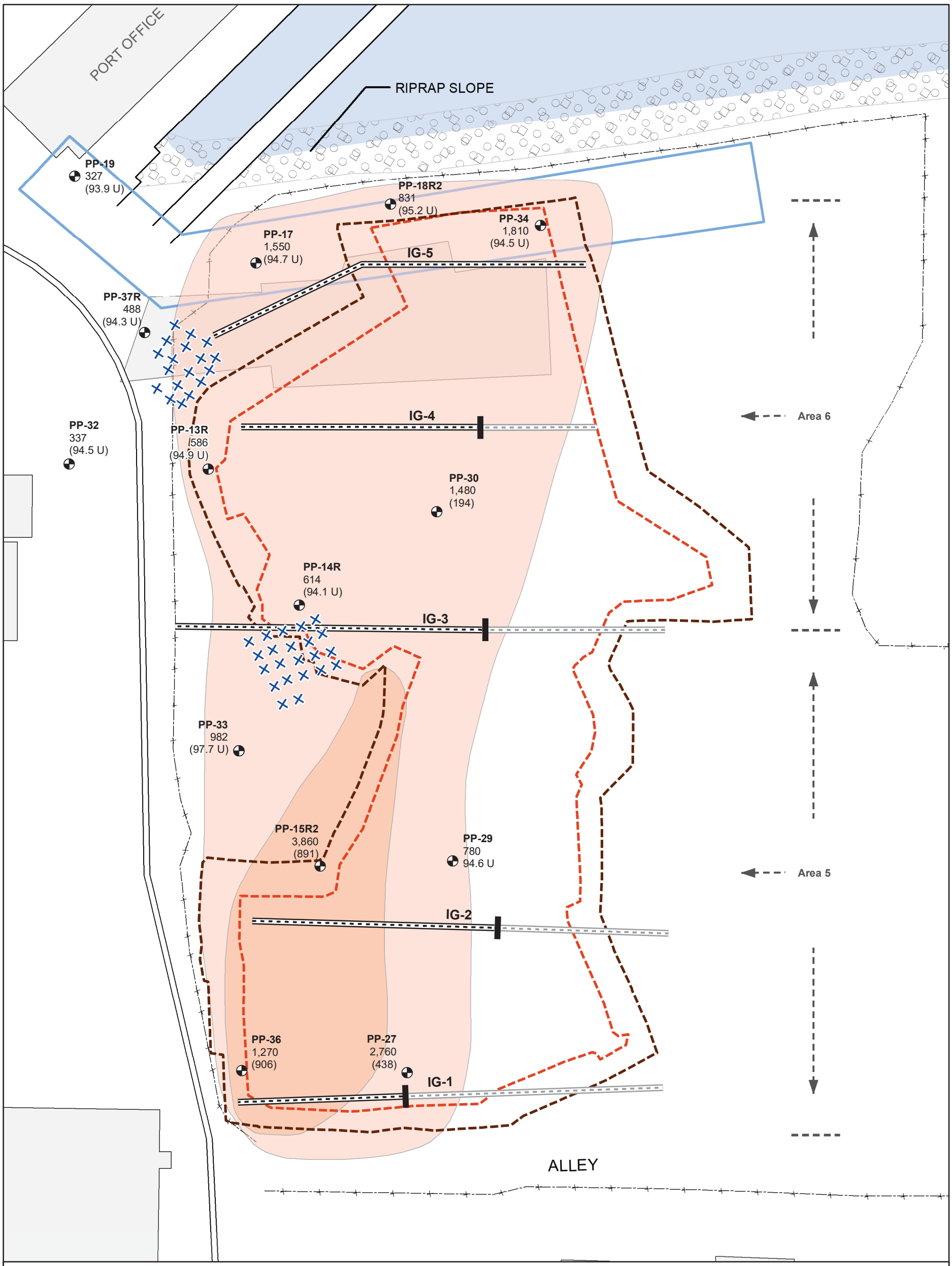
Figure 2.2
Post-Remediation CPOC
GRO Concentrations in Groundwater

1/10/2025



Legend

- Well
- Carbon-Injection Location
- Infiltration Gallery and ID Number
- 2" PVC Capped Below Grade

Extent of DRO in Groundwater (µg/L)

- >500
- >500 with SGC

- 2015 Excavation Area Toe of Slope
- 2015 Excavation Area Top of Slope
- Conditional Point of Compliance Monitoring Wells
- Temporary Fence
- Existing Structure
- Intertidal Area

Location Label

PP-36 ← Location
878 ← DRO Result
(759) ← DRO Result with SGC

Notes:
- All results reported in µg/L.
- Cleanup level is 500 µg/L.
- If duplicate collected, greater concentration reported.
- Results rounded to three significant figures.

Abbreviations:
DRO = Diesel-range organics
µg/L = Micrograms per liter
PVC = Polyvinyl chloride
SGC = Silica gel cleanup

Qualifier:
U = Analyte is not detected at the associated reporting limit.

0 30 60 120
Scale in Feet

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Figure 2.3a
April 2024 DRO Concentrations in Groundwater

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1/10/2025

PORT OFFICE

RIPRAP SLOPE

PP-19
324
(101 U)

PP-18R2
529
(93.5 U)

PP-17
1,030
(183)

PP-34
1,590
(328)

IG-5

PP-37R
421
(93.6 U)

IG-4

PP-32
363
(93.9 U)

PP-13R
418
(95.6 U)

PP-30
1,350
(297)

PP-14R
694
(97.7 U)

IG-3

PP-33
571
(94.7 U)

PP-15R2
2,290
(737)

PP-29
583
(204)

IG-2

PP-36
878
(759)

PP-27
1,290
(425)

IG-1

Area 6

Area 5

ALLEY

Legend

- Well
- Carbon-Injection Location
- Infiltration Gallery and ID Number
- 2" PVC Capped Below Grade

Extent of DRO in Groundwater (µg/L)

- >500
- >500 with SGC

- 2015 Excavation Area Toe of Slope
- 2015 Excavation Area Top of Slope
- Conditional Point of Compliance Monitoring Wells
- Temporary Fence
- Existing Structure
- Intertidal Area

Location Label

PP-36 ← Location
878 ← DRO Result
(759) ← DRO Result with SGC

Notes:
- All results reported in µg/L.
- Cleanup level is 500 µg/L.
- If duplicate collected, greater concentration reported.
- Results rounded to three significant figures.

Abbreviations:
DRO = Diesel-range organics
µg/L = Micrograms per liter
PVC = Polyvinyl chloride
SGC = Silica gel cleanup

Qualifier:
U = Analyte is not detected at the associated reporting limit.

0 30 60 120
Scale in Feet

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Figure 2.3b
October 2024 DRO Concentrations in Groundwater

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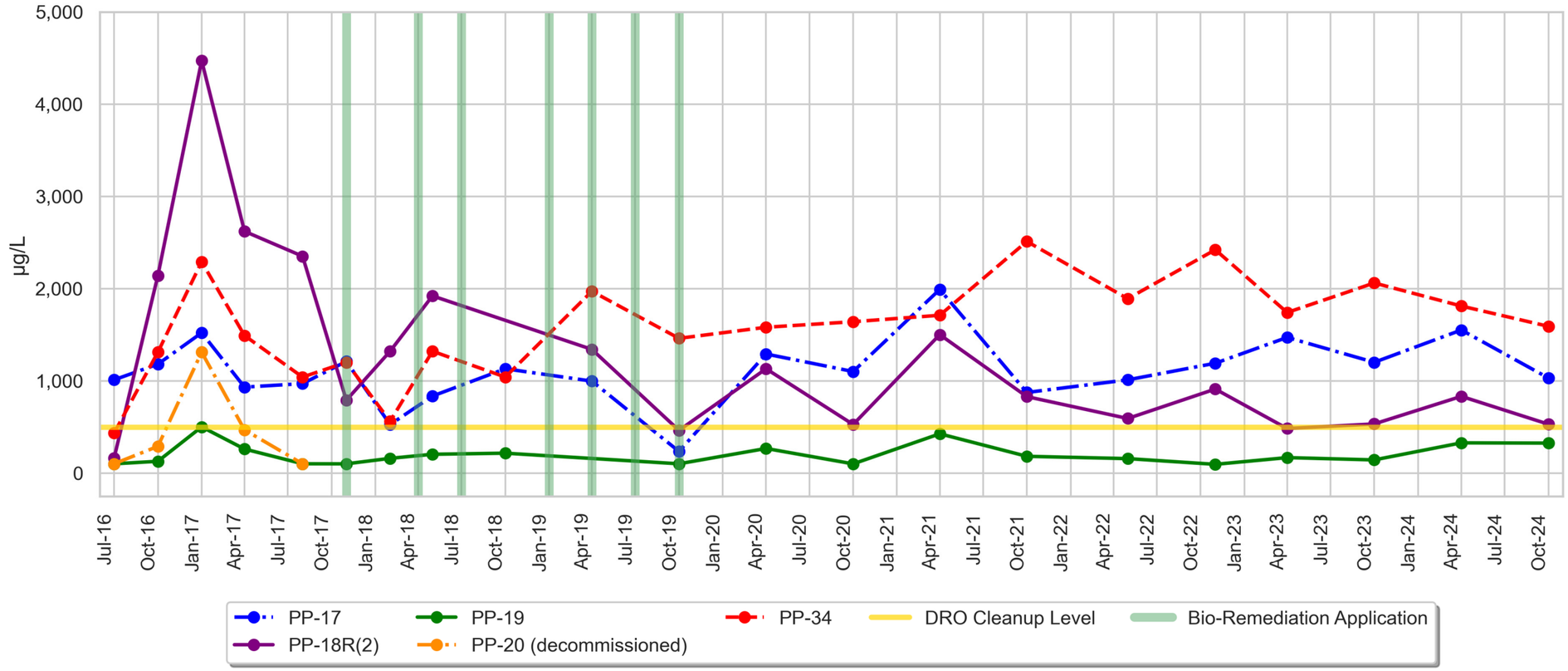
1/10/2025



Abbreviations:
CPOC = Conditional point of compliance
DRO = Diesel-range organics
µg/L = Micrograms per liter

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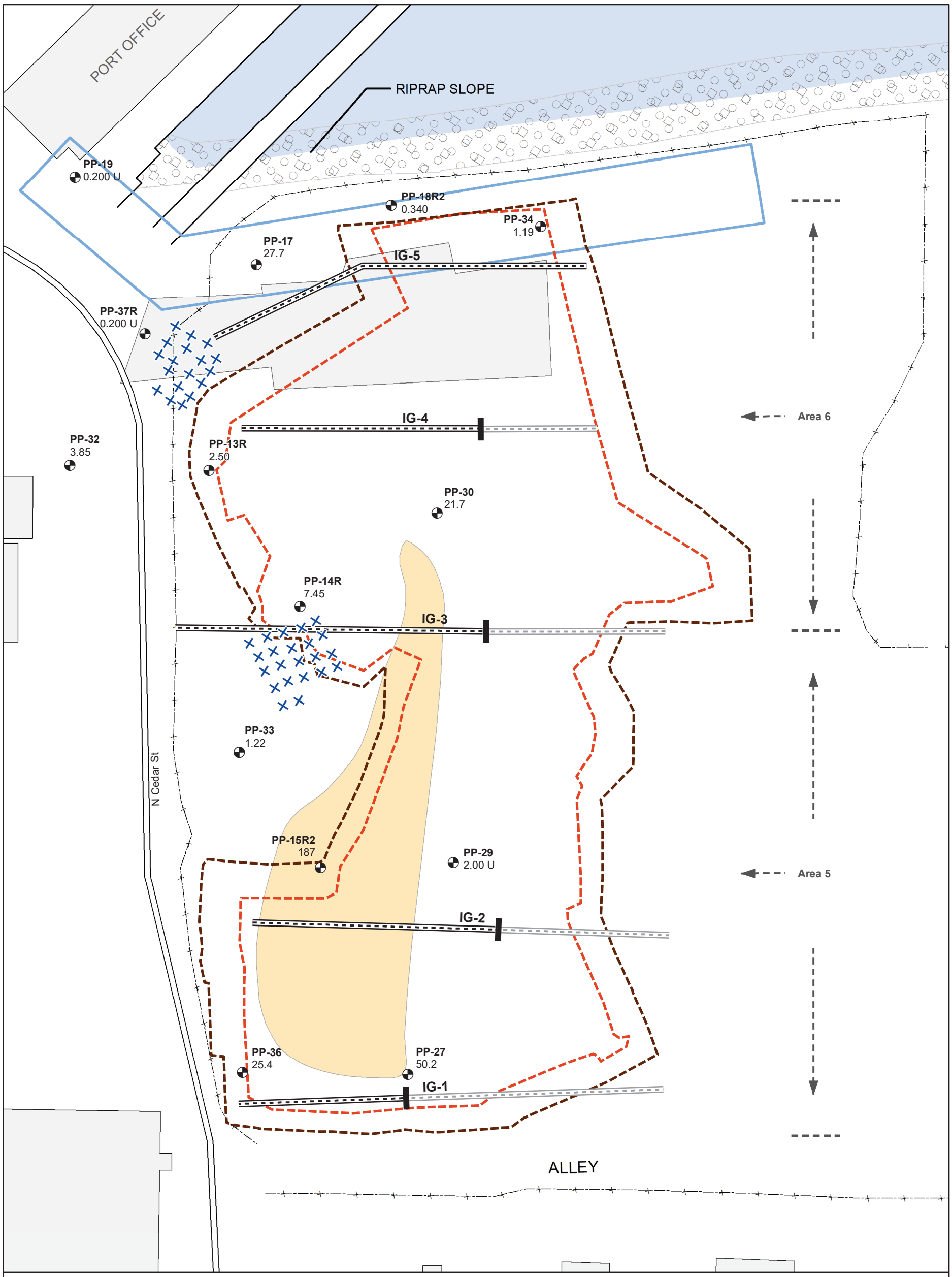
Figure 2.4
Post-Remediation CPOC
DRO Concentrations in Groundwater

1/10/2025



Legend

- Well
- Carbon-Injection Location
- Infiltration Gallery and ID Number
- 2" PVC Capped Below Grade

Extent of Benzene in Groundwater (µg/L)

- >51
- 2015 Excavation Area Toe of Slope
- 2015 Excavation Area Top of Slope
- Conditional Point of Compliance Monitoring Wells
- Temporary Fence
- Existing Structure
- Intertidal Area

Notes:
- All results reported in µg/L.
- Cleanup level is 51 µg/L.
- If duplicate collected, greater concentration reported.
- Results rounded to three significant figures.

