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April 20, 2021

Mohsen Kourehdar
Washington State Department of Ecology
Toxics Cleanup Program
300 Desmond Drive
Lacey, WA 98503-1274

Subject: Draft Feasibility Study Report
Former Arkema Manufacturing Site
2901 and 2920 Taylor Way, Tacoma, Washington
Agreed Order No. DE 5668, Facility/Site ID No. 1220, Cleanup Site ID No. 3405

Dear Mr. Kourehdar:

On behalf of the Port of Tacoma (Port) and in accordance with the agreed order between the Port and Washington State Department of Ecology (Ecology), PIONEER Technologies Corporation is submitting for your review the draft Feasibility Study (FS) Report for the Former Arkema Manufacturing Site (Site).

The Port would like to schedule a conference call with you as soon as possible to discuss the draft FS Report. Please do not hesitate to contact me at (360) 570-1700 x105 or Scott Hooton at (253) 383-9428 if you have any questions about the draft FS Report.

Respectfully,

Troy Bussey, Jr., P.E. (WA, CA, NC, SC), L.G. (WA, CA, NC, SC), L.HG. (WA)
Principal Engineer

Enclosures:
Feasibility Study Report

cc: Andy Smith, Washington State Department of Ecology (electronic copy only)
Kristine Koch, United States Environmental Protection Agency (electronic copy only)
Scott Hooton, Port of Tacoma (electronic copy only)
Rob Healy, Port of Tacoma (electronic copy only)
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Paul Fuglevand, Dalton, Olmsted & Fuglevand, Inc. (electronic copy only)
Joel Massmann, Keta Waters (electronic copy only)
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Feasibility Study Report

Former Arkema Manufacturing Site

Agreed Order No. DE 5668
Facility/Site ID No. 1220
Cleanup Site ID No. 3405

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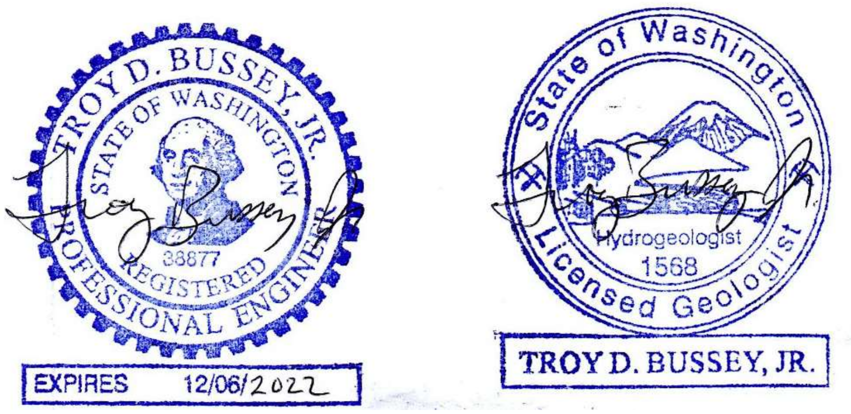
April 2021

Professional Certification

This document was prepared under my direction. The information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I hereby certify that I was in responsible charge of the work performed for this document.



April 20, 2021

Troy D. Bussey Jr. | Date
Principal Engineer
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Executive Summary

The purpose of this Feasibility Study (FS) is to develop and evaluate cleanup action alternatives (alternatives) for the Former Arkema Manufacturing Site (Site) in accordance with Model Toxics Control Act (MTCA) regulations. Key components of the FS process include (1) establishing constituents of concern (COCs) and cleanup standards, (2) assembling and evaluating alternatives using MTCA requirements, and (3) proposing a recommended alternative. The purpose of this FS Report (Report) is to document the Site FS process and present the recommended alternative for the Site. The Site is one of many source areas included within Operable Unit OU 05 of the larger Commencement Bay/Nearshore Tide Flats (CB/NT) Comprehensive Environmental Response, Compensation and Liability Act site.

COCs, cleanup standards, and alternatives are defined in this Report. The primary COC is arsenic. Other Site COCs are copper, lead, mercury, nickel, tetrachloroethylene, trichloroethylene, vinyl chloride, and chloroform. The soil cleanup levels are default MTCA Method C soil direct contact cleanup levels for commercial/industrial land use. The groundwater cleanup levels are default MTCA Method B surface water cleanup levels. Five alternatives were assembled and evaluated in this Report. The five alternatives were evaluated relative to the MTCA requirements for remedy selection.

Alternative 2 is the recommended alternative because it satisfies the four MTCA threshold requirements and is the alternative that uses permanent solutions to the maximum extent practicable. Alternative 2 includes 25 remedial components and provides approximately $92 million of beneficial remediation activities. Alternative 2 protects human health and the environment, provides a fourth phase of active arsenic remediation to supplement the completed Phases 1 through 3 of active arsenic remediation, employs reliable and proven technologies, includes robust monitoring, maintenance, and controls to help ensure protectiveness over the long-term, can be implemented relatively quickly, is cost-effective, and does not contain any significant negative tradeoffs.

The recommended groundwater point of compliance (POC) is surface water at locations as close as technically possible to the point or points where groundwater flows into surface water. The recommended groundwater POC is the only POC option that can provide for a reasonable restoration time frame. The estimated restoration time frames for the other four groundwater POC options (ranging from 3,700 years to greater than 10,000 years for Alternative 2) are unacceptable and unreasonable. The recommended groundwater POC is consistent with the groundwater POC established by the United States Environmental Protection Agency (USEPA) for the CB/NT site (USEPA 2000) and is consistent with groundwater POC precedents at other complex MTCA shoreline sites (e.g., South State Street Manufactured Gas Plant, BNSF Skykomish Former Maintenance and Fueling Facility, Everett ASARCO Smelter). Although (1) MTCA groundwater cleanup standards have already been achieved at the recommended groundwater POC, and (2) CB/NT cleanup standards have already been achieved, robust monitoring and maintenance will be conducted as part of Alternative 2 for the foreseeable future to ensure ongoing compliance with MTCA and CB/NT cleanup standards in surface water and sediment.

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List of Acronyms

Acronym	Explanation
Alternative	Cleanup Action Alternative
APR	Active Plume Remediation
BAZ	Biologically Active Zone
bgs	Below Ground Surface
CAA	Cleanup Action Alternative
CAO	Cleanup Action Objective
CAP	Cleanup Action Plan
Caustic	Sodium Hydroxide
CB/NT	Commencement Bay/Nearshore Tide Flats
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CF	Chloroform
CL	Cleanup Level
COC	Constituent of Concern
COPC	Constituent of Potential Concern
CPOC	Conditional Point of Compliance
CSM	Conceptual Site Model
DOF	Dalton, Olmsted, & Fuglevand, Inc.
EC	Engineering Control
Ecology	Washington State Department of Ecology
Eh	Activity of Electrons
EPC	Exposure Point Control
ERM	Environmental Resources Management
FS	Feasibility Study
IC	Institutional Control
ICF	ICF Technology Incorporated
ITRC	Interstate Technology & Regulatory Council
kg/year	Kilograms per Year
mg/kg	Milligrams per Kilogram
MNA	Monitored Natural Attenuation
MNA&LTC	Monitored Natural Attenuation and Long-Term Controls

Acronym	Explanation
MTCA	Model Toxics Control Act
MW	Monitoring Well
NBA	North Boundary Area
NSDS	Nylon-Screen Diffusion Sampler
PCE	Tetrachloroethylene
PDI	Pre-Design Investigation
Penite	Sodium Arsenite
pH	Activity of Hydrogen Ions
PIONEER	PIONEER Technologies Corporation
PMI	Port Maritime Industrial
Port	Port of Tacoma
POC	Point of Compliance
PPS	Pushpoint Sampler
PRB	Permeable Reactive Barrier
P&T	Pump & Treat
Report	FS Report
RI	Remedial Investigation
RL	Remediation Level
Site	Former Arkema Manufacturing Site
SL	Screening Level
SPW	Sheet Pile Wall
SQO	Sediment Quality Objective
TCE	Trichloroethylene
ug/L	Micrograms per Liter
USEPA	United States Environmental Protection Agency
USG	United States Gypsum
VC	Vinyl Chloride
VI	Vapor Intrusion
VOC	Volatile Organic Compound
WAC	Washington Administrative Code
Wypenn	Wypenn Property
XRF	X-ray Fluorescence

SECTION 1: INTRODUCTION

1.1 Purpose

The purpose of this Feasibility Study (FS) is to develop and evaluate cleanup action alternatives (alternatives or CAAs) for the Former Arkema Manufacturing Site (Site) in accordance with Model Toxics Control Act (MTCA) regulations.[1] Key components of the FS process include (1) establishing the constituents of concern (COCs) and cleanup standards, (2) screening remedial technologies to determine the most promising technologies, (3) assembling the retained technologies into alternatives, (4) evaluating the assembled alternatives using MTCA requirements, and (5) proposing a recommended alternative for stakeholder and public review. The purpose of this FS Report (Report) is to document the Site FS process and present the recommended alternative for the Site. This Report was prepared in accordance with MTCA regulations in Washington Administrative Code (WAC) 173-340-350.

1.2 Site Boundary

Consistent with Port of Tacoma (Port) practices, all references to direction (i.e., north, south, east, and west) in this Report are in relation to "site north," which is parallel to the Hylebos Waterway shoreline (see Figure 1-1). "Site north" is approximately 45 degrees west (counterclockwise) from true north. Both "site north" and true north are shown on the figures for this Report.

The relevant Arkema properties are an approximately 45-acre portion of a 64.8-acre parcel (tax parcel number 0321351053) located at 2901 Taylor Way and a 3.2-acre parcel (tax parcel number 0321362056) located at 2920 Taylor Way in Tacoma, Washington.[2] The combined Arkema property boundary is shown on Figure 1-1.

The Site boundary is the same as the Arkema property boundary with the following exceptions (see Figure 1-1):

- The North Boundary Area (NBA) and groundwater downgradient (east) of the NBA are now part of the Former United States Gypsum (USG) Taylor Way Plant Site since impacts from former USG operations have come to be located on the NBA (Washington State Department of Ecology [Ecology] 2021a; PIONEER Technologies Corporation [PIONEER] 2021).
- A triangular-shaped portion of the Intermediate Aquifer on the adjacent Arkema Mound site is part of the Site boundary (Dalton, Olmsted, & Fuglevand, Inc. [DOF] 2013).

It is also important to recognize that the Site is part of the larger Commencement Bay/Nearshore Tide Flats (CB/NT) Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) site. The Site is one of many source areas included within Operable Unit OU 05 of the CB/NT site. Ecology is

[1] The term Arkema refers to Arkema and all other companies that operated the former manufacturing facility (i.e., Tacoma Electrochemical Company, Pennsylvania Salt Manufacturing Company of Washington, Pennwalt Corporation, Atochem Inc., Elf Atochem North America, and Atofina Inc.).

[2] The Port purchased these properties from Arkema in May 2007. The Wypenn property (Wypenn) is located at 2920 Taylor Way.

the lead agency for OU 05 source control actions, with United States Environmental Protection Agency (USEPA) coordination and oversight (USEPA 2014).

Key areas/features within the Site boundary include the former Central Manufacturing Area, former Penite Pits #1 and #2, the former Penite Manufacturing Building, the former Caustic Manufacturing Area, the former Taylor Lake area surface impoundments, the main arsenic plume, and the sheet pile wall (SPW; see Figure 1-1). Other areas that are used to reference locations in this Report include Wypenn, East Channel Ditch, and volatile organic compound (VOC) vapor intrusion (VI) Areas A through C (see Figure 1-1).

1.3 Report Focus

This Report is focused on the most important Site context and content to enable readers to understand the relevant details for this complex Site and facilitate effective remedy selection. As a result, this Report does not reiterate all of the background information and results presented in the Ecology-approved FS Data Gap Investigation Report (PIONEER 2019; Ecology 2019). Rather, the most pertinent elements of the FS Data Gap Investigation Report are summarized in this Report and select figures, charts, and tables from the FS Data Gap Investigation Report in Appendix A.

Furthermore, since the potential for groundwater transport of arsenic in the main arsenic plume to cause unacceptable exposures in Hylebos Waterway surface water and sediment is the primary concern for this Site, the contents in this Report are focused on that concern. However, there are other potential Site concerns (e.g., soil direct contact and VI pathways) that also need to be addressed. In order to focus the main body of the Report on the main arsenic plume, these "other potential Site concerns" are discussed in Appendix B.

1.4 Report Organization

The remainder of this Report is organized as follows:

- Section 2: Background Information
- Section 3: Constituents of Concern, Cleanup Standards, and Cleanup Action Objectives
- Section 4: Identification and Screening of Remedial Technologies
- Section 5: Development of the Cleanup Action Alternatives
- Section 6: Evaluation of the Cleanup Action Alternatives
- Section 7: The Recommended Cleanup Action Alternative
- Section 8: References

SECTION 2: BACKGROUND INFORMATION

A summary of the Site background information most pertinent to this Report is presented in this section. For a more comprehensive summary of background information, refer to the FS Data Gap Investigation Report (PIONEER 2019).

2.1 Hydrogeology

The relevant hydrostratigraphic units at the Site, from shallowest to deepest, correspond to a specific lithologic unit and include the following:

- **Upper Aquifer**: The Upper Aquifer is the saturated portion of the fill unit. The thickness of the Upper Aquifer is approximately ten to 15 feet. Upper Aquifer groundwater is typically encountered at depths of less than six feet below ground surface (bgs) in most portions of the Site, and is encountered at depths less than two feet bgs within portions of the main arsenic plume.
- **First Aquitard**: The First Aquitard is the upper silt unit. The thickness of the First Aquitard is approximately five to ten feet. Thin and/or leaky portions of the First Aquitard have been identified in portions of the Site (see Figure 2-1).
- **Intermediate Aquifer**: The Intermediate Aquifer is the intermediate sand unit. The thickness of the Intermediate Aquifer is approximately ten to 20 feet.
- **Second Aquitard**: The Second Aquitard is the lower silt unit. The thickness of the Second Aquitard is approximately five to 15 feet.
- **Deep Aquifer**: The Deep Aquifer is the lower sand unit. The thickness of the Deep Aquifer appears to be at least 20 feet thick.

In general, for the main arsenic plume, groundwater in all three aquifers flows east towards the Hylebos Waterway. There may also be localized groundwater flow in the Upper Aquifer and Intermediate Aquifer towards the north or south near the SPW. The Intermediate Aquifer and the Deep Aquifer are tidally influenced and can experience flow reversals. Tidal fluctuations and mixing occur seaward of the SPW in the Upper Aquifer, but are less noticeable in the Upper Aquifer landward of the SPW.

The primary hydrostratigraphic units of interest for this Report are the Upper Aquifer, First Aquitard, and Intermediate Aquifer because the majority of the arsenic mass is located in these three units.

2.2 Overview of Operational History

The Site was used as a chemical manufacturing facility from 1927 to 1997 and the majority of the manufacturing operations were performed in the former Central Manufacturing Area (see Figure 1-1). The products that were manufactured in that area included chlorine, sodium hydroxide (caustic), sodium chlorate, hydrochloric acid, and sodium arsenite (Penite). Penite, which is the product most relevant to this Report, was manufactured between circa 1944 and the early 1970s. The remaining chlorine-based manufacturing facility operations ceased in 1997, at which time the manufacturing facilities were dismantled and removed from the Site. The Port removed all remaining aboveground structures in 2008. The Site is covered with vegetation, crushed rock, and some former building/tank foundations. The planned future land use for the Site is Port Maritime Industrial (PMI), consistent with the Port's Land Use Plan (Port 2014) and local zoning.

2.3 Overview of Regulatory Context

Investigation and cleanup work associated with the Site has been performed under three separate but interrelated regulatory programs:

- CERCLA: The Site is one of many source areas included within Operable Unit OU 05 of the CB/NT site. Cleanup of the Site shoreline and the Head of the Hylebos Waterway (the portion of the Waterway where Site groundwater discharges) were completed as part of remedial actions for the CB/NT CERCLA site.
- Clean Water Act: Previous upland Site investigations and pre-2011 remedial actions were completed pursuant to a 1987 Consent Decree between Arkema and Ecology.
- MTCA: The Remedial Investigation (RI) Report (DOF 2013; Ecology 2013) and this Report were prepared pursuant to Agreed Order No. DE 5668 between the Port and Ecology. The Agreed Order became effective on July 25, 2011.

2.4 Definition of Arsenic Plume Terms

To facilitate clear communication about arsenic in groundwater at the Site, the following terms are used for the purposes of this Report:

- Main arsenic plume: The main arsenic plume is conceptually defined as the plan-view area encompassed by the 2017 Upper Aquifer dissolved arsenic isoconcentration contour of 500 micrograms per liter (ug/L), areas downgradient of this contour, and associated areas with activity of hydrogen ions (pH) levels exceeding nine (see Figure 1-1). The main arsenic plume includes groundwater within this plan-view area in the Upper, Intermediate, and Deep Aquifers.
- Source Area: The source area for the main arsenic plume is generally defined as the area encompassed by the known and potential Penite manufacturing features shown on Figure 1-1.
- Plume core: The plume core is loosely defined as the areas where historical and/or 2017 arsenic concentrations in monitoring wells (MWs) exceeded 50,000 ug/L.
- Groundwater: Groundwater is defined in WAC 173-340-200 as "water in a saturated zone or stratum beneath the surface of land or below a surface water."
- Pore water: Pore water is defined as the subset of groundwater that is located within the 0 - 10 centimeter biologically active zone (BAZ) used for the CB/NT site (DOF 2011).
- Surface water: Surface water is defined in WAC 173-340-200 as "lakes, rivers, ponds, streams, inland waters, salt waters, and all other surface waters and water courses within the state of Washington or under the jurisdiction of the state of Washington."

2.5 Summary of the Conceptual Site Model

A summary of the current conceptual site model (CSM) for the main arsenic plume is presented in this section. The CSM includes conceptual site fate and transport elements and a conceptual site exposure model. A more detailed version of the CSM is presented in the FS Data Gap Investigation Report (PIONEER 2019). The CSM will be updated as new information is obtained.

Key conceptual fate and transport elements are:

- Former Penite Pits #1 and #2 are known primary sources and sludge-like material remains in former Penite Pit #2.
- The former Penite Manufacturing Building is a suspected third primary source based on the nature of historical Penite manufacturing operations, evaluation results presented in the FS Data Gap Investigation Report, and groundwater modeling results.[3]
- Transport of arsenic in groundwater from the source area towards the Hylebos Waterway is currently conceptualized as three separate plume lobes emanating from each of the three primary sources that have combined to form a single large arsenic plume. Groundwater in the Upper and Intermediate Aquifers near former Penite Pit #1 generally flows due east towards the SPW, while groundwater near former Penite Pit #2 has a slight southeastern flow direction and groundwater near the former Penite Manufacturing Building has a slight northeastern flow direction. The central plume lobe emanating from former Penite Pit #1 is currently less prominent than the northern and southern lobes because of the success of completed remediation actions within and downgradient of former Penite Pit #1.
- Completed remedial actions (i.e., soil excavations and operation of the arsenic pump-and-treat [P&T] system) have removed arsenic mass from the main arsenic plume.
- The majority of arsenic within the main arsenic plume is either precipitated or co-precipitated with highly stable minerals or co-precipitated with metal oxides.
- Elevated pH levels within the northern and southern portions of the main arsenic plume limit opportunities for sorption and cause reducing conditions (e.g., activity of electrons [Eh] less than 0 volts) that further hamper sorption and limit co-precipitation with metal oxides in these areas.
- Thin/leaky First Aquitard locations upgradient of 124+00-2 on the landward side of the SPW are preferential pathways that likely contribute to elevated dissolved arsenic concentrations at 124+00-2 and two pore water nylon-screen diffusion sampler (NSDS) locations downgradient of 124+00-2.
- The main arsenic plume is stable or declining due to completed remedial actions and ongoing natural attenuation processes.
- The existing SPW, intertidal shoreline cap, and subtidal shoreline cap help attenuate arsenic concentrations in groundwater prior to discharge to surface water.
- Highly favorable geochemical conditions for arsenic attenuation are present near the shoreline due to mixing of marine surface water with groundwater.
- The mixing of surface water within groundwater in the transition zone along the Site shoreline causes hydraulic tidal dispersion, which limits the amount of fresh groundwater discharged to surface water.

The key exposure pathways for the purposes of this Report are those related to potential surface water and sediment exposures:

- Absorption by marine aquatic organisms
- Bioaccumulation by marine aquatic organisms
- Incidental ingestion and dermal contact with surface water and sediment by recreators/fishers
- Consumption of marine aquatic organisms by recreators/fishers

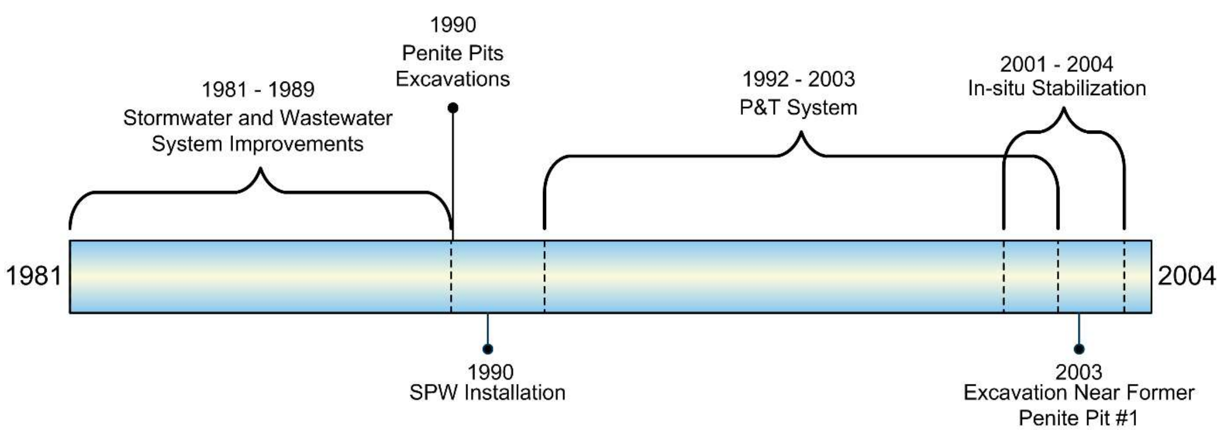
[3] When used in this Report, the term former Penite Manufacturing Building refers to the former building itself and the three adjacent former tanks located immediately southeast of the former building.

Other complete and potentially complete exposure pathways are soil direct contact, VI, and groundwater direct contact pathways. The complete and potentially complete soil direct contact pathways are incidental ingestion, dermal contact, and inhalation of particulates from surface soil by on-site workers and trespassers, and incidental ingestion, dermal contact, and inhalation of particulates from subsurface soil by utility workers. The potentially complete VI pathway is inhalation of indoor air vapors by on-site workers if an occupied building is constructed without a VI mitigation system in VOC VI Areas A, B, or C. The potentially complete groundwater dermal contact pathway is dermal contact with subsurface groundwater by utility workers. Additional discussion about and remedial components to address the soil direct contact, VI, and groundwater direct contact pathways are presented in Appendix B.

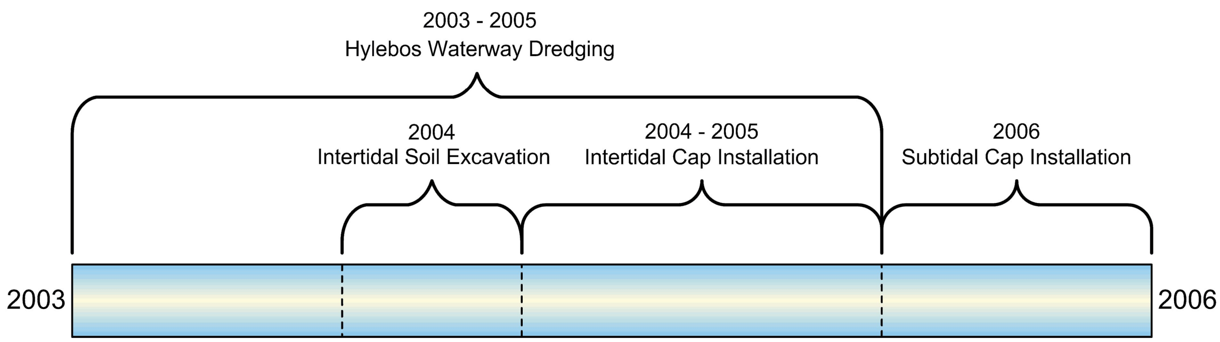
2.6 Overview of Completed Remedial Actions

A substantial number of cleanup activities have been completed for the Site pursuant to CERCLA, the Clean Water Act, and MTCA. Approximately $16 million dollars have been spent through February 2021 to investigate and evaluate the Site, and approximately $66 million dollars have been spent through February 2021 to cleanup the Site (Groff Murphy Trachtenberg & Everard, PLLC 2006; DOF 2011; PIONEER 2016; 2021 personal correspondence with DOF and the Port). Completed remedial actions include improving historical stormwater and wastewater systems, removing soil and sediment, installing soil and sediment caps, installing a SPW, installing and operating a P&T system for the main arsenic plume, conducting in-situ stabilization for the main arsenic plume, remediating VOC source areas, and completing remediation for miscellaneous other releases (see Table 2-1, Figure 2-1A, and Figure 2-1B in Appendix A).

A timeline of the most important completed remedial actions within the plume core of the main arsenic plume are presented in the following graphic.



A timeline of the most important completed remedial actions along the shoreline and within the Hylebos Waterway (on the seaward side of the main arsenic plume) are presented in the following graphic.



The completed remedial actions most responsible for reducing arsenic concentrations and minimizing arsenic exposures in Hylebos Waterway surface water and sediment can be categorized into three phases of active arsenic remediation:

- Phase 1 of active arsenic remediation occurred between 1990 and 2003 and included remedial components that removed mass within the main arsenic plume and decreased discharge to the Hylebos Waterway (e.g., removing source area soil, installing a SPW, installing and operating a P&T system for the main arsenic plume)[4]
- Phase 2 of active arsenic remediation occurred between 2001 and 2004 and consisted of two polishing components that provided additional reductions of arsenic concentrations within the main arsenic plume (i.e., removing additional source area soil and conducting in-situ stabilization within portions of the main arsenic plume)
- Phase 3 of active arsenic remediation occurred between 2003 and 2006 and consisted of remedial components within the Hylebos Waterway and along the Site shoreline (i.e., dredging Hylebos Waterway sediment, removing shoreline soil, and installing intertidal and subtidal shoreline caps)

2.7 Benefits from Completed Phases of Active Arsenic Remediation

The three completed phases of active arsenic remediation have resulted in four key benefits, which are summarized in this section in order of increasing significance.

Benefit 1: Phase 1 and Phase 2 of active arsenic remediation have substantially reduced arsenic concentrations within the main arsenic plume. The evolution of the main arsenic plume over time relative to the completed phases of active arsenic remediation is presented in Appendix C.[5] As shown in Appendix C and discussed in the FS Data Gap Investigation Report (e.g., Appendix A Chart 6-1), the dissolved arsenic concentrations within the plume core have generally declined by at least one order of magnitude between 1989 and current. In addition, dissolved arsenic concentrations within the main

[4] Although the stormwater and wastewater system improvements in the 1980s were important completed remedial actions, these improvements were not included within the Phase 1 of active arsenic remediation category because their improvements occurred before the selection of the original groundwater remedy pursuant to the Clean Water Act.

[5] The shape for some of the data-driven, dissolved arsenic isoconcentration contours in Appendix C were informed by groundwater modeling results obtained during the calibration and verification of the Site groundwater model.

arsenic plume have generally been stable or declining since circa 2007 or 2008 based on the evaluations of multiple lines of evidence presented in the FS Data Gap Investigation Report.

Benefit 2: Phase 1 through Phase 3 of active arsenic remediation have substantially reduced arsenic concentrations along the Hylebos Waterway shoreline. A key conclusion of the FS Data Gap Investigation Report was that dissolved arsenic concentrations entering the shoreline area near the SPW have likely decreased by at least two orders of magnitude between 1989 and 2017. However, the FS Data Gap Investigation Report did not evaluate the long-term benefits from Phase 1 through Phase 3 of active arsenic remediation within the shoreline area itself because of the lack of historical arsenic results in this area prior to 2004. Subsequent to preparation of the FS Data Gap Investigation Report, a few pre-2004 arsenic shoreline results were discovered that enabled a better understanding of how dissolved arsenic concentrations along the shoreline have changed over time. The evolution of dissolved arsenic concentrations within the shoreline area (along a transect near the center of the main arsenic plume) is presented in Appendix D. The results shown in Appendix D suggest that dissolved arsenic concentrations in vertical shoreline MWs immediately downgradient of the SPW decreased by three orders of magnitude between circa 1990 and 2017. Similarly, the results shown in Appendix D suggest that dissolved arsenic concentrations where Upper Aquifer groundwater discharges to surface water decreased by two orders of magnitude between circa 1990 and 2017.

Benefit 3: Phase 1 through Phase 3 of active arsenic remediation have substantially reduced the mass discharge of arsenic to the Hylebos Waterway. The selected CB/NT remedy included the groundwater source control goal of reducing the arsenic mass discharge by 80% from the circa 1990 estimate of 2,400 kilograms/year to 480 kilograms/year (Tetra Tech 1988; USEPA 1989; ICF Technology Incorporated [ICF] 1990c). The current mass discharge of arsenic to the Hylebos Waterway was recently estimated with the Site groundwater model to be approximately 10 kilograms/year. A comparison of the circa 1990 arsenic mass discharge with the current arsenic mass discharge relative to the source control goal is presented in Appendix D. As shown in Appendix D, the arsenic mass discharge has decreased by approximately 99.6% from circa 1990 to current (which corresponds to two additional 80% reductions on top of the original 80% reduction goal).

Benefit 4: Phase 1 through Phase 3 of active arsenic remediation have achieved criteria for protection of human health and the environment at the actual exposure point locations in surface water and sediment. Current dissolved arsenic concentrations in surface water samples collected as close as technically possible to where groundwater flows into surface water are less than the default MTCA background concentration of 5 ug/L (PIONEER 2019). Arsenic concentrations in all sediment samples collected within the sediment BAZ have been less than the 57 milligrams per kilogram (mg/kg) sediment quality objective (SQO) since Phase 3 of active arsenic remediation was completed (DOF 2011, 2013, 2018; PIONEER 2019).

2.8 Summary of Current Conditions for the Main Arsenic Plume

Although current and anticipated future surface water and sediment concentrations are protective of human health and the environment at exposure point locations (i.e., surface water concentrations are less than background and sediment concentrations are less than the SQO), additional active arsenic remediation (beyond the three completed phases of active arsenic remediation) will likely be necessary for the main arsenic plume in order to use permanent solutions to the maximum extent practicable. As a result, the current conditions and CSM elements most salient for developing additional active arsenic remediation components were identified (see following bullets) and were summarized on Figure 2-1.[6]

- The 5,000 ug/L and 50,000 ug/L dissolved arsenic isoconcentration contours, which highlight the areas with the highest remaining concentrations at the Site (e.g., current plume core).[7]
- Upper Aquifer Angled Shoreline MW and Intermediate Aquifer pushpoint sampler (PPS) locations with a current dissolved arsenic concentration exceeding the MTCA screening level (SL) for protection of aquatic organisms (36 ug/L). Upper Aquifer Angled Shoreline MWs and Intermediate Aquifer PPSs are one of several potential points of compliance (POC) options for the main arsenic plume (see Section 3.3.3). The MTCA SL for protection of aquatic organisms (36 ug/L) is a potential groundwater remediation level (RL).
- Upper Aquifer and Intermediate Aquifer pore water NSDS locations with a current dissolved arsenic concentration exceeding the MTCA SL for protection of aquatic organisms (36 ug/L). Pore water NSDSs are one of several potential POC options for the main arsenic plume (see Section 3.3.3). The MTCA SL for protection of aquatic organisms (36 ug/L) is a potential groundwater RL.
- Locations of known and potential Penite manufacturing features, which include known primary sources (i.e., former Penite Pits #1 and #2) and a suspected primary source (i.e., former Penite Manufacturing Building).
- Locations where the First Aquitard is thin or leaky.[8] These locations could provide a preferential pathway for arsenic migration from the Upper Aquifer to the Intermediate Aquifer. In particular, the two thin/leaky First Aquitard locations immediately upgradient of 124+00-2 on the landward side of the SPW likely contribute to elevated dissolved arsenic concentrations at 124+00-2 and two pore water NSDSs downgradient of 124+00-2.
- Locations where pH currently exceed or equal 10. These locations have notably high pH levels that will likely limit opportunities for arsenic sorption and cause reducing conditions that further hamper arsenic sorption and limit co-precipitation of arsenic with metal oxides for an extended time frame.
- Locations where active arsenic remediation components have already been completed and remain intact (i.e., soil and sediment removals, soil and sediment caps, SPW).

In summary, the key dissolved arsenic concentrations that will inform the development of additional active arsenic remediation components are (see Figure 2-1):

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[6] Additional details on current conditions are presented in Figures 5-1 through 5-9, Figure 5-21, Figure 5-23, Figures 6-13 through 6-15, Figure 7-1, and Figure 7-2 in Appendix A.

[7] The data-driven isoconcentration contours shown in Figure 2-1 are updated versions of the contours presented in the FS Data Gap Investigation Report. As anticipated in the FS Data Gap Investigation Report, the contours were updated based on output from the Site groundwater model.

[8] Two additional thin/leaky First Aquitard locations were identified subsequent to preparation of the FS Data Gap Investigation Report. The identification of one location was based on output from the Site groundwater model and the boring log for MW 125+50-3 (DOF 2013). The identification of the other location was based on the boring log for Boring C-1 (Intera 1995).

- The 2017 and 2018 concentrations in 124+00-2 (on the order of 50,000 ug/L) were one to four orders of magnitude higher than concentrations in the other Intermediate Aquifer vertical shoreline MWs and the Upper Aquifer vertical shoreline MWs.[9]
- One Upper Aquifer Angled Shoreline MW (125+50-0) and three Intermediate Aquifer PPS locations (120+75-ST1, 123+25-ST1, and 128+50-ST1) exceeded 36 ug/L in 2017 or 2018.[10]
- One Upper Aquifer pore water NSDS location (125+50-0-DS) and two Intermediate Aquifer pore water NSDS locations (123+25-ST1-DS and 125+00-ST1-DS) exceeded 36 ug/L in 2017 or 2018.[11]
- One pore water NSDS location exceeded 360 ug/L in 2017 or 2018 (550 ug/L in 123+25-ST1-DS).

2.9 Key Site-Specific Challenges for Remediating the Main Arsenic Plume

Key site-specific challenges for groundwater remediation of the main arsenic plume include:

- Groundwater treatment and containment remedial components will not destroy or degrade elemental arsenic. These remedial components only have the ability to limit arsenic mobility.
- Nearly all of the remaining arsenic mass at the Site is present in First Aquitard soil. It is difficult to effectively treat arsenic in First Aquitard soil because (1) treatment injections cannot effectively penetrate low permeability units, (2) the First Aquitard already has a hydraulic conductivity similar to what solidification could achieve, and (3) most of the arsenic in the First Aquitard is already precipitated/mineralized. Furthermore, it would not be prudent to excavate the entire thickness of First Aquitard soil because that activity would compromise the integrity of this important vertical transport barrier and increase arsenic concentrations in the Intermediate and Deep Aquifers.
- At complex sites, initial concentration reductions are almost always easier to achieve than subsequent concentration reductions. For instance, concentration reductions of two orders of magnitude in individual MWs is the recommended Interstate Technology & Regulatory Council (ITRC) objective for site closure at complex sites (ITRC 2017). Since substantial reductions of dissolved arsenic concentrations within the plume core and along the shoreline have already been achieved, it will be difficult for any groundwater remedy to obtain additional order of magnitude reductions within the main arsenic plume.
- The current dissolved arsenic concentration at 124+00-2 (approximately 50,000 ug/L) is four orders of magnitude greater than the MTCA groundwater cleanup level (CL) of 5 ug/L. Reducing arsenic concentrations at 124+00-2 by 99.99% to achieve the 5 ug/L CL within a reasonable restoration time frame is not practicable.
- Based on groundwater modeling results that are presented later in this Report, the restoration time frame to achieve the 5 ug/L CL will be extremely long for the standard groundwater POC and almost all groundwater conditional POC (CPOC) options, regardless of how much additional active remediation is performed.

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[9] The dissolved arsenic concentrations in the 124+00-2 samples collected during 2017 and 2018 were 39,000 ug/L and 76,000 ug/L, respectively.

[10] Dissolved arsenic concentrations in 125+50-0, 120+75-ST1, 123+25-ST1, and 128+50-ST1 ranged from 75 ug/L to 110 ug/L, 48 ug/L to 280 ug/L, 160 ug/L to 190 ug/L, and 3.1 ug/L to 70 ug/L, respectively.

[11] Dissolved arsenic concentrations in 125+50-0-DS and 125+00-ST1-DS ranged from 39 ug/L to 44 ug/L and 6.4 ug/L to 44 ug/L, respectively. 123+25-ST1-DS was only sampled in 2018 (with a dissolved arsenic concentration of 550 ug/L).

SECTION 3: CONSTITUENTS OF CONCERN, CLEANUP STANDARDS, AND CLEANUP ACTION OBJECTIVES

COCs, cleanup standards, and cleanup action objectives (CAOs) are defined in this section to provide a basis for developing the alternatives, evaluating the alternatives, and determining the ultimate success of the selected alternative during cleanup action implementation.

In accordance with WAC 173-340-700(3), MTCA cleanup standards “consist of the following: (a) cleanup levels for hazardous substances present at the site; (b) the location where these cleanup levels must be met (point of compliance); and (c) other regulatory requirements that apply to the site because of the type of action and/or location of the site (‘applicable state and federal laws’).”

3.1 Constituents of Concern

The nine Site COCs are arsenic plus the eight other constituents of potential concern (COPCs) discussed in Appendix B: copper, lead[12], mercury, nickel, tetrachloroethylene (PCE), trichloroethylene (TCE), vinyl chloride (VC), and chloroform (CF).

3.2 Relevant Existing CB/NT Cleanup Standards for the Main Arsenic Plume

Since this MTCA Site is part of the larger CERCLA CB/NT site, the existing CB/NT cleanup standards that are relevant to the main arsenic plume are presented in this section. The CB/NT cleanup standards were developed to (1) facilitate source control, and (2) protect all human and ecological surface water and sediment receptors. In developing these cleanup standards, USEPA established the groundwater POC as surface water above the sediment/water interface and the sediment POC as the BAZ (0 - 10 centimeters). As summarized in the following table, all relevant existing CB/NT cleanup standards have been achieved.[13] In other words, the main arsenic plume does not pose an unacceptable risk or hazard to human or ecological receptors unless the main arsenic plume causes future arsenic concentrations in the sediment BAZ to exceed the 57 mg/kg SQO or future arsenic concentrations in surface water to exceed 5 ug/L.

[12] Lead is a COC for soil only. Lead was eliminated as a groundwater COPC in the RI Report (DOF 2013).

[13] Although all CB/NT cleanup standards have been achieved, USEPA still expects the MTCA source control process to be completed to USEPA’s satisfaction (USEPA 2014).

Relevant Existing CB/NT Cleanup Standard	Cleanup Standard Achieved?	Rationale
Reduce arsenic mass discharge to Hylebos Waterway by 80% from the circa 1990 estimate of 2,400 kilograms/year to 480 kilograms/year (Tetra Tech 1988; USEPA 1989; ICF 1990c).	Yes	The current arsenic mass discharge to Hylebos Waterway is approximately 10 kilograms/year based on groundwater modeling results presented later in this Report.
Achieve SQO of 57 mg/kg for arsenic in the BAZ of 0 - 10 centimeters (USEPA 1989, 2000).	Yes	The SQO was achieved in the BAZ during Phase 3 of active arsenic remediation (DOF 2011).
Ensure groundwater flowing through the intertidal and subtidal sediment caps will not recontaminate sediment such that arsenic concentrations in the BAZ (0 - 10 centimeters) exceed the 57 mg/kg SQO (USEPA 2000).	Yes	All arsenic concentrations in sediment samples collected since Phase 3 of active arsenic remediation was completed were less than the 57 mg/kg SQO (DOF 2011, 2013, 2018; PIONEER 2019). Future sediment monitoring is a component of all alternatives to ensure this standard continues to be satisfied in the future.
Ensure groundwater flowing through the sediment caps will not cause arsenic concentrations in surface water to exceed “background concentrations or marine chronic water quality criteria” (USEPA 2000).	Yes	All dissolved arsenic concentrations in surface water samples collected where groundwater discharges to surface water are less than 5 ug/L, which is the current MTCA background concentration (PIONEER 2019). The "marine chronic water quality criteria" for arsenic is 36 ug/L. Future surface water monitoring is a component of all alternatives to ensure this standard continues to be satisfied in the future.

3.3 MTCA Groundwater Cleanup Standards

3.3.1 Groundwater CLs

The groundwater CL for dissolved arsenic of 5 ug/L is based on the protection of potential surface water receptors and the current Ecology-accepted background concentration for arsenic in groundwater.[14] Specifically, this default arsenic CL of 5 ug/L is based on protection of human health (e.g., consumption of marine aquatic organisms by recreators/fishers) even though USEPA concluded that arsenic in the Hylebos Waterway does not pose an unacceptable risk to human health (USEPA 1989; PIONEER 2019). If appropriate, the dissolved arsenic groundwater CL may be adjusted in the future to account for regional or site-specific background concentrations.

The groundwater CLs for copper, mercury, nickel, PCE, TCE, VC, and CF are the surface water SLs presented in Appendix B.

3.3.2 Potential Arsenic Groundwater RL

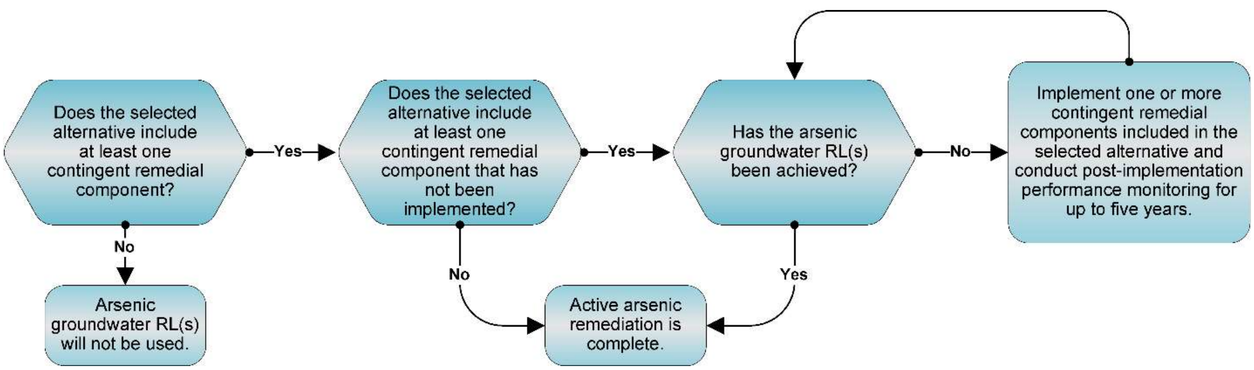
If the selected alternative includes contingent remedial components, then one or more arsenic groundwater RLs will be developed to determine whether or not contingent remedial components

[14] MTCA surface water cleanup levels are based on Chapter 173-201A of the WAC, regulations developed pursuant to Section 304 of the Clean Water Act, and 40 Code of Federal Regulations 131. These regulations explicitly indicate that the criteria are intended for use with dissolved arsenic. Thus, dissolved arsenic concentrations are used for evaluating compliance.

specifically identified in this Report need to be deployed. The RL(s) would be developed and the decision about whether or not to deploy a contingent remedial component would likely occur after all of the non-contingent active plume remediation components have been constructed and up to five years of performance monitoring have been conducted. Potential groundwater RL options include, but are not limited to:

- Achieving dissolved arsenic concentrations of less than or equal to 36 ug/L in all pore water NSDS locations.
- Achieving dissolved arsenic concentrations of less than or equal to an RL developed based on site-specific toxicity testing in all pore water NSDS locations.
- Achieving a to-be-determined RL in all vertical shoreline MWs that is expected based on monitoring and modeling results to achieve dissolved arsenic concentrations of less than or equal to 36 ug/L (or an RL developed based on site-specific toxicity testing) in all pore water NSDS locations within an acceptable time frame.
- Achieving stable or decreasing dissolved arsenic concentration trends in all vertical shoreline MWs.

The following flowchart illustrates how arsenic groundwater RL(s) would be used to determine if contingent remedial components need to be deployed.



3.3.3 Groundwater POC Options

A number of groundwater POC options are potentially applicable to this Site based on MTCA regulations for the protection of potential surface water receptors. The standard groundwater POC, which is defined in WAC 173-340-720(8)(b) as all groundwater across a site, is potentially applicable to all sites. However, this standard POC is typically not appropriate for complex sites like this Site because it is not practicable to achieve groundwater CLs throughout the site within a reasonable restoration time frame. In addition, the standard groundwater POC is unnecessarily conservative for protection of marine surface water and sediment receptors because the standard POC assumes that (1) marine aquatic organisms live in upland fresh groundwater, and (2) recreators/fishers consume marine aquatic organisms obtained from upland fresh groundwater. As a result, MTCA regulations allow two general types of groundwater CPOCs that could be applied to a complex shoreline site such as this Site. Per WAC 173-340-720(8)(c), the first general CPOC option is "as close as practicable to the source of hazardous substances" but not exceeding the property boundary. Since this Site abuts surface water, a second general CPOC option per WAC 173-340-720(8)(d)(i) if certain criteria are met is "within the surface water as close as technically possible to the point or points where ground water flows into the surface water."

For each alternative evaluated in the FS Report, restoration time frames in the Upper and Intermediate Aquifers were determined for five POC options (i.e., the standard groundwater POC and four different potential groundwater CPOCs).[15] The four specific CPOC locations in the Upper and Intermediate Aquifers to be considered as potential POCs are (see Figure 3-1):

1. Upper Aquifer and Intermediate Aquifer vertical shoreline MWs
2. Upper Aquifer Angled Shoreline MWs (located approximately two feet landward of the surface water interface) and Intermediate Aquifer PPS locations (which have a pump intake approximately one foot landward of the surface water interface)
3. Upper Aquifer and Intermediate Aquifer pore water NSDSs conservatively located within the BAZ at a depth of approximately 10 centimeters
4. Surface water samples collected as close as technically possible to where groundwater flows into surface water

In accordance with MTCA regulations, the selected groundwater POC location will need to provide for a reasonable restoration time frame. Although what constitutes a reasonable restoration time frame is subjective, Ecology typically has a strong preference for shorter restoration time frames. The selected groundwater POC will be determined based on an evaluation of estimated restoration time frames for all five groundwater POC options. Although all five POC options listed above were evaluated, the groundwater modeling results that are presented later in this Report indicate the restoration time frame to achieve the 5 ug/L CL will be extremely long for four of the five groundwater POC options, regardless of how much additional active remediation is performed. In similar situations at other complex MTCA shoreline sites, Ecology has approved POCs of surface water or pore water in the BAZ (see Table 3-1 for a review of select MTCA groundwater POC precedents).

3.4 Cleanup Action Objectives for the Main Arsenic Plume

Short-term, medium-term, and long-term CAOs were developed for the main arsenic plume to provide written objectives of what each phase of remediation is intended to accomplish, provide an organizational structure for the assembly of alternatives in Section 5, and communicate conceptual time frame expectations for the different phases of remediation (see Table 3-2). The use of these type of interim objectives can provide important milestones for evaluating remediation progress at complex sites (ITRC 2017). From a protection of human health and the environment perspective, the most important CAO is the short-term CAO (i.e., achieve relevant existing CB/NT cleanup standards in order to protect human health and the environment at the exposure point locations). Fortunately, the short-term CAO has already been achieved after decades of cleanup during Phases 1 through 3 of active arsenic remediation.

[15] The groundwater POC for the Deep Aquifer will be the Deep Aquifer vertical shoreline MWs.

3.5 MTCA Soil Cleanup Standards

3.5.1 Soil CLs

The arsenic soil CL for the Site is 88 mg/kg and is based on the protection of commercial/industrial workers for the soil direct contact pathway. The arsenic soil CL is the MTCA Standard Method C industrial soil CL for the soil direct contact pathway. This same arsenic soil CL was used for the Wypenn Interim Action (DOF 2015b), the Arkema Mound Interim Action (DOF 2015a), and other cleanups at nearby sites such as Superlon (Pacific Environmental & Redevelopment Corporation and PIONEER 2014) and the Former Reichhold Site (Floyd Snider 2008).

The soil CLs for copper, lead, mercury, nickel, PCE, TCE, VC, and CF are the soil direct contact SLs presented in Appendix B.

3.5.2 Arsenic Soil RL

An arsenic soil RL will be developed and used for a focused source area excavation component within select alternatives. A focused excavation of elevated arsenic soil concentrations (e.g., greater than 20,000 mg/kg) within the source area would remove similar amounts of arsenic mass as more aggressive excavation options (see Appendix A Table 6-2). The soil RL will be determined based on pre-design investigation (PDI) results (i.e., additional soil sampling in the vicinity of the former Penite Manufacturing Building and former Penite Pits #1 and #2) and a Getis-Ord hotspot analysis.

3.5.3 Soil POC

Since the soil cleanup standards are based on incidental soil ingestion, the soil POC is from ground surface to 15 feet bgs in accordance with WAC 173-340-745(7) and 173-340-740(6)(d). All alternatives that include soil containment (i.e., cap/cover) are capable of satisfying this POC in accordance with WAC 173-340-740(6)(f) by including institutional controls (ICs) and compliance monitoring as remedial components.

3.6 Other Regulatory Requirements

No other applicable state and federal laws or regulations have been identified at this time that would modify the cleanup standards given the type of alternatives being considered or the location of the Site. However, a preliminary evaluation of potentially applicable or relevant and appropriate requirements for cleanup action implementation is included in Appendix E. Further assessment and/or action (e.g., obtaining permits) will be necessary before cleanup action implementation activities are initiated in order to address these requirements.

SECTION 4: IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

The identification and screening of remedial technologies to determine the most promising and feasible technologies for addressing the main arsenic plume are summarized below.

4.1 Identification of Remedial Technologies

A total of 27 unique remedial technologies were identified as potential remedial components of alternatives for the main arsenic plume. The identified technologies and a brief description of each technology are presented in Table 4-1. The list of identified technologies (which includes innovative treatment technologies) was determined based on the technologies used previously at this Site, the technologies used at similar sites, the technologies included on USEPA's Contaminated Site Clean-up Information website (https://clu-in.org), and professional judgment. The identified technologies were sorted into the following general response action categorizes to assist with the screening process:

- Mass removal
- Treatment
- Containment
- Monitoring and control

4.2 Screening of Remedial Technologies

Consistent with MTCA regulations, screening was conducted to reduce the number of identified remedial technologies in order to focus the assembly of alternatives on the most promising and feasible technologies. In accordance with USEPA guidance, effectiveness, implementability, and cost criteria were used to screen the technologies (USEPA 1988). Screening was qualitatively performed based on Site characteristics, arsenic characteristics, technology capabilities, and professional judgment. The highest rated technologies during the screening were retained for further consideration when assembling alternatives. The 14 retained technologies were (see Table 4-1):

- Soil excavation and off-site disposal
- Sediment dredging and off-site disposal[16]
- Groundwater extraction, on-site treatment, and off-site disposal[17]
- In-situ solidification
- In-situ stabilization
- Monitored natural attenuation (MNA)
- Sediment cap

[16] The technology was retained because it was used during Phase 3 of active arsenic remediation, but will not be considered for future phases of active remediation because Hylebos Waterway dredging near the Site is complete.

[17] The technology was retained because it was used during Phase 1 of active arsenic remediation, but will not be considered for future phases of active remediation based on the relative effectiveness, implementability, and cost ratings.

- Surface soil cap
- Barrier wall
- Surface water monitoring
- Sediment monitoring
- Groundwater monitoring
- Engineering controls (ECs)
- ICs

SECTION 5: DEVELOPMENT OF THE CLEANUP ACTION ALTERNATIVES

A total of five alternatives were assembled based on the current conditions, cleanup standards, CAOs, the 14 remedial technologies that were retained for the main arsenic plume in Section 4, and professional judgment. A wide range of alternatives were assembled. On one end of the spectrum, Alternative 1 relies on the benefits obtained from Phases 1 through 3 of active arsenic remediation, with the addition of controls and some limited monitoring and maintenance to help ensure protection of human health and the environment. On the other end of the spectrum, Alternative 5 (which is intended to serve as the most permanent alternative per MTCA remedy selection regulations) includes extensive future soil excavation and extensive future groundwater treatment in addition to the Phases 1 through 3 of active arsenic remediation. Alternatives 2 through 5 all have a robust collection of monitoring, maintenance, and controls (in addition to future active remediation components) to help ensure protection of human health and the environment. All alternatives include the remedial components that were determined to be necessary to address the "other potential Site concerns" (see Appendix B). The remedial components associated with Alternatives 1 through 5 are presented in Table 5-1. The conceptual locations for remedial components included in Alternatives 1 through 5 that involve future active remediation construction are shown on Figures 5-1 through 5-5, respectively. These same five alternatives (minus the remedial components to address "other potential Site concerns") were previously submitted to Ecology in a July 2020 Cleanup Action Alternatives document (PIONEER 2020).

SECTION 6: EVALUATION OF THE CLEANUP ACTION ALTERNATIVES

The five alternatives developed in Section 5 were evaluated in this section using the MTCA remedy selection process and criteria described in WAC 173-340-360.

6.1 Evaluation Process and Criteria

The five alternatives were evaluated using a two-step process. The first step of the evaluation process was to determine whether or not each alternative could satisfy the four MTCA threshold requirements for remedy selection in WAC 173-340-360(2)(a). Each alternative that satisfied all four threshold requirements was evaluated further using two of the three MTCA "other" requirements for remedy selection (also known as balancing criteria) in WAC 173-340-360(2)(b). The two "other" requirements evaluated in this Report were (1) "use permanent solutions to the maximum extent practicable", and (2) "provide for a reasonable restoration time frame." The third "other" requirement (i.e., "consider public concerns") was not evaluated at this time because public comments have not yet been solicited for this Report. The "consider public concerns" requirement will be formally evaluated after the public comment period for the draft FS Report and the draft Cleanup Action Plan (CAP) is completed.

6.1.1 MTCA Threshold Requirements Evaluation

The four MTCA threshold requirements are:

- "Protect human health and the environment"
- "Comply with cleanup standards"
- "Comply with applicable state and federal laws"
- "Provide for compliance monitoring"

The ability of a given alternative to satisfy these four threshold requirements was evaluated qualitatively by considering the nature and extent of COC exceedances, cleanup standards, the remedial components included in the alternative, and professional judgment. The MTCA threshold requirements evaluation is presented in Table 6-1.

6.1.2 Disproportionate Cost Analysis

In accordance with WAC 173-340-360(3)(b), a disproportionate cost analysis conducted with the methodology in WAC 173-340-360(3)(e) was used to determine if permanent solutions are being used to the maximum extent practicable. As stated in WAC 173-340-360(3)(b), the disproportionate cost analysis "shall compare the costs and benefits of the cleanup action alternatives evaluated in the feasibility study." Per WAC 173-340-360(3)(f)(iii), costs mean "the cost to implement the alternative, including the cost of construction, the net present value of any long-term costs, and agency oversight costs that are cost recoverable." The five specified benefits in WAC 173-340-360(3)(f) evaluated as part of the disproportionate cost analysis were:[18]

- Protectiveness: "Overall protectiveness of human health and the environment, including the degree to which existing risks are reduced, time required to reduce risk at the facility and attain cleanup standards, on-site and offsite risks resulting from implementing the alternative, and improvement of the overall environmental quality."
- Permanence: "The degree to which the alternative permanently reduces the toxicity, mobility or volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of waste treatment process, and the characteristics and quantity of treatment residuals generated."
- Effectiveness over the long term: "The degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on-site at concentrations that exceed cleanup levels, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes."
- Management of short-term risks: "The risk to human health and the environment associated with the alternative during construction and implementation, and the effectiveness of measures that will be taken to manage such risks."
- Technical and administrative implementability: "Ability to be implemented including consideration of whether the alternative is technically possible, availability of necessary offsite facilities, services and materials, administrative and regulatory requirements, scheduling, size, complexity, monitoring requirements, access for construction operations and monitoring, and integration with existing facility operations and other current or potential remedial actions."

In accordance with WAC 173-340-360(3)(e)(i), "costs are disproportionate to benefits if the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of the other lower cost alternative." In practice, this disproportionate cost determination often entails calculating the relative benefit/cost ratio for each alternative to see which alternative has the highest benefit/cost ratio. Typically, the alternative with the highest relative benefit/cost ratio satisfies the MTCA criterion to "use permanent solutions to the maximum extent practicable." For this Report, a relative benefit/cost ratio was calculated for each alternative using the following steps:

- A ranking (score) was assigned to each of the five benefits based on professional judgment.
- Each ranking (score) was multiplied by a weighting factor. The weighting factors for the five benefits were:[19]
  - Protectiveness: 30%
  - Permanence: 20%

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[18] The sixth benefit (i.e., "consideration of public concerns") was not evaluated at this time because public comments have not yet been solicited for this Report. This benefit will be formally evaluated after the public comment period for the draft FS Report and the draft CAP is completed.

[19] When consideration of public concerns is evaluated, its weighting factor will be 10%.

- Effectiveness over the long term: 20%
- Management of short-term risks: 10%
- Technical and administrative implementability: 10%

- The individual weighted benefit scores were summed to calculate the total weighted benefit.
- An order of magnitude cost to implement each alternative was estimated on a net present value basis.
- The total weighted benefit was multiplied by 1,000 and divided by the estimated cost in millions to determine the relative benefit/cost ratio.

The cost estimates used in the calculation of the relative benefit/cost ratios are presented in Appendix F.[20] A summary of the estimated costs for each alternative (including without and with deployed contingent remedial components for Alternatives 3 and 4) is presented in Table 6-2. The scoring of benefits and the calculation of the relative benefit/cost ratios are presented in Table 6-3.

6.1.3 Reasonable Restoration Time Frame Evaluation

In accordance with WAC 173-340-360(4), an evaluation was conducted to determine which groundwater POC options provide for a reasonable restoration time frame. The restoration time frame is defined in WAC 173-340-200 as "the period of time needed to achieve the required cleanup levels at the point of compliance established for the site." Groundwater POC options were evaluated rather than alternatives because all alternatives had similar estimated time frames for a given POC (see Table 6-2). Pursuant to WAC 173-340-360(4)(b), the factors used to determine if a given POC provides for a reasonable restoration time frame were:

- "Potential risks posed by the site to human health and environment;
- Practicability of achieving a shorter restoration time frame;
- Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;
- Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;
- Availability of alternative water supplies;
- Likely effectiveness and reliability of institutional controls;
- Ability to control and monitor migration of hazardous substances from the site;
- Toxicity of the hazardous substances at the site; and
- Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions."

Groundwater restoration time frames were determined for each alternative (including without and with deployed contingent remedial components for Alternatives 3 and 4) and each groundwater POC option. The Site groundwater model was used to estimate restoration time frames for all groundwater POCs except for the surface water POC option. Descriptions of the Site groundwater model, the assumptions

[20] The cost estimates in Appendix F were prepared solely to facilitate relative comparisons between alternatives for the purposes of this Report, and were intended to have an accuracy of roughly -30% to +50%.

used to simulate the alternatives, and the estimated restoration time frames for the simulated alternatives and POCs are included in Appendix G. Estimated restoration time frames for the surface water POC option were based on 2017 and 2018 empirical data (PIONEER 2019). A summary of the estimated restoration time frames for each alternative and POC option is presented in Table 6-2. The estimated arsenic mass discharge for each alternative relative to the CB/NT source control goal is also presented in Table 6-2. The reasonable restoration time frame evaluation is presented in Table 6-4.

An evaluation of soil restoration time frames for the five alternatives was also conducted.

6.2 Evaluation Results

6.2.1 MTCA Threshold Requirements Evaluation

All five alternatives satisfy the MTCA threshold requirements (see Table 6-1). Thus, all five alternatives were included in the disproportionate cost analysis and reasonable restoration time frame evaluation.

6.2.2 Disproportionate Cost Analysis

The relative benefit/cost ratios in the disproportionate cost analysis from highest to lowest were (see Table 6-3):

- Alternative 2: 71
- Alternative 3: 55
- Alternative 1: 53
- Alternative 4: 48
- Alternative 5: 27

Based on these relative benefit/cost ratios, Alternative 2 utilizes permanent solutions to the maximum extent practicable.

6.2.3 Reasonable Restoration Time Frame Evaluation

The estimated restoration time frames for the five groundwater POC options are:

- All Site groundwater: Greater than 10,000 years for all alternatives
- Vertical shoreline MWs: Greater than 10,000 years for all alternatives
- Angled Shoreline MWs/PPSs: Ranges from 4,000 years to greater than 10,000 years
- Pore water NSDSs: Ranges from 3,100 years to greater than 10,000 years
- Surface Water at locations as close as technically possible to the point or points where groundwater flows into surface water: Zero years for all alternatives

A groundwater POC of surface water at locations as close as technically possible to the point or points where groundwater flows into surface water is the only groundwater POC option that can provide for a reasonable restoration time frame (see Table 6-4). This surface water POC does not negatively impact human health and the environment and it provides equivalent or superior benefits compared to other POC options for the factors to be considered when determining whether a POC provides for a reasonable restoration time frame. The estimated restoration time frames for the other four groundwater POC options are unacceptable, and it is practicable to achieve a reasonable restoration time frame that does not negatively impact human health and the environment by using the surface water POC. Although cleanup standards for the main arsenic plume have already been achieved in surface water at locations as close as technically possible to the point or points where groundwater flows into surface water, monitoring and maintenance will be conducted for the foreseeable future to ensure ongoing compliance with cleanup standards in surface water.

All five alternatives provide for a reasonable soil restoration time frame. Soil cleanup standards would be achieved as soon as construction activities for the soil cap/cover and/or soil excavation remedial components are completed (e.g., within five to 15 years following completion of the final CAP depending on which alternative is selected).

SECTION 7: THE RECOMMENDED CLEANUP ACTION ALTERNATIVE

Alternative 2 is the recommended alternative because it satisfies the four MTCA threshold requirements and is the alternative that uses permanent solutions to the maximum extent practicable (i.e., highest benefit/cost ratio). Alternative 2 protects human health and the environment, provides a fourth phase of active arsenic remediation to supplement Phases 1 through 3 of active arsenic remediation, employs reliable and proven technologies, includes robust monitoring, maintenance, and controls to help ensure protectiveness over the long-term, can be implemented relatively quickly, is cost-effective, and does not contain any significant negative tradeoffs. Alternative 2 provides approximately $92 million of beneficial remediation activities (not counting the $16 million of investigation and evaluation activities that have improved the understanding of the Site). Alternative 2 includes the following 25 remedial components:

- EPC-1A: Completed remedial actions during Phase 3 of active arsenic remediation (e.g., dredging Hylebos Waterway sediment, removing shoreline soil, and installing intertidal and subtidal shoreline caps)
- EPC-1B: Monitoring and maintenance of the existing shoreline caps
- EPC-2A: Subtidal shoreline cap extension
- EPC-2B: Monitoring and maintenance of EPC-2A
- EPC-3: Surface water and sediment monitoring
- APR-1A: Completed remedial actions during Phases 1 and 2 of active arsenic remediation (e.g., removing source area soil, installing a SPW, installing and operating a P&T system, conducting in-situ stabilization)
- APR-1B: Monitoring and maintenance of the existing SPW
- APR-2: Focused source area excavation
- APR-3A: General surface cap/cover for soil direct contact pathway
- APR-3B: Monitoring and maintenance of APR-3A
- APR-11: Performance groundwater monitoring
- MNA&LTC-1: Long-term groundwater monitoring
- MNA&LTC-2: Periodic MNA evaluations
- MNA&LTC-3: Applicable ECs
- MNA&LTC-4: Applicable ICs
- OPSC-1: 2014 Wypenn Interim Action
- OPSC-2: 2013 to 2014 Arkema Mound Interim Action
- OPSC-3: Completed active VOC remediation in VOC VI Area A
- OPSC-4: Completed active VOC remediation in VOC VI Area B
- OPSC-5: Upper Aquifer groundwater monitoring downgradient of Wypenn
- OPSC-6: Groundwater and surface water monitoring for copper, mercury, nickel, PCE, TCE, VC, and CF
- OPSC-7: Decommission Angled Shoreline MWs

- OPSC-8: VI evaluation(s)
- OPSC-9: Installation of VI mitigation system(s)
- OPSC-10: Installation of VI mitigation system(s)

The recommended groundwater POC is surface water at locations as close as technically possible to the point or points where groundwater flows into surface water. The recommended groundwater POC is the only POC option that can provide for a reasonable restoration time frame. The estimated restoration time frames for the other four groundwater POC options (ranging from 3,700 years to greater than 10,000 years for Alternative 2 and from 3,100 years to greater than 10,000 years for the other alternatives) are unacceptable and unreasonable. The recommended POC is consistent with the groundwater POC established by USEPA for the larger CB/NT site (USEPA 2000). Furthermore, the recommended POC is consistent with groundwater POC precedents at other complex MTCA shoreline sites such as the South State Street Manufactured Gas Plant, the BNSF Skykomish Former Maintenance and Fueling Facility, and the Everett ASARCO Smelter (see Table 3-1). Although (1) MTCA groundwater cleanup standards have already been achieved at the recommended groundwater POC, and (2) CB/NT cleanup standards have already been achieved, robust monitoring and maintenance will be conducted as part of Alternative 2 for the foreseeable future to ensure ongoing compliance with MTCA and CB/NT cleanup standards in surface water and sediment.

Approval of the recommended groundwater POC is subject to the seven conditions in WAC 173-340-720(8)(d)(i). The seven conditions are listed below along with an explanation of how the conditions are or will be satisfied:

- "It has been demonstrated that the contaminated groundwater is entering the surface water and will continue to enter the surface water even after implementation of the selected cleanup action": Arsenic concentrations in pore water NSDSs demonstrate that arsenic-impacted groundwater is entering the surface water. Arsenic groundwater concentrations in vertical shoreline MWs and groundwater modeling results demonstrate that arsenic-impacted groundwater will continue to enter surface water, regardless of which alternative is selected.
- "It has been demonstrated under WAC 173-340-350 through 173-340-390 that it is not practicable to meet the cleanup level at a point within the groundwater before entering the surface water, within a reasonable restoration time frame": The reasonable restoration time frame evaluation in Section 6.2.3 demonstrated that it is not practicable to meet the cleanup level at a point within groundwater in a reasonable restoration time frame.
- "Use of a mixing zone under WAC 173-201A-100 to demonstrate compliance with surface water cleanup levels shall not be allowed": Methods for evaluating or demonstrating compliance with cleanup levels will not use a mixing zone.
- "Groundwater discharges shall be provided with all known available and reasonable methods of treatment before being released into surface waters": The recommended alternative includes all known available and reasonable methods of treatment in accordance with the MTCA remedy selection regulations (as documented in this Report).
- "Groundwater discharges shall not result in violations of sediment quality values published in chapter 173-204 WAC": All arsenic concentrations in sediment samples collected since Phase 3 of active arsenic remediation was completed have been less than the 57 mg/kg sediment quality values in Chapter 173-204 WAC (DOF 2011, 2013, 2018; PIONEER 2019). Future exceedances of

sediment quality values are not expected for a variety of reasons, including that dissolved arsenic concentrations in the main arsenic plume are stable or declining. However, sediment monitoring is included in the recommended alternative to ensure arsenic sediment concentrations do not exceed sediment quality values in the future.

- "Groundwater and surface water monitoring shall be conducted to assess the long-term performance of the selected cleanup action including potential bioaccumulation problems resulting from surface water concentrations below method detection limits": Groundwater and surface water are included in the recommended alternative to assess the long-term performance of the recommended alternative.
- "Before approving the conditional point of compliance, a notice of the proposal shall be mailed to the natural resource trustees, the Washington state department of natural resources and the United States Army Corps of Engineers": The required notice will be submitted to the required organizations before the CAP is finalized.

It must also be noted that alternatives that include more active remediation than Alternative 2 and groundwater POCs that are located landward of the recommended groundwater POC are not necessary for protection of human health and the environment. Phase 1 through Phase 3 of active arsenic remediation have already achieved all CB/NT cleanup standards, which were specifically developed to ensure protection of human health and the environment at the actual exposure point locations in surface water and sediment. Future surface water and sediment concentrations are also expected to be protective of human health and the environment (with future monitoring per Alternative 2 to provide confirmation) because (1) the main arsenic plume is already stable or declining, (2) Phase 4 of active arsenic remediation (i.e., Alternative 2) will further remediate the main arsenic plume, and (3) highly favorable natural attenuation processes for arsenic are present in nearshore groundwater (PIONEER 2019). POCs landward of the recommended groundwater POC add unnecessary conservatism by assuming that (1) marine aquatic organisms live in groundwater, and (2) recreators/fishers consume marine aquatic organisms obtained from groundwater. In addition, multiple tissue studies have concluded that arsenic concentrations in marine organisms within the Hylebos Waterway downgradient of the Site are consistent with other urban and non-urban areas of Puget Sound and/or do not pose an unacceptable risk (USEPA 1989; Washington State Department of Fish and Wildlife 2014; Tacoma-Pierce County Health Department 2014; Anchor QEA 2020).

Approval of Alternative 2 and a groundwater POC of surface water (at locations as close as technically possible to the point or points where groundwater flows into surface water) as the selected remedy is subject to a pending public review of this Report and a draft CAP. Once Ecology finalizes the CAP, the recommended alternative will be implemented in accordance with the final CAP and the remedial design. The remedial design for the selected alternative may differ slightly from the alternative description presented in this Report based on agency decisions, input from the public and other stakeholders, supplemental data that will be collected to support the remedial design, and other new information that was not considered when developing this Report. Remedial design documents (e.g., construction plans and specifications) will be submitted to Ecology for review and approval prior to initiating cleanup action implementation. It is anticipated that construction of all active remediation components will be completed within less than five years following remedy selection.

SECTION 8: REFERENCES

Anchor QEA. 2020. Hylebos Waterway Fish Tissue Arsenic and Human Health Risk Analyses Memorandum from Nathan Soccorsy and Clay Patmont to Kim Seely. September 14.

AWARE Corporation. 1981. Hydrogeologic and Engineering Evaluation of Waste Management Facilities, Pennwalt Corporation Plant. Tacoma, Washington. November.

Boateng. 2002. Annual Report: Volatile Organic Compound Sampling for Natural Attenuation November 2002. Atofina Chemicals, Inc. 2901 Taylor Way, Tacoma, Washington. December.

Boateng. 2003. Penite Area Groundwater Monitoring Report May 2003. Atofina Chemicals, Inc. 2901 Taylor Way, Tacoma, Washington. July.

DOF. 2011. Remedial Action Construction Report. Head of the Hylebos Waterway Problem Area Commencement Bay Nearshore/Tideflats Superfund Site Tacoma, Washington. August.

DOF. 2013. Final Remedial Investigation Report for Former Arkema Manufacturing Plant. 2901 & 2920 Taylor Way, Tacoma, Washington. September.

DOF. 2015a. As-Built Report, 2013 Interim Action. 3009 Taylor Way Interim Action. April 6.

DOF. 2015b. Interim Action Construction Report Wypenn Property Tacoma, Washington. January.

DOF. 2018. 2017 Sediment Sampling Data Report, Head of Hylebos Waterway Problem Area, Head of Hylebos Waterway of the CB/NT Superfund Site. March.

DOF. 2019. Hylebos - Arkema Southeast Shoreline Erosion Technical Memorandum from Paul Fuglevand to Scott Hooton. December 31.

Ecology. 1994. Natural Background Soil Metals Concentrations in Washington State, Publication No. 94-115. October.

Ecology. 2001. Memorandum from Pete Kmet to Interested Persons with the subject of “Calculations for Table 745-1; Method A Soil Cleanup Levels for Commercial/Industrial Land Uses”, February 9.

Ecology. 2013. Email from Dominick Reale (Ecology) to Matt Dalton (DOF) titled "RE: Arkema Draft RI - Revised Exec Summary." September 9.

Ecology. 2015. Lincoln-Taylor Drains Sampling Project 5-4-15. May.

Ecology. 2019. Email from Mohsen Kourehdar (Ecology) to Scott Hooton (Port) titled “Data Gap Study - Arkema - FSID 1220.” September 12.

Ecology. 2021a. Letter from Joyce Mercuri to Nizar Hindi and Scott Hooton with a subject of "Re: Agreed Order No. DE 3405: Expansion of scope for Remedial Actions at the USG Taylor Way Plant Site (Cleanup Site ID #5003), under Agreed Order No. DE 3405, to include contamination within the North Boundary Area," January 13.

Ecology. 2021b. Toxics Cleanup Program’s Cleanup Levels and Risk Calculations database, https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx, accessed February.

Elf Atochem North America Incorporated. 1995. Extension of the Sheetpile Barrier Wall Elf Atochem North America, Tacoma Plant. September 30.

ERM. 2003a. Residual Phase Arsenic Stabilization Work Plan. ATOFINA Chemicals, Inc. Tacoma, Washington. July.

ERM. 2003b. Soil Interim Remedial Action Work Plan. ATOFINA Chemicals, Inc. Tacoma, Washington. May.

ERM. 2003c. Volatile Organic Compounds Interim Remedial Action Work Plan. ATOFINA Chemicals, Inc. Tacoma, Washington. July 29.

ERM. 2005. Draft Residual Phase Arsenic Stabilization Completion Report. Arkema Facility. Tacoma, Washington. February.

Floyd Snider. 2008. Focused Feasibility Study. Reichhold/SSA Containers Facility, Tacoma, Washington. October.

Groff Murphy Trachtenberg & Everard, PLLC. 2006. Letter from Stephen T. Parkinson to Dom Reale, Bob Warren, Rebecca Lawson, and Elliott Furst regarding the State of Washington, Department of Ecology v. Pennwalt Corporation, Inc. Thurston County Superior Court, Case No. 87-2-01199-0. October 12.

Hart Crowser. 1986. Hydrogeologic and Groundwater Quality Update. Pennwalt Corporation Tacoma Plant. Tacoma, Washington. November 24.

Hart Crowser. 2015. Status Report No. 18, Groundwater Compliance Monitoring OFA/Pennwalt Area, Blair Backup Property. February 4.

ICF. 1990a. Construction Report, Sheet Pile Waterway Barrier Project 100, ATOCHEM North America, Tacoma Facility. December 20.

ICF. 1990b. Expedited Response Actions to Mitigate Arsenic Migration from the ATOCHEM North America Inorganic Chemical Division Tacoma Plant. February.

ICF. 1990c. Final Remedial Action Plan for the Penite Site at the Atochem North America Tacoma Facility. December.

ICF. 1991. Results of the ERA Barrier Monitoring Program at the Atochem North America Tacoma Facility. February.

ICF. 1992. Groundwater Monitoring Plan, Atochem North America Inorganic Chemical Division Tacoma Plant. April.

ICF. 1995. Operations and Maintenance/Health and Safety Manual for the Elf Atochem North America Tacoma Facility. September.

Intera. 1995. A Reappraisal of Arsenic Fate and Transport beneath the Elf Atochem Chemical Plant, Tacoma, Washington. August 22.

ITRC. 2017. Remediation Management of Complex Sites (RMCS-1), 'https://rmcs-1.itrcweb.org. October.

MPS Incorporated. 1990. Penite Excavation Field Report, Expedited Response Action, Uppermost Aquifer Arsenic Mitigation. Atochem North America, 2901 Taylor Way, Tacoma, Washington. February 22.

Oakley, D. and Korte, N.E. 1996. Nickel and Chromium in Ground Water Samples as Influenced by Well Construction and Sampling Methods. Groundwater Monitoring and Remediation, Winter.

Pacific Environmental & Redevelopment Corporation and PIONEER. 2014. Final Feasibility Study for On-Property Soils and Perched Water. Superlon Plastics Property Tacoma, WA. December 17.

PIONEER. 2015. Presentation to Ecology and United States Environmental Protection Agency titled "Fate and Transport, CSEM, RAOs, and FS Schedule Discussion." March 31.

PIONEER. 2016. Presentation to Ecology titled "Overview of Proposed FS Data Gap Investigation Activities." March 30.

PIONEER. 2019. Feasibility Study Data Gap Investigation Report, Former Arkema Manufacturing Site. July.

PIONEER. 2020. Cleanup Action Alternatives, Former Arkema Manufacturing Site. July.

PIONEER. 2021. North Boundary Area Feasibility Study Report, Former USG Taylor Way Plant Site. January.

Port. 2014. Land Use & Transportation Plan 2014. June.

TetraTech. 1988. Commencement Bay Nearshore/Tideflats Feasibility Study: Volume 1. December.

Tacoma-Pierce County Health Department. 2014. Final Report for the Mussel Watch Gradient Project, Ecology Grant Number G1200564, A Sub-Project of the Mussel Watch Pilot Expansion Study 2012-2013, Hylebos Waterway and Ruston Way. June 23.

USEPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final. October.

USEPA. 1989. Commencement Bay Nearshore/Tideflats Record of Decision. September.

USEPA. 2000. Explanation of Significant Differences, Commencement Bay Nearshore/Tideflats Superfund Site. August.

USEPA. 2014. Fourth Five-Year Review Report for Commencement Bay Nearshore/Tideflats Superfund Site. December 1.

Washington State Department of Fish and Wildlife. 2014. Toxic Contaminants in Puget Sound's Nearshore Biota: A Large-Scale Synoptic Survey Using Transplanted Mussels (Mytilus trossulus), Final Report, Puget Sound Ecosystem Monitoring Program. September 4.

References are included in the CD provided in the hardcopy or can be accessed via the listed website.

Figures

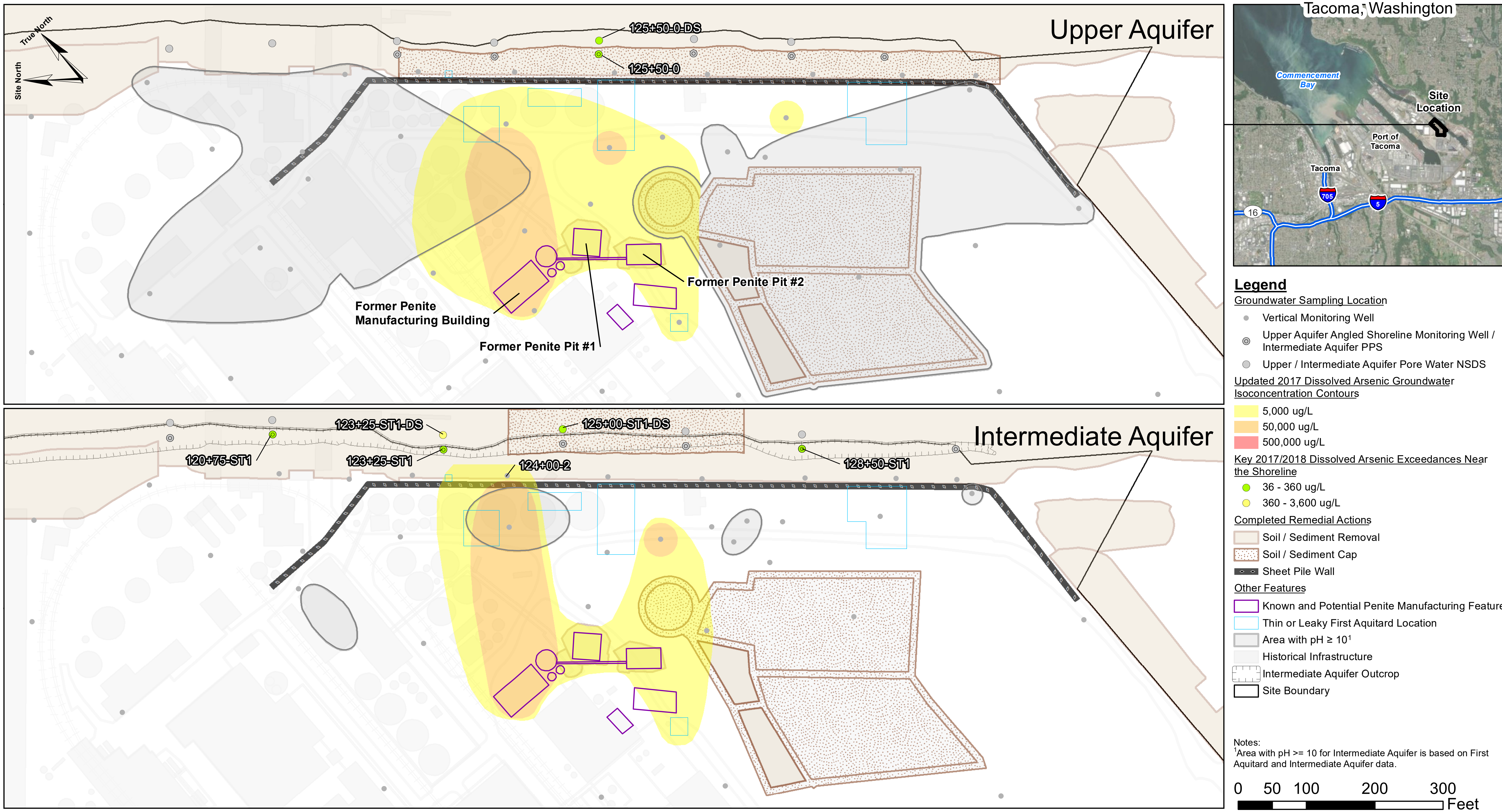
Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.

Document Path: G:\Projects\Arkema\Maps\FS Report\Fig_1-1_Site_Areas.mxd; Author: VN; Date Saved: 3/24/2021

PIONEER TECHNOLOGIES CORPORATION

Key Site Areas and Other Areas
FS Report
Former Arkema Manufacturing Site

Figure 1-1



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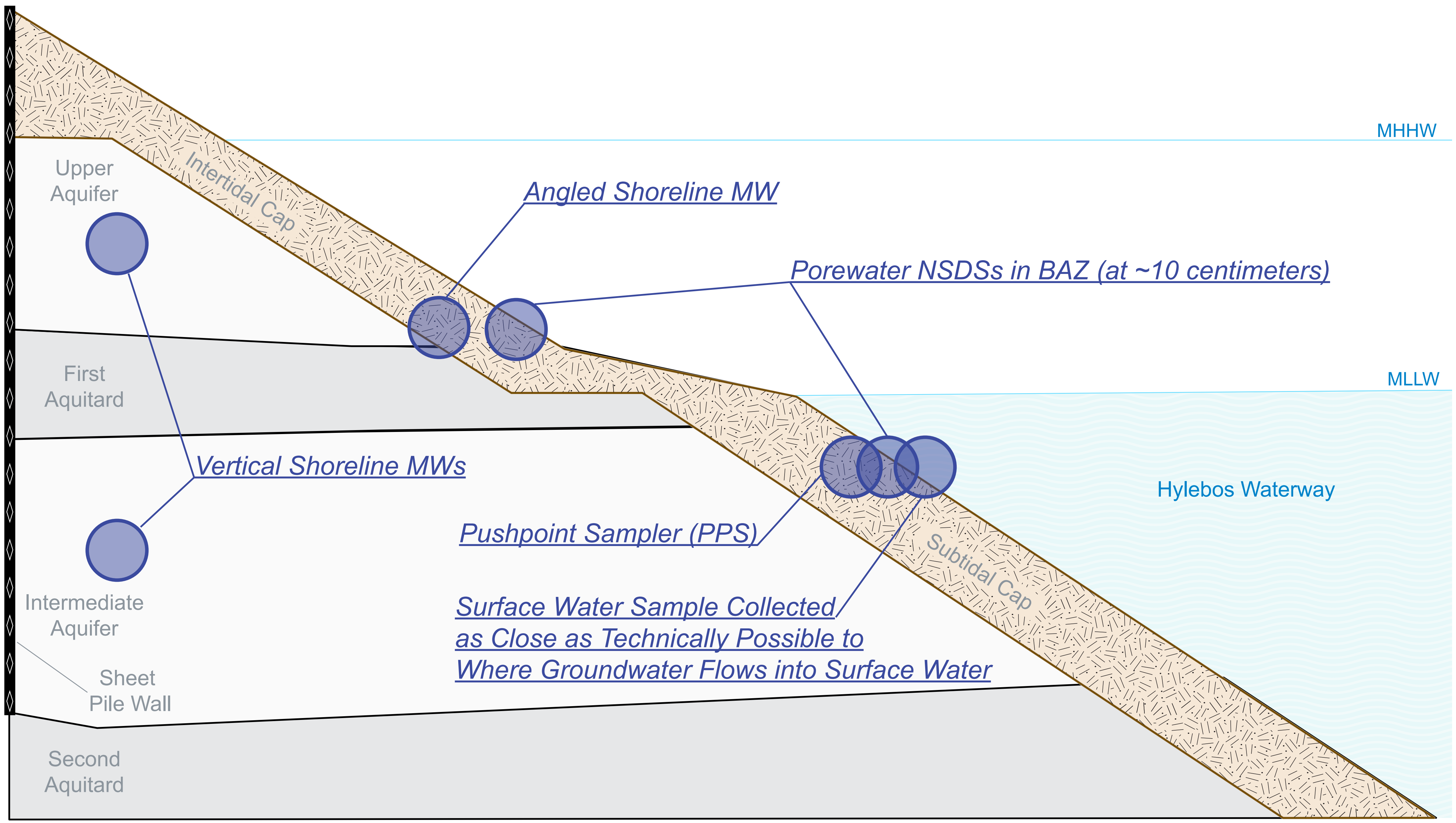
PIONEER TECHNOLOGIES CORPORATION

Summary of Current Conditions for the Main Arsenic Plume
FS Report
Former Arkema Manufacturing Site

Figure 2-1



Legend

Potential Groundwater Conditional Point of Compliance Location

PIONEER TECHNOLOGIES CORPORATION

Potential Groundwater Conditional Point of Compliance Locations
FS Report
Former Arkema Manufacturing Site

Figure 3-1

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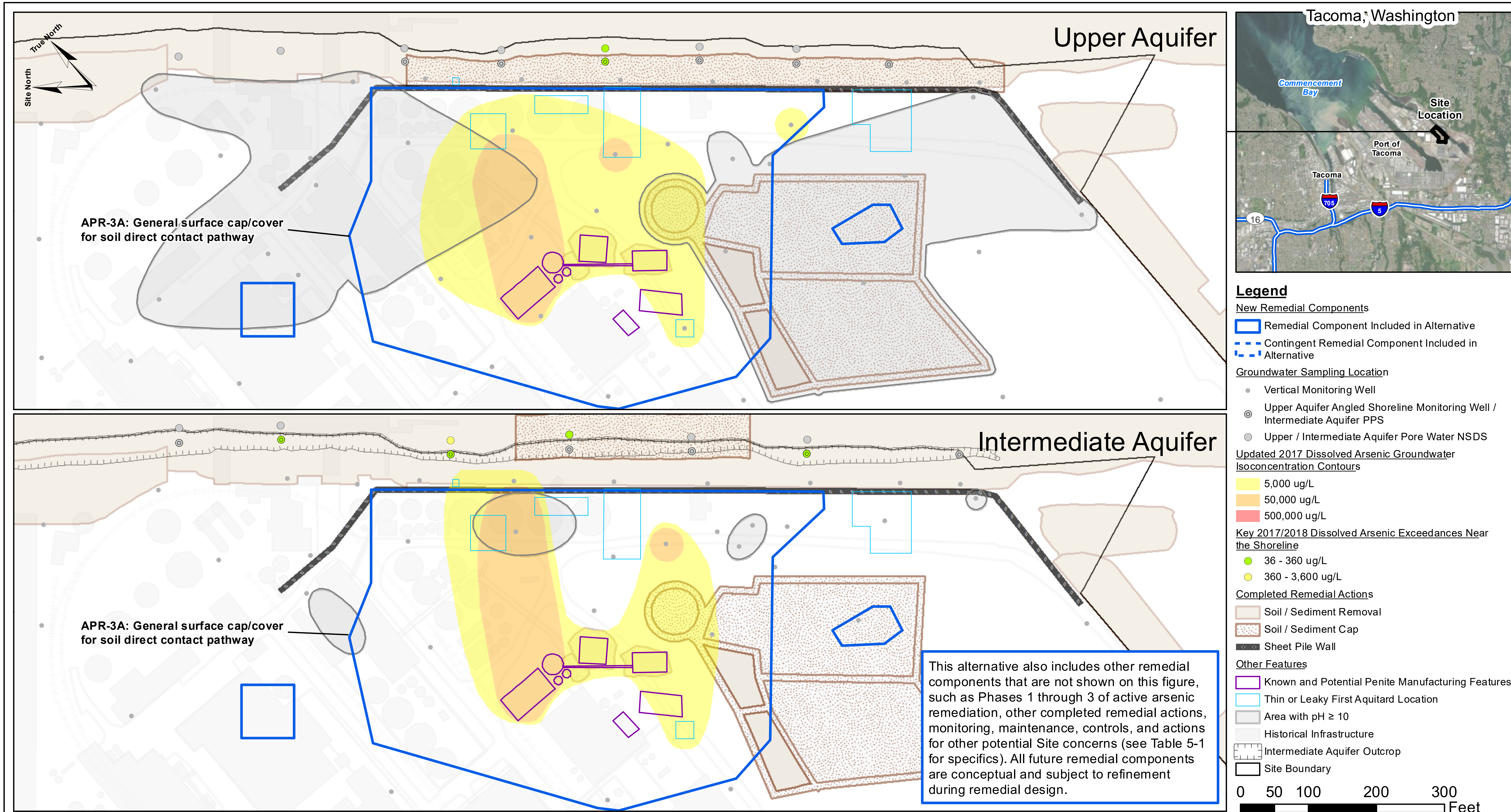
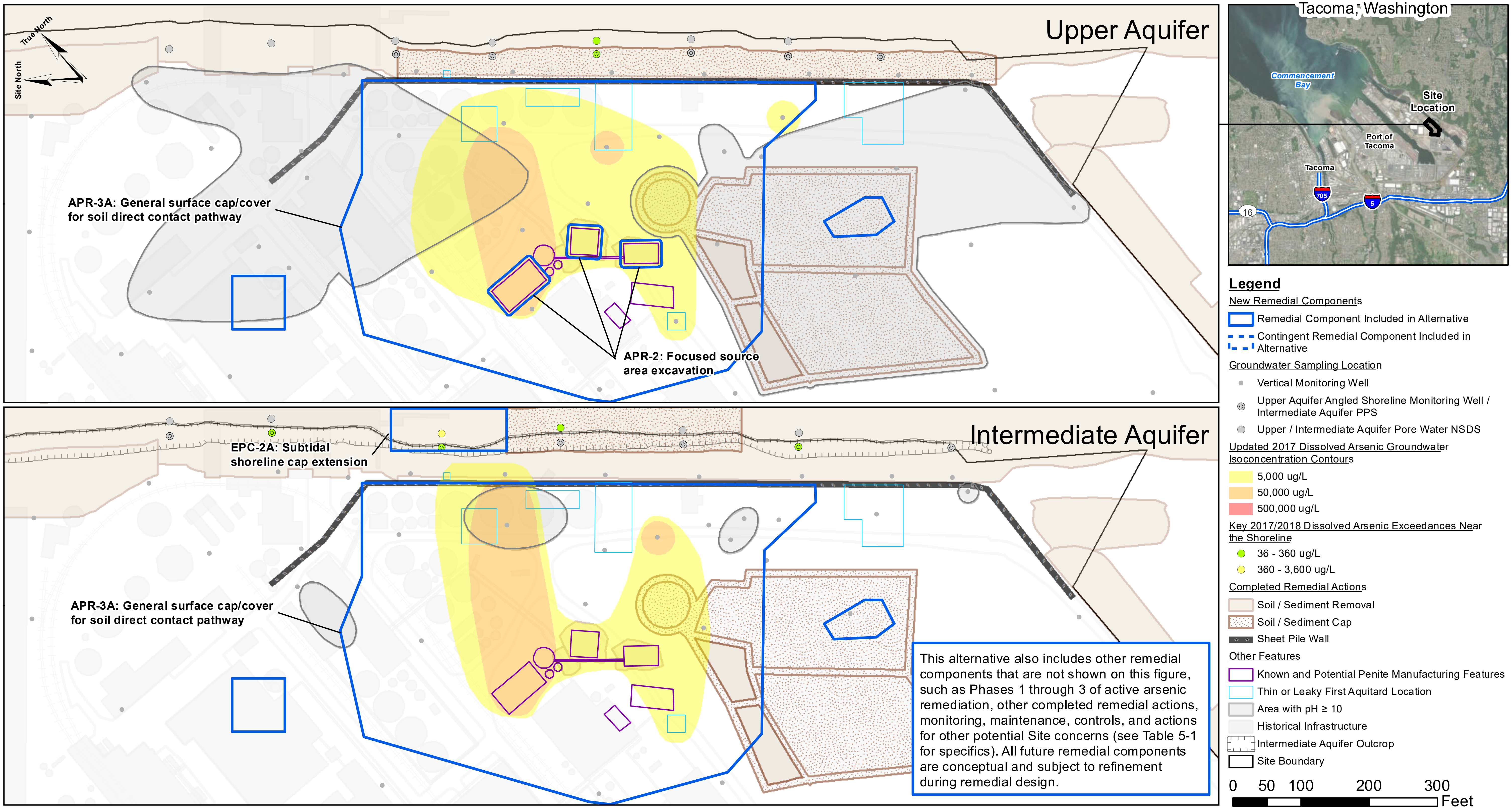


PIONEER TECHNOLOGIES CORPORATION

Remedial Components Included in Alternative 1
FS Report
Former Arkema Manufacturing Site

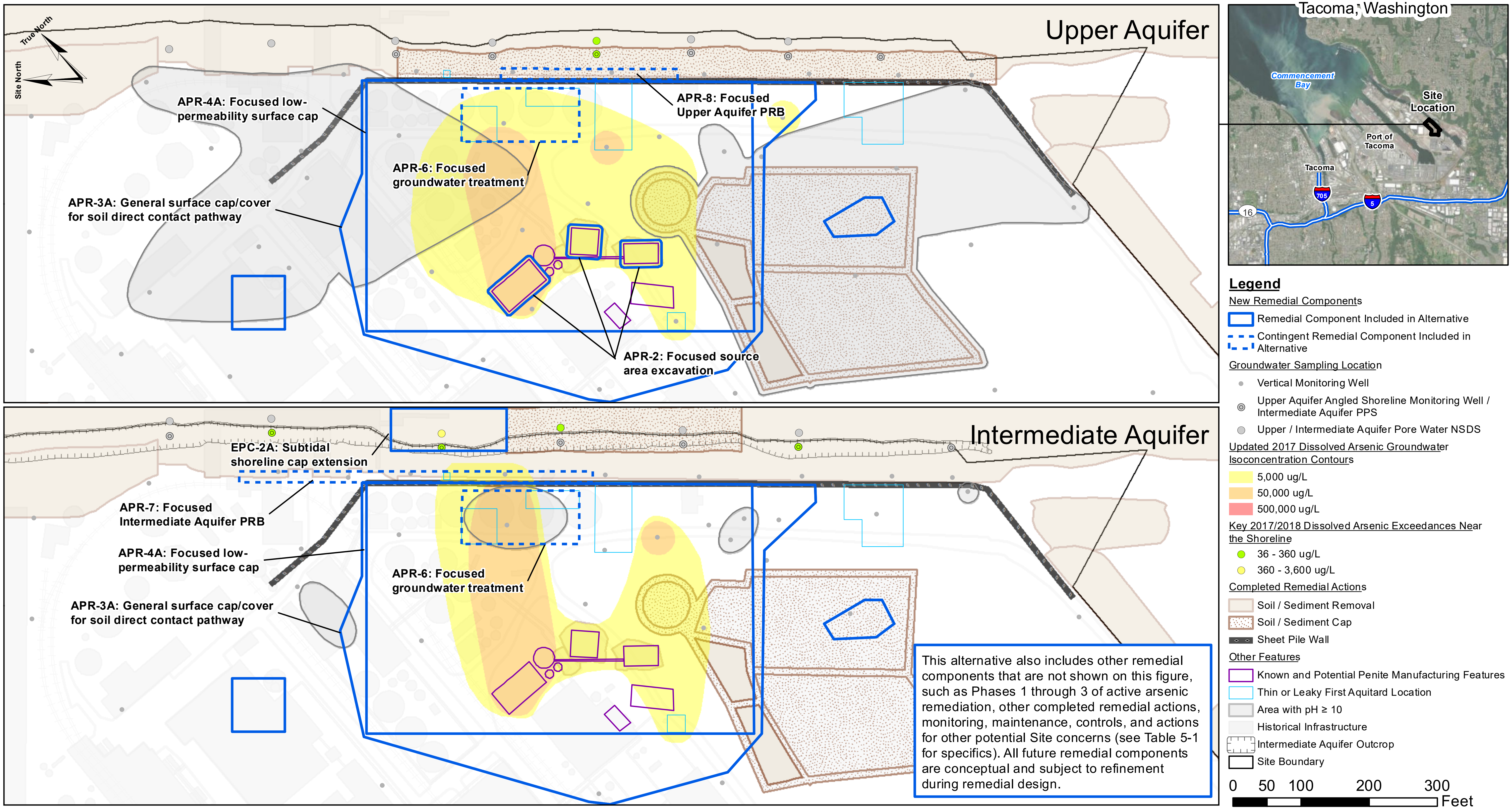
Figure 5-1



PIONEER TECHNOLOGIES CORPORATION

Remedial Components Included in Alternative 2
FS Report
Former Arkema Manufacturing Site

Figure 5-2



PIONEER TECHNOLOGIES CORPORATION

Remedial Components Included in Alternative 3
FS Report
Former Arkema Manufacturing Site

Figure 5-3

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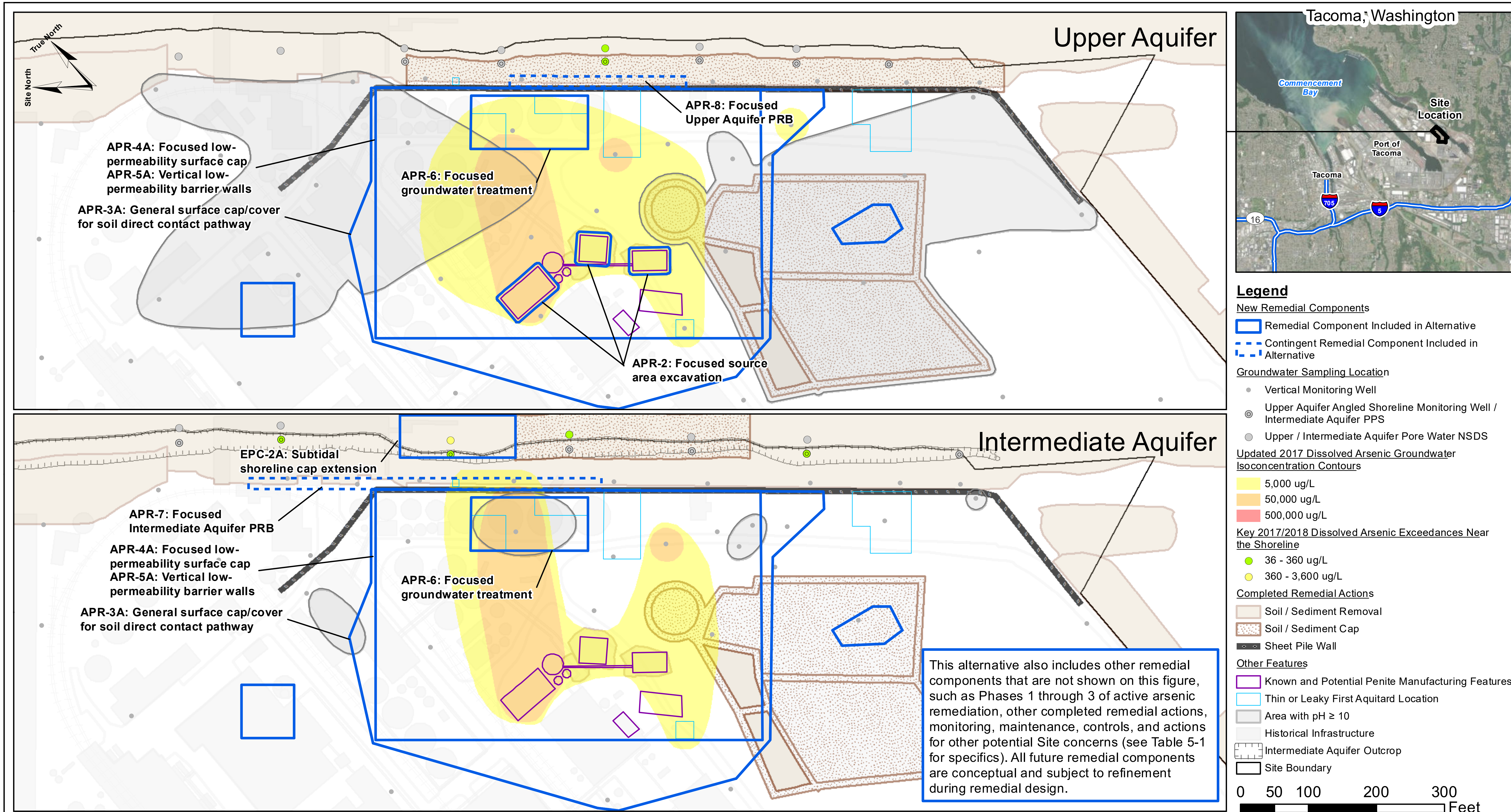

PIONEER TECHNOLOGIES CORPORATION

Remedial Components Included in Alternative 4
FS Report
Former Arkema Manufacturing Site

Figure 5-4

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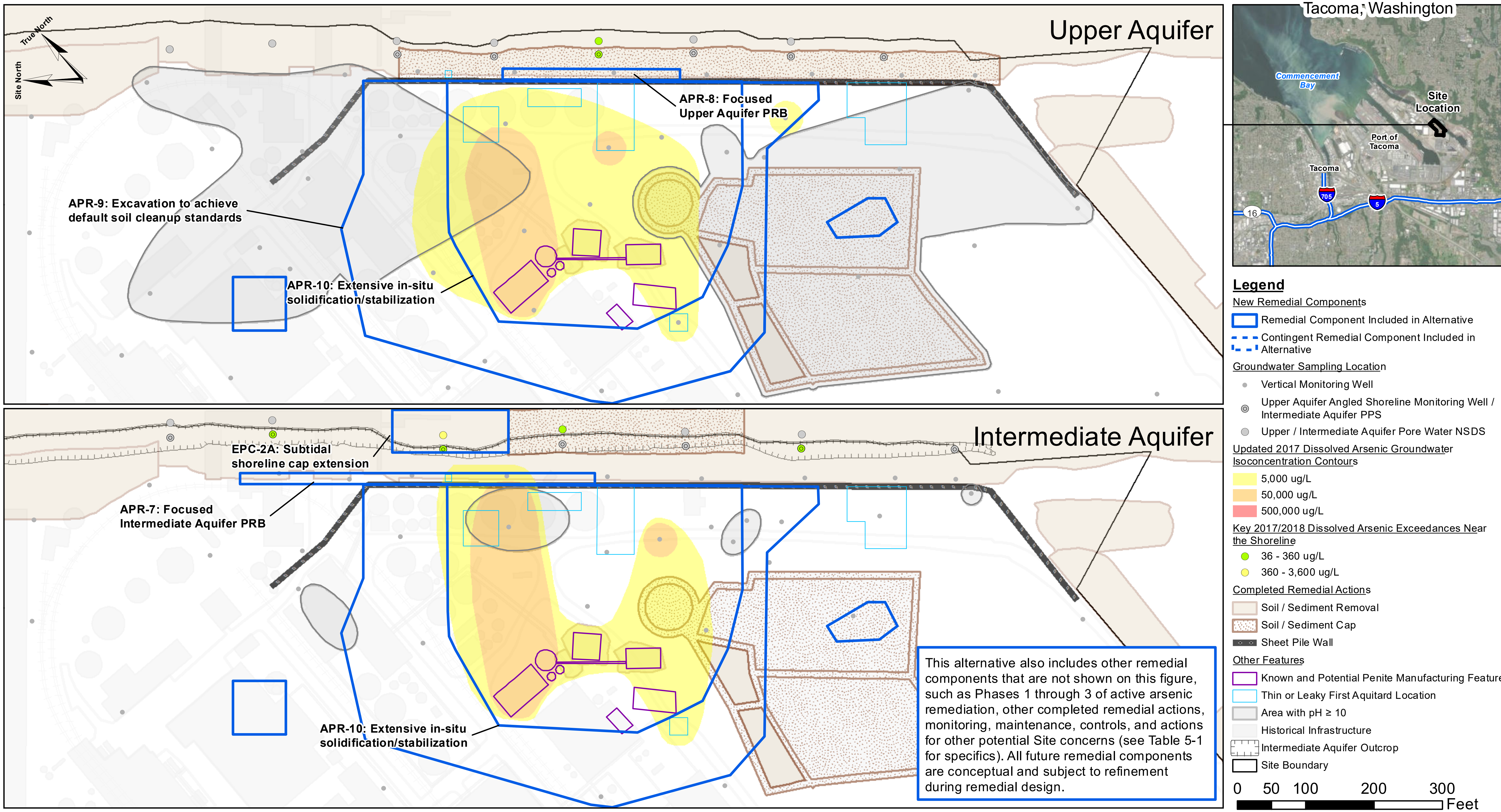

Remedial Components Included in Alternative 5
FS Report
Former Arkema Manufacturing Site

Figure 5-5

PIONEER TECHNOLOGIES CORPORATION

Tables

Table 3-1: Review of Select MTCA Groundwater CPOC Precedents

Site Name	Groundwater POC Description	Apparent Groundwater POC Locations in Practice	Document Reference[(1)]	Section Number(s) for Quote(s)[(1)]
South State Street Manufactured Gas Plant (Agreed Order No. DE 7655)	"At sites where groundwater cleanup levels are based on the protection of surface water beneficial uses, MTCA allows Ecology to approve use of a conditional point of compliance located as close as technically possible to the point where groundwater flows into surface water (WAC 173-340-720[8][d][i]). Use of this conditional point of compliance is subject to several conditions. Those conditions and their applicability to the Site are described below. ■ *Contaminated groundwater enters the surface water and will continue to enter the surface water even after implementation of the selected cleanup action.* This condition is demonstrated in the RI by groundwater quality at shoreline monitoring wells and the continuity of contamination from the upland into sediment, and based on the cleanup alternatives as described in the FS (Section 4). ■ *It is not practicable to meet the cleanup level at a point within the groundwater before entering the surface water, within a reasonable restoration time frame* . This condition is established through the technology screening and cleanup alternatives evaluations described in the FS (Section 5). ■ *A mixing zone is not used to demonstrate compliance with surface water cleanup levels.* Methods to document remedy compliance with cleanup levels will not utilize the mixing zone concepts. ■ *All known available and reasonable methods of treatment shall be used for groundwater before discharge to surface water.* An evaluation of all known available and reasonable technology (AKART) methods of groundwater treatment is presented in the FS and applicable methods are incorporated into the cleanup alternatives. ■ *Groundwater discharges do not result in exceedances of sediment quality values in Chapter 173-204 WAC.* Groundwater cleanup levels are protective of marine sediment. ■ *Groundwater and surface water monitoring are performed to evaluate performance of the cleanup action including consideration of the potential for discharges at levels below method detection limits to cause bioaccumulative effects.* Compliance monitoring for remedy performance will be conducted following implementation; details will be specified in the CAP. ■ *Notice of proposed conditional points of compliance is made to natural resource trustees, DNR and USACE.* Required notice and request for comment will be made by Ecology after the cleanup alternative has been selected."	Surface water	GeoEngineers. 2019. Final Feasibility Study, South State Street Manufactured Gas Plant, Bellingham, Washington. January 22.	2.3.2
BNSF Skykomish Former Maintenance and Fueling Facility (Consent Decree No. 07-2-33672-9 SEA)	"The CUL is applicable at the groundwater conditional point of compliance (CPOC), defined as the surface water boundary where groundwater enters the Skykomish River and Former Maloney Creek. The CUL is intended to protect sediments in the Skykomish River and Former Maloney Creek from recontamination by groundwater."	Surface water	Farallon Consulting. 2018. 2017 Site-Wide Groundwater Monitoring Report, BNSF Former Maintenance and Fueling Facility, Skykomish, Washington. July 6.	10.2
Everett ASARCO Smelter (Ecology-lead site)	"The point of compliance for groundwater in the Lowland Area is where groundwater enters surface waters of the Lowland Area (wetlands and ponds). The point of compliance for groundwater entering the Snohomish River is at the shoreline where groundwater discharges to the Snohomish River."	Shoreline seeps for Area D4	GeoEngineers. 2016. Final Cleanup Action Plan, Everett Smelter Site, Lowland Area, Everett, Washington. November 10.	3.1.2
Port of Bellingham Georgia-Pacific West (Agreed Order No. DE 6834)	"Based on the evaluation of the groundwater point of compliance, the proposed conditional points of compliance for the RAU are located in the sediment bioactive zones of the Log Pond to the north and Bellingham Bay to the west. This point-of-compliance scenario is appropriate because it is expected to allow for a reasonable restoration time frame, whereas the other scenarios considered (standard point of compliance and conditional points of compliance at the property boundary) would not."	BAZ pore water	Aspect Consulting. 2018. Feasibility Study Chlor-Alkali Redial Action Unit, Vol. 2b of RI/FS, Georgia-Pacific West Site, Bellingham, Washington. June.	9.3
Jacobson Terminals (Voluntary Cleanup Program No. NW0611)	"It is anticipated that it will not be practicable to meet CULs throughout the Site within a reasonable restoration timeframe, and therefore a conditional POC will be established at the groundwater–surface-water interface."	BAZ pore water?	Hart Crowser. 2016. Draft Cleanup Action Plan, Jacobson Terminals, 5350 30th Avenue NW, Seattle, Washington. May 25.	4.2.4
R. G. Haley International Corporation Site (Agreed Order No. DE 2186)	"Ecology has determined that the cleanup action selected for the Haley Site meets the regulatory requirements for use of a conditional point of compliance for groundwater. At such sites, the conditional point of compliance must be located as close as technically possible to the source of contamination; analyses conducted during the FS indicate this is likely to be located at the point where groundwater flows into surface water. However, final location(s) will be established in the monitoring plan described in Section 6.6."	BAZ pore water?	Ecology. 2018. Cleanup Action Plan, R.G. Haley International Corporation Site, Bellingham, Washington. April.	3.2
Port of Bellingham Weldcraft Steel and Marine (Agreed Order No. DE 03TCPBE-5623)	"it appears that groundwater cleanup standards for copper, nickel, and zinc can be achieved for the work yard area using a conditional point of compliance at the shoreline, provided background surface water quality for metals is taken into consideration." "Compliance monitoring would evaluate groundwater quality at the proposed conditional point of compliance at the shoreline and surface water in the marina in proximity to the groundwater conditional point of compliance; groundwater compliance monitoring may include porewater sampling within the marine sediment near the bulkhead, depending on evaluations conducted during remedial design."	To be determined groundwater, BAZ pore water, and/or surface water?	Landau Associates. 2014. Public Review Draft Remedial Investigation/Feasibility Study Report, Weldcraft Steel and Marine (Gate 2 Boatyard), Bellingham, Washington. May 14.	9.1.2.2 and 14.1
Cornwall Avenue Landfill (Agreed Order No. DE 1778)	"If ground water discharge to surface water represents the highest beneficial use, MTCA provides for a conditional point of compliance at the location of discharge of ground water to the surface water receiving body (i.e., the shoreline). The conditional point of compliance is acceptable under MTCA for properties abutting surface water if the conditions established under WAC 173-340-720(8)(d)(i) are satisfied. The Site meets the required MTCA conditions; therefore the downgradient edge of the Site, as close as technically possible to the point-of-entry of ground water to Bellingham Bay, will be established as the point of compliance for Site ground water. The achievement of ground water CLs will be measured at the shoreline using a network of angled ground water monitoring wells screened within the vertical range of the intertidal zone." "Additionally, the ground water compliance monitoring system will be integrated into the sand filter treatment layer to provide more representative samples of ground water at the ground water/surface water interface."	Angled Shoreline MWs	Ecology. 2014. Cleanup Action Plan, Cornwall Avenue Landfill, Bellingham, Washington. October 10.	2.2.2 and 4.2.2.2
Weyerhaeuser Longview Chlor-Alkali Plant (Agreed Order No. DE 1037)	"As provided under 173-340-720(8)(d)(i), a conditional POC for groundwater will be established that is located within the river as close as technically possible to the point or points where ground water flows into the River."	Vertical Shoreline MWs	Ecology. 2004. Weyerhaeuser Longview Final Cleanup Action Plan. January 28.	3.3.2
Port of Bellingham Harris Ave Shipyard (Agreed Order No. DE 7342)	"The groundwater POC is at the shoreline where groundwater discharges into surface water through the sediments."	Vertical Shoreline MWs	Floyd Snider. 2019. Port of Bellingham Harris Avenue Shipyard Remedial Investigation/Feasibility Study, Volume 1. June.	5.3
Port of Everett North Marina Ameron/Hulbert Site (Agreed Order No. DE 6677)	"It is proposed that the downgradient edge of the Site, as close as technically possible to the point of entry of groundwater to surface water at the 12th Street Yacht Basin, will be the conditional point of compliance for Site groundwater."	Vertical Shoreline MWs	Landau Associates. 2014. Final Remedial Investigation/Feasibility Study, North Marina Ameron/Hulbert Site, Everett, Washington. April 30.	9.1.1.2
Alcoa/Evergreen Vancouver Site (Enforcement Order 4931)	"It is anticipated that it would not practicable to meet the some or all groundwater cleanup levels throughout the Site within a reasonable timeframe. Therefore, compliance with groundwater cleanup levels would be measured at Conditional POC wells located along the shoreline, down-gradient from the respective source areas in accordance with WAC 173-340-720(8)(c)."	Vertical Shoreline MWs	Anchor Environmental. 2008. Remedial Investigation/Feasibility Study, Alcoa/Evergreen Vancouver Site. September.	9.5

Notes:

A comprehensive review of all MTCA POC precedents was not conducted. Rather, this table was created based on a review of remedy selection documents for a limited list of MTCA shoreline sites identified by the Port (e.g., sites mentioned in recent Ecology Site Registers). All documents referenced in this table are public documents obtained from the Ecology website.

(1) The listed section number(s) are the section numbers for documents in the Document Reference column of this table.

Table 3-2: Cleanup Action Objectives for the Main Arsenic Plume

CAO Type	CAO	Remediation Category	Key Remedial Components	Time Frame
Short-term	Achieve relevant existing CB/NT cleanup standards in order to protect human health and the environment at the exposure point locations.	Exposure Point Control (EPC)	• Phase 3 of active arsenic remediation (completed) • Future exposure point control remedial components included in the selected alternative • Periodic surface water and sediment monitoring to provide ongoing confirmation that human health and the environment are protected	The short-term CAO has already been achieved. The relevant existing CB/NT cleanup standards have been achieved as discussed in Section 3.2. It is anticipated that construction of any future exposure point control remedial component (i.e., shoreline cap extension) would be completed within five years following remedy selection. Unless specifically excluded from the selected alternative, monitoring and maintenance of existing/future exposure point control infrastructure (i.e., existing shoreline caps, shoreline cap extension) would be conducted for the foreseeable future. Periodic surface water and sediment monitoring would occur for the foreseeable future to ensure dissolved arsenic concentrations in surface water where groundwater discharges to surface water remain less than the 5 ug/L CL, and arsenic sediment concentrations in the BAZ remain less than the 57 mg/kg SQO.
Medium-term	Implement active plume remediation to reduce arsenic groundwater concentrations prior to discharge to the Hylebos Waterway.	Active Plume Remediation (APR)	• Phase 1 and Phase 2 of active arsenic remediation (completed) • Future active plume remediation components included in the selected alternative • Contingent future active plume remediation components included in the selected alternative, if necessary	Phase 1 and Phase 2 of active arsenic remediation are complete. It is anticipated that construction of any future active plume remediation components (including any necessary contingent components) would be completed within five to 15 years following remedy selection (depending on which alternative is selected and whether or not the alternative includes contingent components). Unless specifically excluded from the selected alternative, monitoring and maintenance of existing/future active plume remediation infrastructure (e.g., existing SPW, surface cap/cover for soil direct contact pathway) would be conducted for the foreseeable future.
Long-term	Allow benefits from the completed remedial actions and natural attenuation to further reduce the magnitude and size of the main arsenic plume over the long-term, and implement controls to minimize any potential exposures to the arsenic plume.	MNA and Long-Term Controls (MNA&LTC)	• Natural attenuation • Long-term groundwater monitoring • Engineering controls • Institutional controls	Unless specifically excluded from the selected alternative, monitoring and natural attenuation evaluations would be conducted for the foreseeable future. It is anticipated that controls would be implemented when necessary, starting immediately following remedy selection. All controls would be maintained and enforced for perpetuity.

Table 4-1: Identification and Screening of Remedial Technologies for the Main Arsenic Plume

			Relative Effectiveness[1]		Relative Implementability[2]		Relative Cost[3]			
Category	**Technology**	**How the Technology Works**	**Rating**	**Comment**	**Rating**	**Comment**	**Rating**	**Comment**	**Retained?**	**Rationale**
Mass Removal	Soil excavation and off-site disposal	Soil containing arsenic is excavated, treated ex-situ as necessary, and disposed of off-site at a facility permitted to receive the waste.[4]	Good	The relative effectiveness rating is good because the technology can easily remove arsenic within the target soil excavation depths (e.g., up to 15 feet bgs).	Good	The relative implementability rating is good because the technology has already been implemented at the Site, and can be easily implemented within the target soil excavation depths (e.g., up to 15 feet bgs).	Good	The relative cost rating is good because a focused excavation would be fairly inexpensive for this Site compared to other technologies in this category. However, since the cost for soil excavation is highly dependent on the volume of soil excavated, large-scale excavations would not receive a good rating.	**Yes**	The technology was retained because the relative effectiveness, implementability, and cost ratings were good, and the technology was used during Phases 1 through 3 of active arsenic remediation.
	Soil excavation and on-site disposal	Soil containing arsenic is excavated, treated ex-situ as necessary, and disposed of on-site in a constructed containment cell or landfill.[4]	Good	The relative effectiveness rating is good because the technology can easily remove arsenic within the target soil excavation depths (e.g., up to 15 feet bgs).	Poor	The relative implementability rating for on-site disposal is poor because of the presence of shallow groundwater at the Site, anticipated permitting issues, and a containment cell/landfill is incompatible with future redevelopment.	Poor	The relative cost rating is poor because of the cost for the large-scale excavations necessary to justify the use of this technology and the containment cell/landfill is expensive to maintain and monitor over a long time frame.	No	The technology was not retained because the relative implementability and cost ratings were poor.
	Sediment dredging and off-site disposal	Hylebos Waterway sediment is dredged and disposed of off-site at a facility permitted to receive the waste.	Good	The relative effectiveness rating is good because the technology can easily remove arsenic at the sediment exposure point.	Good	The relative implementability rating is good because the technology has already been implemented at the Site.	Poor	The relative cost rating is poor because of the high cost associated with sediment dredging.	**Yes**	The technology was retained because it was used during Phase 3 of active arsenic remediation, but will not be considered for future phases of active remediation because Hylebos Waterway dredging near the Site is complete.
	Groundwater extraction, on-site treatment, and off-site disposal	Groundwater containing arsenic is extracted, treated with an ex-situ technology, and disposed of off-site at a facility permitted to receive the waste.	Fair	The relative effectiveness rating is fair because an arsenic mass removal asymptote was reached during 11 years of operating the previous groundwater P&T system, and the technology is generally less effective than other technologies for removing mass in the source area or exposure point locations.	Fair	The relative implementability rating is fair because the technology requires more operation, maintenance, and monitoring than other technologies (especially considering difficulties with treating elevated arsenic and pH concentrations), and the associated infrastructure might be incompatible with future redevelopment.	Poor	The relative cost rating is poor because the technology is expensive to operate, maintain, and monitor over a long time frame.	**Yes**	The technology was retained because it was used during Phase 1 of active arsenic remediation, but will not be considered for future phases of active remediation because the relative effectiveness, implementability, and cost ratings were poor or fair.
	Groundwater extraction, on-site treatment, and on-site disposal	Groundwater containing arsenic is extracted, treated with an ex-situ technology, and disposed of on-site.	Fair	The relative effectiveness rating is fair because an arsenic mass removal asymptote was reached during 11 years of operating the previous groundwater P&T system, and the technology is generally less effective than other technologies for removing mass in the source area or exposure point locations.	Poor	The relative implementability rating is fair because the technology requires more operation, maintenance, and monitoring than other technologies (especially considering difficulties with treating elevated arsenic and pH concentrations), the associated infrastructure might be incompatible with future redevelopment, and it is unlikely that the necessary permits could be obtained.	Poor	The relative cost rating is poor because the technology is expensive to operate, maintain, and monitor over a long time frame.	No	The technology was not retained because the relative effectiveness, implementability, and cost ratings were poor or fair.
	Groundwater extraction and off-site disposal	Groundwater containing arsenic is extracted and disposed of off-site at a facility permitted to receive the waste (without any treatment).	Fair	The relative effectiveness rating is fair because an arsenic mass removal asymptote was reached during 11 years of operating the previous groundwater P&T system, and the technology is generally less effective than other technologies for removing mass in the source area or exposure point locations.	Poor	The relative implementability rating is poor because direct discharge of extracted groundwater without treatment (e.g., disposal to a sewer associated with a publicly owned treatment works) is unlikely to be allowed given the arsenic concentrations in Site groundwater.	Fair	The relative cost rating is fair because, although there would be no treatment-related costs, the long-term disposal costs would be high.	No	The technology was not retained because the relative effectiveness, implementability, and cost ratings were poor or fair.
	In-situ flushing	Additives (e.g., caustic) are injected into soil and groundwater to increase arsenic solubility and mobility so that arsenic can more easily be removed from groundwater with a P&T system or similar extraction system.	Fair	The relative effectiveness rating is fair because the technology's effectiveness has not been adequately proven and it may be less reliable than other technologies.	Poor	The relative implementability rating is poor because it is unlikely that the necessary permits could be obtained.	Fair	The relative cost rating is fair because the cost for this technology would likely be higher than some technologies (e.g., focused soil excavation and off-site disposal) and lower than some technologies (e.g., sediment dredging and off-site disposal).	No	The technology was not retained because the relative effectiveness, implementability, and cost ratings were poor or fair.
	Air sparging and soil vapor extraction	Air is injected into source area groundwater to volatilize constituents to soil gas. A vacuum is used to extract the constituents from the soil gas.	Poor	The relative effectiveness rating is poor because the technology is not compatible for arsenic because arsenic is not volatile.	Fair	The relative implementability rating is fair because the technology could be easily implemented within the Upper Aquifer, but is not implementable in the Intermediate Aquifer.	Fair	The relative cost rating is fair because the cost for this technology would likely be higher than some technologies (e.g., focused soil excavation and off-site disposal) and lower than some technologies (e.g., sediment dredging and off-site disposal).	No	The technology was not retained because it is not compatible for arsenic. However, air sparging could be used for oxidation purposes in support of in-situ stabilization.

Table 4-1: Identification and Screening of Remedial Technologies for the Main Arsenic Plume

Category	Technology	How the Technology Works	Relative Effectiveness[1]		Relative Implementability[2]		Relative Cost[3]		Retained?	Rationale
			Rating	Comment	Rating	Comment	Rating	Comment		
Treatment	In-situ solidification	Solidification amendments (e.g., cement) are mixed with soil and groundwater containing arsenic to form a low-permeability monolith that reduces arsenic mobility. Often used in conjunction with in-situ stabilization.	Good	The relative effectiveness rating is good because the proven effectiveness of the technology for limiting arsenic mobility is better than other technologies in the category, and solidification could address preferential flow paths near 124+00-2.	Fair	The relative implementability rating is fair because, although the technology is generally implementable, subsurface debris (e.g., pilings) would need to be removed before solidification can be conducted and a large solidified subsurface mass might be incompatible with future redevelopment.	Fair	The relative cost rating is fair because the cost for this technology would likely be higher than some technologies (e.g., phytoremediation) and lower than some technologies (e.g., in-situ thermal treatment).	**Yes**	The technology was retained because the relative effectiveness rating was good, the relative implementability and cost ratings were fair, and the technology is often used in conjunction with in-situ stabilization.
	In-situ stabilization	Stabilization amendments are mixed with soil and groundwater containing arsenic to cause chemical reactions that improve the ability of arsenic to bind to soil and precipitate with minerals (which reduces arsenic mobility).[5] Often used in conjunction with in-situ solidification.	Good	The relative effectiveness rating is good because the proven effectiveness of the technology for limiting arsenic mobility is better than other technologies in the category.	Good	The relative implementability rating is good because the technology can be easily implemented and has already been implemented at the Site.	Fair	The relative cost rating is fair because the cost for this technology would likely be higher than some technologies (e.g., phytoremediation) and lower than some technologies (e.g., in-situ thermal treatment).	**Yes**	The technology was retained because the relative effectiveness and implementability ratings were good, the relative cost rating was fair, and the technology was used during Phase 2 of active arsenic remediation.
	In-situ bioremediation	Carbon sources, microbes, and/or other amendments are injected into groundwater to biologically degrade constituents to less toxic byproducts.	Poor	The relative effectiveness rating is poor because the technology is not compatible for arsenic because arsenic cannot be degraded.	Good	The relative implementability rating is good because the technology can be easily implemented.	Good	The relative cost rating is good because the cost for this technology is fairly inexpensive.	No	The technology was not retained because it is not compatible for arsenic.
	In-situ thermal treatment	Soil and groundwater are heated with an electrical current or steam to vaporize constituents from soil and groundwater to soil gas. A vacuum is used to extract the constituents from soil gas.	Poor	The relative effectiveness rating is poor because the technology is not compatible for arsenic because arsenic is not volatile.	Fair	The relative implementability rating is fair because the technology requires significantly more design, construction, operation, maintenance, and monitoring than other technologies.	Poor	The relative cost rating is poor because the technology is generally more expensive than other technologies.	No	The technology was not retained because it is not compatible for arsenic.
	In-situ vitrification	Soil and groundwater are heated to extremely high temperatures with an electrical current, and then cooled to create a chemically inert and stable glass and crystalline monolith that immobilizes arsenic.	Good	The relative effectiveness rating is good because the potential effectiveness of the technology is high.	Poor	The relative implementability rating is poor because the technology requires significantly more design, construction, operation, maintenance, and monitoring than other technologies, and a large vitrified subsurface mass might be incompatible with redevelopment.	Poor	The relative cost rating is poor because the technology is substantially more expensive than other technologies.	No	The technology was not retained because the relative implementability and cost ratings were poor.
	Electrokinetic remediation	An electrical current, cathodes, and anodes are used to mobilize charged species in soil and groundwater (e.g., negatively charged arsenic oxyanions would move towards the anodes). Removal or precipitation/co-precipitation of arsenic would then be conducted at the anodes.	Fair	The relative effectiveness rating is fair because the technology is not a proven technology for arsenic and is most suitable for sites with substantial amounts of clay in the subsurface.	Fair	The relative implementability rating is fair because the technology requires significantly more design, construction, operation, maintenance, and monitoring than other technologies.	Poor	The relative cost rating is poor because the technology is generally more expensive than other technologies.	No	The technology was not retained because the relative effectiveness, implementability, and cost ratings were poor or fair.
	Phyto-remediation	Tree roots uptake arsenic from impacted groundwater and the trees degrade or respire the arsenic.	Fair	The relative effectiveness rating is fair because the technology could provide some polishing treatment for arsenic in the Upper Aquifer, but would likely not treat arsenic in the Intermediate Aquifer.	Poor	The relative implementability rating is poor because the technology is incompatible with future redevelopment.	Good	The relative cost rating is good because the cost for this technology is fairly inexpensive.	No	This technology was not retained because the technology is incompatible with future redevelopment.
	Constructed wetlands	Arsenic in impacted groundwater migrating into a constructed wetland are attenuated by wetland ecosystem processes.	Fair	The relative effectiveness rating is fair because the technology could provide some polishing treatment for arsenic in the Upper Aquifer, but would not treat arsenic in the Intermediate Aquifer.	Poor	The relative implementability rating is poor because an upland wetland is incompatible with future redevelopment, and a shoreline wetland is incompatible with the Hylebos Waterway.	Fair	The relative cost rating is fair because the cost for this technology would likely be higher than some technologies (e.g., phytoremediation) and lower than some technologies (e.g., in-situ thermal treatment).	No	The technology was not retained because the relative effectiveness, implementability, and cost ratings were poor or fair.
	MNA	Natural processes (e.g., precipitation, co-precipitation, sorption, hydraulic tidal dispersion) decrease arsenic concentrations in groundwater. Periodic monitoring is conducted to verify that natural processes are reducing arsenic groundwater concentrations as anticipated.	Good	The relative effectiveness rating is good because existing Site data have demonstrated that natural attenuation is occurring, arsenic groundwater concentrations in the main arsenic plume are stable or declining, and arsenic concentrations at the surface water and sediment exposure points are already protective of human health and the environment.	Good	The relative implementability rating is good because the technology can be easily implemented.	Fair	The relative cost rating is fair because, although there are no construction, operation, or maintenance costs, the technology is expensive to monitor over a long time frame. .	**Yes**	The technology was retained because the relative effectiveness and implementability ratings were good, and the relative cost rating was fair.
	Funnel and gate	This containment/treatment hybrid uses vertical barrier walls to funnel groundwater containing arsenic towards a treatment "gate" where focused groundwater treatment can occur (e.g., creating a treatment gate within the existing SPW).	Poor	The relative effectiveness rating is poor because a funnel would undo the attenuation benefit of the existing SPW and the treatment gate could not provide suitable treatment prior to discharge into the Hylebos Waterway for the concentrated plume flowing through the gate.	Poor	The relative implementability rating is poor because it is unlikely that Ecology would approve using a technology that could increase the arsenic mass discharge to the Hylebos Waterway.	Fair	The relative cost rating is fair because the cost for this technology would likely be higher than some technologies (e.g., phytoremediation) and lower than some technologies (e.g., in-situ thermal treatment).	No	The technology was not retained because the relative effectiveness, implementability, and cost ratings were poor or fair.

Table 4-1: Identification and Screening of Remedial Technologies for the Main Arsenic Plume

Category	Technology	How the Technology Works	Relative Effectiveness[1]		Relative Implementability[2]		Relative Cost[3]		Retained?	Rationale
			Rating	Comment	Rating	Comment	Rating	Comment		
Containment	Sediment cap	An engineered cap consisting of several layers of soil and rock is constructed along the shoreline to prevent potential exposure to arsenic in sediment and to enhance arsenic attenuation along the shoreline by providing sorption surfaces and enhancing marine surface water mixing (which increases hydraulic tidal dispersion and produces favorable geochemical conditions for arsenic attenuation).	Good	The relative effectiveness rating is good because the technology has a proven effectiveness for reducing arsenic concentrations near the shoreline (see Appendix D).	Fair	The relative implementability rating is fair because, although the technology has already been implemented at the Site, working in water to install a subtidal sediment cap presents some technical challenges.	Good	The relative cost rating is good because the cost for this technology is fairly inexpensive.	**Yes**	The technology was retained because the relative effectiveness and cost ratings were good, the relative implementability rating was fair, and the technology was used during Phase 3 of active arsenic remediation.
Containment	Surface soil cap	An impervious or low-permeability cap is placed over the top of soil containing arsenic to decrease infiltration and arsenic mobility.	Fair	The relative effectiveness rating is fair because the technology can reduce the mass discharge rate to the Hylebos Waterway in the short term, but it increases the duration of mass discharge to the Hylebos Waterway and increases the restoration time frame.	Good	The relative implementability rating is good because the technology can be easily implemented and has already been implemented at the Site. In addition, a soil cap/cover will likely be necessary to facilitate future redevelopment.	Fair	The relative cost rating is fair because the cost for this technology would likely be higher than some technologies (e.g., sediment cap) and lower than some technologies (e.g., hydraulic containment).	**Yes**	The technology was retained because the relative implementability rating was good, the relative effectiveness and cost ratings were fair, and the technology will likely be necessary to facilitate future redevelopment.
Containment	Barrier wall	An engineered vertical barrier wall (e.g., SPW, slurry wall) is used to control the migration of groundwater containing arsenic prior to discharge to the Hylebos Waterway.	Fair	The relative effectiveness rating is fair because the technology can reduce the mass discharge rate to the Hylebos Waterway in the short term, but it increases the duration of mass discharge to the Hylebos Waterway and increases the restoration time frame.	Fair	The relative implementability rating is fair because, although the technology has already been implemented at the Site, installing barrier walls in areas with elevated pH and tidal influences presents some technical challenges.	Fair	The relative cost rating is fair because the cost for this technology would likely be higher than some technologies (e.g., sediment cap) and lower than some technologies (e.g., hydraulic containment).	**Yes**	The technology was retained because there were no poor relative ratings, and the technology was used during Phase 1 of active arsenic remediation (i.e., SPW).
Containment	Hydraulic containment	Hydraulic containment with a groundwater P&T system is used to control the migration of groundwater containing arsenic prior to discharge to the Hylebos Waterway.	Fair	The relative effectiveness rating is fair because the technology can reduce the mass discharge rate to the Hylebos Waterway in the short term, but it increases the duration of mass discharge to the Hylebos Waterway and increases the restoration time frame.	Poor	The relative implementability rating is poor because the technology requires more operation, maintenance, and monitoring than other technologies (especially considering difficulties with treating elevated arsenic and pH concentrations), and the associated infrastructure might be incompatible with future redevelopment.	Poor	The relative cost rating is poor because the technology is expensive to operate, maintain, and monitor over a long time frame.	No	This technology was not retained because the relative effectiveness, implementability, and cost ratings were poor or fair.
Monitoring and Control	Surface water monitoring	Surface water samples are collected at the potential exposure point to ensure that arsenic concentrations are not exceeding applicable criteria.	Good	The relative effectiveness rating is good because monitoring results can be used to determine whether or not exposures are acceptable.	Good	The relative implementability rating is good because the technology can be easily implemented and has already been implemented at the Site.	Good	The relative cost rating is good because the technology is inexpensive to implement.	**Yes**	The technology was retained because the relative effectiveness, implementability, and cost ratings were good.
Monitoring and Control	Sediment monitoring	Sediment samples are collected at the potential exposure point to ensure that arsenic concentrations are not exceeding applicable criteria.	Good	The relative effectiveness rating is good because monitoring results can be used to determine whether or not exposures are acceptable.	Good	The relative implementability rating is good because the technology can be easily implemented and has already been implemented at the Site.	Good	The relative cost rating is good because the technology is inexpensive to implement.	**Yes**	The technology was retained because the relative effectiveness, implementability, and cost ratings were good.
Monitoring and Control	Groundwater monitoring	Groundwater samples are collected within the main arsenic plume to evaluate natural attenuation of arsenic.	Good	The relative effectiveness rating is good because monitoring results can be used to assess ongoing natural attenuation.	Good	The relative implementability rating is good because the technology can be easily implemented and has already been implemented at the Site.	Poor	The relative cost rating is poor because the costs will be high over a long time frame.	**Yes**	The technology was retained because the relative effectiveness and implementability ratings were good.
Monitoring and Control	Engineering controls	Engineered equipment and/or procedures are used to minimize arsenic exposures for workers during the remediation, redevelopment, and post-remediation and post-redevelopment phases.	Good	The relative effectiveness rating is good because the technology can minimize potential exposures and the potential for human error.	Good	The relative implementability rating is good because the technology can be easily implemented and has already been implemented at the Site.	Good	The relative cost rating is good because the technology is inexpensive to implement.	**Yes**	The technology was retained because the relative effectiveness, implementability, and cost ratings were good.
Monitoring and Control	Institutional controls	An administrative and/or legal mechanism (e.g., environmental covenant) is used to require certain activities (e.g., periodic surface water and sediment sampling) and restrict certain activities (e.g., prevent groundwater dewatering without an approved groundwater management plan and health and safety plan).	Good	The relative effectiveness rating is good because the technology can help ensure that certain activities are conducted over the long-term and prevent other activities from occurring.	Good	The relative implementability rating is good because the technology can be easily implemented at the Site.	Good	The relative cost rating is good because the technology is inexpensive to implement.	**Yes**	The technology was retained because the relative effectiveness, implementability, and cost ratings were good.

Notes:

[1] Relative effectiveness was qualitatively rated as good, fair, or poor relative to other technologies within the same category. The following were considered in the evaluation of the technology: (1) whether or not the technology would likely help achieve CAOs, and (2) whether or not the technology was proven and reliable for reducing arsenic concentrations based on Site conditions. The ratings were based on Site characteristics, arsenic characteristics, technology capabilities, and professional judgment.

[2] Relative implementability was qualitatively rated as good, fair, or poor relative to other technologies within the same category. The following were considered in the evaluation of the technology: (1) the amount of design, construction, operation, maintenance, and monitoring necessary to successfully implement the technology, (2) whether or not the technology was compatible with likely redevelopment scenarios, and (3) administrative/regulatory factors (e.g., would Ecology likely approve use of the technology, could permits be obtained). The ratings were based on Site characteristics, arsenic characteristics, technology capabilities, and professional judgment.

[3] Relative cost was qualitatively rated as good, fair, or poor relative to other technologies within the same category. The following were considered in the evaluation of the technology: (1) design, construction, operation, maintenance, monitoring, and periodic repair/replacement costs, and (2) indirect costs (e.g., permitting, regulatory oversight, consultants). The ratings were based on Site characteristics, arsenic characteristics, technology capabilities, and professional judgment.

[4] For this Site, ex-situ treatment would include ex-situ stabilization to convert hazardous waste to non-hazardous waste to the extent practicable. Depending on the extent of excavation, ex-situ treatment could include soil washing to separate the fine-grained soil (which typically contain more arsenic) from course-grained soil.

[5] For this Site, in-situ stabilization approaches could include, but are not limited to, precipitation and co-precipitation of arsenic under oxidizing conditions (e.g., the use of hydrogen peroxide and ferric chloride during Phase 2 of active arsenic remediation), precipitation and co-precipitation of arsenic under reducing conditions, and neutralization of elevated pH (and increasing Eh in the process) to increase arsenic co-precipitation with metal oxides and sorption. In-situ stabilization delivery mechanisms could include, but are not limited to, deep auger mixing, permeable reactive barriers (PRBs), injections, and reactive horizontal wells/trenches.

Table 5-1: Remedial Components in Cleanup Action Alternatives

Remediation Category	Remedial Components			Alternative Number				
	Number	Name	Summary Description	1	2	3	4	5
Exposure Point Control (Short-Term CAO)	EPC-1A	Completed remedial actions during Phase 3 of active arsenic remediation	Actions were conducted between 2003 and 2006 and included dredging Hylebos Waterway sediment, removing shoreline soil, and installing intertidal and subtidal shoreline caps.	X	X	X	X	X
	EPC-1B	Monitoring and maintenance of the existing shoreline caps	Periodic monitoring of the existing shoreline caps would be conducted in accordance with a future Cleanup Infrastructure Monitoring and Maintenance Plan. The shoreline caps would be repaired as necessary based on monitoring results.		X	X	X	X
	EPC-2A	Subtidal shoreline cap extension	The subtidal shoreline cap would be extended to the north so that the northern terminus (which is currently near Hylebos Waterway Station 124+25) is as close as practicable to the southern side of the existing dock (anticipated to be near Hylebos Waterway Station 122+50). The cap extension would be constructed similar to the existing cap (e.g., the bottom layer of the cap would be a sand/gravel filter layer, the middle layer would consist of quarry spalls to make the slope constructible and decrease erosion, and the top layer would consist of a fish mix for habitat enhancement). This component would likely include some removal of sediment to create a slope suitable for cap construction and enhance the habitat.		X	X	X	X
	EPC-2B	Monitoring and maintenance of EPC-2A	Periodic monitoring of the shoreline cap extension would be conducted in accordance with a future Cleanup Infrastructure Monitoring and Maintenance Plan. The shoreline cap extension would be repaired as necessary based on monitoring results.		X	X	X	X
	EPC-3	Surface water and sediment monitoring	Periodic surface water monitoring locations would likely be the same as the three FS Data Gap Investigation locations plus downgradient of 124+00-2 and near the East Channel Ditch outfall. Periodic sediment sampling would likely consist of grab samples at the aforementioned surface water locations (as a separate requirement from CB/NT sediment sampling).	X	X	X	X	X
Active Plume Remediation (Medium-Term CAO)	APR-1A	Completed remedial actions during Phases 1 and 2 of active arsenic remediation	Actions were conducted between 1990 and 2003 and included removing source area soil, installing a SPW, installing and operating a P&T system for the main arsenic plume, removing additional source area soil, and conducting in-situ stabilization within portions of the main arsenic plume.	X	X	X	X	X
	APR-1B	Monitoring and maintenance of the existing SPW	Periodic monitoring of the existing SPW would be conducted in accordance with a future Cleanup Infrastructure Monitoring and Maintenance Plan. The SPW would be repaired or replaced as necessary based on monitoring results.		X	X	X	X
	APR-2	Focused source area excavation	Soil would be excavated where arsenic concentrations in Upper Aquifer samples exceed a to-be-determined soil RL (e.g., 20,000 mg/kg), treated with ex-situ stabilization, and disposed of off-site. In-place arsenic soil concentrations exceeding 20,000 mg/kg remain in only two samples: 25,000 mg/kg in a PT-33 sample that was just upgradient of former Penite Pit #1, and 165,000 mg/kg in a PTC-102 sample within former Penite Pit #2. The arsenic concentrations in these PTC-102 and PT-33 samples are one to two orders of magnitude higher than any other remaining soil concentration at the Site, and are consistent with soil concentrations within the former Penite Pits prior to the 1990 and 2003 Penite Pit excavations. It is anticipated that additional residual source material may be present within and immediately surrounding former Penite Pit #1, former Penite Pit #2, and the former Penite Manufacturing Building. The soil RL and corresponding excavation locations would be determined based on the results of a pre-design investigation and a Getis-Ord hotspot analysis. This component would likely include removing the top foot or two of the First Aquitard within a given excavation, and backfilling the bottom of the excavation with low-permeability soil and a stabilization amendment. If the design excavation volume was substantially larger than currently expected, in-situ solidification/stabilization may be considered instead of excavation.		X	X	X	
	APR-3A	General surface cap/cover for soil direct contact pathway	A cap/cover would be installed on the ground surface where arsenic concentrations in soil samples collected shallower than 15 feet bgs exceed the soil CL (88 mg/kg). Although this remedial component is primarily associated with the soil direct contact pathway, it is included with active plume remediation because it is expected that a cap/cover would eventually include working surfaces (e.g., asphalt, concrete) that minimize infiltration.	X	X	X	X	
	APR-3B	Monitoring and maintenance of APR-3A	Periodic monitoring of the cap/cover would be conducted in accordance with a future Cleanup Infrastructure Monitoring and Maintenance Plan. The cap/cover would be repaired as necessary based on monitoring results.	X	X	X	X	
	APR-4A	Focused low-permeability surface cap	A low-permeability clay cap would be installed to minimize infiltration into the plume core. In order to minimize damage to the cap during post-redevelopment operations, the clay cap would be overlain by a sand layer and APR-3A.			X	X	
	APR-4B	Monitoring and maintenance of APR-4A	There should be minimal need for periodic monitoring and maintenance of the low-permeability surface cap based on the conceptual design outlined above. However, monitoring and maintenance procedures following catastrophic events (e.g., earthquake) would be described in a future Cleanup Infrastructure Monitoring and Maintenance Plan.			X	X	
	APR-5A	Vertical low-permeability barrier walls	Vertical low-permeability barrier walls (e.g., slurry walls) would be installed on all four sides of the perimeter of the focused low-permeability surface cap (APR-4A). The new wall on the east side would be landward of the existing SPW. The walls would extend from near ground surface into the top of the Second Aquitard. The walls would be thicker than the existing SPW, but would not be impermeable.				X	
	APR-5B	Monitoring and maintenance of APR-5A	Periodic monitoring of the walls would be conducted in accordance with a future Cleanup Infrastructure Monitoring and Maintenance Plan. The walls would be repaired as necessary based on monitoring results.				X	
	APR-6	Focused groundwater treatment	Focused groundwater treatment would be conducted landward of the SPW to reduce Intermediate Aquifer groundwater concentrations at and downgradient of 124+00-2. Treatment would occur within the area immediately upgradient of 124+00-2 that includes two thin or leaky First Aquitard locations and pH greater than 10. Treatment within this focused area would likely extend from the top of the Upper Aquifer saturated zone to the bottom of the Intermediate Aquifer. The treatment approach (e.g., in-situ solidification/stabilization, neutralization) would be determined based on the results of a pre-design investigation and a subsequent treatability study.(1)			C	X	
	APR-7	Focused Intermediate Aquifer PRB	An in-situ stabilization PRB would be installed via drilling injections in the Intermediate Aquifer immediately seaward of the SPW to address elevated arsenic groundwater concentrations in 120+75-ST1, 123+25-ST1, 123+25-ST1-DS, and 125+00-ST1-DS. The in-situ stabilization amendment(s) would be determined based on a pre-design treatability study.			C	C	X
	APR-8	Focused Upper Aquifer PRB	An in-situ stabilization PRB would be installed via drilling injections in the Upper Aquifer immediately seaward of the SPW to address elevated arsenic groundwater concentrations in 120+50-0 and 125+50-0-DS. The in-situ stabilization amendment(s) would be determined based on a pre-design treatability study.			C	C	X
	APR-9	Excavation to achieve default soil cleanup standards	Soil would be excavated where arsenic concentrations in soil samples collected shallower than 15 feet bgs exceed the soil CL (88 mg/kg), treated with ex-situ stabilization as necessary, and disposed of off-site.					X
	APR-10	Extensive in-situ solidification/stabilization	In-situ solidification/stabilization would be conducted across a large area landward of the SPW to address the elevated arsenic groundwater concentrations in the Upper and Intermediate Aquifers and the elevated arsenic soil concentrations in the First Aquitard. In-situ solidification/stabilization would extend from near ground surface into the top of the Second Aquitard. The in-situ solidification/stabilization amendments would be determined based on a pre-design treatability study.					X
	APR-11	Performance groundwater monitoring	Groundwater monitoring would be conducted to assess the performance of the completed and future remedial components.		X	X	X	X

Table 5-1: Remedial Components in Cleanup Action Alternatives

Remediation Category	Remedial Components			Alternative Number				
	Number	Name	Summary Description	1	2	3	4	5
MNA and Long-Term Controls (Long-Term CAO)	**MNA&LTC-1**	Long-term groundwater monitoring	Groundwater monitoring would be conducted to support periodic MNA evaluations.		X	X	X	X
	MNA&LTC-2	Periodic MNA evaluations	Periodic MNA evaluations (e.g., Ricker plume stability analysis, Mann-Kendall trend analysis) would be conducted to assess the ongoing ability of MNA to decrease arsenic groundwater concentrations.		X	X	X	X
	MNA&LTC-3	Applicable ECs	ECs would be developed and implemented to minimize arsenic exposures for workers during the remediation, redevelopment, and post-remediation and post-redevelopment phases. ECs are expected to include project-specific health and safety plans, health and safety procedures, worker protection monitoring, waste management programs, controls during remediation (e.g., site control, dust control), perimeter fencing and signs, a soil and materials management plan for any excavations during the redevelopment and post-remediation and redevelopment phases, and a groundwater management plan for any dewatering during the redevelopment and post-remediation and redevelopment phases (including dewatering utility excavations to minimize groundwater dermal contact by utility workers).	X	X	X	X	X
	MNA&LTC-4	Applicable ICs	ICs would be implemented, maintained, and enforced via an environmental covenant on the 2901 Taylor Way property that is recorded with Pierce County. The environmental covenant would require certain activities such as (1) conducting annual land use inspections, (2) conducting a VI evaluation for any proposed occupied building within 100 feet of VOC VI Areas A through C, (3) installing a VI mitigation system (e.g., VI membrane and passive convertible venting system that can be converted to an active sub-slab depressurization system if necessary) for any proposed occupied building within 100 feet of VOC VI Areas A through C unless Ecology approves that such a system is not necessary based on VI evaluation results, (4) conducting operation, maintenance, and monitoring for any installed VI mitigation system, and (5) dewatering for any utility excavation in which the potential for utility worker dermal contact with arsenic-impacted groundwater is unacceptable. The environmental covenant would also restrict certain activities such as (1) excavation during the redevelopment and post-remediation and redevelopment phases without a health and safety plan and a soil and materials management plan approved by Ecology, (2) groundwater dewatering during the redevelopment and post-remediation and redevelopment phases without a health and safety plan and a groundwater management plan approved by Ecology, (3) use of groundwater for drinking water, and (4) residential land use.	X	X	X	X	X
Other Potential Site Concerns	**OPSC-1**	2014 Wypenn Interim Action	The completed interim action removed arsenic-impacted soil in Wypenn to comply with the arsenic soil direct contact CL of 88 mg/kg (DOF 2015b).	X	X	X	X	X
	OPSC-2	2013 to 2014 Arkema Mound Interim Action	As part of the completed interim action, elevated arsenic soil concentrations on the south bank of the East Channel Ditch were removed, arsenic-impacted sediment in the East Channel Ditch was removed, and a stormwater treatment and conveyance system was installed in the East Channel Ditch to provide ongoing water treatment (DOF 2015a).	X	X	X	X	X
	OPSC-3	Completed active VOC remediation in VOC VI Area A	A soil vapor extraction system and a groundwater P&T system were installed and operated in VOC VI Area A from 1996 to 2000 (Boateng 2002).	X	X	X	X	X
	OPSC-4	Completed active VOC remediation in VOC VI Area B	In-situ chemical oxidation was performed in VOC VI Area B in 2003 (ERM 2003c).	X	X	X	X	X
	OPSC-5	Upper Aquifer groundwater monitoring downgradient of Wypenn	Periodic Upper Aquifer groundwater monitoring will be conducted downgradient of Wypenn to assess the long-term benefits of the completed interim action. It is anticipated that up to three MWs would be sampled.	X	X	X	X	X
	OPSC-6	Groundwater and surface water monitoring for copper, mercury, nickel, PCE, TCE, VC, and CF	Periodic groundwater and surface water monitoring will be conducted to ensure copper, mercury, nickel, PCE, TCE, VC, and CF do not migrate to the Hylebos Waterway.	X	X	X	X	X
	OPSC-7	Decommission Angled Shoreline MWs	Angled Shoreline MWs will be decommissioned to eliminate the stainless steel source of elevated nickel concentrations near these MWs.	X	X	X	X	X
	OPSC-8	VI evaluation(s)	A VI evaluation will be conducted as necessary to assess the need for a VI mitigation system for each occupied building proposed within 100 feet of VOC VI Areas A through C.	X	X	X	X	X
	OPSC-9	Installation of VI mitigation system(s)	A VI mitigation system will be installed as necessary based on VI evaluation results for each occupied building proposed within 100 feet of VOC VI Areas A through C.	X	X	X	X	X
	OPSC-10	Operation, maintenance, and monitoring of VI mitigation system(s)	Each VI mitigation system installed pursuant to OPSC-9 will be operated, maintained, and monitored for the life of the system.	X	X	X	X	X

Notes:

C: Contingent remedial component included in the alternative; ECs: engineering controls; IC: institutional controls; PRB: permeable reactive barrier; SPW: sheet pile wall; X: remedial component included in the alternative

The remedial components that involve new active remediation are highlighted in blue (and shown on Figures 5-1 through 5-5 as applicable).

(1) Pre-design investigation activities to assess the cause of elevated arsenic concentrations at 124+00-2 have not been determined yet, but could include one or more of the following activities: conducting a geophysical survey of the top of the First Aquitard and preferential flow pathways (e.g., thin/leaky First Aquitard locations, former stream channels, former sewer lines, pilings), installing additional MWs, collecting additional groundwater and pore water samples, conducting a tracer test to assess arsenic transport from the source area to 124+00-2, and/or conducting a tracer test to determine potential preferential SPW leakage locations.

Table 6-1: MTCA Threshold Requirements Evaluation

MTCA Threshold Requirement	Alternative 1		Alternative 2		Alternative 3		Alternative 4		Alternative 5	
	Satisfy the Requirement?	Rationale	Satisfy the Requirement?	Rationale	Satisfy the Requirement?	Rationale	Satisfy the Requirement?	Rationale	Satisfy the Requirement?	Rationale
Protect human health and the environment	Yes	The alternative would satisfy this requirement by including remedial components to ensure protectiveness of human health and the environment for all exposure pathways (e.g., surface water/sediment, soil direct contact, and VI pathways). Phase 1 through Phase 3 of active arsenic remediation (which are included in this alternative) have already achieved criteria for protection of human health and the environment at the actual exposure point locations in surface water and sediment. Current dissolved arsenic concentrations in surface water samples collected as close as technically possible to where groundwater flows into surface water are less than the default MTCA background concentration of 5 ug/L. Arsenic concentrations in all sediment samples collected within the sediment BAZ have been less than the 57 mg/kg SQO since Phase 3 of active arsenic remediation was completed. Future arsenic surface water and sediment concentrations are expected to be protective of human health and the environment (with future monitoring to provide confirmation) because the arsenic plume is stable or declining due to Phase 1 through Phase 3 of active arsenic remediation and ongoing natural attenuation processes (including highly favorable geochemical conditions and hydraulic tidal dispersion near the shoreline due to mixing of marine surface water with groundwater). Although a substantial amount of arsenic will remain in the upland portion of the Site (primarily in the First Aquitard) regardless of which alternative is selected, all CB/NT cleanup standards have been achieved. The CB/NT cleanup standards were specifically developed to ensure protection of human health and the environment for surface water and sediment exposures in the Hylebos Waterway. Non-arsenic COCs do not pose a concern for surface water and sediment receptors (see Appendix B). The soil direct contact pathways would be addressed with completed soil excavation activities, cap/cover, and ICs. The VI pathway would be addressed with completed remedial actions for VOC VI Areas A and B, natural attenuation, installation of VI mitigation systems for future occupied buildings as necessary, and ICs. Moreover, the alternative includes monitoring and maintenance to assess and ensure long-term protection of human health and the environment.	Yes	The alternative would satisfy this requirement by including remedial components to ensure protectiveness of human health and the environment for all exposure pathways (e.g., surface water/sediment, soil direct contact, and VI pathways). Phase 1 through Phase 3 of active arsenic remediation (which are included in this alternative) have already achieved criteria for protection of human health and the environment at the actual exposure point locations in surface water and sediment. Current dissolved arsenic concentrations in surface water samples collected as close as technically possible to where groundwater flows into surface water are less than the default MTCA background concentration of 5 ug/L. Arsenic concentrations in all sediment samples collected within the sediment BAZ have been less than the 57 mg/kg SQO since Phase 3 of active arsenic remediation was completed. Future arsenic surface water and sediment concentrations are expected to be protective of human health and the environment (with future monitoring to provide confirmation) because the arsenic plume is stable or declining due to Phase 1 through Phase 3 of active arsenic remediation and ongoing natural attenuation processes (including highly favorable geochemical conditions and hydraulic tidal dispersion near the shoreline due to mixing of marine surface water with groundwater). Although a substantial amount of arsenic will remain in the upland portion of the Site (primarily in the First Aquitard) regardless of which alternative is selected, all CB/NT cleanup standards have been achieved. The CB/NT cleanup standards were specifically developed to ensure protection of human health and the environment for surface water and sediment exposures in the Hylebos Waterway. Non-arsenic COCs do not pose a concern for surface water and sediment receptors (see Appendix B). The soil direct contact pathways would be addressed with completed soil excavation activities, proposed soil excavation activities, cap/cover, and ICs. The VI pathway would be addressed with completed remedial actions for VOC VI Areas A and B, natural attenuation, installation of VI mitigation systems for future occupied buildings as necessary, and ICs. Moreover, the alternative includes monitoring and maintenance to assess and ensure long-term protection of human health and the environment.	Yes	The alternative would satisfy this requirement by including remedial components to ensure protectiveness of human health and the environment for all exposure pathways (e.g., surface water/sediment, soil direct contact, and VI pathways). Phase 1 through Phase 3 of active arsenic remediation (which are included in this alternative) have already achieved criteria for protection of human health and the environment at the actual exposure point locations in surface water and sediment. Current dissolved arsenic concentrations in surface water samples collected as close as technically possible to where groundwater flows into surface water are less than the default MTCA background concentration of 5 ug/L. Arsenic concentrations in all sediment samples collected within the sediment BAZ have been less than the 57 mg/kg SQO since Phase 3 of active arsenic remediation was completed. Future arsenic surface water and sediment concentrations are expected to be protective of human health and the environment (with future monitoring to provide confirmation) because the arsenic plume is stable or declining due to Phase 1 through Phase 3 of active arsenic remediation and ongoing natural attenuation processes (including highly favorable geochemical conditions and hydraulic tidal dispersion near the shoreline due to mixing of marine surface water with groundwater). Although a substantial amount of arsenic will remain in the upland portion of the Site (primarily in the First Aquitard) regardless of which alternative is selected, all CB/NT cleanup standards have been achieved. The CB/NT cleanup standards were specifically developed to ensure protection of human health and the environment for surface water and sediment exposures in the Hylebos Waterway. Non-arsenic COCs do not pose a concern for surface water and sediment receptors (see Appendix B). The soil direct contact pathways would be addressed with completed soil excavation activities, proposed soil excavation activities, cap/cover, and ICs. The VI pathway would be addressed with completed remedial actions for VOC VI Areas A and B, natural attenuation, installation of VI mitigation systems for future occupied buildings as necessary, and ICs. Moreover, the alternative includes monitoring and maintenance to assess and ensure long-term protection of human health and the environment.	Yes	The alternative would satisfy this requirement by including remedial components to ensure protectiveness of human health and the environment for all exposure pathways (e.g., surface water/sediment, soil direct contact, and VI pathways). Phase 1 through Phase 3 of active arsenic remediation (which are included in this alternative) have already achieved criteria for protection of human health and the environment at the actual exposure point locations in surface water and sediment. Current dissolved arsenic concentrations in surface water samples collected as close as technically possible to where groundwater flows into surface water are less than the default MTCA background concentration of 5 ug/L. Arsenic concentrations in all sediment samples collected within the sediment BAZ have been less than the 57 mg/kg SQO since Phase 3 of active arsenic remediation was completed. Future arsenic surface water and sediment concentrations are expected to be protective of human health and the environment (with future monitoring to provide confirmation) because the arsenic plume is stable or declining due to Phase 1 through Phase 3 of active arsenic remediation and ongoing natural attenuation processes (including highly favorable geochemical conditions and hydraulic tidal dispersion near the shoreline due to mixing of marine surface water with groundwater). Although a substantial amount of arsenic will remain in the upland portion of the Site (primarily in the First Aquitard) regardless of which alternative is selected, all CB/NT cleanup standards have been achieved. The CB/NT cleanup standards were specifically developed to ensure protection of human health and the environment for surface water and sediment exposures in the Hylebos Waterway. Non-arsenic COCs do not pose a concern for surface water and sediment receptors (see Appendix B). The soil direct contact pathways would be addressed with completed soil excavation activities, proposed soil excavation activities, cap/cover, and ICs. The VI pathway would be addressed with completed remedial actions for VOC VI Areas A and B, natural attenuation, installation of VI mitigation systems for future occupied buildings as necessary, and ICs. Moreover, the alternative includes monitoring and maintenance to assess and ensure long-term protection of human health and the environment.	Yes	The alternative would satisfy this requirement by including remedial components to ensure protectiveness of human health and the environment for all exposure pathways (e.g., surface water/sediment, soil direct contact, and VI pathways). Phase 1 through Phase 3 of active arsenic remediation (which are included in this alternative) have already achieved criteria for protection of human health and the environment at the actual exposure point locations in surface water and sediment. Current dissolved arsenic concentrations in surface water samples collected as close as technically possible to where groundwater flows into surface water are less than the default MTCA background concentration of 5 ug/L. Arsenic concentrations in all sediment samples collected within the sediment BAZ have been less than the 57 mg/kg SQO since Phase 3 of active arsenic remediation was completed. Future arsenic surface water and sediment concentrations are expected to be protective of human health and the environment (with future monitoring to provide confirmation) because the arsenic plume is stable or declining due to Phase 1 through Phase 3 of active arsenic remediation and ongoing natural attenuation processes (including highly favorable geochemical conditions and hydraulic tidal dispersion near the shoreline due to mixing of marine surface water with groundwater). Although a substantial amount of arsenic will remain in the upland portion of the Site (primarily in the First Aquitard) regardless of which alternative is selected, all CB/NT cleanup standards have been achieved. The CB/NT cleanup standards were specifically developed to ensure protection of human health and the environment for surface water and sediment exposures in the Hylebos Waterway. Non-arsenic COCs do not pose a concern for surface water and sediment receptors (see Appendix B). The soil direct contact pathways would be addressed with completed soil excavation activities, proposed soil excavation activities, and ICs. The VI pathway would be addressed with completed remedial actions for VOC VI Areas A and B, natural attenuation, installation of VI mitigation systems for future occupied buildings as necessary, and ICs. Moreover, the alternative includes monitoring and maintenance to assess and ensure long-term protection of human health and the environment.

Table 6-1: MTCA Threshold Requirements Evaluation

MTCA Threshold Requirement	Alternative 1: Satisfy the Requirement?	Alternative 1: Rationale	Alternative 2: Satisfy the Requirement?	Alternative 2: Rationale	Alternative 3: Satisfy the Requirement?	Alternative 3: Rationale	Alternative 4: Satisfy the Requirement?	Alternative 4: Rationale	Alternative 5: Satisfy the Requirement?	Alternative 5: Rationale
Comply with cleanup standards	Yes	The alternative would satisfy this requirement because all CB/NT cleanup standards have been achieved (with future monitoring to provide confirmation) and MTCA soil and groundwater cleanup standards would be achieved. MTCA soil cleanup standards would be achieved via completed soil excavation activities and a cap/cover. MTCA groundwater cleanup standards would be achieved over time with the remedial components included in the alternative. The time to achieve groundwater cleanup standards would depend on the selected POC.	Yes	The alternative would satisfy this requirement because all CB/NT cleanup standards have been achieved (with future monitoring to provide confirmation) and MTCA soil and groundwater cleanup standards would be achieved. MTCA soil cleanup standards would be achieved via completed soil excavation activities, proposed soil excavation activities, and a cap/cover. MTCA groundwater cleanup standards would be achieved over time with the remedial components included in the alternative. The time to achieve groundwater cleanup standards would depend on the selected POC.	Yes	The alternative would satisfy this requirement because all CB/NT cleanup standards have been achieved (with future monitoring to provide confirmation) and MTCA soil and groundwater cleanup standards would be achieved. MTCA soil cleanup standards would be achieved via completed soil excavation activities, proposed soil excavation activities, and a cap/cover. MTCA groundwater cleanup standards would be achieved over time with the remedial components included in the alternative. The time to achieve groundwater cleanup standards would depend on the selected POC.	Yes	The alternative would satisfy this requirement because all CB/NT cleanup standards have been achieved (with future monitoring to provide confirmation) and MTCA soil and groundwater cleanup standards would be achieved. MTCA soil cleanup standards would be achieved via completed soil excavation activities, proposed soil excavation activities, and a cap/cover. MTCA groundwater cleanup standards would be achieved over time with the remedial components included in the alternative. The time to achieve groundwater cleanup standards would depend on the selected POC.	Yes	The alternative would satisfy this requirement because all CB/NT cleanup standards have been achieved (with future monitoring to provide confirmation) and MTCA soil and groundwater cleanup standards would be achieved. MTCA soil cleanup standards would be achieved via completed soil excavation activities and proposed soil excavation activities. MTCA groundwater cleanup standards would be achieved over time with the remedial components included in the alternative. The time to achieve groundwater cleanup standards would depend on the selected POC.
Comply with applicable state and federal laws	Yes	The alternative has the capability and would be designed to satisfy this requirement (see Appendix E).	Yes	The alternative has the capability and would be designed to satisfy this requirement (see Appendix E).	Yes	The alternative has the capability and would be designed to satisfy this requirement (see Appendix E).	Yes	The alternative has the capability and would be designed to satisfy this requirement (see Appendix E).	Yes	The alternative has the capability and would be designed to satisfy this requirement (see Appendix E).
Provide for compliance monitoring [1]	Yes	The alternative would satisfy this requirement because it includes compliance monitoring. Specifically, the alternative would include protection monitoring (i.e., monitoring, controls, and procedures specified in project-specific health and safety plans), performance monitoring (e.g., construction quality control measures, monitoring required by a permit or ARAR [see Appendix E]), and confirmational monitoring (i.e., EPC-3, APR-3B, OPSC-5, OPSC-6, OPSC-8, OPSC-10).	Yes	The alternative would satisfy this requirement because it includes compliance monitoring. Specifically, the alternative would include protection monitoring (i.e., monitoring, controls, and procedures specified in project-specific health and safety plans), performance monitoring (e.g., construction quality control measures, excavation soil sidewall and bottom sampling for APR-2, waste characterization sampling for applicable remedial components, performance groundwater monitoring [APR-11], monitoring required by a permit or ARAR [see Appendix E]), and confirmational monitoring (i.e., EPC-1B, EPC-2B, EPC-3, APR-1B, APR-3B, MNA&LTC-1, OPSC-5, OPSC-6, OPSC-8, OPSC-10).	Yes	The alternative would satisfy this requirement because it includes compliance monitoring. Specifically, the alternative would include protection monitoring (i.e., monitoring, controls, and procedures specified in project-specific health and safety plans), performance monitoring (e.g., construction quality control measures, excavation soil sidewall and bottom sampling for APR-2, waste characterization sampling for applicable remedial components, performance groundwater monitoring [APR-11], monitoring required by a permit or ARAR [see Appendix E]), and confirmational monitoring (i.e., EPC-1B, EPC-2B, EPC-3, APR-1B, APR-3B, APR-4B, MNA&LTC-1, OPSC-5, OPSC-6, OPSC-8, OPSC-10).	Yes	The alternative would satisfy this requirement because it includes compliance monitoring. Specifically, the alternative would include protection monitoring (i.e., monitoring, controls, and procedures specified in project-specific health and safety plans), performance monitoring (e.g., construction quality control measures, excavation soil sidewall and bottom sampling for APR-2, waste characterization sampling for applicable remedial components, performance groundwater monitoring [APR-11], monitoring required by a permit or ARAR [see Appendix E]), and confirmational monitoring (i.e., EPC-1B, EPC-2B, EPC-3, APR-1B, APR-3B, APR-4B, APR-5B, MNA&LTC-1, OPSC-5, OPSC-6, OPSC-8, OPSC-10).	Yes	The alternative would satisfy this requirement because it includes compliance monitoring. Specifically, the alternative would include protection monitoring (i.e., monitoring, controls, and procedures specified in project-specific health and safety plans), performance monitoring (e.g., construction quality control measures, excavation soil sidewall and bottom sampling for APR-9, waste characterization sampling for applicable remedial components, performance groundwater monitoring [APR-11], monitoring required by a permit or ARAR [see Appendix E]), and confirmational monitoring (i.e., EPC-1B, EPC-2B, EPC-3, APR-1B, MNA&LTC-1, OPSC-5, OPSC-6, OPSC-8, OPSC-10).
Satisfy All MTCA Threshold Requirements?	**Yes**		**Yes**		**Yes**		**Yes**		**Yes**	

Notes:

ARAR: Applicable or relevant and appropriate requirement

The text in blue font indicates differences between the alternatives.

[1] Per WAC 173-340-410(1), compliance monitoring includes protection monitoring, performance monitoring, and confirmational monitoring. Protection monitoring confirms "that human health and the environment are adequately protected during construction and the operation and maintenance period of an interim action or cleanup action as described in the safety and health plan." Performance monitoring confirms "that the interim action or cleanup action has attained cleanup standards and, if appropriate, remediation levels or other performance standards such as construction quality control measurements or monitoring necessary to demonstrate compliance with a permit or, where a permit exemption applies, the substantive requirements of other laws." Confirmational monitoring confirms "the long-term effectiveness of the interim action or cleanup action once cleanup standards and, if appropriate, remediation levels or other performance standards have been attained."

Table 6-2: Summary of Estimated Restoration Time Frames, Mass Discharges, and Costs for the Alternatives

Category	Item	Alternative 1	Alternative 2	Alternative 3	Alternative 3 (With Contingent Components)	Alternative 4	Alternative 4 (With Contingent Components)	Alternative 5
Estimated Restoration Time Frames [1] (years)	POC = all Site groundwater	> 10,000	> 10,000	> 10,000	> 10,000	> 10,000	> 10,000	> 10,000
	POC = Vertical Shoreline MWs	> 10,000	> 10,000	> 10,000	> 10,000	> 10,000	> 10,000	> 10,000
	POC = Angled Shoreline MWs/PPSs	> 10,000	4,600	7,700	> 10,000	> 10,000	> 10,000	4,000
	POC = Pore Water NSDSs	> 10,000	3,700	6,500	> 10,000	> 10,000	> 10,000	3,100
	POC = Surface Water (at locations as close as technically possible to the point or points where groundwater flows into surface water)	0 [2]	0 [2]	0 [2]	0 [2]	0 [2]	0 [2]	0 [2]
Estimated Arsenic Mass Discharge to Hylebos Water	Average Mass Discharge Over Next 100 Years [1] (kg/year)	10	9.9	7.9	4.6	2.1	2.1	3.2
	1990 CB/NT 80% Source Control Goal (480 kg/year) Achieved?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Reduction from 1990 Pre-Remediation Mass Discharge	99.6%	99.6%	99.7%	99.8%	99.9%	99.9%	99.9%
Estimated Total Cost for All POCs [3] (in millions of dollars)	Past + Future Costs with Contingency	$77	$92	$96	$107	$108	$111	$263
	Future Costs with Contingency	$11	$26	$30	$41	$42	$45	$196

Notes:

MW: monitoring well; NSDS: nylon-screen diffusion sampler; POC: point of compliance; PPS: pushpoint sampler

(1) Restoration time frames and arsenic mass discharges were estimated with the groundwater model (see Appendix G) and were rounded to two significant figures, with one exception. The estimated restoration time frames for a POC of surface water (at locations as close as technically possible to the point or points where groundwater flows into surface water) were estimated with empirical data (PIONEER 2019).

(2) Although cleanup standards for the main arsenic plume have already been achieved in surface water (at locations as close as technically possible to the point or points where groundwater flows into surface water), monitoring and maintenance (for applicable remedial components) would be conducted for the foreseeable future to ensure ongoing compliance with cleanup standards in surface water.

(3) Estimated costs are presented in Appendix F, and were rounded to the nearest million.