Abbreviations:
µg/L = Micrograms per liter
PVC = Polyvinyl chloride

Qualifier:
U = Analyte is not detected at the associated reporting limit.

0 30 60 120
Scale in Feet

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Figure 2.5a
April 2024 Benzene Concentrations in Groundwater

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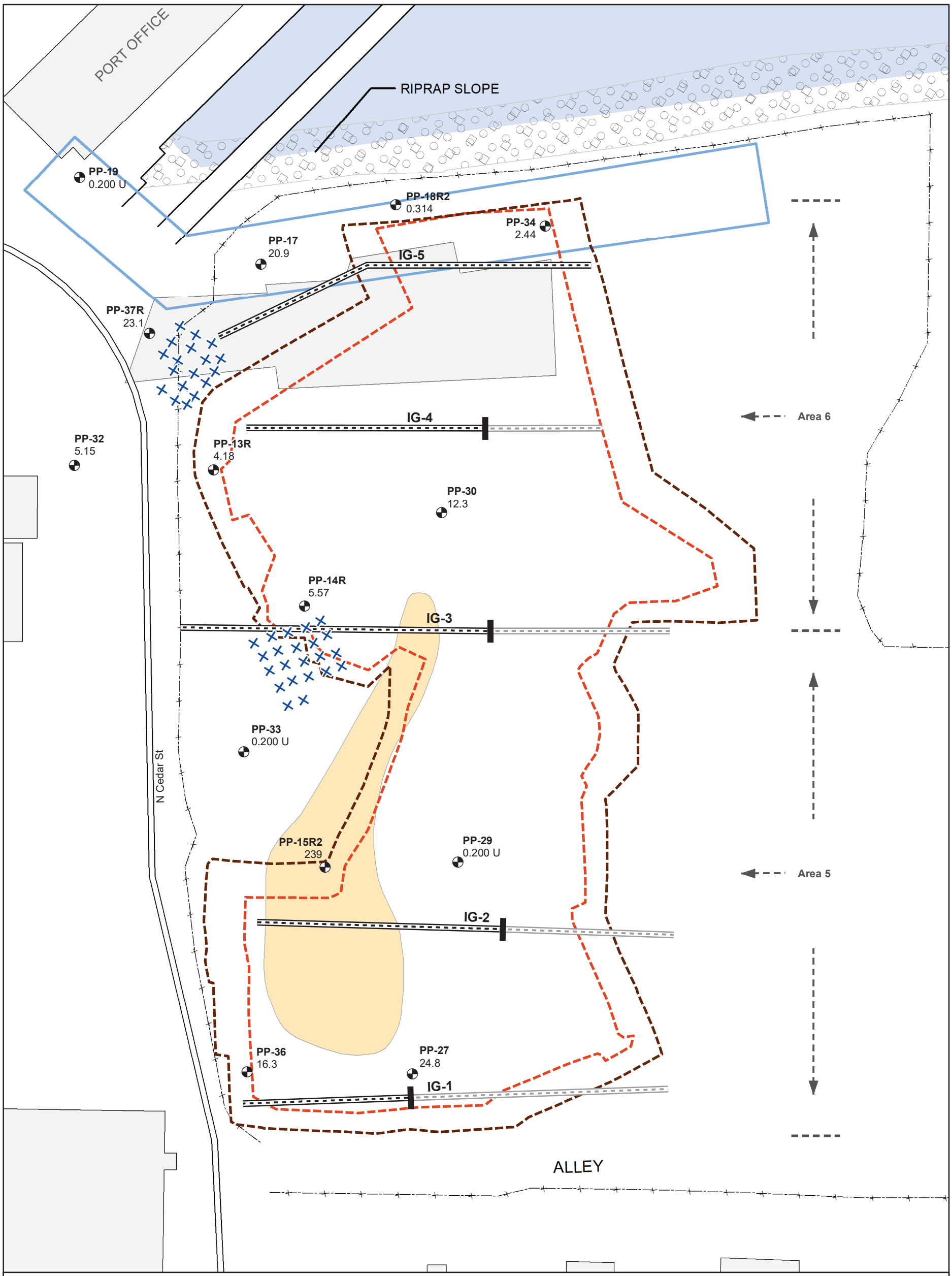
1/9/2025



Legend

- Well
- Carbon-Injection Location
- Infiltration Gallery and ID Number
- 2" PVC Capped Below Grade

Extent of Benzene in Groundwater (µg/L)

- >51
- 2015 Excavation Area Toe of Slope
- 2015 Excavation Area Top of Slope
- Conditional Point of Compliance Monitoring Wells
- Temporary Fence
- Existing Structure
- Intertidal Area

Notes:
- All results reported in µg/L.
- Cleanup level is 51 µg/L.
- If duplicate collected, greater concentration reported.
- Results rounded to three significant figures.

Abbreviations:
µg/L = Micrograms per liter
PVC = Polyvinyl chloride

Qualifier:
U = Analyte is not detected at the associated reporting limit.

0 30 60 120
Scale in Feet

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Figure 2.5b
October 2024 Benzene Concentrations in Groundwater

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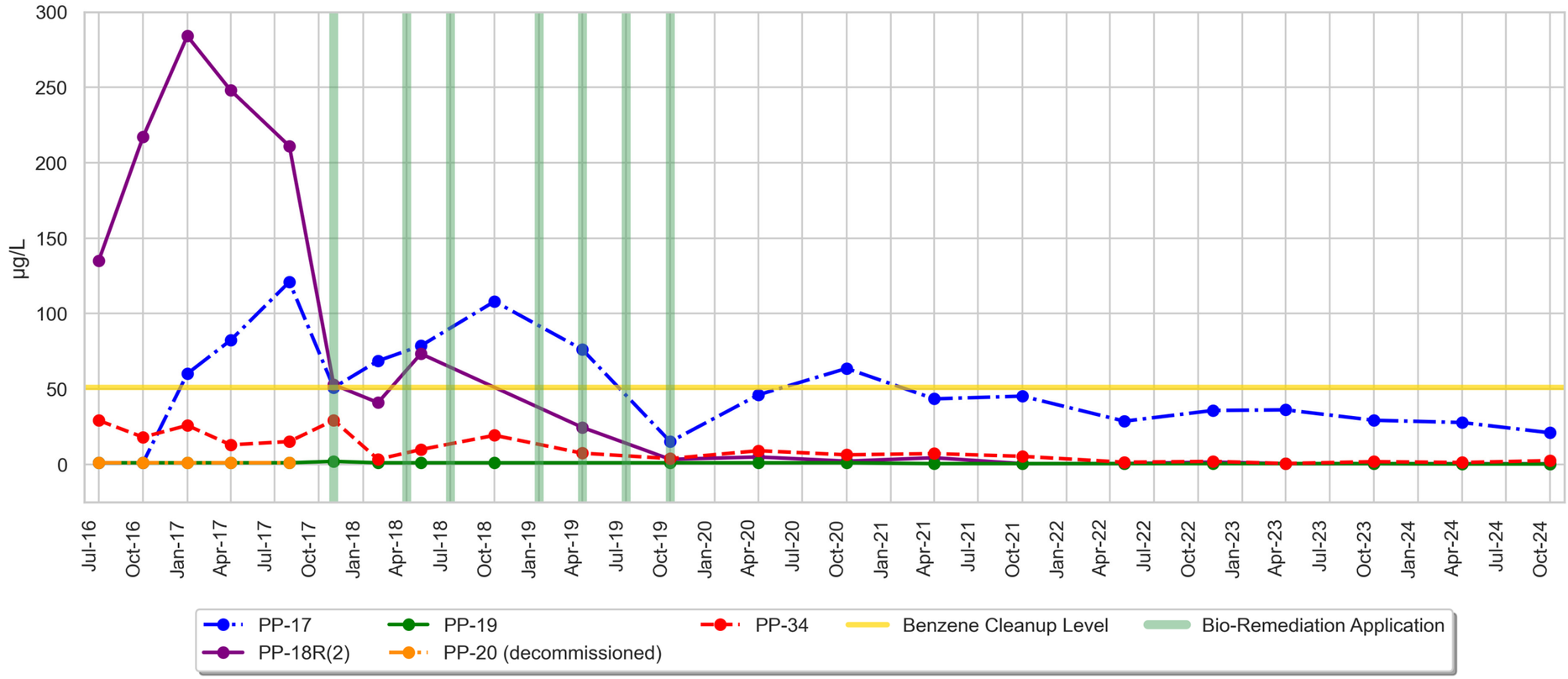
1/9/2025



Abbreviations:
CPOC = Conditional point of compliance
µg/L = Micrograms per liter

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Figure 2.6
Post-Remediation CPOC
Benzene Concentrations in Groundwater

1/10/2025

2024 Annual Progress Report for the K Ply Site

K Ply Site

Appendix A
Cumulative Post-Remediation Groundwater Results (2016 to 2024)

Table A.1
Cumulative Analytical Groundwater Results

Analyte Class	Total Petroleum Hydrocarbons (TPH)						Benzene, Toluene, Ethylbenzene, and Xylenes			
Analyte	Gasoline-Range Organics	Diesel-Range Organics	Diesel-Range Organics (Silica Gel)	Oil-Range Organics[1]	Oil-Range Organics (Silica Gel)	Total TPH (DRO + ORO)	Benzene	Ethylbenzene	Toluene	Xylene (total)
Unit	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Criteria	800	500	500	500	500	500	51.0	--	--	--
Sample Location and Date										
Conditional Point of Compliance Monitoring Wells										
PP-17 (Screened Interval 5–15 ft)										
3/21/2016	100 U						1.00 U	1.00 U	1.00 U	3.00 U
7/27/2016	59.5	417 J[2]		1,010		1,430 J	1.00 U	1.00 U	1.00 U	1.00 U
10/27/2016	102	257	153	1,180	543	1,440	1.00 U	1.00 U	1.00 U	1.00 U
1/26/2017	195	160	49.8 U	1,520	633	1,680	60.1	1.00 U	1.00 U	1.00 U
4/26/2017	287	167		931		1,100	82.3	1.10	1.09	2.01
8/2/2017	147	135 [2]		969		1,100	121	1.32	1.31	2.33
11/7/2017	404	471		1,210		1,680	50.9	1.00 U	1.00 U	1.23
2/8/2018	228	91.1 [2]		525		616	68.6	1.06	1.00 U	1.39
5/2/2018[3]	352	218 [2]		834		1,050	78.6	1.76	1.07	2.52
10/25/2018	417	354		1,130		1,480	108	2.70	1.04	2.76
4/8/2019	341	49.6 U		996		996	76.2	1.80	1.00 U	2.62
10/22/2019	150	49.8 UJ	49.8 UJ	234 J	178 J	234 J	15.0	1.00 U	1.00 U	1.00 U
4/27/2020[3]	353	158 [2]		1,290		1,450	46.1	1.53	1.00 U	2.70
10/21/2020	375	49.3 U		1,100		1,100	63.6	1.90	1.00 U	3.34
4/21/2021	272	99.5 U		1,990		1,990	43.4	1.68	0.750 U	2.75
10/13/2021	397	873		98.1 U		873	45.2	1.77	0.750 U	2.98
5/4/2022[3]	291	1,010 [2]	651 [2]	93.6 U	93.6 U	1,010	28.6	1.41	0.750 U	2.40
11/10/2022	317	1,190 [2]	194 J[2,4]	94.2 U	94.2 U	1,190	35.7	3.56	1.31	5.52
4/19/2023[3]	298	1,470 [2]	274 J[4]	94.8 U	94.8 U	1,470	36.1	1.84	1.00 U	3.00
10/26/2023	226	1,200 J[2]	229 J	95.1 U	95.1 U	1,200 J	29.2	1.41	1.00 U	2.38
4/17/2024	249	1,550 [2]	94.7 U	142 U	94.7 U	1,550	27.7	5.00 U	5.00 U	10.0 U
10/10/2024	171	1,030 [2, 4]	183 [2, 4]	143 U	143 U	1,030 [2, 4]	20.9	1.20	0.518	2.23
PP-18R2 (Screened Interval 10–20 ft)[5]										
7/28/2016	835	151 J[2]		163		314	135	2.10	2.82	6.69
10/27/2016	503	1,090	406	2,140	1,200	3,230	217	1.31	1.00 U	2.05
1/26/2017	921	494	279	4,470	1,760	4,960	284	11.2	4.32	19.4
4/26/2017	1,130	643		2,620		3,260	248	12.9	4.46	22.6
8/2/2017	1,780	572 J[2]		2,350 J		2,920	211	15.5	3.93	19.8
11/7/2017	538	425		789		1,210	52.8	7.06	1.20	9.74
2/8/2018	401	596 [2]		1,320		1,920	40.9	14.4	1.65	15.7
5/2/2018	1,900	781 [2]		1,920		2,700	73.3	17.8	1.94	20.2
4/8/2019[3]	4,320	50.4 U	50.4 U	1,340	1,120	1,340	24.5	19.8	1.00 U	6.09
10/22/2019	1,950	84.6 J[2]	129 J[2]	462 J	375 J	547 J	3.28	13.4	1.00 U	1.23
4/27/2020	1,730	271 [2]		1,130		1,400	4.87	9.84	1.00 U	1.61
10/21/2020	829	242 [2]		526		768	2.09	7.14	1.00 U	1.00 U
4/21/2021	933	394 [2]		1,500		1,890	4.34	4.20	0.750 U	1.31
10/13/2021	337	828		98.9 U		828	0.440 U	0.400 U	0.750 U	1.00 U
5/4/2022	336 [2]	591 [2]	307 [2]	93.9 U	93.9 U	591	0.485	1.27	0.750 U	1.00 U
11/10/2022	217	910 [2]	172 J[4]	94.7 U	94.7 U	910	1.47	1.02	1.00 U	1.00 U
4/19/2023	50.0 U	482 [2]	93.1 U	93.1 U	93.1 U	482	0.440 U	0.400 U	1.00 U	1.00 U
10/26/2023	89.9	532 J[2]	95.4 U	95.4 U	95.4 U	532 J	0.440 U	0.400 U	1.00 U	1.00 U
4/17/2024	99.1 [2]	831 [2]	95.2 U	143 U	95.2 U	831	0.340	0.500 U	0.500 U	1.00 U
10/10/2024 [3]	50.0 U	529 [2]	93.5 U	140 U	140 U	529 [2]	0.314	0.500 U	0.500 U	1.00 U
PP-19 (Screened Interval 5–15 ft)										
3/21/2016	100 U						1.00 U	1.00 U	1.00 U	3.00 U
7/27/2016	50.0 U	49.9 U		99.7 U		99.7 U	1.00 U	1.00 U	1.00 U	1.00 U
10/27/2016	50.0 U	50.0 U		127		127	1.00 U	1.00 U	1.00 U	1.00 U
1/26/2017	50.0 U	49.8 U	49.8 U	500	248	500	1.00 U	1.00 U	1.00 U	1.00 U
4/26/2017	50.0 U	49.8 U		260		260	1.00 U	1.00 U	1.00 U	1.00 U
8/2/2017	50.0 U	50.0 U		100 U		100 U	1.00 U	1.00 U	1.00 U	1.00 U
11/7/2017	50.0 U	49.7 U		99.4 U		99.4 U	1.96	1.00 U	1.00 U	1.00 U
2/8/2018	50.0 U	50.0 U		159		159	1.00 U	1.00 U	1.00 U	1.00 U
5/2/2018	50.0 U	50.2 U		203		203	1.00 U	1.00 U	1.00 U	1.00 U
10/25/2018	50.0 U	50.0 U		215		215	1.00 U	1.00 U	1.00 U	1.00 U
10/22/2019	50.0 U	49.9 UJ		99.9 UJ		99.9 UJ	1.00 U	1.00 U	1.00 U	1.00 U
4/27/2020	50.0 U	49.9 U		266		226	1.00 U	1.00 U	1.00 U	1.00 U
10/21/2020	50.0 U	49.5 U		99.0 U		99.0 U	1.00 U	1.00 U	1.00 U	1.00 U
4/20/2021	50.0 U	98.5 U		425		425	0.440 U	0.400 U	0.750 U	1.00 U
10/13/2021	50.0 U	181		98.8 U		198 U	0.440 U	0.400 U	0.750 U	1.00 U
5/4/2022	50.0 U	156 [2]	94.9 U	94.9 U	94.9 U	190 U	0.440 U	0.400 U	0.750 U	1.00 U
11/10/2022	50.0 U	166 [2]		94.1 U		188 U	0.440 U	0.400 U	1.00 U	1.00 U
4/19/2023	50.0 U	167 [2]		93.0 U		186 U	0.440 U	0.400 U	1.00 U	1.00 U
10/26/2023	50.0 U	142 J[2]	95.4 U	95.4 U	95.4 U	191 U	0.440 U	0.400 U	1.00 U	1.00 U
4/17/2024	50.0 U	327 [2]	93.9 U	141 U	93.9 U	327	0.200 U	0.500 U	0.500 U	1.00 U
10/10/2024	50.0 U	324 [2]	101 U	151 U	151 U	324 [2]	0.200 U	0.500 U	0.500 U	1.00 U
PP-20 (Screened Interval 8–18 ft) (Decommissioned)										
7/26/2016	50.0 U	50.1 U		100 U		100 U	1.00 U	1.00 U	1.00 U	1.00 U
10/27/2016	50.0 U	50.0 U	92.7	289	177	289	1.00 U	1.00 U	1.00 U	1.00 U
1/26/2017	50.0 U	49.9 U	49.9 U	1,310	454	1,310	1.00 U	1.00 U	1.00 U	1.00 U
4/26/2017	50.0 U	49.8 U		468		468	1.00 U	1.00 U	1.00 U	1.00 U
8/2/2017	50.0 U	50.0 U		100 U		100 U	1.00 U	1.00 U	1.00 U	1.00 U

Table A.1
Cumulative Analytical Groundwater Results

Analyte Class	Total Petroleum Hydrocarbons (TPH)						Benzene, Toluene, Ethylbenzene, and Xylenes			
Analyte	Gasoline-Range Organics	Diesel-Range Organics	Diesel-Range Organics (Silica Gel)	Oil-Range Organics[1]	Oil-Range Organics (Silica Gel)	Total TPH (DRO + ORO)	Benzene	Ethylbenzene	Toluene	Xylene (total)
Unit	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Criteria	800	500	500	500	500	500	51.0	--	--	--
Sample Location and Date										
Conditional Point of Compliance Monitoring Wells (cont.)										
PP-34 (Screened Interval 8–18 ft)										
7/28/2016	1,510	328 J[2]		433		761	29.1	76.3	7.19	132
10/27/2016	665	603	493	1,310	772	1,910	18.0	35.1	3.77	62.6
1/26/2017	1,220	503	348	2,290	688	2,790	25.8	61.8	4.10	88.7
4/26/2017	1,420	357		1,490		1,850	12.9	70.4	3.81	83.9
8/2/2017	1,480	238 [2]		1,040		1,280	15.1	117	5.26	122
11/7/2017[3]	1,000	695		1,200		1,900	29.2	82.6	3.92	86.1
2/8/2018	309	212 [2]		560		772	3.31	15.2	1.00 U	15.0
5/2/2018	1,130	458 [2]		1,320		1,780	9.78	44.6	1.81	45.0
10/25/2018	1,140	417 [2]		1,040		1,460	19.2	60.8	2.30	51.9
4/8/2019	749	50.0 U		1,970		1,970	7.39	29.4	1.38	23.9
10/22/2019	249	90.7 J[2]	105 J[2]	1,460 J	1,030 J	1,550 J	3.79	9.81	1.00 U	6.53
4/27/2020	552	376 [2]		1,580		1,960	9.01	17.4	1.00 U	10.6
10/21/2020	351	114 [2]		1,640		1,750	6.28	20.9	1.00 U	11.6
4/21/2021[3]	307	99.9 U		1,710		1,710	7.09	13.8	0.750 U	8.54
10/13/2021	403	2,510 [6]		98.2 U[6]		2,510	5.28	16.9	0.750 U	10.1
		110 [2,7]	110 [2,7]	250 U[7]	250 U[7]	110				
5/4/2022	174	1,890 [2]	969 [2]	93.7 U	93.7 U	1,890	1.37	5.23	0.750 U	3.30
11/10/2022	140	2,420 [2]	260 J[4]	94.3 U	94.3 U	2,420	1.94	7.56	1.00 U	4.96
4/19/2023	86.5	1,740 [2]	199	95.1 U	95.1 U	1,740	0.522	2.04	1.00 U	1.67
10/26/2023	205	2,060 J[2]	177	94.3 U	94.3 U	2,060 J	1.75	5.90	1.00 U	4.18
4/17/2024	155 [2]	1,810 J[2]	94.5 U	142 U	94.5 U	1,810 J	1.19	3.94	0.500 U	3.05
10/10/2024	180	1,590 [2, 4]	328 [2, 4]	142 U	142 U	1,590 [2, 4]	2.44	8.41	0.619	7.21
Other Site Monitoring Wells										
PP-4R (Screened Interval 8–18 ft) (Decommissioned)										
7/26/2016	2,240	352 J[2]		205 J[2]		557 J	26.6	117	3.64	18.3
10/26/2016	667	125		618		743	6.64	1.00 U	1.00 U	1.00 U
1/25/2017	921	49.7 U		548		548	16.8	7.68	1.00 U	1.11
4/25/2017	3,090	172		728		900	38.6	105	3.80	14.8
8/2/2017	1,070	50.0 U		367		367	22.9	63.8	1.25	1.67
PP-13R (Screened Interval 5–15 ft)										
7/28/2016	4,560	124 J[2]		377		501 J	1.00 U	5.44	24.3	43.2
10/27/2016	340	157		611		768	106	1.00 U	1.96	2.55
1/25/2017	66.5	49.8 U		1,030		1,030	7.43	1.00 U	1.00 U	1.00 U
4/25/2017	1,460	80.7 J		1,060		1,140 J	518	1.31	6.61	4.96
8/2/2017	6,700	156 [2]		518		674	1,730	3.94	26.6	32.9
11/7/2017	7,630	289		481		770	2,150	4.49	28.0	32.9
2/8/2018	159	106 [2]		565		671	39.8	1.00 U	1.00 U	1.43
5/2/2018	1,110	302 [2]		1,150		1,450	358	1.68	6.00	7.48
10/25/2018[3]	546	94.9 [2]		398		483	123	1.00 U	1.54	2.17
4/8/2019	433	50.0 U		684		684	163	1.00 U	1.52	2.07
10/21/2019	1,100	49.7 UJ		646 J		646 J	606	1.00 U	2.50	3.99
4/27/2020	446	122 [2]		975		1,100	209	1.00 U	1.00 U	1.00 U
10/21/2020	250	49.2 U		201		201	80.1	1.00 U	1.00 U	1.00 U
4/21/2021	71.4	99.3 U		909		909	20.8	0.400 U	0.750 U	1.00 U
10/13/2021	93.8	501		99.4 U		501	26.7	0.400 U	0.750 U	1.00 U
5/4/2022	50.0 U	845 [2]	414 [2]	93.3 U	93.3 U	845	2.81	0.400 U	0.750 U	1.00 U
11/11/2022	50.0 U	873 [2]	123 [2]	98.1 U	98.1 U	873	2.81	0.400 U	1.00 U	1.00 U
4/19/2023	50.0 U	501 [2]	164	93.3 U	93.3 U	501	3.27	0.400 U	1.00 U	1.00 U
10/26/2023	50.0 U	405 J[2]	161 J	94.6 U	94.6 U	405 J	18.6	0.400 U	1.00 U	1.00 U
4/17/2024	50.0 U	586 [2]	94.9 U	142 U	94.9 U	586	2.50	5.00 U	5.00 U	10.0 U
10/10/2024	50.0 U	418 [2]	95.6 U	143 U	143 U	418 [2]	4.18	0.500 U	0.500 U	1.00 U
PP-14R (Screened Interval 5–15 ft)										
7/28/2016	4,350	105 J[2]		99.4 U		105 J	1,550	35.7	42.6	51.2
10/27/2016	5,640	90.0		193		283	2,120	20.9	35.1	51.7
1/25/2017	4,140	266		1,440		1,710	1,180	12.7	20.8	20.7
4/25/2017	7,290	60.3		552		612	1,870	15.6	27.7	27.5
8/2/2017	6,480	168 [2]		480		648	1,960	6.51	19.1	19.1
11/7/2017	7,430	185		299		484	2,100	7.67	18.7	20.6
2/8/2018	1,320	249 [2]		710		959	415	2.78	3.60	3.20
5/2/2018	9,690	156 [2]		475		631	1,290	3.42	4.93	4.21
10/25/2018	1,490	282 [2]		674		956	362	1.76	3.07	3.30
4/8/2019	830	49.6 U		141		141	356	1.58	2.67	2.00
10/21/2019	209	49.3 UJ		296 J		296 J	38.4	1.00 U	1.00 U	1.00 U
4/27/2020	375	80.6 [2]		290		371	83.8	1.00 U	1.00 U	1.00 U
10/21/2020	420	56.5 [2]		472		529	105	1.00 U	1.00 U	1.00 U
4/20/2021	78.0	99.2 U		477		518	25.9	0.400 U	0.750 U	1.00 U
10/13/2021[3]	156	1,570 J		99.0 U		1,570 J	24.4	0.400 U	0.750 U	1.00 U
5/4/2022	82.1 [2]	752 J[2]	200 [2]	95.4 UJ	95.4 U	752	9.91	0.400 U	0.750 U	1.00 U
11/10/2022	127	353 [2,4]		94.3 U		353	3.18	0.400 U	1.00 U	1.00 U
4/19/2023	290 [2]	873 [2]	94.8 U	94.8 U	94.8 U	873	115	0.400 U	1.00 U	1.00 U
10/26/2023	635	1,030 J[2]	154 J	94.4 U	94.4 U	1,030 J	260	2.00 U	5.00 U	5.00 U
4/17/2024	50.0 U	614 [2]	94.1 U	141 U	94.1 U	614	7.45	5.00 U	5.00 U	10.0 U
10/10/2024	50.0 U	694 [2]	97.7 U	147 U	147 U	694 [2]	5.57	0.500 U	0.500 U	1.00 U