Table 6-3: Disproportionate Cost Analysis

Benefit	General Benefit Description	Benefit Component	Key Similarities and Differences	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Protectiveness	Overall protectiveness of human health and the environment, including the degree to which existing risks are reduced, time required to reduce risk at the facility and attain cleanup standards, on-site and offsite risks resulting from implementing the alternative, and improvement of the overall environmental quality.	Overall protectiveness of human health and the environment	Similarities for All Alternatives	All alternatives include remedial components to ensure protectiveness of human health and the environment for all exposure pathways (e.g., surface water/sediment, soil direct contact, and VI pathways). Phase 1 through Phase 3 of active arsenic remediation (which are included in all alternatives) have already achieved criteria for protection of human health and the environment at the actual exposure point locations in surface water and sediment. Current dissolved arsenic concentrations in surface water samples collected as close as technically possible to where groundwater flows into surface water are less than the default MTCA background concentration of 5 ug/L. Arsenic concentrations in all sediment samples collected within the sediment BAZ have been less than the 57 mg/kg SQO since Phase 3 of active arsenic remediation was completed. Future arsenic surface water and sediment concentrations are expected to be protective of human health and the environment (with future monitoring to provide confirmation) because the arsenic plume is stable or declining due to Phase 1 through Phase 3 of active arsenic remediation and ongoing natural attenuation processes (including highly favorable geochemical conditions and hydraulic tidal dispersion near the shoreline due to mixing of marine surface water with groundwater). In general, the overall protectiveness is the same or relatively similar for all alternatives.				
			Notable Differences	Unlike the other alternatives, Alternative 1 includes less safeguards (e.g., no groundwater monitoring to assess future arsenic concentrations in upland groundwater [APR-11 and MNA&LTC-1], no monitoring and maintenance of the existing sheet pile wall [APR-1B], no additional removal of known and suspected residual source material in/near the former Penite Pits and Penite Manufacturing Building [APR-2]) to help ensure overall protectiveness.	--	--	--	Unlike the other alternatives, Alternative 5 addresses the remaining soil direct contact exceedances with soil excavation rather than with a cap/cover approach.
		Degree to which existing risks are reduced [1]	Similarities for All Alternatives	All alternatives include remedial components to reduce/eliminate risk for all exposure pathways (e.g., surface water/sediment, soil direct contact, and VI pathways). Phase 1 through Phase 3 of active arsenic remediation (which are included in all alternatives) have substantially reduced arsenic concentrations within the main arsenic plume, arsenic concentrations along the Hylebos Waterway shoreline, and the mass discharge of arsenic to the Hylebos Waterway. The future arsenic mass discharge reductions are essentially the same for all alternatives (i.e., 99.6% to 99.9% reduction from the 1990 pre-remediation mass discharge). More importantly, the 99.6% to 99.9% mass discharge reduction provided by the alternatives substantially eclipse the CB/NT source control goal for an 80% reduction in arsenic mass discharge. In general, the degree of risk reduction is the same or relatively similar for all alternatives.				
			Notable Differences	Unlike the other alternatives, Alternative 1 does not include additional removal of known and suspected residual source material in/near the former Penite Pits and Penite Manufacturing Building (APR-2 or APR-9).	--	--	--	Alternative 5 includes more future removal of arsenic soil mass than the other alternatives (although even Alternative 5 would only remove a portion of First Aquitard soil - where the majority of arsenic mass is located).
		Time required to reduce risk at the facility and attain cleanup standards	Similarities for All Alternatives	The estimated restoration time frame for all alternatives is greater than 10,000 years if the selected POC is all Site groundwater or vertical shoreline MWs. The estimated restoration time frame for all alternatives is 0 years if the selected POC is surface water (at locations as close as technically possible to the point or points where groundwater flows into surface water). If surface water is the selected POC, monitoring and maintenance (for applicable remedial components) would continue to be conducted for the foreseeable future to ensure ongoing compliance with cleanup standards in surface water. In general, the estimated restoration time frames are the same or relatively similar for all alternatives.				
			Notable Differences	--	The estimated restoration time frames to attain MTCA cleanup standards for Alternatives 2 and 5 are shorter than the estimated restoration time frames for Alternatives 1, 3, and 4 if the selected POC is Angled Shoreline MWs/PPSs or pore water NSDSs.	--	--	The estimated restoration time frames to attain MTCA cleanup standards for Alternatives 2 and 5 are shorter than the estimated restoration time frames for Alternatives 1, 3, and 4 if the selected POC is Angled Shoreline MWs/PPSs or pore water NSDSs.
		On-site and offsite risks resulting from implementing the alternative	Similarities for All Alternatives	All alternatives will further reduce on-site risks for all exposure pathways (e.g., surface water/sediment, soil direct contact, and VI pathways) on top of the risk reduction gained from Phase 1 through Phase 3 of active arsenic remediation and other completed remedial actions. No off-site risks are anticipated for any alternative other than the potential off-site risks associated with disposing of excavated arsenic-impacted waste at an off-site facility permitted to accept the waste. Monitoring, maintenance, and controls are included in all alternatives to confirm/ensure risks are adequately addressed for the life of the Site. In general, the on-site risks and potential off-site risks are the same or relatively similar for all alternatives.				
			Notable Differences	Unlike the other alternatives, Alternative 1 does not include groundwater monitoring to assess future arsenic concentrations in upland groundwater (APR-11 and MNA&LTC-1) or monitoring and maintenance of the existing sheet pile wall (APR-1B). Alternative 1 cannot cause off-site risks associated with disposing of excavated arsenic-impacted waste at an off-site facility since Alternative 1 does not include additional soil excavation activities.	--	--	--	Alternative 5 poses the most potential off-site risks associated with disposing of excavated arsenic-impacted waste at an off-site facility since Alternative 5 includes substantially more soil removal than the other alternatives.
		Improvement of the overall environmental quality	Similarities for All Alternatives	All alternatives will substantially improve the overall environmental quality for all exposure pathways (e.g., surface water/sediment, soil direct contact, and VI pathways). Although a substantial amount of arsenic will remain in the upland portion of the Site (primarily in the First Aquitard) regardless of which alternative is selected, all CB/NT cleanup standards have been achieved. The CB/NT cleanup standards were specifically developed to ensure protection of the overall environmental quality for surface water and sediment exposures in the Hylebos Waterway. Specifically, the dredging of the Hylebos Waterway and the installation of shoreline caps during Phase 3 of active arsenic remediation have substantially improved the environmental quality at the surface water and sediment exposure points. All remaining soil direct contact exceedances will be addressed with a cap/cover or soil excavation. VI mitigation will be implemented for occupied buildings as necessary. In general, the improvement of the overall environmental quality is the same or relatively similar for all alternatives.				
			Notable Differences	Unlike the other alternatives, Alternative 1 does not include the subtidal shoreline cap extension (EPC-2A), which is expected to improve the environmental quality at the surface water and sediment exposure points downgradient of 124+00-2.	--	--	--	Alternative 5 includes more future removal of arsenic soil mass than the other alternatives (although even Alternative 5 would only remove a portion of First Aquitard soil - where the majority of arsenic mass is located).
		Rating for Alternative [2] (30% Weighting Factor)		3	7	6	6	9

Table 6-3: Disproportionate Cost Analysis

Benefit	General Benefit Description	Benefit Component	Key Similarities and Differences	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Permanence	The degree to which the alternative permanently reduces the toxicity, mobility or volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of waste treatment process, and the characteristics and quantity of treatment residuals generated.	Degree to which the alternative permanently reduces the toxicity, mobility or volume of hazardous substances	Similarities for All Alternatives	The toxicity of elemental arsenic cannot be reduced. Phase 1 through Phase 3 of active arsenic remediation (which are included in all alternatives) have reduced arsenic mobility and plume volume (see Appendices C and D). Since the arsenic plume is stable or declining, natural attenuation processes will continue to reduce arsenic mobility and plume volume over the long-term. However, the ability of future remedial components to substantially reduce arsenic mobility and plume volume is limited since elemental arsenic cannot be destroyed or degraded, and subsequent concentration reductions are more difficult to achieve at complex sites than initial concentration reductions. Completed remedial actions in VOC VI areas have reduced mobility and plume volume for volatile COCs, and natural attenuation will continue to reduce mobility and plume volume for volatile COCs over time. In general, the degrees of permanent reduction in toxicity, mobility, and volume are the same or relatively similar for all alternatives.				
			Notable Differences	--	--	--	Unlike the other alternatives, the vertical barrier walls included in Alternative 4 (APR-4) would increase arsenic mobility and plume volume by substantially increasing arsenic transport to the Deep Aquifer.	Alternative 5 includes more future removal of arsenic soil mass than the other alternatives (although even Alternative 5 would only remove a portion of First Aquitard soil - where the majority of arsenic mass is located). Unlike the other alternatives, Alternative 5 aims to permanently address the remaining soil direct contact exceedances with soil excavation (rather than a cap/cover). However, it is possible that new soil direct contact exceedances will develop over time as arsenic in groundwater adsorbs or precipitates/co-precipitates onto clean backfill soil.
		Adequacy of the alternative in destroying the hazardous substances	Similarities for All Alternatives	Elemental arsenic cannot be destroyed or degraded. Elemental arsenic can only be transferred to another location (e.g., landfill), transferred to another media (e.g., from groundwater to soil), or diluted. Volatile COCs have likely been destroyed (via degradation) during completed remedial actions and will likely continue to be destroyed (via degradation) over time with natural attenuation.				
			Notable Differences	--	--	--	--	--
		Reduction or elimination of hazardous substance releases and sources of releases	Similarities for All Alternatives	Phase 1 through Phase 3 of active arsenic remediation and other completed remedial actions (which are included in all alternatives) have addressed all known and suspected releases and sources of releases, with the exception of some known and suspected residual source material in/near the former Penite Pits and Penite Manufacturing Building.				
			Notable Alternative Differences	Unlike the other alternatives, Alternative 1 does not include additional removal of known and suspected residual source material in/near the former Penite Pits and Penite Manufacturing Building (APR-2 or APR-9).	--	--	--	--
		The degree of irreversibility of waste treatment process	Similarities for All Alternatives	Natural geochemical attenuation mechanisms (e.g., precipitation or co-precipitation with highly stable minerals, co-precipitation with metal oxides, sorption) and the in-situ groundwater treatment components (i.e., in-situ stabilization or in-situ solidification/stabilization) limit arsenic mobility by transferring arsenic from groundwater to soil. However, some of these natural mechanisms and all arsenic treatment processes are potentially reversible if geochemical conditions change over time. Fortunately, the majority of arsenic within the main arsenic plume is either precipitated or co-precipitated with highly stable minerals or co-precipitated with metal oxides. Arsenic that has precipitated or co-precipitated with highly stable minerals is not environmentally available for transport back to the dissolved phase because the arsenic has been incorporated into the mineral and the mineral will remain intact under a wide range of geochemical conditions (including current and anticipated future geochemical conditions at the Site). Arsenic that is co-precipitated with metal oxides is not reversible as long as oxygen remains present. Fortunately, the mixing of surface water within groundwater in the hyporheic transition zone will maintain oxygen in the hyporheic transition zone before groundwater discharges to surface water.				
			Notable Differences	Unlike the other alternatives, Alternative 1 does not include future upland groundwater monitoring (APR-11 and MNA&LTC-1) to assess the potential reversibility of natural geochemical attenuation mechanisms and in-situ groundwater treatment components.	--	--	--	--
		Characteristics and quantity of treatment residuals generated	Similarities for All Alternatives	Not applicable.				
			Notable Differences	Not applicable.				
		Rating for Alternative (2) *(20% Weighting Factor)*		2	6	6	4	8

Table 6-3: Disproportionate Cost Analysis

Benefit	General Benefit Description	Benefit Component	Key Similarities and Differences	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Effectiveness over the long term	The degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on-site at concentrations that exceed cleanup levels, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes.	Degree of certainty that the alternative will be successful	Similarities for All Alternatives	There is a relatively high degree of certainty that all alternatives would be successful at protecting human health and the environment given the amount of remediation that has already been completed (e.g., Phases 1 through 3 of active arsenic remediation), and the fact that all CB/NT cleanup standards have been achieved, MTCA cleanup standards have been achieved at the surface water/sediment exposure points, and the arsenic plume is stable or declining. Moreover, all alternatives include remedial components to address all potential exposure pathways, and all alternatives include monitoring and maintenance to assess and ensure long-term protection of human health and the environment. In general, the degree of certainty is the same or relatively similar for all alternatives.				
			Notable Differences	Unlike the other alternatives, Alternative 1 does not include (1) the subtidal shoreline cap extension (EPC-2A), which is expected to improve the environmental quality at the surface water and sediment exposure points downgradient of 124+00-2, (2) additional removal of known and suspected residual source material in/near the former Penite Pits and Penite Manufacturing Building (APR-2 or APR-9), or (3) future upland groundwater monitoring (APR-11 and MNA&LTC-1) to provide additional certainty that the alternative will be successful.	--	--	--	Alternative 5 includes more future removal of arsenic soil mass than the other alternatives (although even Alternative 5 would only remove a portion of First Aquitard soil - where the majority of arsenic mass is located). In addition, Alternative 5 includes substantially more future groundwater treatment than the other alternatives.
		Reliability of the alternative during the period of time hazardous substances are expected to remain on-site at concentrations that exceed cleanup levels	Similarities for All Alternatives	Arsenic will remain on-site at concentrations that exceed CLs for perpetuity regardless of which alternative is selected. All alternatives include completed remedial actions (e.g., Phase 1 through 3 of active arsenic remediation) and future remedial components that are proven and reliable technologies. Highly favorable geochemical conditions for arsenic attenuation near the shoreline and hydraulic tidal dispersion within groundwater in the hyporheic transition zone provide additional layers of reliability for preventing unacceptable surface water or sediment exposures. Thus, the reliability is essentially the same for all alternatives.				
			Notable Differences	--	--	--	--	--
		Magnitude of residual risk with the alternative in place	Similarities for All Alternatives	Although arsenic will remain on-site at concentrations that exceed CLs for perpetuity (regardless of which alternative is selected), none of the alternatives pose an unacceptable risk to human health and the environment. There are no unacceptable residual risks at the surface water and sediment exposure points. All residual risks for potentially complete soil direct contact pathways will be addressed via a cap/cover or soil excavation. All residual risk for the potentially complete VI pathway will be addressed by installing VI mitigation for occupied buildings as necessary. All alternatives include controls to ensure incomplete pathways remain incomplete. Thus, the magnitude of residual risk is the same for all alternatives.				
			Notable Differences	--	--	--	--	--
		Effectiveness of controls required to manage treatment residues or remaining wastes	Similarities for All Alternatives	All alternatives include monitoring, maintenance, and controls to effectively and reliably ensure potential risks for all relevant pathways are addressed over the long-term.				
			Notable Differences	Unlike the other alternatives, Alternative 1 does not include groundwater monitoring to assess future arsenic concentrations in upland groundwater (APR-11 and MNA&LTC-1) or monitoring and maintenance of the existing sheet pile wall (APR-1B).	--	--	--	--
		Rating for Alternative [(2)] *(20% Weighting Factor)*		4	7	7	7	9

Table 6-3: Disproportionate Cost Analysis

Benefit	General Benefit Description	Benefit Component	Key Similarities and Differences	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Management of short-term risks	The risk to human health and the environment associated with the alternative during construction and implementation, and the effectiveness of measures that will be taken to manage such risks.	Risk to human health and the environment associated with the alternative during construction and implementation	Similarities for All Alternatives	All alternatives pose potential short-term risks to remediation workers and redevelopment workers. The relative degree of potential short-term risks to remediation workers for a given alternative is directly proportional to the size and scope of construction activities. In other words, the larger the size and scope of construction activities, the larger the frequency and magnitude of potential worker exposures to arsenic-impacted media. Likewise, the larger the number of off-site truck haul trips, the larger the potential traffic risks for truck drivers, other drivers, cyclists, and pedestrians. None of the alternatives are expected to pose any unacceptable short-term risks to the environment as a result of construction or implementation activities as long as health and safety programs, waste management programs, construction safety practices, and ECs are developed and implemented properly for each phase of remediation and redevelopment.				
			Notable Differences	Alternative 1 poses the least risks for remediation workers and the least traffic risks (e.g., approximately 700 off-site truck trips for cap/cover activities).	Alternative 2 poses the second least risks for remediation workers and the second least traffic risks (e.g., approximately 1,300 off-site truck trips for excavation and cap/cover activities).	Alternative 3 poses the third most risks for remediation workers and ties for the second most traffic risks (e.g., approximately 2,800 off-site truck trips for excavation and cap/cover activities).	Alternative 4 poses the second most risks for remediation workers and ties for the second most traffic risks (e.g., approximately 2,800 off-site truck trips for excavation and cap/cover activities).	Alternative 5 poses substantially more risks for remediation workers and substantially more traffic risks (e.g., approximately 18,000 off-site truck trips for excavation activities) compared to the other alternatives. However, the risk for subsurface utility workers during redevelopment would be lower for Alternative 5 compared to other alternatives since subsurface soil direct contact exceedances would be removed.
		Effectiveness of measures that will be taken to manage such risks	Similarities for All Alternatives	All alternatives include controls to ensure that proven and effective measures for minimizing risks to human health and the environment are implemented during construction and implementation (e.g., health and safety programs, waste management programs, construction safety practices, ECs). Thus, the effectiveness of measures is the same for all alternatives.				
			Notable Differences	--	--	--	--	--
		Rating for Alternative (2) *(10% Weighting Factor)*		10	9	8	7	6

Table 6-3: Disproportionate Cost Analysis

Benefit	General Benefit Description	Benefit Component	Key Similarities and Differences	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Technical and administrative implementability	Ability to be implemented including consideration of whether the alternative is technically possible, availability of necessary offsite facilities, services and materials, administrative and regulatory requirements, scheduling, size, complexity, monitoring requirements, access for construction operations and monitoring, and integration with existing facility operations and other current or potential remedial actions.	Whether the alternative is technically possible	Similarities for All Alternatives	All alternatives are technically possible.				
			Notable Differences	--	--	--	--	--
		Availability of necessary offsite facilities, services and materials	Similarities for All Alternatives	All necessary off-site facilities, services, and materials are expected to be available for all alternatives.				
			Notable Differences	--	--	--	--	--
		Administrative and regulatory requirements	Similarities for All Alternatives	In general, the amount of administrative and regulatory requirements is expected to be relatively limited for all alternatives (see Appendix E).				
			Notable Differences	--	--	--	--	The administrative and regulatory requirements will likely be more substantial for Alternative 5 because the size, scope, and complexity for implementing Alternative 5 are substantially larger than the other alternatives.
		Scheduling, size, and complexity	Similarities for All Alternatives	The scheduling, size, and complexity of each alternative are directly proportional to the number of active remediation components to be constructed in a given alternative, the size and scope of those active remediation components, and whether or not a given alternative includes contingent or phased remedial components. In other words, implementation difficulty increases as the number of active remediation components increases and as the size and scope of active remediation components increase. Likewise, implementation difficulty increases if implementation needs to be phased due to contingent components or the size/complexity of one or more active remediation component(s).				
			Notable Differences	Alternative 1 is the easiest alternative to implement since it includes construction of one future active remediation component, the scope and complexity of that active remediation component are substantially less than the scope and complexity of any other alternative, and there are no contingent remedial components.	Alternative 2 is the second easiest alternative to implement since it includes construction of three future active remediation components, the combined scope and complexity of those active remediation component are more than Alternative 1 and less than Alternative 3, and there are no contingent remedial components.	Alternative 3 is the third most difficult alternative to implement since it includes construction of up to seven future active remediation components, the combined scope and complexity of those active remediation component are more than Alternative 2 and less than Alternative 4, and there are three contingent remedial components.	Alternative 4 is the second most difficult alternative to implement since it includes construction of up to eight future active remediation components, the combined scope and complexity of those active remediation component are more than Alternative 3 and less than Alternative 5, and there are two contingent remedial components.	Alternative 5 is the most difficult alternative to implement since it includes construction of five future active remediation components, the combined scope and complexity of those active remediation components (particularly APR-9 and APR-10) are substantially larger than any other alternative, and the size and cost of Alternative 5 would require Alternative 5 to be implemented in phases over a relatively long time period.
		Monitoring requirements	Similarities for All Alternatives	All alternatives include specifically identified monitoring remedial components (e.g., the surface water and sediment monitoring of EPC-3) and protection/performance monitoring during construction of other remedial components (e.g., an excavation remedial component would likely include monitoring associated with a health and safety plan, excavation sidewall and bottom sampling, waste characterization sampling, and construction quality control monitoring). The difficulty in implementing monitoring requirements for a given alternative is generally proportional to the number, scope, and complexity of the monitoring requirements.				
			Notable Differences	Alternative 1 has the easiest monitoring implementation because the combined scope and complexity of the six specifically identified monitoring remedial components plus the protection/performance monitoring for the one future construction remedial component are substantially less than any other alternative.	Alternative 2 has the second easiest monitoring implementation because the combined scope and complexity of the twelve specifically identified monitoring remedial components plus the protection/performance monitoring for the three future construction remedial components are more than Alternative 1 and less than Alternative 3.	Alternative 3 has the third most difficult monitoring implementation because the combined scope and complexity of the thirteen specifically identified monitoring remedial components plus the protection/performance monitoring for up to seven future construction remediation components are more than Alternative 2 and less than Alternative 4.	Alternative 4 has the second most difficult monitoring implementation because the combined scope and complexity for the fourteen specifically identified monitoring remedial components plus the protection/performance monitoring for up to eight future construction remediation components are more than Alternative 3 and less than Alternative 5.	Alternative 5 has the most difficult monitoring implementation because the combined scope and complexity for the eleven specifically identified monitoring remedial components plus the protection/performance monitoring for the five future construction remediation components (particularly APR-9 and APR-10) are substantially larger than any other alternative.
		Access for construction operations and monitoring	Similarities for All Alternatives	All alternatives would include construction operations and monitoring. Since the Site currently consists of vacant land, there are little to no current access issues for construction operations and monitoring. However, the Port is planning to redevelop the Site as soon as possible. Once redevelopment begins, all future access for construction operations and monitoring will become substantially more challenging.				
			Notable Differences	--	--	Alternatives 3 through 5 have more difficult access than Alternatives 1 and 2 because Alternatives 3 through 5 include contingent or phased remedial components that would most likely be constructed after redevelopment begins.		
		Integration with existing facility operations and other current or potential remedial actions	Similarities for All Alternatives	Although there are not existing facility operations, the Port is planning to redevelop the Site as soon as possible. Integration with facility operations will become substantially more challenging once redevelopment begins. None of the alternatives would preclude other current or potential remedial actions.				
			Notable Differences	--	--	Alternatives 3 through 5 are substantially more difficult to integrate with future operations than Alternatives 1 and 2 because Alternatives 3 through 5 include contingent/phased remedial components that would most likely be constructed concurrently with future operations.		
		Rating for Alternative (2) *(10% Weighting Factor)*		10	9	7	6	5

Table 6-3: Disproportionate Cost Analysis

Benefit	General Benefit Description	Benefit Component	Key Similarities and Differences	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Consideration of public concerns	Whether the community has concerns regarding the alternative and, if so, the extent to which the alternative addresses those concerns.	Not applicable	Similarities for All Alternatives	This benefit will be formally evaluated after the public comment period for the draft FS Report and the draft CAP is completed.				
			Notable Differences	This benefit will be formally evaluated after the public comment period for the draft FS Report and the draft CAP is completed.				
		Rating for Alternative [2] *(10% Weighting Factor)*		To be determined	To be determined	To be determined	To be determined	To be determined
Total Weighted Benefit [3]				4.1	6.5	5.9	5.3	7.2
Estimated Cost (in millions) [4]				$77	$92	$107	$111	$263
Relative Benefit/Cost Ratio [5]				53	71	55	48	27

Notes:

--: The notable difference(s) between the alternatives is indicated by the text for a different alternative or no notable difference exists between the alternatives.

[1] Mass discharge of arsenic to the Hylebos Waterway was used as a surrogate to assess this benefit component for pathways associated with surface water and sediment exposures.

[2] Each benefit was rated from 1 (lowest rating) to 10 (highest rating), with consideration of the absolute benefit provided by the alternative and the relative benefit compared to the other alternatives.

[3] The total weighted benefit = protectiveness rating * 0.3 + permanence rating * 0.2 + effectiveness over the long term rating * 0.2 + management of short-term risks rating * 0.1 + technical and administrative implementability rating * 0.1 + consideration of public concerns * 0.1.

[4] Costs were estimated for each alternative as presented in Appendix F. The costs included in this table are the estimated total costs on a net present value basis, including any contingent remedial components and a cost contingency on future costs.

[5] The relative benefit/cost ratio = (1,000 * the total weighted benefit)/estimated cost in millions of dollars.

Table 6-4: Reasonable Groundwater Restoration Time Frame Evaluation

Factors to be Considered When Determining Whether a POC Provides for a Reasonable Restoration Time Frame	Is the Factor Relevant for Differentiating Between POCs?	POC = All Site Groundwater (> 10,000 years for all alternatives)	POC = Vertical Shoreline MWs (> 10,000 years for all alternatives)	POC = Angled Shoreline MWs/PPSs (ranges from 4,000 to > 10,000 years)	POC = Pore Water NSDSs (ranges from 3,100 to > 10,000 years)	POC = Surface Water at Locations as Close as Technically Possible to the Point or Points Where Groundwater Flows into Surface Water (zero years for all alternatives) [1]
Potential risks posed by the site to human health and environment	No	The factor is not relevant for differentiating between POCs because Phase 1 through Phase 3 of active arsenic remediation have already achieved criteria for protection of human health and the environment at the actual exposure point locations in surface water and sediment. Current dissolved arsenic concentrations in surface water samples collected as close as technically possible to where groundwater flows into surface water are less than the default MTCA background concentration of 5 ug/L. Arsenic concentrations in all sediment samples collected within the sediment BAZ have been less than the 57 mg/kg SQO since Phase 3 of active arsenic remediation was completed. Future arsenic surface water and sediment concentrations are expected to be protective of human health and the environment (with future monitoring to provide confirmation) because the arsenic plume is stable or declining due to Phase 1 through Phase 3 of active arsenic remediation and ongoing natural attenuation processes (including highly favorable geochemical conditions and hydraulic tidal dispersion near the shoreline due to mixing of marine surface water with groundwater). Although a substantial amount of arsenic will remain in the upland portion of the Site (primarily in the First Aquitard) regardless of which alternative is selected, all CB/NT cleanup standards have been achieved. The CB/NT cleanup standards were specifically developed to ensure protection of human health and the environment for surface water and sediment exposures in the Hylebos Waterway. Although POCs landward of surface water are generally preferred by Ecology from a conservative policy perspective, selecting a landward POC does not actually change the actual surface water or sediment exposures or risks.				
Practicability of achieving a shorter restoration time frame	**Yes**	It is practicable to achieve a shorter restoration time frame by using surface water at locations as close as technically possible to the point or points where groundwater flows into surface water as the POC.				
Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site	No	This factor is not relevant for differentiating between POCs because (1) the Site is currently undeveloped, (2) there are no current drinking water uses at the Site or downgradient of the Site, and (3) there are no current unacceptable surface water or sediment risks (see discussion on the "potential risks posed by the site to human health and environment" factor).				
Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site	No	This factor is not relevant for differentiating between POCs because (1) the Site will be developed for Port Maritime Industrial Use, (2) there are no anticipated future drinking water uses at the Site or downgradient of the Site (and an IC will prevent future drinking water use at the Site), and (3) there are no anticipated future unacceptable surface water or sediment risks (see discussion on the "potential risks posed by the site to human health and environment" factor).				
Availability of alternative water supplies	No	This factor is not relevant for differentiating between POCs because (1) Site groundwater is not potable because of salinity from salt water intrusion and historical storage of salt on the salt pads, and (2) the City of Tacoma municipal water supply is readily available for future Port Maritime Industrial land use.				
Likely effectiveness and reliability of institutional controls	No	This factor is not relevant for differentiating between POCs because (1) ICs are generally effective and reliable, and (2) it is unlikely that certain restricted activities (e.g., residential land use, drinking water use) would ever occur given anticipated future land use and the salinity of impacted groundwater.				
Ability to control and monitor migration of hazardous substances from the site	No	This factor is not relevant for differentiating between POCs because (1) Phase 1 through Phase 3 of active arsenic remediation have already achieved criteria for protection of human health and the environment at the actual exposure point locations in surface water and sediment, (2) additional future remedial components are proposed to further limit arsenic migration to the extent practicable, and (3) all alternatives include monitoring, maintenance, and controls to assess potential future migration and ensure long-term protection of human health and the environment.				
Toxicity of the hazardous substances at the site	No	This factor is not relevant for differentiating between POCs because a substantial amount of arsenic will remain in the upland portion of the Site (primarily in the First Aquitard) and arsenic will remain in on-site groundwater at concentrations that exceed CLs for perpetuity regardless of which POC or alternative is selected.				
Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions	No	This factor is not relevant for differentiating between POCs because natural attenuation processes have been documented at the Site and are a key reason why criteria for protection of human health and the environment have been achieved at the actual exposure point locations in surface water and sediment (PIONEER 2019). Natural geochemical attenuation mechanisms (e.g., precipitation or co-precipitation with highly stable minerals, co-precipitation with metal oxides, sorption) limit arsenic mobility by transferring arsenic from groundwater to soil. The majority of arsenic within the main arsenic plume is either precipitated or co-precipitated with highly stable minerals or co-precipitated with metal oxides. Furthermore, highly favorable geochemical conditions and hydraulic tidal dispersion near the shoreline (due to mixing of marine surface water with groundwater) also attenuate arsenic concentrations prior to exposure point locations.				
Does the POC Provide for a Reasonable Restoration Time Frame?		**No**	**No**	**No**	**No**	**Yes**
Rationale		The estimated restoration time frames of greater than 10,000 years for all alternatives are unacceptable, and it is practicable to achieve a reasonable restoration time frame that does not negatively impact human health and the environment by using a POC of surface water at locations as close as technically possible to the point or points where groundwater flows into surface water.	The estimated restoration time frames of greater than 10,000 years for all alternatives are unacceptable, and it is practicable to achieve a reasonable restoration time frame that does not negatively impact human health and the environment by using a POC of surface water at locations as close as technically possible to the point or points where groundwater flows into surface water.	The estimated restoration time frames ranging from 4,000 years to greater than 10,000 years are unacceptable, and it is practicable to achieve a reasonable restoration time frame that does not negatively impact human health and the environment by using a POC of surface water at locations as close as technically possible to the point or points where groundwater flows into surface water.	The estimated restoration time frames ranging from 3,100 years to greater than 10,000 years are unacceptable, and it is practicable to achieve a reasonable restoration time frame that does not negatively impact human health and the environment by using a POC of surface water at locations as close as technically possible to the point or points where groundwater flows into surface water.	A POC of surface water at locations as close as technically possible to the point or points where groundwater flows into surface water is the only POC option that can provide for a reasonable restoration time frame. This POC does not negatively impact human health and the environment and it provides equivalent or superior benefits compared to other POC options for the factors to be considered when determining whether a POC provides for a reasonable restoration time frame.

Notes:

MW: monitoring well; NSDS: nylon-screen diffusion sampler; POC: point of compliance; PPS: pushpoint sampler

[1] Although cleanup standards for the main arsenic plume have already been achieved in surface water (at locations as close as technically possible to the point or points where groundwater flows into surface water), monitoring and maintenance (for applicable remedial components) would be conducted for the foreseeable future to ensure ongoing compliance with cleanup standards in surface water.

Appendix A

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Vicinity Map
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 1-1

Legend

- Former Arkema Manufacturing Property Boundary
- RI/FS Site Boundary
- Surrounding Site Boundaries

Notes:
The surrounding site boundaries are based on tax parcel boundaries obtained from Pierce County, except for along the USG boundary and the Arkema Mound boundary where they border the RI/FS Site Boundary.
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.

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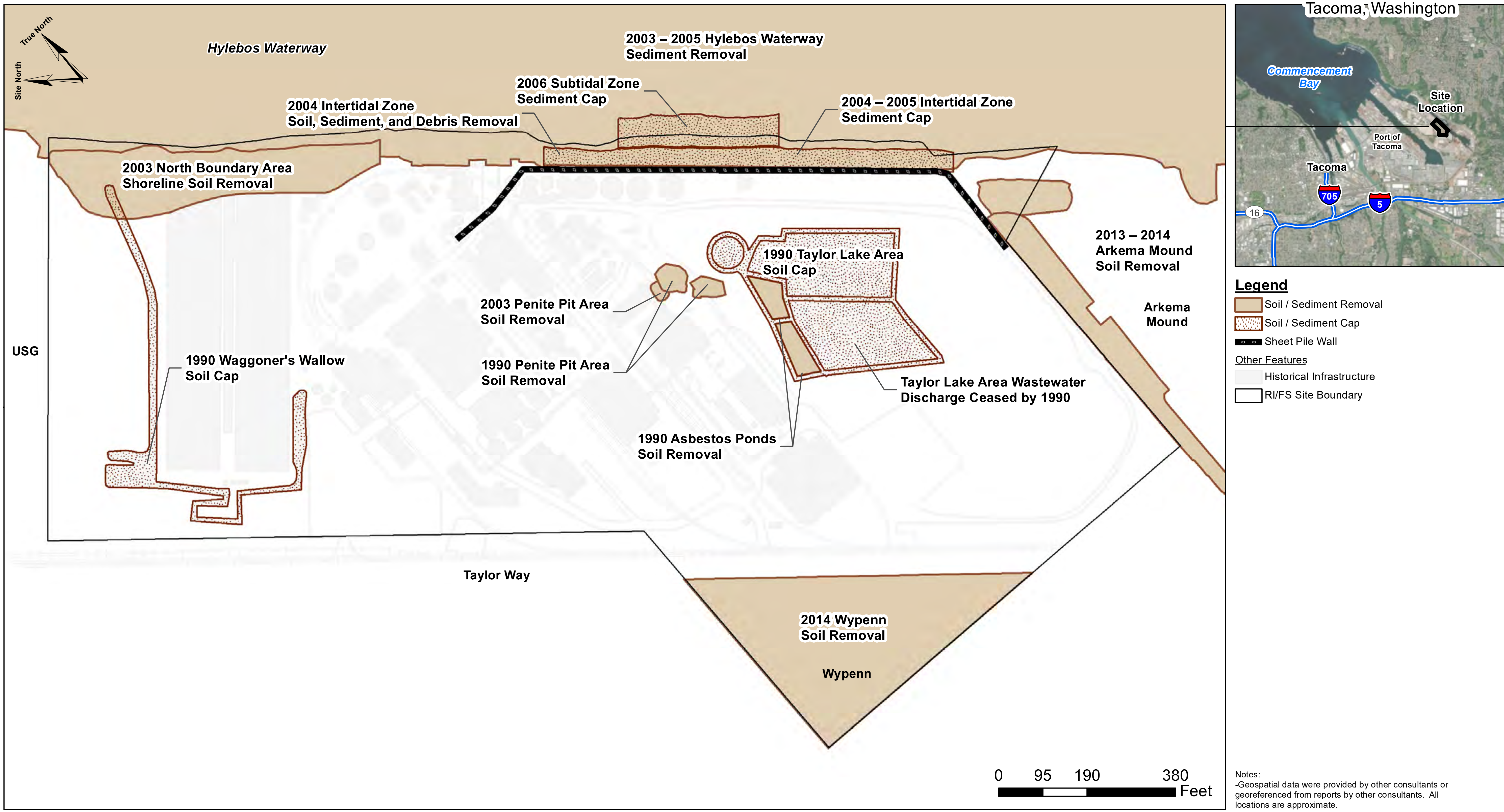
Site Location
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 1-2



Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.

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Completed Remedial Actions – Part A
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 2-1A

Legend

- Arsenic P&T Upper Aquifer Extraction Well
- Arsenic P&T Upper Aquifer Extraction Trench
- Arsenic P&T Intermediate Aquifer Extraction Well
- Arsenic In-Situ Stabilization Upper Aquifer Injection Areas
- Arsenic In-Situ Stabilization Intermediate Aquifer Injection Areas
- VOC Remediation Areas
- Remediation of Other Miscellaneous Releases

Other Features

- Sheet Pile Wall
- Historical Infrastructure
- RI/FS Site Boundary

Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.

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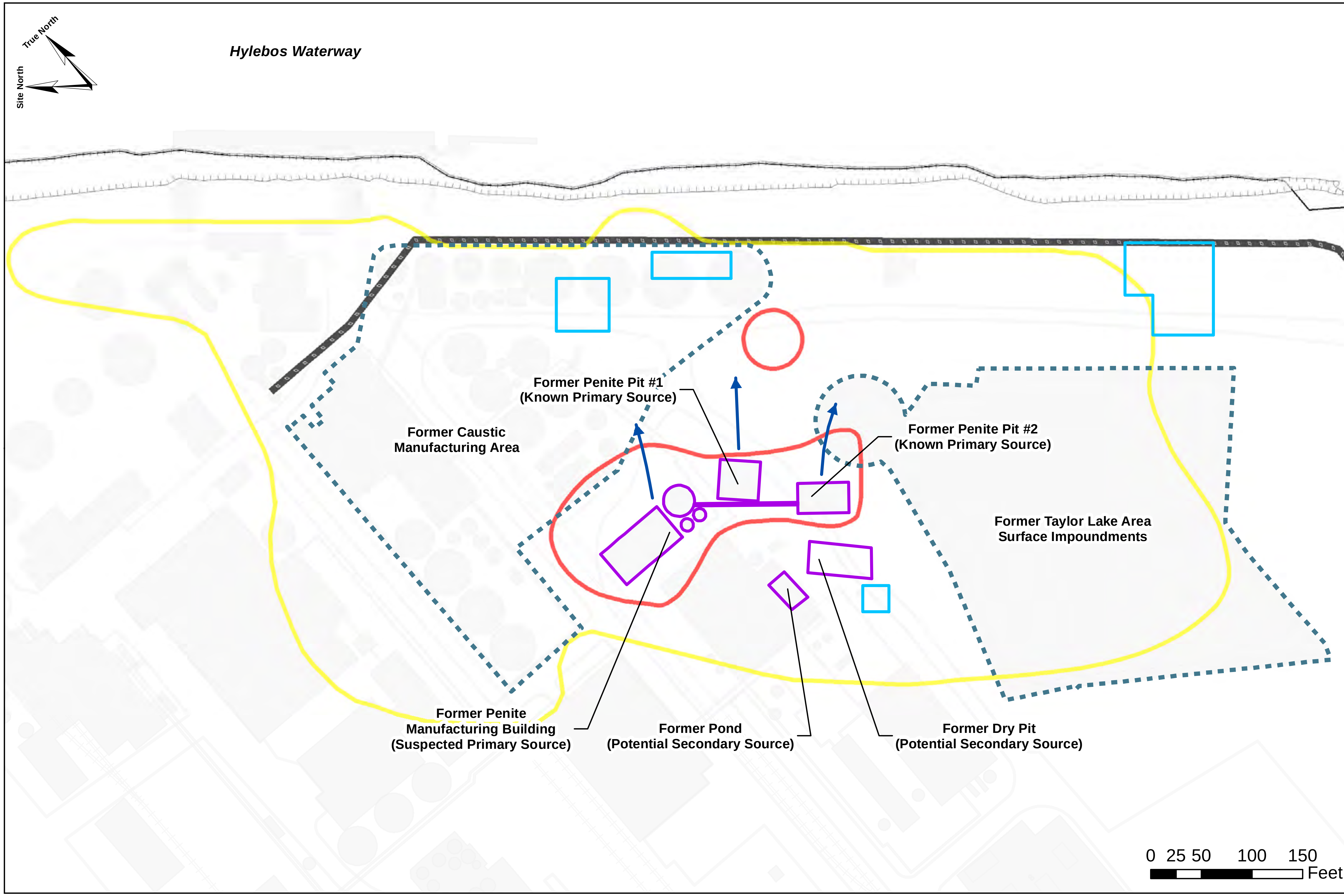
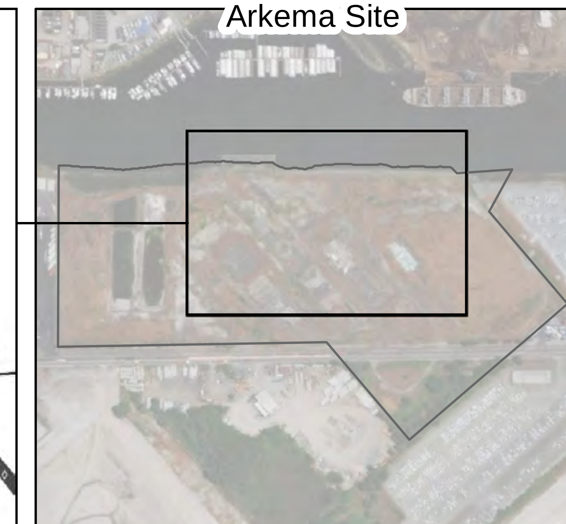
Completed Remedial Actions – Part B
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 2-1B





Legend

- Known and Potential Penite Manufacturing Features
- Historical Manufacturing Operation Potentially Associated With Elevated pH
- Thin or Leaky First Aquitard Location (Intera 1995)
- Conceptual Current Groundwater Flow Direction East of the Source Area

2017 Upper Aquifer Dissolved Arsenic Groundwater Isoconcentration Contours[1]

- 500 ug/L
- 50,000 ug/L

Other Features

- Historical Infrastructure
- Intermediate Aquifer Outcrop
- RI/FS Site Boundary
- Sheet Pile Wall

Notes:
[1]The contours will most likely be revised in the future based on insights gained during ongoing calibration/verification of the groundwater models.
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.

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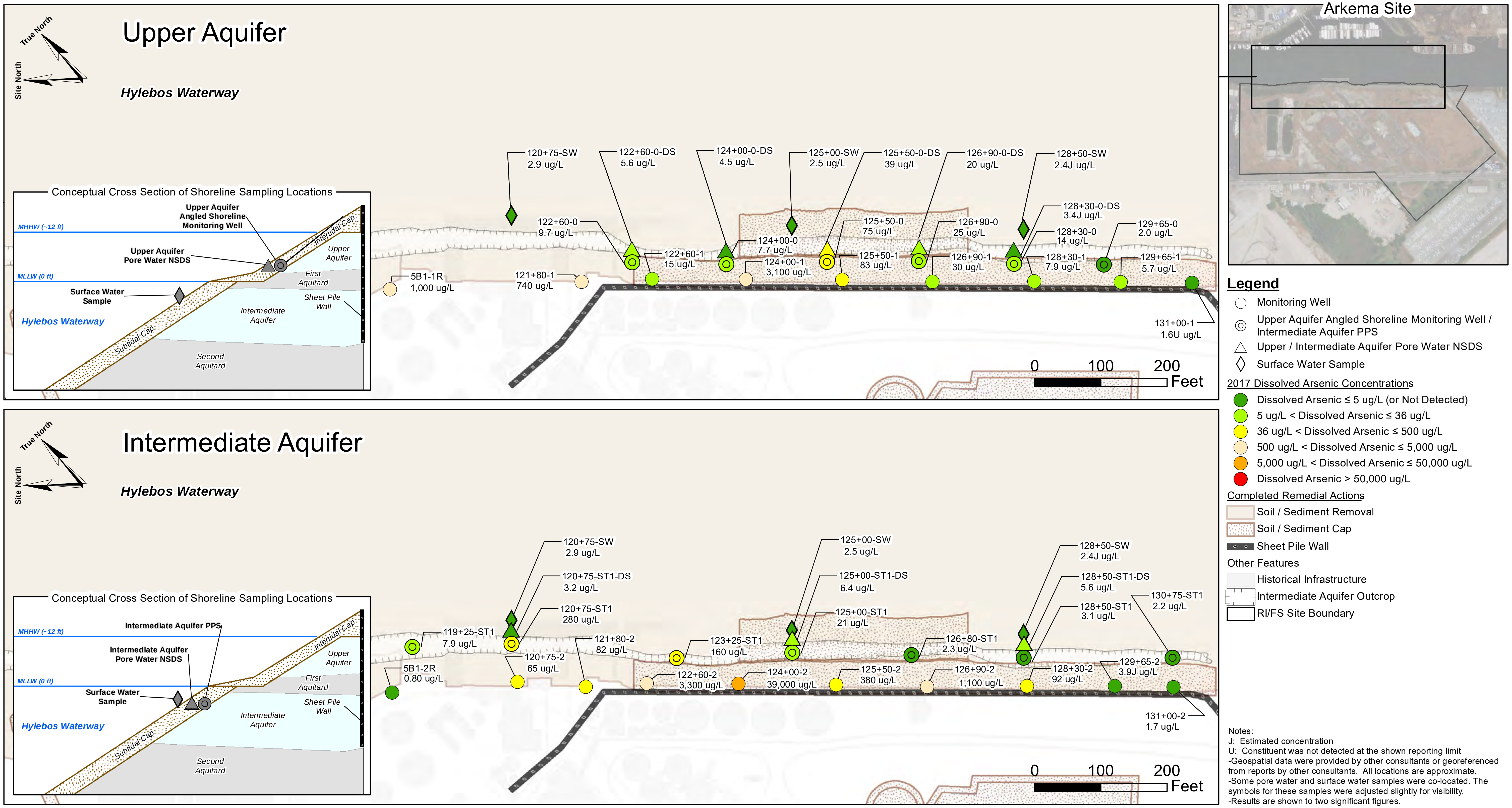
Key Features Related to Arsenic Plume Transport
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 2-2



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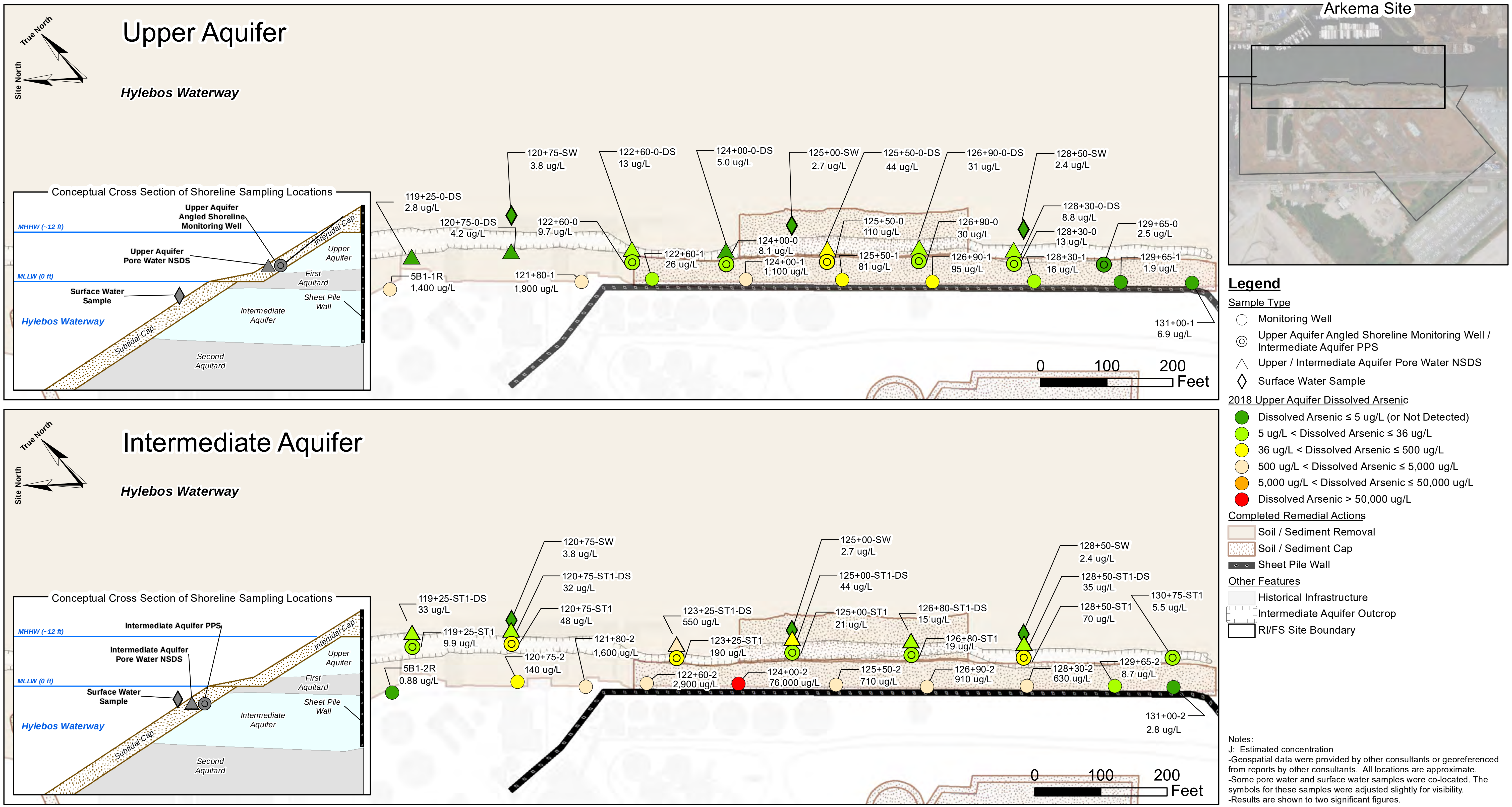
2017 Closeup of Shoreline Dissolved Arsenic Concentrations
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 5-1



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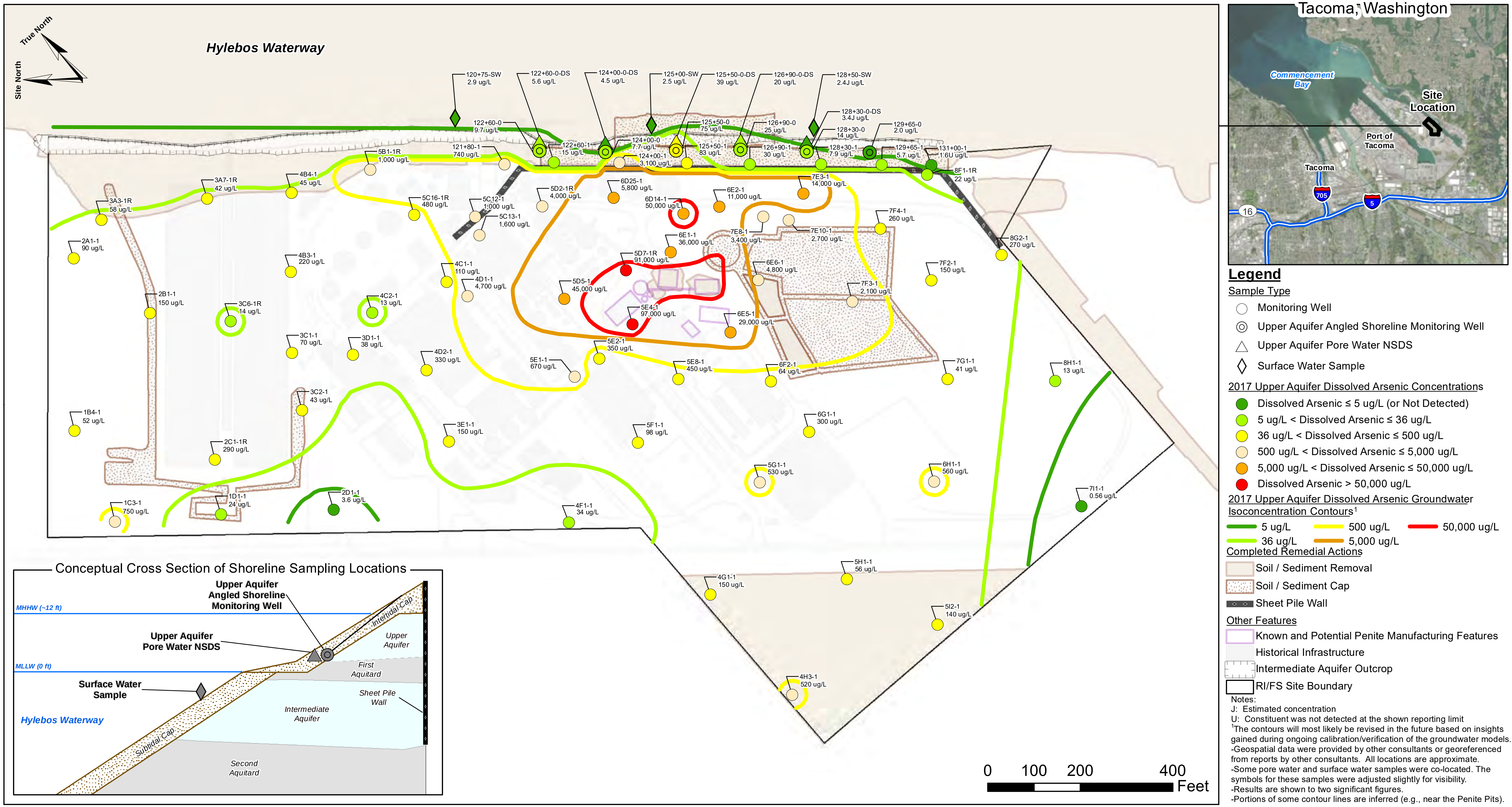
2018 Closeup of Shoreline Dissolved Arsenic Concentrations
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 5-2



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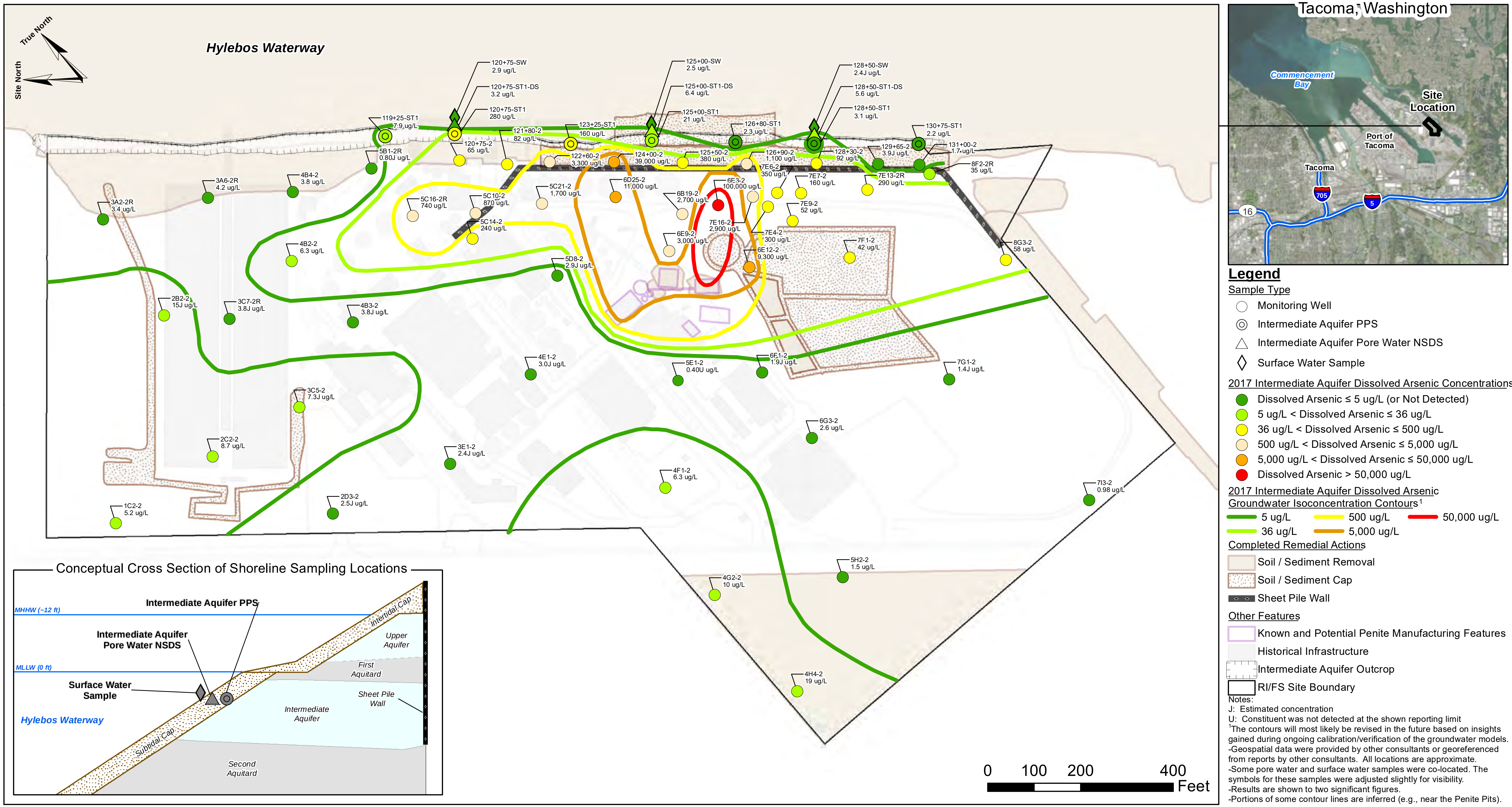
2017 Dissolved Arsenic Concentrations in the Upper Aquifer
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

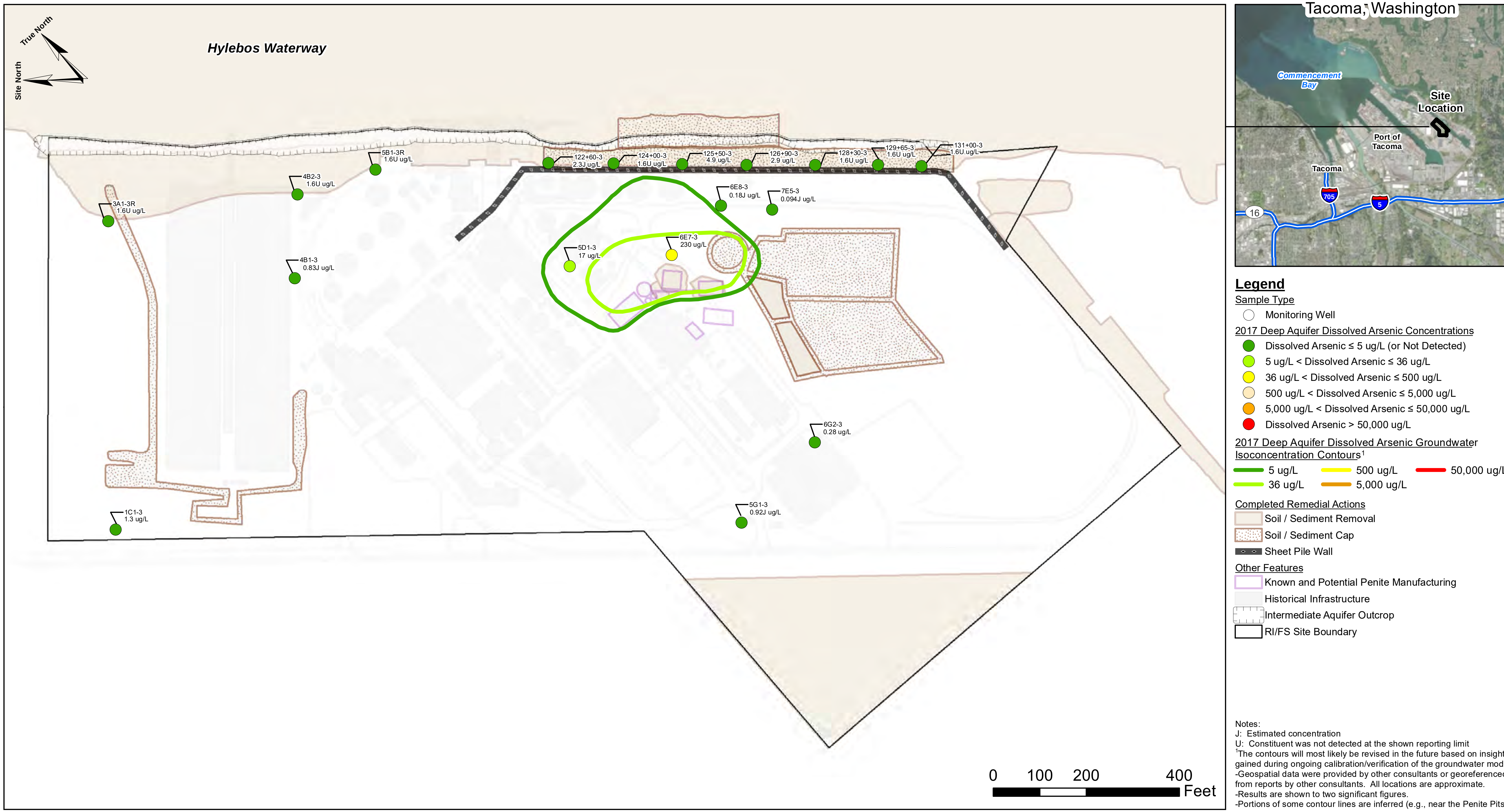
Figure 5-3



PIONEER TECHNOLOGIES CORPORATION

2017 Dissolved Arsenic Concentrations in the Intermediate Aquifer
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 5-4



Notes:
J: Estimated concentration
U: Constituent was not detected at the shown reporting limit
[1]The contours will most likely be revised in the future based on insights gained during ongoing calibration/verification of the groundwater models.
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-Results are shown to two significant figures.
-Portions of some contour lines are inferred (e.g., near the Penite Pits).

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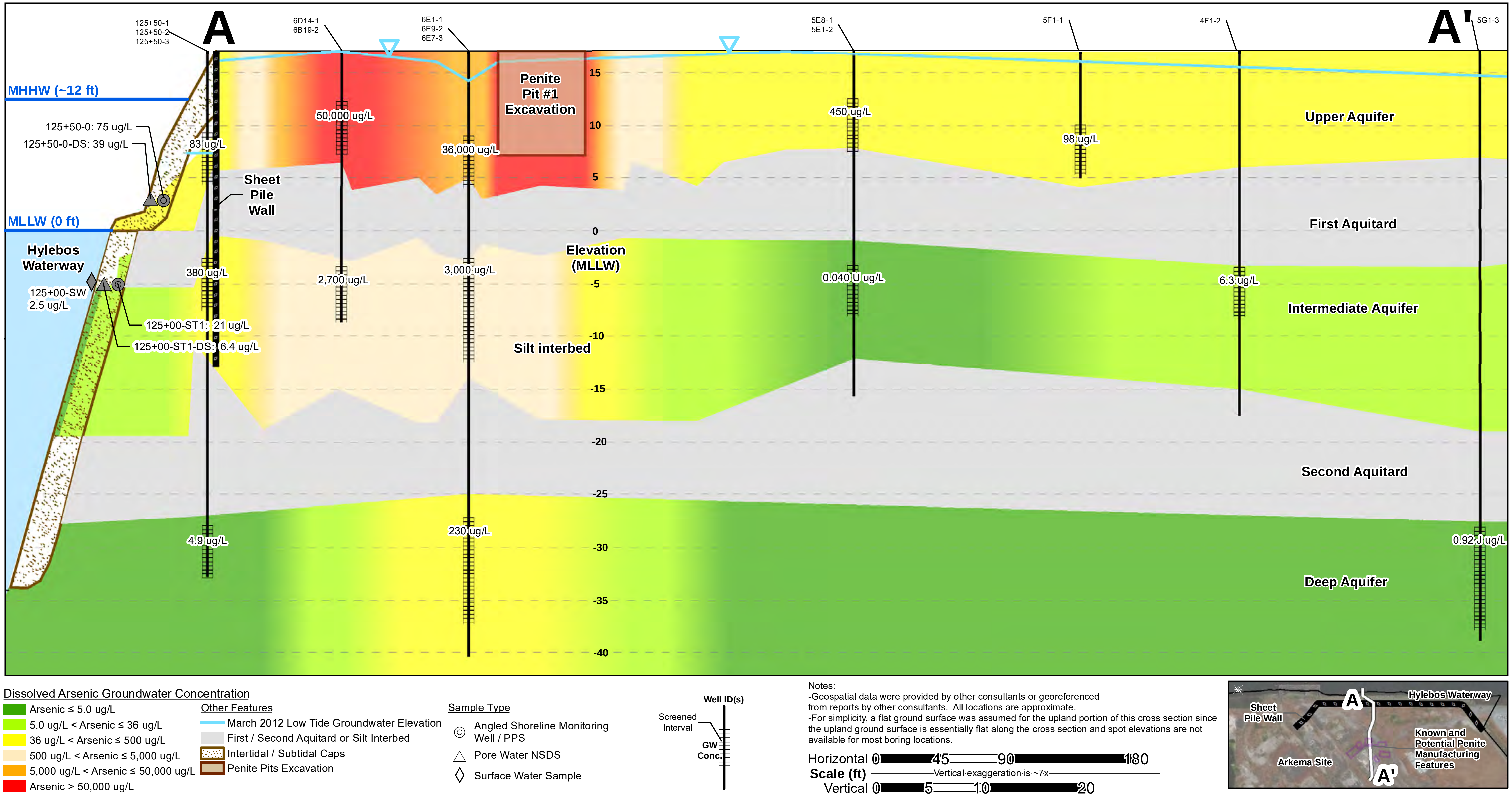
2017 Dissolved Arsenic Concentrations in the Deep Aquifer
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 5-5

Document Path: G:\Projects\Arkema\Maps\FS Data Gap Investigation Report\5-5_2017_DA_Diss_As.mxd; Author: KR; Date Saved: 7/19/2019

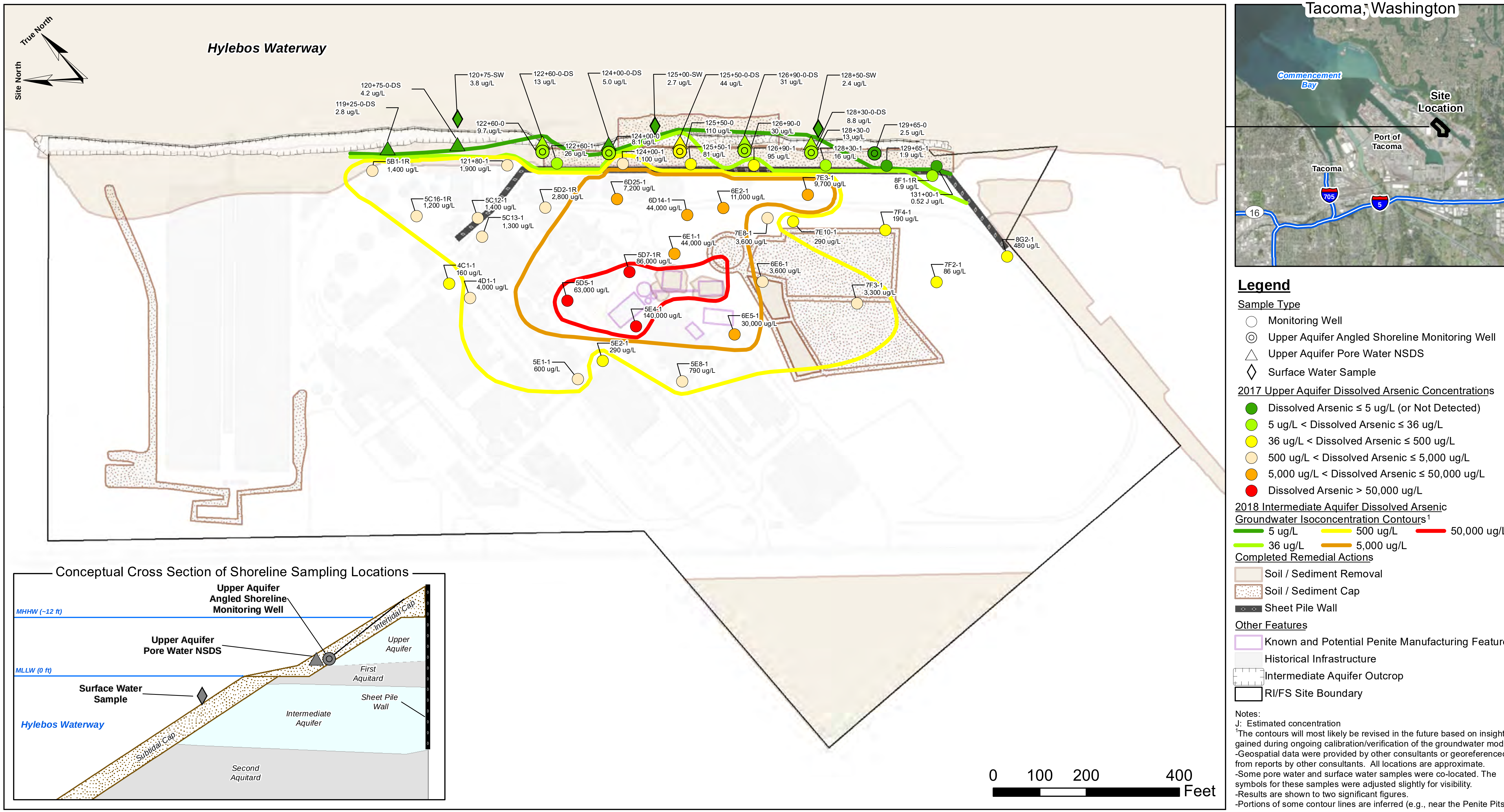


PIONEER
TECHNOLOGIES CORPORATION

Conceptual Cross Section of 2017 Dissolved Arsenic Concentrations
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 5-6

Document Path: G:\Projects\Arkema\Maps\FS Data Gap Investigation Report\5-6_X_Section_Diss_As.mxd; Author: VN; Date Saved: 7/24/2019



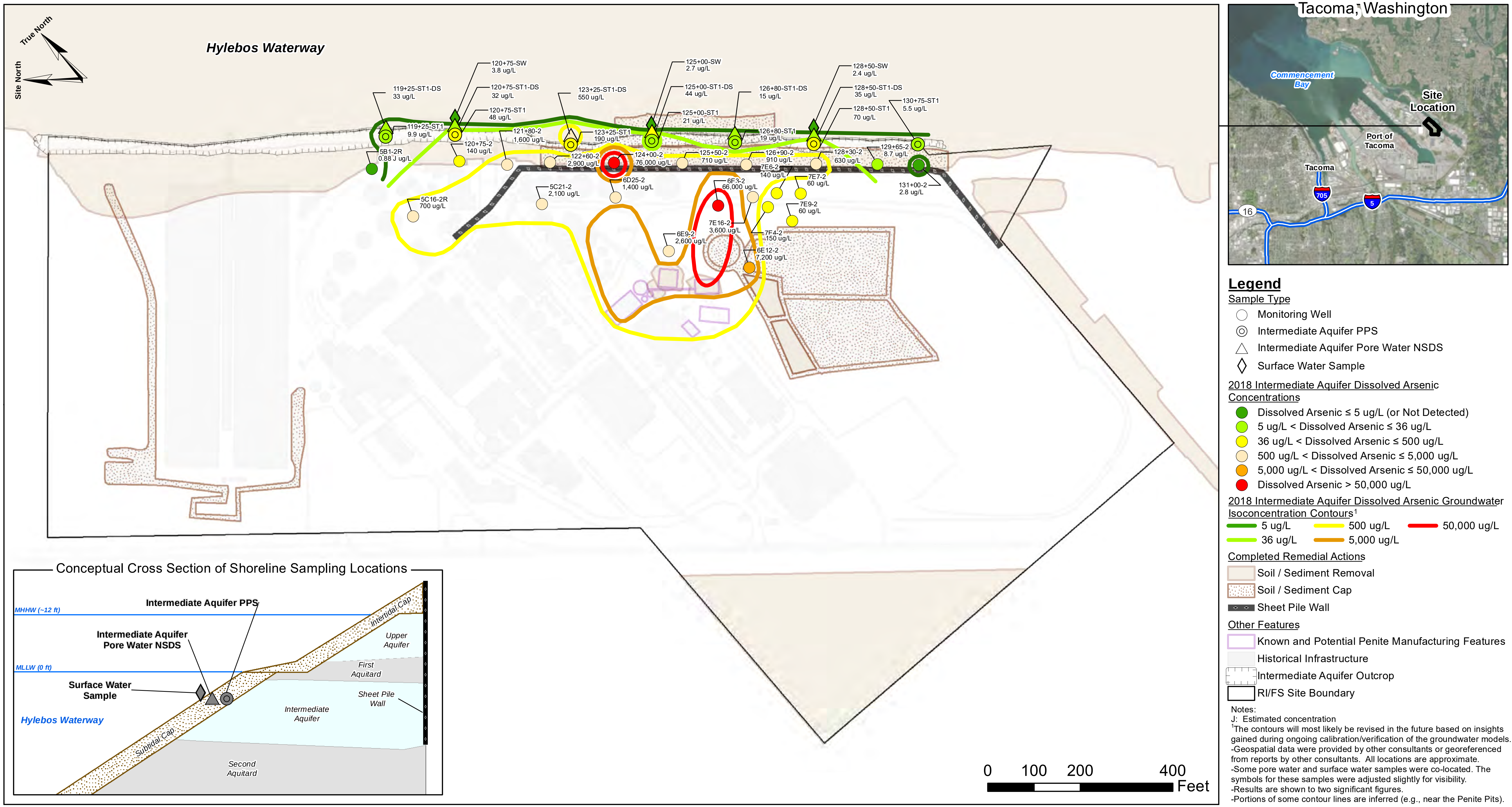
2018 Dissolved Arsenic Concentrations in the Upper Aquifer

FS Data Gap Investigation Report

Former Arkema Manufacturing Site

Figure 5-7

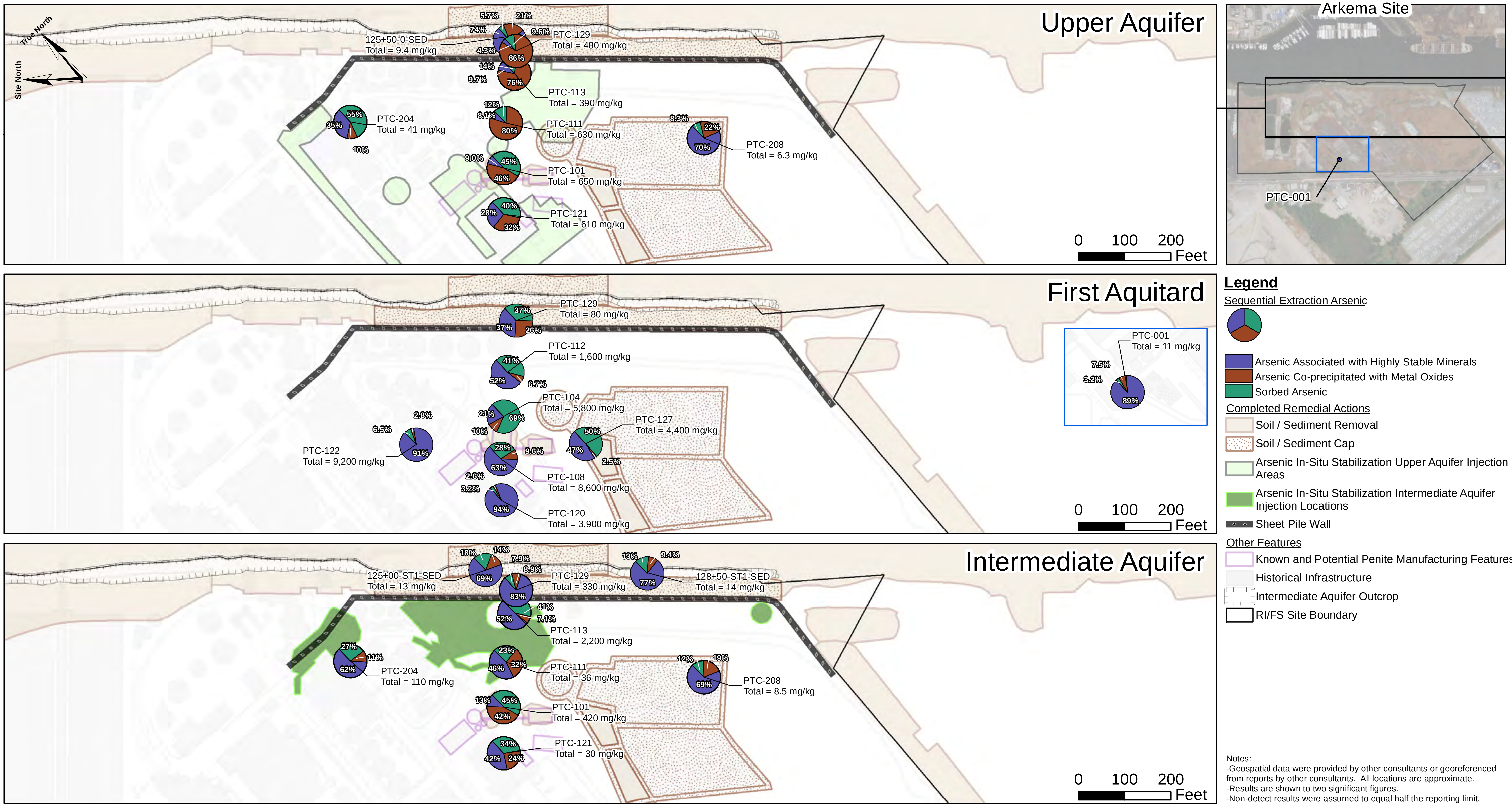
PIONEER TECHNOLOGIES CORPORATION



PIONEER TECHNOLOGIES CORPORATION

2018 Dissolved Arsenic Concentrations in the Intermediate Aquifer
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 5-8

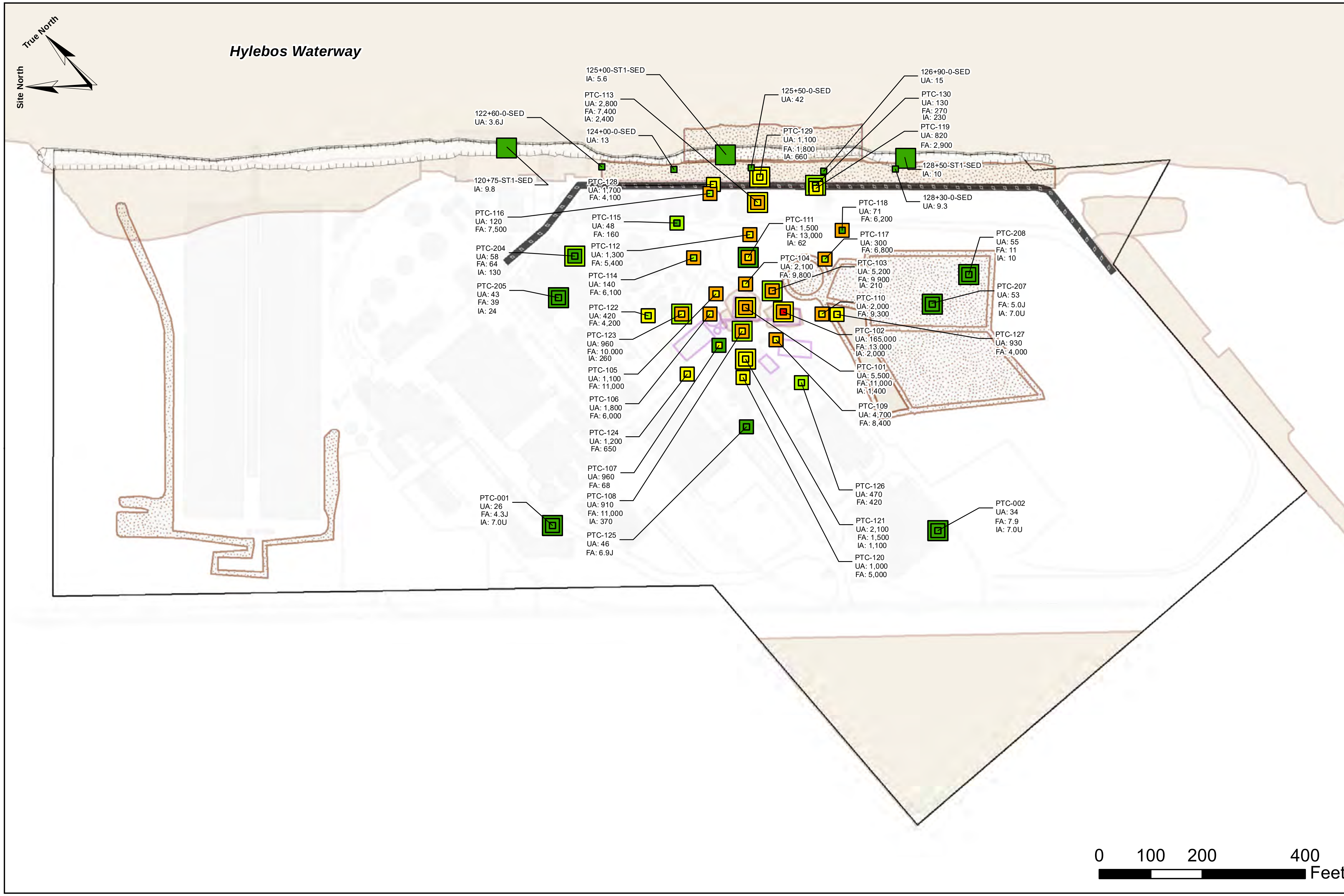


PIONEER TECHNOLOGIES CORPORATION

Summary of Sequential Extraction Arsenic Results for Soil and Sediment
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 5-9

Document Path: G:\Projects\Arkema\Maps\FS Data Gap Investigation Report\5-9_Summary_Seq_Ext_As_SO_SED.mxd; Author: VN; Date Saved: 7/19/2019



Legend

Lithologic Unit

- Upper Aquifer
- First Aquitard
- Intermediate Aquifer

Arsenic Soil or Sediment Concentration

- Arsenic ≤ 88 mg/kg (or Not Detected)
- 88 mg/kg < Arsenic ≤ 590 mg/kg
- 590 mg/kg < Arsenic ≤ 5,000 mg/kg
- 5,000 mg/kg < Arsenic ≤ 20,000 mg/kg
- Arsenic > 20,000 mg/kg

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features

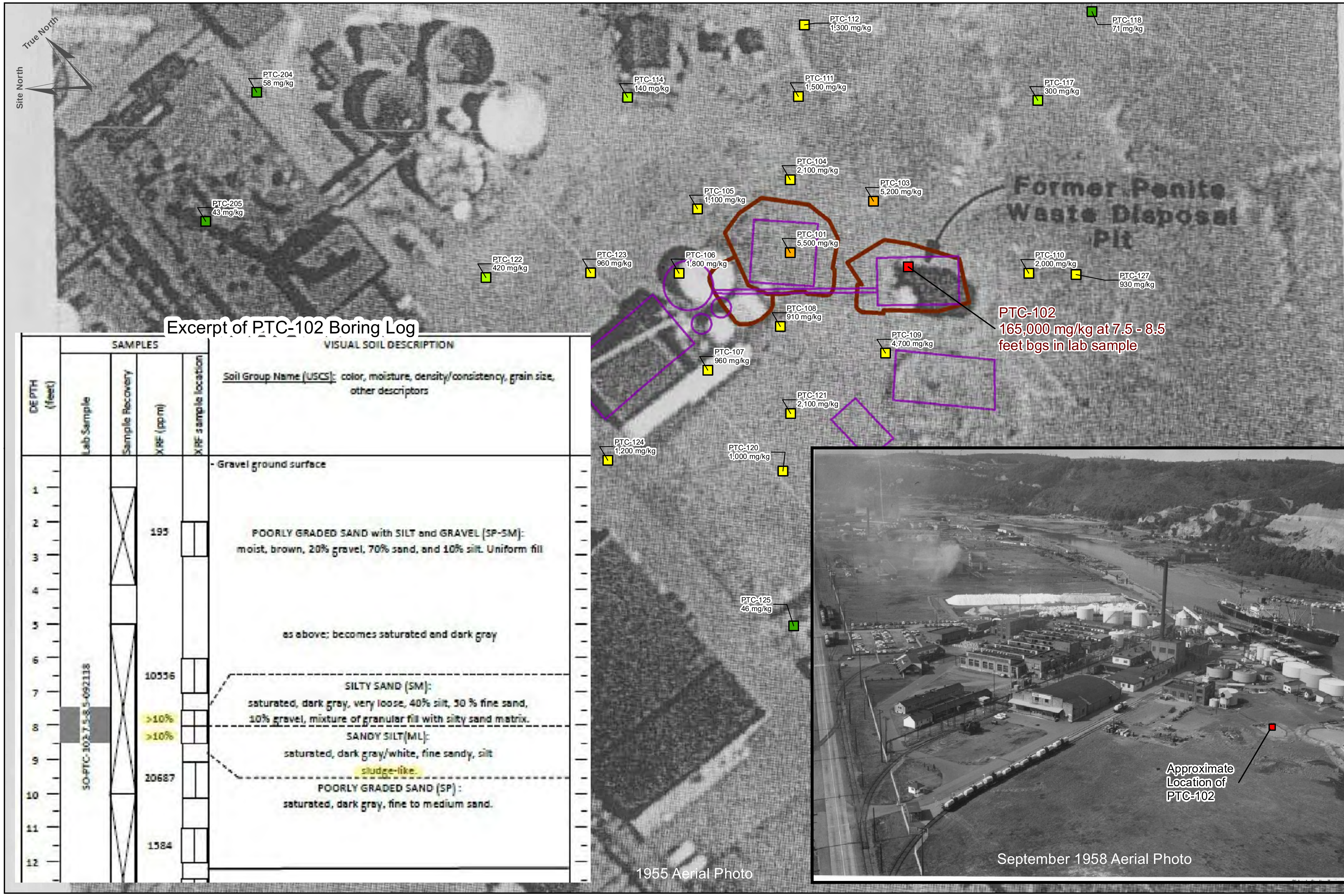
- Known and Potential Penite Manufacturing Features
- Historical Infrastructure
- Intermediate Aquifer Outcrop
- RI/FS Site Boundary

Notes:
J: Estimated concentration
U: Constituent was not detected at the shown reporting limit
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-The maximum concentration is shown if multiple sample intervals were collected from the same lithologic unit in a given boring.
-Both laboratory and field x-ray fluorescence sample results were included.
-Results are shown to two significant figures.

PIONEER TECHNOLOGIES CORPORATION

Arsenic Soil Concentrations in 2017 and 2018 Borings (By Lithologic Unit)
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

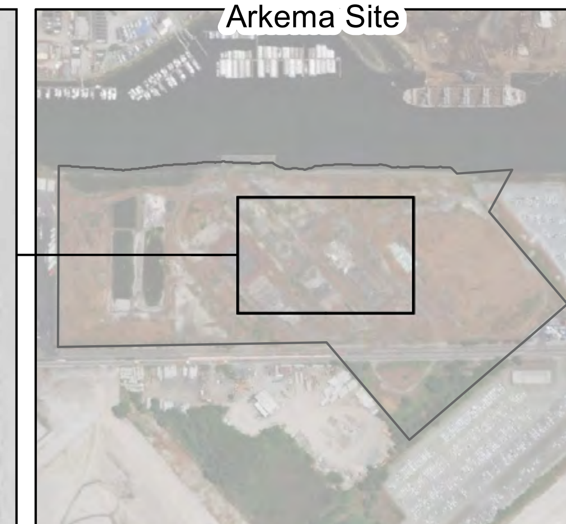
Figure 5-21



Excerpt of PTC-102 Boring Log

DEPTH (feet)	SAMPLES: Lab Sample	Sample Recovery	XRF (ppm)	XRF sample location	VISUAL SOIL DESCRIPTION — Soil Group Name (USCS): color, moisture, density/consistency, grain size, other descriptors
					- Gravel ground surface
1					
2			195		POORLY GRADED SAND with SILT and GRAVEL (SP-SM): moist, brown, 20% gravel, 70% sand, and 10% silt. Uniform fill
3					
4					
5					as above; becomes saturated and dark gray
6					
7			10556		SILTY SAND (SM): saturated, dark gray, very loose, 40% silt, 30 % fine sand, 10% gravel, mixture of granular fill with silty sand matrix.
8	SO-PTC-102-7.5-8.5-092118		>10%		
			>10%		SANDY SILT(ML): saturated, dark gray/white, fine sandy, silt sludge-like.
9					
10			20687		POORLY GRADED SAND (SP): saturated, dark gray, fine to medium sand.
11					
12			1584		

Arkema Site



Legend

Maximum Upper Aquifer Arsenic Soil Concentration in 2017 and 2018 Soil Borings

- Arsenic ≤ 88 mg/kg (or Not Detected)
- 88 mg/kg < Arsenic ≤ 590 mg/kg
- 590 mg/kg < Arsenic ≤ 5,000 mg/kg
- 5,000 mg/kg < Arsenic ≤ 20,000 mg/kg
- Arsenic > 20,000 mg/kg

Other Features

- Known and Potential Penite Manufacturing Features
- Soil / Sediment Removal

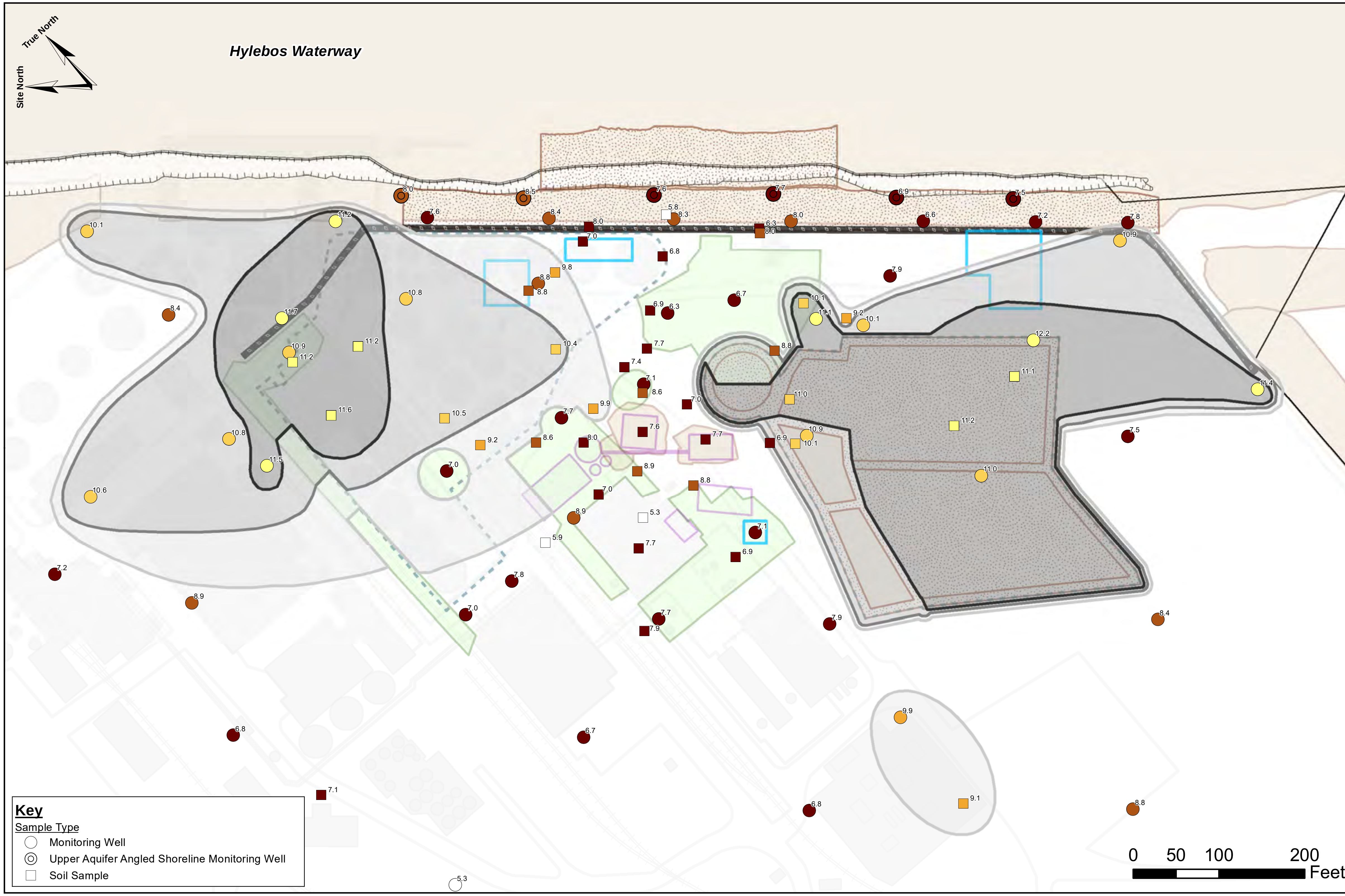
Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-The maximum concentration is shown if multiple sample intervals were collected from the same lithologic unit in a given boring.
-Both laboratory and field x-ray fluorescence sample results were included.
-Results are shown to two significant figures.

0 25 50 100 Feet

PIONEER TECHNOLOGIES CORPORATION

Remaining Source in Former Penite Pit #2
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 5-23



Legend

Groundwater and Soil pH Results

Groundwater (2017-2018)	Soil (2012-2018)
pH ≤ 6	pH ≤ 6
6 < pH ≤ 8	6 < pH ≤ 8
8 < pH ≤ 9	8 < pH ≤ 9
9 < pH ≤ 10	9 < pH ≤ 10
10 < pH ≤ 11	10 < pH ≤ 11
pH > 11	pH > 11

Areas With Elevated pH in the Upper Aquifer

pH ≥ 9 pH ≥ 10 pH ≥ 11

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Arsenic In-Situ Stabilization Upper Aquifer Injection Areas
- Sheet Pile Wall

Other Features

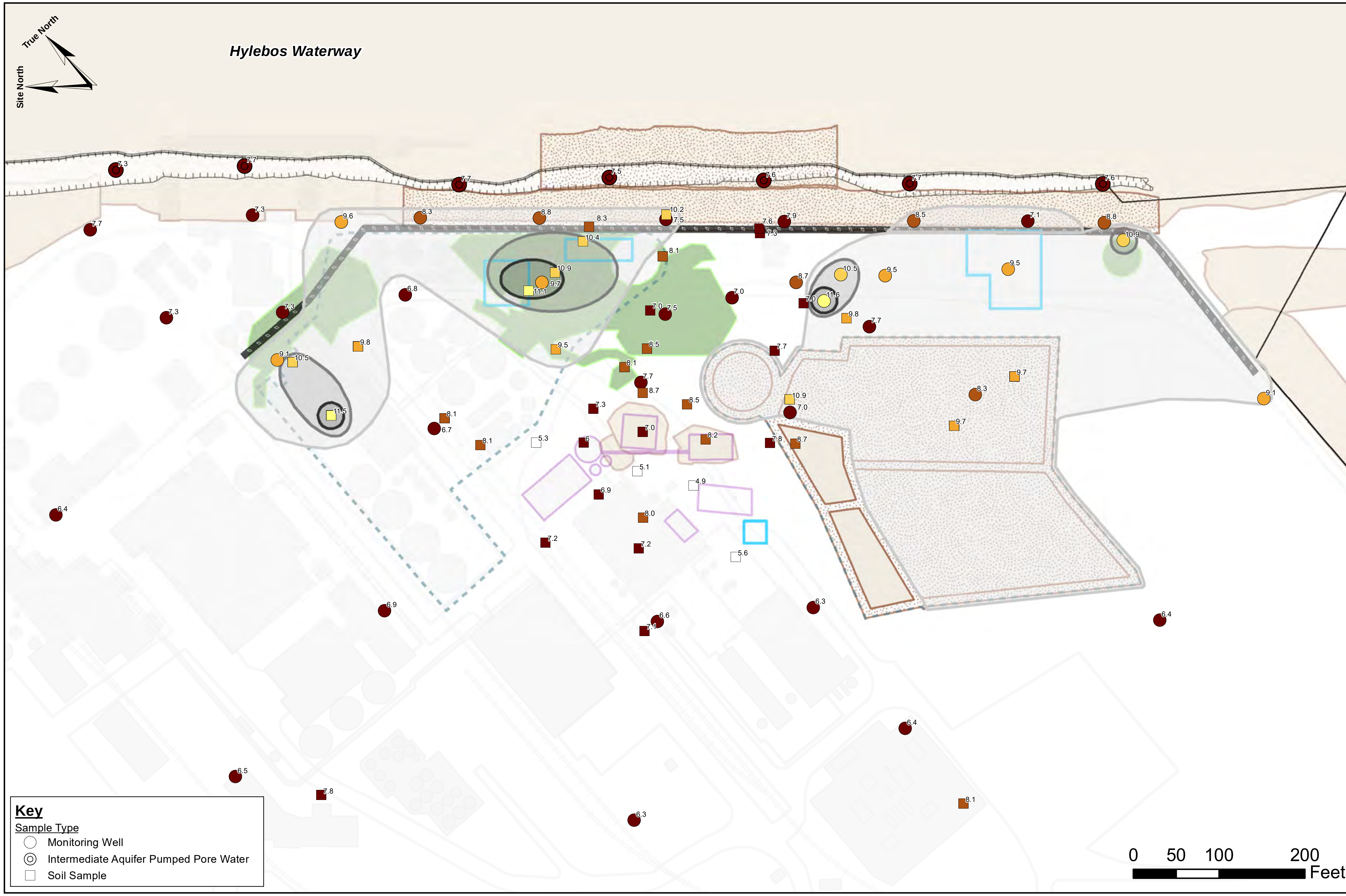
- Known and Potential Penite Manufacturing Features
- Historical Manufacturing Operation Potentially Associated With Elevated pH
- Thin or Leaky First Aquitard Location (Intera 1995)
- Historical Infrastructure
- Intermediate Aquifer Outcrop
- RI/FS Site Boundary

Notes:
-If a contour encompasses a result from a lower pH bin, it is because there were apparently conflicting results for nearby sample locations and upon further review it was determined that the result for the lower pH bin was either (1) slightly below the contour value or (2) the MW had a 2012 or 2013 pH result that would have placed the location within the contour. For instance, there are two samples encompassed within the pH 11 contour around the Former Taylor Lake Area even though these two samples are shown in the pH 10 to 11 bin. These two samples were included within the pH 11 contour because they had pH results of 10.97 and 10.96.
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-The maximum concentration at each location is presented.

PIONEER TECHNOLOGIES CORPORATION

Current Areas with Elevated pH in the Upper Aquifer
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 6-13



Legend

Groundwater and Soil pH Results

Groundwater (2017-2018)	Soil (2012-2018)
pH ≤ 6	pH ≤ 6
6 < pH ≤ 8	6 < pH ≤ 8
8 < pH ≤ 9	8 < pH ≤ 9
9 < pH ≤ 10	9 < pH ≤ 10
10 < pH ≤ 11	10 < pH ≤ 11
pH > 11	pH > 11

Areas With Elevated pH in the First Aquitard and/or the Intermediate Aquifer

pH ≥ 9 pH ≥ 10 pH ≥ 11

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Arsenic In-Situ Stabilization Intermediate Aquifer Injection Areas
- Sheet Pile Wall

Other Features

- Known and Potential Penite Manufacturing Features
- Historical Manufacturing Operation Potentially Associated With Elevated pH
- Thin or Leaky First Aquitard Location (Intera 1995)
- Historical Infrastructure
- Intermediate Aquifer Outcrop
- RI/FS Site Boundary

Notes:

-If a contour encompasses a result from a lower pH bin, it is because there were apparently conflicting results for nearby sample locations and upon further review it was determined that the result for the lower pH bin was either (1) slightly below the contour value or (2) the MW had a 2012 or 2013 pH result that would have placed the location within the contour. For instance, there are two sample locations encompassed within the pH 11 contour near the thin/leaky First Aquitard location due east of the former Penite Manufacturing Building even though these two samples are not shown in the pH > 11 bin. The soil location was included within the pH 11 contour because it had a pH result of 10.94 while the MW location was included within the pH 11 contour because it had a pH of 11.3 during the 2013 sampling event.

-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.

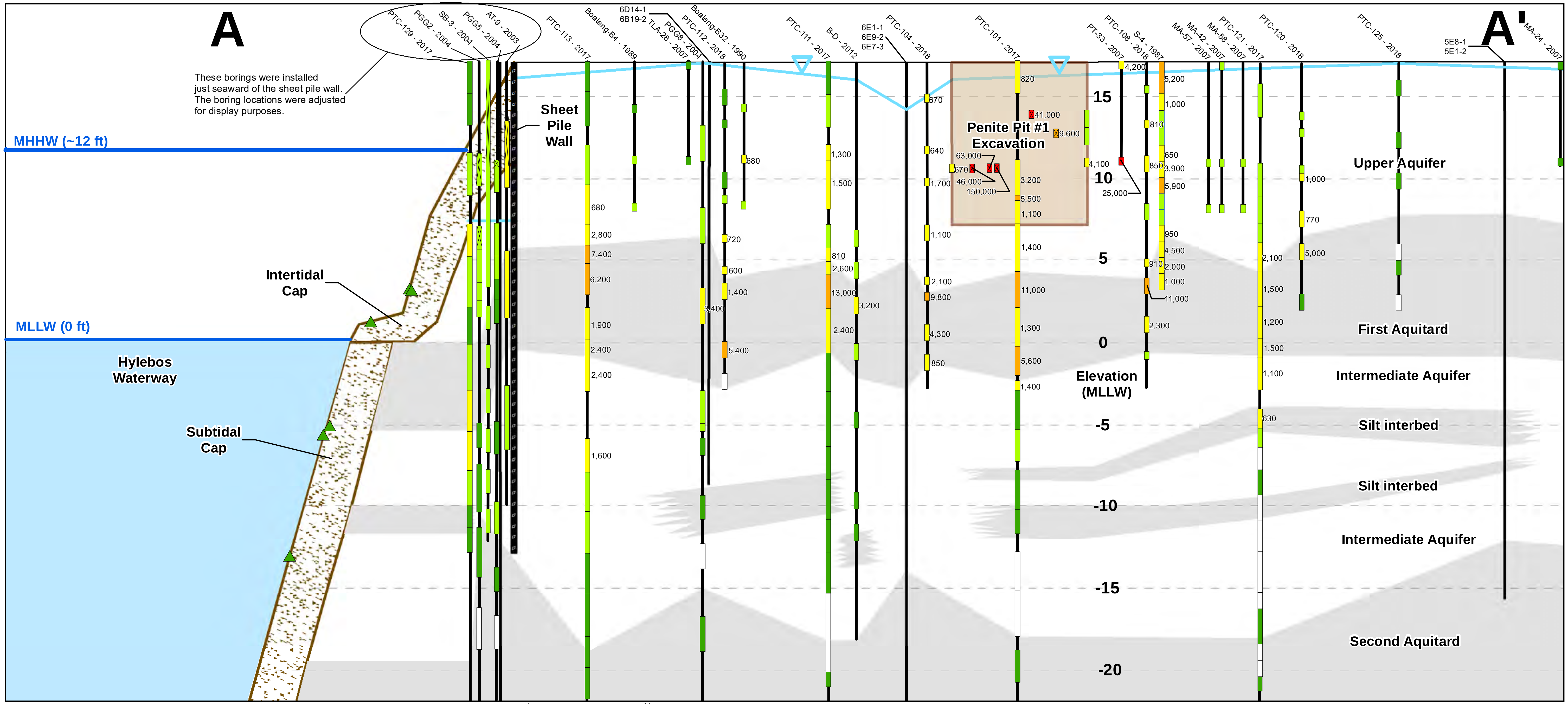
-The maximum concentration at each location is presented.