Table A.1
Cumulative Analytical Groundwater Results

Analyte Class	Total Petroleum Hydrocarbons (TPH)						Benzene, Toluene, Ethylbenzene, and Xylenes			
Analyte	Gasoline-Range Organics	Diesel-Range Organics	Diesel-Range Organics (Silica Gel)	Oil-Range Organics[1]	Oil-Range Organics (Silica Gel)	Total TPH (DRO + ORO)	Benzene	Ethylbenzene	Toluene	Xylene (total)
Unit	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Criteria	800	500	500	500	500	500	51.0	--	--	--
Sample Location and Date										
Other Site Monitoring Wells (cont.)										
PP-15R2 (Screened Interval 5–15 ft)										
7/27/2016	9,940	574 J[2]		526		1,100 J	1.00 U	215	29.7	41.8
10/26/2016	1,040	217		289		506	542 J	106	13.7	33.1
1/25/2017[3]	15,200	1,110		3,640		4,750	622	704	42.9	351
4/25/2017	18,500	501		2,810		3,310	490	912	31.9	520
8/2/2017	7,260	277 [2]		1,520		1,800	1,190	171	11.2	68.6
11/8/2017	4,840	649		1,470		2,120	1,200	48.5	11.6	73.1
2/8/2018	11,600	990 [2]		2,010		3,000	265	887	52.6	234
5/2/2018	10,600	843 [2]		2,190		3,030	1,440	324	18.4	78.9
10/25/2018	3,560	405 [2]		959		1,360	828	21.2	10.0 U	27.6
4/8/2019	7,540	574	499	1,990	1,380	2,560	367	117	10.1	79.8
10/21/2019	6,950	411 J[2]		871 J		1,280 J	1,680	44.6	8.10	40.2
4/27/2020	7,480	447 [2]		2,120		2,570	404	232	15.7	79.9
10/21/2020	5,070	189 [2]		1,530		1,720	809	62.0	5.82	42.0
4/20/2021	6,800	335 [2]		3,210		3,540	456	388	23.7	91.2
10/13/2021	7,660	2,240 [6]		99.0 U[6]		2,240	1,550	70.2	7.15	33.3
		1,600 [2,7]	520 [2,7]	730 [2,7]	250 U[7]	2,330				
5/4/2022	8,870	7,330 [2]	2,930 [2]	96.0 U	96.0 U	7,330	359	482	23.5	130
11/11/2022	8,140	3,110 J[2,4]	1,200 J[4]	95.4 U	95.4 U	3,110 J	502	183	26.1	71.4
4/19/2023	4,590 J[2]	2,680 J[2]	1,090 [4]	92.1 U	92.1 U	2,680 J	921	60.7	13.1	31.7
10/27/2023	3,740	1,420 J[2]	469 J	93.5 U	93.5 U	1,420 J	1,170	8.00 U	20.0 U	20.0 U
4/17/2024	3,660 [2]	3,860 J[2]	891 [4]	144 U	96.2 U	3,860 J	187	136	6.98	18.4
10/10/2024	2,200	2,290 [2, 4]	737 [4]	147 U	147 U	2,290 [2, 4]	239	10.0 U	10.0 U	20.0 U
PP-27 (Screened Interval 5–15 ft)										
7/27/2016	507	90.4 J[2]		257		347 J	64.0	28.0	5.51	27.5
10/26/2016	298	72.4		421		493	19.0	3.97	1.00 U	4.24
1/25/2017	3,810	1,060		2,960		4,020	455	75.1	16.3	80.7
4/25/2017	4,460	744		1,360		2,100	464	130	15.1	86.5
8/2/2017	1,230	120 [2]		323		443	101	31.6	2.80	17.4
11/8/2017	313 J	249		434		683	73.8	17.4	2.02	10.2
2/8/2018	2,060	1,390 [2]		1,330		2,720	240	99.7	11.3	66.2
5/3/2018	1,700	585 [2]		1,090		1,680	136	51.7	4.50	26.0
10/25/2018	428	198 [2]		235		433	27.6	11.2	1.00 U	6.47
4/8/2019	1,710	1,050		405		1,460	95.7	58.8	5.85	38.7
10/21/2019	960	150 J[2]		158 J		308 J	43.2	31.4	1.83	12.1
4/27/2020	1,940	681 [2]		992		1,670	85.1	67.3	6.15	34.9
10/21/2020	1,220	179 [2]		525		704	69.4	46.3	3.42	19.5
4/20/2021	1,740	1,360 [2]		906		2,270	73.6	61.5	5.68	38.1
10/13/2021	1,100	841		98.5 U		841	31.3	31.8	1.60	11.2
5/4/2022	1,810	1,710 [2]	1,170 [2]	93.1 U	93.1 U	1,710	58.1	56.1	4.15	28.0
11/11/2022	1,800	1,780 J[2,4]	547 J[4]	94.6 U	94.6 U	1,780 J	54.0	54.9	4.91	27.3
4/19/2023	1,040	1,750 J[2]	545 [4]	93.6 U	93.6 U	1,750 J	52.6	43.4	3.92	21.5
10/27/2023	1,410	1,760 J[2]	580 J	94.5 U	94.5 U	1,760 J	47.7	49.2	5.00 U	18.6
4/17/2024	1,220 [2]	2,760 J[2]	438 [4]	144 U	95.8 U	2,760 J	50.2	46.4	5.00 U	24.2
10/10/2024	828	1,290 [2, 4]	425 [4]	144 U	144 U	1,290 [2, 4]	24.8	35.0	2.14	14.8
PP-28 (Screened Interval 5–15 ft) (Decommissioned)										
7/27/2016[3]	387	149 J[2]		100 U		149 J	25.7	3.08	1.00 U	2.35
10/26/2016	5,270	1,680		152		1,830	23.4	151	1.31	157
1/25/2017	769	157		615		772	1.00 U	7.44	1.00 U	3.72
4/25/2017	4,500	1,050		100 U		1,050	1.00 U	38.7	1.00 U	16.8
8/2/2017	3,870	546 [2]		99.8 U		546	1,050	48.8	2.05	13.2
11/8/2017	1,750	774		227		1,000	1.00 U	23.5	1.00 U	8.30
2/8/2018	91.7	189 [2]		182		371	1.00 U	1.00 U	1.00 U	1.00 U
5/3/2018	1,740	482		192		674	1.00 U	5.76	1.00 U	1.38
PP-29 (Screened Interval 5–15 ft)										
7/28/2016	4,170	531 J[2]		985		1,520 J	1,480	40.8	14.6	83.9
10/26/2016	160	268 J		402		670 J	35.3	1.00 U	1.00 U	1.00 U
1/25/2017	1,550	174		1,650		1,820	448	13.2	4.97	24.4
4/25/2017[3]	3,180	586		1,750		2,310	878	19.7	6.40	30.6
8/2/2017	752	183 [2]		1,190		1,370	202	4.67	1.53	6.81
11/8/2017	997	646		1,560		2,210	326	5.29	1.85	7.33
2/8/2018	288	387 [2]		664		1,050	55.7	6.12	3.93	15.8
5/3/2018	324	179 [2]		921		1,100	38.9	3.10	1.00 U	5.78
10/25/2018	170	487 [2]		952		1,440	10.9	1.00 U	1.00 U	1.00 U
4/8/2019	145	49.9 U		1,660		1,660	17.9	1.28	1.00 U	1.41
10/21/2019	252	49.2 UJ		836 J		836 J	26.4	1.00 U	1.00 U	1.00 U
4/27/2020	322	112 [2]		1,420		1,530	20.3	4.14	1.00 U	1.00 U
10/21/2020[3]	55.8	93.8 [2]		863		952	1.00 U	1.00 U	1.00 U	1.00 U
4/20/2021	50.0 U	99.7 U		1,400		1,400	4.23	0.400 U	0.750 U	1.00 U
10/13/2021	65.6	1,180 J		98.8 U		1,180 J	0.440 U	0.400 U	0.750 U	1.00 U
5/4/2022	115	1,790 [2]	790 [2]	93.4 U	93.4 U	1,790	7.88	0.753	0.750 U	1.00 U
11/11/2022[3]	55.7	1,130 [2]	112 [2]	101 U	96.7 U	1,130	1.28	0.400 U	1.00 U	1.00 U
4/19/2023	50.0 U	427 [2]	93.1 U	93.1 U	93.1 U	427	0.440 U	0.400 U	1.00 U	1.00 U
10/27/2023	50.0 U	1,210 J[2]	93.7 U	93.7 U	93.7 U	1,210 J	0.440 U	0.400 U	1.00 U	1.00 U
4/17/2024	500 U	780 [2]	94.6 U	142 U	94.6 U	780	2.00 U	5.00 U	5.00 U	10.0 U
10/10/2024	50.0 U	583 [2]	204 [2]	141 U	141 U	583 [2]	0.200 U	0.500 U	0.500 U	1.00 U

Table A.1
Cumulative Analytical Groundwater Results

Analyte Class	Total Petroleum Hydrocarbons (TPH)						Benzene, Toluene, Ethylbenzene, and Xylenes			
Analyte	Gasoline-Range Organics	Diesel-Range Organics	Diesel-Range Organics (Silica Gel)	Oil-Range Organics[1]	Oil-Range Organics (Silica Gel)	Total TPH (DRO + ORO)	Benzene	Ethylbenzene	Toluene	Xylene (total)
Unit	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Criteria	800	500	500	500	500	500	51.0	--	--	--
Sample Location and Date										
Other Site Monitoring Wells (cont.)										
PP-30 (Screened Interval 5–15 ft)										
7/28/2016	2,310	1,210		1,430		2,640	450	61.2	8.89	86.9
10/27/2016	2,980	164		353		517	539	10.1	4.42	39.5
1/25/2017	1,570	1,510		4,330		5,840	139	25.9	4.55	43.6
4/25/2017	1,920	1,040		3,090		4,130	132	37.9	5.92	81.3
8/2/2017	1,460	453 [2]		1,890		2,340	184	26.5	4.15	56.3
11/7/2017	1,280	987		1,640		2,630	229	32.1	4.12	56.3
2/8/2018	862	910 [2]		3,560		4,470	26.7	11.0	1.40	14.2
5/2/2018	2,800	865 [2]		2,530		3,400	99.5	125	4.47	108
10/25/2018	1,640	547 [2]		1,200		1,750	294	22.1	1.52	31.3
4/8/2019	1,180	49.9 U	49.9 U	3,060	1,760	3,060	36.1	44.4	2.74	42.9
10/22/2019	963	167 J[2]	138 J[2]	2,690 J	1,610 J	2,860 J	119	12.6	1.54	15.0
4/27/2020	1,220	668 [2]		2,530		3,200	60.7	19.2	1.44	18.6
10/21/2020	853	394 [2]		2,680		3,070	118	13.6	1.74	16.5
4/21/2021	522	99.5 U		2,420		2,470	37.2	9.68	0.961	8.07
10/13/2021	863	1,580		99.3 U		1,580	31.5	3.96	0.750 U	5.21
5/4/2022	365	704 [2]	755 [2]	94.7 U	94.7 U	704	17.9	3.83	0.750 U	2.80
11/10/2022	353	2,030 J[2,4]	261 J[2,4]	98.6 U	98.6 U	2,030 J	18.5	4.39	1.00 U	7.00
4/19/2023	439	1,510 J[2]	241 [4]	92.9 U	92.9 U	1,510 J	24.0	4.23	1.03	4.67
10/26/2023[3]	651	1,630 J[2]	192	95.4 U	95.4 U	1,630 J	18.0	2.63	1.00 U	3.87
4/17/2024	401 [2]	1,480 J[2]	194 [4]	143 U	95.6 U	1,480 J	21.7	3.10	0.789	3.01
10/10/2024	347	1,350 [2, 4]	297 [2, 4]	145 U	145 U	1,350 [2, 4]	12.3	3.10	0.703	3.34
PP-31 (Screened Interval 5–15 ft) (Decommissioned)										
7/28/2016	356	125 J[2]		234		359 J	1.73	6.47	1.00 U	8.92
10/26/2016	360	72.0		335		407	1.42	2.65	1.00 U	4.05
1/25/2017	97.9	121		853		974	1.00 U	1.15	1.00 U	1.36
4/25/2017	1,580	129		616		745	1.94	41.4	1.57	44.5
8/2/2017	158	72.3 [2]		496		568	1.45	16.1	1.00 U	11.4
PP-32 (Screened Interval 8–18 ft)										
7/28/2016	296	50.0 U		142		142	113	1.00 U	1.00 U	1.00 U
10/27/2016	50.0 U	50.3 U		152		152	2.74	1.00 U	1.00 U	1.00 U
1/26/2017	373	50.0 U		542		542	160	1.00 U	1.00 U	1.00 U
4/26/2017	289	49.8 U		114		114	97.0	1.00 U	1.00 U	1.00 U
8/2/2017	114	49.8 U		99.6 U		99.6 U	80.4	1.00 U	1.00 U	1.00 U
11/8/2017	50.0 U	50.0 U		159		159	40.3	1.00 U	1.00 U	1.00 U
2/8/2018	50.0 U	49.7 U		99.4 U		99.4 U	26.1	1.00 U	1.00 U	1.00 U
5/2/2018	221	49.9 U		175 J		175 J	88.4	1.00 U	1.00 U	1.00 U
10/25/2018	85.1	50.1 U		100 U		100 U	30.1	1.00 U	1.00 U	1.00 U
4/8/2019	50.0 U	49.9 U		271		271	2.37	1.00 U	1.00 U	1.00 U
10/22/2019	95.0	49.4 UJ		146 J		146 J	34.1	1.00 U	1.00 U	1.00 U
4/27/2020	50.0 U	49.6 U		231		231	1.00 U	1.00 U	1.00 U	1.00 U
10/21/2020	50.0 U	49.3 U		332		332	16.2	1.00 U	1.00 U	1.00 U
4/20/2021	50.0 U	98.6 U		414		414	0.440 U	0.400 U	0.750 U	1.00 U
10/13/2021	57.1	347		98.6 U		347	8.86	0.400 U	0.750 U	1.00 U
5/4/2022	50.0 U	187 [2]	92.0 U	92.0 U	92.0 U	187	1.20	0.400 U	0.750 U	1.00 U
11/10/2022	50.0 U	355 [2]		95.8 U		355	8.16	0.400 U	1.00 U	1.00 U
4/19/2023	50.0 U	259 [2]	93.5 U	93.5 U	93.5 U	259	0.440 U	0.400 U	1.00 U	1.00 U
10/27/2023	50.0 U	428 J[2]	96.5 U	96.5 U	96.5 U	428 J	1.64	0.400 U	1.00 U	1.00 U
4/18/2024	50.0 U	337 [2]	94.5 U	142 U	94.5 U	337	3.85	0.500 U	0.500 U	1.00 U
10/10/2024	50.0 U	363 [2, 4]	93.9 U	141 U	141 U	363 [2, 4]	5.15	0.500 U	0.500 U	1.00 U
PP-33 (Screened Interval 5–15 ft)										
7/28/2016	1,560	55.0 J[2]		99.5 U		55.0 J	670	3.90	6.30	4.38
10/26/2016[3]	50.0 U	94.8		140		235	1.00 U	1.00 U	1.00 U	1.00 U
1/25/2017	316	109		520		629	49.6	1.00 U	1.00 U	1.00 U
4/25/2017	442	170		685		855	80.6	1.00 U	1.00 U	1.11
8/2/2017	457	49.8 U		99.6 U		99.6 U	207	1.00 U	1.24	1.03
11/7/2017	50.0 U	146		264		410	20.1	1.00 U	1.00 U	1.12
2/8/2018[3]	1,160	218 [2]		614		832	128	2.09	1.57	1.93
5/3/2018	647	205 [2]		690		895	164	1.00 U	1.10	1.00 U
10/25/2018	81.4	142		302		444	1.00 U	1.00 U	1.00 U	1.00 U
4/8/2019	128	49.9 U		416		416	1.04	1.00 U	1.00 U	1.00 U
10/21/2019	50.0 U	49.4 UJ		254 J		254 J	1.00 U	1.00 U	1.00 U	1.00 U
4/27/2020	50.0 U	68.6 [2]		831		900	1.00 U	1.00 U	1.00 U	1.00 U
10/21/2020	50.0 U	50.0 U		366		366	1.00 U	1.00 U	1.00 U	1.00 U
4/20/2021	50.0 U	98.7 U		1,460		1,460	0.440 U	0.400 U	0.750 U	1.00 U
10/13/2021	50.0 U	663		99.6 U		663	0.440 U	0.400 U	0.750 U	1.00 U
5/4/2022	243 [2]	1,380 [2]	800 [2]	96.9 U	96.9 U	1,380	31.5	1.82	1.37	1.00 U
11/11/2022	50.0 U	801 [2]	94.0 U	94.0 U	94.0 U	801	5.23	0.400 U	1.00 U	1.00 U
4/19/2023	50.0 U	590 [2]	93.0 U	93.0 U	93.0 U	590	0.440 U	0.400 U	1.00 U	1.00 U
10/26/2023	50.0 U	701 J[2]	93.6 U	93.6 U	93.6 U	701 J	0.440 U	0.400 U	1.00 U	1.00 U
4/17/2024[3]	50.0 U	982 [2]	97.7 U	146 U	97.7 U	982	1.22	0.500 U	0.500 U	1.00 U
10/10/2024	50.0 U	571 [2]	94.7 U	142 U	142 U	571 [2]	0.200 U	0.500 U	0.500 U	1.00 U