PIONEER TECHNOLOGIES CORPORATION

Current Areas with Elevated pH in the First Aquitard and/or the Intermediate Aquifer
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 6-14

Document Path: G:\Projects\Arkema\Maps\FS Data Gap Investigation Report\6-14_Current_IA_pH_SO_GW_2017-2018_Litho.mxd; Author: VN; Date Saved: 6/19/2019



Arsenic Soil/Sediment Concentration[1]

- Nondetect
- Nondetect < Arsenic ≤ 88 mg/kg
- 88 mg/kg < Arsenic ≤ 590 mg/kg
- 590 mg/kg < Arsenic ≤ 5,000 mg/kg
- 5,000 mg/kg < Arsenic ≤ 20,000 mg/kg
- Arsenic > 20,000 mg/kg
- No Longer In Place

Other Features

- March 2012 Low Tide Groundwater Elevation
- First / Second Aquitard or Silt Interbed
- Intertidal / Subtidal Caps
- Penite Pits Excavation

Boring ID and year

Soil Sample Interval

Concentration in mg/kg

Sediment Sample

Notes:

[1]Both laboratory and field XRF concentrations are shown on this figure. If both types of data were collected from a boring interval, the maximum concentration is displayed.

-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.

-For simplicity, a flat ground surface was assumed for the upland portion of this cross section since the upland ground surface is essentially flat along the cross section and spot elevations are not available for most boring locations.

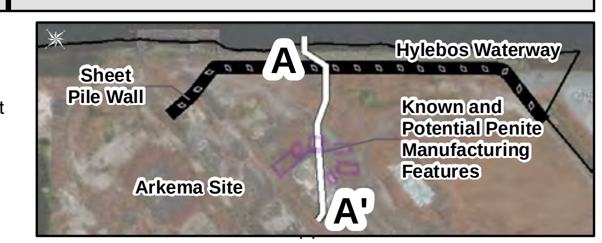
-Concentrations greater than 590 mg/kg in borings landward of the SPW are labeled. Results are shown to two significant figures.

Scale (ft)

Horizontal 0 30 60 120

Vertical exaggeration is ~7x

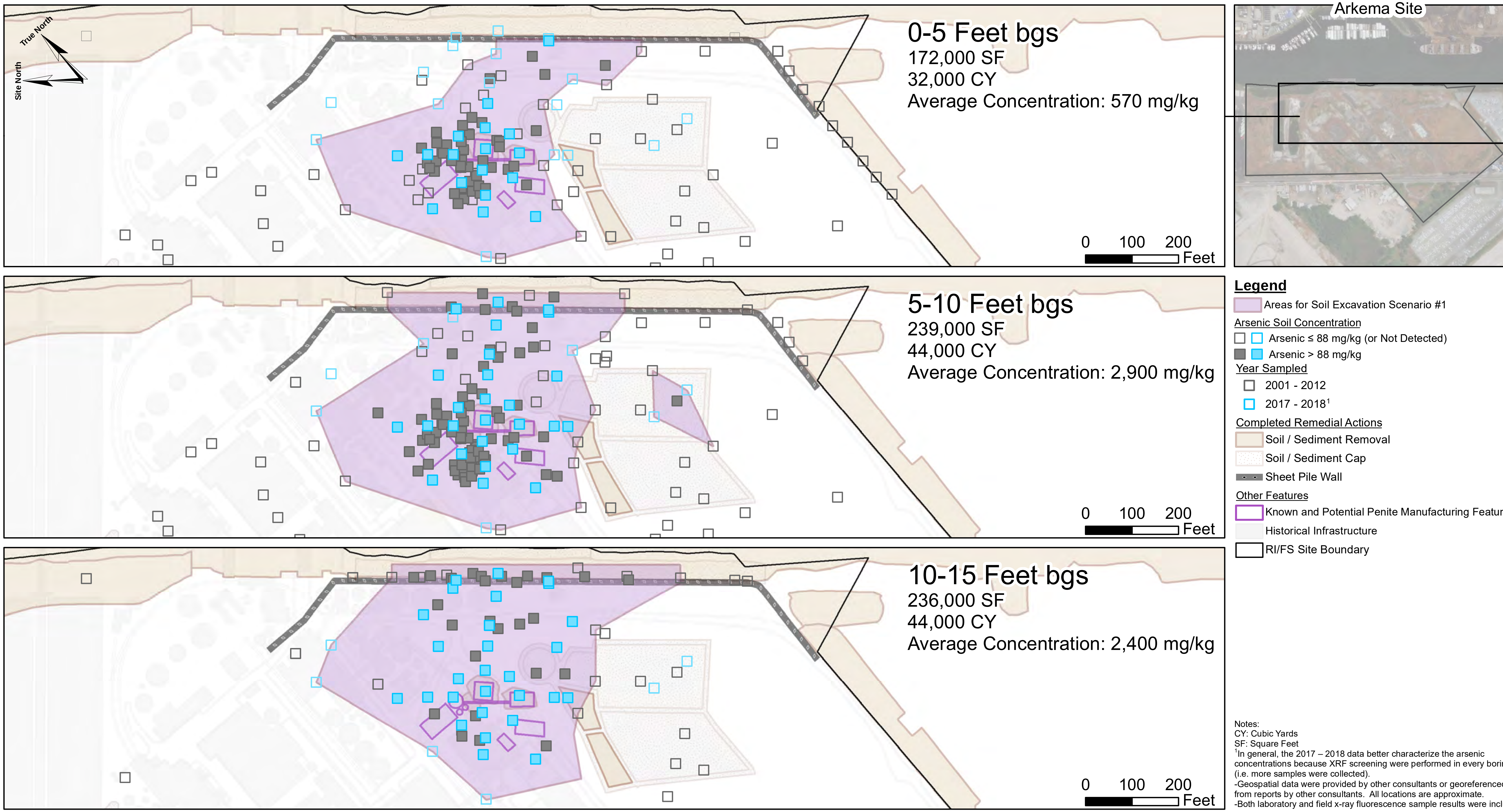
Vertical 0 5 10 20



PIONEER TECHNOLOGIES CORPORATION

Conceptual Cross Section of Arsenic Soil and Sediment Concentrations
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 6-15

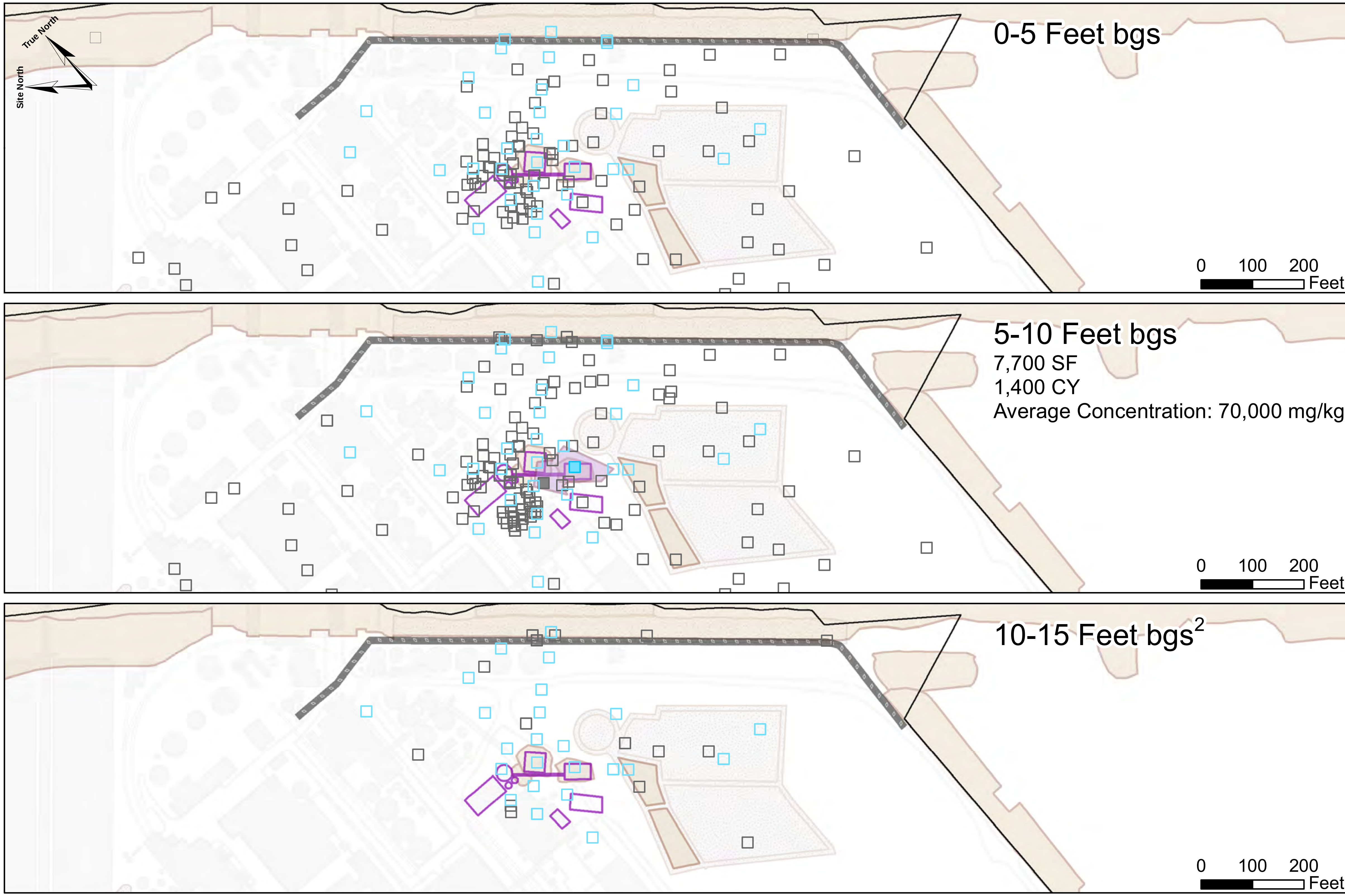


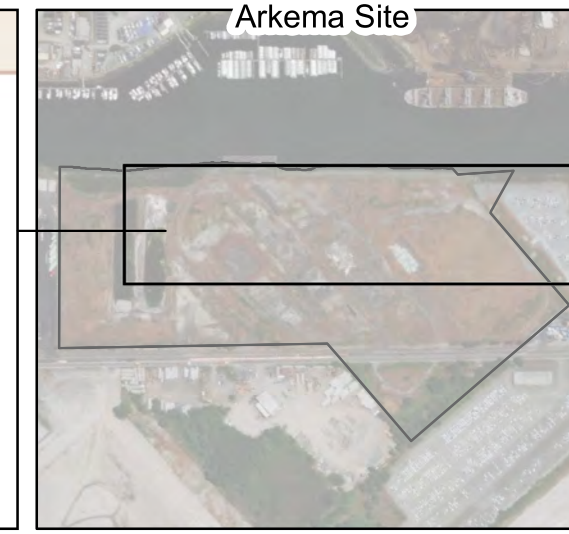
Notes:
CY: Cubic Yards
SF: Square Feet
[1]In general, the 2017 – 2018 data better characterize the arsenic concentrations because XRF screening were performed in every boring (i.e. more samples were collected).
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-Both laboratory and field x-ray fluorescence sample results were included.

PIONEER TECHNOLOGIES CORPORATION

Areas for Soil Excavation Scenario #1
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 6-16





Legend

Areas for Soil Excavation Scenario #3

Arsenic Soil Concentration
- Arsenic ≤ 10,000 mg/kg (or Not Detected)
- Arsenic > 10,000 mg/kg

Year Sampled
- 2001 - 2012
- 2017 - 2018[1]

Completed Remedial Actions
- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features
- Known and Potential Penite Manufacturing Features
- Historical Infrastructure
- RI/FS Site Boundary

Notes:
CY: Cubic Yards
SF: Square Feet
[1]In general, the 2017 – 2018 data better characterize the arsenic concentrations because XRF screening were performed in every boring (i.e. more samples were collected).
[2]For this excavation scenario, the point of compliance depth is 15 feet or the top of the 1st Aquitard, whichever occurs first. The average depth to the top of the 1st Aquitard was assumed to be 13 feet based on borings advanced within the excavation footprint.
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-Both laboratory and field x-ray fluorescence sample results were included.

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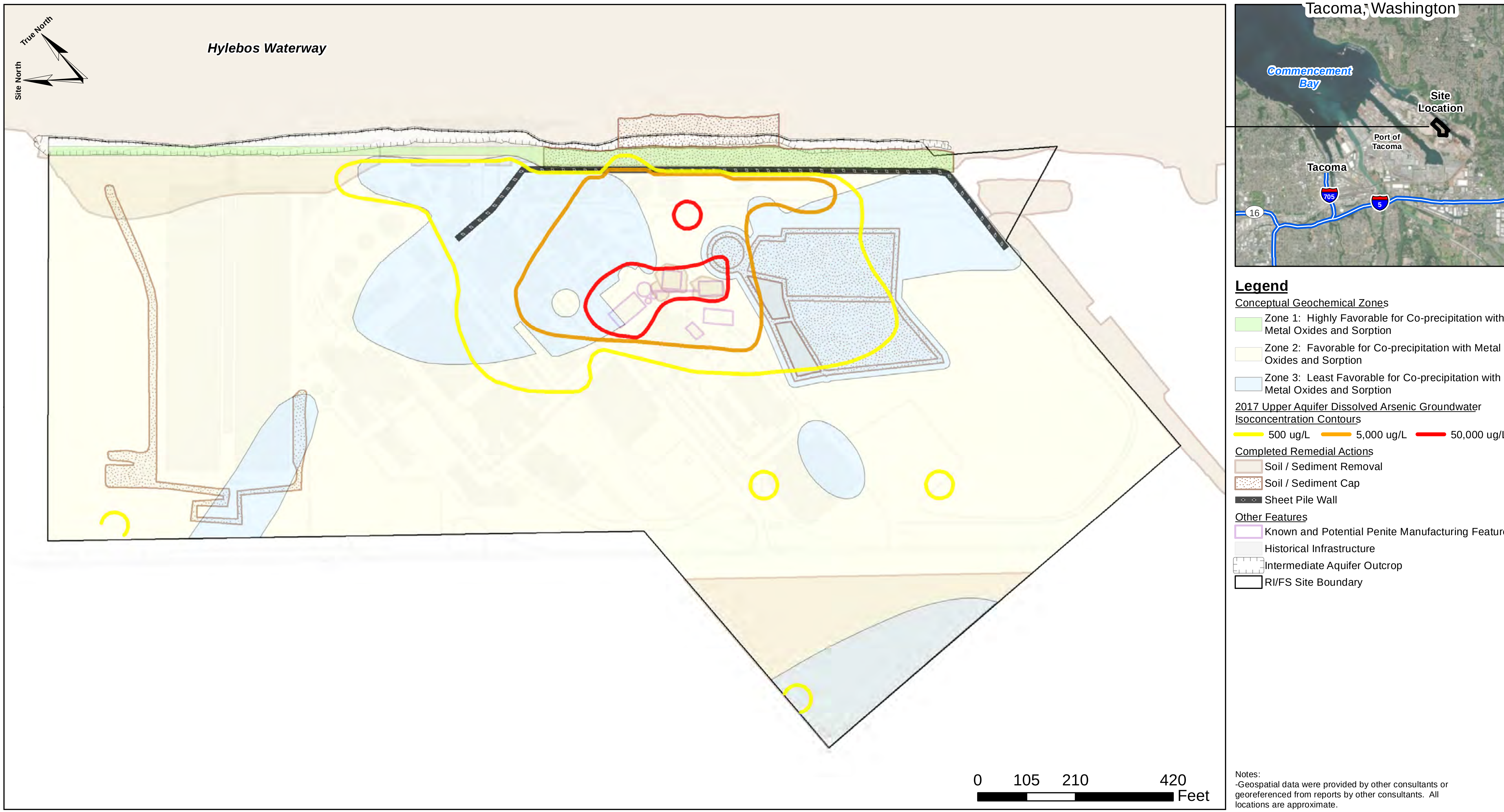
Areas for Soil Excavation Scenario #3
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 6-18

Document Path: G:\Projects\Arkema\Maps\FS Data Gap Investigation Report\6-18_Excavation_Senario3.mxd; Author: VN; Date Saved: 6/19/2019

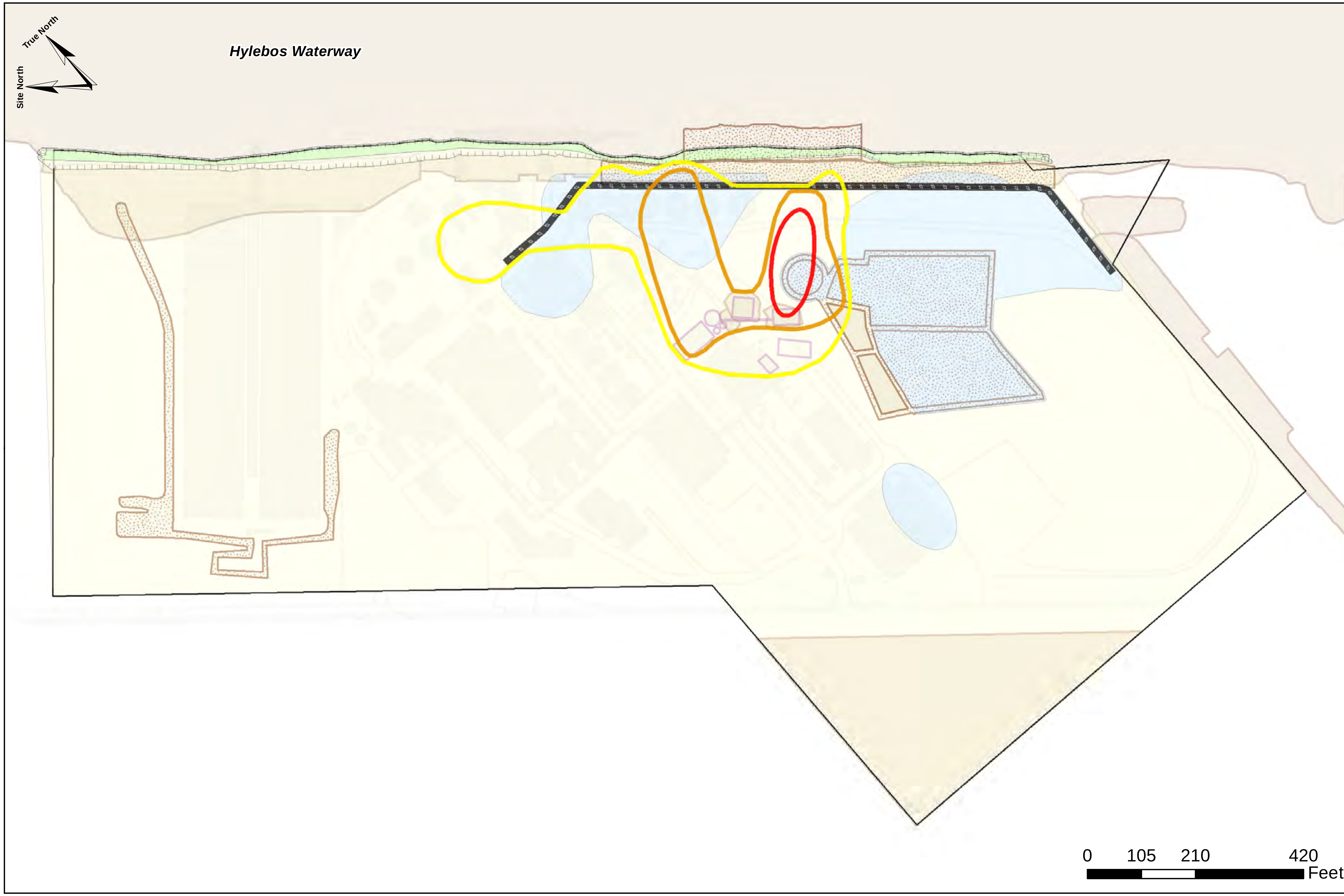


Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.

PIONEER TECHNOLOGIES CORPORATION

Conceptual Upper Aquifer Geochemical Zones for
Co-precipitation with Metal Oxides and Sorption
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 7-1



Legend

Conceptual Geochemical Zones
- Zone 1: Highly Favorable for Co-precipitation with Metal Oxides and Sorption
- Zone 2: Favorable for Co-precipitation with Metal Oxides and Sorption
- Zone 3: Least Favorable for Co-precipitation with Metal Oxides and Sorption

2017 Intermediate Aquifer Dissolved Arsenic Groundwater Isoconcentration Contours
- 500 ug/L
- 5,000 ug/L
- 50,000 ug/L

Completed Remedial Actions
- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features
- Known and Potential Penite Manufacturing Features
- Historical Infrastructure
- Intermediate Aquifer Outcrop
- RI/FS Site Boundary

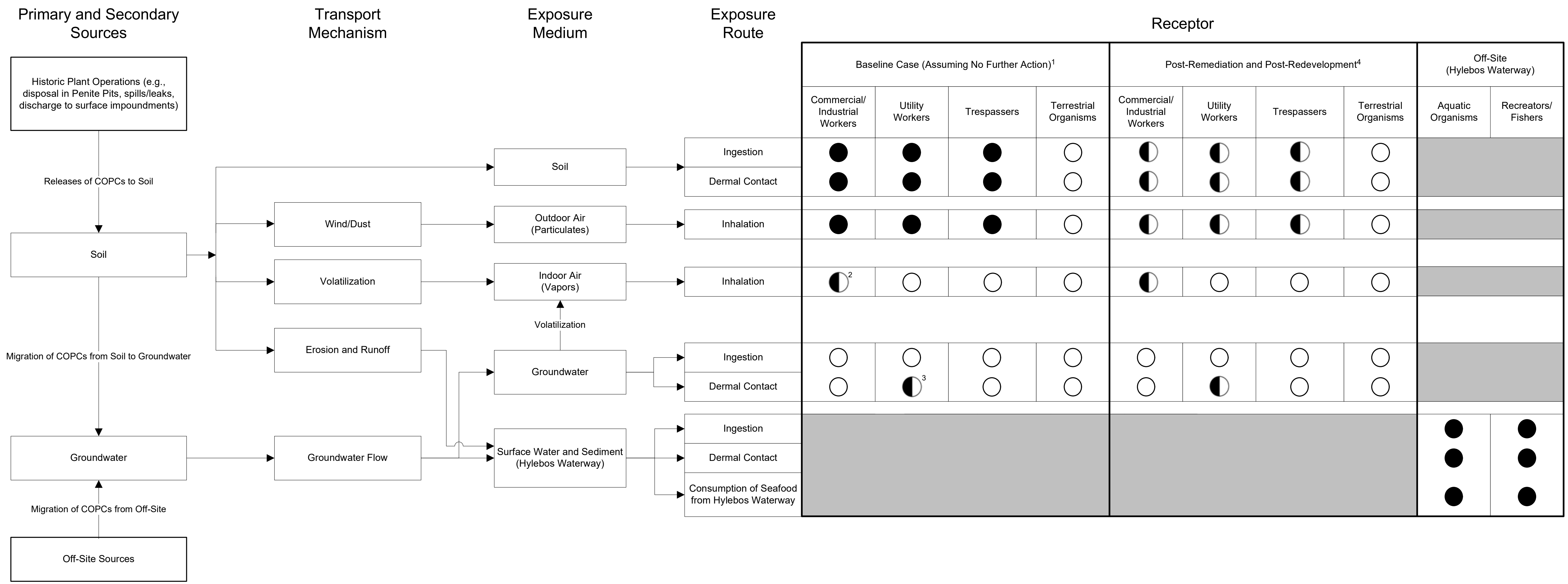
Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.

PIONEER TECHNOLOGIES CORPORATION

Conceptual Intermediate Aquifer Geochemical Zones for Co-precipitation with Metal Oxides and Sorption FS Data Gap Investigation Report Former Arkema Manufacturing Site

Figure 7-2

Document Path: G:\Projects\Arkema\Maps\FS Data Gap Investigation Report\7-2_IA_Conceptual_Geochemical.mxd; Author: SM; Date Saved: 6/27/2019



Key

- ● = Complete Pathway
- ◐ = Potentially Complete Pathway
- ○ = Incomplete Pathway

Notes:

These exposure scenarios are reasonable maximum exposures and are considered protective of other similar exposure scenarios (e.g., the off-site recreator scenarios are more protective than other off-site human exposure scenarios). All potential receptors are on-site unless otherwise noted. The shaded boxes represent exposure pathways that are not applicable.

Potential exposures for remediation construction workers and redevelopment construction workers will be addressed as necessary during remedy implementation and redevelopment activities, respectively. Specifically, it is expected that these potential exposures will be controlled with institutional and engineering controls designed to prevent unacceptable exposures. For instance, it is expected that all applicable workers will be contractually required to comply with Occupational Safety & Health Administration regulations as appropriate (e.g., Hazardous Waste Operations and Emergency Response training, health and safety plan, dust control measures, personnel monitoring, personal protective equipment).

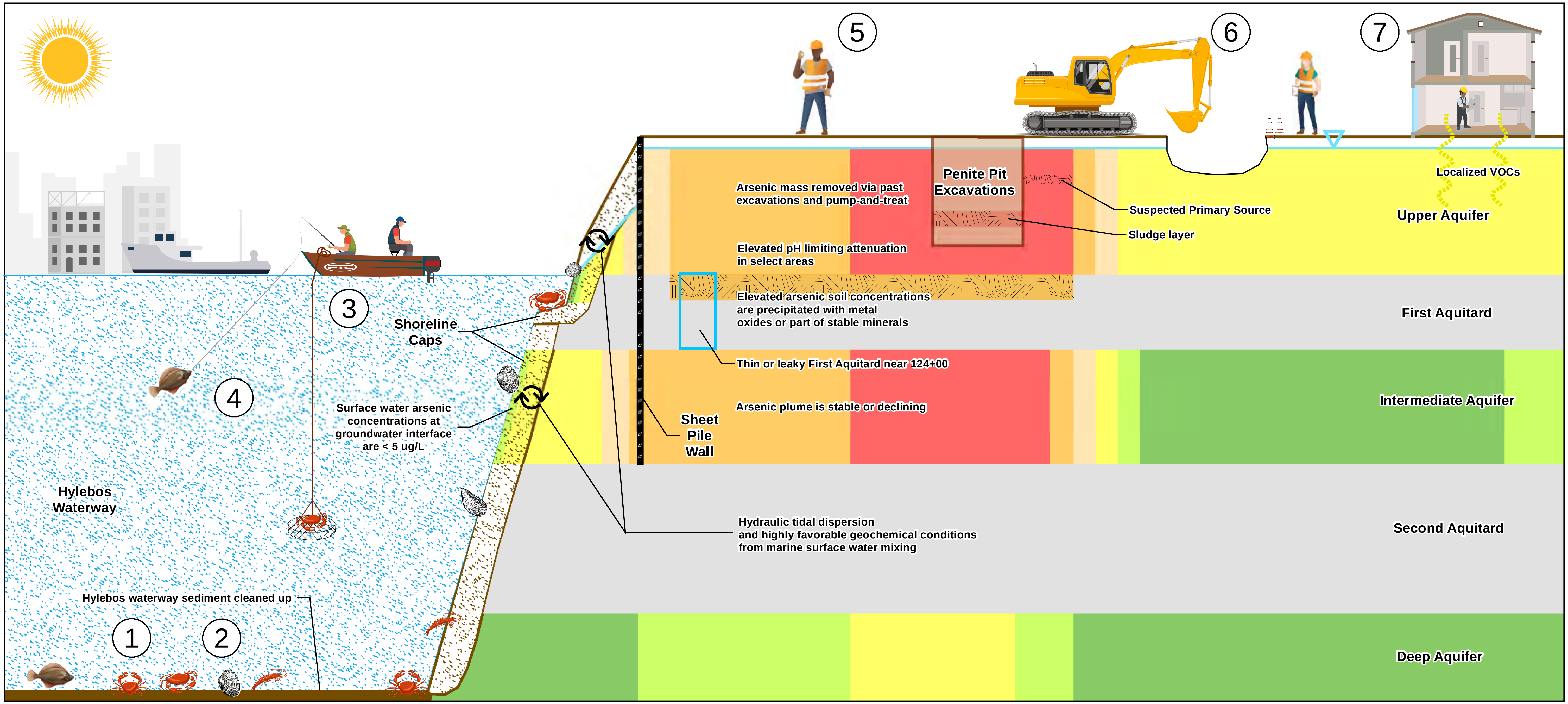
The terrestrial ecological pathway is not a complete and significant pathway at the Site per WAC 173-340-7491(1) since the Site does not have any meaningful terrestrial habitat because it was previously developed for industrial use and it will be redeveloped in the future for Port maritime industrial use (e.g., grading activities and installation of a cap/cover, construction of buildings and operational areas for a container yard).

1. This baseline scenario was used to determine the pathways of potential concern. It was assumed that the Site will be redeveloped without any controls or further remedial action, even though this is not a realistic scenario. The baseline scenario is not representative of current exposures (e.g., there are no current commercial/industrial worker exposures since there are no commercial/industrial workers currently at the site and there are no current trespasser exposures since an existing perimeter fence and signs prevent access to the site).
2. This pathway is considered potentially complete; however, it could be complete if new buildings are constructed without vapor intrusion mitigation systems at locations with applicable groundwater VOC exceedances. Since the VOC exceedance footprints in the Upper Aquifer are relatively small, the pathway would be incomplete if buildings are not constructed over these relatively small areas.
3. Although this pathway could hypothetically be complete in the baseline case, it is more likely that this pathway would be incomplete since (1) utilities are ideally installed in the unsaturated zone, and (2) any saturated zone work would involve dewatering the utility excavation prior to anyone entering the utility excavation.
4. The potentially complete pathways may be complete or incomplete depending on the final site remedy. For example, if the final remedy includes installing a cap/cover over applicable soil exceedances, then soil ingestion, soil dermal contact, and particulate inhalation exposures for post-remediation and post-redevelopment commercial/industrial workers and trespassers will be incomplete. Likewise, if vapor intrusion mitigation systems are installed in new buildings constructed in locations with applicable groundwater VOC exceedances, then indoor air inhalation exposures for post-remediation and post-redevelopment commercial/industrial workers will be incomplete. Similarly, if the final remedy includes institutional and engineering controls designed to prevent unacceptable exposures (as outlined above for remediation construction workers and redevelopment construction workers), then soil ingestion, soil dermal contact, particulate inhalation, and groundwater dermal contact exposures for post-remediation and post-redevelopment utility workers will be controlled.

PIONEER TECHNOLOGIES CORPORATION

Conceptual Site Exposure Model
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 7-3



1 Ingestion and dermal contact with surface water and sediment by aquatic organisms.

2 Consumption of seafood by aquatic organisms.

3 Incidental ingestion and dermal contact with surface water and sediment by recreators/ fishers.

4 Consumption of seafood by recreators/ fishers.

5 Incidental ingestion, dermal contact, and inhalation of particulates from surface soil by on-site workers and trespassers.

6 Incidental ingestion, dermal contact, and inhalation of particulates from subsurface soil by utility workers.

7 Inhalation of indoor air vapors by on-site workers if occupied building is constructed without vapor instrusion mitigation systems in the few isolated areas that have VOCs.

Note:
Not to Scale

PIONEER TECHNOLOGIES CORPORATION

Overview of the Conceptual Site Model
FS Data Gap Investigation Report
Former Arkema Manufacturing Site

Figure 7-4

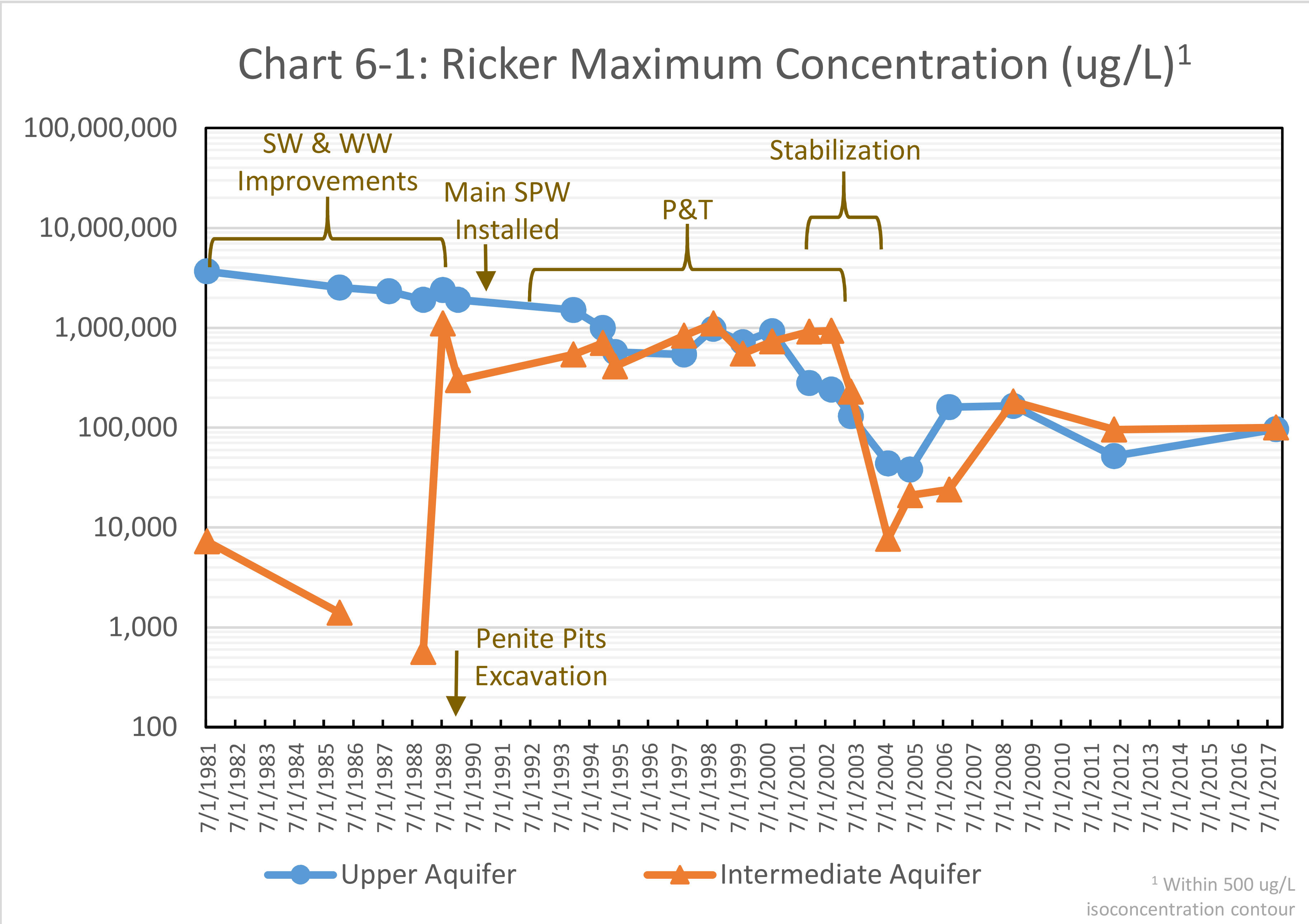


Chart 6-1: Ricker Maximum Concentration (ug/L)[1]
100,000,000
10,000,000
1,000,000
100,000
10,000
1,000
100
SW & WW Improvements
Main SPW Installed
P&T
Stabilization
Penite Pits Excavation
7/1/1981
7/1/1982
7/1/1983
7/1/1984
7/1/1985
7/1/1986
7/1/1987
7/1/1988
7/1/1989
7/1/1990
7/1/1991
7/1/1992
7/1/1993
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7/1/2006
7/1/2007
7/1/2008
7/1/2009
7/1/2010
7/1/2011
7/1/2012
7/1/2013
7/1/2014
7/1/2015
7/1/2016
7/1/2017
Upper Aquifer
Intermediate Aquifer
[1] Within 500 ug/L isoconcentration contour

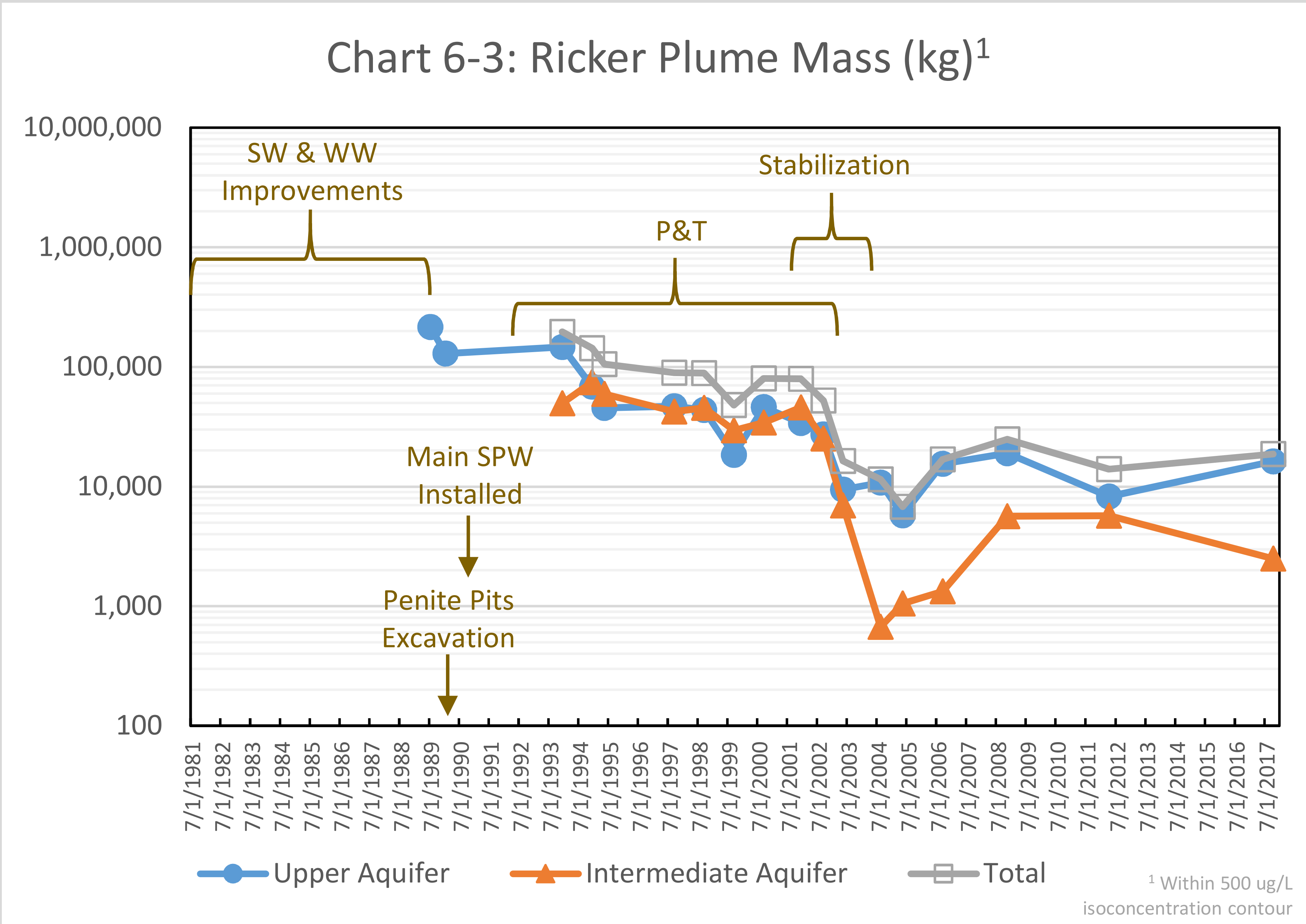
Chart 6-3: Ricker Plume Mass (kg)[1]
10,000,000
1,000,000
100,000
10,000
1,000
100
SW & WW Improvements
P&T
Stabilization
Main SPW Installed
Penite Pits Excavation
7/1/1981
7/1/1982
7/1/1983
7/1/1984
7/1/1985
7/1/1986
7/1/1987
7/1/1988
7/1/1989
7/1/1990
7/1/1991
7/1/1992
7/1/1993
7/1/1994
7/1/1995
7/1/1996
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7/1/2006
7/1/2007
7/1/2008
7/1/2009
7/1/2010
7/1/2011
7/1/2012
7/1/2013
7/1/2014
7/1/2015
7/1/2016
7/1/2017
Upper Aquifer
Intermediate Aquifer
Total
[1] Within 500 ug/L isoconcentration contour

Table 2-1: Summary of Completed Remedial Actions

Remediation Category	Figure	Date(s)	Completed Remedial Action
Historical Stormwater and Wastewater Improvements	N/A	November 1981 and August 1986	Improvements were made to the stormwater collection and treatment system, which decreased the arsenic mass discharging from the Site to the Hylebos Waterway. Three stormwater catch basins near the former Penite Pits were sealed in 1981 and the system was modified in 1981 and 1986 to improve collection and treatment (AWARE Corporation 1981; Hart Crowser 1986). No stormwater infrastructure remains at the Site.
		1980s	Wastewater discharges to the Taylor Lake Area surface impoundments ceased by 1990. Discontinuing this practice reduced recharge to the Upper Aquifer in this area and decreased the transport of elevated pH to groundwater.
Soil/Sediment Removal	Figure 2-1A	January 1990	Approximately 3,000 CY of soil within and surrounding the former Penite Pits was excavated due to elevated arsenic soil concentrations and disposed of off-site (MPS Incorporated 1990; ICF 1990b).
		1990	Approximately 1,200 CY of sludge (containing asbestos and elevated pH) from the former Asbestos Ponds (two of the former Taylor Lake Area surface impoundments) was excavated and disposed of off-site (ICF 1990b).
		2003	Approximately 185 CY of soil northwest of former Penite Pit #1 was excavated due to elevated arsenic soil concentrations and disposed of off-site (ERM 2003b).
		2003	Soil and sediment were excavated from the North Boundary Area shoreline and disposed of off-site as part of the reconfiguration of the shoreline in this area (DOF 2011).
		2003 to 2005	Hylebos Waterway sediment was dredged adjacent to the Site (including the areas where sediment caps were subsequently placed) and disposed of off-site (DOF 2011).
		2004	Approximately 13,100 tons of soil, sediment, and debris were excavated from the intertidal zone of the Site shoreline due to elevated arsenic concentrations and disposed of off-site (DOF 2011).
		2013 to 2014	Approximately 25,000 tons of soil was excavated from the Arkema Mound site due to elevated arsenic soil concentrations and disposed of off-site. This action is included as a soil removal IA since a small portion of the soil was from within the Site boundary (DOF 2015a).
		2014	Approximately 2,200 tons of soil was excavated from Wypenn due to elevated arsenic soil concentrations and disposed of off-site during an IA to achieve compliance with the MTCA Standard Method C industrial soil cleanup level of 88 mg/kg for the soil direct contact pathway (DOF 2015b).
Soil/Sediment Cap	Figure 2-1A	1990	All of the former Taylor Lake Area surface impoundments and the former Waggoner's Wallow surface impoundment in the North Boundary Area were backfilled with soil (DOF 2013). The thickness of the soil cap is likely one to four feet based on the depth of the former surface impoundments (AWARE Corporation 1981).
		2004 to 2005	A three-foot-thick sediment cap was installed in the intertidal zone of the Site shoreline (seaward of the SPW) as part of the backfill for the 2004 intertidal soil removal (DOF 2011).
		2006	A four-foot-thick sediment cap was installed in the subtidal zone of the Site shoreline (seaward of the sheet pile wall) to cap elevated arsenic concentrations in sediment that could not feasibly be dredged (DOF 2011).
SPW	Figure 2-1A	October 1990	A SPW was installed west of the Site shoreline to reduce arsenic mass discharge from the Site to the Hylebos Waterway (ICF 1990a, 1990b). The SPW was constructed of interlocking steel sheet piles that were 21.6 inches wide, 0.315 inches thick, and 30 feet long. The SPW was seated into the Second Aquifer. Every second joint was welded, and joints that were not welded were sealed with an asphalt material. Two gaps in the top part of the SPW were discovered and filled in 2004 (see Appendix A). The source of these two gaps is unknown but may have been due to the SPW construction or earth movement during the 2001 Nisqually earthquake.
		February 1991 to April 1992	The SPW was extended to the south to improve containment of arsenic in groundwater near the southern end of the original wall (ICF 1991, 1992). This extension is referred to as the southern SPW wing.
		August 1995	The SPW was extended to the north to improve containment of arsenic in groundwater near the northern end of the original SPW (Elf Atochem 1995). The 1995 and 1997 extensions are referred to as the northern SPW wing.
		June 1997	The northern portion of the SPW was further extended to improve containment of arsenic in groundwater near the northern end of the SPW (DOF 2013). The 1995 and 1997 extensions are referred to as the northern SPW wing.
Arsenic P&T System	Figure 2-1B	1992 to 2003	A groundwater P&T system that included four Upper Aquifer extraction trenches, 15 Upper Aquifer extraction wells, and five Intermediate Aquifer extraction wells was installed and operated within the main arsenic plume (ICF 1990c, 1995; DOF 2013). The P&T system removed more than 22,000 pounds of arsenic (Boateng 2003). Once the arsenic concentrations in the extracted groundwater reached an asymptote, the P&T system was shut down as part of a planned transition from P&T to polishing with in-situ stabilization (ICF 1990c).
In-Situ Stabilization	Figure 2-1B	November 2001 to June 2004	In situ stabilization was performed within portions of the main arsenic plume as a planned post-P&T polishing activity (ICF 1990c; ERM 2003a, 2005). In-situ stabilization consisted of injecting hydrogen peroxide and ferric chloride into the Upper and Intermediate Aquifers to reduce pH, oxidize arsenite to arsenate, and provide ferric iron, which combined to facilitate sorption and co-precipitation of arsenic in groundwater onto soil. Approximately 139 tons of iron was injected (ERM 2005).
VOC Remediation	Figure 2-1B	1996 to 2000	A soil vapor extraction system and a groundwater P&T system were installed and operated in order to remove VOCs in a few areas along the southern border of the North Boundary Area where localized VOCs in groundwater was identified (Boateng 2002).
		2003	In-situ chemical oxidation was performed in 2003 (using hydrogen peroxide) to treat VOCs in an area east of the former Taylor Lake Area surface impoundments where localized VOCs in groundwater where identified (ERM 2003c).
Remediation of Miscellaneous Releases	Figure 2-1B	Various	Historical process-related spills were remediated (e.g., sodium chlorate, No. 2 fuel, hydrochloric acid) as necessary (DOF 2013).

Notes:
CY: cubic yards
ERM: Environmental Resources Management
N/A: Not applicable
ICF: ICF Technology Incorporated

Table 2-2: Comparison of Arsenic Concentrations (mg/kg Wet Weight) in Puget Sound and Site Mussels

Dataset	Number of Samples	Minimum	Mean	Median	90th Percentile	Maximum
All Transplanted Mussels in WDFW PSEMP Study [1]	90	0.65	0.87	0.86	0.98	1.2
Transplanted Mussels in Hylebos Waterway Downgradient of Site	9	0.84	0.95	0.93	1.0	1.1
All Native Mussels in WDFW PSEMP Study [1]	6	0.58	0.79	0.81	0.91	0.95
Native Mussels in Hylebos Waterway Downgradient of Site	1	0.82				

Notes:

[1] Includes sampling locations in Puget Sound (north, central, and south), the Whidbey Basin, the Bellingham Basin, Admiralty Inlet, the San Juan Archipelago, and Hood Canal. A specific subset of sample locations that constitutes a "background" cannot be readily determined since the study objective was to achieve "the most extensive geographic coverage possible." However, many of the sample locations are likely representative of background concentrations within Puget Sound and surrounding marine waters. Examples of several sample locations expected to be representative of background concentrations are shown below.

Table 6-1: Discussion of Main Arsenic Plume MWs with Potential Post-2004 Rebound

Apparent Increasing Trend After Circa 2007 or 2008?	Plume Area	MW	Aquifer	2017 and 2018 Dissolved Arsenic Concentrations (ug/L)	Discussion
Yes	Surrounding Former Penite Manufacturing Building	5D7-1R	Upper	91,000 and 86,000	● Suspected Upper Aquifer source material near the former Penite Manufacturing Building is likely contributing to the apparent increasing trend in this MW since circa 2007 or 2008.
Yes		5E4-1	Upper	97,000 and 140,000	● Suspected Upper Aquifer source material near the former Penite Manufacturing Building is likely contributing to the apparent increasing trend in this MW since circa 2007 or 2008.
Yes		5D5-1	Upper	45,000 and 63,000	● Suspected Upper Aquifer source material near the former Penite Manufacturing Building is likely contributing to the apparent increasing trend in this MW since circa 2007 or 2008. ● Elevated pH and reducing conditions upgradient of this MW may limit co-precipitation with metal oxides and sorption near this MW.
Yes	Downgradient of Former Penite Manufacturing Building	124+00-2	Intermediate	39,000 and 76,000	● Transport of suspected Upper Aquifer source material near the former Penite Manufacturing Building is likely contributing to the apparent increasing trend in this MW since circa 2007 or 2008. ● The thin or leaky First Aquitard locations upgradient of this MW likely provide preferential pathways for Upper Aquifer mass to enter the Intermediate Aquifer upgradient of this MW. ● Elevated pH and reducing conditions in the thin or leaky First Aquitard locations and the Intermediate Aquifer upgradient of this MW likely limits co-precipitation with metal oxides and sorption near this MW.
Yes		124+00-1	Upper	3,100 and 1,100	● Transport of suspected Upper Aquifer source material near the former Penite Manufacturing Building is likely contributing to the apparent increasing trend in this MW since circa 2007 or 2008. ● Elevated pH and reducing conditions upgradient of this MW likely limits co-precipitation with metal oxides and sorption near this MW.
Yes	Downgradient of Former Penite Pit #2	6E3-2	Intermediate	100,000 and 63,000	● Transport of Upper Aquifer source material in former Penite Pits #2 is likely contributing to the apparent increasing trend in this MW since circa 2007 or 2008. ● Elevated pH and reducing conditions upgradient of this MW likely limits co-precipitation with metal oxides and sorption near this MW.
Yes		7E3-1	Upper	14,000 and 9,700	● Transport of Upper Aquifer source material in former Penite Pits #2 is likely contributing to the apparent increasing trend in this MW since circa 2007 or 2008. ● Elevated pH and reducing conditions upgradient of this MW likely limits co-precipitation with metal oxides and sorption near this MW.
Yes		7E16-2	Intermediate	2,900 and 3,600	● Transport of Upper Aquifer source material in former Penite Pits #2 is likely contributing to the apparent increasing trend in this MW since circa 2007 or 2008. ● Elevated pH and reducing conditions upgradient of this MW likely limits co-precipitation with metal oxides and sorption near this MW.
Yes	Near Northern SPW Wing	5C16-1R	Upper	480 and 1,200	● Elevated pH and reducing conditions upgradient of this MW may limit co-precipitation with metal oxides and sorption near this MW.
Yes	Upgradient of Source Area (But Within Main Arsenic Plume)	5E8-1	Upper	450 and 790	● Although there is an apparent increasing trend in this MW since circa 2007 or 2008, the potential increasing concentrations are not a significant concern because the MW is upgradient of the source area and dissolved arsenic concentrations are relatively low.
No	Downgradient of Former Penite Pits #1 and #2	6D14-1	Upper	50,000 and 44,000	● This MW was identified for potential post-2004 rebound based solely on the Mann-Kendall trend analysis of 2005 to 2017 data. The Mann-Kendall trend analysis indicated an apparent increasing trend because dissolved arsenic concentrations were temporarily depressed in 2005 and 2006 following in-situ stabilization. Dissolved arsenic concentrations in this MW were stable after circa 2007 or 2008.
No	Downgradient of Former Penite Pit #2	7E8-1	Upper	3,400 and 3,600	● This MW was identified for potential post-2004 rebound based solely on the Mann-Kendall trend analysis of 2005 to 2017 data. The Mann-Kendall trend analysis indicated an apparent increasing trend because dissolved arsenic concentrations were temporarily depressed in 2005 and 2006 following in-situ stabilization. Dissolved arsenic concentrations in this MW were stable after circa 2007 or 2008.
No	Upgradient of Source Area (But Within Main Arsenic Plume)	5E1-1	Upper	670 and 600	● This MW was identified for potential post-2004 rebound based solely on the Mann-Kendall trend analysis of 2005 to 2017 data. The Mann-Kendall trend analysis indicated an apparent increasing trend because dissolved arsenic concentrations were temporarily depressed in 2005 and 2006 following in-situ stabilization. Dissolved arsenic concentrations in this MW were stable after circa 2007 or 2008.

Table 6-2: Conceptual Estimates of Arsenic Mass in Soil Excavation Scenarios

Scenario Number	Scenario Description	Excavation Depth (1) (feet bgs)	Estimated Excavation Volume (1) (CY)	Associated Average Arsenic Concentration (1) (mg/kg)	Estimated Arsenic Mass (2) (kg)	Total Estimated Scenario Mass (kg)	Percentage of Mass Relative to Baseline Scenario (4)
1	Excavate soil with arsenic concentrations exceeding 88 mg/kg to a depth of 15 feet bgs.	0 - 5	32,000	570	25,000	343,000	37%
		5 -10	44,000	2,900	174,000		
		10 - 15	44,000	2,400	144,000		
2	Excavate soil with arsenic concentrations exceeding 590 mg/kg to a depth of 15 feet bgs or the top of the 1st Aquitard (whichever occurs first).	0 - 5	4,300	1,100	6,000	145,000	15%
		5 -10	18,000	5,200	128,000		
		10 - 15 (3)	9,800	860	11,000		
3	Excavate soil with arsenic concentrations exceeding 10,000 mg/kg to a depth of 15 feet bgs or the top of the 1st Aquitard (whichever occurs first).	0 - 5	N/A	N/A	N/A	134,000	14%
		5 -10	1,400	70,000	134,000		
		10 - 15 (3)	N/A	N/A	N/A		
4	Excavate soil with arsenic concentrations exceeding 20,000 mg/kg to a depth of 15 feet bgs or the top of the 1st Aquitard (whichever occurs first).	0 - 5	N/A	N/A	N/A	134,000	14%
		5 -10	1,400	70,000	134,000		
		10 - 15 (3)	N/A	N/A	N/A		

Notes:

CY: cubic yards, kg: kilograms, mg/kg: milligrams per kilogram, N/A: not applicable

(1) Values from Figures 6-16 through 6-19. Values rounded to two significant figures.

(2) Arsenic mass (kg) = excavation volume (CY) * assumed soil density of 1.5 tons/cy * 2000 pounds/ton * kg/2.2 pounds * arsenic concentration (mg/kg) * kg/1,000,000 mg. Values rounded to nearest 1,000.

(3) For this excavation scenario, the point of compliance depth is 15 feet or the top of the 1st Aquitard, whichever occurs first. The average depth to the top of the 1st Aquitard was assumed to be 13 feet based on borings advanced within the excavation footprint.

(4) The baseline scenario is excavating soil with arsenic concentrations exceeding 20 mg/kg to a depth of 15 feet bgs. The total mass for the baseline scenario was estimated to be 936,000 kg based on existing data and simplifying assumptions (see figure in Appendix H).

Appendix B

Other Potential Site Concerns

Former Arkema Manufacturing Site

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SECTION 1: BACKGROUND INFORMATION

1.1 Purpose

The primary concern for this Feasibility Study (FS) Report is the potential for groundwater transport of arsenic in the main arsenic plume at the Former Arkema Manufacturing Site (Site) to cause unacceptable exposures for Hylebos Waterway surface water and sediment receptors. However, for completeness, there are other potential exposure pathways of concern, other constituents of potential concern (COPCs), and other minor arsenic concerns outside of the main arsenic plume that also needed to be acknowledged and discussed. The purpose of this appendix is to summarize these "other potential Site concerns" and determine whether or not any additional future remedial components are needed to address these other potential Site concerns. Since this appendix is intended to be a summary, refer to the rest of this FS Report and the FS Data Gap Investigation Report for a more comprehensive summary of background information (PIONEER 2019).

1.2 Other Exposure Pathways

Although the key exposure pathways for the Site are related to potential surface water and sediment exposures, the soil direct contact, vapor intrusion (VI), and groundwater direct contact pathways are also complete and potentially complete exposure pathways. The complete and potentially complete soil direct contact pathways are incidental ingestion, dermal contact, and inhalation of particulates from surface soil by on-site workers and trespassers, and incidental ingestion, dermal contact, and inhalation of particulates from subsurface soil by utility workers. The potentially complete VI pathway is inhalation of indoor air vapors by on-site workers if an occupied building is constructed without VI mitigation systems in volatile organic compound (VOC) VI Areas A, B, or C. The potentially complete groundwater direct contact pathway is dermal contact with subsurface groundwater by utility workers.

1.3 Constituents of Potential Concern

Although arsenic is the primary COPC, the other eight Site COPCs for soil and groundwater identified in the Remedial Investigation (RI) Report (Dalton, Olmsted, & Fuglevand, Inc. [DOF] 2013) are:

- Copper
- Lead (soil only) [1]
- Mercury
- Nickel
- Tetrachloroethylene (PCE)
- Trichloroethylene (TCE)
- Vinyl chloride (VC)
- Chloroform (CF)

[1] Lead was eliminated as a groundwater COPC in the RI report (DOF 2013).

Four constituents (i.e., chromium, selenium, zinc, and dichloro-diphenyl-trichloroethane) were identified in the RI Report as COPCs solely due to the potential terrestrial ecological pathway (DOF 2013). However, the Site is excluded from a terrestrial ecological evaluation in accordance with Washington Administrative Code (WAC) 173-340-7491(1)(b) because the Site was previously developed for industrial use and it will be redeveloped in the future for Port Maritime Industrial use (e.g., grading activities, construction of industrial operational areas and buildings, installation of an industrial working surface). Thus, these four constituents were eliminated as COPCs (PIONEER 2019).

1.4 Screening Levels

Soil direct contact screening levels (SLs) and surface water SLs were calculated for all COPCs, and VI groundwater SLs were calculated for the four VOC COPCs (i.e., PCE, TCE, VC, and CF) in order to assist in the evaluation of other potential Site concerns. Soil direct contact and surface water SLs for all COPCs are presented in Tables B-1 and B-2, respectively. The soil direct contact SLs are Standard Method C soil direct contact cleanup levels (CLs) for commercial/industrial land use in accordance with WAC 173-340-740(3)(b)(iii)(B) and WAC 173-340-745(5)(b)(iii)(B), respectively.[2] The surface water SLs are Standard Method B surface water CLs in accordance with WAC 173-340-730(3)(b)(i) and 173-340-730(3)(b)(iii) for the protection of potential downgradient surface water and sediment receptors. In addition, natural background groundwater arsenic, copper, mercury, and nickel concentrations predicted by the Model Toxics Control Act (MTCA) fixed parameter three-phase partitioning model in WAC 173-340-747(4) from natural background soil concentrations are presented in Table B-3. These predicted natural background groundwater concentrations provide utility in helping to distinguish between a potential Site release and potential natural groundwater concentrations for naturally occurring metals. The VI groundwater SLs, which are presented in Table B-4, are Standard Method C VI groundwater SLs (Washington State Department of Ecology [Ecology] 2021b).

1.5 Identification of the Other Potential Site Concerns

Based on the exposure pathways and COPCs presented in this appendix as well as information presented in the RI Report (DOF 2013), the other potential Site concerns are:

- Soil direct contact in the 2901 Taylor Way portion of the Site boundary
- Soil direct contact in the Wypenn portion of the Site boundary
- Arsenic in groundwater upgradient of the main arsenic plume (e.g., Wypenn)
- Arsenic in the Taylor Way storm sewer[3]
- Potential arsenic discharge from groundwater to the Hylebos Waterway via the East Channel Ditch

[2] Consistent with the RI Report, soil-to-groundwater SLs were not necessary since actual groundwater impacts are being used to evaluate the potential for potential groundwater-based transport and exposure pathways (DOF 2013).

[3] This potential concern is based on total arsenic concentrations of 33 ug/L to 260 ug/L in three May 2015 storm sewer samples between the northern portion of the Site/Blair Backup Property and the northern portion of the Murray Pacific #1/Superlon sites and one May 2015 outfall sample (Ecology 2015). A total arsenic concentration of 80 ug/L was detected in the only sample collected near the Site.

- Potential groundwater transport of copper, mercury, nickel, PCE, TCE, VC, and CF to the Hylebos Waterway
- VI in VOC VI Areas A through C
- Groundwater dermal contact by utility workers
- Prohibit residential land use and the use of groundwater as drinking water at the 2901 Taylor Way property

The locations of Wypenn, the portion of the Taylor Way storm sewer downgradient of the Site, the East Channel Ditch, and VOC VI Areas A through C are shown on Figure 1-1 in the main portion of the FS Report.[4]

[4] The North Boundary Area is not a potential Site concern because the North Boundary Area is no longer located within the Site boundary (Ecology 2021a; PIONEER 2021).

SECTION 2: EVALUATION OF OTHER POTENTIAL SITE CONCERNS

An evaluation of the other potential Site concerns was conducted to determine whether or not additional future remedial components need to be added to the five alternatives in order to address the other potential Site concerns. As part of the evaluation, completed remedial actions and remedial components associated with the main arsenic plume were considered since these completed and proposed actions address many of the other potential Site concerns. The evaluation is presented in Table B-5.

As summarized in Table B-5, the following completed remedial actions (designated as "OPSC-") partially or fully address some of the other potential Site concerns:

- OPSC-1: 2014 Wypenn Interim Action
- OPSC-2: 2013 to 2014 Arkema Mound Interim Action
- OPSC-3: Completed active VOC remediation in VOC VI Area A
- OPSC-4: Completed active VOC remediation in VOC VI Area B

As summarized in Table B-5, the following remedial components for the main arsenic plume partially or fully address some of the other potential Site concerns:

- APR-3A: General surface cap/cover for soil direct contact pathway
- EPC-3: Surface water and sediment monitoring
- MNA&LTC-3: Applicable engineering controls
- MNA&LTC-4: Applicable institutional controls

Based on the evaluation presented in Table B-5, the following additional future remedial components (designated as "OPSC-") will need to be added to all alternatives (to further supplement the completed remedial actions and remedial components for the main arsenic plume):

- OPSC-5: Upper Aquifer groundwater monitoring downgradient of Wypenn
- OPSC-6: Groundwater and surface water monitoring for copper, mercury, nickel, PCE, TCE, VC, and CF
- OPSC-7: Decommission Angled Shoreline MWs
- OPSC-8: VI evaluation(s)
- OPSC-9: Installation of VI mitigation system(s)
- OPSC-10: Operation, maintenance, and monitoring of VI mitigation system(s)

SECTION 3: REFERENCES

DOF. 2013. Final Remedial Investigation Report for Former Arkema Manufacturing Plant. 2901 & 2920 Taylor Way, Tacoma, Washington. September.

DOF. 2015a. As-Built Report, 2013 Interim Action. 3009 Taylor Way Interim Action. April 6.

DOF. 2015b. Interim Action Construction Report Wypenn Property Tacoma, Washington. January.

Ecology. 1994. Natural Background Soil Metals Concentrations in Washington State, Publication No. 94-115. October.

Ecology. 2001. Memorandum from Pete Kmet to Interested Persons with the subject of "Calculations for Table 745-1; Method A Soil Cleanup Levels for Commercial/Industrial Land Uses", February 9.

Ecology. 2015. Lincoln-Taylor Drains Sampling Project 5-4-15. May.

Ecology. 2021a. Letter from Joyce Mercuri to Nizar Hindi and Scott Hooton with a subject of "Re: Agreed Order No. DE 3405: Expansion of scope for Remedial Actions at the USG Taylor Way Plant Site (Cleanup Site ID #5003), under Agreed Order No. DE 3405, to include contamination within the North Boundary Area," January 13.

Ecology. 2021b. Toxics Cleanup Program's Cleanup Levels and Risk Calculations database, https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx, accessed February.

Hart Crowser. 2015. Status Report No. 18, Groundwater Compliance Monitoring OFA/Pennwalt Area, Blair Backup Property. February 4.

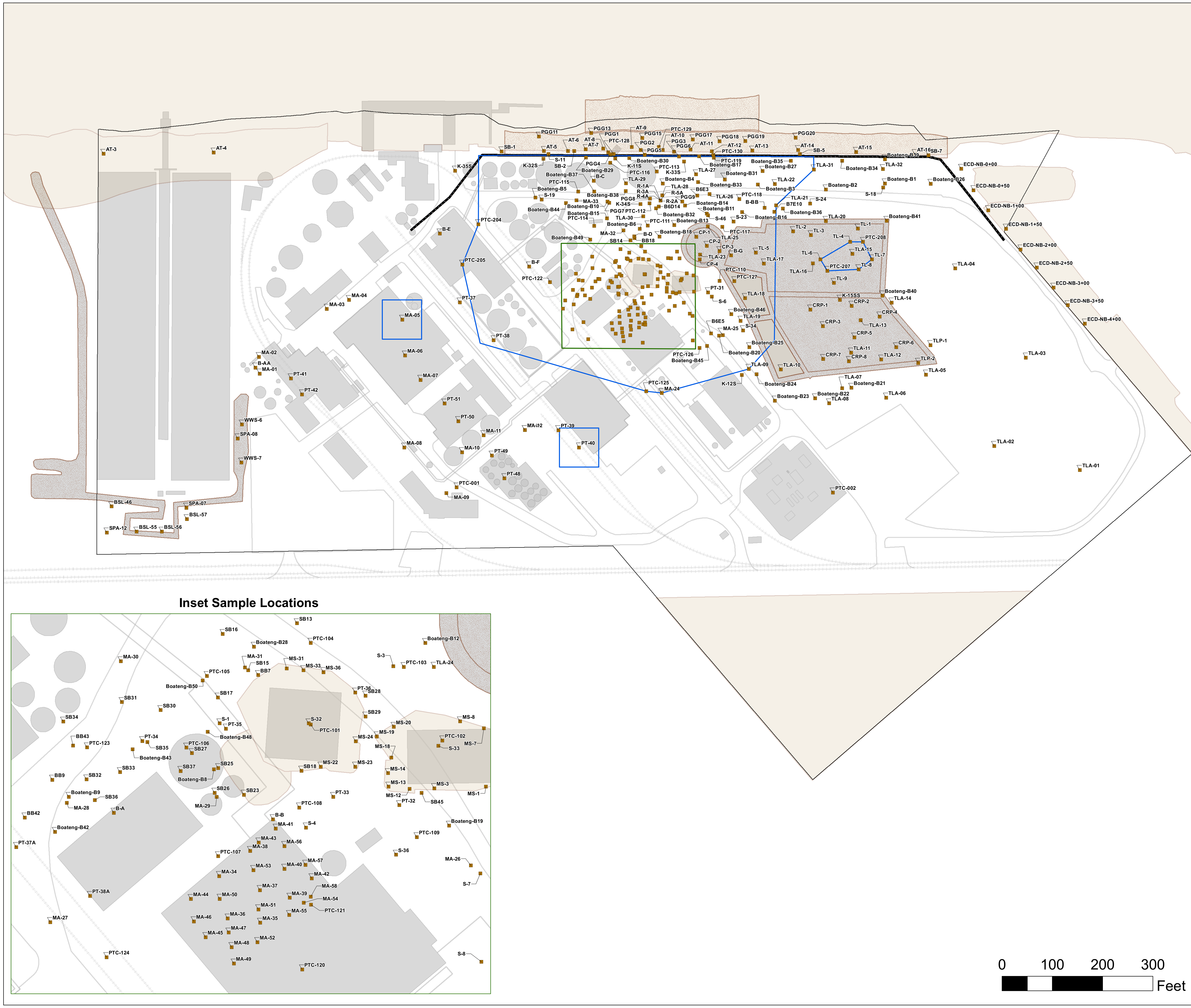
Oakley, D. and Korte, N.E. 1996. Nickel and Chromium in Ground Water Samples as Influenced by Well Construction and Sampling Methods. Groundwater Monitoring and Remediation, Winter.

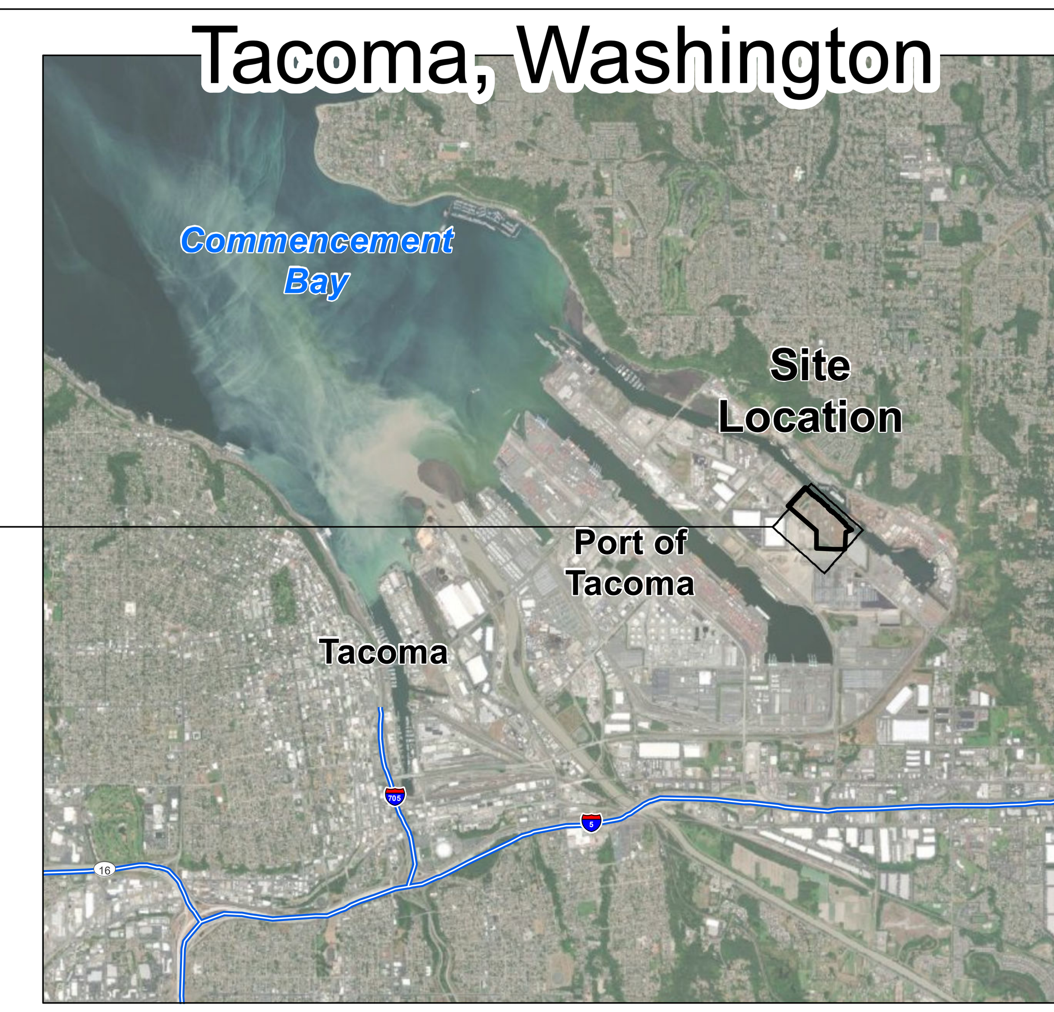
PIONEER. 2015. Presentation to Ecology and United States Environmental Protection Agency titled "Fate and Transport, CSEM, RAOs, and FS Schedule Discussion." March 31.

PIONEER. 2019. Feasibility Study Data Gap Investigation Report, Former Arkema Manufacturing Site. July.

PIONEER. 2021. North Boundary Area Feasibility Study Report, Former USG Taylor Way Plant Site. January.

Figures





Legend

- Soil Sample Locations
- APR-3A Remedial Component Footprint

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features of Interest

- Historical Infrastructure
- Site Boundary

Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-All in-place soil results between ground surface and 15 feet below ground surface are included in this figure.
-Both laboratory and field x-ray fluorescence sample results were included.

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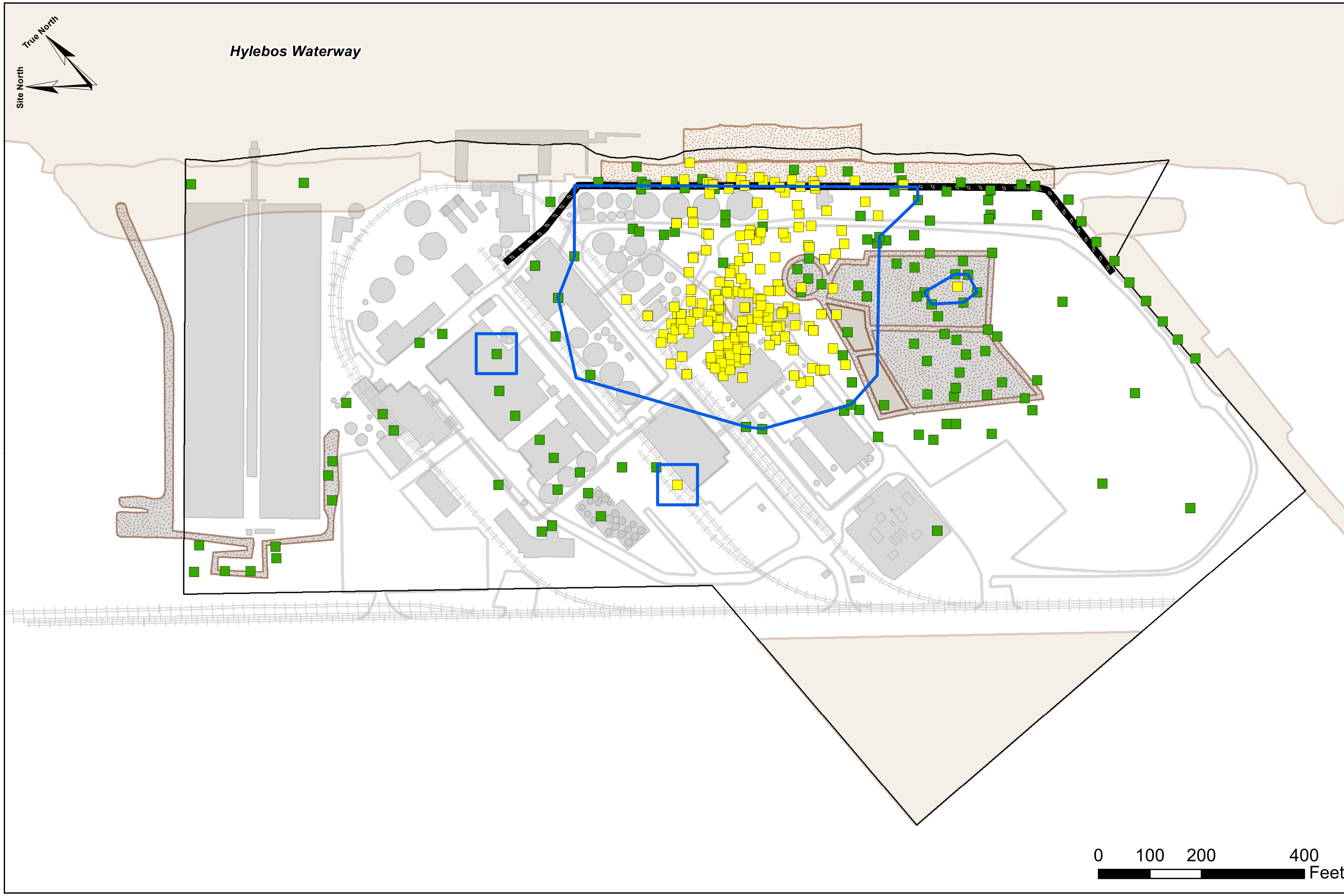
Soil Sampling Locations in the
2901 Taylor Way Portion of the Site Boundary
FS Report
Former Arkema Manufacturing Site

Figure B-1



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APR-3A Remedial Component Footprint

Arsenic Soil Concentration
- Arsenic ≤ 88 mg/kg (or non-detect)
- Arsenic > 88 mg/kg

Completed Remedial Actions
- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features of Interest
- Historical Infrastructure
- Site Boundary

Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-All in-place soil results between ground surface and 15 feet below ground surface are included in this figure.
-The maximum concentration is shown if multiple sample intervals were collected in a given boring.
-Both laboratory and field x-ray fluorescence sample results were included.

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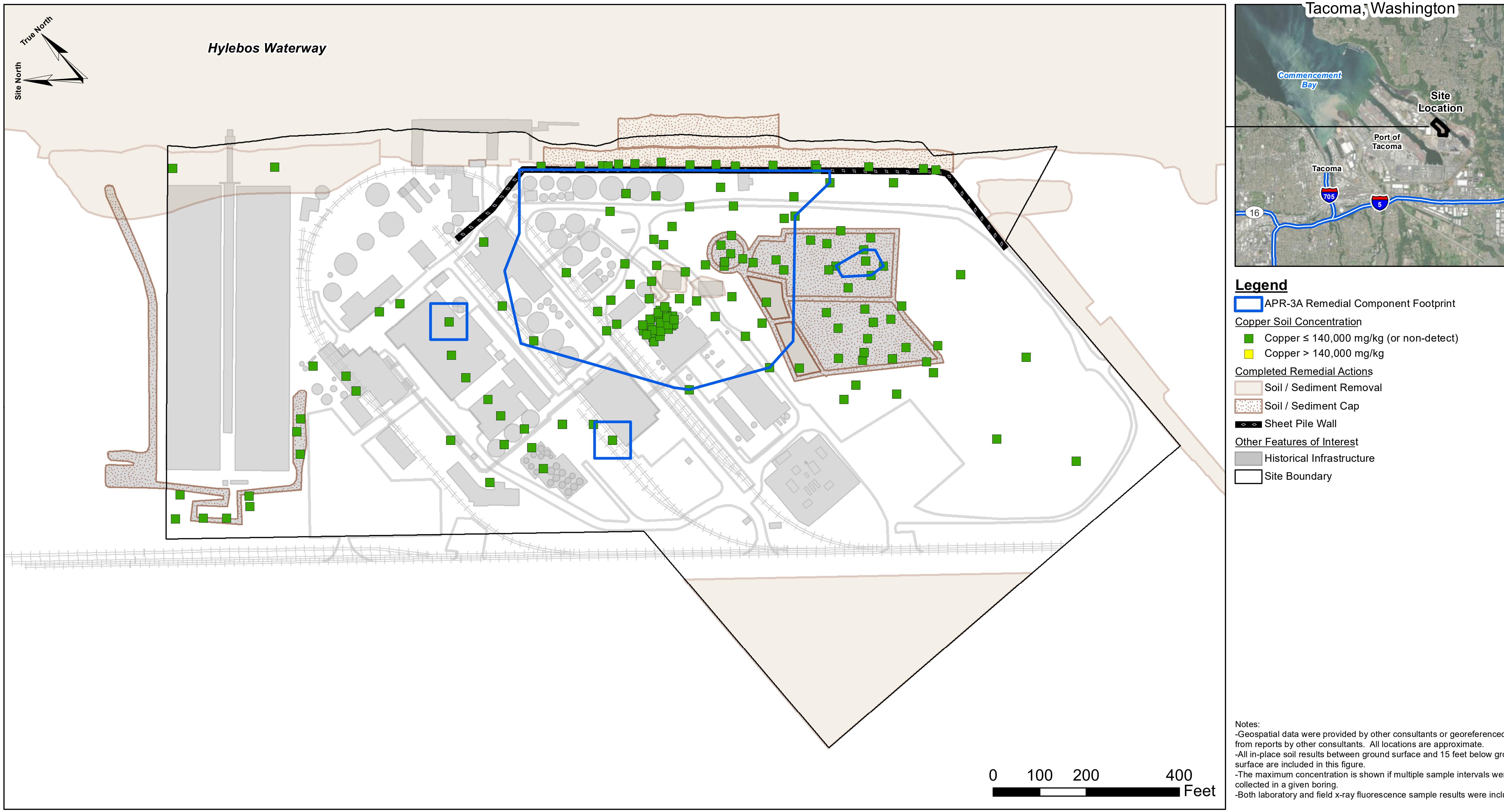
Arsenic Soil Direct Contact Results in the
2901 Taylor Way Portion of the Site Boundary
FS Report
Former Arkema Manufacturing Site

Figure B-2



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APR-3A Remedial Component Footprint

Copper Soil Concentration

- Copper ≤ 140,000 mg/kg (or non-detect)
- Copper > 140,000 mg/kg

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features of Interest

- Historical Infrastructure
- Site Boundary

Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-All in-place soil results between ground surface and 15 feet below ground surface are included in this figure.
-The maximum concentration is shown if multiple sample intervals were collected in a given boring.
-Both laboratory and field x-ray fluorescence sample results were included.

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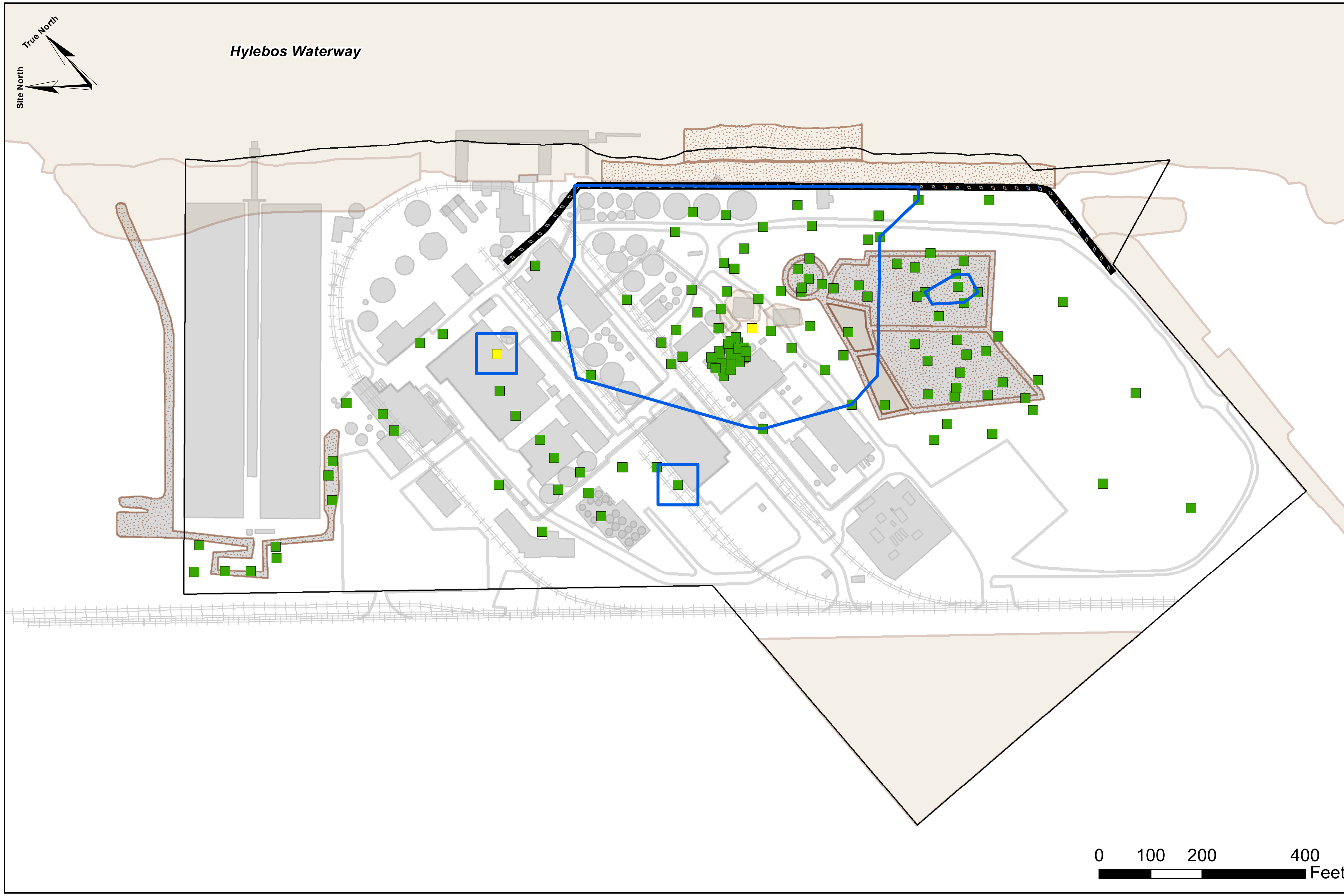
Copper Soil Direct Contact Results in the
2901 Taylor Way Portion of the Site Boundary
FS Report
Former Arkema Manufacturing Site

Figure B-3



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APR-3A Remedial Component Footprint

Lead Soil Concentration

Lead ≤ 1,000 mg/kg (or non-detect)

Lead > 1,000 mg/kg

Completed Remedial Actions

Soil / Sediment Removal

Soil / Sediment Cap

Sheet Pile Wall

Other Features of Interest

Historical Infrastructure

Site Boundary

Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-All in-place soil results between ground surface and 15 feet below ground surface are included in this figure.
-The maximum concentration is shown if multiple sample intervals were collected in a given boring.
-Both laboratory and field x-ray fluorescence sample results were included.

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Lead Soil Direct Contact Results in the
2901 Taylor Way Portion of the Site Boundary
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Former Arkema Manufacturing Site

Figure B-4

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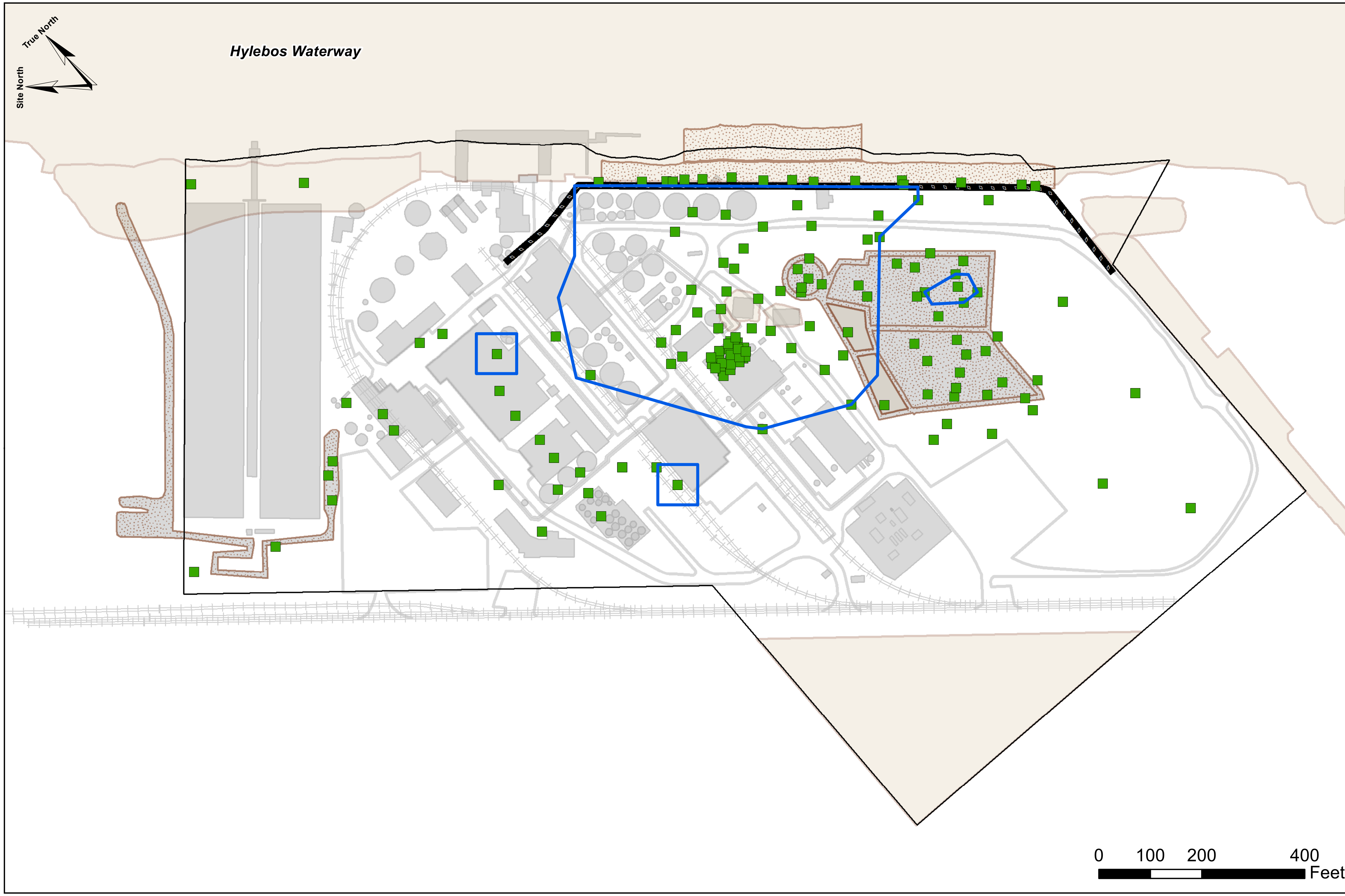

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APR-3A Remedial Component Footprint

Mercury Soil Concentration

- Mercury ≤ 1,050 mg/kg (or non-detect)
- Mercury > 1,050 mg/kg

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features of Interest

- Historical Infrastructure
- Site Boundary

Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-All in-place soil results between ground surface and 15 feet below ground surface are included in this figure.
-The maximum concentration is shown if multiple sample intervals were collected in a given boring.
-Both laboratory and field x-ray fluorescence sample results were included.

Document Path: G:\Projects\Arkema\Maps\FS Report\App B\B-5_Mercury_Soil.mxd; Author: VN; Date Saved: 3/26/2021

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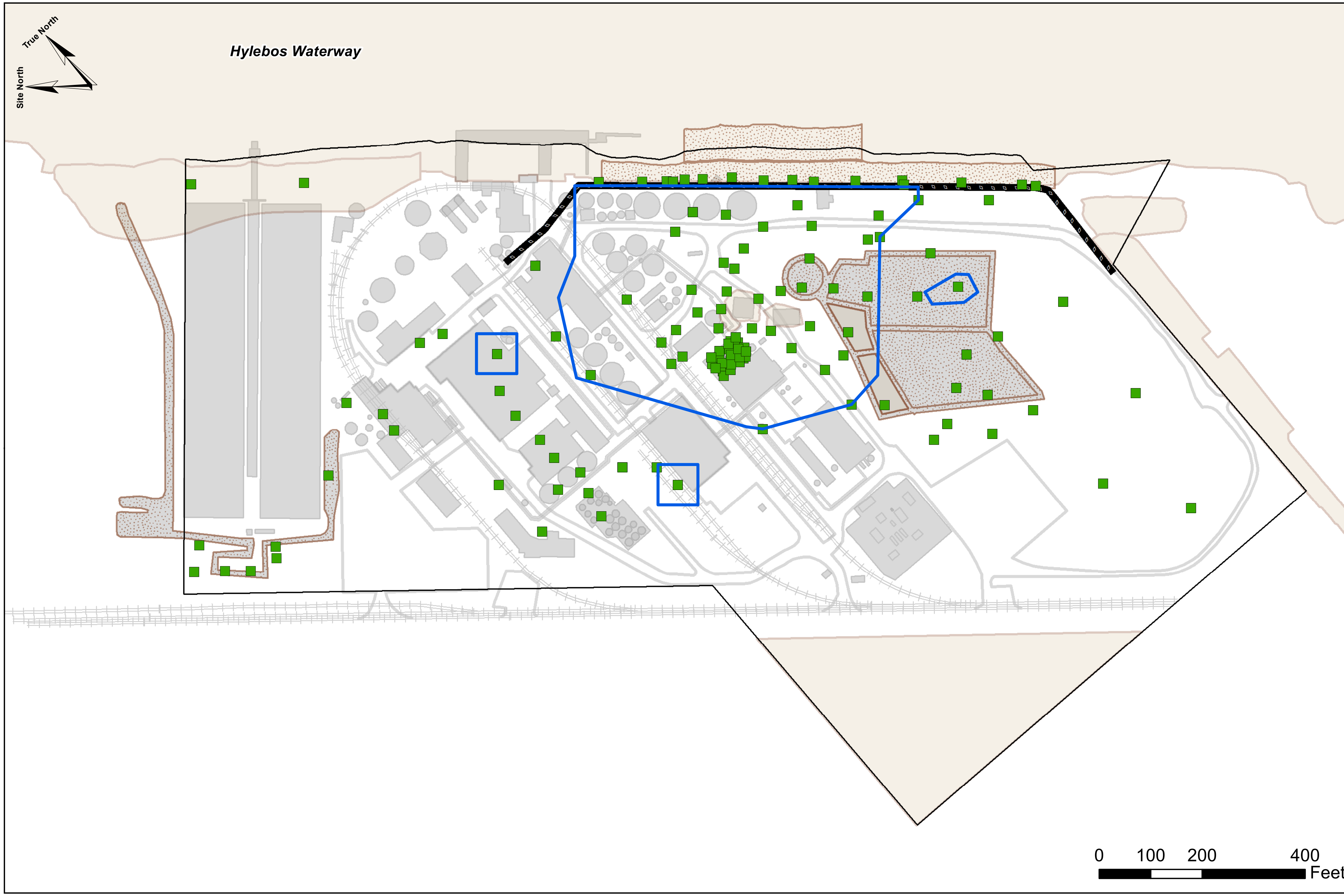
Mercury Soil Direct Contact Results in the
2901 Taylor Way Portion of the Site Boundary
FS Report
Former Arkema Manufacturing Site

Figure B-5



Legend

APR-3A Remedial Component Footprint

Nickel Soil Concentration
- Nickel ≤ 70,000 mg/kg (or non-detect)
- Nickel > 70,000 mg/kg

Completed Remedial Actions
- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features of Interest
- Historical Infrastructure
- Site Boundary

Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-All in-place soil results between ground surface and 15 feet below ground surface are included in this figure.
-The maximum concentration is shown if multiple sample intervals were collected in a given boring.
-Both laboratory and field x-ray fluorescence sample results were included.

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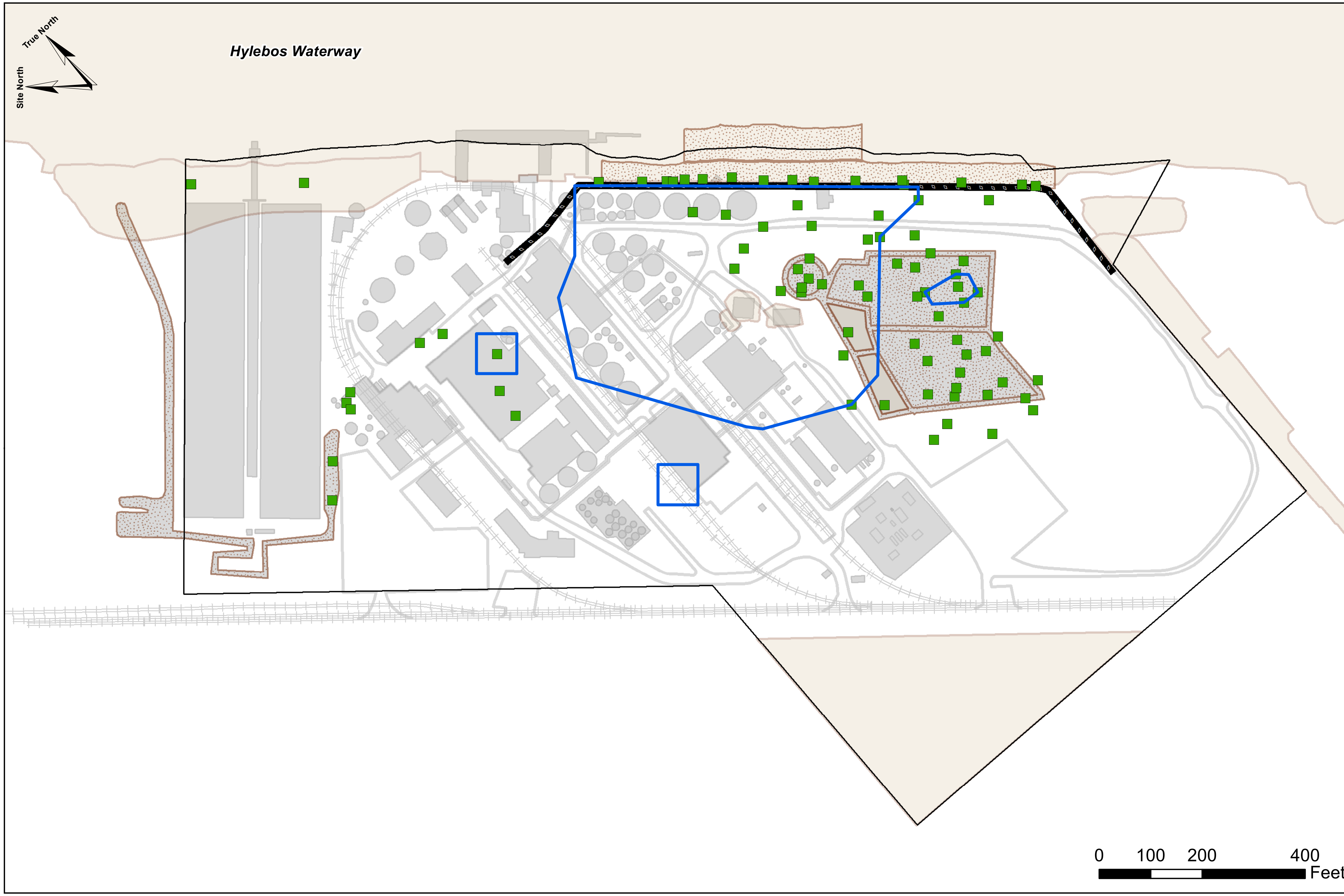
Nickel Soil Direct Contact Exceedances in the 2901 Taylor Way Portion of the Site Boundary
FS Report
Former Arkema Manufacturing Site

Figure B-6

Document Path: G:\Projects\Arkema\Maps\FS Report\App B\B-6_Nickel_Soil.mxd; Author: VN; Date Saved: 3/26/2021



Legend

APR-3A Remedial Component Footprint

Tetrachloroethylene

- Tetrachloroethylene ≤ 21,000 mg/kg (or non-detect)
- Tetrachloroethylene > 21,000 mg/kg

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features of Interest

- Historical Infrastructure
- Site Boundary

Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-All in-place soil results between ground surface and 15 feet below ground surface are included in this figure.
-The maximum concentration is shown if multiple sample intervals were collected in a given boring.
-Both laboratory and field x-ray fluorescence sample results were included.

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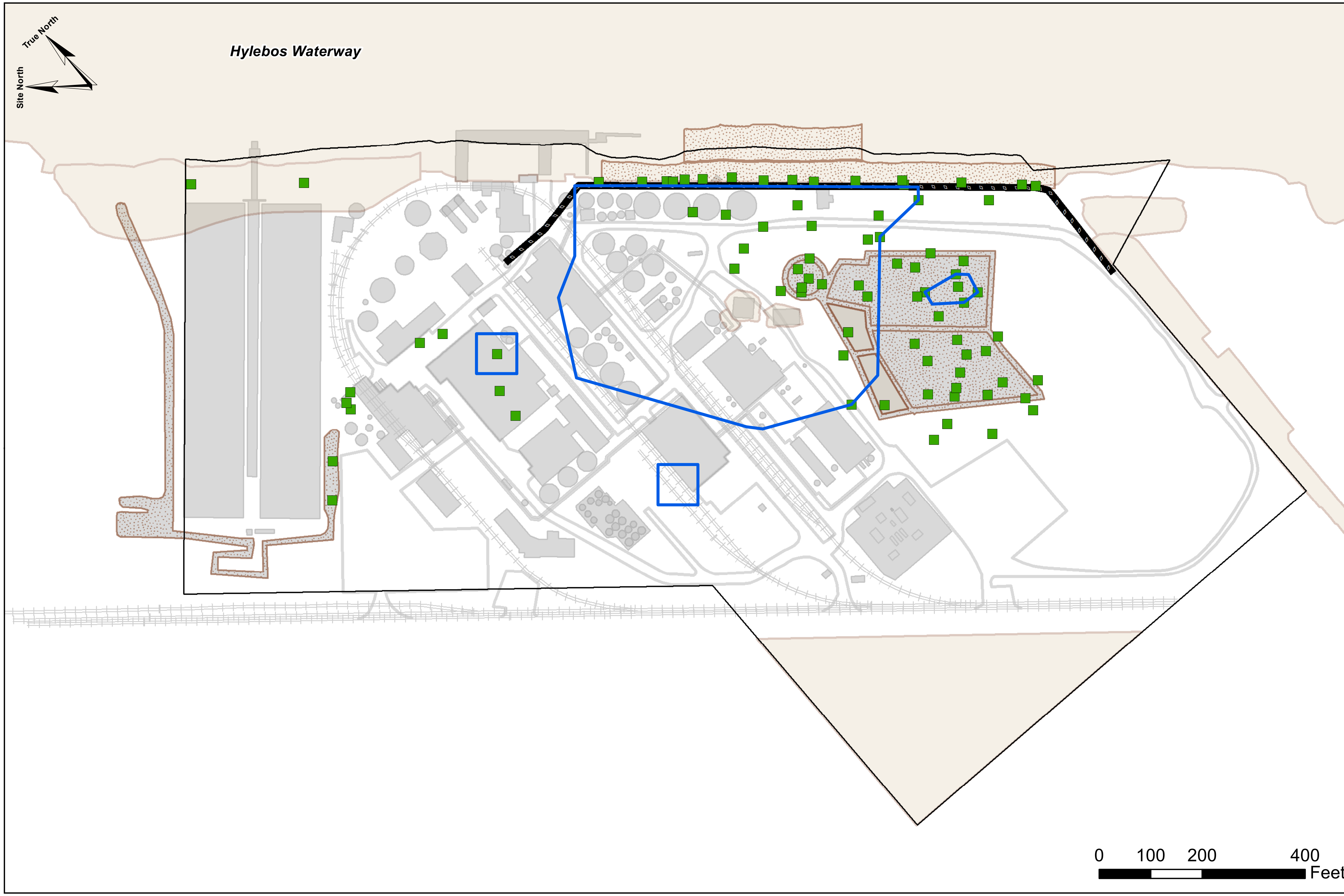
Tetrachloroethylene Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary
FS Report
Former Arkema Manufacturing Site

Figure B-7



Legend

APR-3A Remedial Component Footprint

Trichloroethylene Soil Concentration

- Trichloroethylene ≤ 1,800 mg/kg (or non-detect)
- Trichloroethylene > 1,800 mg/kg

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features of Interest

- Historical Infrastructure
- Site Boundary

Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-All in-place soil results between ground surface and 15 feet below ground surface are included in this figure.
-The maximum concentration is shown if multiple sample intervals were collected in a given boring.
-Both laboratory and field x-ray fluorescence sample results were included.

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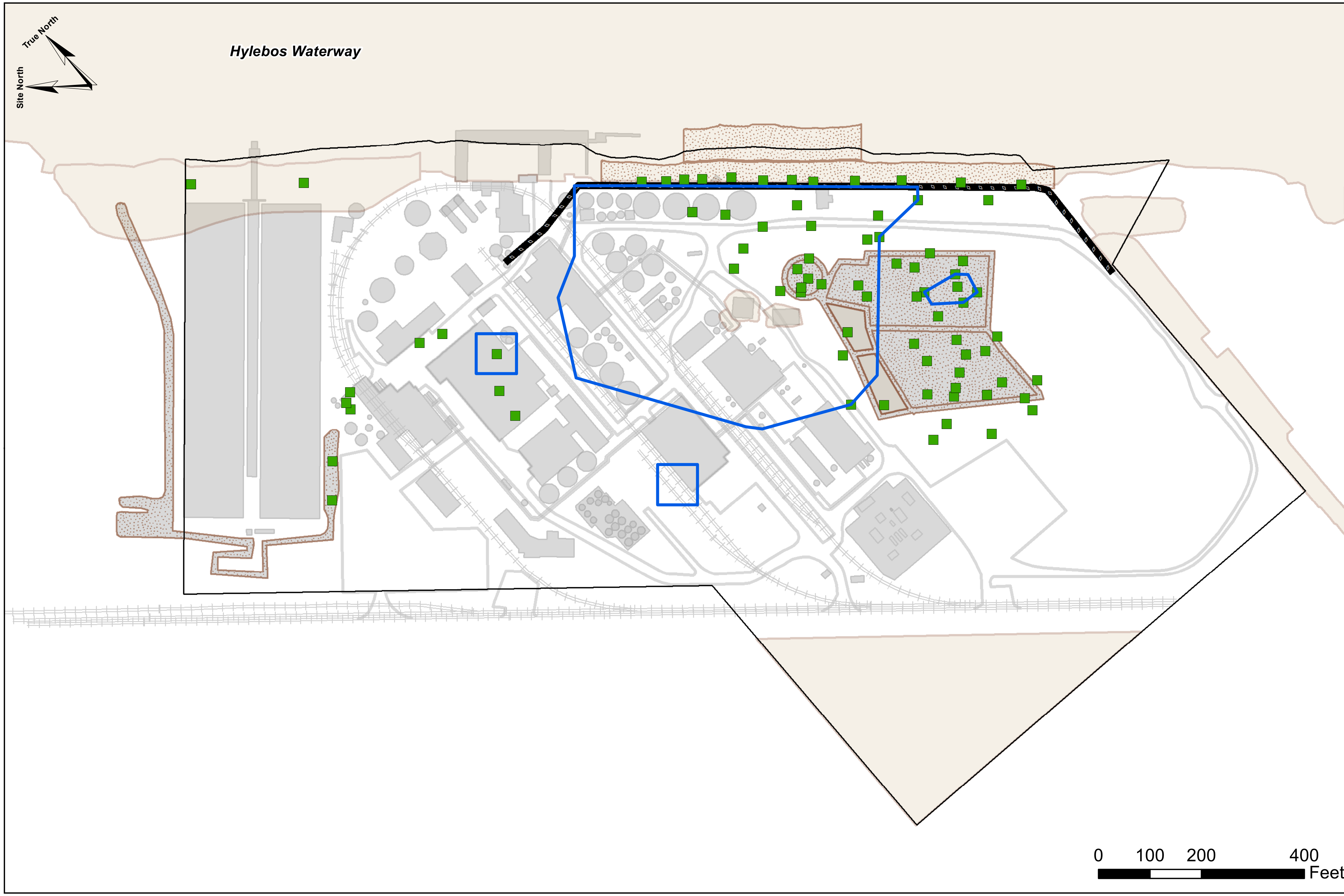
Trichloroethylene Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary
FS Report
Former Arkema Manufacturing Site

Figure B-8



Legend

APR-3A Remedial Component Footprint

Vinyl Chloride Soil Concentration
- Vinyl Chloride ≤ 88 mg/kg (or non-detect)
- Vinyl Chloride > 88 mg/kg

Completed Remedial Actions
- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features of Interest
- Historical Infrastructure
- Site Boundary

Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-All in-place soil results between ground surface and 15 feet below ground surface are included in this figure.
-The maximum concentration is shown if multiple sample intervals were collected in a given boring.
-Both laboratory and field x-ray fluorescence sample results were included.

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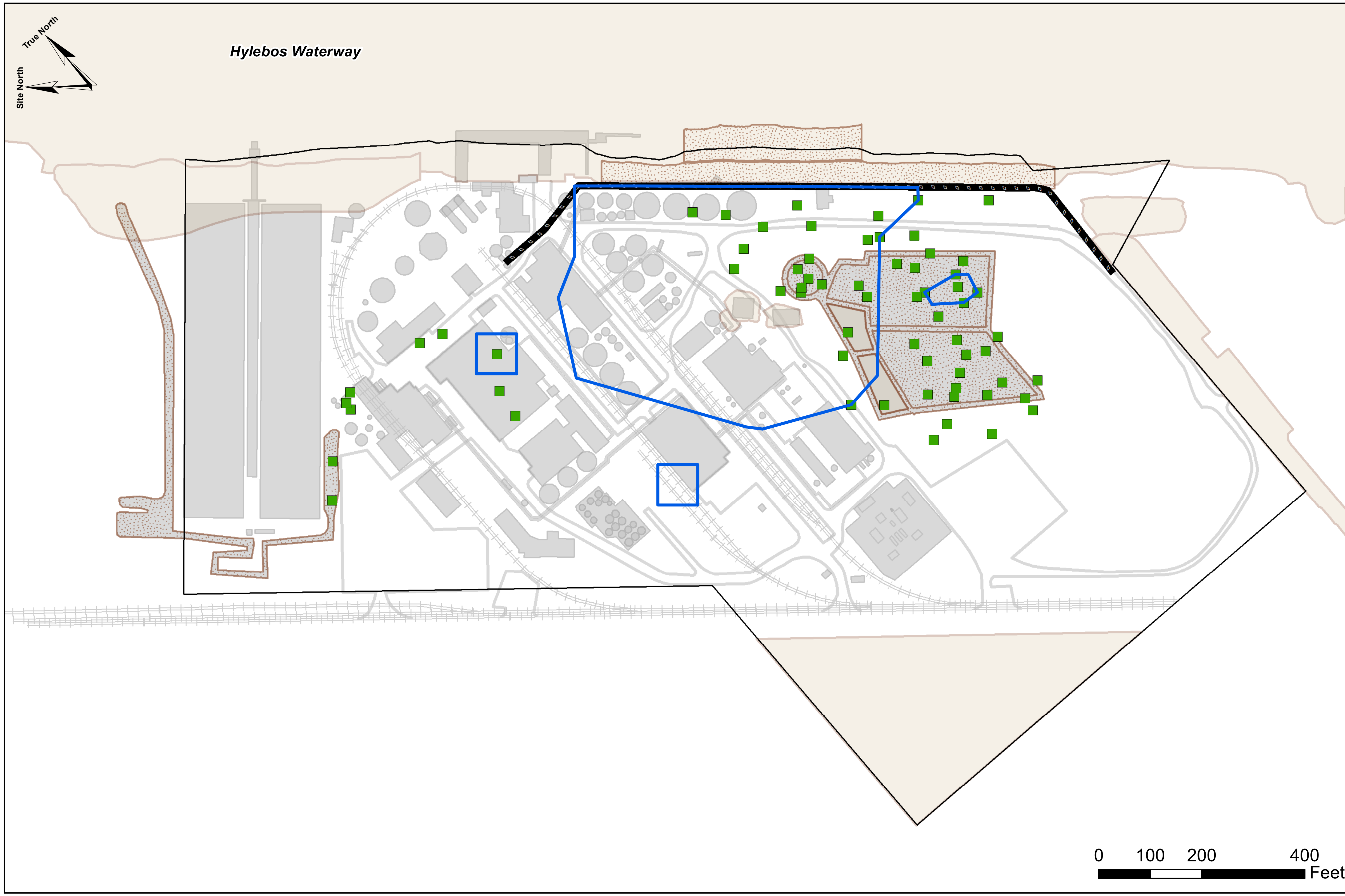
Vinyl Chloride Soil Direct Contact Results in the
2901 Taylor Way Portion of the Site Boundary
FS Report
Former Arkema Manufacturing Site

Figure B-9

Document Path: G:\Projects\Arkema\Maps\FS Report\App B\B-9_Vinyl Chloride_Soil.mxd; Author: VN; Date Saved: 3/26/2021



Legend

APR-3A Remedial Component Footprint

Chloroform Soil Concentration

- Chloroform ≤ 4,200 mg/kg (or non-detect)
- Chloroform > 4,200 mg/kg

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features of Interest

- Historical Infrastructure
- Site Boundary

Notes:
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-All in-place soil results between ground surface and 15 feet below ground surface are included in this figure.
-The maximum concentration is shown if multiple sample intervals were collected in a given boring.
-Both laboratory and field x-ray fluorescence sample results were included.

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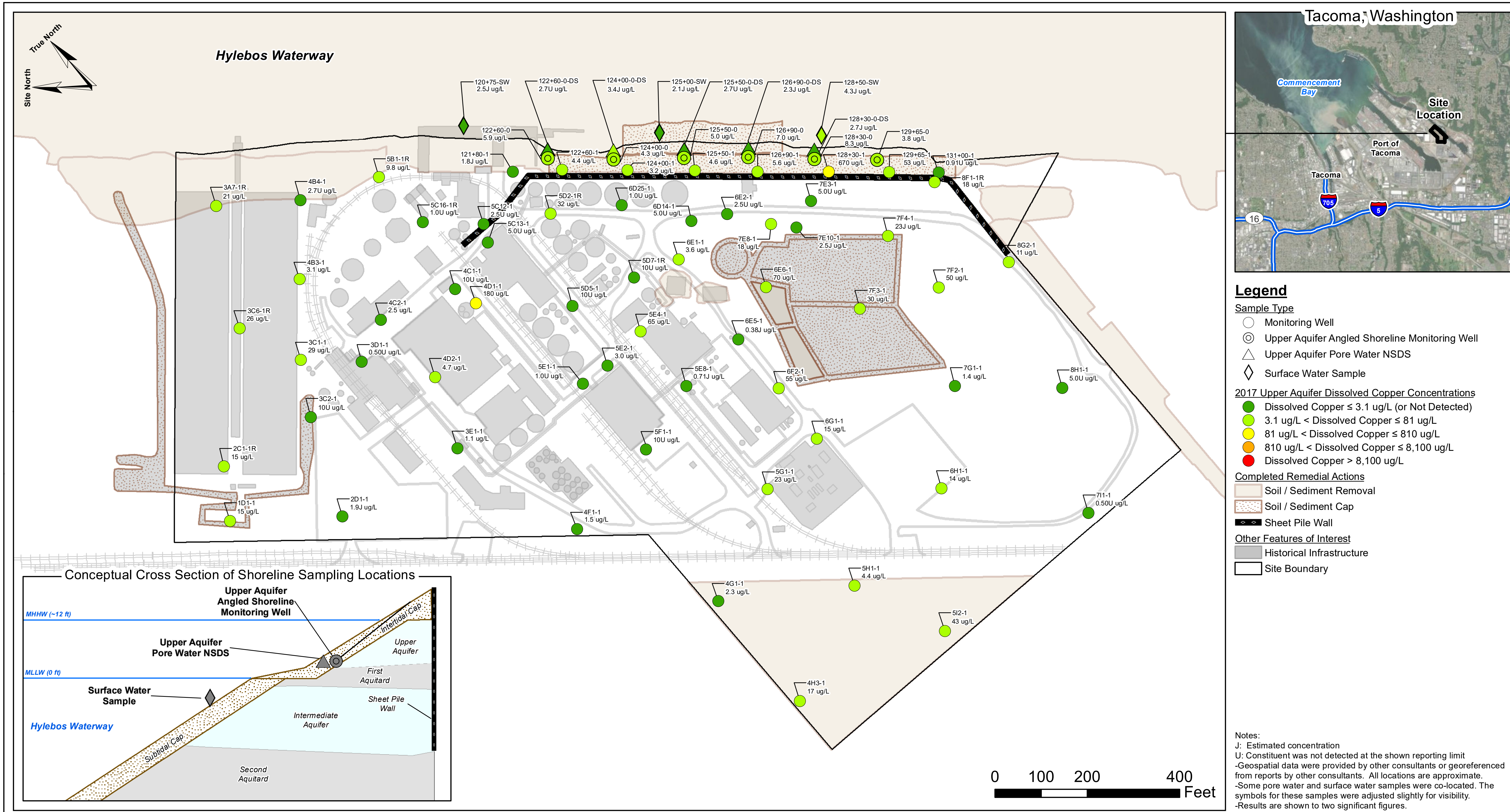
Chloroform Soil Direct Contact Results in the
2901 Taylor Way Portion of the Site Boundary
FS Report
Former Arkema Manufacturing Site

Figure B-10

Document Path: G:\Projects\Arkema\Maps\FS Report\App B\B-10_Chloroform_Soil.mxd; Author: VN; Date Saved: 3/26/2021

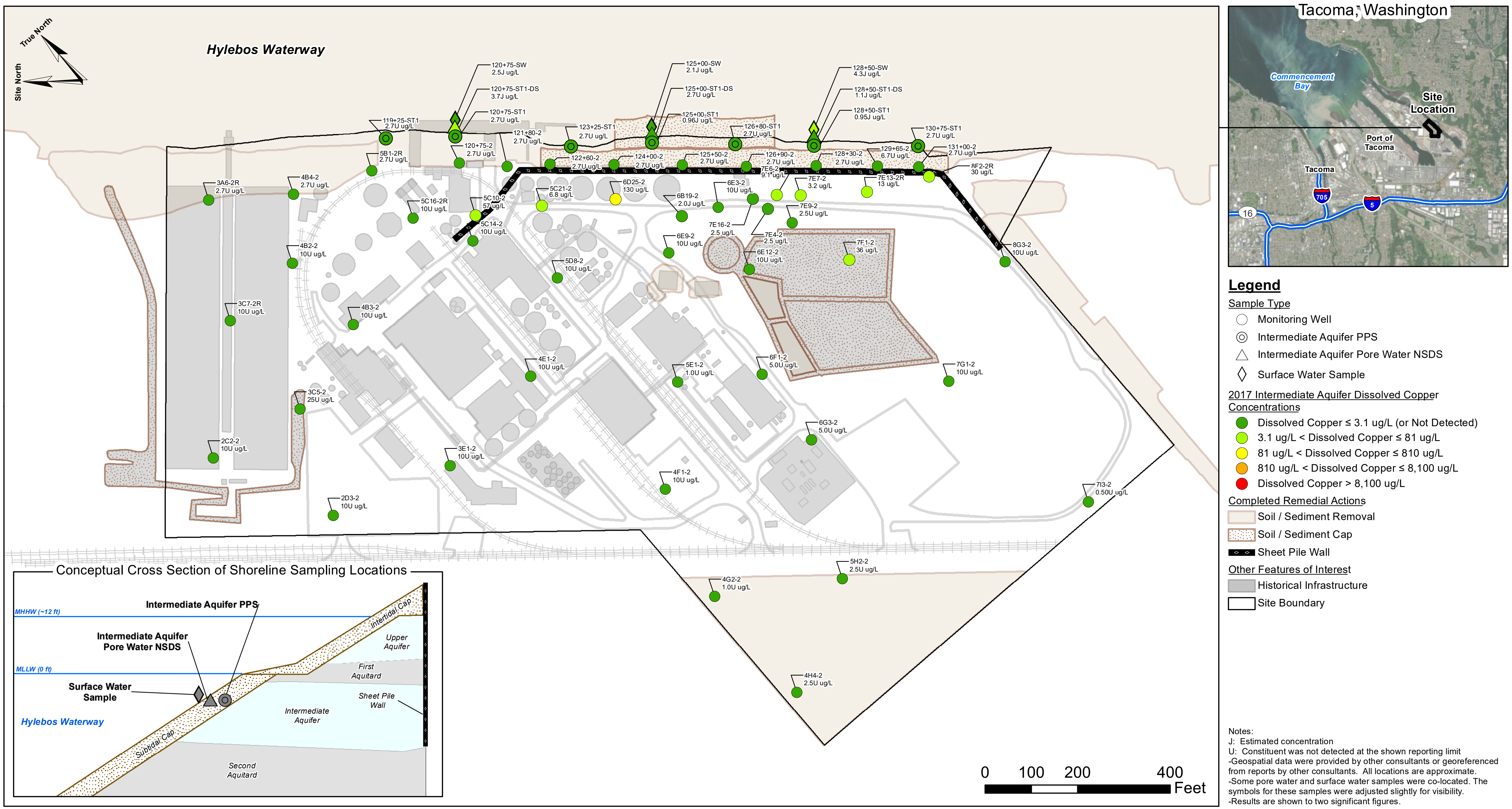


PIONEER TECHNOLOGIES CORPORATION

2017 Dissolved Copper Surface Water SL Exceedances in the Upper Aquifer
FS Report
Former Arkema Manufacturing Site

Figure B-11

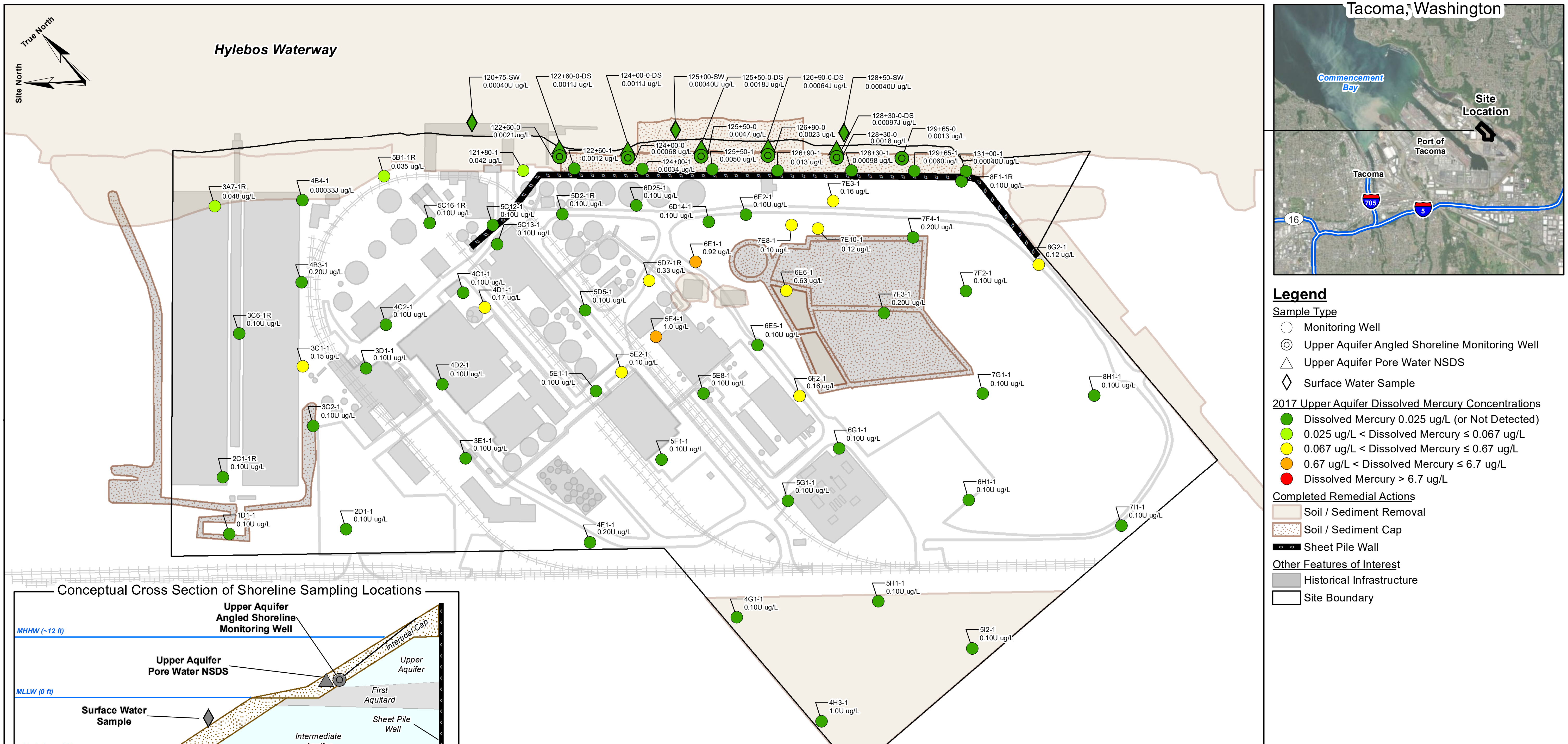
Document Path: G:\Projects\Arkema\Maps\FS Report\App B\B-11_2017_UA_Copper.mxd; Author: VN; Date Saved: 3/23/2021



PIONEER TECHNOLOGIES CORPORATION

2017 Dissolved Copper Surface Water SL Exceedances in the Intermediate Aquifer
FS Report
Former Arkema Manufacturing Site

Figure B-12

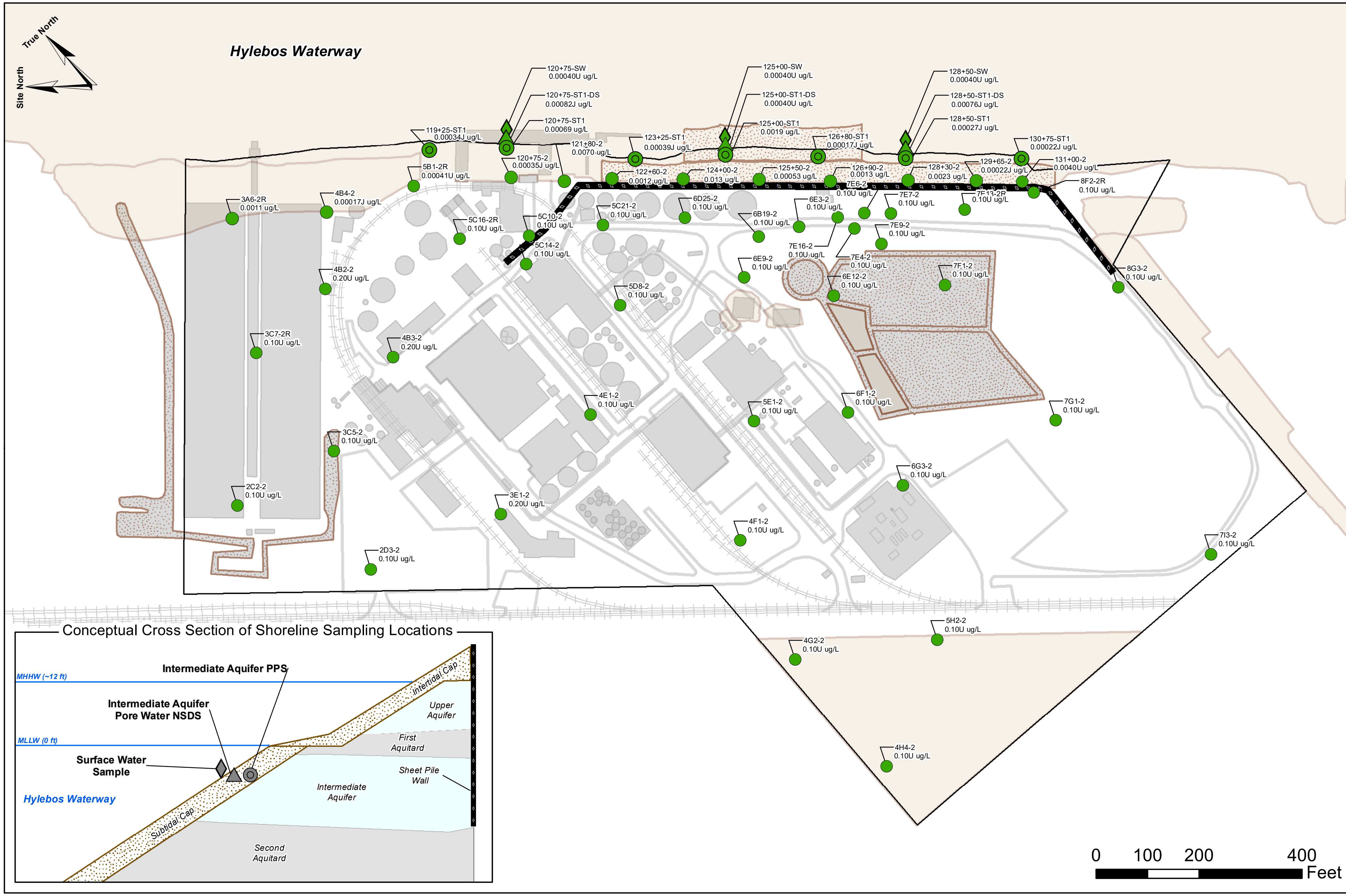


Notes:
J: Estimated concentration
U: Constituent was not detected at the shown reporting limit
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-Some pore water and surface water samples were co-located. The symbols for these samples were adjusted slightly for visibility.
-Results are shown to two significant figures.

PIONEER TECHNOLOGIES CORPORATION

2017 Dissolved Mercury Surface Water SL Exceedances in the Upper Aquifer
FS Report
Former Arkema Manufacturing Site

Figure B-13



Legend

Sample Type
- Monitoring Well
- Intermediate Aquifer PPS
- Intermediate Aquifer Pore Water NSDS
- Surface Water Sample

2017 Intermediate Aquifer Dissolved Mercury Concentrations
- Dissolved Mercury 0.025 ug/L (or Not Detected)
- 0.025 ug/L < Dissolved Mercury ≤ 0.067 ug/L
- 0.067 ug/L < Dissolved Mercury ≤ 0.67 ug/L
- 0.67 ug/L < Dissolved Mercury ≤ 6.7 ug/L
- Dissolved Mercury > 6.7 ug/L

Completed Remedial Actions
- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features of Interest
- Historical Infrastructure
- Site Boundary

Notes:
J: Estimated concentration
U: Constituent was not detected at the shown reporting limit
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-Some pore water and surface water samples were co-located. The symbols for these samples were adjusted slightly for visibility.
-Results are shown to two significant figures.

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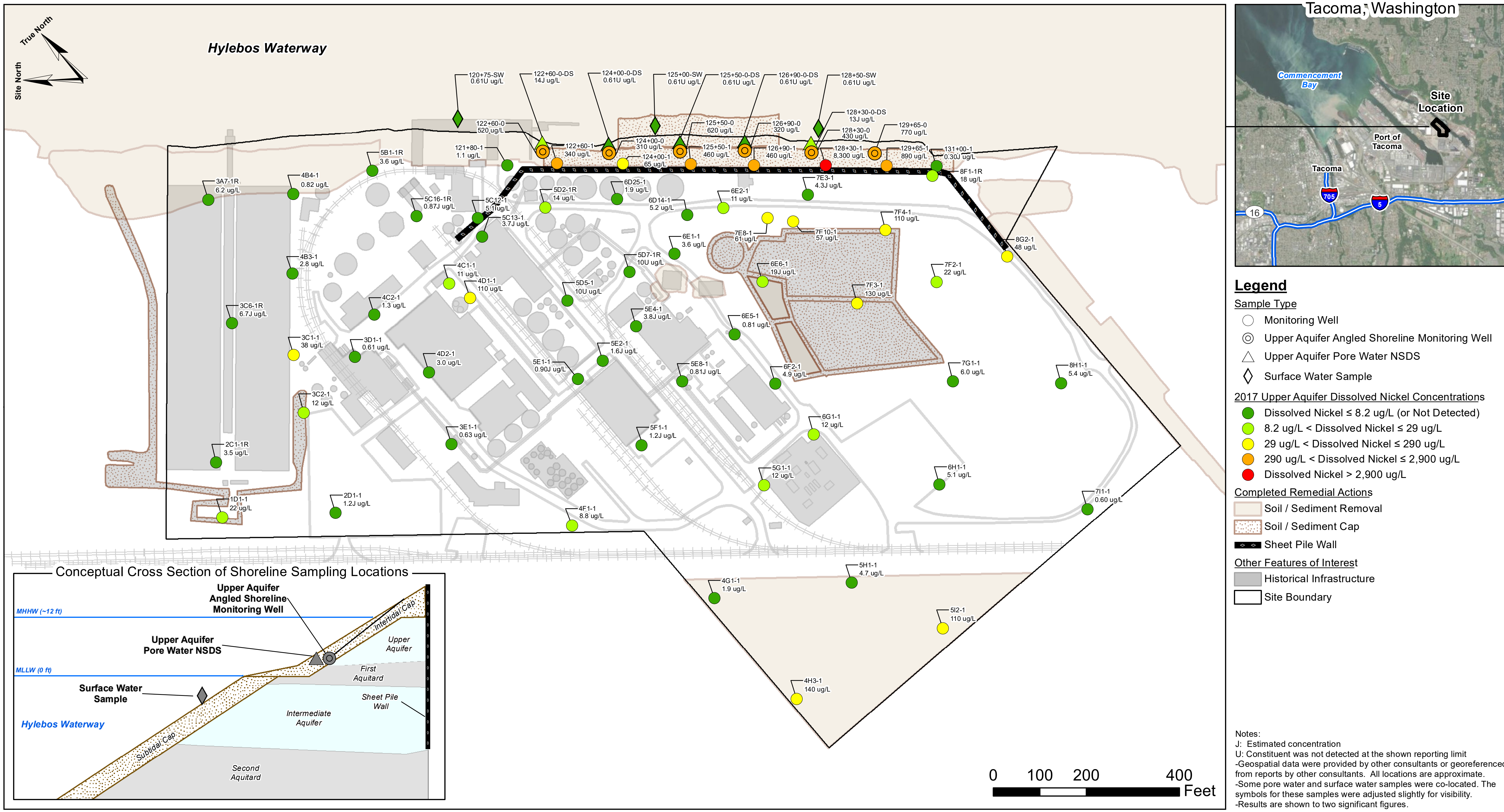
2017 Dissolved Mercury Surface Water SL Exceedances in the Intermediate Aquifer
FS Report
Former Arkema Manufacturing Site

Figure B-14

Document Path: G:\Projects\Arkema\Maps\FS Report\App B\B-14_2017_IA_Mercury.mxd; Author: VN; Date Saved: 3/17/2021

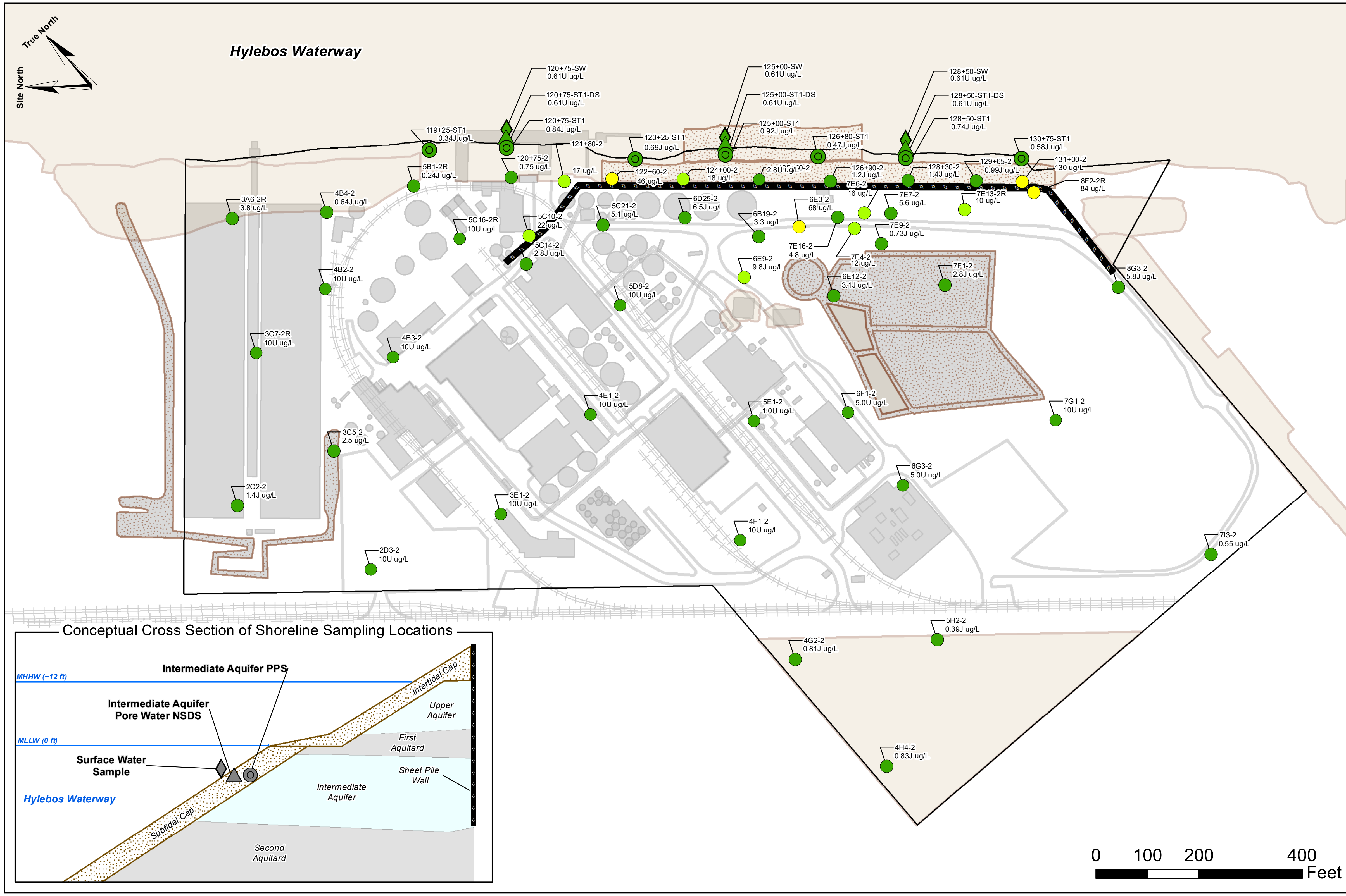


PIONEER TECHNOLOGIES CORPORATION

2017 Dissolved Nickel Surface Water SL Exceedances in the Upper Aquifer
FS Report
Former Arkema Manufacturing Site

Figure B-15

Document Path: G:\Projects\Arkema\Maps\FS Report\App B\B-15_2017_UA_Nickel.mxd; Author: VN; Date Saved: 3/17/2021



Legend

Sample Type

- Monitoring Well
- Intermediate Aquifer PPS
- Intermediate Aquifer Pore Water NSDS
- Surface Water Sample

2017 Intermediate Aquifer Dissolved Nickel Concentrations

- Dissolved Nickel ≤ 8.2 ug/L (or Not Detected)
- 8.2 ug/L < Dissolved Nickel ≤ 29 ug/L
- 29 ug/L < Dissolved Nickel ≤ 290 ug/L
- 290 ug/L < Dissolved Nickel ≤ 2,900 ug/L
- Dissolved Nickel > 2,900 ug/L

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features of Interest

- Historical Infrastructure
- Site Boundary

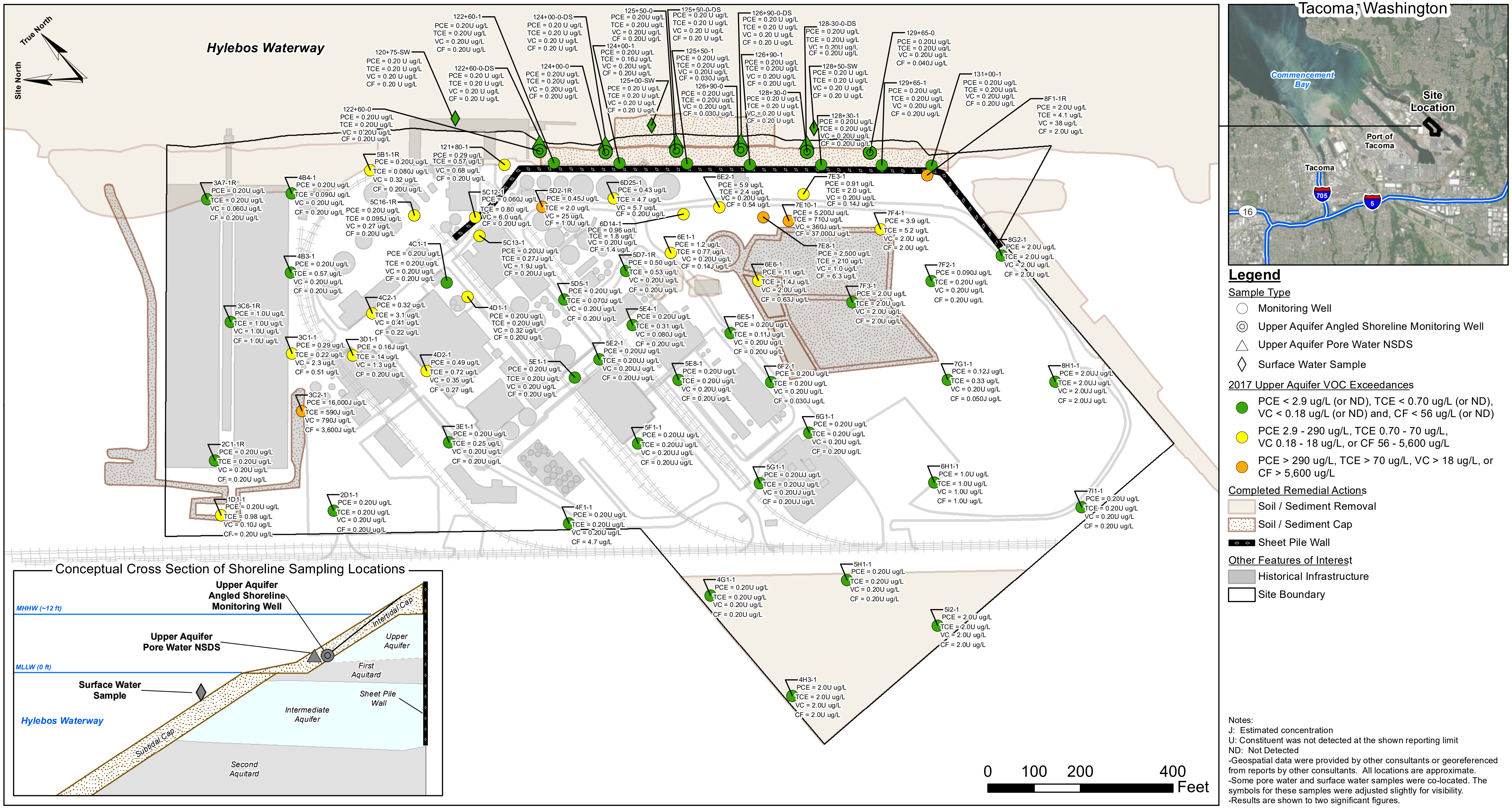
Notes:
J: Estimated concentration
U: Constituent was not detected at the shown reporting limit
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-Some pore water and surface water samples were co-located. The symbols for these samples were adjusted slightly for visibility.
-Results are shown to two significant figures.

PIONEER TECHNOLOGIES CORPORATION

2017 Dissolved Nickel Surface Water SL Exeedances in the Intermediate Aquifer
FS Report
Former Arkema Manufacturing Site

Figure B-16

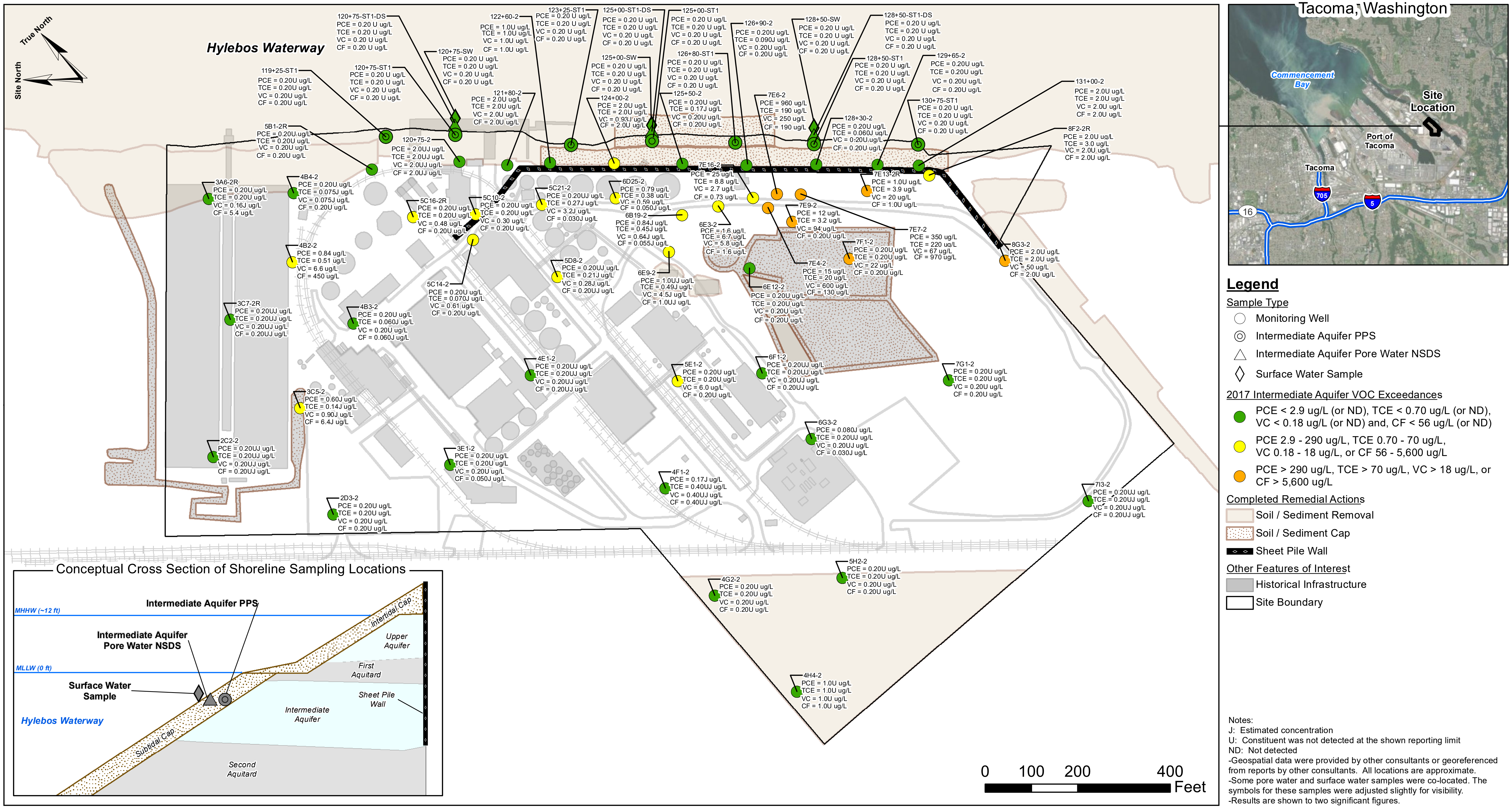
Document Path: G:\Projects\Arkema\Maps\FS Report\App B\B-16_2017_IA_Nickel.mxd; Author: VN; Date Saved: 3/17/2021



PIONEER TECHNOLOGIES CORPORATION

2017 VOC Surface Water SL Exceedances in the Upper Aquifer
FS Report
Former Arkema Manufacturing Site

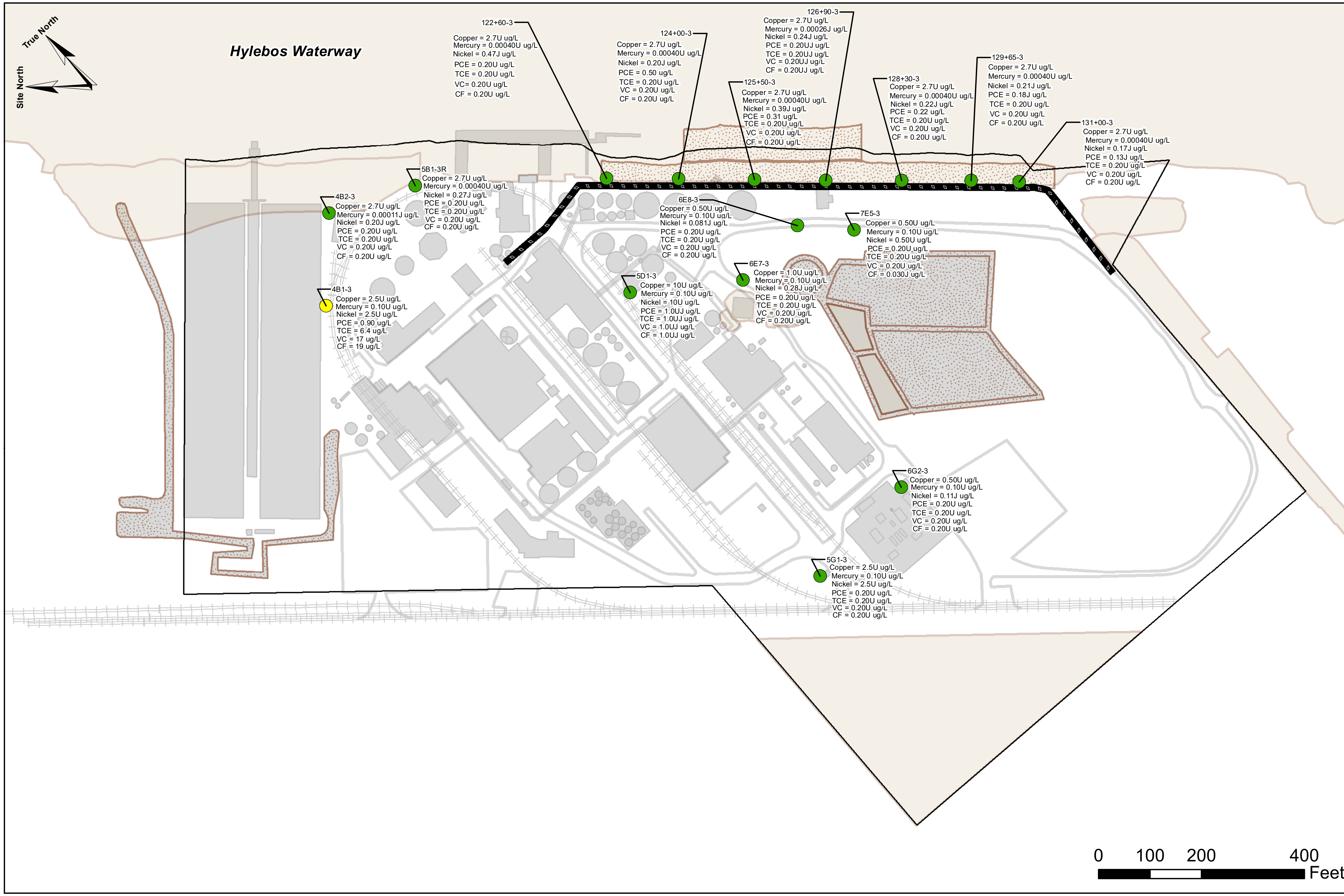
Figure B-17



PIONEER TECHNOLOGIES CORPORATION

2017 VOC Surface Water SL Exceedances in the Intermediate Aquifer
FS Report
Former Arkema Manufacturing Site

Figure B-18



Legend

Sample Type

- Monitoring Well

2017 Deep Aquifer Non-Arsenic Exceedances

- Copper ≤ 3.1 ug/L (or ND), Mercury ≤ 0.025 ug/L (or ND), Nickel ≤ 8.2 ug/L (or ND), PCE ≤ 2.9 ug/L (or ND), TCE ≤ 0.70 ug/L (or ND), VC ≤ 0.18 ug/L (or ND), and CF ≤ 56 ug/L (or ND)
- Copper 3.1 - 810 ug/L, Mercury 0.025 - 0.67 ug/L, Nickel 8.2 - 290 ug/L, PCE 2.9 - 290 ug/L, TCE 0.70 - 70 ug/L, VC 0.18 - 18 ug/L, or CF 56 - 5,600 ug/L
- Copper > 3.1 ug/L, Mercury > 0.67 ug/L, Nickel > 290 ug/L, PCE > 290 ug/L, TCE > 70 ug/L, VC > 18 ug/L, or CF > 5,600 ug/L

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features of Interest

- Historical Infrastructure
- Site Boundary

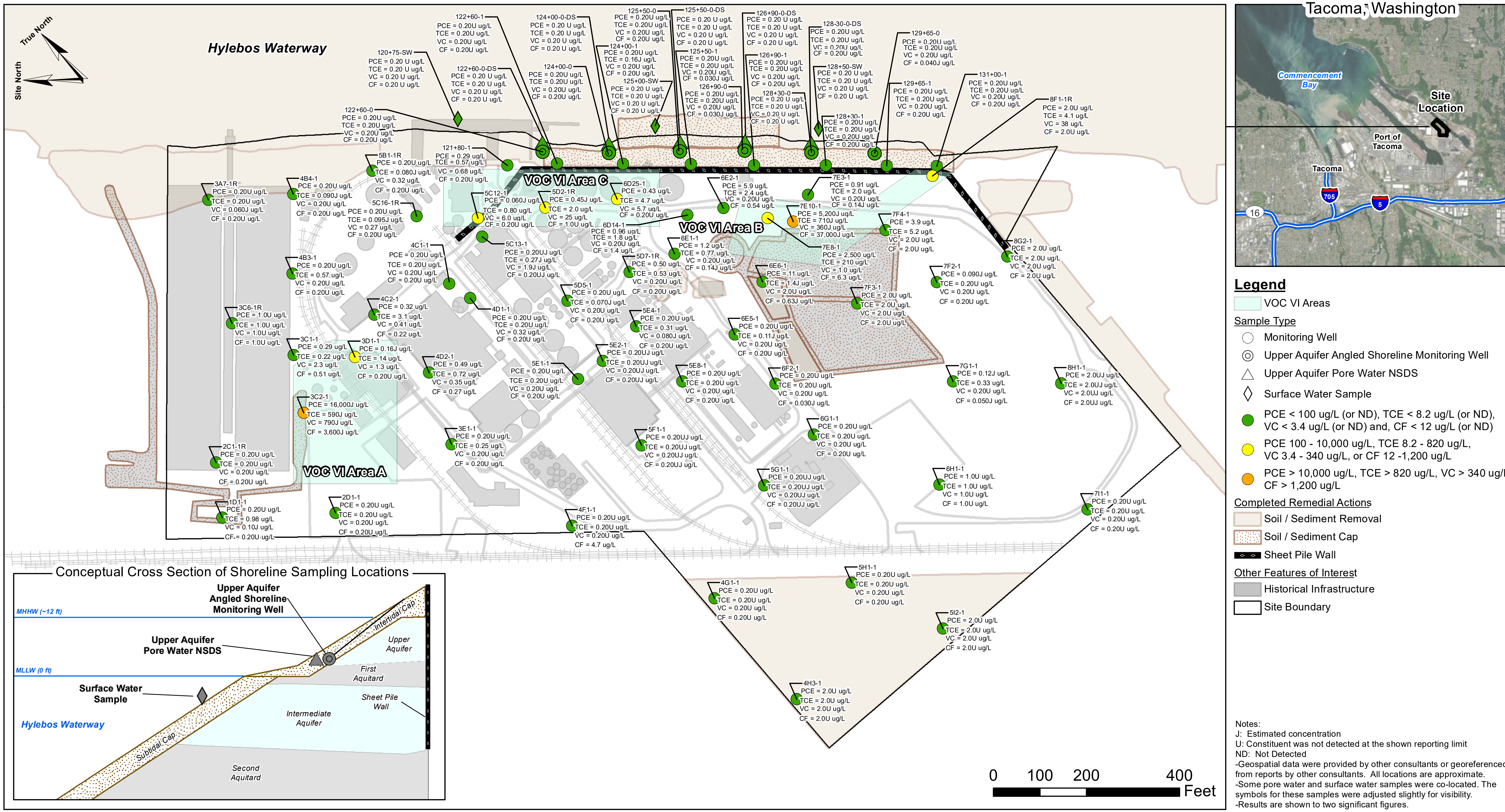
Notes:
J: Estimated concentration
U: Constituent was not detected at the shown reporting limit
ND: Not Detected
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-Some pore water and surface water samples were co-located. The symbols for these samples were adjusted slightly for visibility.
-Results are shown to two significant figures.

PIONEER TECHNOLOGIES CORPORATION

2017 Non-Arsenic Surface Water SL Exceedances in the Deep Aquifer
FS Report
Former Arkema Manufacturing Site

Figure B-19

Document Path: G:\Projects\Arkema\Maps\FS Report\App B\B-19_2017_DA_NonArsenic.mxd; Author: VN; Date Saved: 3/24/2021



PIONEER TECHNOLOGIES CORPORATION

2017 VOC Vapor Intrusion SL Exceedances in the Upper Aquifer
FS Report
Former Arkema Manufacturing Site

Figure B-20

Tables

Table B-1: Soil Direct Contact Screening Levels

COPC	Standard Method C Soil Value for Carcinogens [1] (mg/kg)	Standard Method C Soil Value for Non-carcinogens [1] (mg/kg)	Soil Direct Contact Screening Level for Commercial/Industrial Land Use [2] (mg/kg)
Arsenic	88	1,100	88
Copper	--	140,000	140,000
Lead	--	--	1,000 [3]
Mercury	--	1,050 [4]	1,050
Nickel	--	70,000	70,000
Tetrachloroethylene	63,000	21,000	21,000
Trichloroethylene	2,900	1,800	1,800
Vinyl Chloride	88	11,000	88
Chloroform	4,200	35,000	4,200

Notes:

--: No value exists for this constituent in the CLARC database (Ecology 2021b).

All values are presented as two significant figures in standard notation.

[1] Values from CLARC (Ecology 2021b), unless otherwise noted.

[2] The screening level is the most stringent of the carcinogenic and non-carcinogenic values.

[3] MTCA Method A industrial soil cleanup level for lead.

[4] Default direct contact values for a commercial/industrial land use scenario (Ecology 2001).

Table B-2: Surface Water Screening Levels

Groundwater COPC	Standard Method B Surface Water Value for Carcinogens [2] (ug/L)	Standard Method B Surface Water Value for Non-Carcinogens [2] (ug/L)	Surface Water Value for Acute Marine Aquatic Life 173-201A WAC [2] (ug/L)	Surface Water Value for Acute Marine Aquatic Life CWA §304 [2] (ug/L)	Surface Water Value for Chronic Marine Aquatic Life 173-201A WAC [2] (ug/L)	Surface Water Value for Chronic Marine Aquatic Life CWA §304 [2] (ug/L)	Surface Water Value for Human Health in Marine Waters 173-201A WAC [2] (ug/L)	Surface Water Value for Human Health in Marine Waters 40 CFR 131.45 [2] (ug/L)	Surface Water Value for Human Health in Marine Waters CWA §304 [2] (ug/L)	SL [3] (ug/L)
Arsenic	0.098	18	69	69	36	36	10	0.14	0.14	5.0 [4]
Copper	--	2,900	4.8	4.8	3.1	3.1	--	--	--	3.1
Mercury	--	--	1.8	1.8	0.025	0.94	--	--	--	0.025
Nickel	--	1,100	74	74	8.2	8.2	190	100	4600	8.2
Tetrachloroethylene	100	500	--	--	--	--	7.1	2.9	29	2.9
Trichloroethylene	4.9	120	--	--	--	--	0.86	0.70	7.0	0.70
Vinyl Chloride	3.7	6,600	--	--	--	--	0.26	0.18	1.6	0.18
Chloroform	56	6,900	--	--	--	--	1,200	600	2,000	56

Notes:

--: No value exists for this constituent in the CLARC database (Ecology 2021b).

All values are presented as two significant figures in standard notation.

[1] Lead is a COPC for soil only.

[2] Values from CLARC (Ecology 2021b), unless otherwise noted.

[3] The screening level is the most stringent of all criteria in this table, subject to necessary adjustments in accordance with WAC 173-340-730(5)(c).

[4] Adjusted to accepted surface water background concentration of 5 ug/L per WAC 173-340-730(5)(c).

Table B-3: Predicted Groundwater Concentrations from Natural Background Soil Concentrations

Groundwater Metal COPC	Puget Sound Natural Background Concentration (1) (mg/kg)	Distribution Coefficient (2) (L/kg)	Henry's Law Constant (2) (unitless)	Predicted Groundwater Concentrations from Natural Background Soil Concentrations (3) (ug/L)
Arsenic	7.3	29	0.00	13
Copper	36	22	0.00	81
Mercury	0.07	52	0.47	0.067
Nickel	38	65	0.00	29

Notes:

(1) Puget Sound natural background soil concentrations (Ecology 1994).

(2) Values from CLARC (Ecology 2021b).

(3) Calculated with the MTCA fixed parameter three-phase partitioning model in WAC 173-340-747(4) and MTCA default inputs.

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Table B-4: Vapor Intrusion Groundwater Screening Levels

Groundwater VOC COPC	Method C Vapor Intrusion Groundwater Value for Carcinogens [(1)] (ug/L)	Method C Vapor Intrusion Groundwater Value for Non-carcinogens [(1)] (ug/L)	Vapor Intrusion Groundwater Screening Level for Commercial/Industrial Land Use [(2)] (ug/L)
Tetrachloroethylene	240	100	100
Trichloroethylene	25	8.2	8.2
Vinyl Chloride	3.4	120	3.4
Chloroform	12	1,100	12

Notes:

All values are presented as two significant figures in standard notation.

[(1)] Values from CLARC (Ecology 2021b), unless otherwise noted.

[(2)] The screening level is the most stringent of the carcinogenic and non-carcinogenic values.

Table B-5: Evaluation of Other Potential Site Concerns

Other Potential Site Concern	Discussion	Completed Remedial Action?	Concern Addressed by or Incorporated into Remedial Component(s) for Main Arsenic Plume?	Additional Future Remedial Component(s) Needed?
Soil direct contact in the 2901 Taylor Way portion of the Site boundary	Remedial component APR-3A (general surface cap/cover for soil direct contact pathway) already addresses all soil direct contact SL exceedances. Soil sampling locations and soil concentrations for all COPCs are presented in Figure B-1 and Tables B-6 through B-8. The footprint of APR-3A relative to the soil direct contact sampling results for each COPC are presented in Figures B-2 through B-10.	No	**Yes** (APR-3A: General surface cap/cover for soil direct contact pathway)	No
Soil direct contact in the Wypenn portion of the Site boundary	The 2014 Wypenn Interim Action already removed all necessary Wypenn soil to comply with the arsenic soil direct contact CL of 88 mg/kg (DOF 2015b). Arsenic was the only soil direct contact COPC for Wypenn (DOF 2013, 2015b).	**Yes** (OPSC-1: 2014 Wypenn Interim Action)	No	No
Arsenic in groundwater upgradient of the main arsenic plume (e.g., Wypenn)	Although (1) arsenic-impacted soil was removed during the 2014 Wypenn Interim Action, (2) arsenic-impacted groundwater exceeding 5 ug/L is present upgradient of Wypenn (Hart Crowser 2015), and (3) dissolved arsenic groundwater concentrations upgradient of the main arsenic plume are insignificant relative to concentrations in the main arsenic plume (e.g., see Figures 5-3 through 5-5 in Appendix A), some limited periodic Upper Aquifer groundwater monitoring will be conducted on the east side of Taylor Way to assess the long-term benefits of the 2014 Wypenn Interim Action.	**Yes** (OPSC-1: 2014 Wypenn Interim Action)	No	**Yes** (OPSC-5: Upper Aquifer groundwater monitoring downgradient of Wypenn)
Arsenic in the Taylor Way storm sewer	No action is needed since (1) the location of the 2015 storm sewer sample in question was upgradient of the Site (DOF 2013), (2) Site Upper Aquifer arsenic concentrations in the vicinity of the 2015 storm sewer sample in question are substantially less than the 80 ug/L detected in the 2015 storm sewer sample (see Figure 5-3 in Appendix A), (3) any Wypenn groundwater discharged to the portion of the storm sewer that is downgradient of the Site flows to the south away from the 2015 storm sewer sample locations (DOF 2013), and (4) the 2014 Wypenn Interim Action removed arsenic in soil to comply with the 88 mg/kg soil CL (DOF 2015b).	**Yes** (OPSC-1: 2014 Wypenn Interim Action)	No	No
Potential arsenic discharge from groundwater to the Hylebos Waterway via the East Channel Ditch	Prior to the 2013 to 2014 Arkema Mound Interim Action, pre-remediation concentrations in the East Channel Ditch sediment and surface/stormwater ranged from 9.4 mg/kg to 203 mg/kg and 11 ug/L to 87 ug/L, respectively (DOF 2013). The fact that the maximum pre-remediation surface soil concentration on the south bank of the East Channel Ditch (1,260 mg/kg) was nearly two orders of magnitude higher than the maximum pre-remediation surface soil concentration on the north bank of the East Channel Ditch (21 mg/kg) suggests that the Arkema Mound site likely contributed more to these pre-remediation arsenic concentrations in the East Channel Ditch sediment and surface/stormwater than the Site (DOF 2013). The 2013 to 2014 Arkema Mound Interim Action addressed the likely primary arsenic sources for pre-remediation arsenic concentrations in East Channel Ditch surface/stormwater by (1) removing the elevated arsenic soil concentrations on the south bank of the East Channel Ditch, and (2) removing the arsenic-impacted sediment in the East Channel Ditch itself (DOF 2015a). In addition, a stormwater treatment and conveyance system was installed in the East Channel Ditch to provide ongoing surface/stormwater treatment (DOF 2015a). Although a small amount of Site groundwater discharges to seeps on the north bank of the East Channel Ditch and the 2012/2013 dissolved arsenic concentrations in four seep samples on the north bank ranged from 170 ug/L to 280 ug/L (DOF 2013), these seep discharges are not expected to cause arsenic surface water or sediment exceedances in the Hylebos Waterway because (1) the stormwater treatment and conveyance system provides water treatment prior to discharge to the Hylebos Waterway, (2) the volume of Site groundwater discharged to the north bank is relatively small compared to the volume of water in the East Channel Ditch, and (3) Site arsenic concentrations in the main arsenic plume are stable or declining. However, to ensure there are no surface water or sediment exceedances in the Hylebos Waterway, periodic surface water and sediment sampling will be conducted near the outfall from the East Channel Ditch stormwater treatment and conveyance system. This monitoring will be conducted as part of existing remedial component EPC-3 (surface water and sediment monitoring).	**Yes** (OPSC-2: 2013 to 2014 Arkema Mound Interim Action)	**Yes** (EPC-3: Surface water and sediment monitoring)	No
Potential groundwater transport of copper, mercury, nickel, PCE, TCE, VC, and CF to the Hylebos Waterway	Although concentrations for these seven constituents exceed surface water SLs in some upland groundwater locations, constituent concentrations attributable to the Site (e.g., metals concentrations greater than natural background concentrations in Table B-3 and VOC concentrations greater than surface water SLs) have been delineated in groundwater upgradient of the Hylebos Waterway (see Figures B-11 through B-19). Nonetheless, periodic groundwater and surface water monitoring will be conducted to ensure copper, mercury, nickel, PCE, TCE, VC, and CF do not migrate to the Hylebos Waterway. In addition, the Angled Shoreline Monitoring Wells (MWs) will be decommissioned because the lines of evidence indicate that marine water mixing within the intertidal shoreline cap is causing corrosion of the type 316 stainless steel used to construct the Angled Shoreline MWs, which in turn releases the relatively large percentage of nickel in the stainless steel itself to Upper Aquifer groundwater near the Angled Shoreline MWs (see Figure B-15; Oakley and Korte 1996; PIONEER 2015, 2019). The existing sheet pile wall is not a suspected source of nickel corrosion based on the substantially lower nickel concentrations in the Intermediate Aquifer (see Figure B-16) and personnel correspondence between Troy Bussey and Skyline Steel (the likely supplier of sheet piles for the existing sheet pile wall).	**Yes** (OPSC-3: Completed active VOC remediation in VOC VI Area A; OPSC-4: Completed active VOC remediation in VOC VI Area B)	No	**Yes** (OPSC-6: Groundwater and surface water monitoring for copper, mercury, nickel, PCE, TCE, VC, and CF; OPSC-7: Decommission Angled Shoreline MWs)
VI in VOC VI Areas A through C	Although a soil vapor extraction system and a groundwater pump-and-treat system were installed and operated in VOC VI Area A from 1996 to 2000 and in-situ chemical oxidation was performed in VOC VI Area B in 2003 (see Table 2-1 in Appendix A), additional remedial action is needed for the VI pathway due to Upper Aquifer VI groundwater SL exceedances in VOC VI Areas A through C (see Figure B-20). Remedial component MNA&LTC-4 (applicable institutional controls) includes provisions to require VI evaluation if an occupied building is proposed within 100 feet of VOC VI Areas A through C. In addition, MNA&LTC-4 (applicable institutional controls) includes provisions to require installation, operation, maintenance, and monitoring of a VI mitigation system for any proposed occupied building within 100 feet of VOC VI Areas A through C unless Ecology approves that such a system is not necessary based on VI evaluation results.	**Yes** (OPSC-3: Completed active VOC remediation in VOC VI Area A; OPSC-4: Completed active VOC remediation in VOC VI Area B)	**Yes** (MNA&LTC-4: Applicable institutional controls)	**Yes**[(1)] (OPSC-8: VI evaluation(s); OPSC-9: Installation of VI mitigation system(s); OPSC-10: Operation, maintenance, and monitoring of VI mitigation system(s))
Groundwater dermal contact by utility workers	Remedial components MNA&LTC-3 (appliable engineering controls) and MNA&LTC-4 (applicable institutional controls) include provisions to address potential groundwater dermal contact by utility workers.	No	**Yes** (MNA&LTC-3: Applicable engineering controls; MNA&LTC-4: Applicable institutional controls)	No
Prohibit residential land use and the use of groundwater as drinking water at the 2901 Taylor Way property	Remedial component MNA&LTC-4 (applicable institutional controls) includes provisions to prohibit residential land use and the use of groundwater as drinking water at the 2901 Taylor Way property.	No	**Yes** (MNA&LTC-4: Applicable institutional controls)	No

Notes:

(1) For FS Report cost estimating purposes, it is assumed that at least one occupied building will be constructed within 100 feet of VOC VI Areas A through C and that installation, operation, maintenance, and monitoring of a VI mitigation system will be necessary for at least one occupied building.