Table A.1
Cumulative Analytical Groundwater Results

Analyte Class	Total Petroleum Hydrocarbons (TPH)						Benzene, Toluene, Ethylbenzene, and Xylenes			
Analyte	Gasoline-Range Organics	Diesel-Range Organics	Diesel-Range Organics (Silica Gel)	Oil-Range Organics[1]	Oil-Range Organics (Silica Gel)	Total TPH (DRO + ORO)	Benzene	Ethylbenzene	Toluene	Xylene (total)
Unit	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Criteria	800	500	500	500	500	500	51.0	--	--	--
Sample Location and Date										
Other Site Monitoring Wells (cont.)										
PP-35 (Screened Interval 8.5–18.5 ft) (Decommissioned)										
7/28/2016	50.0 U	50.1 U		100 U		100 U	1.00 U	1.00 U	1.00 U	1.00 U
10/27/2016	50.0 U	58.8		169		228	1.00 U	1.00 U	1.00 U	1.00 U
1/26/2017	50.0 U	49.7 U		405		405	1.00 U	1.00 U	1.00 U	1.00 U
4/26/2017	50.0 U	49.9 U		329		329	1.00 U	1.00 U	1.00 U	1.00 U
8/2/2017	50.0 U	49.9 U		99.8 U		99.8 U	1.00 U	1.00 U	1.00 U	1.00 U
PP-36 (Screened Interval 5–15 ft)										
7/27/2016	297	49.8 U		99.7 U		99.7 U	**90.6**	4.72	1.00 U	3.50
10/26/2016	**2,900**	49.8 U		**622**		**622**	**321**	246	4.28	9.83
1/25/2017	**6,000**	255		**1,240**		**1,500**	**323**	355	4.01	15.2
4/25/2017	**6,170**	282		**693**		**975**	**530**	301	6.95	27.7
8/2/2017[3]	**1,320**	63.3 [2]		374		437	**153**	39.6	1.64	6.77
11/8/2017	515	229		435		**664**	**153**	22.2	1.04	4.38
2/8/2018	**5,310**	408 [2]		497		**905**	**272**	348	5.09	17.5
5/3/2018	**5,350**	274 [2]		337 J		**611 J**	**290**	346	5.04	19.1
10/25/2018	513	58.9 [2]		149		208	23.6	4.13	1.00 U	1.00 U
4/8/2019	**4,200**	49.5 U		327		327	**160**	194	3.02	8.51
10/22/2019	**1,610**	110 J[2]		**624 J**		**734 J**	37.5	37.9	1.00 U	34.1
4/27/2020	**2,910**	219 [2]		424		**643**	39.5	72.2	1.13	3.86
10/21/2020	**1,970**	103 [2]		379		482	47.7	42.1	1.42	1.85
4/21/2021	**1,520**	152 J[2]		466 J		**618 J**	37.6	26.5	0.762	2.78
10/13/2021	**898**	458		98.1 U		458	5.09	0.928	0.750 U	1.00 U
5/4/2022	**2,710 J**[2]	**822** [2]	**861** [2]	93.9 U	93.9 U	**822**	31.0	19.4	0.750 U	2.80
11/10/2022	**1,810**	**944 J**[2,4]	490 J[4]	93.8 U	93.8 U	**944 J**	29.6	20.9	1.00 U	3.39
4/19/2023	**2,180** [8]	**1,210 J**[2]	**923** [4]	93.3 U	93.3 U	**1,210 J**	36.9	32.4	1.11	3.76
10/26/2023	**833**	429 J[2]	273	93.5 U	93.5 U	429 J	3.86	1.64	1.00 U	1.00 U
4/18/2024	**2,640** [2]	**1,270 J**[2]	**906** [4]	144 U	96.1 U	**1,270 J**	25.4	28.1	5.00 U	10.0 U
10/10/2024	**1,820**	**878** [2, 4]	**759** [4]	143 U	143 U	**878** [2, 4]	16.3	13.9	0.507	2.27
PP-37R (Screened Interval 10–20 ft)[9]										
8/4/2017	**3,640**	56.9 [2]		99.7 U		56.9	**1,420**	1.00 U	3.97	1.22
11/7/2017	50.0 U	131		339		470	20.1	1.00 U	1.00 U	1.00 U
2/8/2018	50.0 U	50.0 U		123		123	1.00 U	1.00 U	1.00 U	1.00 U
5/2/2018	50.0 U	49.8 U		131		131	15.7	1.00 U	1.00 U	1.00 U
4/8/2019	135	50.1 U		324		324	**72.1**	1.00 U	1.00 U	1.00 U
10/21/2019[3]	219	49.4 UJ	49.4 UJ	276 J	135 J	276 J	**80.6**	1.00 U	1.00 U	1.00 U
4/27/2020	50.0 U	49.7 U		401		401	5.50	1.00 U	1.00 U	1.00 U
10/21/2020	221	49.2 U		251		251	**100**	1.00 U	1.00 U	1.00 U
4/21/2021	177	98.2 U		**958**		**958**	**89.7**	0.400 U	0.750 U	1.00 U
10/13/2021	235	**548**		98.1 U		**548**	**100**	0.400 U	0.750 U	1.00 U
5/4/2022	50.0 U	349 [2]	288 [2]	94.3 U	94.3 U	349	0.492	0.400 U	0.750 U	1.00 U
11/10/2022	50.0 U	473 J[2,4]		98.8 U		473 J	1.16	0.400 U	1.00 U	1.00 U
4/19/2023	167 [2]	391 [2]	94.6 U	94.6 U	94.6 U	391	**110**	0.400 U	1.00 U	1.00 U
10/26/2023	94.3	463 J[2]	104	94.7 U	94.7 U	463 J	39.7	0.400 U	1.00 U	1.00 U
4/17/2024	50.0 U	488 [2]	94.3 U	141 U	94.3 U	488	0.200 U	0.500 U	0.500 U	1.00 U
10/10/2024	50.3	421 [2]	93.6 U	140 U	140 U	421 [2]	23.1	0.500 U	0.500 U	1.00 U
PZ-12 (Screened Interval 5–15 ft) (Decommissioned)										
3/21/2016[3]	260						**85.0**	1.00 U	1.20	3.00 U
7/26/2016	50.0 U	49.7 U		99.4 U		99.4 U	37.7	1.00 U	1.00 U	1.00 U
10/27/2016	769	49.5 U		125		125	**339**	1.10	4.30	3.11
1/26/2017	50.0 U	49.8 U		338		338	1.00 U	1.00 U	1.00 U	1.00 U
4/26/2017	50.0 U	49.8 U		101		101	13.9	1.00 U	1.00 U	1.00 U
PZ-15S (Screened Interval 7–12 ft) (Decommissioned)										
8/3/2017	**2,650**	260 [2]		**1,640**		**1,900**	28.1	103	4.79	140
PZ-15D (Screened Interval 13–18 ft) (Decommissioned)										
8/3/2017	50.0 U	49.8 U		99.6 U			2.76	1.00 U	1.00 U	1.00 U
Monitoring Wells Downgradient of Log Pond Area										
PP-21 (Screened Interval 8–18 ft)										
10/26/2023	50.0 U	259 J[2]	93.3 U	93.3 U	93.3 U	259 J	0.440 U	0.400 U	1.00 U	1.00 U
PP-22 (Screened Interval 8–18 ft)										
10/26/2023	50.0 U	336 J[2]	94.1 U	94.1 U	94.1 U	336 J	0.440 U	0.400 U	1.00 U	1.00 U
Temporary Wells										
GSL-A (Screened Interval 7–12 ft)										
8/4/2017	**3,820**	362 [2]		**1,490**		**1,850**	**1,250**	8.17	10.9	12.2
GSL-B (Screened Interval 7–12 ft)										
8/4/2017	**4,230**	70.1 [2]		106		176	**871**	14.3	22.2	35.2
GSL-C (Screened Interval 7–12 ft)										
8/4/2017	**7,160**	295 [2]		**1,440**		**1,740**	**1,180**	8.15	6.04	13.2
GSL-D (Screened Interval 7–12 ft)										
8/4/2017	**13,900**	468 [2]		**907**		**1,380**	**3,340**	17.7	25.2	45.7
GSL-E (Screened Interval 7–12 ft)										
8/4/2017	**11,800**	**609** [2]		**1,210**		**1,820**	**4,100**	34.4	37.4	37.2
GSL-F (Screened Interval 7.5–12.5 ft)										
8/4/2017	**12,100**	**714** [2]		**1,780**		**2,490**	**2,230**	204	11.0	131
GSL-G (Screened Interval 8–13 ft)										
8/4/2017	**5,310**	**786** [2]		**3,770**		**4,560**	**1,490**	18.4	13.4	28.2

Table A.1
Cumulative Analytical Groundwater Results

Analyte Class	Total Petroleum Hydrocarbons (TPH)						Benzene, Toluene, Ethylbenzene, and Xylenes			
Analyte	Gasoline-Range Organics	Diesel-Range Organics	Diesel-Range Organics (Silica Gel)	Oil-Range Organics[1]	Oil-Range Organics (Silica Gel)	Total TPH (DRO + ORO)	Benzene	Ethylbenzene	Toluene	Xylene (total)
Unit	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Criteria	800	500	500	500	500	500	51.0	--	--	--
Sample Location and Date										
Temporary Wells (cont.)										
GSL-H (Screened Interval 7.5–12.5 ft)										
8/3/2017	**1,400**	433 [2]		**2,260**		**2,690**	**256**	7.07	3.98	12.2
GSL-I (Screened Interval 5–10 ft)										
8/3/2017	**1,530**	357 [2]		**1,550**		**1,910**	**85.2**	72.1	5.54	83.4
GSL-I (Screened Interval 10–15 ft)										
8/3/2017	**2,300**	453 [2]		**2,310**		**2,760**	**173**	27.9	5.07	41.8
GSL-I (Screened Interval 15–20 ft)										
8/3/2017	176	73.0 [2]		268		341	14.1	2.07	1.00 U	2.87

Notes:

Blank cells are intentional.
All results have been rounded to 3 significant figures.
-- Not available.
RED/BOLD Detected concentration that exceeds criterion.
1 Coordination with laboratory on quantification of DRO versus ORO was conducted between the April and October 2021 monitoring events. Laboratory concluded that overlap of DRO and ORO carbon ranges in a single peak is more indicative of a weathered diesel rather than heavy oil. ORO results reported prior to October 2021 are interpreted as a weathered-diesel product based on labortory coordination and conceptual site model of residual diesel contamination in soil acting as source to groundwater.
2 Chromatogram indicates unresolved compounds not consistent with a petroleum standard; refer to annual reports for laboratory-specific comments.
3 A field duplicate was collected. The greatest detected value or lowest non-detected value is reported.
4 Detection is due to overlap with gasoline range material; refer to annual reports for laboratory-specific comments.
5 PP-18R was replaced by PP-18R2 in March 2019, approximately 25 feet north.
6 Results analyzed by Fremont Analytical (now Alliance Technical Group).
7 Split volume analyzed and reported by Friedman & Bruya, Inc.
8 Chromatographic pattern indicates weathered gasoline or Stoddard; refer to annual reports for laboratory-specific comments.
9 PP-37 was screened 5–15 feet bgs, but was replaced by PP-37R in March 2019, which is screened 10–20 ft bgs.

Abbreviations:

bgs Below ground surface
DRO Diesel-range organics
ft Feet
µg/L Micrograms per liter
ORO Oil-range organics

Qualifiers:

J Concentration is estimated but acceptable for most uses.
U Analyte is not detected at the associated reporting limit.
UJ Analyte is not detected at the associated reporting limit, which is considered to be an estimate.

Table A.2
Groundwater Analytical Results: Geochemical Parameters

	Conventionals						Metals			Field Parameters	
Analyte	Biochemical Oxygen Demand	Chemical Oxygen Demand	Bromide	Methane	Nitrate (as Nitrogen)	Sulfate	Iron, Dissolved	Iron, Total	Manganese, Total	Dissolved Oxygen	Oxidation–Reduction Potential
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	mg/L	mV
Sample Location and Date [1]											
Conditional Point of Compliance Monitoring Wells											
PP-17 (Screened Interval 5–15 ft)											
7/27/2016	5.64	57.7	--	0.00500 U	--	--	617	835	--	NM	NM
10/27/2016	11.2	--	--	0.193	--	--	592	1,020	--	0	-75.0
1/26/2017	6.57	--	--	0.229	--	570	213	444	--	0.72	-94.0
4/26/2017	--	--	--	--	--	110	--	--	--	0.78	-165.0
11/7/2017	--	--	--	--	--	39.7	--	--	--	0	57.0
2/8/2018	--	--	--	0.279	--	257	--	--	--	0	-147.0
05/2/2018 [2]	--	--	2.18	--	--	191	--	--	--	0	-143.0
10/25/2018	--	--	3.84 JQ	--	--	161	--	--	--	0	-134.0
4/8/2019	--	--	--	--	--	243	--	--	--	3.36	-108.7
10/22/2019	--	--	77.0 J	--	--	1,410 J	--	--	--	0.23	-207.0
04/27/2020 [2]	--	--	--	--	--	144	--	--	--	0	-180.9
10/21/2020	--	--	--	--	--	114	--	--	--	0.75	-98.7
4/21/2021	--	--	--	--	--	89.5	--	--	--	0.50	0
10/13/2021	--	--	--	--	--	92.5	--	--	--	1.15	108.0
5/4/2022 [2]	--	--	--	--	--	--	--	--	--	0.66	96.0
11/10/2022	--	--	--	--	--	--	--	--	--	6.23	-164.9
4/19/2023	--	--	--	--	--	--	--	--	--	0	-116.5
10/26/2023	--	--	--	--	--	--	--	--	--	0.30	-35.5
4/17/2024	--	--	--	--	--	--	--	--	--	0.35	-296.6
10/10/2024	--	--	--	--	--	98.9	--	--	--	0.37	-248.9
PP-18R2 [3] **(Screened Interval 10–20 ft)**											
7/28/2016	15.2	38.5	--	5.48 J	--	--	100 U	676	--	NM	NM
10/27/2016	20.3	--	--	0.117	--	--	100 U	100 U	--	0	-244.0
1/26/2017	11.6	--	--	0.259	--	41.0	100 U	101	--	0.66	-192.0
4/26/2017	--	--	--	--	--	44.2	--	--	--	0.96	-180.0
11/7/2017	--	--	--	--	--	45.9	--	--	--	0	2.0
2/8/2018	--	--	--	0.381	--	97.8	--	--	--	0	-184.0
5/2/2018	--	--	0.361	--	--	62.0	--	--	--	0	-226.0
04/8/2019 [2]	--	--	--	--	--	130	--	--	--	0.63	-83.0
10/22/2019	--	--	16.4 J	--	--	266 J	--	--	--	0.53	-61.0
4/27/2020	--	--	2.98	--	--	148	--	--	--	0.11	-93.0
10/21/2020	--	--	--	--	--	300	--	--	--	0.76	-66.6
4/21/2021	--	--	--	--	--	163	--	--	--	0.63	24.7
10/13/2021	--	--	--	--	--	286	--	--	--	1.07	74.7
5/4/2022	--	--	--	--	--	--	--	--	--	2.27	127.5
11/10/2022	--	--	--	--	--	--	--	--	--	5.79	-143.2
4/19/2023	--	--	--	--	--	--	--	--	--	1.64	-19.0
10/26/2023	--	--	--	--	--	--	--	--	--	1.55	-42.1
4/17/2024	--	--	--	--	--	--	--	--	--	0.93	-158.1
10/10/2024	--	--	--	--	--	140	--	--	--	0.41	-48.6
PP-19 (Screened Interval 5–15 ft)											
7/27/2016	2.00 U	80.9	--	0.00696	--	--	100 U	100 U	--	NM	NM
10/27/2016	2.00 U	--	--	0.00500 U	--	--	500 U	500 U	--	3.01	49.0
1/26/2017	2.00 U	--	--	0.00509	--	610	100 U	291	--	4.50	105.0
4/26/2017	--	--	--	--	--	518	--	--	--	4.00	154.0
10/22/2019	--	--	--	--	--	740 J	--	--	--	2.39	0.5
4/27/2020	--	--	--	--	--	274	--	--	--	1.38	58.5
10/21/2020	--	--	--	--	--	1,010	--	--	--	1.64	176.5
4/20/2021	--	--	--	--	--	210	--	--	--	1.26	102.1
10/13/2021	--	--	--	--	--	1,170	--	--	--	3.16	154.5
5/4/2022	--	--	--	--	--	--	--	--	--	8.60 [4]	107.1
11/10/2022	--	--	--	--	--	--	--	--	--	2.64	22.2
4/19/2023	--	--	--	--	--	--	--	--	--	3.58	63.4
10/26/2023	--	--	--	--	--	--	--	--	--	2.44	172.1
4/17/2024	--	--	--	--	--	--	--	--	--	1.25	134.9
10/10/2024	--	--	--	--	--	--	--	--	--	0.75	125.8
PP-34 (Screened Interval 8–18 ft)											
7/28/2016	10.8	53.1	--	1.03	--	--	100 U	422	--	NM	NM
10/27/2016	8.26	--	--	0.0795	--	--	100 U	771	--	0	-178.0
1/26/2017	7.16	--	--	0.838	--	38.6	100 U	134	--	0.78	-244.0
4/26/2017	--	--	--	--	--	47.8	--	--	--	0.76	-143.0
11/07/2017 [2]	--	--	--	--	--	41.8	--	--	--	0	-3.0
2/8/2018	--	--	--	0.197	--	106	--	--	--	0	-186.0
5/2/2018	--	--	0.410	--	--	63.0	--	--	--	1.24	103.0
10/25/2018	--	--	1.49 JQ	--	--	53.5	--	--	--	0	-211.0
4/8/2019	--	--	--	--	--	101	--	--	--	0.44	-94.0
10/22/2019	--	--	24.9 J	--	--	403 J	--	--	--	0.21	-232.0
4/27/2020	--	--	3.31	--	--	60.6	--	--	--	0.03	-104.0
10/21/2020	--	--	--	--	--	51.0	--	--	--	0.70	-264.0
4/21/2021 [2]	--	--	--	--	--	40.4	--	--	--	0.57	-6.8
10/13/2021	--	--	--	--	--	35.4	--	--	--	0.74	17.3
5/4/2022	--	--	--	--	--	--	--	--	--	0.75	141.2
11/10/2022	--	--	--	--	--	--	--	--	--	5.66	-656.9
4/19/2023	--	--	--	--	--	--	--	--	--	0	-113.4
10/26/2023	--	--	--	--	--	--	--	--	--	0.28	-178.2
4/17/2024	--	--	--	--	--	--	--	--	--	0.36	-247.6
10/10/2024	--	--	--	--	--	40.0	--	--	--	0.37	-241.2

Table A.2
Groundwater Analytical Results: Geochemical Parameters

Analyte	Conventionals						Metals			Field Parameters	
	Biochemical Oxygen Demand	Chemical Oxygen Demand	Bromide	Methane	Nitrate (as Nitrogen)	Sulfate	Iron, Dissolved	Iron, Total	Manganese, Total	Dissolved Oxygen	Oxidation–Reduction Potential
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	mg/L	mV
Sample Location and Date [1]											
Other Site Monitoring Wells											
PP-13R (Screened Interval 5–15 ft)											
7/28/2016	32.9	51.7	--	12.1 J	--	--	152	1,470	--	NM	NM
10/27/2016	30.7	--	--	1.74	--	--	259	427	--	0	-110.0
1/25/2017	2.00 U	--	--	0.0915	--	164	100 U	100 U	--	0	-208.0
4/25/2017	--	--	--	--	--	54.9	--	--	--	0.61	-207.0
11/7/2017	--	--	--	--	--	5.07	--	--	--	0	-68.0
2/8/2018	--	--	--	0.308	--	148	--	--	--	0	-226.0
5/2/2018	--	--	--	--	--	208	--	--	--	0	-192.0
10/25/2018 [2]	--	--	1.88	--	--	14.7	--	--	--	0.17	-159.0
4/8/2019	--	--	--	--	--	129	--	--	--	0.38	-191.0
10/21/2019	--	--	6.36 J	--	--	74.0 J	--	--	--	0.42	-135.0
4/27/2020	--	--	--	--	--	91.4	--	--	--	0.29	-176.6
10/21/2020	--	--	--	--	--	49.9	--	--	--	0.80	28.8
4/21/2021	--	--	--	--	--	108	--	--	--	0.52	48.9
10/13/2021	--	--	--	--	--	64.2	--	--	--	1.53	-213.2
5/4/2022	--	--	--	--	--	--	--	--	--	7.34 [4]	-85.1
11/10/2022	--	--	--	--	--	--	--	--	--	2.02	-150.9
4/19/2023	--	--	--	--	--	--	--	--	--	0.18	-60.2
10/26/2023	--	--	--	--	--	--	--	--	--	0.28	53.1
4/17/2024	--	--	--	--	--	--	--	--	--	0	-63.6
10/10/2024	--	--	--	--	--	112	--	--	--	0.26	-49.5
PP-14R (Screened Interval 5–15 ft)											
7/28/2016	25.5	35.9	--	8.28 J	--	--	100 U	287	--	NM	NM
10/27/2016	35.5	--	--	2.23	--	--	100 U	206	--	0	-110.0
1/25/2017	12.0	--	--	6.80 J	--	221	100 U	100 U	--	0.54	-208.0
4/25/2017	--	--	--	--	--	231	--	--	--	0.60	-151.0
11/7/2017	--	--	--	--	--	11.0	--	--	--	0	-78.0
2/8/2018	--	--	--	0.911	--	337	--	--	--	0	-157.0
5/2/2018	--	--	--	--	--	155	--	--	--	0	-87.0
10/25/2018	--	--	1.32	--	--	30.4	--	--	--	0.22	-155.0
4/8/2019	--	--	--	--	--	334	--	--	--	0.41	-140.0
10/21/2019	--	--	--	--	--	1,060 J	--	--	--	0.18	-247.0
4/27/2020	--	--	--	--	--	264	--	--	--	0.33	-151.4
10/21/2020	--	--	--	--	--	58.4	--	--	--	0.21	-203.1
4/20/2021	--	--	--	--	--	201	--	--	--	0.61	56.4
10/13/2021 [2]	--	--	--	--	--	178	--	--	--	0.77	20.6
5/4/2022	--	--	--	--	--	--	--	--	--	7.02 [4]	-125.6
11/10/2022	--	--	--	--	--	--	--	--	--	1.93	-80.6
4/19/2023	--	--	--	--	--	--	--	--	--	0.16	-43.2
10/26/2023	--	--	--	--	--	--	--	--	--	0.31	4.8
4/17/2024	--	--	--	--	0.20 U	139	--	30.0 U	11.0	0.0	-71.1
10/10/2024	--	--	--	--	--	207	--	--	--	0.23	-66.1
PP-15R2 (Screened Interval 5–15 ft)											
7/27/2016	30.9	70.9	--	7.40 J	--	--	212	1,670	--	NM	NM
10/26/2016	39.6	--	--	1.05	--	--	1,950	2,210	--	0.81	-130.0
01/25/2017 [2]	21.6	--	--	5.34	--	225	535	1,100	--	0.60	-166.0
4/25/2017	--	--	--	--	--	181	--	--	--	0.62	-152.0
11/8/2017	--	--	--	--	--	7.70	--	--	--	0	-56.0
2/8/2018	--	--	--	1.54	--	68.8	--	--	--	0.16	-199.6
5/2/2018	--	--	--	--	--	11.8	--	--	--	0	-165.0
10/25/2018	--	--	1.13	--	--	0.780	--	--	--	0.22	-127.0
4/8/2019	--	--	--	--	--	14.9	--	--	--	0.45	-146.0
10/21/2019	--	--	--	--	--	4.78 J	--	--	--	0.18	-240.0
4/27/2020	--	--	3.34	--	--	45.0	--	--	--	0.22	-282.5
10/21/2020	--	--	--	--	--	3.00 U	--	--	--	0.29	-110.8
4/20/2021	--	--	--	--	--	0.864	--	--	--	0.41	-129.3
10/13/2021	--	--	--	--	--	6.00 U	--	--	--	0.60	-21.8
5/4/2022	--	--	--	--	--	--	--	--	--	0.53	-6.5
11/11/2022	--	--	--	--	--	--	--	--	--	1.82	-120.9
4/19/2023	--	--	--	--	--	--	--	--	--	0.19	-45.8
10/27/2023	--	--	--	--	--	--	--	--	--	0.29	0.7
4/17/2024	--	--	--	--	1.00 U	18.2	--	446	239	0.0	-150.9
10/10/2024	--	--	--	--	--	3.66	--	--	--	0.23	-112.3
PP-27 (Screened Interval 5–15 ft)											
7/27/2016	10.4	54.4	--	3.51	--	--	199	20,100	--	NM	NM
10/26/2016	8.23	--	--	0.111	--	--	100 U	4,090	--	0	-192.0
1/25/2017	17.7	--	--	1.11	--	18.8	100 U	1,520	--	0.70	-139.0
4/25/2017	--	--	--	--	--	31.0	--	--	--	0.77	-210.0
11/8/2017	--	--	--	--	--	16.4	--	--	--	0.15	-193.0
2/8/2018	--	--	--	1.14	--	52.6	--	--	--	0.60	-177.0
5/3/2018	--	--	--	--	--	124	--	--	--	1.25	74.0
10/25/2018	--	--	0.838	--	--	0.714	--	--	--	0.23	-158.0
4/8/2019	--	--	--	--	--	118	--	--	--	3.80	27.4
10/21/2019	--	--	--	--	--	42.5 J	--	--	--	0.14	-385.0
4/27/2020	--	--	--	--	--	16.4	--	--	--	0	-143.2
10/21/2020	--	--	--	--	--	6.74	--	--	--	0.64	-156.0
4/20/2021	--	--	--	--	--	6.69	--	--	--	0.50	110.8
10/13/2021	--	--	--	--	--	2.21	--	--	--	1.44	-364.4
5/4/2022	--	--	--	--	--	--	--	--	--	0.60	91.9
11/11/2022	--	--	--	--	--	--	--	--	--	6.66	-193.8
4/19/2023	--	--	--	--	--	--	--	--	--	0.23	-134.4
10/27/2023	--	--	--	--	--	--	--	--	--	0.16	-141.1
4/17/2024	--	--	--	--	--	--	--	--	--	0.42	-284.9
10/10/2024	--	--	--	--	--	--	--	--	--	0.28	-233.7