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)			
					Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
AT-10	SO-AT-10-041103-12-16	4/11/2003	12	16	92		--	
AT-11	SO-AT-11-041403-12-16	4/14/2003	12	16	1,400		--	
AT-12	SO-AT-12-041403-12-16	4/14/2003	12	16	2,300		--	
AT-13	SO-AT-13-042903-13-16	4/29/2003	13	16	170		--	
AT-14	SO-AT-14-041403-12-16	4/14/2003	12	16	51		--	
AT-15	SO-AT-15-041403-12-16	4/14/2003	12	16	27		--	
AT-16	SO-AT-16-041403-12-16	4/14/2003	12	16	15	U	--	
AT-16	SO-AT-16-041403-4-8	4/14/2003	4	8	14	U	--	
AT-3	SO-AT-3-041103-1-4	4/11/2003	1	4	18		--	
AT-3	SO-AT-3-041103-12-16	4/11/2003	12	16	17		--	
AT-4	SO-AT-4-041103-1-4	4/11/2003	1	4	12	U	--	
AT-4	SO-AT-4-041103-12-16	4/11/2003	12	16	15	U	--	
AT-5	SO-AT-5-041103-12-16	4/11/2003	12	16	13	U	--	
AT-6	SO-AT-6-041103-12-16	4/11/2003	12	16	150		--	
AT-7	SO-AT-7-041103-12-16	4/11/2003	12	16	150		--	
AT-8	SO-AT-8-041103-12-16	4/11/2003	12	16	16	U	--	
AT-9	SO-AT-9-041103-12-16	4/11/2003	12	16	2,200		--	
B-A	SO-AKM-S-BA-10/11-101008-10-11	10/10/2008	10	11	170		--	
B-A	SO-AKM-S-BA-13/14-101008-13-14	10/10/2008	13	14	10		--	
B-A	SO-AKM-S-BA-3/4-101008-3-4	10/10/2008	3	4	1,600		--	
B-A	SO-AKM-S-BA-5/6-101008-5-6	10/10/2008	5	6	150		--	
B-A	SO-AKM-S-BA-7/8-101008-7-8	10/10/2008	7	8	290		--	
B-AA	SO-B-AA-072212-12-12	7/22/2012	12	12	7	U	--	
B-AA	SO-B-AA-072212-3-3	7/22/2012	3	3	12		--	
B-B	SO-AKM-S-BB-12/13-101008-12-13	10/10/2008	12	13	3800.0		--	
B-B	SO-AKM-S-BB-3/4-101008-3-4	10/10/2008	3	4	15		--	
B-B	SO-AKM-S-BB-6/7-101008-6-7	10/10/2008	6	7	4,200		--	
B-B	SO-AKM-S-BB-9/10-101008-9-10	10/10/2008	9	10	290		--	
B-BB	SO-B-BB-072212-14-14	7/22/2012	14	14	11		--	
B-BB	SO-B-BB-072212-9-9	7/22/2012	9	9	29.0		--	
B-C	SO-B-C-072212-11-11	7/22/2012	11	11	30		--	
B-C	SO-B-C-072212-12-12	7/22/2012	12	12	150.0		--	
B-C	SO-B-C-072212-13.5-13.5	7/22/2012	13.5	13.5	170		--	
B-C	SO-B-C-072212-15-15	7/22/2012	15	15	2,100		--	
B-C	SO-B-C-072212-8-8_DC	7/22/2012	8	8	19		--	
B-D	SO-B-D-072312-11-11	7/23/2012	11	11	310		--	
B-D	SO-B-D-072312-13-13	7/23/2012	13	13	250		--	
B-D	SO-B-D-072312-15-15	7/23/2012	15	15	3,200		--	
B-E	SO-B-E-072312-10-10	7/23/2012	10	10	10	U	--	
B-E	SO-B-E-072312-14-14	7/23/2012	14	14	8	U	--	
B-E	SO-B-E-072312-5-5	7/23/2012	5	5	12		--	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)(1,2)	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)			
					Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
B-E	SO-B-E-072312-8-8	7/23/2012	8	8	23		--	
B-F	SO-B-F-072312-12-12	7/23/2012	12	12	68		--	
B-F	SO-B-F-072312-14-14	7/23/2012	14	14	25		--	
B-F	SO-B-F-072312-7-7	7/23/2012	7	7	110		--	
B-G	SO-B-G-072312-10-10_DC	7/23/2012	10	10	230		--	
B-G	SO-B-G-072312-13-13	7/23/2012	13	13	260		--	
B-G	SO-B-G-072312-15-15	7/23/2012	15	15	1,400		--	
B6D14	SO-AKM-S-B6D14-1-100908-7-8	10/9/2008	7	8	400		--	
B6D14	SO-AKM-S-B6D14-1A-100908-14-15	10/9/2008	14	15	1,500		--	
B6E3	SO-AKM-S-B6E3-1-100808-6-8	10/8/2008	6	8	300		--	
B6E3	SO-AKM-S-B6E3-1A-100808-12-15.5	10/8/2008	12	15.5	3,000		--	
B6E5	SO-AKM-S-B6E5-1-100908-6-8	10/9/2008	6	8	92		--	
B6E5	SO-AKM-S-B6E5-1A-100908-12-13	10/9/2008	12	13	700.0		--	
B7E10	SO-AKM-S-B7E10-1-100808-6-8	10/8/2008	6	8	11.0		--	
B7E10	SO-AKM-S-B7E10-1A-100808-12-13	10/8/2008	12	13	4		--	
BB18	SO-BB18-123198-6-6	12/31/1998	6	6	1,700		--	
BB42	SO-BB42-123198-6-6	12/31/1998	6	6	160		--	
BB43	SO-BB43-123198-6-6	12/31/1998	6	6	1,600		--	
BB7	SO-BB7-123198-6-6	12/31/1998	6	6	2,100		--	
BB9	SO-BB9-123198-6-6	12/31/1998	6	6	190		--	
Boateng-B1	SO-Boateng-B1-112789-3-3	11/27/1989	3	3	5.0		--	
Boateng-B1	SO-Boateng-B1-112789-6-6	11/27/1989	6	6	10.0		--	
Boateng-B1	SO-Boateng-B1-112789-9-9	11/27/1989	9	9	7.0		--	
Boateng-B10	SO-Boateng-B10-112789-3-3	11/27/1989	3	3	13		--	
Boateng-B10	SO-Boateng-B10-112789-6-6	11/27/1989	6	6	770		--	
Boateng-B10	SO-Boateng-B10-112789-9-9	11/27/1989	9	9	830		--	
Boateng-B11	SO-Boateng-B11-112789-3-3	11/27/1989	3	3	18		--	
Boateng-B11	SO-Boateng-B11-112789-6-6	11/27/1989	6	6	2,300		--	
Boateng-B11	SO-Boateng-B11-112789-9-9	11/27/1989	9	9	300		--	
Boateng-B12	SO-Boateng-B12-112789-3-3	11/27/1989	3	3	410		--	
Boateng-B12	SO-Boateng-B12-112789-6-6	11/27/1989	6	6	2,100		--	
Boateng-B12	SO-Boateng-B12-112789-9-9	11/27/1989	9	9	900		--	
Boateng-B13	SO-Boateng-B13-112789-3-3	11/27/1989	3	3	140		--	
Boateng-B13	SO-Boateng-B13-112789-6-6	11/27/1989	6	6	770		--	
Boateng-B13	SO-Boateng-B13-112789-9-9	11/27/1989	9	9	720		--	
Boateng-B14	SO-Boateng-B14-112789-3-3	11/27/1989	3	3	160		--	
Boateng-B14	SO-Boateng-B14-112789-9-9	11/27/1989	9	9	530		--	
Boateng-B15	SO-Boateng-B15-112789-3-3	11/27/1989	3	3	25		--	
Boateng-B15	SO-Boateng-B15-112789-6-6	11/27/1989	6	6	720		--	
Boateng-B15	SO-Boateng-B15-112789-9-9	11/27/1989	9	9	58		--	
Boateng-B16	SO-Boateng-B16-112789-3-3	11/27/1989	3	3	1,200		--	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)(1,2)	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)			
					Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
Boateng-B16	SO-Boateng-B16-112789-6-6	11/27/1989	6	6	1,100		--	
Boateng-B16	SO-Boateng-B16-112789-9-9	11/27/1989	9	9	220		--	
Boateng-B17	SO-Boateng-B17-112789-3-3	11/27/1989	3	3	92		--	
Boateng-B17	SO-Boateng-B17-112789-6-6	11/27/1989	6	6	79		--	
Boateng-B17	SO-Boateng-B17-112789-9-9	11/27/1989	9	9	32		--	
Boateng-B18	SO-Boateng-B18-112789-3-3	11/27/1989	3	3	300		--	
Boateng-B18	SO-Boateng-B18-112789-6-6	11/27/1989	6	6	640		--	
Boateng-B18	SO-Boateng-B18-112789-9-9	11/27/1989	9	9	69		--	
Boateng-B19	SO-Boateng-B19-112789-3-3	11/27/1989	3	3	120		--	
Boateng-B19	SO-Boateng-B19-112789-6-6	11/27/1989	6	6	210		--	
Boateng-B19	SO-Boateng-B19-112789-9-9	11/27/1989	9	9	300		--	
Boateng-B2	SO-Boateng-B2-112789-3-3	11/27/1989	3	3	4.0		--	
Boateng-B2	SO-Boateng-B2-112789-6-6	11/27/1989	6	6	9.0		--	
Boateng-B2	SO-Boateng-B2-112789-9-9	11/27/1989	9	9	15		--	
Boateng-B20	SO-Boateng-B20-112789-3-3	11/27/1989	3	3	380		--	
Boateng-B20	SO-Boateng-B20-112789-6-6	11/27/1989	6	6	3,000		--	
Boateng-B20	SO-Boateng-B20-112789-9-9	11/27/1989	9	9	570		--	
Boateng-B21	SO-Boateng-B21-012990-3-3	1/29/1990	3	3	15		--	
Boateng-B21	SO-Boateng-B21-012990-6-6	1/29/1990	6	6	9.0		--	
Boateng-B21	SO-Boateng-B21-012990-9-9	1/29/1990	9	9	7.0		--	
Boateng-B22	SO-Boateng-B22-012990-3-3	1/29/1990	3	3	27		--	
Boateng-B22	SO-Boateng-B22-012990-6-6	1/29/1990	6	6	6.0		--	
Boateng-B22	SO-Boateng-B22-012990-9-9	1/29/1990	9	9	9.0		--	
Boateng-B23	SO-Boateng-B23-012990-3-3	1/29/1990	3	3	10.0		--	
Boateng-B23	SO-Boateng-B23-012990-6-6	1/29/1990	6	6	6.0		--	
Boateng-B23	SO-Boateng-B23-012990-9-9	1/29/1990	9	9	8.0		--	
Boateng-B24	SO-Boateng-B24-012990-3-3	1/29/1990	3	3	9.0		--	
Boateng-B24	SO-Boateng-B24-012990-6-6	1/29/1990	6	6	8.0		--	
Boateng-B24	SO-Boateng-B24-012990-9-9	1/29/1990	9	9	8.0		--	
Boateng-B25	SO-Boateng-B25-012990-3-3	1/29/1990	3	3	23		--	
Boateng-B25	SO-Boateng-B25-012990-6-6	1/29/1990	6	6	13		--	
Boateng-B25	SO-Boateng-B25-012990-9-9	1/29/1990	9	9	53		--	
Boateng-B26	SO-Boateng-B26-012990-3-3	1/29/1990	3	3	27		--	
Boateng-B26	SO-Boateng-B26-012990-6-6	1/29/1990	6	6	8.0		--	
Boateng-B26	SO-Boateng-B26-012990-9-9	1/29/1990	9	9	29		--	
Boateng-B27	SO-Boateng-B27-012990-3-3	1/29/1990	3	3	4.0		--	
Boateng-B27	SO-Boateng-B27-012990-6-6	1/29/1990	6	6	37		--	
Boateng-B27	SO-Boateng-B27-012990-9-9	1/29/1990	9	9	360		--	
Boateng-B28	SO-Boateng-B28-012990-3-3	1/29/1990	3	3	99		--	
Boateng-B28	SO-Boateng-B28-012990-6-6	1/29/1990	6	6	1,800		--	
Boateng-B28	SO-Boateng-B28-012990-9-9	1/29/1990	9	9	410		--	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)(1,2)	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg) Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
Boateng-B29	SO-Boateng-B29-012990-3-3	1/29/1990	3	3	20		--	
Boateng-B29	SO-Boateng-B29-012990-6-6	1/29/1990	6	6	25		--	
Boateng-B29	SO-Boateng-B29-012990-9-9	1/29/1990	9	9	12		--	
Boateng-B3	SO-Boateng-B3-112789-3-3	11/27/1989	3	3	14		--	
Boateng-B3	SO-Boateng-B3-112789-6-6	11/27/1989	6	6	31		--	
Boateng-B3	SO-Boateng-B3-112789-9-9	11/27/1989	9	9	57		--	
Boateng-B30	SO-Boateng-B30-012990-3-3	1/29/1990	3	3	40		--	
Boateng-B30	SO-Boateng-B30-012990-6-6	1/29/1990	6	6	81		--	
Boateng-B30	SO-Boateng-B30-012990-9-9	1/29/1990	9	9	1,100		--	
Boateng-B31	SO-Boateng-B31-012990-3-3	1/29/1990	3	3	15		--	
Boateng-B31	SO-Boateng-B31-012990-6-6	1/29/1990	6	6	190		--	
Boateng-B31	SO-Boateng-B31-012990-9-9	1/29/1990	9	9	590		--	
Boateng-B32	SO-Boateng-B32-012990-3-3	1/29/1990	3	3	120		--	
Boateng-B32	SO-Boateng-B32-012990-6-6	1/29/1990	6	6	680		--	
Boateng-B32	SO-Boateng-B32-012990-9-9	1/29/1990	9	9	190		--	
Boateng-B33	SO-Boateng-B33-012990-3-3	1/29/1990	3	3	800		--	
Boateng-B33	SO-Boateng-B33-012990-6-6	1/29/1990	6	6	610		--	
Boateng-B33	SO-Boateng-B33-012990-9-9	1/29/1990	9	9	420		--	
Boateng-B34	SO-Boateng-B34-012990-3-3	1/29/1990	3	3	37		--	
Boateng-B34	SO-Boateng-B34-012990-6-6	1/29/1990	6	6	12		--	
Boateng-B34	SO-Boateng-B34-012990-9-9	1/29/1990	9	9	5.0		--	
Boateng-B35	SO-Boateng-B35-012990-3-3	1/29/1990	3	3	6.0		--	
Boateng-B35	SO-Boateng-B35-012990-6-6	1/29/1990	6	6	8.0		--	
Boateng-B35	SO-Boateng-B35-012990-9-9	1/29/1990	9	9	7.0		--	
Boateng-B36	SO-Boateng-B36-012990-3-3	1/29/1990	3	3	15		--	
Boateng-B36	SO-Boateng-B36-012990-6-6	1/29/1990	6	6	5.0		--	
Boateng-B36	SO-Boateng-B36-012990-9-9	1/29/1990	9	9	8.0		--	
Boateng-B37	SO-Boateng-B37-012990-3-3	1/29/1990	3	3	260		--	
Boateng-B37	SO-Boateng-B37-012990-6-6	1/29/1990	6	6	1,100		--	
Boateng-B37	SO-Boateng-B37-012990-9-9	1/29/1990	9	9	74		--	
Boateng-B38	SO-Boateng-B38-012990-3-3	1/29/1990	3	3	43		--	
Boateng-B38	SO-Boateng-B38-012990-6-6	1/29/1990	6	6	37		--	
Boateng-B38	SO-Boateng-B38-012990-9-9	1/29/1990	9	9	38		--	
Boateng-B39	SO-Boateng-B39-012990-3-3	1/29/1990	3	3	6.0		--	
Boateng-B39	SO-Boateng-B39-012990-6-6	1/29/1990	6	6	6.0		--	
Boateng-B39	SO-Boateng-B39-012990-9-9	1/29/1990	9	9	5.0		--	
Boateng-B4	SO-Boateng-B4-112789-3-3	11/27/1989	3	3	2.0		--	
Boateng-B4	SO-Boateng-B4-112789-6-6	11/27/1989	6	6	440		--	
Boateng-B4	SO-Boateng-B4-112789-9-9	11/27/1989	9	9	410		--	
Boateng-B40	SO-Boateng-B40-012990-3-3	1/29/1990	3	3	6.0		--	
Boateng-B40	SO-Boateng-B40-012990-6-6	1/29/1990	6	6	6.0		--	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)(1,2)	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg) Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
Boateng-B40	SO-Boateng-B40-012990-9-9	1/29/1990	9	9	8.0		--	
Boateng-B41	SO-Boateng-B41-012990-3-3	1/29/1990	3	3	18		--	
Boateng-B41	SO-Boateng-B41-012990-6-6	1/29/1990	6	6	5.0		--	
Boateng-B41	SO-Boateng-B41-012990-9-9	1/29/1990	9	9	6.0		--	
Boateng-B42	SO-Boateng-B42-012990-3-3	1/29/1990	3	3	820		--	
Boateng-B42	SO-Boateng-B42-012990-6-6	1/29/1990	6	6	220		--	
Boateng-B42	SO-Boateng-B42-012990-9-9	1/29/1990	9	9	830		--	
Boateng-B43	SO-Boateng-B43-012990-3-3	1/29/1990	3	3	600		--	
Boateng-B43	SO-Boateng-B43-012990-6-6	1/29/1990	6	6	520		--	
Boateng-B43	SO-Boateng-B43-012990-9-9	1/29/1990	9	9	310		--	
Boateng-B44	SO-Boateng-B44-012990-3-3	1/29/1990	3	3	30		--	
Boateng-B44	SO-Boateng-B44-012990-6-6	1/29/1990	6	6	16		--	
Boateng-B44	SO-Boateng-B44-012990-9-9	1/29/1990	9	9	37		--	
Boateng-B45	SO-Boateng-B45-012990-3-3	1/29/1990	3	3	730		--	
Boateng-B45	SO-Boateng-B45-012990-6-6	1/29/1990	6	6	440		--	
Boateng-B45	SO-Boateng-B45-012990-9-9	1/29/1990	9	9	530		--	
Boateng-B46	SO-Boateng-B46-012990-3-3	1/29/1990	3	3	56		--	
Boateng-B46	SO-Boateng-B46-012990-6-6	1/29/1990	6	6	770		--	
Boateng-B46	SO-Boateng-B46-012990-9-9	1/29/1990	9	9	70		--	
Boateng-B48	SO-Boateng-B48-012990-3-3	1/29/1990	3	3	1,200		--	
Boateng-B48	SO-Boateng-B48-012990-6-6	1/29/1990	6	6	1,600		--	
Boateng-B48	SO-Boateng-B48-012990-9-9	1/29/1990	9	9	1,100		--	
Boateng-B49	SO-Boateng-B49-012990-3-3	1/29/1990	3	3	23		--	
Boateng-B49	SO-Boateng-B49-012990-6-6	1/29/1990	6	6	66		--	
Boateng-B49	SO-Boateng-B49-012990-9-9	1/29/1990	9	9	100		--	
Boateng-B5	SO-Boateng-B5-112789-3-3	11/27/1989	3	3	48		--	
Boateng-B5	SO-Boateng-B5-112789-6-6	11/27/1989	6	6	19		--	
Boateng-B5	SO-Boateng-B5-112789-9-9	11/27/1989	9	9	28		--	
Boateng-B50	SO-Boateng-B50-012990-3-3	1/29/1990	3	3	54		--	
Boateng-B50	SO-Boateng-B50-012990-6-6	1/29/1990	6	6	9,100		--	
Boateng-B50	SO-Boateng-B50-012990-9-9	1/29/1990	9	9	680		--	
Boateng-B6	SO-Boateng-B6-112789-3-3	11/27/1989	3	3	12		--	
Boateng-B6	SO-Boateng-B6-112789-6-6	11/27/1989	6	6	220		--	
Boateng-B6	SO-Boateng-B6-112789-9-9	11/27/1989	9	9	590		--	
Boateng-B8	SO-Boateng-B8-112789-3-3	11/27/1989	3	3	2,600		--	
Boateng-B8	SO-Boateng-B8-112789-6-6	11/27/1989	6	6	1,900		--	
Boateng-B8	SO-Boateng-B8-112789-9-9	11/27/1989	9	9	510		--	
Boateng-B9	SO-Boateng-B9-112789-3-3	11/27/1989	3	3	870		--	
Boateng-B9	SO-Boateng-B9-112789-6-6	11/27/1989	6	6	440		--	
Boateng-B9	SO-Boateng-B9-112789-9-9	11/27/1989	9	9	380		--	
BSL-46	SO-BSL-46-0911900.33-0.5	9/11/1990	0.33	0.5	26		--	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)			
					Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
BSL-55	SO-BSL-55-0911900.33-0.5_DC	9/11/1990	0.33	0.5	32		--	
BSL-56	SO-BSL-56-0911900.33-0.5	9/11/1990	0.33	0.5	42		--	
BSL-57	SO-BSL-57-0911900.33-0.5	9/11/1990	0.33	0.5	30		--	
CP-1	SO-CP-1-060689-0-2	6/6/1989	0	2	4.6		--	
CP-2	SO-CP-2-060689-0-4.8	6/6/1989	0	4.8	16		--	
CP-3	SO-CP-3-060689-0-3.8	6/6/1989	0	3.8	6.7		--	
CP-4	SO-CP-4-060689-0-1.7	6/6/1989	0	1.7	6.8		--	
CRP-1	SO-CRP-1-060789-0-4.5	6/7/1989	0	4.5	1.1		--	
CRP-2	SO-CRP-2-060789-0-5	6/7/1989	0	5	1.7		--	
CRP-3	SO-CRP-3-060789-0-5	6/7/1989	0	5	1.1		--	
CRP-4	SO-CRP-4-060789-0-3	6/7/1989	0	3	4.3		--	
CRP-5	SO-CRP-5-060789-0-6.3	6/7/1989	0	6.3	2.0		--	
CRP-6	SO-CRP-6-060789-0-5.5	6/7/1989	0	5.5	2.3		--	
CRP-7	SO-CRP-7-060789-0-4.3	6/7/1989	0	4.3	2.9		--	
CRP-8	SO-CRP-8-060789-0-5.3	6/7/1989	0	5.3	3.5		--	
ECD-NB-0+00	SO-AKM-S-ECD-0+00A--040612	4/6/2012	0.5	2	12		--	
ECD-NB-0+00	SO-AKM-S-ECD-0+00B--040612	4/6/2012	2	4	2.4		--	
ECD-NB-0+00	SO-AKM-S-ECD-0+00C--040612	4/6/2012	4	6	19		--	
ECD-NB-0+00	SO-AKM-S-ECD-0+00D--040612	4/6/2012	6.3	7.5	11		--	
ECD-NB-0+50	SO-AKM-S-ECD-0+50A--040612	4/6/2012	0.5	2	11		--	
ECD-NB-0+50	SO-AKM-S-ECD-0+50B--040612	4/6/2012	2	3.5	9.3		--	
ECD-NB-0+50	SO-AKM-S-ECD-0+50C--040612	4/6/2012	3.5	5	5.8		--	
ECD-NB-0+50	SO-AKM-S-ECD-0+50D--040612	4/6/2012	5	6.5	9.3		--	
ECD-NB-1+00	SO-AKM-S-ECD-1+00A--040612	4/6/2012	0.5	1	9.0		--	
ECD-NB-1+00	SO-AKM-S-ECD-1+00B--040612	4/6/2012	1	3.5	21		--	
ECD-NB-1+00	SO-AKM-S-ECD-1+00C--040612	4/6/2012	3.5	5	10.0		--	
ECD-NB-1+00	SO-AKM-S-ECD-1+00D--040612	4/6/2012	5	5.5	8.4		--	
ECD-NB-1+50	SO-AKM-S-ECD-1+50A--040612	4/6/2012	0.5	1.5	7.5		--	
ECD-NB-1+50	SO-AKM-S-ECD-1+50B--040612	4/6/2012	1.5	3	12		--	
ECD-NB-1+50	SO-AKM-S-ECD-1+50C--040612	4/6/2012	3	5.5	17		--	
ECD-NB-2+00	SO-AKM-S-ECD-2+00A--040612	4/6/2012	0.5	1.5	11		--	
ECD-NB-2+00	SO-AKM-S-ECD-2+00B--040612	4/6/2012	1.5	2	6.0		--	
ECD-NB-2+50	SO-AKM-S-ECD-2+50A--040612	4/6/2012	0.5	1.5	4.4		--	
ECD-NB-2+50	SO-AKM-S-ECD-2+50B--040612	4/6/2012	1.5	2	8.2		--	
ECD-NB-3+00	SO-AKM-S-ECD-3+00A--040612	4/6/2012	0.5	2	4.0		--	
ECD-NB-3+50	SO-AKM-S-ECD-3+50A--040612	4/6/2012	0.5	1.5	3.3		--	
ECD-NB-4+00	SO-AKM-S-ECD-4+00A--040612	4/6/2012	0.5	1.5	14		--	
K-11S	SO-K-11S-113089-11-11.7	11/30/1989	11	11.7	8.6		--	
K-11S	SO-K-11S-113089-14-14.7	11/30/1989	14	14.7	2.1		--	
K-12S	SO-K-12S-113089-10.4-11	11/30/1989	10.4	11	22		--	
K-12S	SO-K-12S-113089-12.5-12.9	11/30/1989	12.5	12.9	1.8		--	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg) Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
K-12S	SO-K-12S-113089-4.5-5.5	11/30/1989	4.5	5.5	27		--	
K-12S	SO-K-12S-113089-6.5-7.5	11/30/1989	6.5	7.5	5.6		--	
K-15SS	SO-K-15SS-113089-12-13.5	11/30/1989	12	13.5	4.80		--	
K-15SS	SO-K-15SS-113089-4.5-6	11/30/1989	4.5	6	.5	U	--	
K-15SS	SO-K-15SS-113089-9-10.5	11/30/1989	9	10.5	3.2		--	
K-32S	SO-K-32S-113089-14.5-15	11/30/1989	14.5	15	52		--	
K-33S	SO-K-33S-113089-9.5-10	11/30/1989	9.5	10	820		--	
K-34S	SO-K-34S-113089-11.5-12	11/30/1989	11.5	12	1,200		--	
K-35S	SO-K-35S-113089-9-9.5	11/30/1989	9	9.5	6.6		--	
MA-03	SO-MA-SB03-042407-6-6	4/24/2007	6	6	2		--	
MA-03	SO-MA-SS03-042407-0-0	4/24/2007	0	0	17.0		--	
MA-04	SO-MA-SB04-042407-6-6	4/24/2007	6	6	3.0		--	
MA-04	SO-MA-SS04-042407-0-0	4/24/2007	0	0	4.6		--	
MA-05	SO-MA-SB05-051107-0.5-0.5	5/11/2007	0.5	0.5	33		--	
MA-05	SO-MA-SB05-051107-6-6	5/11/2007	6	6	3		--	
MA-05	SO-MA-SS05-051107-0-0	5/11/2007	0	0	66.0		--	
MA-06	SO-MA-SB06-051507-6-6	5/15/2007	6	6	4.3		--	
MA-06	SO-MA-SS06-051507-0-0	5/15/2007	0	0	2.1		--	
MA-07	SO-MA-SB07-051107-6-6	5/11/2007	6	6	1.8		--	
MA-07	SO-MA-SS07-051107-0-0	5/11/2007	0	0	2.2		--	
MA-08	SO-MA-SB08-042607-6-6	4/26/2007	6	6	27		--	
MA-08	SO-MA-SS08-042607-0-0	4/26/2007	0	0	14		--	
MA-09	SO-MA-SB09-042607-6-6	4/26/2007	6	6	4		--	
MA-09	SO-MA-SS09-042607-0-0	4/26/2007	0	0	14.0		--	
MA-10	SO-MA-SB10-051407-6-6	5/14/2007	6	6	1.8		--	
MA-10	SO-MA-SS10-051407-0-0	5/14/2007	0	0	3.1		--	
MA-11	SO-MA-SB11-051407-6-6	5/14/2007	6	6	11.0		--	
MA-11	SO-MA-SS11-051407-0-0	5/14/2007	0	0	4		--	
MA-12	SO-MA-SB12-051407-6-6	5/14/2007	6	6	40		--	
MA-12	SO-MA-SS12-051407-0-0	5/14/2007	0	0	15		--	
MA-24	SO-MA-SB24-051507-6-6	5/15/2007	6	6	9.6		--	
MA-24	SO-MA-SS24-051507-0-0	5/15/2007	0	0	9.0		--	
MA-25	SO-MA-SB25-042507-6-6	4/25/2007	6	6	110		--	
MA-25	SO-MA-SS25-042507-0-0	4/25/2007	0	0	37		--	
MA-26	SO-MA-SB26-042507-6-6	4/25/2007	6	6	270		--	
MA-26	SO-MA-SS26-042507-0-0	4/25/2007	0	0	160		--	
MA-27	SO-MA-SB27-042407-6-6	4/24/2007	6	6	210		--	
MA-27	SO-MA-SS27-042407-0-0	4/24/2007	0	0	16		--	
MA-28	SO-MA-SB28-042407-6-6	4/24/2007	6	6	600		--	
MA-28	SO-MA-SS28-042407-0-0	4/24/2007	0	0	60		--	
MA-29	SO-MA-SB29-042407-6-6	4/24/2007	6	6	420		--	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)(1,2)	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)			
					Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
MA-29	SO-MA-SS29-042407-0-0	4/24/2007	0	0	15		--	
MA-30	SO-MA-SB30-042407-6-6	4/24/2007	6	6	210		--	
MA-30	SO-MA-SS30-042407-0-0	4/24/2007	0	0	150		--	
MA-31	SO-MA-SB31-042407-6-6	4/24/2007	6	6	770		--	
MA-31	SO-MA-SS31-042407-0-0	4/24/2007	0	0	62		--	
MA-32	SO-MA-SB32-042407-6-6	4/24/2007	6	6	62.0		--	
MA-32	SO-MA-SS32-042407-0-0	4/24/2007	0	0	7		--	
MA-33	SO-MA-SB33-042407-6-6	4/24/2007	6	6	31.0		--	
MA-33	SO-MA-SS33-042407-0-0	4/24/2007	0	0	6		--	
MA-34	SO-MA-SB34-051107-10-10	5/11/2007	10	10	570		--	
MA-34	SO-MA-SB34-051107-6-6	5/11/2007	6	6	350		--	
MA-34	SO-MA-SS34-051107-0-0	5/11/2007	0	0	330		--	
MA-35	SO-MA-SB35-051407-6-6	5/14/2007	6	6	380		--	
MA-35	SO-MA-SB35-051407-9-9	5/14/2007	9	9	260		--	
MA-35	SO-MA-SS35-051407-0-0	5/14/2007	0	0	66		--	
MA-36	SO-MA-SB36-051407-6-6	5/14/2007	6	6	630		--	
MA-36	SO-MA-SB36-051507-9-9	5/15/2007	9	9	700		--	
MA-36	SO-MA-SS36-051407-0-0	5/14/2007	0	0	100		--	
MA-37	SO-MA-SB37-051407-6-6	5/14/2007	6	6	550		--	
MA-37	SO-MA-SB37-051407-9-9	5/14/2007	9	9	170		--	
MA-37	SO-MA-SS37-051407-0-0	5/14/2007	0	0	160		--	
MA-38	SO-MA-SB38-051407-6-6	5/14/2007	6	6	150		--	
MA-38	SO-MA-SS38-051407-0-0	5/14/2007	0	0	430		--	
MA-39	SO-MA-SB39-051407-6-6	5/14/2007	6	6	230		--	
MA-39	SO-MA-SB39-051407-9-9	5/14/2007	9	9	50		--	
MA-39	SO-MA-SS39-051407-0-0	5/14/2007	0	0	320		--	
MA-40	SO-MA-SB40-051407-6-6	5/14/2007	6	6	210		--	
MA-40	SO-MA-SB40-051407-8.5-8.5	5/14/2007	8.5	8.5	79		--	
MA-40	SO-MA-SS40-051407-0-0	5/14/2007	0	0	250		--	
MA-41	SO-MA-SB41-051107-6-6	5/11/2007	6	6	170		--	
MA-41	SO-MA-SB41-051107-9.5-9.5	5/11/2007	9.5	9.5	190		--	
MA-41	SO-MA-SS41-051107-0-0	5/11/2007	0	0	100		--	
MA-42	SO-MA-SB42-051107-6-6	5/11/2007	6	6	280		--	
MA-42	SO-MA-SB42-051107-9-9	5/11/2007	9	9	250		--	
MA-42	SO-MA-SS42-051107-0-0	5/11/2007	0	0	130		--	
MA-43	SO-MA-SB43-052907-7-7	5/29/2007	7	7	160		--	
MA-44	SO-MA-SB44-051607-6-6	5/16/2007	6	6	1,300		--	
MA-44	SO-MA-SB44-051607-9-9	5/16/2007	9	9	97		--	
MA-44	SO-MA-SS44-051607-0-0	5/16/2007	0	0	310		--	
MA-45	SO-MA-SB45-051607-6-6	5/16/2007	6	6	340		--	
MA-45	SO-MA-SB45-051607-9-9	5/16/2007	9	9	810		--	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)(1,2)	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg) Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
MA-45	SO-MA-SS45-051607-0-0	5/16/2007	0	0	240		--	
MA-46	SO-MA-SB46-052907-6-6	5/29/2007	6	6	140		--	
MA-46	SO-MA-SB46-052907-8-8	5/29/2007	8	8	720		--	
MA-47	SO-MA-SB47-052907-6-6	5/29/2007	6	6	350		--	
MA-47	SO-MA-SB47-052907-8-8	5/29/2007	8	8	810		--	
MA-48	SO-MA-SB48-052907-6-6	5/29/2007	6	6	66		--	
MA-48	SO-MA-SB48-052907-9.5-9.5	5/29/2007	9.5	9.5	880		--	
MA-49	SO-MA-SB49-052907-6-6	5/29/2007	6	6	41		--	
MA-49	SO-MA-SB49-052907-8.5-8.5	5/29/2007	8.5	8.5	460		--	
MA-50	SO-MA-SB50-052907-10-10	5/29/2007	10	10	120		--	
MA-50	SO-MA-SB50-052907-6-6	5/29/2007	6	6	300		--	
MA-51	SO-MA-SB51-052907-6-6	5/29/2007	6	6	170		--	
MA-51	SO-MA-SB51-052907-9.5-9.5	5/29/2007	9.5	9.5	140		--	
MA-52	SO-MA-SB52-052907-6-6	5/29/2007	6	6	230		--	
MA-52	SO-MA-SB52-052907-8.5-8.5	5/29/2007	8.5	8.5	1,200		--	
MA-53	SO-MA-SB53-052907-9-9	5/29/2007	9	9	310		--	
MA-54	SO-MA-SB54-052907-6-6	5/29/2007	6	6	190		--	
MA-54	SO-MA-SB54-052907-8.5-8.5	5/29/2007	8.5	8.5	400		--	
MA-55	SO-MA-SB55-052907-10-10	5/29/2007	10	10	260		--	
MA-55	SO-MA-SB55-052907-6-6	5/29/2007	6	6	260		--	
MA-56	SO-MA-SB56-052907-6-6	5/29/2007	6	6	180		--	
MA-56	SO-MA-SB56-052907-9.5-9.5	5/29/2007	9.5	9.5	88		--	
MA-57	SO-MA-SB57-052907-6-6	5/29/2007	6	6	160		--	
MA-57	SO-MA-SB57-052907-9-9	5/29/2007	9	9	170		--	
MA-58	SO-MA-SB58-052907-6-6	5/29/2007	6	6	110		--	
MA-58	SO-MA-SB58-052907-9-9	5/29/2007	9	9	290		--	
MS-1	SO-MS-1-011690-5-5	1/16/1990	5	5	310		--	
MS-12	SO-MS-12-012090-6-6	1/20/1990	6	6	680		--	
MS-13	SO-MS-13-012090-6-6	1/20/1990	6	6	610		--	
MS-14	SO-MS-14-012090-4-4	1/20/1990	4	4	1,100		--	
MS-18	SO-MS-18-012290-7-7	1/22/1990	7	7	470		--	
MS-19	SO-MS-19-012290-6-6	1/22/1990	6	6	620		--	
MS-20	SO-MS-20-012290-6-6	1/22/1990	6	6	1,900		--	
MS-22	SO-MS-22-012490-6-6	1/24/1990	6	6	4,100		--	
MS-23	SO-MS-23-012490-6-6	1/24/1990	6	6	3,100		--	
MS-24	SO-MS-24-012490-5-5	1/24/1990	5	5	410		--	
MS-3	SO-MS-3-011790-4-4	1/17/1990	4	4	200		--	
MS-31	SO-MS-31-012990-6-6_DC	1/29/1990	6	6	1,200		--	
MS-33	SO-MS-33-012990-6-6	1/29/1990	6	6	670		--	
MS-36	SO-MS-36-012990-6-6	1/29/1990	6	6	2,000		--	
MS-7	SO-MS-7-011890-5-5	1/18/1990	5	5	220		--	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg) Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
MS-8	SO-MS-8-011890-5-5	1/18/1990	5	5	1,200		--	
PGG1	SO-PGG1-013004-10.0-13.0	1/30/2004	10	13	3,100		--	
PGG1	SO-PGG1-013004-14.0-16.0	1/30/2004	14	16	800		--	
PGG1	SO-PGG1-013004-6.5-8.0	1/30/2004	6.5	8	140		--	
PGG11	SO-PGG11-040904-6.5-10	4/9/2004	6.5	10	82		--	
PGG13	SO-PGG13-040904-4.8-7.5	4/9/2004	4.8	7.5	260		--	
PGG15	SO-PGG15-040704-8-12	4/7/2004	8	12	290		--	
PGG17	SO-PGG17-040704-8-12	4/7/2004	8	12	79		--	
PGG18	SO-PGG18-040904-6.8-10	4/9/2004	6.8	10	120		--	
PGG19	SO-PGG19-040804-10-12	4/8/2004	10	12	14		--	
PGG2	SO-PGG2-020304-10.5-12.0	2/3/2004	10.5	12	250		--	
PGG2	SO-PGG2-020304-12.0-14.0	2/3/2004	12	14	210		--	
PGG2	SO-PGG2-020304-14.0-15.0	2/3/2004	14	15	250		--	
PGG2	SO-PGG2-020304-14.5-16.0	2/3/2004	14.5	16	130		--	
PGG20	SO-PGG20-040804-6-10	4/8/2004	6	10	5.8		--	
PGG3	SO-PGG3-012904-7.0-8.0	1/29/2004	7	8	150		--	
PGG3	SO-PGG3-012904-9.0-10.0	1/29/2004	9	10	190		--	
PGG4	SO-PGG4-012904-11.0-12.5	1/29/2004	11	12.5	1,700		--	
PGG4	SO-PGG4-012904-14.0-17.0	1/29/2004	14	17	7	U	--	
PGG4	SO-PGG4-012904-6.0-8.0	1/29/2004	6	8	52.0		--	
PGG5	SO-PGG5-020304-10.0-12.0	2/3/2004	10	12	430		--	
PGG5	SO-PGG5-020304-12.0-13.5	2/3/2004	12	13.5	170		--	
PGG5	SO-PGG5-020304-13.5-14.5	2/3/2004	13.5	14.5	71		--	
PGG5	SO-PGG5-020304-14.5-16.0	2/3/2004	14.5	16	69		--	
PGG5	SO-PGG5-020304-6.0-8.0	2/3/2004	6	8	160		--	
PGG6	SO-PGG6-012804-10.0-12.0	1/28/2004	10	12	5,300		--	
PGG6	SO-PGG6-012804-14.0-16.0	1/28/2004	14	16	1,200		--	
PGG6	SO-PGG6-012804-6.0-8.0	1/28/2004	6	8	200		--	
PGG7	SO-PGG7-012604-11.0-12.0	1/26/2004	11	12	9,100		--	
PGG7	SO-PGG7-012604-13.0-16.0	1/26/2004	13	16	4,000		--	
PGG7	SO-PGG7-012604-6.0-8.5	1/26/2004	6	8.5	150		--	
PGG7	SO-PGG7-012604-9.0-11.0	1/26/2004	9	11	74		--	
PGG8	SO-PGG8-012704-14.0-16.0	1/27/2004	14	16	3,400		--	
PGG8	SO-PGG8-012704-4.0-6.0	1/27/2004	4	6	100		--	
PGG8	SO-PGG8-012704-9.0-11.0	1/27/2004	9	11	160		--	
PGG9	SO-PGG9-012804-14.0-16.0	1/28/2004	14	16	5,600		--	
PGG9	SO-PGG9-012804-6.0-7.5	1/28/2004	6	7.5	21		--	
PGG9	SO-PGG9-012804-9.0-11.0	1/28/2004	9	11	300		--	
PT-31	SO-PT-SB31-042507-6-6	4/25/2007	6	6	210		--	
PT-31	SO-PT-SS31-042507-0-0	4/25/2007	0	0	17		--	
PT-32	SO-PT-SB32-051607-6-6	5/16/2007	6	6	420	J	--	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg) Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
PT-32	SO-PT-SS32-051607-0-0	5/16/2007	0	0	720		--	
PT-33	SO-PT-SB33-051607-6-6	5/16/2007	6	6	25,000		--	
PT-33	SO-PT-SS33-051607-0-0	5/16/2007	0	0	4,200		--	
PT-34	SO-PT-SB34-051507-6-6	5/15/2007	6	6	550		--	
PT-34	SO-PT-SS34-051507-0-0	5/15/2007	0	0	67		--	
PT-35	SO-PT-SB35-042507-6-6	4/25/2007	6	6	3,300		--	
PT-35	SO-PT-SS35-042507-0-0	4/25/2007	0	0	210		--	
PT-36	SO-PT-SB36-042507-6-6	4/25/2007	6	6	630		--	
PT-36	SO-PT-SS36-042507-0-0	4/25/2007	0	0	220		--	
PT-37	SO-PT-SB37-042507-6-6	4/25/2007	6	6	4.4		--	
PT-37	SO-PT-SS37-042507-0-0	4/25/2007	0	0	6.2		--	
PT-37A	SO-PT-SB37A-051507-6-6	5/15/2007	6	6	1100.0		--	
PT-37A	SO-PT-SS37A-051507-0-0	5/15/2007	0	0	7		--	
PT-38	SO-PT-SB38-042507-6-6	4/25/2007	6	6	10		--	
PT-38	SO-PT-SS38-042507-0-0	4/25/2007	0	0	21.0		--	
PT-38A	SO-PT-SB38A-051507-6-6	5/15/2007	6	6	570		--	
PT-38A	SO-PT-SS38A-051507-0-0	5/15/2007	0	0	24		--	
PT-39	SO-PT-SB39-042607-6-6	4/26/2007	6	6	20		--	
PT-39	SO-PT-SS39-042607-0-0	4/26/2007	0	0	69		--	
PT-40	SO-PT-SB40-042607-6-6	4/26/2007	6	6	140		--	
PT-40	SO-PT-SS40-042607-0-0	4/26/2007	0	0	450		--	
PT-41	SO-PT-SB41-042607-6-6	4/26/2007	6	6	3		--	
PT-41	SO-PT-SS41-042607-0-0	4/26/2007	0	0	18.0		--	
PT-42	SO-PT-SB42-042607-6-6	4/26/2007	6	6	5.1		--	
PT-42	SO-PT-SS42-042607-0-0	4/26/2007	0	0	7.0		--	
PT-43	SO-PT-SB43-051407-6-6	5/14/2007	6	6	21		--	
PT-43	SO-PT-SS43-051407-0-0	5/14/2007	0	0	15		--	
PT-48	SO-PT-SB48-051507-6-6	5/15/2007	6	6	5.3		--	
PT-48	SO-PT-SS48-051507-0-0	5/15/2007	0	0	4.8		--	
PT-49	SO-PT-SB49-051507-6-6	5/15/2007	6	6	9		--	
PT-49	SO-PT-SS49-051507-0-0	5/15/2007	0	0	38.0		--	
PT-50	SO-PT-SB50-043007-6-6	4/30/2007	6	6	2.8		--	
PT-50	SO-PT-SS50-043007-0-0	4/30/2007	0	0	7.4		--	
PT-51	SO-PT-SB51-043007-6-6	4/30/2007	6	6	2.4		--	
PTC-001	SO-PTC-001-091517-11.5-13.5	9/15/2017	11.5	13.5	4	J	--	
PTC-001	SO-PTC-001-091517-2.5-4.5	9/15/2017	2.5	4.5	3	J	--	
PTC-002	SO-PTC-002-091317-13.0-15.0	9/13/2017	13	15	8	J	--	
PTC-002	SO-PTC-002-091317-2.0-4.0	9/13/2017	2	4	1.6	J	--	
PTC-101	SO-PTC-101-091417-13.0-15.0	9/14/2017	13	15	4,900		--	
PTC-101	SO-PTC-101-091417-8.2-10.2	9/14/2017	8.2	10.2	790		--	
PTC-102	SO-PTC-102-092118-14.5-15.0	9/21/2018	14.5	15	9,800		13000.0	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)			
					Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
PTC-102	SO-PTC-102-092118-7.5-8.5	9/21/2018	7.5	8.5	170000.0		--	
PTC-103	SO-PTC-103-092118-12.8-13.8	9/21/2018	12.8	13.8	5,800		9900.0	
PTC-103	SO-PTC-103-092118-7.5-8.5	9/21/2018	7.5	8.5	1,500		5,200	
PTC-104	SO-PTC-104-092018-13.4-13.9	9/20/2018	13.4	13.9	900		2,100	
PTC-104	SO-PTC-104-092018-14.2-14.7	9/20/2018	14.2	14.7	8300.0		9,800	
PTC-105	SO-PTC-105-092418-13.0-14.0	9/24/2018	13	14	7,900		--	
PTC-105	SO-PTC-105-092418-8.0-9.0_DC	9/24/2018	8	9	1,100		1000.0	
PTC-106	SO-PTC-106-092418-13.0-14.0	9/24/2018	13	14	4,700		6000.0	
PTC-106	SO-PTC-106-092418-7.0-8.0	9/24/2018	7	8	1,400		1800.0	
PTC-107	SO-PTC-107-092418-11.0-12.0	9/24/2018	11	12	20		68.0	
PTC-107	SO-PTC-107-092418-6.0-7.0	9/24/2018	6	7	150		250.0	
PTC-108	SO-PTC-108-092118-12.0-12.5	9/21/2018	12	12.5	830.0		910	
PTC-108	SO-PTC-108-092118-13.2-14.2	9/21/2018	13.2	14.2	11,000		8,900	
PTC-109	SO-PTC-109-092418-13.0-14.0	9/24/2018	13	14	6,300		8,400	
PTC-109	SO-PTC-109-092418-5.0-6.0	9/24/2018	5	6	4,700		980	
PTC-110	SO-PTC-110-091818-11-12	9/18/2018	11	12	300		200	
PTC-111	SO-PTC-111-091817-13.1-15.0	9/18/2017	13.1	15	10,000		--	
PTC-111	SO-PTC-111-091817-6.0-8.0	9/18/2017	6	8	960		--	
PTC-112	SO-PTC-112-092018-10.5-11.0	9/20/2018	10.5	11	720		1,300	
PTC-113	SO-PTC-113-092017-12.3-14.3	9/20/2017	12.3	14.3	6,200		--	
PTC-113	SO-PTC-113-092017-7.5-10.0_DC	9/20/2017	7.5	10	410		--	
PTC-114	SO-PTC-114-092018-13.3-13.8	9/20/2018	13.3	13.8	2,700		6,100	
PTC-114	SO-PTC-114-092018-7.0-7.5	9/20/2018	7	7.5	120		140	
PTC-115	SO-PTC-115-091918-14.5-15.0	9/19/2018	14.5	15	160		100	
PTC-115	SO-PTC-115-091918-7.5-8.0	9/19/2018	7.5	8	36		24	
PTC-116	SO-PTC-116-091918-13.1-13.6	9/19/2018	13.1	13.6	7,500		3,500	
PTC-116	SO-PTC-116-091918-8.5-9.0	9/19/2018	8.5	9	77		40	
PTC-117	SO-PTC-117-092018-14.5-15.0	9/20/2018	14.5	15	4,600		6,800	
PTC-117	SO-PTC-117-092018-6.4-6.9_DC	9/20/2018	6.4	6.9	300		290	
PTC-118	SO-PTC-118-092018-10.5-11.0	9/20/2018	10.5	11	6,200		4,500	
PTC-118	SO-PTC-118-092018-8.0-8.5	9/20/2018	8	8.5	71		47	
PTC-119	SO-PTC-119-091918-11.5-12.0	9/19/2018	11.5	12	2,900		2,300	
PTC-119	SO-PTC-119-091918-6.0-6.5	9/19/2018	6	6.5	590		820	
PTC-120	SO-PTC-120-092118-11.0-12.0	9/21/2018	11	12	3,900		5,000	
PTC-120	SO-PTC-120-092118-9.0-10.0	9/21/2018	9	10	770		660	
PTC-121	SO-PTC-121-091817-11.0-13.0	9/18/2017	11	13	2,100		--	
PTC-121	SO-PTC-121-091817-13.1-15.0	9/18/2017	13.1	15	1,100		--	
PTC-122	SO-PTC-122-091818-2.0-3.0	9/18/2018	2	3	350		--	
PTC-122	SO-PTC-122-091818-9.5-10.5	9/18/2018	9.5	10.5	3,800		--	
PTC-123	SO-PTC-123-091718-13.0-14.0	9/17/2018	13	14	4,600		10,000	
PTC-123	SO-PTC-123-091718-3.5-4.0	9/17/2018	3.5	4	650		830	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)(1,2)	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg) Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
PTC-124	SO-PTC-124-091718-12.0-13.0	9/17/2018	12	13	24		--	
PTC-124	SO-PTC-124-091718-8.5-9.5	9/17/2018	8.5	9.5	1,200		--	
PTC-125	SO-PTC-125-091718-1.0-2.0	9/17/2018	1	2	46		35	
PTC-125	SO-PTC-125-091718-12.0-13.0	9/17/2018	12	13	7	J	--	
PTC-126	SO-PTC-126-091818-13.5-14	9/18/2018	13.5	14	420		410	
PTC-126	SO-PTC-126-091818-9-10	9/18/2018	9	10	310		470	
PTC-127	SO-PTC-127-091818-7.0-7.5	9/18/2018	7	7.5	930		210	
PTC-128	SO-PTC-128-091918-6.0-6.5	9/19/2018	6	6.5	56		1,700	
PTC-128	SO-PTC-128-091918-7.5-8.0	9/19/2018	7.5	8	4,100		1,200	
PTC-129	SO-PTC-129-092017-10.0-12.0	9/20/2017	10	12	350		--	
PTC-130	SO-PTC-130-091918-11.0-11.5	9/19/2018	11	11.5	260		270	
PTC-130	SO-PTC-130-091918-9.5-10.0	9/19/2018	9.5	10	130		100	
PTC-204	SO-PTC-204-091917-10.8-12.8	9/19/2017	10.8	12.8	34		--	
PTC-204	SO-PTC-204-091917-12.8-14.8	9/19/2017	12.8	14.8	38		--	
PTC-205	SO-PTC-205-091917--10.5-12.4	9/19/2017	0	10.5	17		--	
PTC-205	SO-PTC-205-091917-8.0-10.0	9/19/2017	8	10	15		--	
PTC-207	SO-PTC-207-091517-10.0-12.0	9/15/2017	10	12	3	J	--	
PTC-208	SO-PTC-208-091317-12.0-14.0	9/13/2017	12	14	2	J	--	
R-1A	SO-R-1A-021594-8.1-8.1	2/15/1994	8.1	8.1	500		--	
R-2A	SO-R-2A-021594-8.6-8.6	2/15/1994	8.6	8.6	440		--	
R-3A	SO-R-3A-021594-9.1-9.1	2/15/1994	9.1	9.1	370		--	
R-4A	SO-R-4A-021594-9.6-9.6	2/15/1994	9.6	9.6	180		--	
R-5A	SO-R-5A-021594-10.1-10.1	2/15/1994	10.1	10.1	160		--	
S-1	SO-S-1-073187-0-1	7/31/1987	0	1	380		--	
S-1	SO-S-1-073187-1-2	7/31/1987	1	2	56		--	
S-1	SO-S-1-073187-10-11	7/31/1987	10	11	640		--	
S-1	SO-S-1-073187-12-13	7/31/1987	12	13	3,200		--	
S-1	SO-S-1-073187-13-14	7/31/1987	13	14	1,700		--	
S-1	SO-S-1-073187-2-3	7/31/1987	2	3	100		--	
S-1	SO-S-1-073187-3-4	7/31/1987	3	4	540		--	
S-1	SO-S-1-073187-4-5	7/31/1987	4	5	1,100		--	
S-1	SO-S-1-073187-5-6	7/31/1987	5	6	2,600		--	
S-1	SO-S-1-073187-6-7	7/31/1987	6	7	2,200		--	
S-1	SO-S-1-073187-7-8	7/31/1987	7	8	980		--	
S-1	SO-S-1-073187-8-9	7/31/1987	8	9	960		--	
S-1	SO-S-1-073187-9-10	7/31/1987	9	10	540		--	
S-11	SO-S-11-113089-10.5-11	11/30/1989	10.5	11	10		--	
S-11	SO-S-11-113089-5-5.5	11/30/1989	5	5.5	10		--	
S-18	SO-S-18-113089-5-5.5	11/30/1989	5	5.5	1		--	
S-18	SO-S-18-113089-6-7	11/30/1989	6	7	1		--	
S-18	SO-S-18-113089-7.5-8.5	11/30/1989	7.5	8.5	1		--	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg) Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
S-19	SO-S-19-113089-11.5-12	11/30/1989	11.5	12	42		--	
S-19	SO-S-19-113089-3-4.5	11/30/1989	3	4.5	18		--	
S-19	SO-S-19-113089-6-7.5	11/30/1989	6	7.5	18		--	
S-23	SO-S-23-113089-2.5-3	11/30/1989	2.5	3	24		--	
S-23	SO-S-23-113089-5.5-6	11/30/1989	5.5	6	220		--	
S-23	SO-S-23-113089-9-9.5	11/30/1989	9	9.5	130		--	
S-24	SO-S-24-113089-11-11.5	11/30/1989	11	11.5	3		--	
S-24	SO-S-24-113089-13-13.5	11/30/1989	13	13.5	4		--	
S-24	SO-S-24-113089-4-5	11/30/1989	4	5	3		--	
S-24	SO-S-24-113089-6-7	11/30/1989	6	7	2		--	
S-24	SO-S-24-113089-9-10	11/30/1989	9	10	2		--	
S-3	SO-S-3-073187-0-1	7/31/1987	0	1	77		--	
S-3	SO-S-3-073187-10-11	7/31/1987	10	11	2,000		--	
S-3	SO-S-3-073187-12-13	7/31/1987	12	13	5,500		--	
S-3	SO-S-3-073187-13-14	7/31/1987	13	14	3,200		--	
S-3	SO-S-3-073187-2-3	7/31/1987	2	3	30		--	
S-3	SO-S-3-073187-3-4	7/31/1987	3	4	210		--	
S-3	SO-S-3-073187-4-5	7/31/1987	4	5	510		--	
S-3	SO-S-3-073187-5-6	7/31/1987	5	6	920		--	
S-3	SO-S-3-073187-6-7	7/31/1987	6	7	990		--	
S-3	SO-S-3-073187-7-8	7/31/1987	7	8	1,100		--	
S-3	SO-S-3-073187-8-9	7/31/1987	8	9	540		--	
S-3	SO-S-3-073187-9-10	7/31/1987	9	10	910		--	
S-32	SO-S-32-113089-12.5-13	11/30/1989	12.5	13	5,000		--	
S-33	SO-S-33-113089-11.2-11.7	11/30/1989	11.2	11.7	6,900		--	
S-34	SO-S-34-113089-2.5-3	11/30/1989	2.5	3	13		--	
S-34	SO-S-34-113089-5.5-6	11/30/1989	5.5	6	2		--	
S-34	SO-S-34-113089-7.5-8	11/30/1989	7.5	8	100		--	
S-36	SO-S-36-113089-4-4.5	11/30/1989	4	4.5	140		--	
S-36	SO-S-36-113089-6-7	11/30/1989	6	7	120		--	
S-36	SO-S-36-113089-8-9	11/30/1989	8	9	2,800		--	
S-4	SO-S-4-073187-0-2	7/31/1987	0	2	5,200		--	
S-4	SO-S-4-073187-10-11	7/31/1987	10	11	950		--	
S-4	SO-S-4-073187-11-12	7/31/1987	11	12	4,500		--	
S-4	SO-S-4-073187-12-13	7/31/1987	12	13	2,000		--	
S-4	SO-S-4-073187-13-14	7/31/1987	13	14	1,000		--	
S-4	SO-S-4-073187-2-3	7/31/1987	2	3	1,000		--	
S-4	SO-S-4-073187-3-4	7/31/1987	3	4	540		--	
S-4	SO-S-4-073187-4-5	7/31/1987	4	5	570		--	
S-4	SO-S-4-073187-5-6	7/31/1987	5	6	650		--	
S-4	SO-S-4-073187-6-7	7/31/1987	6	7	3,900		--	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)(1,2)	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg) Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
S-4	SO-S-4-073187-7-8	7/31/1987	7	8	5,900		--	
S-4	SO-S-4-073187-8-9	7/31/1987	8	9	530		--	
S-4	SO-S-4-073187-9-10	7/31/1987	9	10	160		--	
S-46	SO-S-46-113089-10-10.5	11/30/1989	10	10.5	800		--	
S-46	SO-S-46-113089-11.5-12	11/30/1989	11.5	12	2,900		--	
S-46	SO-S-46-113089-2.5-3	11/30/1989	2.5	3	31		--	
S-46	SO-S-46-113089-7-7.5	11/30/1989	7	7.5	1,100		--	
S-6	SO-S-6-073187-0-1	7/31/1987	0	1	300		--	
S-6	SO-S-6-073187-1-2	7/31/1987	1	2	180		--	
S-6	SO-S-6-073187-10-11	7/31/1987	10	11	4,500		--	
S-6	SO-S-6-073187-11-12	7/31/1987	11	12	3,100		--	
S-6	SO-S-6-073187-2-3	7/31/1987	2	3	72		--	
S-6	SO-S-6-073187-3-4	7/31/1987	3	4	180		--	
S-6	SO-S-6-073187-4-5	7/31/1987	4	5	100		--	
S-6	SO-S-6-073187-5-6	7/31/1987	5	6	150		--	
S-6	SO-S-6-073187-6-7	7/31/1987	6	7	160		--	
S-6	SO-S-6-073187-7-8	7/31/1987	7	8	1,200		--	
S-6	SO-S-6-073187-8-9	7/31/1987	8	9	620		--	
S-6	SO-S-6-073187-9-10	7/31/1987	9	10	2,500		--	
S-7	SO-S-7-073187-0-1	7/31/1987	0	1	440		--	
S-7	SO-S-7-073187-1-2	7/31/1987	1	2	370		--	
S-7	SO-S-7-073187-10-11	7/31/1987	10	11	3,600		--	
S-7	SO-S-7-073187-11-12	7/31/1987	11	12	1,700		--	
S-7	SO-S-7-073187-13-14	7/31/1987	13	14	770		--	
S-7	SO-S-7-073187-2-3	7/31/1987	2	3	970		--	
S-7	SO-S-7-073187-3-4	7/31/1987	3	4	2,000		--	
S-7	SO-S-7-073187-4-5	7/31/1987	4	5	370		--	
S-7	SO-S-7-073187-5-6	7/31/1987	5	6	120		--	
S-7	SO-S-7-073187-6-7	7/31/1987	6	7	150		--	
S-7	SO-S-7-073187-7-8	7/31/1987	7	8	730		--	
S-7	SO-S-7-073187-8-10	7/31/1987	8	10	610		--	
S-8	SO-S-8-073187-0-1	7/31/1987	0	1	240		--	
S-8	SO-S-8-073187-1-2	7/31/1987	1	2	71		--	
S-8	SO-S-8-073187-10-11	7/31/1987	10	11	270		--	
S-8	SO-S-8-073187-12-13	7/31/1987	12	13	650		--	
S-8	SO-S-8-073187-13-14	7/31/1987	13	14	920		--	
S-8	SO-S-8-073187-2-3	7/31/1987	2	3	520		--	
S-8	SO-S-8-073187-3-4	7/31/1987	3	4	570		--	
S-8	SO-S-8-073187-4-5	7/31/1987	4	5	840		--	
S-8	SO-S-8-073187-5-6	7/31/1987	5	6	930		--	
S-8	SO-S-8-073187-6-7	7/31/1987	6	7	1,800		--	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[(1,2)]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg) Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
S-8	SO-S-8-073187-7-8	7/31/1987	7	8	220		--	
S-8	SO-S-8-073187-8-9	7/31/1987	8	9	1,200		--	
S-8	SO-S-8-073187-9-10	7/31/1987	9	10	430		--	
SB-1	SO-SB-1-062603-10.0-11.5	6/26/2003	10	11.5	55		--	
SB-1	SO-SB-1-062603-12.5-14.0	6/26/2003	12.5	14	36		--	
SB-2	SO-SB-2-062603-10.0-11.5	6/26/2003	10	11.5	45		--	
SB-2	SO-SB-2-062603-12.5-14.0	6/26/2003	12.5	14	45		--	
SB-5	SO-SB-5-062703-12.5-14.0	6/27/2003	12.5	14	190		--	
SB-7	SO-SB-7-060104-10.0-11.5	6/1/2004	10	11.5	6	U	--	
SB-7	SO-SB-7-060104-12.5-14.0	6/1/2004	12.5	14	7	U	--	
SB-7	SO-SB-7-063003-7.5-9.0	6/30/2003	7.5	9	7	U	--	
SB13	SO-SB13-101601-3-5	10/16/2001	3	5	330		--	
SB13	SO-SB13-101601-5-7	10/16/2001	5	7	1800.0		--	
SB14	SO-SB14-101601-3-5	10/16/2001	3	5	1,700		--	
SB14	SO-SB14-101601-5-7	10/16/2001	5	7	1,700		--	
SB15	SO-SB15-101601-3-5	10/16/2001	3	5	5,600		--	
SB15	SO-SB15-101601-5-6	10/16/2001	5	6	150		--	
SB16	SO-SB16-101601-3-5	10/16/2001	3	5	140		--	
SB16	SO-SB16-101601-5-7	10/16/2001	5	7	1,300		--	
SB17	SO-SB17-101701-3-5	10/17/2001	3	5	660		--	
SB17	SO-SB17-101701-5-7	10/17/2001	5	7	2,300		--	
SB18	SO-SB18-101701-3-4	10/17/2001	3	4	110		--	
SB18	SO-SB18-101701-4-5	10/17/2001	4	5	270		--	
SB23	SO-SB23-101701-3-5	10/17/2001	3	5	440		--	
SB23	SO-SB23-101701-5-7	10/17/2001	5	7	610		--	
SB25	SO-SB25-101701-3-5	10/17/2001	3	5	1,500		--	
SB25	SO-SB25-101701-5-7	10/17/2001	5	7	1,700		--	
SB26	SO-SB26-101701-3-5.5	10/17/2001	3	5.5	590		--	
SB26	SO-SB26-101701-5.5-7	10/17/2001	5.5	7	1,200		--	
SB27	SO-SB27-101701-3-4	10/17/2001	3	4	350		--	
SB27	SO-SB27-101701-4-6	10/17/2001	4	6	1,400		--	
SB28	SO-SB28-101701-3-4.5	10/17/2001	3	4.5	420		--	
SB28	SO-SB28-101701-4.5-6	10/17/2001	4.5	6	1,000		--	
SB29	SO-SB29-101701-3-5	10/17/2001	3	5	1,700		--	
SB29	SO-SB29-101701-5-6	10/17/2001	5	6	2,300		--	
SB30	SO-SB30-101701-3-5	10/17/2001	3	5	240		--	
SB30	SO-SB30-101701-5-7	10/17/2001	5	7	860		--	
SB31	SO-SB31-101701-3-5	10/17/2001	3	5	1,600		--	
SB31	SO-SB31-101701-5-7	10/17/2001	5	7	810		--	
SB32	SO-SB32-101701-4-5	10/17/2001	4	5	590		--	
SB32	SO-SB32-101701-5-7	10/17/2001	5	7	1,900		--	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)(1,2)	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg) Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
SB32	SO-SB32-101701-7-8	10/17/2001	7	8	1,800		--	
SB33	SO-SB33-101701-4-6	10/17/2001	4	6	3,200		--	
SB33	SO-SB33-101701-6-8	10/17/2001	6	8	390		--	
SB34	SO-SB34-101801-4-6	10/18/2001	4	6	480		--	
SB34	SO-SB34-101801-6-8	10/18/2001	6	8	670		--	
SB35	SO-SB35-101801-4-7	10/18/2001	4	7	870		--	
SB35	SO-SB35-101801-7-8	10/18/2001	7	8	580		--	
SB36	SO-SB36-101801-4-6.5	10/18/2001	4	6.5	1,300		--	
SB36	SO-SB36-101801-6.5-8	10/18/2001	6.5	8	710		--	
SB37	SO-SB37-101801-4-6	10/18/2001	4	6	1,700		--	
SB37	SO-SB37-101801-6-8	10/18/2001	6	8	930		--	
SB45	SO-SB45-101801-4-6	10/18/2001	4	6	220		--	
SB45	SO-SB45-101801-6-8	10/18/2001	6	8	940		--	
SPA-07	SO-SPA-SB07-042307-6-6	4/23/2007	6	6	6		--	
SPA-07	SO-SPA-SS07-042307-0-0	4/23/2007	0	0	9		--	
SPA-08	SO-SPA-SB08-042307-6-6	4/23/2007	6	6	19		--	
SPA-08	SO-SPA-SS08-042307-0-0	4/23/2007	0	0	14		--	
SPA-12	SO-SPA-SB12-042307-6-6	4/23/2007	6	6	19		--	
SPA-12	SO-SPA-SS12-042307-0-0	4/23/2007	0	0	9		--	
TL-1	SO-TL-1-060689-0-3.6	6/6/1989	0	3.6	7		--	
TL-2	SO-TL-2-060689-0-3.7	6/6/1989	0	3.7	7		--	
TL-3	SO-TL-3-060689-0-3.75	6/6/1989	0	3.75	6.5		--	
TL-4	SO-TL-4-060689-0-4	6/6/1989	0	4	5		--	
TL-5	SO-TL-5-060689-0-5	6/6/1989	0	5	4		--	
TL-6	SO-TL-6-060689-0-3.9	6/6/1989	0	3.9	3		--	
TL-7	SO-TL-7-060689-0-4.2	6/6/1989	0	4.2	3		--	
TL-8	SO-TL-8-060689-0-4.2	6/6/1989	0	4.2	5		--	
TL-9	SO-TL-9-060689-0-3.7	6/6/1989	0	3.7	5		--	
TLA-01	SO-TLA-SB01-050107-6-6	5/1/2007	6	6	4		--	
TLA-01	SO-TLA-SS01-050107-0-0	5/1/2007	0	0	18.0		--	
TLA-02	SO-TLA-SB02-050107-6-6	5/1/2007	6	6	22		--	
TLA-02	SO-TLA-SS02-050107-0-0	5/1/2007	0	0	7		--	
TLA-03	SO-TLA-SB03-050107-6-6	5/1/2007	6	6	10		--	
TLA-03	SO-TLA-SS03-050107-0-0	5/1/2007	0	0	16		--	
TLA-04	SO-TLA-SB04-050107-6-6	5/1/2007	6	6	3		--	
TLA-04	SO-TLA-SS04-050107-0-0	5/1/2007	0	0	12		--	
TLA-05	SO-TLA-SB05-050107-6-6	5/1/2007	6	6	12		--	
TLA-05	SO-TLA-SS05-050107-0-0	5/1/2007	0	0	8		--	
TLA-06	SO-TLA-SB06-050207-06-06	5/2/2007	6	6	29		--	
TLA-06	SO-TLA-SS06-050207-0-0	5/2/2007	0	0	4		--	
TLA-07	SO-TLA-SB07-043007-6-6	4/30/2007	6	6	12		--	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)(1,2)	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg) Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
TLA-07	SO-TLA-SB07-053007-10-10	5/30/2007	10	10	1		--	
TLA-07	SO-TLA-SS07-043007-0-0	4/30/2007	0	0	5		--	
TLA-08	SO-TLA-SB08-042507-6-6	4/25/2007	6	6	24		--	
TLA-08	SO-TLA-SS08-042507-0-0	4/25/2007	0	0	24	J	--	
TLA-09	SO-TLA-SB09-050707-6-6	5/7/2007	6	6	57	J	--	
TLA-09	SO-TLA-SS09-050707-0-0	5/7/2007	0	0	30		--	
TLA-10	SO-TLA-SB10-050207-6-6	5/2/2007	6	6	21		--	
TLA-10	SO-TLA-SS10-050207-0-0	5/2/2007	0	0	5		--	
TLA-11	SO-TLA-SB11-050707-6-6	5/7/2007	6	6	12.0		--	
TLA-11	SO-TLA-SB11-051607-10-10	5/16/2007	10	10	19.0		--	
TLA-11	SO-TLA-SS11-050707-0-0	5/7/2007	0	0	4.70		--	
TLA-12	SO-TLA-SB12-050207-6-6	5/2/2007	6	6	7.30		--	
TLA-12	SO-TLA-SB12-053007-10-10	5/30/2007	10	10	18.0		--	
TLA-12	SO-TLA-SS12-050207-0-0	5/2/2007	0	0	11		--	
TLA-13	SO-TLA-SB13-050107-6-6	5/1/2007	6	6	13		--	
TLA-13	SO-TLA-SB13-051507-12-12	5/15/2007	12	12	19		--	
TLA-13	SO-TLA-SS13-050107-0-0	5/1/2007	0	0	44		--	
TLA-14	SO-TLA-SB14-050207-6-6	5/2/2007	6	6	7		--	
TLA-14	SO-TLA-SS14-050207-0-0	5/2/2007	0	0	57		--	
TLA-15	SO-TLA-SB15-050207-6-6	5/2/2007	6	6	100.0		--	
TLA-15	SO-TLA-SB15-053007-10-10	5/30/2007	10	10	3.8		--	
TLA-15	SO-TLA-SS15-050207-0-0	5/2/2007	0	0	28.0		--	
TLA-16	SO-TLA-SB16-050207-6-6	5/2/2007	6	6	15.0		--	
TLA-16	SO-TLA-SB16-051607-10-10	5/16/2007	10	10	56.0		--	
TLA-16	SO-TLA-SS16-050207-0-0	5/2/2007	0	0	19		--	
TLA-17	SO-TLA-SB17-050207-6-6	5/2/2007	6	6	15		--	
TLA-17	SO-TLA-SB17-051607-10-10	5/16/2007	10	10	43		--	
TLA-17	SO-TLA-SS17-050207-0-0	5/2/2007	0	0	17		--	
TLA-18	SO-TLA-SB18-050207-6-6	5/2/2007	6	6	25		--	
TLA-18	SO-TLA-SB18-051607-10-10	5/16/2007	10	10	45		--	
TLA-18	SO-TLA-SS18-050207-0-0	5/2/2007	0	0	17		--	
TLA-19	SO-TLA-SB19-050207-6-6	5/2/2007	6	6	68		--	
TLA-19	SO-TLA-SS19-050207-0-0	5/2/2007	0	0	11		--	
TLA-20	SO-TLA-SB20-050207-6-6	5/2/2007	6	6	16		--	
TLA-20	SO-TLA-SS20-050207-0-0	5/2/2007	0	0	12		--	
TLA-21	SO-TLA-SB21-043007-6-6	4/30/2007	6	6	18		--	
TLA-21	SO-TLA-SS21-043007-0-0	4/30/2007	0	0	63		--	
TLA-22	SO-TLA-SB22-043007-6-6	4/30/2007	6	6	9		--	
TLA-22	SO-TLA-SS22-043007-0-0	4/30/2007	0	0	120		--	
TLA-23	SO-TLA-SB23-050107-6-6	5/1/2007	6	6	43.0		--	
TLA-23	SO-TLA-SB23-053007-10-10	5/30/2007	10	10	190		--	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)			
					Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
TLA-23	SO-TLA-SS23-050107-0-0	5/1/2007	0	0	180		--	
TLA-24	SO-TLA-SB24-050707-6-6	5/7/2007	6	6	180		--	
TLA-24	SO-TLA-SS24-050707-0-0	5/7/2007	0	0	11		--	
TLA-25	SO-TLA-SB25-050107-6-6	5/1/2007	6	6	33		--	
TLA-25	SO-TLA-SS25-050107-0-0	5/1/2007	0	0	63		--	
TLA-26	SO-TLA-SB26-050107-6-6	5/1/2007	6	6	23		--	
TLA-26	SO-TLA-SS26-050107-0-0	5/1/2007	0	0	93		--	
TLA-27	SO-TLA-SB27-050107-6-6	5/1/2007	6	6	280		--	
TLA-27	SO-TLA-SS27-050107-0-0	5/1/2007	0	0	100		--	
TLA-28	SO-TLA-SB28-050107-6-6	5/1/2007	6	6	32		--	
TLA-28	SO-TLA-SS28-050107-0-0	5/1/2007	0	0	21		--	
TLA-29	SO-TLA-SB29-050107-6-6	5/1/2007	6	6	65		--	
TLA-29	SO-TLA-SS29-050107-0-0	5/1/2007	0	0	8		--	
TLA-30	SO-TLA-SB30-050707-6-6	5/7/2007	6	6	160		--	
TLA-30	SO-TLA-SS30-050707-0-0	5/7/2007	0	0	16		--	
TLA-31	SO-TLA-SB31-050807-6-6	5/8/2007	6	6	21		--	
TLA-31	SO-TLA-SS31-050807-0-0	5/8/2007	0	0	5		--	
TLA-32	SO-TLA-SB32-050807-6-6	5/8/2007	6	6	11		--	
TLA-32	SO-TLA-SS32-050807-0-0	5/8/2007	0	0	8		--	
TLP-1	SO-TLP-1-060789-0-1.5	6/7/1989	0	1.5	10		--	
TLP-2	SO-TLP-2-060789-0	6/7/1989	0	0	29		--	
WWS-6	SO-WWS-6-060889-0-0.8	6/8/1989	0	0.8	9		--	
WWS-7	SO-WWS-7-060889-0-0.5	6/8/1989	0	0.5	13		--	
PTC-001	SO-PTC-001-091517-0-1.5	9/15/2017	0	1.5	--		26	
PTC-001	SO-PTC-001-091517-1.5-2.5	9/15/2017	1.5	2.5	--		22	
PTC-001	SO-PTC-001-091517-10-11.5	9/15/2017	10	11.5	--		5	U
PTC-001	SO-PTC-001-091517-11.5-13	9/15/2017	11.5	13	--		7	U
PTC-001	SO-PTC-001-091517-13-15	9/15/2017	13	15	--		7	U
PTC-001	SO-PTC-001-091517-2.5-3.5	9/15/2017	2.5	3.5	--		17	
PTC-001	SO-PTC-001-091517-5-8	9/15/2017	5	8	--		7	U
PTC-002	SO-PTC-002-091217-0-2	9/12/2017	0	2	--		21	
PTC-002	SO-PTC-002-091217-10-11	9/12/2017	10	11	--		7	U
PTC-002	SO-PTC-002-091217-11-12	9/12/2017	11	12	--		8	
PTC-002	SO-PTC-002-091217-12-15	9/12/2017	12	15	--		7	U
PTC-002	SO-PTC-002-091217-2-3.5	9/12/2017	2	3.5	--		34	
PTC-002	SO-PTC-002-091217-5-7	9/12/2017	5	7	--		27	
PTC-002	SO-PTC-002-091217-7-9	9/12/2017	7	9	--		7	U
PTC-002	SO-PTC-002-091217-9-10	9/12/2017	9	10	--		7	U
PTC-101	SO-PTC-101-091417-0-2	9/14/2017	0	2	--		820	
PTC-101	SO-PTC-101-091417-10-13	9/14/2017	10	13	--		1,400	
PTC-101	SO-PTC-101-091417-13-15	9/14/2017	13	15	--		11,000	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg) Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
PTC-101	SO-PTC-101-091417-6-8.2	9/14/2017	6	8.2	--		3,200	
PTC-101	SO-PTC-101-091417-8.2-8.5	9/14/2017	8.2	8.5	--		5,500	
PTC-101	SO-PTC-101-091417-8.5-10	9/14/2017	8.5	10	--		1,100	
PTC-102	SO-PTC-102-092118-11-12	9/21/2018	11	12	--		1,600	
PTC-102	SO-PTC-102-092118-12.5-13.5	9/21/2018	12.5	13.5	--		5,300	
PTC-102	SO-PTC-102-092118-2-3	9/21/2018	2	3	--		190	
PTC-102	SO-PTC-102-092118-6-7	9/21/2018	6	7	--		11,000	
PTC-102	SO-PTC-102-092118-7.5-8	9/21/2018	7.5	8	--		100,000	>
PTC-102	SO-PTC-102-092118-8-8.5	9/21/2018	8	8.5	--		100,000	>
PTC-102	SO-PTC-102-092118-9-10	9/21/2018	9	10	--		21,000	
PTC-103	SO-PTC-103-092118-1.5-2.5	9/21/2018	1.5	2.5	--		2,900	
PTC-103	SO-PTC-103-092118-11-12	9/21/2018	11	12	--		300	
PTC-103	SO-PTC-103-092118-4-5	9/21/2018	4	5	--		750	
PTC-103	SO-PTC-103-092118-6-7	9/21/2018	6	7	--		2,100	
PTC-104	SO-PTC-104-092018-10-11	9/20/2018	10	11	--		1,100	
PTC-104	SO-PTC-104-092018-2-2.5	9/20/2018	2	2.5	--		670	
PTC-104	SO-PTC-104-092018-5-5.5	9/20/2018	5	5.5	--		640	
PTC-104	SO-PTC-104-092018-7-7.5	9/20/2018	7	7.5	--		1,700	
PTC-105	SO-PTC-105-092418-1-2	9/24/2018	1	2	--		35	
PTC-105	SO-PTC-105-092418-11-12	9/24/2018	11	12	--		460	
PTC-105	SO-PTC-105-092418-13-14	9/24/2018	13	14	--		11,000	
PTC-105	SO-PTC-105-092418-3-4	9/24/2018	3	4	--		230	
PTC-105	SO-PTC-105-092418-6-7	9/24/2018	6	7	--		920	
PTC-106	SO-PTC-106-092418-11-12	9/24/2018	11	12	--		710	
PTC-106	SO-PTC-106-092418-12.6-12.9	9/24/2018	12.6	12.9	--		2,700	
PTC-106	SO-PTC-106-092418-2-2.5	9/24/2018	2	2.5	--		510	
PTC-106	SO-PTC-106-092418-5-6	9/24/2018	5	6	--		1,400	
PTC-107	SO-PTC-107-092418-1.5-2	9/24/2018	1.5	2	--		120	
PTC-107	SO-PTC-107-092418-10-11	9/24/2018	10	11	--		960	
PTC-107	SO-PTC-107-092418-14-15	9/24/2018	14	15	--		8	
PTC-108	SO-PTC-108-092118-1.5-2	9/21/2018	1.5	2	--		320	
PTC-108	SO-PTC-108-092118-3.5-4	9/21/2018	3.5	4	--		810	
PTC-108	SO-PTC-108-092118-5.5-6.5	9/21/2018	5.5	6.5	--		850	
PTC-108	SO-PTC-108-092118-8.5-9.5	9/21/2018	8.5	9.5	--		370	
PTC-109	SO-PTC-109-092418-11-12	9/24/2018	11	12	--		840	
PTC-109	SO-PTC-109-092418-2-3	9/24/2018	2	3	--		280	
PTC-109	SO-PTC-109-092418-8-9	9/24/2018	8	9	--		110	
PTC-110	SO-PTC-110-091818-14.5-15	9/18/2018	14.5	15	--		2,000	
PTC-110	SO-PTC-110-091818-2-2.5	9/18/2018	2	2.5	--		62	
PTC-110	SO-PTC-110-091818-5-5.5	9/18/2018	5	5.5	--		270	
PTC-110	SO-PTC-110-091818-7.5-8	9/18/2018	7.5	8	--		150	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)			
					Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
PTC-111	SO-PTC-111-091817-0-2	9/18/2017	0	2	--		64	
PTC-111	SO-PTC-111-091817-10-11.6	9/18/2017	10	11.6	--		420	
PTC-111	SO-PTC-111-091817-11.6-12.4	9/18/2017	11.6	12.4	--		810	
PTC-111	SO-PTC-111-091817-12.4-13.1	9/18/2017	12.4	13.1	--		2,600	
PTC-111	SO-PTC-111-091817-13.1-15	9/18/2017	13.1	15	--		13,000	
PTC-111	SO-PTC-111-091817-2-4	9/18/2017	2	4	--		130	
PTC-111	SO-PTC-111-091817-5-6	9/18/2017	5	6	--		1,300	
PTC-111	SO-PTC-111-091817-6-9	9/18/2017	6	9	--		1,500	
PTC-112	SO-PTC-112-092018-1.5-2.5	9/20/2018	1.5	2.5	--		71	
PTC-112	SO-PTC-112-092018-12.5-13	9/20/2018	12.5	13	--		600	
PTC-112	SO-PTC-112-092018-13.5-14.5	9/20/2018	13.5	14.5	--		1,400	
PTC-112	SO-PTC-112-092018-3.5-4	9/20/2018	3.5	4	--		81	
PTC-112	SO-PTC-112-092018-6.5-7.5	9/20/2018	6.5	7.5	--		76	
PTC-112	SO-PTC-112-092018-8-8.5	9/20/2018	8	8.5	--		240	
PTC-113	SO-PTC-113-092017-0-1.8	9/20/2017	0	1.8	--		57	
PTC-113	SO-PTC-113-092017-1.8-4	9/20/2017	1.8	4	--		19	
PTC-113	SO-PTC-113-092017-10-11.3	9/20/2017	10	11.3	--		2,800	
PTC-113	SO-PTC-113-092017-11.3-12.5	9/20/2017	11.3	12.5	--		7,400	
PTC-113	SO-PTC-113-092017-12.5-15	9/20/2017	12.5	15	--		4,400	
PTC-113	SO-PTC-113-092017-5-7.5	9/20/2017	5	7.5	--		99	
PTC-113	SO-PTC-113-092017-7.5-10	9/20/2017	7.5	10	--		680	
PTC-114	SO-PTC-114-092018-1.5-2	9/20/2018	1.5	2	--		75	
PTC-114	SO-PTC-114-092018-10-10.5	9/20/2018	10	10.5	--		53	
PTC-114	SO-PTC-114-092018-3.5-4	9/20/2018	3.5	4	--		56	
PTC-115	SO-PTC-115-091918-10.5-11	9/19/2018	10.5	11	--		19	
PTC-115	SO-PTC-115-091918-12.5-13	9/19/2018	12.5	13	--		42	
PTC-115	SO-PTC-115-091918-2-2.5	9/19/2018	2	2.5	--		18	
PTC-115	SO-PTC-115-091918-5-5.5	9/19/2018	5	5.5	--		48	
PTC-116	SO-PTC-116-091918-1-1.5	9/19/2018	1	1.5	--		11	
PTC-116	SO-PTC-116-091918-11-11.5	9/19/2018	11	11.5	--		120	
PTC-116	SO-PTC-116-091918-5.5-6	9/19/2018	5.5	6	--		24	
PTC-117	SO-PTC-117-092018-0.9-1.5	9/20/2018	0.9	1.5	--		11	
PTC-117	SO-PTC-117-092018-10.5-11.5	9/20/2018	10.5	11.5	--		170	
PTC-117	SO-PTC-117-092018-12-13	9/20/2018	12	13	--		1,900	
PTC-117	SO-PTC-117-092018-9-9.5	9/20/2018	9	9.5	--		68	
PTC-118	SO-PTC-118-092018-12-12.5	9/20/2018	12	12.5	--		490	
PTC-118	SO-PTC-118-092018-14.5-15	9/20/2018	14.5	15	--		43	
PTC-118	SO-PTC-118-092018-2-2.5	9/20/2018	2	2.5	--		7	
PTC-118	SO-PTC-118-092018-5-5.5	9/20/2018	5	5.5	--		44	
PTC-119	SO-PTC-119-091918-1-1.5	9/19/2018	1	1.5	--		60	
PTC-119	SO-PTC-119-091918-14.5-15	9/19/2018	14.5	15	--		760	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)			
					Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
PTC-119	SO-PTC-119-091918-3.5-4	9/19/2018	3.5	4	--		320	
PTC-119	SO-PTC-119-091918-8.5-9	9/19/2018	8.5	9	--		390	
PTC-120	SO-PTC-120-092118-14-15	9/21/2018	14	15	--		86	
PTC-120	SO-PTC-120-092118-3-3.5	9/21/2018	3	3.5	--		210	
PTC-120	SO-PTC-120-092118-4-4.5	9/21/2018	4	4.5	--		300	
PTC-120	SO-PTC-120-092118-6-7	9/21/2018	6	7	--		90	
PTC-120	SO-PTC-120-092118-6.5-7	9/21/2018	6.5	7	--		1,000	
PTC-121	SO-PTC-121-091817-1.5-3.5	9/18/2017	1.5	3.5	--		290	
PTC-121	SO-PTC-121-091817-10-11.2	9/18/2017	10	11.2	--		460	
PTC-121	SO-PTC-121-091817-11.2-13.1	9/18/2017	11.2	13.1	--		1,700	
PTC-121	SO-PTC-121-091817-13.1-15	9/18/2017	13.1	15	--		1,500	
PTC-121	SO-PTC-121-091817-6.3-8.3	9/18/2017	6.3	8.3	--		240	
PTC-121	SO-PTC-121-091817-8.3-10	9/18/2017	8.3	10	--		360	
PTC-122	SO-PTC-122-091818-12-12.5	9/18/2018	12	12.5	--		150	
PTC-122	SO-PTC-122-091818-14-14.5	9/18/2018	14	14.5	--		9	
PTC-122	SO-PTC-122-091818-2-2.5	9/18/2018	2	2.5	--		420	
PTC-122	SO-PTC-122-091818-5-5.5	9/18/2018	5	5.5	--		180	
PTC-122	SO-PTC-122-091818-7-7.5	9/18/2018	7	7.5	--		190	
PTC-122	SO-PTC-122-091818-9.5-10	9/18/2018	9.5	10	--		4,200	
PTC-123	SO-PTC-123-091718-11-12	9/17/2018	11	12	--		1,300	
PTC-123	SO-PTC-123-091718-14-15	9/17/2018	14	15	--		260	
PTC-123	SO-PTC-123-091718-2-2.6	9/17/2018	2	2.6	--		960	
PTC-123	SO-PTC-123-091718-6.5-7.5	9/17/2018	6.5	7.5	--		560	
PTC-123	SO-PTC-123-091718-9-10	9/17/2018	9	10	--		450	
PTC-124	SO-PTC-124-091718-11-12	9/17/2018	11	12	--		35	
PTC-124	SO-PTC-124-091718-14-15	9/17/2018	14	15	--		7	
PTC-124	SO-PTC-124-091718-2.5-3.5	9/17/2018	2.5	3.5	--		490	
PTC-124	SO-PTC-124-091718-6-7	9/17/2018	6	7	--		280	
PTC-124	SO-PTC-124-091718-9-9-5	9/17/2018	9	9	--		650	
PTC-125	SO-PTC-125-091718-11-12	9/17/2018	11	12	--		7	U
PTC-125	SO-PTC-125-091718-14-15	9/17/2018	14	15	--		8	U
PTC-125	SO-PTC-125-091718-4-5	9/17/2018	4	5	--		11	
PTC-125	SO-PTC-125-091718-6.5-7.5	9/17/2018	6.5	7.5	--		8	
PTC-126	SO-PTC-126-091818-11-11.5	9/18/2018	11	11.5	--		330	
PTC-126	SO-PTC-126-091818-2-2.5	9/18/2018	2	2.5	--		410	
PTC-126	SO-PTC-126-091818-3.5-4	9/18/2018	3.5	4	--		130	
PTC-126	SO-PTC-126-091818-6-6.8	9/18/2018	6	6.8	--		230	
PTC-127	SO-PTC-127-091818-10-10.5	9/18/2018	10	10.5	--		190	
PTC-127	SO-PTC-127-091818-12-12.5	9/18/2018	12	12.5	--		22	
PTC-127	SO-PTC-127-091818-14.5-15	9/18/2018	14.5	15	--		91	
PTC-127	SO-PTC-127-091818-2-2.5	9/18/2018	2	2.5	--		78	

Table B-6: Arsenic Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)			
					Arsenic (Lab)	Qualifer	Arsenic (XRF)	Qualifer
PTC-127	SO-PTC-127-091818-4.5-5	9/18/2018	4.5	5	--		54	
PTC-128	SO-PTC-128-091918-1.5-2	9/19/2018	1.5	2	--		20	
PTC-128	SO-PTC-128-091918-10.5-11	9/19/2018	10.5	11	--		36	
PTC-128	SO-PTC-128-091918-12.5-13	9/19/2018	12.5	13	--		200	
PTC-129	SO-PTC-129-092017-0-2	9/20/2017	0	2	--		29	
PTC-129	SO-PTC-129-092017-10-12	9/20/2017	10	12	--		1,100	
PTC-129	SO-PTC-129-092017-12-15	9/20/2017	12	15	--		89	
PTC-129	SO-PTC-129-092017-2-4	9/20/2017	2	4	--		67	
PTC-129	SO-PTC-129-092017-5.5-8.2	9/20/2017	5.5	8.2	--		510	
PTC-130	SO-PTC-130-091918-1-1.5	9/19/2018	1	1.5	--		13	
PTC-130	SO-PTC-130-091918-13-13.5	9/19/2018	13	13.5	--		100	
PTC-130	SO-PTC-130-091918-7-7.5	9/19/2018	7	7.5	--		99	
PTC-204	SO-PTC-204-091917-0-1.5	9/19/2017	0	1.5	--		33	
PTC-204	SO-PTC-204-091917-1.5-5	9/19/2017	1.5	5	--		7	U
PTC-204	SO-PTC-204-091917-10-12.8	9/19/2017	10	12.8	--		40	
PTC-204	SO-PTC-204-091917-12.8-15	9/19/2017	12.8	15	--		64	
PTC-204	SO-PTC-204-091917-5-7.5	9/19/2017	5	7.5	--		34	
PTC-204	SO-PTC-204-091917-7.5-10	9/19/2017	7.5	10	--		58	
PTC-205	SO-PTC-205-091917-0-2	9/19/2017	0	2	--		43	
PTC-205	SO-PTC-205-091917-10.5-12.4	9/19/2017	10.5	12.4	--		39	
PTC-205	SO-PTC-205-091917-12.4-15	9/19/2017	12.4	15	--		16	
PTC-205	SO-PTC-205-091917-2-3	9/19/2017	2	3	--		30	
PTC-205	SO-PTC-205-091917-5-7.5	9/19/2017	5	7.5	--		17	
PTC-205	SO-PTC-205-091917-7.5-10	9/19/2017	7.5	10	--		21	
PTC-207	SO-PTC-207-091517-1-1.5	9/15/2017	1	1.5	--		53	
PTC-207	SO-PTC-207-091517-1.5-4	9/15/2017	1.5	4	--		6	U
PTC-207	SO-PTC-207-091517-10-11	9/15/2017	10	11	--		7	U
PTC-207	SO-PTC-207-091517-11-13	9/15/2017	11	13	--		7	U
PTC-207	SO-PTC-207-091517-13-15	9/15/2017	13	15	--		12	
PTC-207	SO-PTC-207-091517-5.5-7	9/15/2017	5.5	7	--		12	
PTC-208	SO-PTC-208-091317-0.5-3	9/13/2017	0.5	3	--		55	
PTC-208	SO-PTC-208-091317-10-12.5	9/13/2017	10	12.5	--		7	U
PTC-208	SO-PTC-208-091317-12.5-15	9/13/2017	12.5	15	--		7	U
PTC-208	SO-PTC-208-091317-5.8-6	9/13/2017	5.8	6	--		55	
PTC-208	SO-PTC-208-091317-6-7.5	9/13/2017	6	7.5	--		7	U
PTC-208	SO-PTC-208-091317-7.5-10	9/13/2017	7.5	10	--		8	U

Notes:

>: Concentration exceeded upper detection limit of XRF (100,000 mg/kg)

J: Estimated value

U: Not detected at shown reporting limit.

Concentrations are shown as two significant figures in standard notation unless that number is greater than 100. If greater than 100, the number is rounded to a whole number.

(1) If the cell is "--" for a given constituent, that means the sample was not analyzed for that constituent.

(2) See Figure B-1 for the locations of these samples (Site IDs).

Table B-7: Copper, Lead, Mercury, and Nickel Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[(1,2)]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)							
					Copper (Lab)	Qualifer	Lead (Lab)	Qualifer	Mercury (Lab)	Qualifer	Nickel (Lab)	Qualifer
AT-10	SO-AT-10-041103-12-16	4/11/2003	12	16	35		--		0.36	U	43	
AT-11	SO-AT-11-041403-12-16	4/14/2003	12	16	21		--		0.39	U	15	
AT-12	SO-AT-12-041403-12-16	4/14/2003	12	16	27		--		0.44	U	21	
AT-13	SO-AT-13-042903-13-16	4/29/2003	13	16	35		--		0.39	U	14	
AT-14	SO-AT-14-041403-12-16	4/14/2003	12	16	30		--		0.38	U	14	
AT-15	SO-AT-15-041403-12-16	4/14/2003	12	16	36		--		0.47	U	25	
AT-16	SO-AT-16-041403-12-16	4/14/2003	12	16	15		--		0.37	U	10	
AT-16	SO-AT-16-041403-4-8	4/14/2003	4	8	27		--		0.36	U	13.0	
AT-3	SO-AT-3-041103-1-4	4/11/2003	1	4	15		--		0.27	U	19	
AT-3	SO-AT-3-041103-12-16	4/11/2003	12	16	27		--		0.42	U	18	
AT-4	SO-AT-4-041103-1-4	4/11/2003	1	4	14		--		0.30	U	30	
AT-4	SO-AT-4-041103-12-16	4/11/2003	12	16	31		--		0.37	U	17	
AT-5	SO-AT-5-041103-12-16	4/11/2003	12	16	9.1		--		0.33	U	5.9	
AT-6	SO-AT-6-041103-12-16	4/11/2003	12	16	20		--		0.35	U	20	
AT-7	SO-AT-7-041103-12-16	4/11/2003	12	16	26		--		0.36	U	13	
AT-8	SO-AT-8-041103-12-16	4/11/2003	12	16	29		--		0.40	U	15	
AT-9	SO-AT-9-041103-12-16	4/11/2003	12	16	29		--		0.37	U	14	
B-AA	SO-B-AA-072212-12-12	7/22/2012	12	12	34		3	U	0.03	U	12.0	
B-AA	SO-B-AA-072212-3-3	7/22/2012	3	3	11		11.0		0.100		8	
B-BB	SO-B-BB-072212-14-14	7/22/2012	14	14	37		3.0	U	0.030	U	15.0	
B-BB	SO-B-BB-072212-9-9	7/22/2012	9	9	11		2.0	U	0.020	U	6	
B-C	SO-B-C-072212-11-11	7/22/2012	11	11	11.0		2.0	U	--		11.0	
B-C	SO-B-C-072212-12-12	7/22/2012	12	12	31		3.0		0.03	U	14	
B-C	SO-B-C-072212-13.5-13.5	7/22/2012	13.5	13.5	29		3.0	U	--		14	
B-C	SO-B-C-072212-15-15	7/22/2012	15	15	21		3.0	U	0.02	U	10	
B-C	SO-B-C-072212-8-8_DC	7/22/2012	8	8	10		2.0	U	0.040		5.0	
B-D	SO-B-D-072312-11-11	7/23/2012	11	11	13		4.0		0.23		11	
B-D	SO-B-D-072312-13-13	7/23/2012	13	13	16		7.0		--		27	
B-D	SO-B-D-072312-15-15	7/23/2012	15	15	41		5.0		0.14		19	
B-E	SO-B-E-072312-10-10	7/23/2012	10	10	39		4.0	U	--		16.0	
B-E	SO-B-E-072312-14-14	7/23/2012	14	14	33		3.0	U	--		15	
B-E	SO-B-E-072312-5-5	7/23/2012	5	5	18		10.0		--		9	
B-E	SO-B-E-072312-8-8	7/23/2012	8	8	16		3.0		--		16	
B-F	SO-B-F-072312-12-12	7/23/2012	12	12	11.0		2.0	U	--		9.0	
B-F	SO-B-F-072312-14-14	7/23/2012	14	14	38		3.0	U	--		15.0	
B-F	SO-B-F-072312-7-7	7/23/2012	7	7	9		2.0	U	--		7	
B-G	SO-B-G-072312-10-10_DC	7/23/2012	10	10	15		3.5		--		8.0	
B-G	SO-B-G-072312-13-13	7/23/2012	13	13	21		2.0		--		11	
B-G	SO-B-G-072312-15-15	7/23/2012	15	15	27		3.0		--		13	
BSL-46	SO-BSL-46-0911900.33-0.5	9/11/1990	0.33	0.5	53		27		--		150	

Table B-7: Copper, Lead, Mercury, and Nickel Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)(1,2)	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)							
					Copper (Lab)	Qualifer	Lead (Lab)	Qualifer	Mercury (Lab)	Qualifer	Nickel (Lab)	Qualifer
BSL-55	SO-BSL-55-0911900.33-0.5_DC	9/11/1990	0.33	0.5	40		24		--		140	
BSL-56	SO-BSL-56-0911900.33-0.5	9/11/1990	0.33	0.5	46		29		--		170	
BSL-57	SO-BSL-57-0911900.33-0.5	9/11/1990	0.33	0.5	46		26		--		150	
CP-1	SO-CP-1-060689-0-2	6/6/1989	0	2	30		42		0.13		--	
CP-2	SO-CP-2-060689-0-4.8	6/6/1989	0	4.8	33		34		0.40		--	
CP-3	SO-CP-3-060689-0-3.8	6/6/1989	0	3.8	32		43		0.33		--	
CP-4	SO-CP-4-060689-0-1.7	6/6/1989	0	1.7	22		29		0.18		--	
CRP-1	SO-CRP-1-060789-0-4.5	6/7/1989	0	4.5	31		11		0.11	U	--	
CRP-2	SO-CRP-2-060789-0-5	6/7/1989	0	5	82		30		0.10		--	
CRP-3	SO-CRP-3-060789-0-5	6/7/1989	0	5	25		48		0.11	U	--	
CRP-4	SO-CRP-4-060789-0-3	6/7/1989	0	3	62		31		0.78		--	
CRP-5	SO-CRP-5-060789-0-6.3	6/7/1989	0	6.3	45		44		0.15		--	
CRP-6	SO-CRP-6-060789-0-5.5	6/7/1989	0	5.5	53		39		0.54		--	
CRP-7	SO-CRP-7-060789-0-4.3	6/7/1989	0	4.3	100		17		0.29		--	
CRP-8	SO-CRP-8-060789-0-5.3	6/7/1989	0	5.3	57		43		1.2		--	
MA-03	SO-MA-SB03-042407-6-6	4/24/2007	6	6	9		6	U	0.03	J	7	
MA-03	SO-MA-SS03-042407-0-0	4/24/2007	0	0	23.0		46.0		0.300	J	12.0	
MA-04	SO-MA-SB04-042407-6-6	4/24/2007	6	6	20		23		0.32	J	8.8	
MA-04	SO-MA-SS04-042407-0-0	4/24/2007	0	0	25		30		0.41	J	9.6	
MA-05	SO-MA-SB05-051107-0.5-0.5	5/11/2007	0.5	0.5	290		1,400		0.09	U	8	
MA-05	SO-MA-SB05-051107-6-6	5/11/2007	6	6	25		67		0.033		10.0	
MA-05	SO-MA-SS05-051107-0-0	5/11/2007	0	0	180		1,900		0.100		25.0	
MA-06	SO-MA-SB06-051507-6-6	5/15/2007	6	6	30		300		0.042		6.4	
MA-06	SO-MA-SS06-051507-0-0	5/15/2007	0	0	37		26		0.029		5.5	
MA-07	SO-MA-SB07-051107-6-6	5/11/2007	6	6	14		4		0.024	U	6.3	
MA-07	SO-MA-SS07-051107-0-0	5/11/2007	0	0	17		24.0		0.023	U	9.1	
MA-08	SO-MA-SB08-042607-6-6	4/26/2007	6	6	20		14		0.025		11	
MA-08	SO-MA-SS08-042607-0-0	4/26/2007	0	0	26		35		0.059		19	
MA-09	SO-MA-SB09-042607-6-6	4/26/2007	6	6	11		6	U	0.025	U	6.0	
MA-09	SO-MA-SS09-042607-0-0	4/26/2007	0	0	17		31.0		0.063		10.0	
MA-10	SO-MA-SB10-051407-6-6	5/14/2007	6	6	14	J	6.2	U	0.025	U	11	
MA-10	SO-MA-SS10-051407-0-0	5/14/2007	0	0	30	J	5.7		0.022	U	11	
MA-11	SO-MA-SB11-051407-6-6	5/14/2007	6	6	20	J	7	U	0.026	U	7	
MA-11	SO-MA-SS11-051407-0-0	5/14/2007	0	0	35	J	14.0		0.031		12.0	
MA-12	SO-MA-SB12-051407-6-6	5/14/2007	6	6	19	J	6	U	0.03	U	10	
MA-12	SO-MA-SS12-051407-0-0	5/14/2007	0	0	21	J	22.0		0.130		28.0	
MA-24	SO-MA-SB24-051507-6-6	5/15/2007	6	6	15	J	6.4	U	0.026	U	5.8	
MA-24	SO-MA-SS24-051507-0-0	5/15/2007	0	0	17	J	6.3	U	0.046		8.4	
MA-25	SO-MA-SB25-042507-6-6	4/25/2007	6	6	21		15		0.28		21	
MA-25	SO-MA-SS25-042507-0-0	4/25/2007	0	0	27		38		0.42		11	

Table B-7: Copper, Lead, Mercury, and Nickel Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[(1,2)]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)							
					Copper (Lab)	Qualifer	Lead (Lab)	Qualifer	Mercury (Lab)	Qualifer	Nickel (Lab)	Qualifer
MA-26	SO-MA-SB26-042507-6-6	4/25/2007	6	6	330		58		45		22	
MA-26	SO-MA-SS26-042507-0-0	4/25/2007	0	0	120	J	51	J	100		21	
MA-27	SO-MA-SB27-042407-6-6	4/24/2007	6	6	11		7	U	0.026	UJ	7	
MA-27	SO-MA-SS27-042407-0-0	4/24/2007	0	0	18		21.0		0.033		11.0	
MA-28	SO-MA-SB28-042407-6-6	4/24/2007	6	6	19	J	8		0.18		10	
MA-28	SO-MA-SS28-042407-0-0	4/24/2007	0	0	58		78.0		0.95		46.0	
MA-29	SO-MA-SB29-042407-6-6	4/24/2007	6	6	89		100.0		23.00		7	
MA-29	SO-MA-SS29-042407-0-0	4/24/2007	0	0	23		9				11.0	
MA-30	SO-MA-SB30-042407-6-6	4/24/2007	6	6	120		90		2.3		19	
MA-30	SO-MA-SS30-042407-0-0	4/24/2007	0	0	80		71		1.5		21	
MA-31	SO-MA-SB31-042407-6-6	4/24/2007	6	6	120		150		34.0		100	
MA-31	SO-MA-SS31-042407-0-0	4/24/2007	0	0	49		28		3		21	
MA-32	SO-MA-SB32-042407-6-6	4/24/2007	6	6	42		31.0		0.61		17	
MA-32	SO-MA-SS32-042407-0-0	4/24/2007	0	0	36		9		0.22		18	
MA-33	SO-MA-SB33-042407-6-6	4/24/2007	6	6	33		21.0		0.160		23	
MA-33	SO-MA-SS33-042407-0-0	4/24/2007	0	0	34		8		0.09		21	
MA-34	SO-MA-SB34-051107-10-10	5/11/2007	10	10	13		12		1.2		7.1	
MA-34	SO-MA-SB34-051107-6-6	5/11/2007	6	6	11		6.1	U	0.12		5.0	
MA-34	SO-MA-SS34-051107-0-0	5/11/2007	0	0	23		35		3.1		9.5	
MA-35	SO-MA-SB35-051407-6-6	5/14/2007	6	6	16		7	U	0.16		8.8	
MA-35	SO-MA-SB35-051407-9-9	5/14/2007	9	9	10		6.3	U	0.03	U	6.6	
MA-35	SO-MA-SS35-051407-0-0	5/14/2007	0	0	12.0		11.0		0.930		8.0	
MA-36	SO-MA-SB36-051407-6-6	5/14/2007	6	6	11		6	U	.1		7	
MA-36	SO-MA-SB36-051507-9-9	5/15/2007	9	9	10		6.3	U	0.03	U	5.3	
MA-36	SO-MA-SS36-051407-0-0	5/14/2007	0	0	35.0		29.0		1.500		12.0	
MA-37	SO-MA-SB37-051407-6-6	5/14/2007	6	6	10		6	U	.1		5.8	
MA-37	SO-MA-SB37-051407-9-9	5/14/2007	9	9	11.0		6.7	U	0.08		6.3	
MA-37	SO-MA-SS37-051407-0-0	5/14/2007	0	0	14		11.0		2.000		7.6	
MA-38	SO-MA-SB38-051407-6-6	5/14/2007	6	6	40		60		0.67		26	
MA-38	SO-MA-SS38-051407-0-0	5/14/2007	0	0	59		100		0.65		32	
MA-39	SO-MA-SB39-051407-6-6	5/14/2007	6	6	11.0		6.4	U	0.13		5.3	
MA-39	SO-MA-SB39-051407-9-9	5/14/2007	9	9	7		6.4	U	0.04		3.8	
MA-39	SO-MA-SS39-051407-0-0	5/14/2007	0	0	9.4		6.5	U	0.170		5.3	
MA-40	SO-MA-SB40-051407-6-6	5/14/2007	6	6	26		7.3		3.2		12	
MA-40	SO-MA-SB40-051407-8.5-8.5	5/14/2007	8.5	8.5	26		6.1	U	.6		9	
MA-40	SO-MA-SS40-051407-0-0	5/14/2007	0	0	16		10.0		2.20		15.0	
MA-41	SO-MA-SB41-051107-6-6	5/11/2007	6	6	40		6	U	3		7	
MA-41	SO-MA-SB41-051107-9.5-9.5	5/11/2007	9.5	9.5	13		6.3	U	.4		6.4	
MA-41	SO-MA-SS41-051107-0-0	5/11/2007	0	0	51		12.0		14.00		11.0	
MA-42	SO-MA-SB42-051107-6-6	5/11/2007	6	6	16		6	U	0.85		5.3	

Table B-7: Copper, Lead, Mercury, and Nickel Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)(1,2)	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)							
					Copper (Lab)	Qualifer	Lead (Lab)	Qualifer	Mercury (Lab)	Qualifer	Nickel (Lab)	Qualifer
MA-42	SO-MA-SB42-051107-9-9	5/11/2007	9	9	16		6.2	U	3.50		5.3	
MA-42	SO-MA-SS42-051107-0-0	5/11/2007	0	0	17		12.0		.7		8.0	
MA-43	SO-MA-SB43-052907-7-7	5/29/2007	7	7	42		15		7.1		13	
MA-44	SO-MA-SB44-051607-6-6	5/16/2007	6	6	21		6	U	.3		9.1	
MA-44	SO-MA-SB44-051607-9-9	5/16/2007	9	9	13		6.6	U	0.04		7.1	
MA-44	SO-MA-SS44-051607-0-0	5/16/2007	0	0	20		21.0		2.600		6.2	
MA-45	SO-MA-SB45-051607-6-6	5/16/2007	6	6	11		6	U	0.08		5	
MA-45	SO-MA-SB45-051607-9-9	5/16/2007	9	9	14		6.4	U	0.026		4.0	
MA-45	SO-MA-SS45-051607-0-0	5/16/2007	0	0	34		13.0		0.950		16.0	
MA-46	SO-MA-SB46-052907-6-6	5/29/2007	6	6	10.0		6.2	U	0.095		7.1	
MA-46	SO-MA-SB46-052907-8-8	5/29/2007	8	8	12		6.6	U	0.033		6.5	
MA-47	SO-MA-SB47-052907-6-6	5/29/2007	6	6	14		6.4	U	0.24		8.2	
MA-47	SO-MA-SB47-052907-8-8	5/29/2007	8	8	7.0		6.4	U	0.028		3.6	
MA-48	SO-MA-SB48-052907-6-6	5/29/2007	6	6	7.3		6.4	U	0.075		5.1	
MA-48	SO-MA-SB48-052907-9.5-9.5	5/29/2007	9.5	9.5	10.0		6.4	U	0.046		5.0	
MA-49	SO-MA-SB49-052907-6-6	5/29/2007	6	6	8.0		6.3	U	0.15		6.0	
MA-49	SO-MA-SB49-052907-8.5-8.5	5/29/2007	8.5	8.5	12		6.5	U	0.075		6.5	
MA-50	SO-MA-SB50-052907-10-10	5/29/2007	10	10	11		6.6	U	0.07		7.8	
MA-50	SO-MA-SB50-052907-6-6	5/29/2007	6	6	12		6.4	U	0.250		6.9	
MA-51	SO-MA-SB51-052907-6-6	5/29/2007	6	6	11		6.2	U	0.43		7.7	
MA-51	SO-MA-SB51-052907-9.5-9.5	5/29/2007	9.5	9.5	8.4		6.6	U	0.062		5.9	
MA-52	SO-MA-SB52-052907-6-6	5/29/2007	6	6	11		6.2	U	0.32		7.6	
MA-52	SO-MA-SB52-052907-8.5-8.5	5/29/2007	8.5	8.5	11		6.8	U	0.034		5.1	
MA-53	SO-MA-SB53-052907-9-9	5/29/2007	9	9	11		6.3	U	0.63		6.3	
MA-54	SO-MA-SB54-052907-6-6	5/29/2007	6	6	9.8		6.3	U	0.31		5.4	
MA-54	SO-MA-SB54-052907-8.5-8.5	5/29/2007	8.5	8.5	8.2		6.4	U	0.14		3.8	
MA-55	SO-MA-SB55-052907-10-10	5/29/2007	10	10	8.4		6.5	U	0.05		6.1	
MA-55	SO-MA-SB55-052907-6-6	5/29/2007	6	6	8.1		6.3	U	0.160		5.6	
MA-56	SO-MA-SB56-052907-6-6	5/29/2007	6	6	36		6.3	U	2.5		9.1	
MA-56	SO-MA-SB56-052907-9.5-9.5	5/29/2007	9.5	9.5	11		6.4	U	0.20		6.9	
MA-57	SO-MA-SB57-052907-6-6	5/29/2007	6	6	35		11		1.5		8.0	
MA-57	SO-MA-SB57-052907-9-9	5/29/2007	9	9	18		6.3	U	3.5		4.9	
MA-58	SO-MA-SB58-052907-6-6	5/29/2007	6	6	13		6.3	U	0.39		4.8	
MA-58	SO-MA-SB58-052907-9-9	5/29/2007	9	9	22		6.5	U	0.069		7.8	
PT-31	SO-PT-SB31-042507-6-6	4/25/2007	6	6	24		25		11.00	J	8	
PT-31	SO-PT-SS31-042507-0-0	4/25/2007	0	0	27		13		1	J	16.0	
PT-32	SO-PT-SB32-051607-6-6	5/16/2007	6	6	23		6	U	2		8	
PT-32	SO-PT-SS32-051607-0-0	5/16/2007	0	0	59		28.0		14.0		14.0	
PT-33	SO-PT-SB33-051607-6-6	5/16/2007	6	6	2,000		1,800		910		30	
PT-33	SO-PT-SS33-051607-0-0	5/16/2007	0	0	510		340		220		11	

Table B-7: Copper, Lead, Mercury, and Nickel Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)							
					Copper (Lab)	Qualifer	Lead (Lab)	Qualifer	Mercury (Lab)	Qualifer	Nickel (Lab)	Qualifer
PT-34	SO-PT-SB34-051507-6-6	5/15/2007	6	6	51		15		3.0		14	
PT-34	SO-PT-SS34-051507-0-0	5/15/2007	0	0	49		41		3.6		32	
PT-35	SO-PT-SB35-042507-6-6	4/25/2007	6	6	210		330		350	J	10	
PT-35	SO-PT-SS35-042507-0-0	4/25/2007	0	0	59		70		21	J	19.0	
PT-36	SO-PT-SB36-042507-6-6	4/25/2007	6	6	38		27		13.0	J	8	
PT-36	SO-PT-SS36-042507-0-0	4/25/2007	0	0	38		25		4	J	21.0	
PT-37	SO-PT-SB37-042507-6-6	4/25/2007	6	6	36		21		0.08		9	
PT-37	SO-PT-SS37-042507-0-0	4/25/2007	0	0	41		47		0.100		39.0	
PT-37A	SO-PT-SB37A-051507-6-6	5/15/2007	6	6	20		7.4		0.39		14	
PT-37A	SO-PT-SS37A-051507-0-0	5/15/2007	0	0	24		5.4	U	0.20		21	
PT-38	SO-PT-SB38-042507-6-6	4/25/2007	6	6	28		6		0.03	U	8	
PT-38	SO-PT-SS38-042507-0-0	4/25/2007	0	0	96		100.0		0.110		29.0	
PT-38A	SO-PT-SB38A-051507-6-6	5/15/2007	6	6	19		17.0		0.81		6	
PT-38A	SO-PT-SS38A-051507-0-0	5/15/2007	0	0	29		7		0.82		14.0	
PT-39	SO-PT-SB39-042607-6-6	4/26/2007	6	6	8		6	U	0.025	U	4	
PT-39	SO-PT-SS39-042607-0-0	4/26/2007	0	0	45.0		65.0		0.025	U	19.0	
PT-40	SO-PT-SB40-042607-6-6	4/26/2007	6	6	19		7		0.053		8	
PT-40	SO-PT-SS40-042607-0-0	4/26/2007	0	0	65		59.0		0.074		17.0	
PT-41	SO-PT-SB41-042607-6-6	4/26/2007	6	6	22		18		0.45		6	
PT-41	SO-PT-SS41-042607-0-0	4/26/2007	0	0	45		110		0.29		19.0	
PT-42	SO-PT-SB42-042607-6-6	4/26/2007	6	6	9		69		0.09		3	U
PT-42	SO-PT-SS42-042607-0-0	4/26/2007	0	0	59.0		60		0.150		15.0	
PT-43	SO-PT-SB43-051407-6-6	5/14/2007	6	6	18	J	6	U	0.03	U	6	
PT-43	SO-PT-SS43-051407-0-0	5/14/2007	0	0	24		19.0		0.130		31.0	
PT-48	SO-PT-SB48-051507-6-6	5/15/2007	6	6	13	J	6.3	U	0.025	U	6.5	
PT-48	SO-PT-SS48-051507-0-0	5/15/2007	0	0	15	J	6.3	U	0.025	U	7.2	
PT-49	SO-PT-SB49-051507-6-6	5/15/2007	6	6	13	J	6.3	U	0.025	U	5.9	
PT-49	SO-PT-SS49-051507-0-0	5/15/2007	0	0	18	J	6.2	U	0.025	U	8.4	
PT-50	SO-PT-SB50-043007-6-6	4/30/2007	6	6	14		16		0.06		13	
PT-50	SO-PT-SS50-043007-0-0	4/30/2007	0	0	32		52		0.280		14	
PT-51	SO-PT-SB51-043007-6-6	4/30/2007	6	6	13		20		0.049		6.5	
SB-1	SO-SB-1-062603-10.0-11.5	6/26/2003	10	11.5	30		--		0.070	U	14	
SB-1	SO-SB-1-062603-12.5-14.0	6/26/2003	12.5	14	29		--		0.070	U	11	
SB-2	SO-SB-2-062603-10.0-11.5	6/26/2003	10	11.5	34		--		0.060	U	16	
SB-2	SO-SB-2-062603-12.5-14.0	6/26/2003	12.5	14	28		--		0.070		18	
SB-5	SO-SB-5-062703-12.5-14.0	6/27/2003	12.5	14	48		--		0.070		22	
SB-7	SO-SB-7-063003-7.5-9.0	6/30/2003	7.5	9	37		--		0.060	U	14	
SPA-07	SO-SPA-SB07-042307-6-6	4/23/2007	6	6	24		11		0.03	UJ	15	J
SPA-07	SO-SPA-SS07-042307-0-0	4/23/2007	0	0	25		13		0.160	J	16	J
SPA-08	SO-SPA-SB08-042307-6-6	4/23/2007	6	6	14		8		0.03	UJ	10	J

Table B-7: Copper, Lead, Mercury, and Nickel Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[(1,2)]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)							
					Copper (Lab)	Qualifer	Lead (Lab)	Qualifer	Mercury (Lab)	Qualifer	Nickel (Lab)	Qualifer
SPA-08	SO-SPA-SS08-042307-0-0	4/23/2007	0	0	73		44.0		0.390	J	36.0	J
SPA-12	SO-SPA-SB12-042307-6-6	4/23/2007	6	6	23		42		0.03	J	13	J
SPA-12	SO-SPA-SS12-042307-0-0	4/23/2007	0	0	24		17		0.170	J	13	J
TL-1	SO-TL-1-060689-0-3.6	6/6/1989	0	3.6	46		42		0.26		--	
TL-2	SO-TL-2-060689-0-3.7	6/6/1989	0	3.7	36		56		0.13		--	
TL-3	SO-TL-3-060689-0-3.75	6/6/1989	0	3.75	34		43		0.18		--	
TL-4	SO-TL-4-060689-0-4	6/6/1989	0	4	38		36		0.094	U	--	
TL-5	SO-TL-5-060689-0-5	6/6/1989	0	5	36		48		0.13		--	
TL-6	SO-TL-6-060689-0-3.9	6/6/1989	0	3.9	34		45		0.26		--	
TL-7	SO-TL-7-060689-0-4.2	6/6/1989	0	4.2	37		37		0.36		--	
TL-8	SO-TL-8-060689-0-4.2	6/6/1989	0	4.2	43		47		0.13		--	
TL-9	SO-TL-9-060689-0-3.7	6/6/1989	0	3.7	32		57		0.12		--	
TLA-01	SO-TLA-SB01-050107-6-6	5/1/2007	6	6	15	J	6	U	0.02	U	18	
TLA-01	SO-TLA-SS01-050107-0-0	5/1/2007	0	0	30	J	21.0		0.100		57	
TLA-02	SO-TLA-SB02-050107-6-6	5/1/2007	6	6	28	J	20		0.07		63	
TLA-02	SO-TLA-SS02-050107-0-0	5/1/2007	0	0	22	J	13		0.130		28	
TLA-03	SO-TLA-SB03-050107-6-6	5/1/2007	6	6	24	J	10		0.04		45	
TLA-03	SO-TLA-SS03-050107-0-0	5/1/2007	0	0	29	J	15.0		0.110		130	
TLA-04	SO-TLA-SB04-050107-6-6	5/1/2007	6	6	15	J	6	U	0.04		74	
TLA-04	SO-TLA-SS04-050107-0-0	5/1/2007	0	0	27	J	15.0		0.140		60	
TLA-05	SO-TLA-SB05-050107-6-6	5/1/2007	6	6	23	J	14.0		0.092		180	
TLA-05	SO-TLA-SS05-050107-0-0	5/1/2007	0	0	22	J	10		0.072		96	
TLA-06	SO-TLA-SB06-050207-06-06	5/2/2007	6	6	24		21		0.074		92	
TLA-06	SO-TLA-SS06-050207-0-0	5/2/2007	0	0	23		12		0.069		130	
TLA-07	SO-TLA-SB07-043007-6-6	4/30/2007	6	6	25	J	13.0		0.074		110	
TLA-07	SO-TLA-SB07-053007-10-10	5/30/2007	10	10	19		11		0.027		9	
TLA-07	SO-TLA-SS07-043007-0-0	4/30/2007	0	0	32	J	10		0.079		21.0	
TLA-08	SO-TLA-SB08-042507-6-6	4/25/2007	6	6	21		11		0.04		14	
TLA-08	SO-TLA-SS08-042507-0-0	4/25/2007	0	0	27	J	17	J	0.160		30	
TLA-09	SO-TLA-SB09-050707-6-6	5/7/2007	6	6	14		6	U	0.06		7	
TLA-09	SO-TLA-SS09-050707-0-0	5/7/2007	0	0	56		20.0		0.670		52.0	
TLA-10	SO-TLA-SB10-050207-6-6	5/2/2007	6	6	59		41		0.30	J	97	
TLA-10	SO-TLA-SS10-050207-0-0	5/2/2007	0	0	35		17		0.26	J	28	
TLA-11	SO-TLA-SB11-050707-6-6	5/7/2007	6	6	28		20.0		0.093		180	
TLA-11	SO-TLA-SB11-051607-10-10	5/16/2007	10	10	24		17		0.059		45	
TLA-11	SO-TLA-SS11-050707-0-0	5/7/2007	0	0	24		8		0.064		14	
TLA-12	SO-TLA-SB12-050207-6-6	5/2/2007	6	6	22		13		0.07		160	
TLA-12	SO-TLA-SB12-053007-10-10	5/30/2007	10	10	25		18		0.069		65	
TLA-12	SO-TLA-SS12-050207-0-0	5/2/2007	0	0	29		17		0.270		51	
TLA-13	SO-TLA-SB13-050107-6-6	5/1/2007	6	6	24	J	21		0.08		180	

Table B-7: Copper, Lead, Mercury, and Nickel Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg) Copper (Lab)	Qualifer	Lead (Lab)	Qualifer	Mercury (Lab)	Qualifer	Nickel (Lab)	Qualifer
TLA-13	SO-TLA-SB13-051507-12-12	5/15/2007	12	12	22		23		0.073		44	
TLA-13	SO-TLA-SS13-050107-0-0	5/1/2007	0	0	36	J	27		0.900		230	
TLA-14	SO-TLA-SB14-050207-6-6	5/2/2007	6	6	23		12		.1		120	
TLA-14	SO-TLA-SS14-050207-0-0	5/2/2007	0	0	33		25		1.00		41	
TLA-15	SO-TLA-SB15-050207-6-6	5/2/2007	6	6	26		20.0		1.10	J	84	
TLA-15	SO-TLA-SB15-053007-10-10	5/30/2007	10	10	20		8		.1		21	
TLA-15	SO-TLA-SS15-050207-0-0	5/2/2007	0	0	32		9.1		0.610	J	19	
TLA-16	SO-TLA-SB16-050207-6-6	5/2/2007	6	6	32		23		0.08	J	300	
TLA-16	SO-TLA-SB16-051607-10-10	5/16/2007	10	10	26		21		0.043		100	
TLA-16	SO-TLA-SS16-050207-0-0	5/2/2007	0	0	30		14		0.140	J	21	
TLA-17	SO-TLA-SB17-050207-6-6	5/2/2007	6	6	41		48		0.14		92	
TLA-17	SO-TLA-SB17-051607-10-10	5/16/2007	10	10	58		40		0.55		17	
TLA-17	SO-TLA-SS17-050207-0-0	5/2/2007	0	0	35		15		0.27	J	29	
TLA-18	SO-TLA-SB18-050207-6-6	5/2/2007	6	6	29		16		0.65	J	130	
TLA-18	SO-TLA-SB18-051607-10-10	5/16/2007	10	10	46		42		0.82		20	
TLA-18	SO-TLA-SS18-050207-0-0	5/2/2007	0	0	54		14		0.64	J	46	
TLA-19	SO-TLA-SB19-050207-6-6	5/2/2007	6	6	27		18		0.94	J	69	
TLA-19	SO-TLA-SS19-050207-0-0	5/2/2007	0	0	37		18		0.40	J	35	
TLA-20	SO-TLA-SB20-050207-6-6	5/2/2007	6	6	30		40		0.10	J	31	
TLA-20	SO-TLA-SS20-050207-0-0	5/2/2007	0	0	34		13		0.150	J	22	
TLA-21	SO-TLA-SB21-043007-6-6	4/30/2007	6	6	86	J	31		0.03		14	
TLA-21	SO-TLA-SS21-043007-0-0	4/30/2007	0	0	110	J	120		0.300		420	
TLA-22	SO-TLA-SB22-043007-6-6	4/30/2007	6	6	12	J	6	U	0.03		8	
TLA-22	SO-TLA-SS22-043007-0-0	4/30/2007	0	0	140	J	160.0		0.940		99.0	
TLA-23	SO-TLA-SB23-050107-6-6	5/1/2007	6	6	18		11		1		110	
TLA-23	SO-TLA-SB23-053007-10-10	5/30/2007	10	10	24		16		1.4		170	
TLA-23	SO-TLA-SS23-050107-0-0	5/1/2007	0	0	46		28		16.0		78	
TLA-24	SO-TLA-SB24-050707-6-6	5/7/2007	6	6	17		46.0		2.00		43	
TLA-24	SO-TLA-SS24-050707-0-0	5/7/2007	0	0	23		5	U	.3		13	
TLA-25	SO-TLA-SB25-050107-6-6	5/1/2007	6	6	15		6	U	.3		18	
TLA-25	SO-TLA-SS25-050107-0-0	5/1/2007	0	0	32		25.0		2.40		58	
TLA-26	SO-TLA-SB26-050107-6-6	5/1/2007	6	6	25		11		.1		17	
TLA-26	SO-TLA-SS26-050107-0-0	5/1/2007	0	0	49		52		2.10		41	
TLA-27	SO-TLA-SB27-050107-6-6	5/1/2007	6	6	22		11		.1		8	
TLA-27	SO-TLA-SS27-050107-0-0	5/1/2007	0	0	47		45		1.40		24.0	
TLA-28	SO-TLA-SB28-050107-6-6	5/1/2007	6	6	19		10		0.59	J	19	J
TLA-28	SO-TLA-SS28-050107-0-0	5/1/2007	0	0	30		25.0		0.34		20	
TLA-29	SO-TLA-SB29-050107-6-6	5/1/2007	6	6	26		22.0		0.36		19	
TLA-29	SO-TLA-SS29-050107-0-0	5/1/2007	0	0	15		8		0.24		15	
TLA-30	SO-TLA-SB30-050707-6-6	5/7/2007	6	6	31		26		0.37		16	

Table B-7: Copper, Lead, Mercury, and Nickel Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)							
					Copper (Lab)	Qualifer	Lead (Lab)	Qualifer	Mercury (Lab)	Qualifer	Nickel (Lab)	Qualifer
TLA-30	SO-TLA-SS30-050707-0-0	5/7/2007	0	0	30		16		0.44		20	
TLA-31	SO-TLA-SB31-050807-6-6	5/8/2007	6	6	23		28.0		0.210		16	
TLA-31	SO-TLA-SS31-050807-0-0	5/8/2007	0	0	23		7		0.06		15	
TLA-32	SO-TLA-SB32-050807-6-6	5/8/2007	6	6	38		28.0		0.110		14	
TLA-32	SO-TLA-SS32-050807-0-0	5/8/2007	0	0	26		8		0.09		22	
TLP-1	SO-TLP-1-060789-0-1.5	6/7/1989	0	1.5	33		24		0.27		--	
TLP-2	SO-TLP-2-060789-0	6/7/1989	0	0	85		84		0.10		--	
WWS-6	SO-WWS-6-060889-0-0.8	6/8/1989	0	0.8	170		69		0.74		--	
WWS-7	SO-WWS-7-060889-0-0.5	6/8/1989	0	0.5	69		56		0.16		--	

Notes:

J: Estimated value

U: Not detected at shown reporting limit.

Concentrations are shown as two significant figures in standard notation unless that number is greater than 100. If greater than 100, the number is rounded to a whole number.

(1) If the cell is "--" for a given constituent, that means the sample was not analyzed for that constituent or constituent results were not available.

(2) See Figure B-1 for the locations of these samples (Site IDs).

Table B-8: VOC Soil Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)(1,2)	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)							
					PCE (Lab)	Qualifer	TCE (Lab)	Qualifer	VC (Lab)	Qualifer	CF (Lab)	Qualifer
AT-10	SO-AT-10-041103-12-16	4/11/2003	12	16	0.0014	U	0.0014	U	0.0014	U	--	
AT-11	SO-AT-11-041403-12-16	4/14/2003	12	16	0.0016	U	0.0016	U	0.0016	U	--	
AT-12	SO-AT-12-041403-12-16	4/14/2003	12	16	0.0018	U	0.0018	U	0.0018	U	--	
AT-13	SO-AT-13-042903-13-16	4/29/2003	13	16	0.0016	U	0.0016	U	0.0016	U	--	
AT-14	SO-AT-14-041403-12-16	4/14/2003	12	16	1.1		0.079		0.044		--	
AT-15	SO-AT-15-041403-12-16	4/14/2003	12	16	0.015		0.0024		0.0019	U	--	
AT-16	SO-AT-16-041403-4-8	4/14/2003	4.0	8.0	1.0		0.020		0.0014	U	--	
AT-16	SO-AT-16-041403-12-16	4/14/2003	12	16	0.0019		0.0015	U	0.0015	U	--	
AT-3	SO-AT-3-041103-1-4	4/11/2003	1.0	4.0	0.0011	U	0.0014		0.0011	U	--	
AT-3	SO-AT-3-041103-12-16	4/11/2003	12	16	0.0017	U	0.0017	U	0.0017	U	--	
AT-4	SO-AT-4-041103-1-4	4/11/2003	1.0	4.0	0.0012	U	0.0012	U	0.0012	U	--	
AT-4	SO-AT-4-041103-12-16	4/11/2003	12	16	0.0015	U	0.0015	U	0.0015	U	--	
AT-5	SO-AT-5-041103-12-16	4/11/2003	12	16	0.0013	U	0.0013	U	0.0013	U	--	
AT-6	SO-AT-6-041103-12-16	4/11/2003	12	16	0.0014	U	0.0014	U	0.0014	U	--	
AT-7	SO-AT-7-041103-12-16	4/11/2003	12	16	0.0014	U	0.0014	U	0.0014	U	--	
AT-8	SO-AT-8-041103-12-16	4/11/2003	12	16	0.0016	U	0.0016	U	0.0016	U	--	
AT-9	SO-AT-9-041103-12-16	4/11/2003	12	16	0.0015	U	0.0015	U	0.0015	U	--	
B-AA	SO-B-AA-072212-3-3	7/22/2012	3.0	3.0	0.015		0.0046		0.0078		0.0057	
B-AA	SO-B-AA-072212-12-12	7/22/2012	12	12	14		4.8	U	4.8	U	580	
B-BB	SO-B-BB-072212-9-9	7/22/2012	9.0	9.0	0.0051		0.0014		0.0012	U	0.0086	
B-BB	SO-B-BB-072212-14-14	7/22/2012	14	14	0.0020	U	0.0020	U	0.0020	U	0.0020	U
B-C	SO-B-C-072212-8-8_DC	7/22/2012	8.0	8.0	0.0035		0.0023		0.0010	U	0.0010	U
B-C	SO-B-C-072212-12-12	7/22/2012	12	12	0.0039		0.0062		0.0080		0.0020	U
B-C	SO-B-C-072212-15-15	7/22/2012	15	15	0.0016	U	0.0016	U	0.0016	U	0.0016	U
B-D	SO-B-D-072312-11-11	7/23/2012	11	11	0.0014	U	0.0014	U	0.0014	U	0.0014	U
B-D	SO-B-D-072312-15-15	7/23/2012	15	15	0.0022	U	0.0022	U	0.0022	U	0.0022	U
CP-1	SO-CP-1-060689-0-2	6/6/1989	0.0	2.0	0.0092	U	0.0092	U	0.018	U	0.0092	U
CP-2	SO-CP-2-060689-0-4.8	6/6/1989	0.0	4.8	0.0086	U	0.0086	U	0.017	U	0.0086	U
CP-3	SO-CP-3-060689-0-3.8	6/6/1989	0.0	3.8	0.0090	U	0.0090	U	0.018	U	0.0090	U
CP-4	SO-CP-4-060689-0-1.7	6/6/1989	0.0	1.7	0.0090	U	0.0090	U	0.018	U	0.0090	U
CRP-1	SO-CRP-1-060789-0-4.5	6/7/1989	0.0	4.5	0.062		0.011	U	0.022	U	0.011	U
CRP-2	SO-CRP-2-060789-0-5	6/7/1989	0.0	5.0	0.051		0.0099	U	0.020	U	0.028	
CRP-3	SO-CRP-3-060789-0-5	6/7/1989	0.0	5.0	0.011	U	0.011	U	0.022	U	0.011	U
CRP-4	SO-CRP-4-060789-0-3	6/7/1989	0.0	3.0	0.0086	U	0.0086	U	0.017	U	0.0086	U
CRP-5	SO-CRP-5-060789-0-6.3	6/7/1989	0.0	6.3	0.031		0.011	U	0.022	U	0.011	U
CRP-6	SO-CRP-6-060789-0-5.5	6/7/1989	0.0	5.5	0.030		0.011	U	0.022	U	0.011	U
CRP-7	SO-CRP-7-060789-0-4.3	6/7/1989	0.0	4.3	0.032		0.011	U	0.021	U	0.078	
CRP-8	SO-CRP-8-060789-0-5.3	6/7/1989	0.0	5.3	0.011	U	0.011	U	0.021	U	0.011	U
MA-01	SO-MA-SB01-042407-6-6	4/24/2007	6.0	6.0	0.0037		0.0023	U	0.0023	U	0.0023	U
MA-02	SO-MA-SB02-042407-6-6	4/24/2007	6.0	6.0	0.012		0.0011	U	0.0011	U	0.0011	U
MA-03	SO-MA-SB03-042407-3-3	4/24/2007	3.0	3.0	0.0012	U	0.0012	U	0.0012	U	0.0012	U

Table B-8: VOC Soil Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)							
					PCE (Lab)	Qualifer	TCE (Lab)	Qualifer	VC (Lab)	Qualifer	CF (Lab)	Qualifer
MA-04	SO-MA-SB04-042407-3-3	4/24/2007	3.0	3.0	0.0014	U	0.0014	U	0.0014	U	0.0014	U
MA-05	SO-MA-SB05-051107-3-3	5/11/2007	3.0	3.0	0.0014	U	0.0014	U	0.0014	U	0.0014	U
MA-06	SO-MA-SB06-051507-3-3	5/15/2007	3.0	3.0	0.0013	U	0.0013	U	0.0013	U	0.0028	
MA-07	SO-MA-SB07-051107-3-3	5/11/2007	3.0	3.0	0.0022		0.0012	U	0.0012	U	0.0012	
S-24	SO-S-24-113089-8.5-9	11/30/1989	8.5	9.0	0.30		--		--		4.0	
SB-1	SO-SB-1-062603-10.0-11.5	6/26/2003	10.0	12	0.0015	U	0.0015	U	--		--	
SB-1	SO-SB-1-062603-12.5-14.0	6/26/2003	13	14	0.0013	U	0.0013	U	--		--	
SB-2	SO-SB-2-062603-10.0-11.5	6/26/2003	10.0	12	0.0015	U	0.0015	U	--		--	
SB-2	SO-SB-2-062603-12.5-14.0	6/26/2003	13	14	0.0012	U	0.0012	U	--		--	
SB-5	SO-SB-5-062703-12.5-14.0	6/27/2003	13	14	0.0013	U	0.0013	U	--		--	
SB-7	SO-SB-7-063003-7.5-9.0	6/30/2003	7.5	9.0	0.013		0.0012	U	--		--	
TL-1	SO-TL-1-060689-0-3.6	6/6/1989	0.0	3.6	0.021		0.0090	U	0.018	U	0.0090	U
TL-2	SO-TL-2-060689-0-3.7	6/6/1989	0.0	3.7	0.44		0.0096	U	0.019	U	0.012	
TL-3	SO-TL-3-060689-0-3.75	6/6/1989	0.0	3.8	0.074		0.0093	U	0.019	U	0.0093	U
TL-4	SO-TL-4-060689-0-4	6/6/1989	0.0	4.0	0.075		0.047	U	0.094	U	0.047	U
TL-5	SO-TL-5-060689-0-5	6/6/1989	0.0	5.0	0.0090	U	0.0090	U	0.018	U	0.0090	U
TL-6	SO-TL-6-060689-0-3.9	6/6/1989	0.0	3.9	0.0094	U	0.0094	U	0.019	U	0.0094	U
TL-7	SO-TL-7-060689-0-4.2	6/6/1989	0.0	4.2	0.0096	U	0.0096	U	0.019	U	0.0096	U
TL-8	SO-TL-8-060689-0-4.2	6/6/1989	0.0	4.2	0.010	U	0.010	U	0.020	U	0.010	U
TL-9	SO-TL-9-060689-0-3.7	6/6/1989	0.0	3.7	0.0098	U	0.0098	U	0.020	U	0.0098	U
TLA-05	SO-TLA-SB05-050107-3-3	5/1/2007	3.0	3.0	0.0085		0.012		0.0010	U	0.0010	U
TLA-06	SO-TLA-SB06-050207-3-3	5/2/2007	3.0	3.0	0.0041		0.00094	U	0.00094	U	0.00094	U
TLA-07	SO-TLA-SB07-053007-3-3	5/30/2007	3.0	3.0	0.0010	U	0.0010	U	0.0010	U	0.0010	U
TLA-07	SO-TLA-SB07-053007-8-8	5/30/2007	8.0	8.0	0.0017	U	0.0017	U	0.0017	U	0.0017	U
TLA-08	SO-TLA-SB08-042507-2-2	4/25/2007	2.0	2.0	0.00099	U	0.00099	U	0.00099	U	0.00099	U
TLA-09	SO-TLA-SB09-050707-2-2	5/7/2007	2.0	2.0	0.00091	U	0.00091	U	0.00091	U	0.00091	U
TLA-10	SO-TLA-SB10-050207-3-3	5/2/2007	3.0	3.0	0.00099	U	0.00099	U	0.00099	U	0.00099	U
TLA-11	SO-TLA-SB11-050707-3-3	5/7/2007	3.0	3.0	0.0012	U	0.0012	U	0.0012	U	0.0012	U
TLA-11	SO-TLA-SB11-051607-8-8	5/16/2007	8.0	8.0	0.0011	U	0.0011	U	0.0011	U	0.0011	U
TLA-12	SO-TLA-SB12-050207-3-3	5/2/2007	3.0	3.0	0.0046		0.00091	U	0.00091	U	0.00091	U
TLA-12	SO-TLA-SB12-053007-8-8	5/30/2007	8.0	8.0	0.0024	J	0.0014	UJ	0.0014	UJ	0.0014	UJ
TLA-13	SO-TLA-SB13-050107-3-3	5/1/2007	3.0	3.0	0.078		0.0068		0.0016	U	0.0016	U
TLA-13	SO-TLA-SB13-051507-8-8	5/15/2007	8.0	8.0	0.0015		0.0012		0.00095	U	0.00095	U
TLA-14	SO-TLA-SB14-050207-3-3	5/2/2007	3.0	3.0	0.0010	U	0.0010	U	0.0010	U	0.0010	U
TLA-15	SO-TLA-SB15-050207-3-3	5/2/2007	3.0	3.0	0.00090	U	0.00090	U	0.00090	U	0.00090	U
TLA-15	SO-TLA-SB15-053007-8-8	5/30/2007	8.0	8.0	0.0013	U	0.0013	U	0.0013	U	0.0013	U
TLA-16	SO-TLA-SB16-050207-3-3	5/2/2007	3.0	3.0	0.0058		0.0023		0.0012	U	0.0012	U
TLA-16	SO-TLA-SB16-051607-8-8	5/16/2007	8.0	8.0	0.0013	U	0.0013	U	0.0013	U	0.0013	U
TLA-17	SO-TLA-SB17-050207-3-3	5/2/2007	3.0	3.0	0.0084		0.00083	U	0.00083	U	0.00083	U
TLA-17	SO-TLA-SB17-051607-8-8	5/16/2007	8.0	8.0	0.026		0.0011	U	0.0011	U	0.0011	U
TLA-18	SO-TLA-SB18-050207-3-3	5/2/2007	3.0	3.0	0.0011	U	0.0011	U	0.0011	U	0.0011	U

Table B-8: VOC Soil Soil Direct Contact Results in the 2901 Taylor Way Portion of the Site Boundary

Sample Location (Site ID)[1,2]	Sample ID	Sample Date	Sample Top (feet bgs)	Sample Bottom (feet bgs)	Soil Concentrations (mg/kg)							
					PCE (Lab)	Qualifer	TCE (Lab)	Qualifer	VC (Lab)	Qualifer	CF (Lab)	Qualifer
TLA-18	SO-TLA-SB18-051607-8-8	5/16/2007	8.0	8.0	0.00099	U	0.00099	U	0.00099	U	0.00099	U
TLA-19	SO-TLA-SB19-050207-3-3	5/2/2007	3.0	3.0	0.00094	U	0.00094	U	0.00094	U	0.00094	U
TLA-20	SO-TLA-SB20-050207-3-3	5/2/2007	3.0	3.0	0.91		0.0026		0.0010	U	0.063	
TLA-21	SO-TLA-SB21-043007-3-3	4/30/2007	3.0	3.0	0.0040		0.0010	U	0.0010	U	0.0048	
TLA-22	SO-TLA-SB22-043007-3-3	4/30/2007	3.0	3.0	0.0051	J	0.0011	U	0.0011	U	0.0011	U
TLA-23	SO-TLA-SB23-050107-3-3	5/1/2007	3.0	3.0	0.00094	U	0.00094	U	0.00094	U	0.00094	U
TLA-23	SO-TLA-SB23-053007-8-8	5/30/2007	8.0	8.0	0.010		0.0026		0.0010	U	0.0010	U
TLA-24	SO-TLA-SB24-050707-3-3	5/7/2007	3.0	3.0	0.0012	U	0.0012	U	0.0012	U	0.0012	U
TLA-25	SO-TLA-SB25-050107-3-3	5/1/2007	3.0	3.0	0.0052		0.0012	U	0.0012	U	0.0015	
TLA-26	SO-TLA-SB26-050107-3-3	5/1/2007	3.0	3.0	0.0014		0.0011	U	0.0011	U	0.0011	U
TLA-27	SO-TLA-SB27-050107-3-3	5/1/2007	3.0	3.0	0.0046		0.0011	U	0.0011	U	0.0011	U
TLA-28	SO-TLA-SB28-050107-3-3	5/1/2007	3.0	3.0	0.0027		0.0010	U	0.0010	U	0.0010	U
TLA-29	SO-TLA-SB29-050107-3-3	5/1/2007	3.0	3.0	0.018		0.0014		0.00099	U	0.00099	U
TLA-30	SO-TLA-SB30-050707-3-3	5/7/2007	3.0	3.0	0.016		0.0011	U	0.0011	U	0.0015	
TLA-31	SO-TLA-SB31-050807-3-3	5/8/2007	3.0	3.0	0.013		0.0052		0.0011	U	0.0049	
TLA-32	SO-TLA-SB32-050807-3-3	5/8/2007	3.0	3.0	0.18		0.50		0.0010	U	0.0052	
TLP-1	SO-TLP-1-060789-0-1.5	6/7/1989	0.0	1.5	0.0099	U	0.0099	U	0.020	U	0.0099	U
TLP-2	SO-TLP-2-060789-0	6/7/1989	0.0	0.0	0.0084	U	0.0084	U	0.017	U	0.0084	U
WWS-6	SO-WWS-6-060889-0-0.8	6/8/1989	0.0	0.80	0.0070	U	0.0070	U	0.014	U	0.0070	U
WWS-7	SO-WWS-7-060889-0-0.5	6/8/1989	0.0	0.50	0.027		0.0070	U	0.014	U	0.0080	

Notes:

J: Estimated value

U: Not detected at shown reporting limit.

Concentrations are shown as two significant figures in standard notation unless that number is greater than 100. If greater than 100, the number is rounded to a whole number.

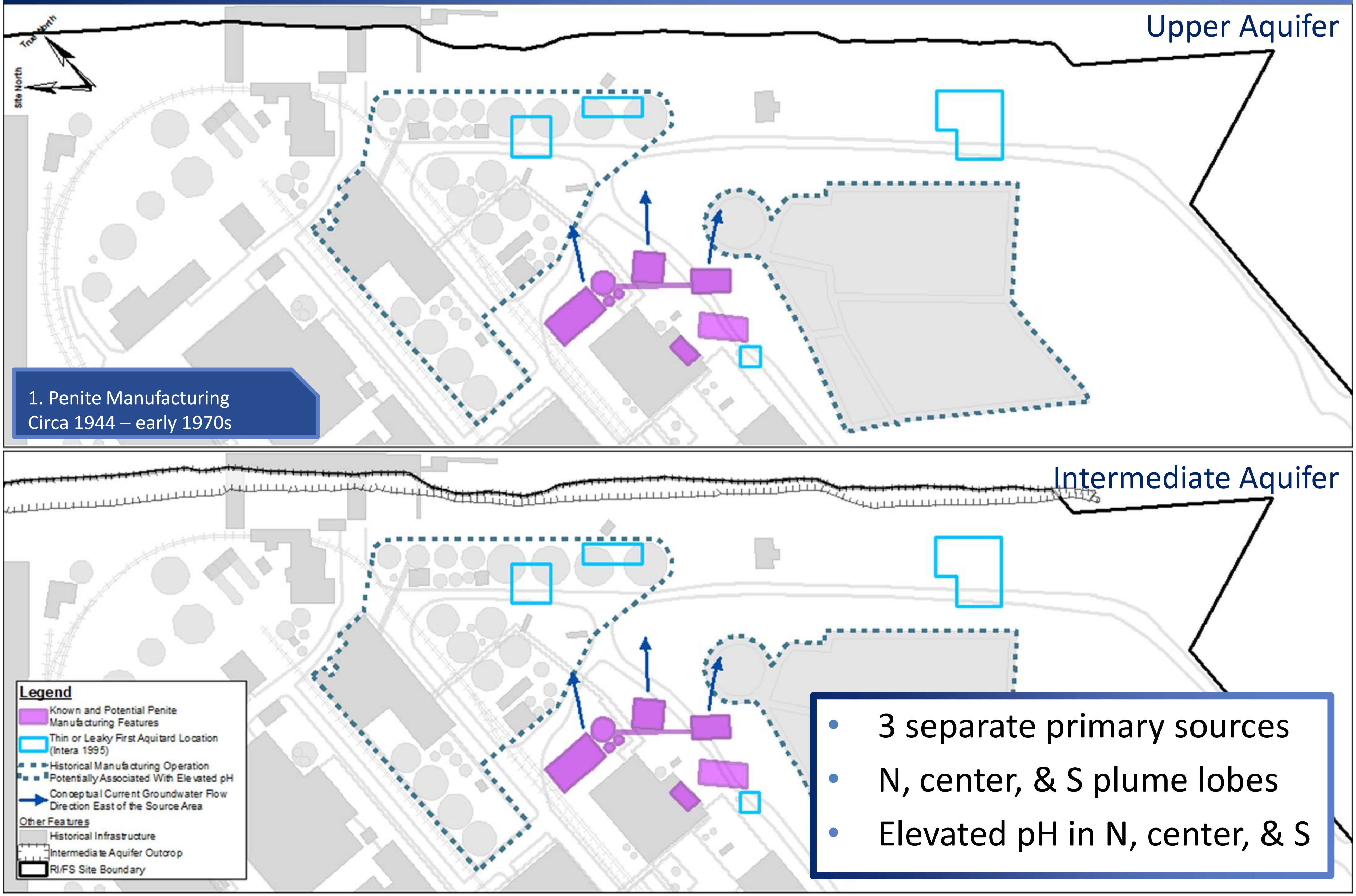
(1) If the cell is "--" for a given constituent, that means the sample was not analyzed for that constituent or constituent results were not available.

(2) See Figure B-1 for the locations of these samples (Site IDs).

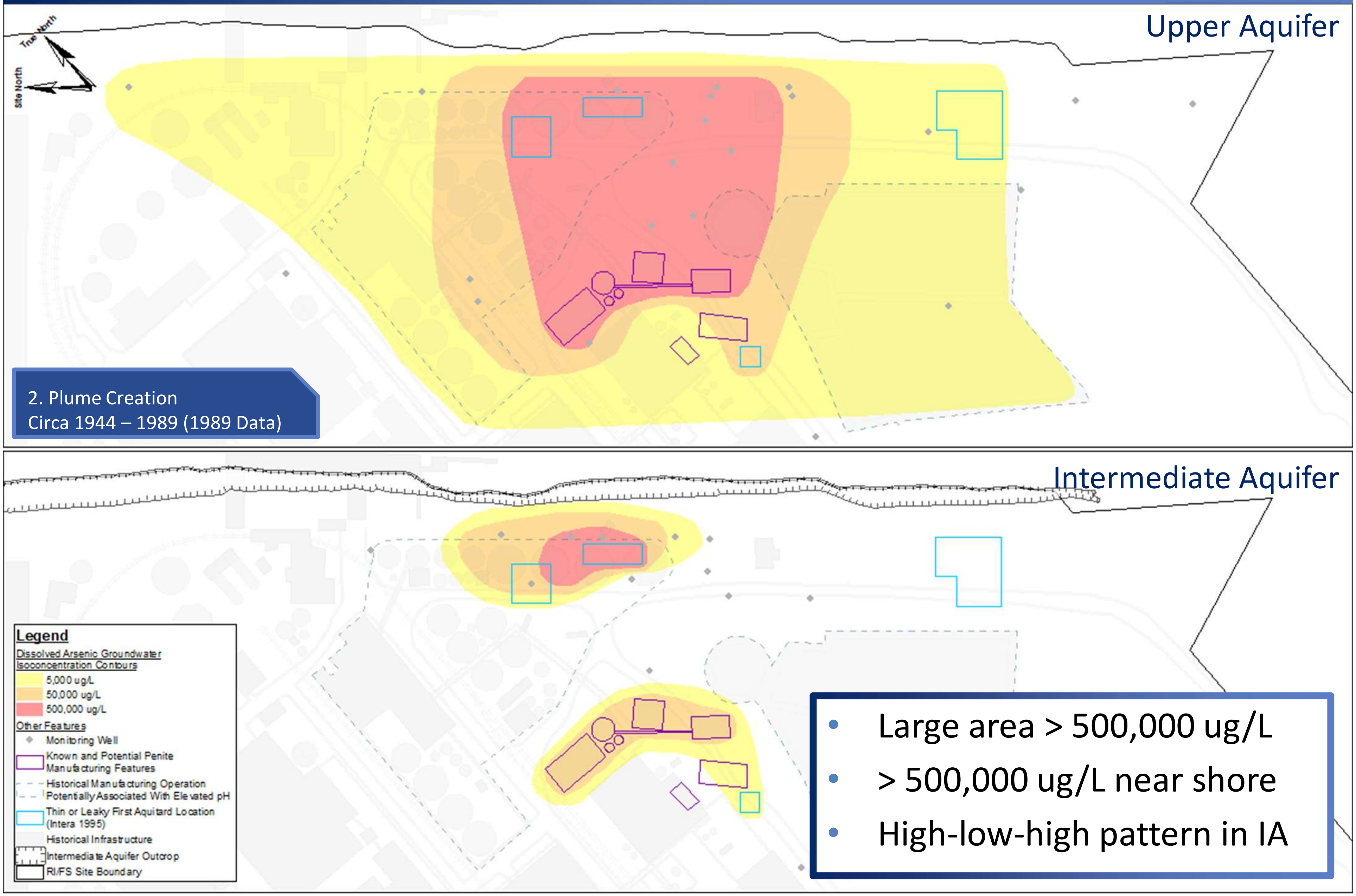
Appendix C

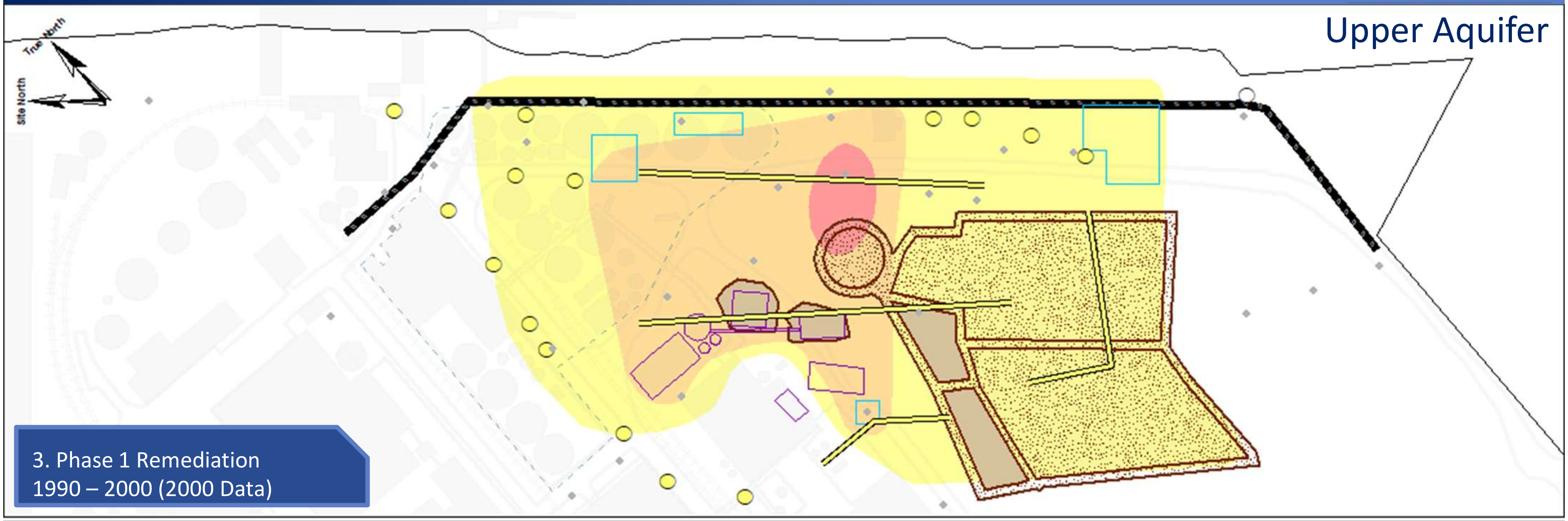
Evolution of the Main Arsenic Plume

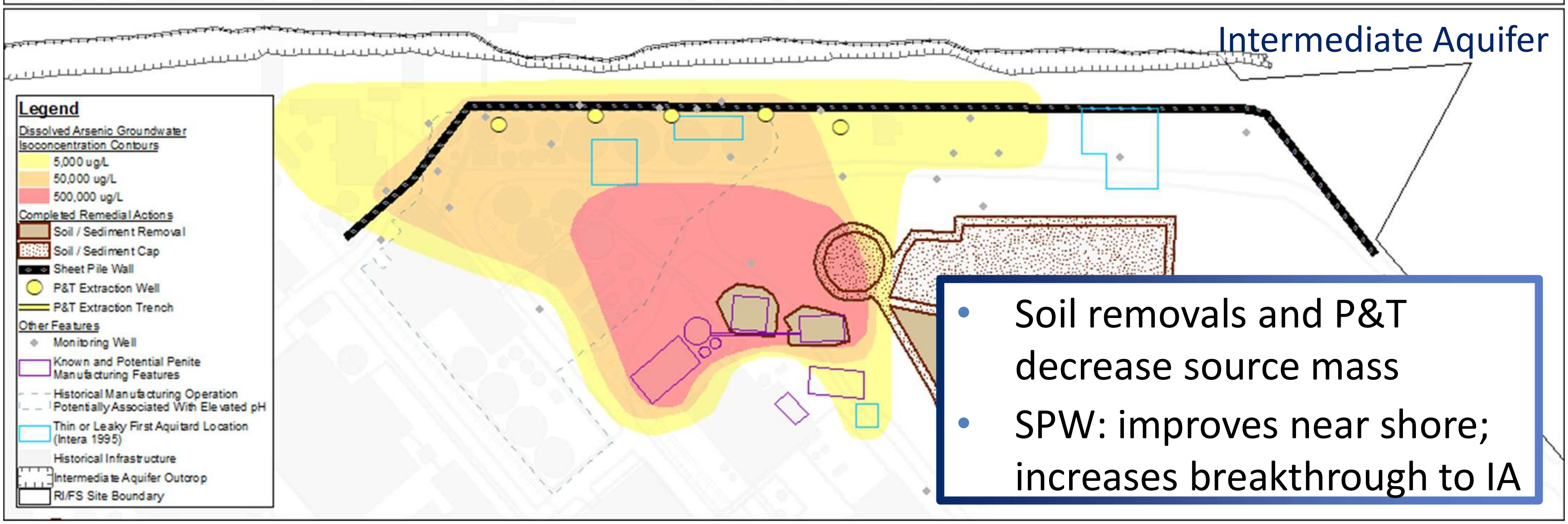
February 2021



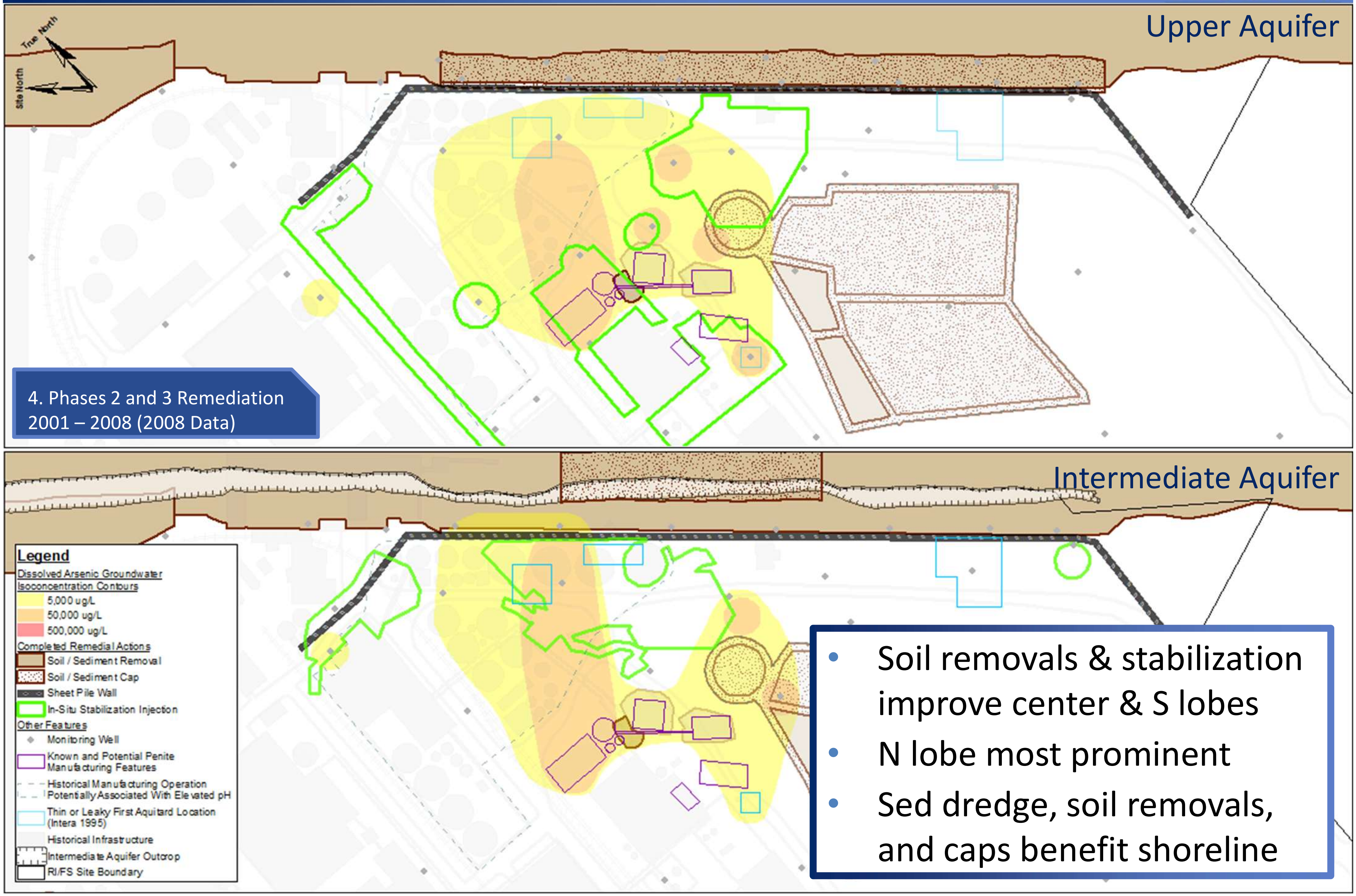
- 3 separate primary sources
- N, center, & S plume lobes
- Elevated pH in N, center, & S


Upper Aquifer
True North
Site North
2. Plume Creation
Circa 1944 – 1989 (1989 Data)
Intermediate Aquifer
Legend
Dissolved Arsenic Groundwater Isoconcentration Contours
5,000 ug/L
50,000 ug/L
500,000 ug/L
Other Features
Monitoring Well
Known and Potential Penite Manufacturing Features
Historical Manufacturing Operation Potentially Associated With Elevated pH
Thin or Leaky First Aquitard Location (Intera 1995)
Historical Infrastructure
Intermediate Aquifer Outcrop
RI/FS Site Boundary
• Large area > 500,000 ug/L
• > 500,000 ug/L near shore
• High-low-high pattern in IA

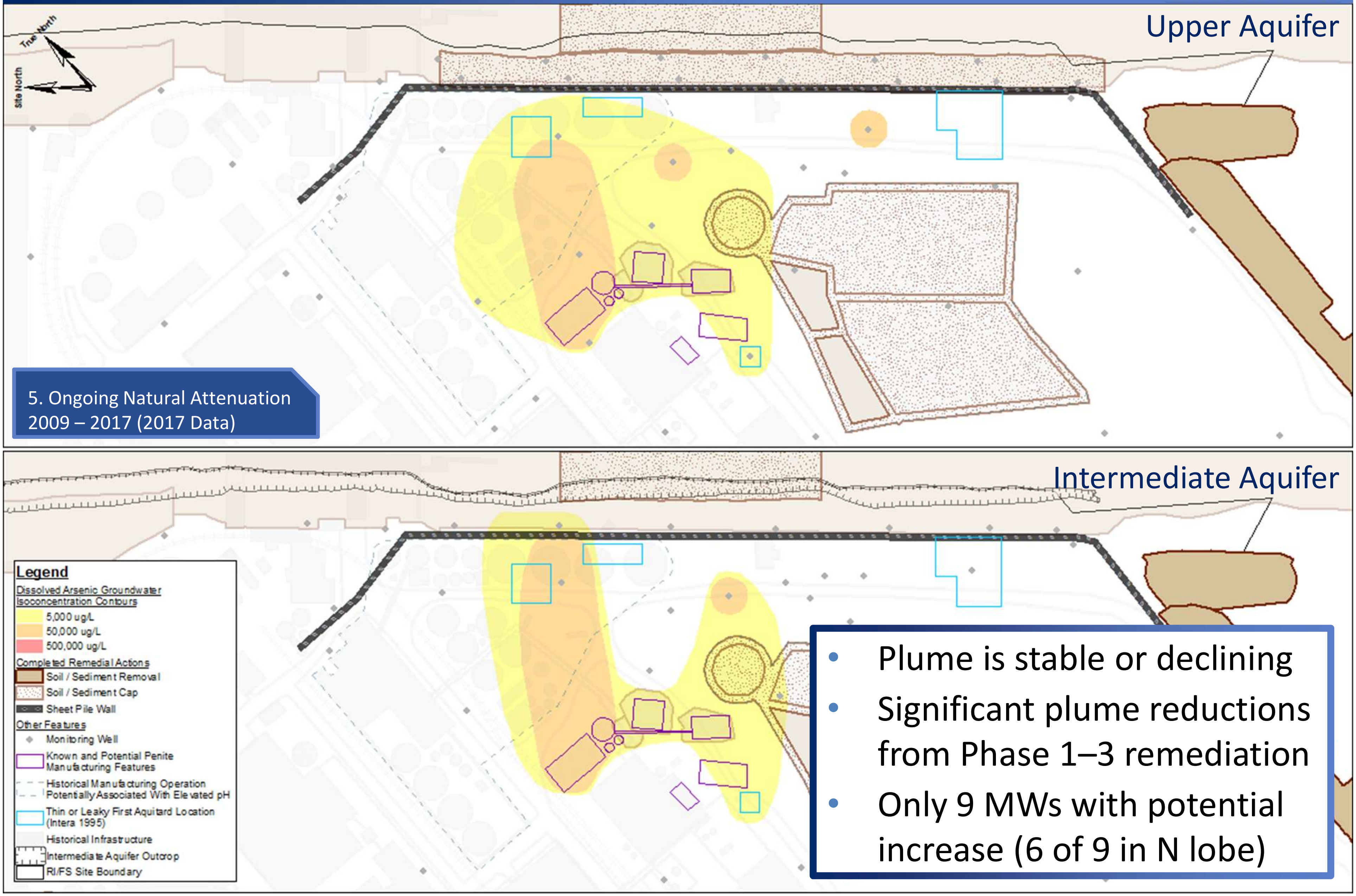




- Soil removals and P&T decrease source mass
- SPW: improves near shore; increases breakthrough to IA



- Soil removals & stabilization improve center & S lobes
- N lobe most prominent
- Sed dredge, soil removals, and caps benefit shoreline



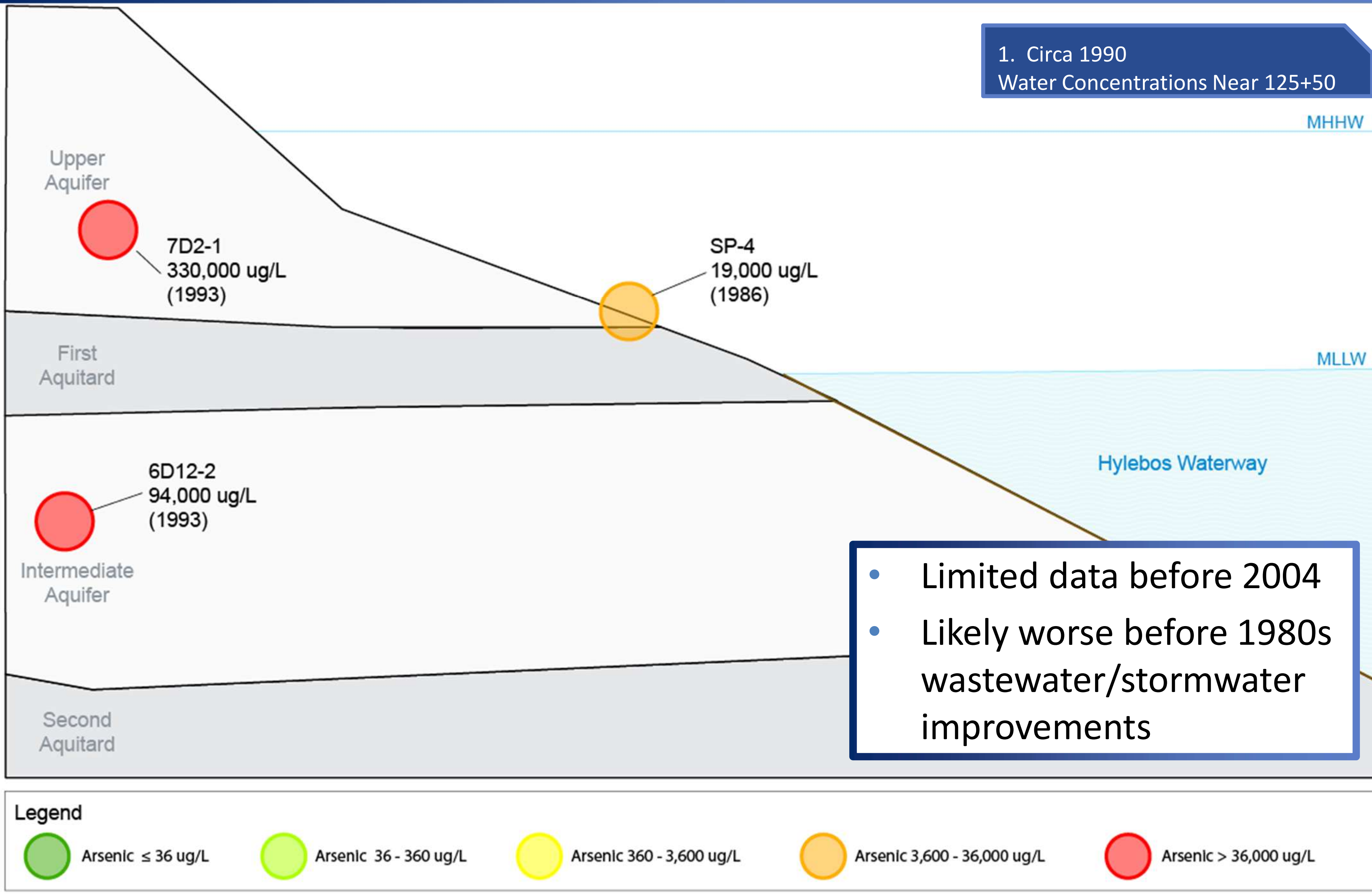
- Plume is stable or declining
- Significant plume reductions from Phase 1–3 remediation
- Only 9 MWs with potential increase (6 of 9 in N lobe)

Appendix D

Evolution of Shoreline Concentrations and Discharges

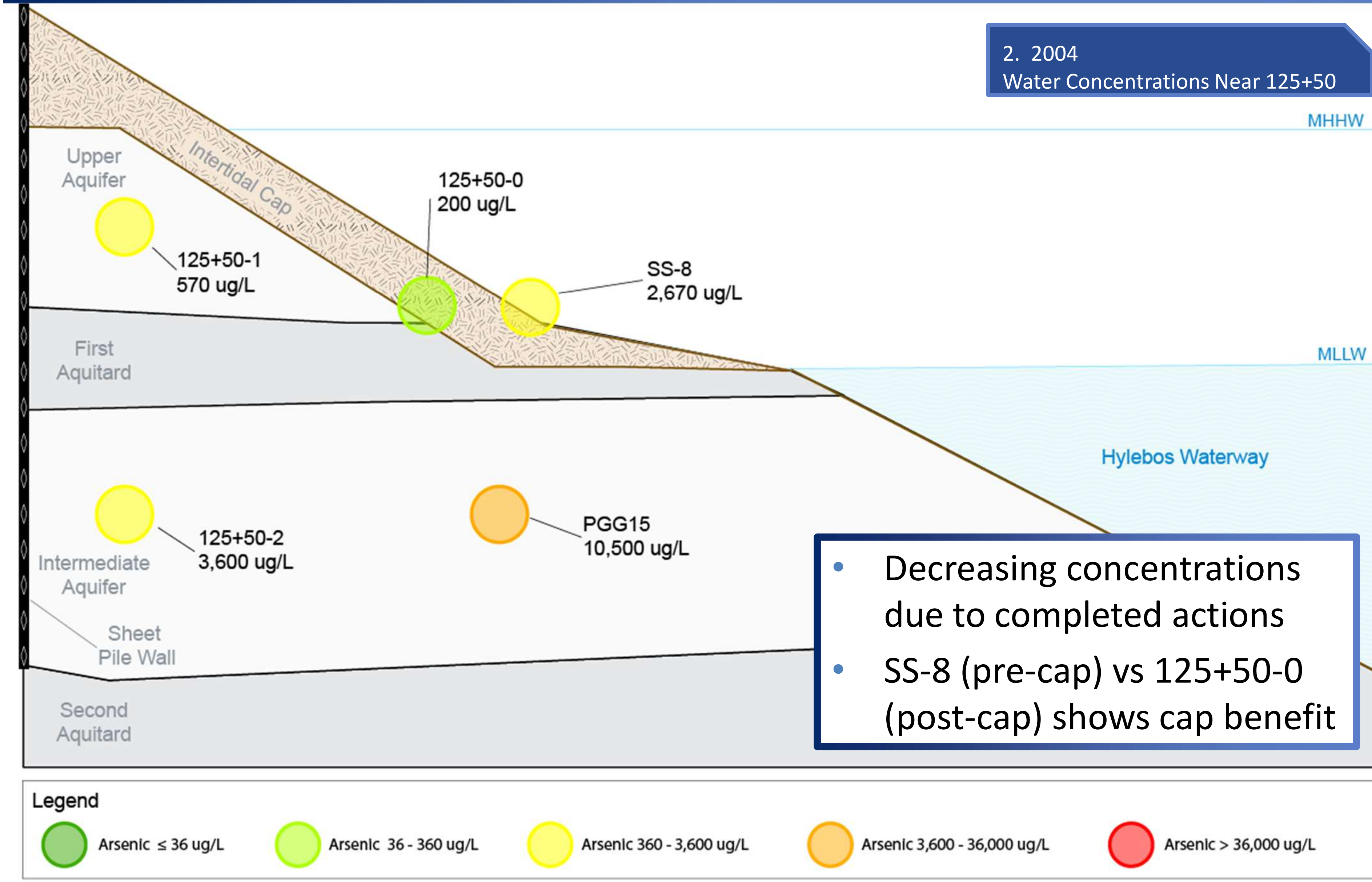
February 2021

1. Circa 1990
Water Concentrations Near 125+50



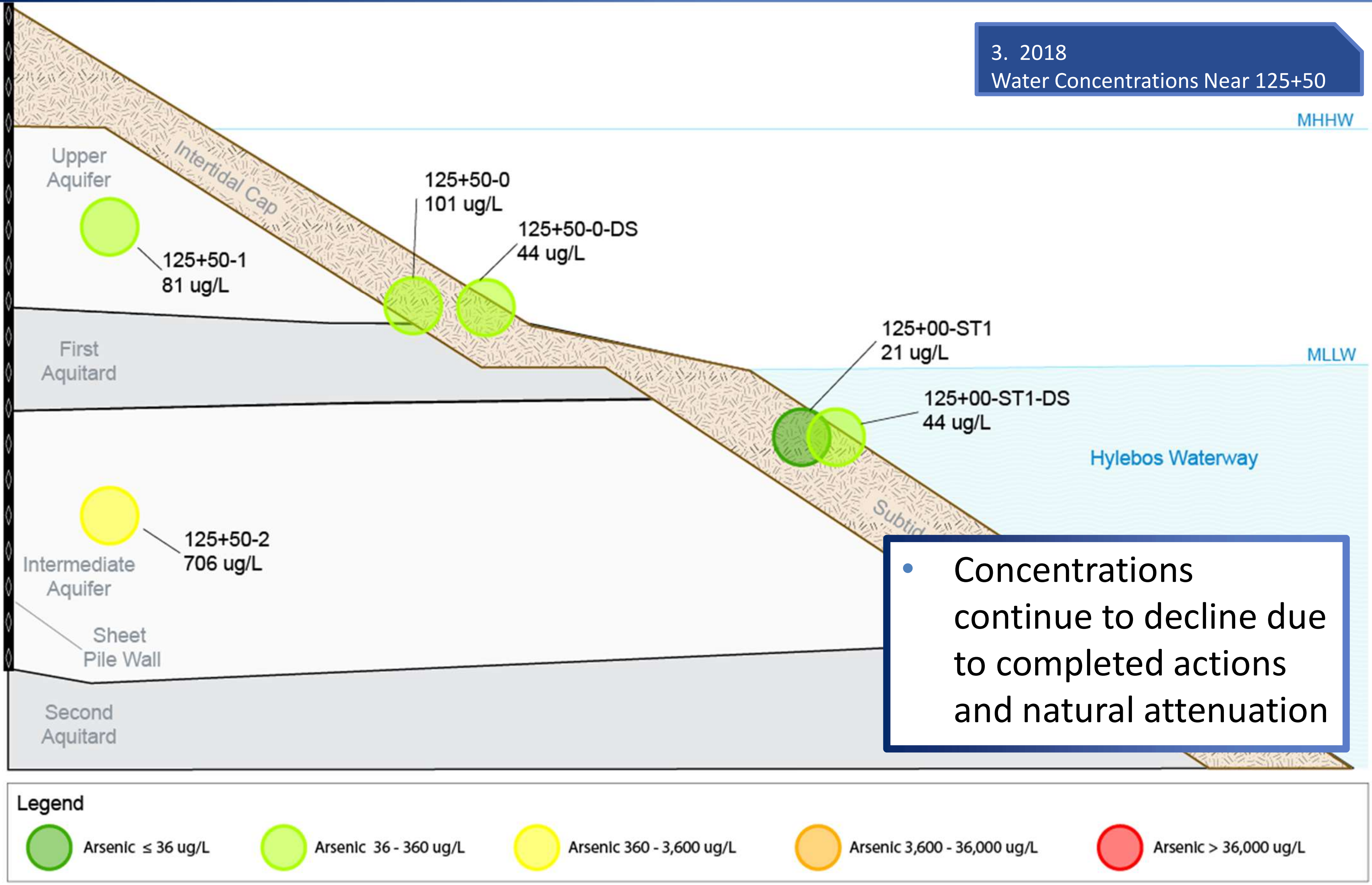
- Limited data before 2004
- Likely worse before 1980s wastewater/stormwater improvements

2. 2004
Water Concentrations Near 125+50



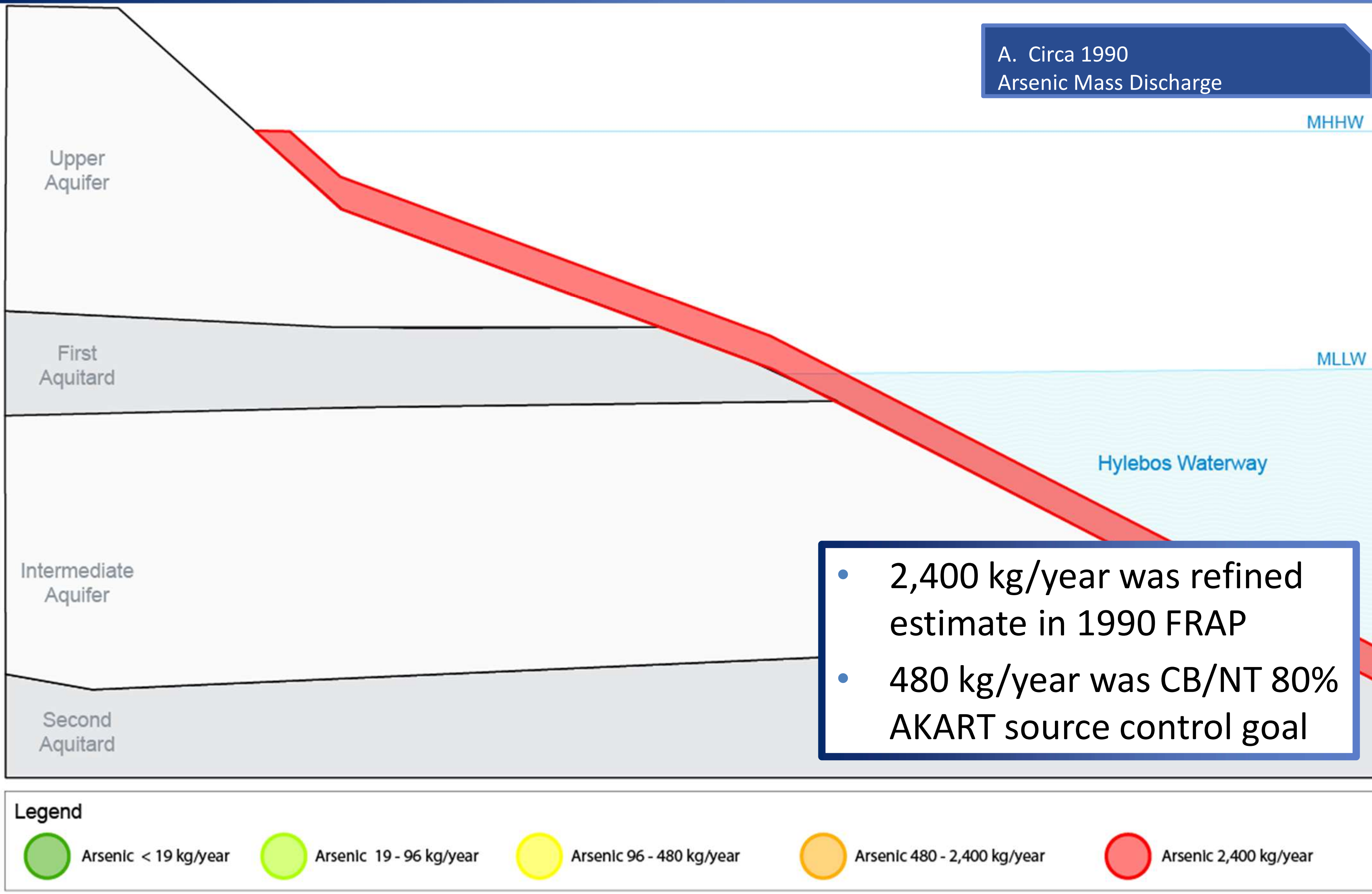
- Decreasing concentrations due to completed actions
- SS-8 (pre-cap) vs 125+50-0 (post-cap) shows cap benefit

3. 2018
Water Concentrations Near 125+50



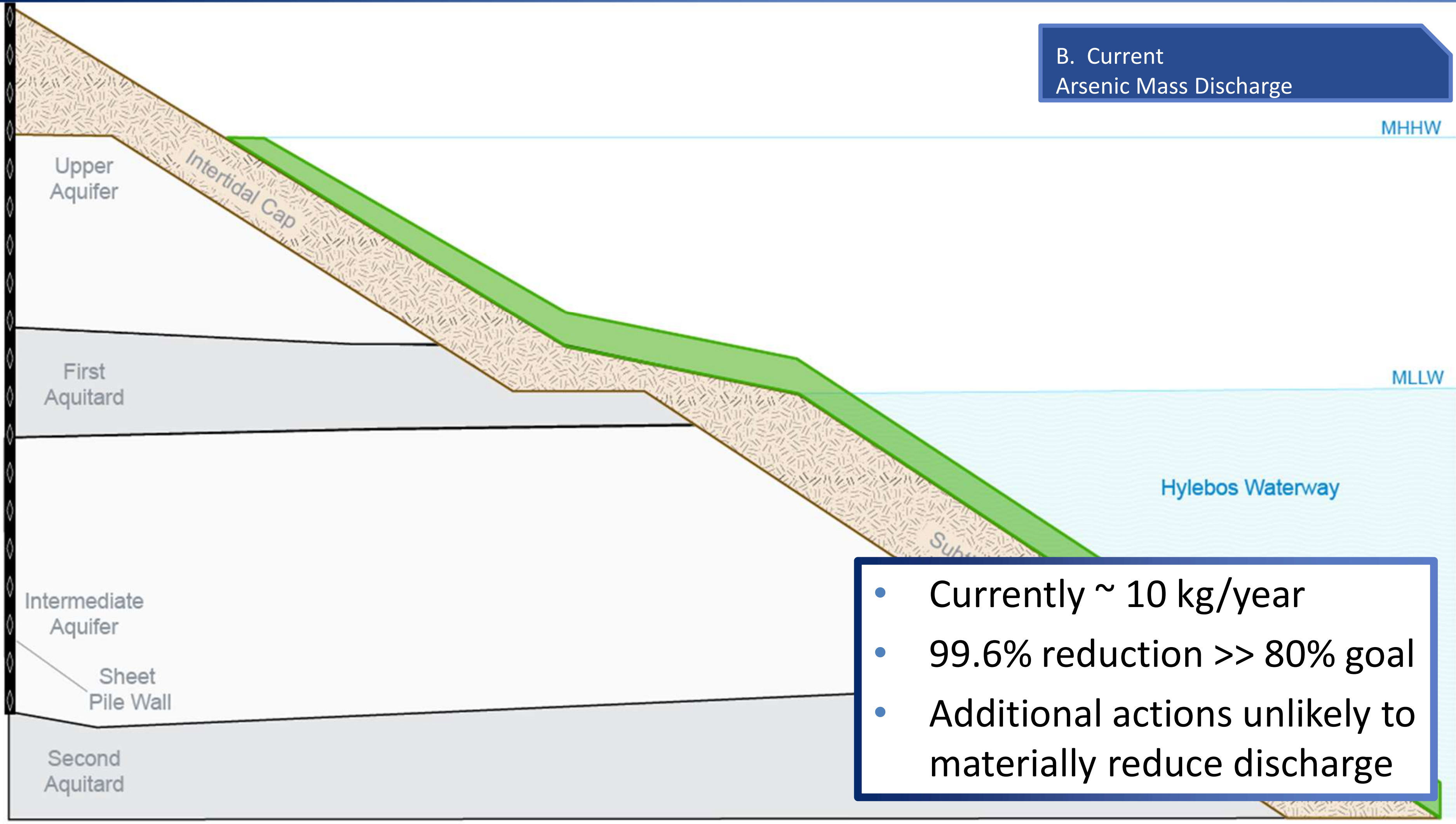
- Concentrations continue to decline due to completed actions and natural attenuation

A. Circa 1990
Arsenic Mass Discharge



- 2,400 kg/year was refined estimate in 1990 FRAP
- 480 kg/year was CB/NT 80% AKART source control goal

B. Current
Arsenic Mass Discharge



- Currently ~ 10 kg/year
- 99.6% reduction >> 80% goal
- Additional actions unlikely to materially reduce discharge

Legend

- Arsenic < 19 kg/year
- Arsenic 19 - 96 kg/year
- Arsenic 96 - 480 kg/year
- Arsenic 480 - 2,400 kg/year
- Arsenic 2,400 kg/year

Appendix E

Table E-1: Preliminary Evaluation of Potentially Applicable or Relevant and Appropriate Requirements (ARARs) for Cleanup Action Implementation

Type	Law/Regulation/Requirement	Brief Synopsis of Law/Regulation/Requirement	Chemical	Location	Action	ARAR?	Comment for Cleanup Action Implementation
Cleanup and Waste Management	State Model Toxics Control Act (Chapter 70.105D RCW, Chapter 173-340 WAC)	Processes and standards are used to identify, investigate, and cleanup sites where hazardous substances are located.	✓		✓	Yes	MTCA regulations are the primary requirement for developing cleanup standards and implementing future remedial components in the selected alternative. ARARs that were already used to develop cleanup levels (e.g., surface water protection ARARs) are not repeated in this table.
	Federal Resource Conservation and Recovery Act (42 USC 6901 et seq., 40 CFR 257-268)	The characterization, generation, transportation, treatment, storage, and disposal of hazardous solid wastes are regulated (Subtitle C), and minimum national guidelines exist for management of non-hazardous solid wastes (Subtitle D).	✓		✓	Yes	The characterization, generation, transportation, treatment, storage, and disposal of any solid waste generated during cleanup action implementation will be conducted in accordance with applicable federal, state, and local waste management regulations. All solid waste generated during cleanup action implementation will be disposed of at an off-site facility permitted to receive the waste.
	State Hazardous Waste Management (Chapter 70.105 RCW, Chapter 173-303 WAC)	The state's regulation for the characterization, generation, transportation, treatment, storage, and disposal of hazardous solid wastes defined in Resource Conservation and Recovery Act Subtitle C and additional dangerous solid wastes defined in Chapter 173-303 WAC.	✓		✓	Yes	
	State Solid Waste Management (Chapter 70.95 RCW, Chapter 173-350 WAC, Chapter 173-304 WAC)	The state's regulation for the management of non-hazardous and non-dangerous solid waste.			✓	Yes	
	Federal Hazardous Materials Transportation (49 USC 5101 et seq., 49 CFR Parts 171-180)	Requirements exist (e.g., packaging, labeling, placarding, communications, emergency response) for the transportation of hazardous materials, including hazardous waste.	✓		✓	Yes	The transportation of any hazardous materials generated during cleanup action implementation will comply with these regulations.
	State Sediment Management Standards (Chapter 70.105D RCW, Chapter 90.48 RCW, various other RCW chapters, Chapter 173-204 WAC)	Processes and standards are used to serve as the basis for making decisions about pollutant discharges that affect surface sediments and the cleanup of contaminated surface sediments.	✓		✓	Yes	The arsenic SQO established for the CB/NT site (57 mg/kg) is the same as the marine sediment cleanup objective for arsenic in Chapter 173-204 WAC.
	State Dredge Materials Management (various RCW chapters, Chapter 332-30-166 WAC)	Requirements exist for open water disposal of dredged material obtained from marine or fresh waters.			✓	No	This is not an ARAR because no dredged material will be disposed of in open water. Any material dredged during cleanup action implementation (i.e., shoreline cap extension) will be disposed of at an off-site facility permitted to receive the waste.
Worker Health and Safety	Federal Occupational Safety and Health Standards (various laws, 29 CFR 1910)	Development and enforcement of national safety standards are used to establish safe and healthful working conditions for workers, including hazardous waste operations and emergency response workers in 29 CFR 1910.120.	✓		✓	Yes	Cleanup action implementation will be conducted in accordance with applicable federal and state safety and health regulations. For instance, cleanup action implementation fieldwork will be conducted in accordance with a project-specific health and safety plan.
	Federal Construction Safety and Heath (Contract Work Hours and Safety Standards Act, 29 CFR 1926)	Development and enforcement of national safety standards are used to establish safe and healthful working conditions for construction workers.			✓	Yes	
	State Industrial Safety and Health Act (Chapter 49.17 RCW, various Chapter 296 WACs)	Development and enforcement of state safety standards are used to establish safe and healthful working conditions for workers, including hazardous waste operations workers (Chapter 296-843 WAC) and construction workers (Chapter 296-155 WAC).	✓		✓	Yes	
	Arsenic Workplace Exposure Rules (Chapter 49.17 RCW, Chapter 296-848 WAC)	Requirements exist to measure and minimize employee exposure to inorganic arsenic.	✓			Yes	
Biological Resources	Federal Endangered Species Act (16 USC 1531 et seq., 50 CFR 17, 50 CFR 402)	The taking of any listed endangered species is prohibited. In addition, federal agencies are required to ensure that any federally funded or permitted project is not likely to jeopardize the continued existence or adversely effect critical habitat for a listed endangered species.		✓		Yes	Although it is unlikely that any remedial components in the cleanup action alternatives would result in the take of an endangered species, migratory bird species, bald eagle, or golden eagle, the potential for adversely affecting these species and the need for any mitigation measures will be assessed during remedial design.
	Federal Migratory Bird Treaty Act (16 USC 703 et seq., 50 CFR 10.13)	The taking of a migratory bird species is prohibited without a permit.		✓		Yes	
	Federal Bald and Golden Eagle Protection Act (16 USC 668 et seq., 50 CFR 22)	The taking (e.g., pursuing, killing, capturing, collecting, disturbing) of a bald or golden eagle, including their parts, nests, or eggs, is prohibited without a permit.		✓		Yes	
	State Bald Eagle Protection Rules (Chapter 77.12.655 RCW, Chapter 220-610-100 WAC)	Requirements exist to protect bald eagle habitat by promoting cooperative land management efforts that incorporate eagle habitat needs.		✓		Yes	
	Federal Fish and Wildlife Coordination Act (16 USC. 661 et seq., 33 CFR 320-330)	Coordination with federal and state fish and wildlife agencies is required to ensure adequate protection of fish and wildlife resources for any federally funded or permitted project that proposes to modify a water body.		✓	✓	Yes	Applicable permits will be obtained, necessary coordination will be completed, and necessary mitigation measures will be incorporated into the remedial design for any in-water construction work (e.g., dredging, filling, and restoration associated with the shoreline cap extension) in order to protect fish and their habitat.
	State Hydraulic Project Approval (Chapter 77.55 RCW, Chapter 220-660 WAC)	Requirements (e.g., obtaining a permit from the Washington Department of Fish and Wildlife) exist for using, diverting, obstructing, or changing the natural flow or bed of a water of the state to ensure that fish and their aquatic habitats are protected.		✓	✓	Yes	
	Tacoma Critical Areas Preservation for Stream Corridors and Fish and Wildlife Habitat Conservation Areas (Chapters 13.11.400-13.11.560 TMC)	Establishes requirements to classify, protect, and preserve Tacoma's stream corridors and fish and wildlife habitat conservation areas. Other critical areas (i.e., wetlands, flood hazard areas, geologically hazardous areas, and critical aquifer recharge areas) were evaluated as separate requirements.		✓	✓	Yes	

Table E-1: Preliminary Evaluation of Potentially Applicable or Relevant and Appropriate Requirements (ARARs) for Cleanup Action Implementation

Type	Law/Regulation/Requirement	Brief Synopsis of Law/Regulation/Requirement	Chemical	Location	Action	ARAR?	Comment for Cleanup Action Implementation
Cultural Resources	Federal Historic Preservation Act (54 USC 300101 et seq., 36 CFR Part 800)	Federal agencies are required to take into account the effect of an action upon any district, site, building, structure, or object that is included in or eligible for the National Register of Historic Places (generally 50 years old or older).		✓		Yes	The potential for cultural resources to be encountered during cleanup action implementation will be assessed during remedial design. If cultural resources on or eligible for the national or Tacoma registers are present, the potential for any adverse effects and the need for any mitigation measures will be assessed. In the unlikely event that a potential archaeological artifact is uncovered during earthwork activities, the activities will be halted and redirected at least 100 feet from the discovery to avoid further impact to the discovery. Project personnel will not collect or move any potential archaeological artifacts. Furthermore, a professional archaeologist would be hired to evaluate the discovery and recommend a course of action in consultation with the State Historic Preservation Office as necessary.
	Federal Archaeological and Historic Preservation Act (54 USC 312501 et seq., 43 CFR 7)	Requirements exist to evaluate and preserve historical and archaeological data.		✓		Yes	
	Tacoma Landmarks and Historic Districts (Chapter 13.07 TMC)	Requirements exist to protect, enhance, and use landmarks, districts, and elements of historic, cultural, architectural, archeological, engineering, and geographic significance located within the City of Tacoma.		✓		Yes	
Water and Shorelines	Federal Clean Water Act (33 USC 1251 et seq., 40 CFR 122-136)	Requirements (e.g., obtaining a NPDES permit) exist for wastewater and stormwater discharges to avoid adversely affecting water quality.	✓		✓	Yes	Management of water generated during any dewatering activities will be further assessed during remedial design. In general, water generated from dewatering would be (1) containerized and disposed of at an off-site facility permitted to receive the waste, (2) treated and re-used in accordance with an applicable permit, and/or (3) discharged to a sanitary or stormwater sewer in accordance with an applicable permit. Best management practices will be implemented during cleanup action implementation to minimize erosion and address potential adverse affects from construction stormwater. An individual construction stormwater NPDES permit or coverage under a general construction stormwater NPDES permit will be obtained as necessary prior to cleanup action implementation.
	State NPDES Permit Program (Chapter 90.48 RCW, Chapter 173-220 WAC)	A state program exists to regulate the discharge of pollutants, wastes, and materials to surface waters of the state via Clean Water Act NPDES permits.	✓		✓	Yes	
	State Waste Discharge Permit Program (Chapter 90.48 RCW, WAC 173-216)	A state program exists to regulate the discharge of waste materials from industrial, commercial, and municipal operations into municipal sewerage systems and waters of the state via non-NPDES individual permits.	✓		✓	Yes	
	State Waste Discharge General Permit Program (Chapter 90.48 RCW, Chapter 173-226 WAC)	A state program exists to regulate the discharge of pollutants, wastes, and other materials to municipal sewerage systems and waters of the state via non-NPDES general permits.	✓		✓	Yes	
	Tacoma Wastewater and Surface Water Management (Chapter 12.08 TMC)	Requirements exist for users of the publicly owned treatment works and the storm drainage system of the City of Tacoma.	✓		✓	Yes	
	Federal Clean Water Act Permits for Dredge or Fill Materials (33 USC 1344, 33 CFR 323)	Unless exempted, the discharge of dredge or fill material into waters of the United States, including wetlands, requires a permit.		✓	✓	Yes	Applicable permits will be obtained, necessary coordination will be completed, and necessary mitigation measures will be incorporated into the remedial design for any in-water construction work (e.g., dredging, filling, and restoration associated with the shoreline cap extension).
	Federal Protection of Wetlands (Executive Order 11990)	Federal agencies shall take actions in order to avoid, to the extent possible, the adverse effects associated with modifications of wetlands and direct or indirect support of new construction in wetlands whenever there is a practicable alternative.		✓	✓	Yes	
	Tacoma Critical Areas Preservation for Wetlands (Chapter 13.11.300-13.11.340)	Regulations exist to classify, protect, and preserve Tacoma's wetlands. Other critical areas were evaluated as separate requirements.		✓	✓	Yes	
	Federal Floodplain Management (Executive Order 11988)	Federal agencies shall take actions in order to avoid, to the extent possible, the adverse effects associated with modifications of floodplains and direct or indirect support of floodplain development whenever there is a practicable alternative.		✓	✓	Yes	Although it is unlikely that any remedial components in the cleanup action alternatives would adversely affect a floodplain or flood hazard area, the potential for adversely affecting a floodplain or flood hazard area and the need for any mitigation measures will be assessed during remedial design.
	State Floodplain Management (Chapter 86.16 RCW, Chapter 173-158 WAC)	Establishes standards to be administered by local governments, and provides assistance to local governments. In addition, local governments are encouraged to avoid the adverse impacts associated with the destruction or modification of wetlands.		✓	✓	Yes	
	Tacoma Critical Areas Preservation for Flood Hazard Areas (Chapter 13.11.600-13.11.640 TMC)	Regulations exist to classify, protect, and preserve Tacoma's flood hazard areas. Other critical areas were evaluated as separate requirements.		✓	✓	Yes	
	State Shoreline Management Act (Chapter 90.58 RCW; Chapter 173-26 WAC)	Requirements exist for substantial development occurring within 200 feet of a state shoreline to prevent harm from uncoordinated and piecemeal development of shorelines.		✓	✓	Yes	Applicable permits will be obtained, necessary coordination will be completed, and necessary mitigation measures will be incorporated into the remedial design for any construction work within 200 feet of the shoreline.
	Tacoma Shoreline Master Program (Chapter 19 TMC)	Implements the state Shoreline Management Act by providing goals, policies, and regulations for shoreline use and protection, and establishing a permit system for substantial development occurring within 200 feet of a City of Tacoma shoreline. Specific requirements for the Port Industrial Area are included in TMC 19.12.		✓	✓	Yes	
	State Well Construction Standards (Chapter 18.104 RCW, Chapter 173-160 WAC)	Establishes standards for construction, maintenance, and decommissioning of water supply wells and resource protection wells (e.g., monitoring wells).			✓	Yes	Monitoring wells associated with cleanup action implementation will be constructed, maintained, and decommissioned in accordance with Chapter 173-160 WAC.
	Federal Drinking Water Standards (Safe Drinking Water Act, 40 CFR 141)	Establishes maximum contaminant levels and other chemical standards for public drinking water systems.	✓			No	These are not ARARs because no current drinking water supplies are located in or downgradient of the Site, groundwater in and downgradient of the Site is not potable, and surface water downgradient of the Site is not potable.
	State Drinking Water Standards (RCW 70A.125, WAC 246-290-310)	Establishes maximum contaminant levels and other chemical standards for public drinking water systems.	✓			No	
	State Water Quality Standards for Groundwater (Chapters 90.48 RCW, Chapter 90.54 RCW, Chapter 173-200 WAC)	Establishes groundwater quality standards to provide for protection of existing and future use of groundwater.	✓		✓	No	This is not an ARAR since cleanup actions approved by Ecology under MTCA are exempt pursuant to WAC 173-200-010(3)(c).