Table A.2
Groundwater Analytical Results: Geochemical Parameters

Analyte	Conventionals						Metals			Field Parameters	
	Biochemical Oxygen Demand	Chemical Oxygen Demand	Bromide	Methane	Nitrate (as Nitrogen)	Sulfate	Iron, Dissolved	Iron, Total	Manganese, Total	Dissolved Oxygen	Oxidation–Reduction Potential
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	mg/L	mV
Sample Location and Date [1]											
Other Site Monitoring Wells (cont.)											
PP-29 (Screened Interval 5–15 ft)											
7/28/2016	20.3	69.6	--	3.34	--	--	100 U	1,750	--	NM	NM
10/26/2016	37.9	--	--	1.70	--	--	100 U	811	--	0	-101.0
1/25/2017	15.6	--	--	2.45	--	152	100 U	100 U	--	1.11	-104.0
04/25/2017 [2]	--	--	--	--	--	123	--	--	--	0.60	-173.0
11/8/2017	--	--	--	--	--	6.90	--	--	--	0	-47.0
2/8/2018	--	--	--	0.227	--	279	--	--	--	2.75	-16.7
5/3/2018	--	--	--	--	--	163	--	--	--	0.07	-49.0
10/25/2018	--	--	0.790	--	--	2.21	--	--	--	0	-77.0
4/8/2019	--	--	--	--	--	264	--	--	--	3.56	14.7
10/21/2019	--	--	--	--	--	27.4 J	--	--	--	0.36	-106.0
4/27/2020	--	--	4.12	--	--	126	--	--	--	1.80	-106.0
10/21/2020 [2]	--	--	--	--	--	26.0	--	--	--	0.74	-67.1
4/20/2021	--	--	--	--	--	35.8	--	--	--	2.93	60.1
10/13/2021	--	--	--	--	--	3.80 JQ	--	--	--	1.39	-104.5
5/4/2022	--	--	--	--	--	--	--	--	--	0.84	46.1
11/11/2022 [2]	--	--	--	--	--	--	--	--	--	7.59 [4]	-42.1
4/19/2023	--	--	--	--	--	--	--	--	--	2.58	58.0
10/27/2023	--	--	--	--	--	--	--	--	--	0.30	55.8
4/17/2024	--	--	--	--	--	--	--	--	--	0.74	-160.7
10/10/2024	--	--	--	--	--	--	--	--	--	0.33	-98.4
PP-30 (Screened Interval 5–15 ft)											
7/28/2016	13.0	91.5	--	3.34	--	--	100 U	287	--	NM	NM
10/27/2016	11.3	--	--	2.14	--	--	163	267	--	0	-171.0
1/25/2017	21.0	--	--	2.10	--	43.2	100 U	339	--	0.55	-278.0
4/25/2017	--	--	--	--	--	59.8	--	--	--	0.60	-272.0
11/7/2017	--	--	--	--	--	25.1	--	--	--	0	-155.0
2/8/2018	--	--	--	0.210	--	60.0	--	--	--	0	-277.0
5/2/2018	--	--	--	--	--	108	--	--	--	0	-221.0
10/25/2018	--	--	0.702	--	--	15.3	--	--	--	0	-221.0
4/8/2019	--	--	--	--	--	130	--	--	--	4.16	-90.4
10/22/2019	--	--	--	--	--	199 J	--	--	--	0.42	-205.0
4/27/2020	--	--	2.56	--	--	90.0	--	--	--	0.01	-126.3
10/21/2020	--	--	--	--	--	54.8	--	--	--	0.29	-21.0
4/21/2021	--	--	--	--	--	66.2	--	--	--	0.50	-3.6
10/13/2021	--	--	--	--	--	15.6	--	--	--	0.71	20.5
5/4/2022	--	--	--	--	--	--	--	--	--	7.00 [4]	-209.6
11/10/2022	--	--	--	--	--	--	--	--	--	1.91	-153.9
4/19/2023	--	--	--	--	--	--	--	--	--	0.17	-101.8
10/26/2023	--	--	--	--	--	--	--	--	--	0.18	-145.6
4/17/2024	--	--	--	--	--	--	--	--	--	0.30	-289.9
10/10/2024	--	--	--	--	--	--	--	--	--	0.22	-46.6
PP-32 (Screened Interval 8–18 ft)											
7/28/2016	22.4	54.4	--	7.63 J	--	--	503	2,290	--	NM	NM
10/27/2016	33.2	--	--	2.14	--	--	466	672	--	0	-107.0
1/26/2017	34.6	--	--	10.0 J	--	16.6	1,390	1,820	--	0.55	-173.0
4/26/2017	--	--	--	--	--	67.6	--	--	--	0.65	-148.0
4/8/2019	--	--	--	--	--	81.3	--	--	--	0.40	-156.0
10/22/2019	--	--	--	--	--	3.45 J	--	--	--	0.15	-248.0
4/27/2020	--	--	--	--	--	161	--	--	--	0.45	-160.6
10/21/2020	--	--	--	--	--	4.21	--	--	--	0.27	25.2
4/20/2021	--	--	--	--	--	140	--	--	--	0.68	77.2
10/13/2021	--	--	--	--	--	1.25	--	--	--	1.46	-199.6
5/4/2022	--	--	--	--	--	--	--	--	--	7.53 [4]	-37.2
11/10/2022	--	--	--	--	--	--	--	--	--	6.39	-142.7
4/19/2023	--	--	--	--	--	--	--	--	--	0.04	-137.5
10/27/2023	--	--	--	--	--	--	--	--	--	0.16	-148.5
4/18/2024	--	--	--	--	--	--	--	--	--	0	-108.5
10/10/2024	--	--	--	--	--	--	--	--	--	0.19	-153.4
PP-33 (Screened Interval 5–15 ft)											
7/28/2016	21.0	48.4	--	5.67 J	--	--	609	2,530	--	NM	NM
10/26/2016 [2]	26.0	--	--	1.07	--	--	1,820	2,030	--	0.07	-127.0
1/25/2017	11.8	--	--	2.71	--	135	588	1,710	--	0.55	-135.0
4/25/2017	--	--	--	--	--	109	--	--	--	0.66	-138.0
11/7/2017	--	--	--	--	--	5.64	--	--	--	0	-86.0
02/08/2018 [2]	--	--	--	0.798	--	192	--	--	--	0.24	-167.0
5/3/2018	--	--	--	--	--	49.1	--	--	--	1.05	52.0
10/25/2018	--	--	0.936	--	--	11.6	--	--	--	0.19	-143.0
4/8/2019	--	--	--	--	--	265	--	--	--	0.39	-136.0
10/21/2019	--	--	--	--	--	26.4 J	--	--	--	0.39	-130.0
4/27/2020	--	--	--	--	--	138	--	--	--	0.69	-146.7
10/21/2020	--	--	--	--	--	16.2	--	--	--	0.27	-104.5
4/20/2021	--	--	--	--	--	108	--	--	--	0.53	77.8
10/13/2021	--	--	--	--	--	14.2	--	--	--	0.72	-5.9
5/4/2022	--	--	--	--	--	--	--	--	--	7.08 [4]	-7.9
11/11/2022	--	--	--	--	--	--	--	--	--	2.10	-86.5
4/19/2023	--	--	--	--	--	--	--	--	--	0.22	-76.8
10/26/2023	--	--	--	--	--	--	--	--	--	0.31	-0.6
4/17/2024 [2]	--	--	--	--	--	--	--	--	--	1.06	-86.5
10/10/2024	--	--	--	--	--	--	--	--	--	0.23	-112.3

Table A.2
Groundwater Analytical Results: Geochemical Parameters

	Conventionals						Metals			Field Parameters	
Analyte	Biochemical Oxygen Demand	Chemical Oxygen Demand	Bromide	Methane	Nitrate (as Nitrogen)	Sulfate	Iron, Dissolved	Iron, Total	Manganese, Total	Dissolved Oxygen	Oxidation–Reduction Potential
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	mg/L	mV
Sample Location and Date [1]											
Other Site Monitoring Wells (cont.)											
PP-36 (Screened Interval 5–15 ft)											
7/27/2016	11.0	30.6	--	2.80	--	--	100 U	10,600	--	NM	NM
10/26/2016	10.1	--	--	0.128	--	--	100 U	12,100	--	0	-112.0
1/25/2017	14.2	--	--	1.41	--	113	507	1,560	--	0.60	-173.0
4/25/2017	--	--	--	--	--	49.0	--	--	--	0.63	-207.0
11/8/2017	--	--	--	--	--	33.8	--	--	--	0	-94.0
2/8/2018	--	--	--	0.211	--	148	--	--	--	0.16	-236.5
5/3/2018	--	--	--	--	--	131	--	--	--	1.49	32.0
10/25/2018	--	--	0.403	--	--	2.50	--	--	--	0.22	-130.0
4/8/2019	--	--	--	--	--	68.5	--	--	--	3.82	-72.6
10/22/2019	--	--	--	--	--	40.1 J	--	--	--	0.20	-199.0
4/27/2020	--	--	2.00 U	--	--	30.1	--	--	--	0.29	-186.5
10/21/2020	--	--	--	--	--	10.1	--	--	--	0.27	-108.1
4/21/2021	--	--	--	--	--	12.0	--	--	--	0.53	15.2
10/2/2021	--	--	--	--	--	0.600 U	--	--	--	1.49	-185.3
5/4/2022	--	--	--	--	--	--	--	--	--	6.78 [4]	-164.4
11/10/2022	--	--	--	--	--	--	--	--	--	5.73	-209.1
4/19/2023	--	--	--	--	--	--	--	--	--	0.03	-126.6
10/26/2023	--	--	--	--	--	--	--	--	--	0.22	-127.2
4/18/2024	--	--	--	--	--	--	--	--	--	0.36	-286.6
10/10/2024	--	--	--	--	--	--	--	--	--	0.41	-203.6
PP-37R [5] **(Screened Interval 10–20 ft)**											
11/8/2017	--	--	--	--	--	7.02	--	--	--	0.13	-4.0
2/8/2018	--	--	--	0.0218	--	148	--	--	--	1.80	9.2
5/2/2018	--	--	--	--	--	131	--	--	--	1.20	66.0
4/8/2019	--	--	--	--	--	12.8	--	--	--	3.40	-12.7
10/21/2019 [2]	--	--	1.92 J	--	--	42.0 J	--	--	--	0.18	-242.0
4/27/2020	--	--	--	--	--	80.2	--	--	--	0.06	-67.3
10/21/2020	--	--	--	--	--	31.7	--	--	--	0.71	-68.1
4/21/2021	--	--	--	--	--	50.0	--	--	--	0.62	15.2
10/13/2021	--	--	--	--	--	4.43 JQ	--	--	--	1.87	-196.8
5/4/2022	--	--	--	--	--	--	--	--	--	0.74	136.9
11/10/2022	--	--	--	--	--	--	--	--	--	1.80	-121.9
4/19/2023	--	--	--	--	--	--	--	--	--	0.01	-130.4
10/26/2023	--	--	--	--	--	--	--	--	--	0.35	-7.3
4/17/2024	--	--	--	--	1.00 U	12.5	--	506	48.8	0.01	-99.8
10/10/2024	--	--	--	--	--	6.17	--	--	--	0.36	-164.9
Monitoring Wells Downgradient of Log Pond Area											
PP-21 (Screened Interval 8–18 ft)											
10/26/2023	--	--	--	--	--	--	--	--	--	0.18	-42.0
PP-22 (Screened Interval 8–18 ft)											
10/26/2023	--	--	--	--	--	--	--	--	--	0.21	-100.7

Notes:

-- Not analyzed or not available.

1 No geochemical parameters were analyzed during the August 2017 sampling event.

2 A field duplicate was collected. The greatest detected value or lowest non-detect value is reported.

3 PP-18R was replaced by PP-18R2 in March 2019, approximately 25 feet north.

4 Field reading biased because of equipment/sensor error.

5 PP-37 was screened 5–15 ft bgs, but was replaced by PP-37R in March 2019, which is screened 10–20 ft bgs.

Abbreviations:

bgs Below ground surface

ft Feet

µg/L Micrograms per liter

mg/L Milligrams per liter

mV Millivolts

NM Not measured

Qualifiers:

J Concentration is estimated but acceptable for most uses.

JQ Concentration is reported between the method detection limit and reporting limit and is considered an estimate.

U Analyte is not detected at the associated reporting limit.

2024 Annual Progress Report for the K Ply Site

K Ply Site

Appendix B
Memorandum of Gene Assay and Compound-Specific Isotope Analysis Results Prepared by Tersus Environmental

Tersus Environmental, LLC

Performance MonitoringReport

K PlySite, Port Angeles, WA

Prepared For:

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Tersus Project No. Q17-2581
June 21, 2024

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June 21, 2024

Pamela Osterhout
Floyd Snider
601 Union Street, Suite 600, Seattle, WA 98101

Reference: **Performance Monitoring Progress Report**
K PlySite
Tersus Project No.Q17-2581

Dear Pamela,

We appreciate Floyd Snider's interest in Tersus Environmental. Please find enclosed our performance monitoring report for your project located in Port Angeles, WA.

Tersus has prepared this report based on the information provided regarding site conditions and field events. Tersus reserves the right to update this report as new information is made available.

Should you have any questions or need additional information regarding this report, please contact us at 919.453.5577. We look forward to supporting you on this project.

Best regards,

Tersus Environmental, LLC

Table of Contents

List of Abbreviations

bssA	benzyl succinate synthase (gene target)
copies/L	gene copies per liter
CSIA	compound-specific isotope analysis
DNA	deoxyribonucleic acid
EPA	Environmental Protection Agency
IT^2	IT2 Isotope Tracer Technologies Inc.
mg/L	milligrams per liter
NahAc	naphthalene Dioxygenase
MW	monitoring well
SO_4	Sulfate ions
Tersus	Tersus Environmental, LLC
TDO	Toluene dioxygenase (gene target)
VOC	volatile organic compounds
‰	Per mil (units)
$\delta^{13}C$	carbon 13 to carbon 12 isotopic ratio (expressed in delta notation)
Δ	isotopic shift
$\Delta\ \delta^{13}C$	carbon isotope shift

1. Introduction

Floyd Snider (Client), in collaboration with Tersus Environmental, LLC (Tersus) is addressing a contaminated aquifer at the K Ply site in Port Angeles, WA (the Site). Constituents of concern include benzene and petroleum hydrocarbons. Chemical oxidation followed by anaerobic bioremediation was proposed as an in situ remediation treatment train to remove contaminant mass and meet dissolved phase concentration goals. Under this approach, TersOx™ NPS (the base-activated sodium persulfate component) and Nutrisulfate™ with TersOx™ Nutrients-QR (the sulfate-based bioremediation component) are planned to be injected at different stages to promote destruction of benzene and other organic constituents of concern groundwater.

Client collected groundwater samples before the planned injection event to verify baseline conditions and suitability of the proposed approach. Tersus, in association with its scientific advisors and strategic partners, drafted the narrative associated with compound-specific isotope analysis (CSIA) results and genetic bioassays, to provide preliminary results with the on-going evaluation.

2. Methodology

Sampling events were carried out using monitoring wells PP-15R and PP-14R located at the heart of the current benzene plume (i.e., the source) and slightly downgradient to two of four horizontal infiltration galleries that can be used to distribute remediation amendments, see Figure 1. Analyses for gene assays and CSIA were subcontracted to SiREM and IT2, respectively.

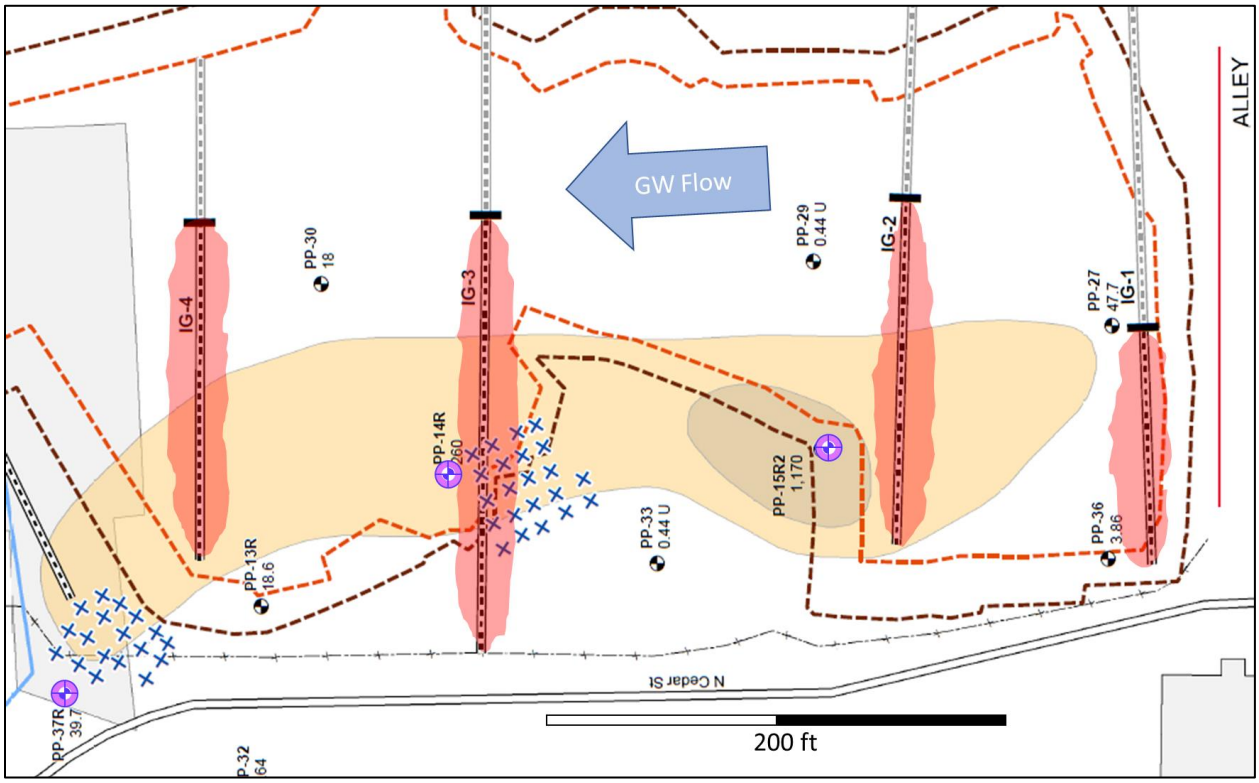

Figure 1. Schematic of site with contaminant extent (grey and orange shadow), infiltration galleries IG-1 through IG-4, planned amendment injection ROI (red shadow), and performance monitoring well locations (PP-14R, PP-15R) which were sampled for baseline conditions).

2.2 Isotope Data Treatment

Data reporting: By convention, measurements of carbon isotope ratios are reported in the δ notation, and expressed relatively to the Vienna-PDB international standard, according to:

$$\delta^{13}C\ (‰) = \left(\frac{R_{sample}}{R_{std}} - 1 \right) 1000 \qquad \text{eq. 1}$$

Where the R_{sample} and R_{std} ratio are the $^{13}C/^{12}C$ ratios of the tested compound and the international standard, respectively.

Interpretation approach: Analysis of a compounds carbon isotope ratio ($\delta^{13}C$), or compound-specific isotope analysis (CSIA), is used to demonstrate an active microbial population or chemical processes (bio)degrading the compound (an organic contaminant dissolved in

groundwater). In this case, the isotopic method is taking advantage of different reaction rates occurring for molecules with or without a heavy isotope (Aelion et al., 2010). More specifically, molecules including a heavy isotope (^{13}C-molecules) tend to accumulate in the remaining contaminant pool with time due to a slightly slower degradation rate compared to molecules having only light isotopes (^{12}C-molecules). In the case of petroleum hydrocarbons, benzene molecules containing ^{13}C will accumulate over time in the remaining pool with respect to ^{12}C-molecules, which translates into progressively more positive (i.e., enriched) δ^{13}C values. These changes in δ^{13}C values over time are direct evidence of compound destruction. More details on CSIA can be found in the Guidance document released by the EPA (Hunkeler et al., 2008).

Finally, the isotopic difference between two measurements, or isotopic shift (Δ), observed for δ^{13}C can serve as an EPA-approved method to demonstrate degradation (Hunkeler et al., 2009). Due to uncertainty errors related to field and analytical procedures, the EPA guideline indicates that a Δ of at least 1‰ (for δ^{13}C) should be observed to suggest presence of degradation process, whereas a Δ of 2 ‰ can be considered as strong evidence of degradation process.

3. Results and Interpretation

3.1 Geochemical Parameters

Dissolved oxygen (DO), pH, ORP, total iron and ferrous iron (Fe_{tot}, Fe^{2+}), manganese, sulfate, and nitrate-N concentrations are reported in Table 1.

pH levels in downgradient monitoring well PP-14R are high to sustain biodegradation activity. The ORP levels should be reflective of sulfate reducing conditions, nevertheless, sulfate levels are relatively high in PP-14R, which may be due to high pH.

The lack of dissolved oxygen (DO) in both monitoring wells suggests historical consumption by biological process consuming organic content and inadequate oxygen recharge, limiting the potential of naturally occurring aerobic biodegradation under current conditions (i.e., high organic content, hydrogeological setting). Negative ORP values, no nitrate detections, and

higher levels of dissolved Fe^{2+} in PP-15R – which has lower ORP values and is closer to the "source" – can serve as evidence of anaerobic conditions under which some contaminants may or have been biodegrading. Similarly, manganese levels are higher in PP-15R than PP-14R because the ORP is lower, increasing the presence of manganese ions. PP-15R also shows lower sulfate levels, which may be an indication of sulfate-reducing conditions.

3.2 Gene assays

Concentrations of TDO gene target (toluene dioxygenase, indicative of aerobic BTE biodegradation), of *abcA* gene target (indicative of microorganisms biodegrading benzene under anaerobic condition) and sulfate reducing bacteria (dsrA) gene target (indicative of microorganisms able to carry out sulfate (SO_4^-) reduction to grow, but without direct evidence of petroleum hydrocarbons consumption) are listed in Table 2.

The presence of toluene dioxygenase (TDO) genes were detected (in the order of 10^4 gene copies/L) in both MWs. Although the low gene concentrations suggest that no significant impact on BTE concentration could be observed or expected, their detection suggests potential for the site to support BTE aerobic biodegradation.

The presence of sulfate reducing bacteria (SRB) genes was also detected in both MWs. Their presence confirms a microbial activity conducting anaerobic biodegradation at the site under sulfate reduction conditions. SRB populations are relatively higher on the monitoring point representative of the contaminant source PP-15R, which is upgradient and more contaminated than PP-14R, suggesting PP-15R has been anaerobic for a longer time. The number of SRB increases as ORP decreases, suggesting ORP levels below -71 are more adequate for sulfate-enhanced biostimulation. Nevertheless, the high pH in PP-14R may be the reason for lack of sulfate consumption. Finally, no *abcA* genes were detected. Note that, while detection of *abcA* genes would support the occurrence of anaerobic benzene biodegradation at the site, not detecting them does not demonstrate lack of anaerobic benzene destruction as other biodegradation pathways using different enzymes may be occurring. (i.e., not all anaerobic benzene markers have been tested)

The presence of both aerobic (TDO) and anaerobic genes (SRB) suggests the presence and potential for both biodegradation conditions. This could be related to monitoring well conditions capturing groundwater from different (vertical) geochemical conditions during sampling (i.e., sampling close to the water table may capture both aerobic and anaerobic conditions).

3.2 VOC Concentration and CSIA

Benzene concentrations for PP-15R and PP-14R are respectively 187.0 and 7.5 ug/L (Table 3). Concentrations show a decreasing trend with respect to groundwater flow direction. Accordingly, such decrease could either be related to physical attenuation process (dispersion, sorption) and/or biodegradation.

The $\delta^{13}C$ values for benzene in both MWs are reported in Table 3. The values are similar since the isotopic difference between two measurements, or isotopic shift (Δ), is less than 1‰. Such lack of isotopic shift indicates that benzene mass transported with groundwater is not significantly biodegrading during migration. Accordingly, the decrease in concentration observed is likely mainly due to physical attenuation.

Table 1. Results for pH, dissolved oxygen (DO), ORP, dissolved iron (Fe^{2+}), total iron (Fe_{tot}), nitrate (as nitrogen), and sulfate concentrations measured for the baseline sampling events in two selected monitoring wells.

MW	Sampling Event		pH	DO	ORP	Fe^{2+}	Fe_{tot}	Mn	Nitrate-N	Sulfate
			--	mg/L	mV	mg/L	mg/L	ug/L	mg/L	mg/L
PP-14R	Baseline	2024-04-17	9.1	0	-71	0.0	0.03U	11.0	0.2U	139
	Post-1									
	Post-2									
PP-15R	Baseline	2024-04-17	7.4	0	-151	0.5	0.5	239	1.0U	18.2
	Post-1									
	Post-2									

U: Under detection limit (quantification limit is reported)

Table 2. Gene assays measured for the baseline and post-1 sampling events in two selected monitoring wells.

MW	Sampling Event		dsrA	abcA	TDO	Prok
			gene copies/L	gene copies/L	gene copies/L	gene copies/L
PP-14R	Baseline	2024-04-17	5.67 E+04	3.28 E+02 U	5.81 E+04 M	1.37 E+08
	Post-1					
	Post-2					
PP-15R	Baseline	2024-04-17	1.14 E+05	5.46 E+02 U	2.90 E+04	3.03 E+08
	Post-1					
	Post-2					

U: Under detection limit (quantification limit is reported)

M Non-specific amplification was observed via melt curve analysis.

Table 3. Concentration results and carbon isotope analysis ($\delta^{13}C$) for benzene measured for the baseline sampling event at two selected monitoring wells.

MW	Sampling Event		Benzene		
			Conc.	$\delta^{13}C$	Std Dev
			ug/L	‰	‰
PP-14R	Baseline	2024-04-17	7.45	-31.3	0.1
	Post-1				
	Post-2				
PP-15R	Baseline	2024-04-17	187.0	-31.6	0.0
	Post-1				
	Post-2				

4. Summary

This baseline report integrates the hydrogeochemical parameters, genetic assays and $\delta^{13}C$ values for benzene. Samples were collected to preliminary assess the potential for an enhanced anaerobic biodegradation approach to address benzene present in groundwater.

The following preliminary remarks can be underlined from the baseline sampling:

- Hydrogeochemical parameters suggest the potential for both aerobic and anaerobic biodegradation mechanisms in both monitoring wells. Evidence of both types of mechanisms may be due to screens collecting groundwater from both aerobic and anaerobic horizons. However, lack of oxygen and nitrate, and sulfate consumption in the source PP-15R may indicate difficulty in efficiently creating aerobic conditions.
- The reported pH values are appropriate for biodegradation activity in PP-15R (7.44) but not in PP-14R (9.04). Measuring levels during the treatment is imperative and action should be taken if the range falls out of circumneutral levels (i.e., between 6 and 9 pH S.U.). Adjusting the pH is critical to promote biodegradation of contaminants.
- No change in $\delta^{13}C$ value for benzene suggested lack of biodegradation under current conditions.

During the treatment period, these performance parameters should be periodically monitored to assess their evolution:

- Change in hydrogeochemical parameters indicating aerobic biodegradation conditions (i.e., for aerobic biostimulation: increase in DO and ORP values, and decrease in dissolved Fe^{2+}). In Tersus' experience, more than one injection, or combining stronger oxidants may be required to consume organic oxygen demand, sustain aerobic conditions sufficiently long times to allow the long term aerobic biodegradation of constituents of concern.
- Alternately, addressing anaerobically biodegradable constituents via nitrate or sulfate additions may be more energy efficient and also help reduce oxygen demand. To date, indicators of anaerobic biodegradation of benzene have been observed.

- For aerobic biostimulation, an increase in aerobic genes (i.e., TOD/TDO) and eventual decrease in anaerobic genes (BssA) is expected. Gene counts during anaerobic biostimulation would trend in the opposite direction.
- Maintaining a circumneutral pH is necessary. Existing high pH conditions could help “activate” a potential sodium persulfate injection. (and eventually neutralize conditions).
- When possible, applying CSIA on BTEX compounds to demonstrate compound degradation.
- A sulfate-enhanced biostimulation to address petroleum hydrocarbons seems feasible.
- Baseline data collected during this sampling round is critical for post injection performance monitoring.

5. References

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