Table E-1: Preliminary Evaluation of Potentially Applicable or Relevant and Appropriate Requirements (ARARs) for Cleanup Action Implementation

Type	Law/Regulation/Requirement	Brief Synopsis of Law/Regulation/Requirement	Chemical	Location	Action	ARAR?	Comment for Cleanup Action Implementation
Air	Federal Clean Air Act (42 USC 7401 et seq., 40 CFR 50)	Air emissions from stationary and mobile sources are regulated by directing states to develop state implementation plans to achieve National Ambient Air Quality Standards.	✓		✓	No	These are not ARARs since none of the cleanup action alternatives include regulated air emissions.
	State General Regulations for Air Pollution Sources (Chapter 70A.15 RCW, Chapter 173-400 WAC)	Establishes standards and rules generally applicable to the control and/or prevention of the emission of air contaminants from stationary sources. Dust control requirements were evaluated as a separate requirement.	✓		✓	No	
	State Controls for New Sources of Toxic Air Pollutants (Chapter 70A.15 RCW, Chapter 173-460 WAC)	Establishes controls for new or modified sources emitting toxic air pollutants by requiring best available control technologies, toxic air pollutant emission quantifications, and human health and safety protection demonstrations.	✓		✓	No	
	State Ambient Air Quality Standards (Chapter 70A.15 RCW, Chapter 173-476 WAC)	Adopts National Ambient Air Quality Standards for particulate matter, lead, sulfur dioxide, nitrogen dioxide, ozone, and carbon monoxide.	✓		✓	No	
	PSCAA Regulation I	Establishes regulations to control the emission of air contaminants from sources (e.g., new sources, outdoor burning, solid fuel burning) in Pierce, King, Snohomish, and Kitsap Counties. Dust control requirements were evaluated as a separate requirement.	✓		✓	No	
	PSCAA Regulation III	Adopts state and federal requirements for regulation of toxic air contaminants in in Pierce, King, Snohomish, and Kitsap Counties.	✓		✓	No	
	Dust control requirements (WAC 173-400-040(9). PSCAA Regulation I Article 9.15)	Requirements exist to implement reasonable precautions to prevent or minimize visible emissions of fugitive dust during activities such as construction.			✓	Yes	Dust control measures (e.g., watering/misting exposed surfaces, covering stockpiles not in use with heavy duty plastic sheeting and securing with ropes and sandbags, covering haul trucks, inspecting haul trucks before they enter public roads and removing any excess dirt on the truck) will be incorporated as necessary into cleanup action implementation.
Other	State Environmental Policy Act (Chapter 43.21C RCW, Chapter 197-11 WAC)	Requires all government agencies to consider and assess the environmental impacts of a proposed action within the state before making a decision. The SEPA procedural requirements are fulfilled via the MTCA remedy selection process pursuant to WAC 197-11-250 through 197-11-268.			✓	Yes	A SEPA checklist will be submitted to Ecology (the lead agency) during the FS phase or draft CAP phase to help Ecology decide whether or not an environmental impact statement needs to be prepared for the selected cleanup action alternative.
	Tacoma Site Development Code (Chapter 2.19 TMC)	Requirements (e.g., obtaining a Site Development Permit) exist for the development and maintenance of building and building sites to minimize negative impacts to the environment.			✓	Yes	Prior to cleanup action implementation, a Site Development Permit will be obtained for upland grading activities associated with cleanup action implementation.
	Tacoma Critical Area Preservation for Geologically Hazardous Areas and Critical Aquifer Recharge Areas (Chapters 13.11.700 - 13.11.820 TMC)	Establishes requirements to classify, protect, and preserve Tacoma's geologically hazardous areas and critical aquifer recharge areas. Other critical areas (i.e., wetlands, stream corridors, fish and wildlife habitat conservation areas, and flood hazard areas) were evaluated as separate requirements.		✓	✓	Yes	Although it is highly unlikely that any geologically hazardous areas or critical aquifer recharge areas would be affected by cleanup action implementation, these critical areas will be further evaluated during remedial design.
	State Noise Control Act (Chapter 70A.20 RCW, Chapter 173-60 WAC)	Establishes maximum noise levels at specified times for specified durations, with some exemptions such as temporary construction activity in 173-60-050(3)(a).			✓	Yes	Cleanup action implementation activities will be designed to comply with applicable noise requirements (e.g., limiting construction activities to the working hours specified in TMC 8.122.070).
	Tacoma Noise Enforcement (Chapter 8.122 TMC)	Requirements exist to mitigate the adverse impact of noise while recognizing the economic value of construction and industry. Construction-specific requirements are included in TMC 8.122.070.			✓	Yes	
	Tacoma Right-of-Way Development (Chapter 2.22 TMC)	Requirements (e.g., obtaining a Right-of-Way Construction Permit or Right-of-Way Use Permit) exist for activities such as installing sidewalks, installing utilities, installing driveways, repairing streets, and activities that temporarily impede the normal flow of vehicular traffic or pedestrian traffic.		✓	✓	No	This is not an ARAR since none of the cleanup action alternatives include construction within, or cause temporary impediment for, a City of Tacoma right-of-way.
	Tacoma Electrical Code (Chapter 12.06A TMC)	Requirements (e.g., obtaining an electrical permit) exist to safeguard people and property from electrical hazards arising from the use of electricity, including temporary power connections and wiring used for remediation systems.			✓	No	This is not an ARAR since none of the cleanup action alternatives include temporary power connections or wiring for remediation systems.

Notes:

ARAR: Applicable or relevant and appropriate; CFR: Code of Federal Regulations; MTCA: Model Toxics Control Act; NPDES: National Pollutant Discharge Elimination System; PSCAA: Puget Sound Clean Air Agency; RCW: Revised Code of Washington; SEPA: State Environmental Policy Act; TMC: Tacoma Municipal Code; USC: United States Code; WAC: Washington Administrative Code

Appendix F

Table F-1: Preliminary Cost Estimates for Alternatives 1 through 5

Category	Item	Estimated Costs for Each Alternative (in millions of dollars)							Cost Estimate Source/Basis
		1	2	3	3 Contingent	4	4 Contingent	5	
Completed Remedial Actions [1]	EPC-1A: Completed remedial actions during Phase 3 of active arsenic remediation	$32.8	$32.8	$32.8	$32.8	$32.8	$32.8	$32.8	Based on summary of costs in Groff Murphy Trachtenberg & Everard, PLLC 2006, DOF 2011, PIONEER 2016, and 2021 personal correspondence with the Port.
	APR-1A: Completed remedial actions during Phases 1 and 2 of active arsenic remediation [2]	$32.3	$32.3	$32.3	$32.3	$32.3	$32.3	$32.3	
	OPSC-1: 2014 Wypenn Interim Action	$0.7	$0.7	$0.7	$0.7	$0.7	$0.7	$0.7	Based on 2021 personal correspondence with the Port.
	OPSC-2: 2013 to 2014 Arkema Mound Interim Action	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	$0.5	Based on 2021 personal correspondence with DOF. Included costs are for activities associated with the East Channel Ditch only.
	Subtotal	$66.3	$66.3	$66.3	$66.3	$66.3	$66.3	$66.3	
Direct Capital Construction Costs [1]	EPC-2A: Subtidal shoreline cap extension	N/A	$1.2	$1.2	$1.2	$1.2	$1.2	$1.2	See Table F-2.
	APR-2: Focused source area excavation	N/A	$3.2	$3.2	$3.2	$3.2	$3.2	N/A	See Table F-2.
	APR-3A: General surface cap/cover for soil direct contact pathway	$1.3	$1.3	$1.3	$1.3	$1.3	$1.3	N/A	See Table F-2.
	APR-4A: Focused low-permeability surface cap	N/A	N/A	$1.2	$1.2	$1.2	$1.2	N/A	See Table F-2.
	APR-5A: Vertical low-permeability barrier walls	N/A	N/A	N/A	N/A	$1.4	$1.4	N/A	See Table F-2.
	APR-6: Focused groundwater treatment	N/A	N/A	N/A	$3.5	$3.5	$3.5	N/A	See Table F-2.
	APR-7: Focused Intermediate Aquifer PRB	N/A	N/A	N/A	$0.8	N/A	$0.8	$0.8	See Table F-2.
	APR-8: Focused Upper Aquifer PRB	N/A	N/A	N/A	$0.5	N/A	$0.5	$0.5	See Table F-2.
	APR-9: Excavation to achieve default soil cleanup standards	N/A	N/A	N/A	N/A	N/A	N/A	$54.0	See Table F-2.
	APR-10: Extensive in-situ solidification/stabilization	N/A	N/A	N/A	N/A	N/A	N/A	$31.5	See Table F-2.
	Miscellaneous Contractor-prepared plans	$0.1	$0.2	$0.2	$0.3	$0.3	$0.4	$0.5	An alternative-specific LS was assumed based on the anticipated number of construction phases and level of effort needed for all remedial components included in the alternative.
	Site prep and miscellaneous construction requirements [3]	$0.1	$0.2	$0.3	$0.4	$0.3	$0.4	$1.0	
	Contractor mobilization and de-mobilization	$0.1	$0.3	$0.3	$0.6	$0.6	$0.7	$4.4	Assumed 5% of direct capital construction costs for all remedial components in the alternative.
	Sales tax (10.2%)	$0.1	$0.6	$0.7	$1.2	$1.2	$1.3	$9.0	Assumed tax applies to direct capital construction costs of all remedial components in the alternative.
	Subtotal	$1.7	$7.0	$8.4	$14.2	$14.2	$15.9	$102.9	
Indirect Capital Construction Costs [1]	Remedial design (and procurement/permitting/ARAR compliance support)	$0.2	$0.6	$0.7	$0.9	$0.9	$1.0	$6.2	Remedial design, construction management, and project management costs were assumed as percentages of direct capital construction costs based on USACE and USEPA guidance (USACE and USEPA 2000). An alternative-specific LS was assumed for permit fees and various consultant documents based on the anticipated level of effort needed for all remedial components included in the alternative.
	Permit fees	$0.0	$0.1	$0.1	$0.1	$0.1	$0.1	$0.2	
	Construction management	$0.1	$0.4	$0.5	$0.9	$0.9	$1.0	$6.2	
	Various consultant documents (e.g., Performance Groundwater Monitoring Plan, construction completion report(s), Cleanup Infrastructure Monitoring and Maintenance Plan, Soil and Materials Management Plan, draft restrictive covenant)	$0.2	$0.2	$0.3	$0.3	$0.3	$0.3	$0.5	
	Project management	$0.1	$0.4	$0.4	$0.7	$0.7	$0.8	$5.1	
	Decommission MWs in construction areas and MWs that will no longer be necessary	$0.6	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	Assumed based on the approximately 160 existing MWs on the property, anticipated level of effort, average total cost of $4,000 to decommission each MW, and average total cost of $5,000 to install each MW.
	Install additional performance MWs as necessary after construction	N/A	$0.3	$0.3	$0.3	$0.3	$0.3	$0.3	
	Confirmation, performance, and compliance sampling and analysis costs during construction	$0.2	$0.4	$0.4	$0.7	$0.7	$0.8	$2.1	The cost for these items was assumed to be a percentage of the direct capital construction costs subtotal. The assumed percentages were 10% for Alternative 1, 5% for Alternatives 2 through 4, and 2% for Alternative 5.
	Port oversight costs								
	Ecology oversight costs								
	Subtotal	$1.4	$2.7	$3.0	$4.2	$4.2	$4.6	$20.9	

PIONEER TECHNOLOGIES CORPORATION

Table F-1: Preliminary Cost Estimates for Alternatives 1 through 5

Category	Item	Estimated Costs for Each Alternative (in millions of dollars)							Cost Estimate Source/Basis
		1	2	3	3 Contingent	4	4 Contingent	5	
Annual or Periodic Costs (1)	EPC-1B: Monitoring and maintenance of the existing shoreline caps	N/A	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	See Table F-4 for calculated net present value (based on costs in Table F-3).
	EPC-2B: Monitoring and maintenance of EPC-2A								
	EPC-3: Surface water and sediment monitoring	$0.1	$0.1	$0.1	$0.1	$0.1	$0.1	$0.1	See Table F-4 for calculated net present value (based on costs in Table F-3).
	APR-1B: Monitoring and maintenance of the existing SPW	N/A	$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	See Table F-4 for calculated net present value (based on costs in Table F-3).
	APR-3B: Monitoring and maintenance of APR-3A	$0.6	$0.6	$0.6	$0.6	$0.6	$0.6	N/A	See Table F-4 for calculated net present value (based on costs in Table F-3).
	APR-4B: Monitoring and maintenance of APR-4A	N/A	N/A	$0.9	$0.9	$0.9	$0.9	N/A	See Table F-4 for calculated net present value (based on costs in Table F-3).
	APR-5B: Monitoring and maintenance of APR-5A	N/A	N/A	N/A	N/A	$0.9	$0.9	N/A	See Table F-4 for calculated net present value (based on costs in Table F-3).
	APR-11: Performance groundwater monitoring	N/A	$0.9	$0.9	$0.9	$0.9	$0.9	$0.9	See Table F-4 for calculated net present value (based on costs in Table F-3).
	MNA&LTC-1: Long-term groundwater monitoring	N/A	$1.7	$1.7	$1.7	$1.7	$1.7	$1.7	See Table F-4 for calculated net present value (based on costs in Table F-3).
	MNA&LTC-2: Periodic MNA evaluations	N/A							
	MNA&LTC-3: Applicable ECs	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	See Table F-4 for calculated net present value (based on costs in Table F-3).
	MNA&LTC-4: Applicable ICs								
	OPSC-5: Upper Aquifer groundwater monitoring downgradient of Wypenn	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	See Table F-6 for calculated net present value (based on costs in Table F-5).
	OPSC-6: Groundwater and surface water monitoring for copper, mercury, nickel, PCE, TCE, VC, and CF	$0.8	$0.8	$0.8	$0.8	$0.8	$0.8	$0.8	See Table F-6 for calculated net present value (based on costs in Table F-5).
	OPSC-7: Decommission Angled Shoreline MWs	$0.1	$0.1	$0.1	$0.1	$0.1	$0.1	$0.1	See Table F-6 for calculated net present value (based on costs in Table F-5).
	OPSC-8: VI evaluation(s)	$0.1	$0.1	$0.1	$0.1	$0.1	$0.1	$0.1	See Table F-6 for calculated net present value (based on costs in Table F-5).
	OPSC-9: Installation of VI mitigation system(s)	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	$0.4	See Table F-6 for calculated net present value (based on costs in Table F-5).
	OPSC-10: Operation, maintenance, and monitoring of VI mitigation system(s)	$1.6	$1.6	$1.6	$1.6	$1.6	$1.6	$1.6	See Table F-6 for calculated net present value (based on costs in Table F-5).
	Subtotal	$4.1	$7.7	$8.6	$8.6	$9.5	$9.5	$7.1	See Table F-6 for calculated net present value (based on costs in Table F-5).
Totals Costs	Total Cost in Millions	$74	$84	$86	$93	$94	$96	$197	Costs of completed remedial actions plus costs of future remedial components.
	Total Cost in Millions With 50% Contingency on Future Costs (4)	$77	$92	$96	$107	$108	$111	$263	
	Total Future Cost in Millions	$7	$17	$20	$27	$28	$30	$131	Costs of future remedial components only.
	Total Future Cost in Millions With 50% Contingency (4)	$11	$26	$30	$41	$42	$45	$196	

Notes:

ARAR: applicable or relevant and appropriate requirement; ECs: engineering controls; ICs: institutional controls; LS: lump sum; MW: monitoring well; N/A: not applicable (for a given alternative); POC: point of compliance; PRB: permeable reactive barrier; SPW: sheet pile wall; SW: surface water

These cost estimates were prepared solely to facilitate relative comparisons between alternatives for the purpose of this Report, and are intended to be -30% to +50%. Since these ballpark estimate were based on a variety of simplifying assumptions and PIONEER has no control over the results from future investigation and remediation activities, the remedial design, Port requirements, the cost of labor, materials, and equipment, or the nature of a particular competitive bidding process at the time the work would be performed, the estimated costs should not be construed to equal actual implementation costs. It is expected that implementation cost estimates will be refined during remedial design, and then following procurement.

These cost estimates do not include any redevelopment costs (e.g., demolition and removal of slabs and foundations, mass grading or waste disposal needed for redevelopment purposes, placement of additional fill on top of the soil cover, ground improvements, utility installation, paving, or stormwater management).

All estimated costs for individual remedial component costs and category subtotals were rounded to the nearest $0.1M (i.e., nearest $100,000). All estimated total costs were rounded to nearest $1M (i.e. nearest $1,000,000).

(1) For simplicity, completed remedial action costs were not adjusted to current dollars. For simplicity, all direct and indirect capital construction costs were assumed to occur in the base year (e.g., 2021). The annual and periodic costs were calculated on a net present value basis, starting in Year 1.

(2) This item also includes other non-arsenic active remediation components completed prior to 2011 (e.g., VOC remedial components designated as OPSC-3 and OPSC-4). This items does not include the $11 million of investigation and evaluation costs incurred by Arkema, $5.2 million of investigation and evaluation costs incurred by the Port through February 2021, and $0.8 million of facility demolition costs incurred by the Port through February 2021.

(3) This item includes miscellaneous costs during remediation construction that are not accounted for in the individual remedial components (e.g., health and safety implementation, site control, creating containment areas for stockpiles, stockpile management, dust control, stormwater control, hydroseeding).

(4) Including a 50% contingency is appropriate given the substantial uncertainty about site conditions and the scope of work, and the absence of a design.

Table F-2: Preliminary Cost Estimates for Key Direct Capital Construction Items

Remedial Component	Item	Qty	Unit	Basis for Quantity Assumption	Unit Cost	Basis for Unit Cost Estimate	Cost
EPC-2A: Subtidal shoreline cap extension	Dredge to create toe trench and trim slope and dispose of dredged materials at the LRI Landfill in Graham, Washington	670	CY	Assumed area of 175 feet (from 122+50 to 124+25) by 68 feet with cap layers and materials consistent with existing subtidal cap (ABAM 2006). Quantities developed by DOF based on average end methods from recent bathymetric cross sections (DOF 2019), assumed trimmed slope of 2:1, assumed toe trench dimensions of 3 feet deep, 5 feet wide, and 2:1 side slopes, and assumed toe berm volume of twice the toe trench volume.	Estimated costs based on previous DOF estimates for similar materials and actions.		$200,000
	Obtain and place cap subgrade material for 2:1 slope	1,980	Ton				$150,000
	Obtain and place toe berm	740	Ton				$70,000
	Obtain and place sand and gravel filter layer	1,830	Ton				$170,000
	Obtain and place quarry spalls layer	1,360	Ton				$120,000
	Obtain and place fish mix layer for habitat enhancement	450	Ton				$50,000
	Bathymetric and diver surveys	1	LS				$100,000
	Placeholder for habitat mitigation if required	1	LS	Qty assumed to simplify estimate.	$300,000	Estimated based on similar items at other sites.	$300,000
						Total [1]	1,200,000
APR-2: Focused source area excavation	PDI to refine excavation area by advancing and sampling soil borings [2]	1	LS	Qty assumed to simplify estimate.	$150,000	Estimated based on anticipated level of effort.	$150,000
	PDI to inform future adaptive site management decisions [2]	1	LS	Qty assumed to simplify estimate.	$150,000	Estimated based on anticipated level of effort.	$150,000
	Ex-situ oxidation and stabilization pilot test work plan, field, lab, and reporting	1	LS	Qty assumed to simplify estimate.	$150,000	Estimated based on anticipated level of effort.	$150,000
	Excavate and stockpile 0-5 feet bgs overburden soil	2,100	Ton	Assumed 1,400 CY to access 5-10 feet bgs soil (see Figure 6-18 in Appendix A) and soil density of 1.5 tons/CY.	$35	Estimated based on similar items at other sites.	$73,500
	Excavate and stockpile soil for on-site treatment and off-site disposal	2,100	Ton	Assumed 1,400 CY to excavate exceedances (see Figure 6-18 in Appendix A) and soil density of 1.5 tons/CY.	$35	Estimated based on similar items at other sites.	$73,500
	Place oxidation and stabilization treatment materials at bottom of excavations (on top of 1st Aquitard soil)	428	Ton	Assumed one foot thick layer of backfill soil on bottom of excavation (largest excavation area shown on Figure 6-18 in Appendix A) receives same dosing as ex-situ oxidation and stabilization.	$200	Assumed to equal unit cost for ex-situ oxidation and stabilization.	$85,556
	Dewatering, treatment, and disposal	1	LS	Qty assumed to simplify estimate.	$500,000	Estimated based on excavation size, shallow depth to groundwater, and off-site disposal of generated water (following treatment).	$500,000
	Ex-situ oxidation and stabilization to minimize Qty of hazardous waste (1st treatment)	2,100	Ton	Assumed 0% of excavated soil would be non-hazardous without any treatment, and the remaining 100% would be treated. Assumed 50% of soil undergoing 1st treatment would be successfully stabilized during 1st treatment.	$200	Estimated $165/ton for materials based on bench test dosing and 2019 correspondence with Premier Magnesia and Carus Corporation, and $35/ton for treatment operations.	$420,000
	Ex-situ oxidation and stabilization to minimize Qty of hazardous waste (2nd treatment)	1,050	Ton	Assumed 75% of soil undergoing 2nd treatment would be successfully stabilized during 2nd treatment. Assumed soil that was not successfully stabilized after 2nd treatment would be disposed of as hazardous waste.	$200	Estimated $165/ton for materials based on bench test dosing and 2019 correspondence with Premier Magnesia and Carus Corporation, and $35/ton for treatment operations.	$210,000
	Dry, load, haul, and dispose of excavated material that is non-hazardous waste at the LRI Landfill in Graham, Washington	1,838	Ton	Assumed Qty based on assumptions in two previous rows.	$70	Estimated $20/ton for drying/loading, $15/ton for haul, and $35/ton for disposal per 2019 LRI correspondence.	$128,625
	Dry, load, haul, treat, and dispose of excavated soil that is hazardous waste at the Waste Management facility in Arlington, Oregon	263	Ton	Assumed Qty based on assumed percentage of soil that was not successfully stabilized after 2nd treatment.	$687	Estimated $20/ton for drying/loading, and $667/ton for haul, treat, and disposal per 2019 Waste Management correspondence.	$180,338
	Licensing cost for ex-situ oxidation and stabilization patent	10	%	Licensing fee is 10% of all excavation, stabilization, haul, and disposal costs based on 2019 TRC correspondence (patent holder).	N/A	N/A	$100,000
	Backfill using overburden soil	2,100	Ton	Assumed Qty equals the Qty from excavate and stockpile 0-5 feet bgs overburden soil.	$10	Estimated based on similar items at other sites.	$21,000
	Gravel borrow, haul, and backfill soil excavations	2,100	Ton	Assumed Qty equals the Qty from excavate and stockpile soil for on-site treatment and off-site disposal.	$35	Estimated based on similar items at other sites.	$73,500
	Contingency for additional excavation, treatment, and disposal Qty based on PDI results	50	%	Assumed based on size of former Penite Pits and former Penite Manufacturing Building relative to excavation footprints on Figure 6-18 in Appendix A.	N/A	N/A	$933,009
						Total [1]	$3,200,000

Table F-2: Preliminary Cost Estimates for Key Direct Capital Construction Items

Remedial Component	Item	Qty	Unit	Basis for Quantity Assumption	Unit Cost	Basis for Unit Cost Estimate	Cost
APR-3A: General surface cap/cover for soil direct contact pathway (3)	Clearing/grubbing	280,000	SF	Area of conceptual APR-3A footprint.	$0.4	Estimated based on similar items at other sites.	$112,000
	Demo structures above slab grade (e.g., former warehouse and treatment structure walls)	15,000	SF	Assumed Qty based on current aerial photograph and field knowledge of Site structures above slab grade.	$9	Estimated based on July-December 2020 "The Guide – Building Construction Material Prices."	$135,000
	Recycle concrete and wood from structures above slab grade	1,000	CY		$40		$40,000
	Fill obvious subsurface vaults/voids (e.g., treatment system vaults) with CDF	500	CY	Assumed Qty based on field knowledge of treatment system vaults. Does not include sanitary sewer or stormwater infrastructure that may remain.	$140	Estimated based on similar items at other sites.	$70,000
	Obtain and place marker (e.g., geotextile) under soil cover	280,000	SF	Area of conceptual APR-3A footprint.	$0.4	Estimated based on 2020 correspondence with NW Linings & Geotextile and DOF for use of a 8-ounce, non-woven fabric dyed orange.	$112,000
	Obtain, place, and compact gravel soil cover	15,556	Ton	Area of conceptual APR-3A footprint. (280,000 SF), assumed thickness of 1 foot, and assumed soil density of 1.5 tons/CY.	$35	Estimated based on similar items at other sites.	$544,444
	Install stormwater bio-swale	1	LS	Qty assumed to simplify estimate.	$300,000	Estimated based on similar item at nearby site, and that Tacoma Stormwater Manual requirements will not be required.	$300,000
						Total (1)	$1,300,000
APR-4A: Focused low-permeability surface cap (4)	Obtain, place, and compact gravel layer to slope the ground surface	23,333	Ton	Area of conceptual APR-4A footprint (210,000 SF), assumed average thickness of 2 feet (more thickness in center and less thickness near sides), and assumed soil density of 1.5 tons/CY.	$35	Estimated based on similar items at other sites.	$816,667
	Obtain and place sand cushion bottom	2,917	Ton	Area of conceptual APR-4A footprint (210,000 SF), assumed thickness of 3 inches, and assumed soil density of 1.5 tons/CY.	$35	Estimated based on similar items at other sites.	$102,083
	Obtain and place low-permeability cap material	210,000	SF	Area of conceptual APR-4A footprint.	$1.0	Estimated based on 2020 correspondence with NW Linings & Geotextile and DOF for use of a geosynthetic clay liner (e.g., Bentomat DN), and that temporary 15-inch cover over the geosynthetic clay liner (rather than manufacturer recommended 24 inches) will be acceptable.	$210,000
	Obtain and place sand cushion top	2,917	Ton	Area of conceptual APR-4A footprint (210,000 SF), assumed thickness of 3 inches, and assumed soil density of 1.5 tons/CY.	$35	Estimated based on similar items at other sites.	$102,083
						Total (1)	$1,200,000
APR-5A: Vertical low-permeability barrier walls	Bench and pilot tests (including work plan, field, lab, and reporting)	1	LS	Qty assumed to simplify estimate.	$200,000	Estimated based on anticipated level of effort.	$200,000
	Placeholder for removal and disposal of subsurface debris/piling within trench	1	LS	Qty assumed to simplify estimate.	$100,000	Estimated based on anticipated level of effort.	$100,000
	Install low-permeability barrier walls	76,000	SF	Length of conceptual APR-5A walls (1,900 LF) and assumed 40 feet depth.	$15	Estimated based on 2020 correspondence with Envirocon and DOF for a conceptual scope that includes construction of a 2.6-foot wide soil-clay slurry wall with a trench excavator, mixing adjacent to the trench, use of attapulgite clay (for resistance to brackish water), a design conductivity of $\leq$ 2.8E-07 cm/s, and placement of all excavated trench soil within the containment area (or reused in the walls).	$1,140,000
						Total (1)	$1,400,000
APR-6: Focused groundwater treatment	PDI to refine understanding of 124+00-2 arsenic concentrations and design treatment (2)	1	LS	Qty assumed to simplify estimate.	$150,000	Estimated based on anticipated level of effort.	$150,000
	Bench and pilot treatability tests (including work plan, field, lab, and reporting)	1	LS	Qty assumed to simplify estimate.	$200,000	Estimated based on anticipated level of effort.	$200,000
	In-situ solidification/stabilization to bottom of Intermediate Aquifer (5)	20,741	CY	Size of conceptual APR-6 footprint (14,000 SF) and assumed 40 feet depth.	$150	Estimated based on 2020 ENTACT correspondence.	$3,111,111
						Total (1)	$3,500,000
APR-7: Focused Intermediate Aquifer PRB	Bench and pilot treatability tests (including work plan, field, lab, and reporting)	1	LS	Qty assumed to simplify estimate.	$200,000	Estimated based on anticipated level of effort.	$200,000
	Obtain, deliver, and temporarily store applicable treatment materials, and drill and inject treatment materials	1	LS	Qty assumed to simplify estimate.	$600,000	Estimated based on 530 LF length for APR-7 in July 2020 Cleanup Action Alternatives document, 1 row of injection points along the length of APR-7, 5 foot radius of influence based on previous Site in-situ stabilization (ERM 2005), treatment materials will be determined by the treatability tests, 2021 ESN Northwest correspondence, 2020 Cascade correspondence, 2020 Regenesis correspondence, and 2021 Adler Tank Rentals correspondence.	$600,000
						Total (1)	$800,000

Table F-2: Preliminary Cost Estimates for Key Direct Capital Construction Items

Remedial Component	Item	Qty	Unit	Basis for Quantity Assumption	Unit Cost	Basis for Unit Cost Estimate	Cost
APR-8: Focused Upper Aquifer PRB	Bench and pilot treatability tests (including work plan, field, lab, and reporting)	1	LS	Qty assumed to simplify estimate.	$200,000	Estimated based on anticipated level of effort.	$200,000
	Obtain, deliver, and temporarily store applicable treatment materials, and drill and inject treatment materials	1	LS	Qty assumed to simplify estimate.	$300,000	Estimated based on 260 LF length for APR-8 in July 2020 Cleanup Action Alternatives document, 1 row of injection points along the length of APR-8, 5 foot radius of influence based on previous Site in-situ stabilization (ERM 2005), treatment materials will be determined by the treatability tests, 2021 ESN Northwest correspondence, 2020 Cascade correspondence, 2020 Regenesis correspondence, and 2021 Adler Tank Rentals correspondence.	$300,000
						Total [1]	$500,000
APR-9: Excavation to achieve default soil cleanup standards	PDI to refine excavation area by advancing and sampling soil borings [2]	1	LS	Qty assumed to simplify estimate.	$400,000	Estimated based on anticipated level of effort.	$400,000
	Ex-situ oxidation and stabilization pilot test work plan, field, lab, and reporting	1	LS	Qty assumed to simplify estimate.	$400,000	Estimated based on anticipated level of effort.	$400,000
	Excavate and stockpile 0-5 feet bgs overburden soil	18,000	Ton	Assumed 12,000 CY to access 5-10 feet bgs soil (see Figure 6-16 in Appendix A) and soil density of 1.5 tons/CY.	$35	Estimated based on similar items at other sites.	$630,000
	Excavate and stockpile soil for on-site treatment and off-site disposal	180,000	Ton	Assumed 120,000 CY to excavate exceedances (see Figure 6-16 in Appendix A) and soil density of 1.5 tons/CY.	$35	Estimated based on similar items at other sites.	$6,300,000
	Place oxidation and stabilization treatment materials at bottom of excavations (on top of 1st Aquitard soil)	13,278	Ton	Assumed one foot thick layer of backfill soil on bottom of excavation (largest excavation area shown on Figure 6-16 in Appendix A) receives same dosing as ex-situ oxidation and stabilization.	$200	Assumed to equal unit cost for ex-situ oxidation and stabilization.	$2,655,556
	Dewatering, treatment, and disposal	1	LS	Qty assumed to simplify estimate.	$4,000,000	Estimated based on excavation size, shallow depth to groundwater, and off-site disposal of generated water (following treatment).	$4,000,000
	Ex-situ oxidation and stabilization to minimize Qty of hazardous waste (1st treatment)	45,000	Ton	Assumed 75% of excavated soil would be non-hazardous without any treatment, and the remaining 25% would be treated. Assumed 50% of soil undergoing 1st treatment would be successfully stabilized during 1st treatment.	$200	Estimated $165/ton for materials based on bench test dosing and 2019 correspondence with Premier Magnesia and Carus Corporation, and $35/ton for treatment operations.	$9,000,000
	Ex-situ oxidation and stabilization to minimize Qty of hazardous waste (2nd treatment)	22,500	Ton	Assumed 75% of soil undergoing 2nd treatment would be successfully stabilized during 2nd treatment. Assumed soil that was not successfully stabilized after 2nd treatment would be disposed of as hazardous waste.	$200	Estimated $165/ton for materials based on bench test dosing and 2019 correspondence with Premier Magnesia and Carus Corporation, and $35/ton for treatment operations.	$4,500,000
	Dry, load, haul, and dispose of excavated material that is non-hazardous waste at the LRI Landfill in Graham, Washington	174,375	Ton	Assumed Qty based on assumptions in two previous rows.	$70	Estimated $20/ton for drying/loading, $15/ton for haul, and $35/ton for disposal per 2019 LRI correspondence.	$12,206,250
	Dry, load, haul, treat, and dispose of excavated soil that is hazardous waste at the Waste Management facility in Arlington, Oregon	5,625	Ton	Assumed Qty based on assumed percentage of soil that was not successfully stabilized after 2nd treatment.	$687	Estimated $20/ton for drying/loading, and $667/ton for haul, treat, and disposal per 2019 Waste Management correspondence.	$3,864,375
	Licensing cost for ex-situ oxidation and stabilization patent	10	%	Licensing fee is 10% of all excavation, stabilization, haul, and disposal costs based on 2019 TRC correspondence (patent holder).	N/A	N/A	$3,590,000
	Backfill using overburden soil	18,000	Ton	Assumed Qty equals the Qty from excavate and stockpile 0-5 feet bgs overburden soil.	$10	Estimated based on similar items at other sites.	$180,000
	Gravel borrow, haul, and backfill soil excavations	180,000	Ton	Assumed Qty equals the Qty from excavate and stockpile soil for on-site treatment and off-site disposal.	$35	Estimated based on similar items at other sites.	$6,300,000
						Total [1]	$54,000,000
APR-10: Extensive in-situ solidification/ stabilization	Bench and pilot treatability tests (including work plan, field, lab, and reporting)	1	LS	Qty assumed to simplify estimate.	$400,000	Estimated based on anticipated level of effort.	$400,000
	In-situ solidification/stabilization to bottom of Intermediate Aquifer	207,407	CY	Size of conceptual APR-10 footprint (140,000 SF) and assumed 40 feet depth.	$150	Estimated based on 2020 ENTACT correspondence.	$31,111,111
						Total [1]	$31,500,000

Notes:

bgs: below ground surface; CDF: controlled density fill; CY: cubic yards; Gal: gallons; LF: lineal feet; LS: lump sum; N/A: not applicable; PDI: pre-design investigation; PRB: permeable reactive barrier; Qty: quantity; SF: square feet

These cost estimates were prepared solely to facilitate relative comparisons between alternatives for the purpose of this Report, and are intended to be -30% to +50%. Since these ballpark estimates were based on a variety of simplifying assumptions and PIONEER has no control over the results from future investigation and remediation activities, the remedial design, Port requirements, the cost of labor, materials, and equipment, or the nature of a particular competitive bidding process at the time the work would be performed, the estimated costs should not be construed to equal actual implementation costs. It is expected that implementation cost estimates will be refined during remedial design, and then following procurement.

(1) Rounded to the nearest $100,000. Additional cost items (e.g., mobilization/demobilization, sales tax, contingency) are accounted for in Table F-1.

(2) PDI items include work plan, field, lab, and reporting. The PDI to inform future adaptive site management decisions is expected to include (1) a tracer test between the source area and the shoreline, (2) a salinity/tidal tracer study across the sheet pile wall, and (3) a geophysical survey of the top of the First Aquitard.

(3) For the purpose of this Report, APR-3A is assumed to only include (1) a marker layer (e.g., geotextile), and (2) 12 inches of gravel. APR-3A (and other remedial components) do not include any Site development or improvement components such as demo/removal of existing concrete slabs, demo/removal of former building foundations, subsurface improvements, excavations, or waste disposal needed for redevelopment purposes, placement of additional fill on top of the soil cover, utility installation, paving, or stormwater management. These Site development and improvement components would be addressed as part of Site redevelopment. Site use after remediation would be restricted or prohibited until site development components are put in place to protect the remedy and manage stormwater.

(4) For purpose of this Report, APR-4A is assumed to include (1) fill to create a sloped surface, (2) a 3 inch sand bottom cushion, (3) low-permeability cap material, and (4) a 3 inch sand top cushion. Since the APR-4A conceptual footprint is a subset of the APR-3A conceptual footprint and APR-4A would be underneath APR-3A, surface preparation costs already included in APR-3A (e.g., clearing/grubbing, demo) are not included in APR-4A.

(5) For the purpose of the cost estimates, it was assumed the treatment technology would be in-situ solidification/stabilization. However, based on PDI and treatability study results, in-situ stabilization or neutralization may be utilized instead of in-situ solidification/stabilization.

Table F-3: Preliminary Cost Estimates for Annual or Periodic Costs of EPC, APR, and MNA&LTC Remedial Components

Remedial Component	Assumed Duration (Years)	Item	Assumed Frequency	Assumed Number of Events	Assumed Cost per Event	Basis for Cost per Event Estimate	Estimated Cost for All Events
EPC-1B: Monitoring and maintenance of the existing shoreline caps (3), and EPC-2B: Monitoring and maintenance of EPC-2A	100 (1)	Visual inspection of shoreline caps (including divers for subtidal caps)	Every 5 years	20	$15,000	Estimated based on similar items at this Site and other Port sites.	$300,000
		Review of periodic bathymetric surveys generated as part of normal Port operations	Every 10 years	10	$10,000	Estimated based on similar items at this Site.	$100,000
		Repair or replace shoreline caps as necessary based on monitoring results	At Year 50	1	$1,000,000	Estimated based on anticipated level of effort.	$1,000,000
						Total (2)	$1,400,000
EPC-3: Surface water and sediment monitoring (4)	100 (1)	Surface water monitoring	Every 5 years	20	$15,000	Estimated based on similar items at this Site assuming up to 6 samples/medium and collecting sediment samples concurrently with surface water samples.	$300,000
		Sediment monitoring	Every 10 years	10	$2,000		$20,000
						Total (2)	$320,000
APR-1B: Monitoring and maintenance of the existing SPW	100 (1)	Inspection of SPW by corrosion engineer	Every 10 years	10	$10,000	Estimated based on similar items at this Site.	$100,000
		Repair or replace SPW as necessary based on monitoring results	At Years 30 and 90	2	$1,000,000	Estimated based on anticipated level of effort.	$2,000,000
						Total (2)	$2,100,000
APR-3B: Monitoring and maintenance of APR-3A	100 (1)	Cover inspections (5)	Annually (Years 1 - 5)	5	$10,000	Estimated based on anticipated level of effort and 2020 Port correspondence regarding similar items at other Port sites.	$50,000
		Cover maintenance prior to redevelopment (5)	Annually (Years 1 - 5)	5	$20,000		$100,000
		Modify cover as necessary to facilitate redevelopment (5)	At Year 5	1	$500,000		$500,000
						Total (2)	$650,000
APR-4B: Monitoring and maintenance of APR-4A	100 (1)	Modify cap as necessary to facilitate redevelopment	At Year 5	1	$500,000	Estimated based on anticipated level of effort.	$500,000
		Inspect buried cap if qualifying event occurs (e.g., earthquake of certain scale)	At Years 20 and 70	2	$20,000	Estimated based on anticipated level of effort.	$40,000
		Repair or replace cap as necessary based on monitoring results	At Years 20 and 70	2	$500,000	Estimated based on anticipated level of effort.	$1,000,000
						Total (2)	$1,540,000
APR-5B: Monitoring and maintenance of APR-5A	100 (1)	Groundwater elevation measurements from additional MWs	See groundwater sampling	52	$10,000	Estimated based on anticipated level of effort assuming measurements during sampling events.	$520,000
		Modify walls as necessary to facilitate redevelopment	At Year 5	1	$500,000	Estimated based on anticipated level of effort.	$500,000
		Inspect walls if qualifying event occurs (e.g., earthquake of certain scale)	At Years 20 and 70	2	$20,000	Estimated based on anticipated level of effort.	$40,000
		Repair or replace walls as necessary based on monitoring results	At Years 20 and 70	2	$500,000	Estimated based on anticipated level of effort.	$1,000,000
						Total (2)	$2,060,000
APR-11: Performance groundwater monitoring (4)	10	Groundwater sampling for key performance MWs	Annually (Years 1 - 10)	10	$60,000	Estimated based on similar Site items assuming 36 MWs (most seaward of SPW).	$600,000
		Groundwater sampling for more comprehensive set of performance MWs	Every 5 years	2	$100,000	Estimated based on similar Site items assuming 60 MWs (in addition to MWs in previous row).	$200,000
		Pore water sampling	At Years 1, 5, and 10	3	$70,000	Estimated based on similar items at this Site.	$210,000
						Total (2)	$1,010,000
MNA&LTC-1: Long-term groundwater monitoring (4), and MNA&LTC-2: Periodic MNA evaluations	90 (Years 11 - 100) (1)	Prepare long-term monitoring plan	At Year 11	1	$40,000	Estimated based on anticipated level of effort.	$40,000
		Groundwater sampling for key long-term MWs	Annually (Years 11 - 20)	10	$60,000	Estimated based on similar Site items assuming 36 MWs (most seaward of SPW).	$600,000
		Groundwater sampling for key long-term MWs	Every 2.5 years (Years 21 - 100)	32	$60,000	Estimated based on similar Site items assuming 36 MWs (most seaward of SPW).	$1,920,000
		Groundwater sampling for more comprehensive set of long-term MWs	Every 5 years	18	$100,000	Estimated based on similar Site items assuming 60 MWs (in addition to MWs in previous row).	$1,800,000
		Pore water sampling	Every 10 years starting at Year 20	9	$70,000	Estimated based on similar items at this Site.	$630,000
		MNA evaluations (e.g., Ricker plume stability analysis, Mann-Kendall trend analysis)		9	$30,000	Estimated based on anticipated level of effort.	$270,000
						Total (2)	$5,260,000
MNA&LTC-3: Applicable ECs and MNA&LTC-4: Applicable ICs	100 (1)	Implement health and safety procedures and adhere to Port controls (e.g., Soil and Materials Management Plan) for post-remediation excavation and dewatering activities	Every 10 years starting at Year 5	10	$100,000	Estimated based on anticipated level of effort.	$1,000,000
		IC Inspections	Annually	100	$2,000	Estimated based on anticipated level of effort.	$200,000
						Total (2)	$1,200,000

Notes:

ECs: engineering controls; ICs: institutional controls; MNA: monitored natural attenuation; MW: monitoring well; N/A: not applicable; POC: point of compliance; PRB: permeable reactive barrier; SPW: sheet pile wall; SW: surface water

The placeholder frequencies and costs included in this table were developed solely to facilitate relative comparisons between alternatives for the purpose of this Report. Since these ballpark estimates were based on a variety of simplifying assumptions and PIONEER has no control over the remedial design, the construction methods, the nature and timing of future maintenance and monitoring, the lifespan of remedial components, or potential future damage to remedial components, the estimated costs should not be construed to equal actual costs. It is expected that the scope and estimated cost for maintenance and monitoring activities will be continually refined over time.

See Table F-4 for net present value calculations of annual or periodic costs.

(1) Although the expectation duration for these remedial components are estimated to be substantially longer than 100 years, a maximum duration of 100 years was assumed for the purpose of these cost estimates since net present value costs beyond 100 years are insignificant to the overall costs.

(2) Rounded to the nearest $10,000.

(3) The estimated cost of this remedial component or item was included for completeness, even though the requirement is currently associated with the CB/NT site. The remedial component or item only applies to the sediment caps downgradient of the main arsenic plume.

(4) Monitoring includes field, lab, and reporting costs associated with arsenic. Monitoring associated with other non-arsenic COCs is a seperate remedial component.

(5) Once the working surface is installed over the soil cover during redevelopment, inspections and routine repairs of the working surface (e.g., filling pavement cracks) would not be necessary because (1) minor damage to the working surface (e.g., pavement cracks) would not cause soil direct contact concerns, and (2) the buried cap (APR-4A) would serve the function of minimizing infiltration (rather than the working surface) for the alternatives that include a low permeability cap.

Table F-4: Net Present Value of Annual or Periodic Costs of EPC, APR, and MNA&LTC Remedial Components

Year	Discount Factor [1]	EPC-1B and EPC-2B		EPC-3		APR-1B		APR-3B		APR-4B		APR-5B		APR-11		MNA&LTC-1 and MNA&LTC-2		MNA&LTC-3 and MNA&LTC-4	
		Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost
1	0.976							$30,000	$29,268			$10,000		$130,000	$126,829			$2,000	$1,951
2	0.952							$30,000	$28,554			$10,000		$60,000	$57,109			$2,000	$1,904
3	0.929							$30,000	$27,858			$10,000		$60,000	$55,716			$2,000	$1,857
4	0.906							$30,000	$27,179			$10,000		$60,000	$54,357			$2,000	$1,812
5	0.884	$15,000	$13,258	$15,000	$13,258			$530,000	$468,443	$500,000	$441,927	$510,000	$450,766	$230,000	$203,286			$102,000	$90,153
6	0.862											$10,000		$60,000	$51,738			$2,000	$1,725
7	0.841											$10,000		$60,000	$50,476			$2,000	$1,683
8	0.821											$10,000		$60,000	$49,245			$2,000	$1,641
9	0.801											$10,000		$60,000	$48,044			$2,000	$1,601
10	0.781	$25,000	$19,530	$17,000	$13,280	$10,000	$7,812					$10,000		$230,000	$179,676			$2,000	$1,562
11	0.762											$10,000				$100,000	$76,214	$2,000	$1,524
12	0.744											$10,000				$60,000	$44,613	$2,000	$1,487
13	0.725											$10,000				$60,000	$43,525	$2,000	$1,451
14	0.708											$10,000				$60,000	$42,464	$2,000	$1,415
15	0.690	$15,000	$10,357	$15,000	$10,357							$10,000				$160,000	$110,474	$102,000	$70,427
16	0.674											$10,000				$60,000	$40,417	$2,000	$1,347
17	0.657											$10,000				$60,000	$39,432	$2,000	$1,314
18	0.641											$10,000				$60,000	$38,470	$2,000	$1,282
19	0.626											$10,000				$60,000	$37,532	$2,000	$1,251
20	0.610	$25,000	$15,257	$17,000	$10,375	$10,000	$6,103			$520,000	$317,341	$530,000	$323,444			$260,000	$158,670	$2,000	$1,221
21	0.595																	$2,000	$1,191
22	0.581																	$2,000	$1,162
23	0.567											$10,000	$5,667			$60,000	$34,002	$2,000	$1,133
24	0.553																	$2,000	$1,106
25	0.539	$15,000	$8,091	$15,000	$8,091							$10,000	$5,394			$160,000	$86,302	$102,000	$55,018
26	0.526																	$2,000	$1,052
27	0.513																	$2,000	$1,027
28	0.501											$10,000	$5,009			$60,000	$30,053	$2,000	$1,002
29	0.489																	$2,000	$977
30	0.477	$25,000	$11,919	$17,000	$8,105	$1,010,000	$481,510					$10,000	$4,767			$260,000	$123,953	$2,000	$953
31	0.465																	$2,000	$930
32	0.454																	$2,000	$908
33	0.443											$10,000	$4,427			$60,000	$26,562	$2,000	$885
34	0.432																	$2,000	$864
35	0.421	$15,000	$6,321	$15,000	$6,321							$10,000	$4,214			$160,000	$67,419	$102,000	$42,980
36	0.411																	$2,000	$822
37	0.401																	$2,000	$802
38	0.391											$10,000	$3,913			$60,000	$23,477	$2,000	$783
39	0.382																	$2,000	$763
40	0.372	$25,000	$9,311	$17,000	$6,331	$10,000	$3,724					$10,000	$3,724			$260,000	$96,832	$2,000	$745
41	0.363																	$2,000	$727
42	0.354																	$2,000	$709
43	0.346											$10,000	$3,458			$60,000	$20,750	$2,000	$692
44	0.337																	$2,000	$675

Table F-4: Net Present Value of Annual or Periodic Costs of EPC, APR, and MNA&LTC Remedial Components

Year	Discount Factor [1]	EPC-1B and EPC-2B		EPC-3		APR-1B		APR-3B		APR-4B		APR-5B		APR-11		MNA&LTC-1 and MNA&LTC-2		MNA&LTC-3 and MNA&LTC-4	
		Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost
45	0.329	$15,000	$4,938	$15,000	$4,938							$10,000	$3,292			$160,000	$52,668	$102,000	$33,576
46	0.321																	$2,000	$642
47	0.313																	$2,000	$627
48	0.306											$10,000	$3,057			$60,000	$18,340	$2,000	$611
49	0.298																	$2,000	$596
50	0.291	$1,025,000	$298,216	$17,000	$4,946	$10,000	$2,909					$10,000	$2,909			$260,000	$75,645	$2,000	$582
51	0.284																	$2,000	$568
52	0.277																	$2,000	$554
53	0.270											$10,000	$2,702			$60,000	$16,210	$2,000	$540
54	0.264																	$2,000	$527
55	0.257	$15,000	$3,857	$15,000	$3,857							$10,000	$2,572			$160,000	$41,144	$102,000	$26,229
56	0.251																	$2,000	$502
57	0.245																	$2,000	$490
58	0.239											$10,000	$2,388			$60,000	$14,327	$2,000	$478
59	0.233																	$2,000	$466
60	0.227	$25,000	$5,682	$17,000	$3,864	$10,000	$2,273					$10,000	$2,273			$260,000	$59,094	$2,000	$455
61	0.222																	$2,000	$443
62	0.216																	$2,000	$433
63	0.211											$10,000	$2,111			$60,000	$12,663	$2,000	$422
64	0.206																	$2,000	$412
65	0.201	$15,000	$3,013	$15,000	$3,013							$10,000	$2,009			$160,000	$32,142	$102,000	$20,490
66	0.196																	$2,000	$392
67	0.191																	$2,000	$382
68	0.187											$10,000	$1,865			$60,000	$11,193	$2,000	$373
69	0.182																	$2,000	$364
70	0.178	$25,000	$4,439	$17,000	$3,018	$10,000	$1,776			$520,000	$92,328	$530,000	$94,103			$260,000	$46,164	$2,000	$355
71	0.173																	$2,000	$346
72	0.169																	$2,000	$338
73	0.165											$10,000	$1,649			$60,000	$9,893	$2,000	$330
74	0.161																	$2,000	$322
75	0.157	$15,000	$2,354	$15,000	$2,354							$10,000	$1,569			$160,000	$25,109	$102,000	$16,007
76	0.153																	$2,000	$306
77	0.149																	$2,000	$299
78	0.146											$10,000	$1,457			$60,000	$8,744	$2,000	$291
79	0.142																	$2,000	$284
80	0.139	$25,000	$3,468	$17,000	$2,358	$10,000	$1,387					$10,000	$1,387			$260,000	$36,063	$2,000	$277
81	0.135																	$2,000	$271
82	0.132																	$2,000	$264
83	0.129											$10,000	$1,288			$60,000	$7,728	$2,000	$258
84	0.126																	$2,000	$251
85	0.123	$15,000	$1,839	$15,000	$1,839							$10,000	$1,226			$160,000	$19,615	$102,000	$12,505
86	0.120																	$2,000	$239
87	0.117																	$2,000	$233
88	0.114											$10,000	$1,138			$60,000	$6,830	$2,000	$228

Table F-4: Net Present Value of Annual or Periodic Costs of EPC, APR, and MNA&LTC Remedial Components

Year	Discount Factor [1]	EPC-1B and EPC-2B		EPC-3		APR-1B		APR-3B		APR-4B		APR-5B		APR-11		MNA&LTC-1 and MNA&LTC-2		MNA&LTC-3 and MNA&LTC-4	
		Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost
89	0.111																	$2,000	$222
90	0.108	$25,000	$2,709	$17,000	$1,842	$1,010,000	$109,439					$10,000	$1,084			$260,000	$28,173	$2,000	$217
91	0.106																	$2,000	$211
92	0.103																	$2,000	$206
93	0.101											$10,000	$1,006			$60,000	$6,037	$2,000	$201
94	0.098																	$2,000	$196
95	0.096	$15,000	$1,437	$15,000	$1,437							$10,000	$958			$160,000	$15,323	$102,000	$9,769
96	0.093																	$2,000	$187
97	0.091																	$2,000	$182
98	0.089											$10,000	$889			$60,000	$5,336	$2,000	$178
99	0.087																	$2,000	$174
100	0.085	$25,000	$2,116	$17,000	$1,439	$10,000	$846					$10,000	$846			$260,000	$22,008	$2,000	$169
Totals [2]		**$1,400,000**	**$400,000**	**$300,000**	**$100,000**	**$2,100,000**	**$600,000**	**$700,000**	**$600,000**	**$1,500,000**	**$900,000**	**$2,100,000**	**$900,000**	**$1,000,000**	**$900,000**	**$5,300,000**	**$1,700,000**	**$1,200,000**	**$400,000**

Notes:

See Table F-3 for the cost estimate details associated with these remedial components. Inflation and depreciation are not included in this estimate.

[1] The net present value calculations assumed an annual 2.5% discount rate based on input from the Port.

[2] Rounded to nearest $100,000.

Table F-5: Preliminary Cost Estimates for Annual or Periodic Costs of OPSC Remedial Components

Remedial Component	Assumed Duration (Years)	Item	Assumed Frequency	Assumed Number of Events	Assumed Cost per Event	Basis for Cost per Event Estimate	Estimated Cost for All Events
OPSC-5: Upper Aquifer groundwater monitoring downgradient of Wypenn [3]	100 [1]	Prepare monitoring plan	At Year 1	1	$10,000	Estimated based on anticipated level of effort.	$10,000
		Groundwater sampling	Every 5 years	20	$5,000	Estimated based on similar Site items assuming 3 MWs analyzed for arsenic only.	$100,000
						Total [2]	$110,000
OPSC-6: Groundwater and surface water monitoring for copper, mercury, nickel, PCE, TCE, VC, and CF [3]	100 [1]	Prepare monitoring plan	At Year 1	1	$20,000	Estimated based on anticipated level of effort.	$20,000
		Groundwater sampling	Every 5 years	20	$100,000	Estimated based on similar Site items assuming 60 MWs.	$2,000,000
		Surface water monitoring	Every 5 years	20	$10,000	Estimated based on similar items at this Site assuming up to 6 samples.	$200,000
						Total [2]	$2,220,000
OPSC-7: Decommission Angled Shoreline MWs	1	Remove six Upper Aquifer Angled Shoreline MWs and repair shoreline cap	At Year 1	1	$60,000	Estimated based on anticipated level of effort.	$60,000
						Total [2]	$60,000
OPSC-8: VI evaluation(s) [4]	1	Prepare investigation plan	At Year 5	1	$20,000	Estimated based on anticipated level of effort.	$20,000
		Groundwater and soil gas sampling [3]	At Year 5	1	$50,000	Estimated based on anticipated level of effort.	$50,000
						Total [2]	$70,000
OPSC-9: Installation of VI mitigation system(s) [4]	1	Install VI membranes	At Year 5	1	$200,000	Estimated based on anticipated level of effort.	$200,000
		Install sub-slab depressurization systems	At Year 5	1	$200,000	Estimated based on anticipated level of effort.	$200,000
		Permitting, construction quality assurance, oversight, reporting, and other costs	At Year 5	1	$100,000	Estimated based on anticipated level of effort.	$100,000
						Total [2]	$500,000
OPSC-10: Operation, maintenance, and monitoring of VI mitigation system(s) [4]	95 (Years 6 - 100) [1]	Prepare operation, maintenance, and monitoring plan	At Year 6	1	$40,000	Estimated based on anticipated level of effort.	$40,000
		Routine operation, maintenance, and monitoring [3]	Annually (Years 6 - 100)	95	$40,000	Estimated based on anticipated level of effort.	$3,800,000
		Replace sub-slab depressurization systems	At Years 30, 60, and 90	3	$300,000	Estimated based on anticipated level of effort.	$900,000
						Total [2]	$4,740,000

Notes:

MW: monitoring well

The placeholder frequencies and costs included in this table were developed solely to facilitate relative comparisons between alternatives for the purpose of this Report. Since these ballpark estimates were based on a variety of simplifying assumptions and PIONEER has no control over the remedial design, the nature and timing of future monitoring, or redevelopment plans, the estimated costs should not be construed to equal actual costs. It is expected that the scope and estimated cost for these activities will be continually refined over time.

See Table F-6 for net present value calculations of periodic costs.

[1] Although the duration for these remedial components may be longer than 100 years, a maximum duration of 100 years was assumed for the purpose of these cost estimates since net present value costs beyond 100 years are insignificant to the overall costs.

[2] Rounded to the nearest $10,000.

[3] Monitoring includes field, lab, and reporting costs.

Table F-6: Net Present Value of Annual or Periodic Costs of OPSC Remedial Components

Year	Discount Factor (1)	OPSC-5		OPSC-6		OPSC-7		OPSC-8		OPSC-9		OPSC-10	
		Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost
1	0.976	$10,000	$9,756	$20,000	$19,512	$60,000	$58,537						$0
2	0.952												$0
3	0.929												$0
4	0.906												$0
5	0.884	$5,000	$4,419	$110,000	$97,224			$70,000	$61,870	$500,000	$441,927		$0
6	0.862											$80,000	$68,984
7	0.841											$40,000	$33,651
8	0.821											$40,000	$32,830
9	0.801											$40,000	$32,029
10	0.781	$5,000	$3,906	$110,000	$85,932							$40,000	$31,248
11	0.762											$40,000	$30,486
12	0.744											$40,000	$29,742
13	0.725											$40,000	$29,017
14	0.708											$40,000	$28,309
15	0.690	$5,000	$3,452	$110,000	$75,951							$40,000	$27,619
16	0.674											$40,000	$26,945
17	0.657											$40,000	$26,288
18	0.641											$40,000	$25,647
19	0.626											$40,000	$25,021
20	0.610	$5,000	$3,051	$110,000	$67,130							$40,000	$24,411
21	0.595											$40,000	$23,815
22	0.581											$40,000	$23,235
23	0.567											$40,000	$22,668
24	0.553											$40,000	$22,115
25	0.539	$5,000	$2,697	$110,000	$59,333							$40,000	$21,576
26	0.526											$40,000	$21,049
27	0.513											$40,000	$20,536
28	0.501											$40,000	$20,035
29	0.489											$40,000	$19,546
30	0.477	$5,000	$2,384	$110,000	$52,442							$340,000	$162,093
31	0.465											$40,000	$18,605
32	0.454											$40,000	$18,151
33	0.443											$40,000	$17,708
34	0.432											$40,000	$17,276
35	0.421	$5,000	$2,107	$110,000	$46,351							$40,000	$16,855
36	0.411											$40,000	$16,444
37	0.401											$40,000	$16,043
38	0.391											$40,000	$15,651
39	0.382											$40,000	$15,270
40	0.372	$5,000	$1,862	$110,000	$40,967							$40,000	$14,897
41	0.363											$40,000	$14,534
42	0.354											$40,000	$14,179
43	0.346											$40,000	$13,834
44	0.337											$40,000	$13,496

Table F-6: Net Present Value of Annual or Periodic Costs of OPSC Remedial Components

Year	Discount Factor [1]	OPSC-5		OPSC-6		OPSC-7		OPSC-8		OPSC-9		OPSC-10	
		Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost
45	0.329	$5,000	$1,646	$110,000	$36,209							$40,000	$13,167
46	0.321											$40,000	$12,846
47	0.313											$40,000	$12,533
48	0.306											$40,000	$12,227
49	0.298											$40,000	$11,929
50	0.291	$5,000	$1,455	$110,000	$32,004							$40,000	$11,638
51	0.284											$40,000	$11,354
52	0.277											$40,000	$11,077
53	0.270											$40,000	$10,807
54	0.264											$40,000	$10,543
55	0.257	$5,000	$1,286	$110,000	$28,287							$40,000	$10,286
56	0.251											$40,000	$10,035
57	0.245											$40,000	$9,790
58	0.239											$40,000	$9,552
59	0.233											$40,000	$9,319
60	0.227	$5,000	$1,136	$110,000	$25,001							$340,000	$77,276
61	0.222											$40,000	$8,870
62	0.216											$40,000	$8,653
63	0.211											$40,000	$8,442
64	0.206											$40,000	$8,236
65	0.201	$5,000	$1,004	$110,000	$22,097							$40,000	$8,035
66	0.196											$40,000	$7,839
67	0.191											$40,000	$7,648
68	0.187											$40,000	$7,462
69	0.182											$40,000	$7,280
70	0.178	$5,000	$888	$110,000	$19,531							$40,000	$7,102
71	0.173											$40,000	$6,929
72	0.169											$40,000	$6,760
73	0.165											$40,000	$6,595
74	0.161											$40,000	$6,434
75	0.157	$5,000	$785	$110,000	$17,262							$40,000	$6,277
76	0.153											$40,000	$6,124
77	0.149											$40,000	$5,975
78	0.146											$40,000	$5,829
79	0.142											$40,000	$5,687
80	0.139	$5,000	$694	$110,000	$15,258							$40,000	$5,548
81	0.135											$40,000	$5,413
82	0.132											$40,000	$5,281
83	0.129											$40,000	$5,152
84	0.126											$40,000	$5,026
85	0.123	$5,000	$613	$110,000	$13,485							$40,000	$4,904
86	0.120											$40,000	$4,784
87	0.117											$40,000	$4,667
88	0.114											$40,000	$4,554

Table F-6: Net Present Value of Annual or Periodic Costs of OPSC Remedial Components

Year	Discount Factor [1]	OPSC-5		OPSC-6		OPSC-7		OPSC-8		OPSC-9		OPSC-10	
		Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost	Total Cost	NPV Cost
89	0.111											$40,000	$4,443
90	0.108	$5,000	$542	$110,000	$11,919							$340,000	$36,841
91	0.106											$40,000	$4,229
92	0.103											$40,000	$4,125
93	0.101											$40,000	$4,025
94	0.098											$40,000	$3,927
95	0.096	$5,000	$479	$110,000	$10,535							$40,000	$3,831
96	0.093											$40,000	$3,737
97	0.091											$40,000	$3,646
98	0.089											$40,000	$3,557
99	0.087											$40,000	$3,471
100	0.085	$5,000	$423	$110,000	$9,311							$40,000	$3,386
	Totals [2]	**$100,000**	**$0**	**$2,200,000**	**$800,000**	**$100,000**	**$100,000**	**$100,000**	**$100,000**	**$500,000**	**$400,000**	**$4,700,000**	**$1,600,000**

Notes:

See Table F-5 for the cost estimate details associated with these remedial components. Inflation and depreciation are not included in this estimate.

[1] The net present value calculations assumed an annual 2.5% discount rate based on input from the Port.

[2] Rounded to nearest $100,000.

Appendix G

Description of Groundwater Flow and Transport Modeling
Former Arkema Manufacturing Site
Tacoma, WA

March 29, 2021

Prepared for

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Appendices

1. Overview

This document describes the development and calibration of a steady-state groundwater flow model and a transient solute transport model intended to support the feasibility study (FS) evaluation of cleanup action alternatives (CAAs or alternatives) at the Former Arkema Manufacturing Site (Arkema) in Tacoma, WA. The flow and transport models described in this report were developed based on previous modeling work associated with the site coupled with additional data and information collected subsequent to that previous work.

The groundwater flow and transport models were designed and constructed to evaluate a range of containment and treatment options for the Arkema site. The groundwater flow model describes steady-state or average groundwater flow directions and groundwater flow rates. The output from the groundwater flow model is then used as input to the groundwater transport model. The transport model is used to describe temporal changes in dissolved and sorbed arsenic concentrations and arsenic mass discharges to the Hylebos Waterway.

Objectives behind the modeling effort include the following:

- Provide input needed to evaluate the benefits and costs associated with various remedial components aimed at achieving the arsenic groundwater cleanup level (i.e., 5 ug/L) at potential points of compliance (i.e., all site groundwater, vertical shoreline monitoring wells [MWs], Angled Shoreline MWs/pushpoint samplers [PPSs], and pore water nylon-screen diffusion samplers [NSDSs]).
- Estimate the restoration time frame to achieve the arsenic groundwater cleanup level of 5 ug/L at potential points of compliance (i.e., all site groundwater, vertical shoreline MWs, Angled Shoreline MWs/PPSs, and pore water NSDSs) for the assembled alternatives.[1]
- Estimate the arsenic mass discharge to the Hylebos Waterway for the assembled alternatives.

2. Groundwater flow model development

2.1 Comparison with previous modeling efforts

A variety of groundwater flow and transport models have been developed for the Arkema site over the last 30 years, as outlined in Table 1. The current (2019)[2] modeling effort builds most directly from the model described in PGG/Massmann (2004). Important improvements to the 2004 groundwater flow model include the following:

[1] The model was developed to predict the effect of alternatives on arsenic concentrations and restoration time frames on an order-of-magnitude scale (rather than predict the exact concentrations trend of each specific MW).

[2] The flow and transport models described in this report were developed over a period between 2017 and 2019 and were applied in 2020 to evaluate cleanup action alternatives.

1. The model area was extended laterally along the waterway to incorporate additional calibration targets and to reduce the impacts of assumed boundary conditions along the model edges. Figure 1 illustrates the original and revised model boundaries.
2. The number of water level observations used as model calibration targets was increased from 23 to 126. The distribution of the calibration targets in the 2019 model is shown in Figure 1.
3. Ground surface elevations and waterway bathymetry in the modeled area were updated using 2010 LiDAR data and 2017 bathymetry data.
4. The hydraulic conductivity assigned to the sheet pile wall was increased based on an analysis of responses in groundwater levels to tidal fluctuations (Pioneer, 2019, Appendix J).
5. Model layering and stratigraphy were revised to reflect updated topography and well log data, as described below in Sections 2.4 and 2.5. Additional stratigraphic information from soil borings completed after 2004 (DOF, 2013; Pioneer, 2019) were incorporated into these revisions.
6. A high-permeability “swale” that had been used in the 2004 model to allow flow beneath the sheet-pile wall was removed. This revision was based on the updated model stratigraphy and based on results from model calibration using the higher-conductivity sheet pile wall, as described below in Section 2.5.
7. Two additional high-permeability “windows” where added to the first aquitard. These windows represent areas where the aquitard is either missing, very thin, or compromised from historic construction activities on the site.
8. The deep aquifer was divided into two layers; one layer intersects the Hylebos Waterway and the second layer extends below the Hylebos Waterway. A low-permeability zone that had been used in the 2004 model to reflect the presence of precipitates along the Hylebos Waterway was removed in the 2019 model. This was done to reflect the removal of precipitated silica minerals as part of the 2004-2006 shoreline excavation and intertidal cap construction.
9. Hydraulic conductivity values and dispersivity values assigned to aquifer and aquitard units were revised based on the updated model calibration.

2.2 Flow model code

The USGS three-dimensional finite-difference groundwater-flow model MODFLOW-2005 (Harbaugh 2005) was used to simulate groundwater flow in the study area. MODFLOW-2005 is one of the industry standard software packages for groundwater flow modeling. The source code is free, public-domain software. MODFLOW-2005 solves the three-dimensional groundwater-flow equation for a porous medium using the finite-difference method. It uses modular packages to represent groundwater-flow system processes, such as recharge, groundwater flow, discharge, and interactions between the aquifer and surface-water bodies. The model was developed to run under the graphical user interfaces GWVistas Version 7.24.[3]

[3] Environmental Simulations, Inc. (ESI), 2020. http://www.groundwatermodels.com/Groundwater_Vistas.php

Water levels at the Arkema site are tidally-influenced. The steady-state flow model is used to describe groundwater flow directions and flow rates that are averaged over the tidal cycles. The solute transport model is used to describe the temporal changes in dissolved and sorbed arsenic concentrations and arsenic fluxes that result from these average groundwater flow conditions.

2.3 Model location and grid

The model area encompasses approximately 180 acres along the Hylebos Waterway, as shown in Figure 1. The Arkema site is located in the central part of the model area. A variable grid spacing is used in the model, as shown in Figure 2. The grid is rotated 43 degrees counterclockwise so that the axes of the grid are parallel and perpendicular to the Waterway. The grid spacing varies from 10 feet by 10 feet in the central part of the model near the contaminant source and plumes to 50 feet by 30 feet in the distal areas of the model. The model is 14 layers thick, resulting in 228,144 active cells. The model uses material properties (e.g., hydraulic conductivity) that are averaged over each model cell. The model output (e.g., groundwater levels and arsenic concentrations) also represents an average value over the model cell.

2.4 Model surface topography

The surface topography in the model is derived from a bare-earth digital-elevation model (DEM) derived from LiDAR data. The DEM grid cell size is 3 ft. The DEM data data were downloaded from the Puget Sound LiDAR consortium.[4] The elevation for each cell in the model was assigned by averaging the DEM data over the model cell.

The bathymetry of the Hylebos Waterway in the model area was obtained from the Port of Tacoma and is derived from a survey conducted in 2017. The resolution of the bathymetry data is 0.5 meters. The bathymetry was used to assign boundary conditions for the Waterway, as described in more detail below.

2.5 Hydrostratigraphy

The model uses fourteen layers to describe the hydrostratigraphy in the model area, as summarized in Table 2. The layering is based on the original PGG/Massmann model (2004) with modifications supported by additional boring log data collected as part of the 2017 to 2018 FS Data Gap Investigation (Pioneer, 2019).

Hydraulic conductivity values were initially assigned based on descriptions from well logs and values included in previous modeling efforts. The hydraulic conductivity values were then adjusted as part of model calibration, as described below. The values used in the calibrated model are listed in Table 2. A 10:1 ratio of horizontal to vertical hydraulic conductivity values is used for the aquitards and a ratio of 1:1 was used for the aquifers.

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[4] Downloaded on 10/17/2017 from http://pugetsoundlidar.ess.washington.edu/lidardata/restricted/nonpslc/pierce2010/pierce2010.html. coverage2017nov09_shp - non_pslc_simp100, Pierce County 2010, Index BE_11487340.

The presence of "windows" within the first aquitard has been long-recognized, dating from the earliest models developed for the site in 1990, as summarized in Table 1. The windows represent areas where the aquitard is either missing, very thin, or compromised from historic construction activities on the site. The location of these windows in the 2019 model is shown in Figure 3. The hydraulic conductivity of the window areas is assigned a value of 30 ft/day, which is the same value used for the intermediate aquifer.

A high-permeability "swale" that had been used in the 2004 model to allow flow beneath the sheet-pile wall was removed in the 2019 model. The swale had been included in the 2004 model based in part on the apparent absence of the first aquitard in boring log 125+50-2. A more recent boring (PTC-129, completed 9/18/2017) located approximately 5.6 feet from 125+50-2 shows the presence of the first aquitard as a 5-foot-thick silt layer between 17 and 22 feet below ground surface (Pioneer, 2019). A review of boring log 125+50-2 shows that no soil samples had been recovered over this depth interval.

2.6 Hydraulic Boundary Conditions

Four general boundary conditions are used in the groundwater flow model to describe groundwater inflow and outflow. The locations of these boundaries are depicted in Figure 2. The first type of boundary is groundwater recharge at the land surface. The value assigned to the recharge rate is 23 inches per year. This value is based on model calibration results and an evaluation of the response of shallow groundwater levels to precipitation events.

The second type of boundary are constant head boundaries that are used to describe the regional groundwater flow system. These boundaries are located along the edges of the model in layers 13 and 14.

The third type of boundary are general head boundaries that are used to describe the Hylebos Waterway. The water level assigned to the Waterway is 7.71 feet MLLW to reflect average tidal levels.

The existing sheet pile wall is incorporated into the groundwater flow model using the wall boundary condition in GWVistas. The wall is assigned a thickness of 0.026 feet and an effective hydraulic conductivity value of 0.0008 ft/day ($2.8x10^{-7}$ cm/s). The thickness is based on the actual thickness of the steel sheet piles used to construct the wall. The hydraulic conductivity value is based on an analysis of responses in groundwater levels to tidal fluctuations (Pioneer, 2019, Appendix J). Two approaches were used to estimate wall hydraulic conductivity. The first approach, which uses data collected in 1990, compared tidal fluctuations measured in a common set of wells before and after the sheet pile wall was installed. The second approach, which uses data collected in 2004, compared tidal fluctuations measured on the water-ward and land-ward sides of the wall.

2.7 Flow model calibration

The groundwater flow model was calibrated using water level data collected on 3/13/2012 (low tide at -0.6 ft) and 3/14/2012 (high tide at +10.6 ft). These data provide the most complete set of contemporaneous observations under high and low tides. Data were collected at 193 locations (108 from the upper aquifer, 65 from the intermediate aquifer, and 20 from the deep aquifer) A subset of these wells was used as the model calibration targets. Wells were used if the difference between low and high tide was less than 0.5 feet. This results in 126 total calibration targets (94 in the upper aquifer and 32 in the intermediate aquifer).

Figure 4 shows the comparison between computed and observed water levels for the final calibrated model. The calibration can be quantified using statistics that describe model residuals, which are defined as the observed water level at a point minus the computed water level at the same point. The mean of the residuals for the calibrated model is 0.05 feet. This is a low value that demonstrates there is no bias toward over- or under-prediction of water levels. The range of the observed values is 10.1 feet and the root mean square error (RMSE) for the residuals is 2.61 feet. The ratio of the RMSE to the range of observations is often used as a measure of the goodness-of-fit between observed and calculated value. The ratio for the final calibration is 25%. This value is higher than ideal, and may be due in part to the effects of averaging tidally-influenced water levels using only two data points (near high tide and near low tide). The RMSE could be reduced by adding additional heterogeneity and complexity to the model, including spatially-varying hydraulic conductivity values and recharge rates. Given that the primary purpose of the modeling effort is to compare the relative effectiveness of various cleanup action alternatives over long time frames, adding heterogeneity solely to improve calibration statistics would not likely improve the utility of the model for its intended purpose.

3. Groundwater transport model development

3.1 Overview of arsenic transport processes

Inorganic arsenic exists as arsenate (As(V), the oxidized form) and arsenite (As(III), the reduced form). These two species of arsenic get transported via advection and dispersion when dissolved in groundwater. However, they both also associate with soils and sediment (i.e., the solid phase), which limits their mobility. The associations with the solid phase range from highly stable and essentially not environmentally available (i.e., precipitated or co-precipitated with recalcitrant minerals), to intermediately stable and available in anaerobic conditions with microbial mediation (i.e., co-precipitated with metal oxide minerals), to reversibly sorbed.

Sorption of arsenate and arsenite is highly sensitive to pH and redox conditions. Sorption is enhanced when pH is in a neutral range (e.g., pH between 6 and 8) compared to a basic pH (e.g., pH greater than 9). Furthermore, sorption decreases proportionally as the pH becomes increasingly basic. pH affects sorption because it impacts the charge of the arsenic species and the charge of the sorption surface. Similarly, sorption is enhanced in oxidizing conditions (e.g., Eh greater than 0 V) compared to reducing conditions (e.g., Eh less than 0 V). In oxidizing conditions, iron oxide minerals are often present, which are important surfaces for arsenic sorption. In addition, inorganic arsenic tends to be speciated as arsenate instead of arenite in oxidizing conditions, and the negatively charged arsenate ion sorbs more strongly than the neutrally charged arsenite molecule.

3.2 Laboratory test results, pH effects, Langmuir isotherms, arsenic transport

Soil from the upper aquifer, first aquitard and intermediate aquifer was collected from an upgradient, unimpacted area of the site for batch adsorption tests (BATs). These tests, which are described in more detail in Pioneer (2019), were carried out by Brooks Applied Lab and were used to determine the sorption capacity and isotherm behavior of site soil. In addition, soil from the upper aquifer, first aquitard and intermediate aquifer at multiple impacted areas throughout the site was collected for sequential extraction tests. These tests were also carried out by Brooks Applied Lab and were used to determine the concentration of arsenic in different solid fractions, including the concentration of sorbed arsenic. Data from both of these tests, as well as site aqueous arsenic concentrations and basic geochemical understanding of arsenic were used to develop sorption isotherms that were used in the model.

Results from the BAT tests were fit with a Langmuir isotherm. The parameters used to describe these isotherms are discussed in Section 3.5 below.

3.3 Comparison with previous transport modeling efforts

Several groundwater transport models were previously developed for the Arkema site, as outlined in Table 1. The 2019 modeling effort builds on these previous models. Important improvements to the previous transport models include the following:

1. Non-linear arsenic sorption was incorporated using Langmuir isotherms. The coefficients used describe these isotherms are based on newly-available laboratory data.
2. Heterogeneity in arsenic sorption was incorporated within the model. This heterogeneity reflects heterogeneity in pH conditions and the impact of these pH conditions on sorption processes.
3. Observed arsenic concentrations were used to calibrate the transport model. This calibration included adjusting sorption parameters and source concentrations to better reflect observed arsenic levels. The previous transport models developed for the site had not been calibrated.

3.4 Transport model code

Arsenic transport was simulated using MT3D (Zheng and Bennett, 2002). MT3D is one of the industry standard software packages for groundwater transport modeling. The source code is free, public-domain software. MT3D solves the three-dimensional solute transport equation for a porous medium using the finite-difference method. Transport processes that are simulated with the MT3D code are advection due to groundwater flow and sorption/desorption between the arsenic and aquifer and aquitard materials.

Output from the steady-state groundwater flow model is used as input to the solute transport model. The solute model describes temporal changes in dissolved and sorbed arsenic concentrations and arsenic fluxes that result from the groundwater flow directions and flow rates calculated with the flow model.

3.5 Arsenic sorption parameters

Langmuir isotherms are used to describe the sorption of arsenic. The expression used is the following:

$$C_s=S_{max}C/(K_l+C)$$

where C_s sorbed concentration (mg/kg) and C=dissolved concentration (mg/L). The isotherms are described using two parameters: the equilibrium constant (K_l) and the total concentration of sorption sites available (S_{max}). Figure 5 shows the shape of the Langmuir isotherms over the range of parameters used in the model. Values were assigned to these parameters based on the results from laboratory batch adsorption tests and sequential extraction tests described in Pioneer (2019) and through transport model calibration described in more detail in subsequent sections.

In the final calibrated model, the equilibrium constant, K_l, is assigned a value of 10 mg/L for all layers. The values assigned to the total concentration of sorption sites available, S_{max}, varied by layer, as summarized in Table 2 The upper aquifer was assigned a S_{max} value of 100 mg/kg and the intermediate aquifer was assigned a S_{max} value of 300 mg/kg. The S_{max} value assigned to the first and second aquitards was 3,000 mg/kg, except for high pH areas in the first aquitard, where the S_{max} was set to 300 mg/kg. Figure 6 shows the distribution of the high pH areas where S_{max} is set to 300 mg/kg in the first aquitard.

3.6 Arsenic boundary conditions

The MT3D model that is used to describe current conditions includes arsenic sources at the locations of the Former Penite Manufacturing Building and Former Penite Pit #2. These source areas are shown in Figure 6. The arsenic input from these sources is 61 kg/year, with 34 kg/year from the Former Penite Manufacturing Building and 27 kg/year from Former Penite Pit #2. These values were assigned as part of model calibration.

3.7 Arsenic initial conditions

Estimates of the initial spatial distribution of arsenic are required to run the transient model. These initial conditions represent estimated conceptual arsenic concentrations in 2008. The initial conditions assigned to the transport model focus on the plume core, as there is limited historical information describing the full plume extent. The plumes are generalized representations of the available data describing arsenic concentrations in the groundwater during the 2008 timeframe. The values assigned are illustrated in Figures 7 through 9. These figures also show the locations of available concentration data that were used to develop and constrain the generalized plumes.

Initial sorbed concentrations in the model are calculated using the initial groundwater concentrations and the Langmuir isotherms shown in Figure 5. This approach assumes equilibrium between the aqueous and sorbed concentrations.

3.8 Transport model calibration

The transport model was calibrated by simulating the evolution of the plume geometries from 2008 to 2017. The primary objective of the calibration was to match the overall plume geometry, concentration patterns, and concentration magnitudes landward of the sheet pile wall as the plumes evolved from 2008 to 2017.

Parameters that were adjusted during calibration of the transport model include initial arsenic concentrations, arsenic source strength, parameters used to describe the Langmuir isotherm, bulk density of the aquifer and aquitard materials, and parameters used to describe dispersion and mixing within the groundwater system. The final set of parameters for the calibrated transport model are presented in Table 3.

Figures 10 and 11 compare the calculated and observed arsenic concentrations for 2017 in the upper aquifer and Figures 12 and 13 compare the calculated and observed arsenic concentrations for 2017 in the intermediate aquifer. The calculated values were derived by running the calibrated model for a 9-year simulation period starting with the initial conditions representing 2008, as described in the previous section. The observed plumes shown in Figures 11 and 13 are generalized representations of the available data describing arsenic concentrations in the groundwater during the 2017 timeframe.

The results of the calibration in terms of concentration averages, maximums, and standard deviations are listed in Table 4. Initial conditions for 2008 are also included in this table. The results show that calculated and observed concentration statistics for 2017 are reasonably similar, particularly considering the magnitude of changes from the 2008 initial conditions.

4. Model applications

The calibrated flow and transport models were used to simulate seven alternative scenarios. These scenarios include various remedial components, as outlined in Table 5. The models were used to estimate the time until arsenic groundwater concentrations fall below the 5 ug/L cleanup level at different potential points of compliance. The models were also used to estimate the average mass discharge of arsenic to the Hylebos Waterway during the next 100 years.

4.1 Estimates of water balances and arsenic mass in the base-case model

Water balances. The calibrated flow model described in Section 2 provides estimates of water balances under 2017 conditions. There are two components to groundwater inflow into the model area: recharge from precipitation and groundwater inflow from adjacent areas. The total inflow from recharge is estimated to be 41,200 cubic feet per day (ft^3/day) or 308,000 gallons per day (gpd). This corresponds to 23 inches per year over a model surface area of 180 acres.

The total inflow associated with the regional flow system is estimated to be 200,970 ft3/day or 1,503,000 gpd. The large majority of this inflow (185,740 ft^3/day or 92% of the total) occurs as inflow along the south and east boundaries of layer 13. The total outflow to the Waterway is 242,152 ft^3/day or 1,811,000 gpd. The large majority of this outflow (200,967 ft^3/day or 83% of the total) occurs as flow across the bottom of the Waterway from model layer 13.

Water balances for an area in the upper aquifer in the vicinity of the arsenic plumes indicate four primary components: inflow from precipitation recharge (13 gallons per minute [gpm]), lateral inflow from adjacent areas (1.0 gpm), outflow through the bottom of the aquifer (11.6 gpm), and outflow through the existing sheet-pile wall (2.3 gpm). The area used to develop this water balance is shown in Figure 14.

Arsenic mass estimates. The total estimated arsenic mass in the model area is 116,000 kilograms. This estimate includes both dissolved and sorbed arsenic. The vast majority of this is in the solid phase. The estimated mass in the dissolved phase is approximately 300 kg. (One pore-volume is therefore equivalent to approximately 300 kg). The total estimated mass in the system is equivalent to approximately 390 pore volumes. The estimated 2019 mass discharge to the Hylebos Waterway is approximately 10 kg/year.

4.2 Incorporating remedial components into the flow and transport models

The approaches used to incorporate the various remedial components into the flow and transport models are described below. The starting point or "base-case" models are the calibrated models described in Sections 2 and 3.

Calculating Angled Shoreline MW, PPS, and pore water NSDS concentrations. Arsenic concentrations at these potential point of compliance locations seaward of the sheet pile wall were calculated by post-processing of the model output. The model output gives concentrations at the vertical shoreline MWs. Attenuation factors were then used to extend the results from the vertical shoreline MWs to downgradient Angled Shoreline MWS, PPSs, and pore water NSDSs using the attenuation factors listed in Table 6.[5] As an example, if the model calculated arsenic concentration at upper aquifer vertical shoreline MW 125+50-1 was 120 ppb, then the estimated arsenic concentrations at an upper aquifer Angled Shoreline MW and an upper aquifer pore water NSDS downgradient of 125+50-1 would be 4 ppb (120 ppb/30) and 2.4 ppb (120 ppb/49), respectively. Likewise, if the model calculated arsenic concentration at intermediate aquifer vertical shoreline MW 124+00-2 was 50,000 ppb, then the estimated arsenic concentrations at an intermediate aquifer PPS and an intermediate aquifer pore water

[5] The attenuation factors were provided by Troy Bussey (Pioneer Technologies) on 2/3/21. The table and figures that summarize the calculations used to develop these attenuation factors is included in Appendix A.

NSDS downgradient of 124+00-2 would be 769 ppb (50,000 ppb/65) and 532 ppb (50,000 ppb/94), respectively.

Subtidal cap extension (EPC-2A). This remedial component is not included in the actual models, but rather is incorporated through post-processing of the model output. Arsenic concentrations at potential point of compliance locations within the subtidal cap extension (i.e., PPS and pore water NSDS locations downgradient of vertical shoreline MWs 122+60-2 and 124+00-2) were assumed to be permanently reduced by 50% as a result of the subtidal cap extension.

Focused UA soil removal (APR-2). Source area locations in the upper aquifer (UA) were assigned initial soil and groundwater concentrations of zero to reflect soil removal. The locations where the initial concentrations were set to zero are shown in Figure 15. This action eliminated the arsenic source term described in Section 3.6. The hydraulic conductivity of the assumed backfill in these excavation locations was kept at the same value as the base-case simulation (i.e., 5 ft/day).

Focused low-permeability surface cap (APR-4A). The low-permeability surface cap was incorporated into the model by reducing the recharge rate in the capped area to 1% of the value used in the base-case model. This corresponds to 0.22 inches per year, as compared to 22 inches per year for the calibrated base-case scenario. The spatial extent of the focused low-permeability surface cap is shown in Figure 16.

Focused ISS upgradient of 124+00-2 (APR-6). The area included in the focused in-situ solidification/stabilization (ISS) remedial component is shown in Figure 17. The hydraulic conductivity in the ISS area was assigned a value of 0.0028 ft/day ($1x10^{-6}$ cm/s) and the initial soil and groundwater concentrations were assigned a value of zero. The ISS treatment area was extended from the land surface to the bottom of the intermediate aquifer (model layer 7).

Vertical barrier walls (APR-5A). The locations of the vertical barrier walls are shown in Figure 17. The walls were extended from the land surface to the bottom of the intermediate aquifer (model layer 7). The walls were assumed to be 2.6 feet thick with hydraulic conductivity equal to 0.0008 ft/day ($2.8x10^{-7}$ cm/s).

Focused permeable reactive barriers (PRBs, APR-7 and APR-8). Permeable reactive barriers were incorporated in the model by assigning an initial groundwater concentration equal to zero and an initial soil concentration equal to one-half the value from the base-case model. The locations of the UA and intermediate aquifer (IA) PRBs are shown in Figure 18. The PRBs were assumed to be 10-feet wide.

Excavation to 88 mg/kg (APR-9). Locations in the upper aquifer (model layer 1) and the top of the first aquitard (model layer 2) where soil concentrations exceed 88 mg/kg were assigned initial soil and groundwater concentrations of zero to reflect soil removal. The locations where the initial concentrations were set to zero are shown in Figure 19. This action eliminated the arsenic source term described in Section 3.6. The hydraulic conductivity of the assumed backfill in these excavation locations was kept at the same value as the base-case simulation (i.e., 5 ft/day in the upper aquifer and 0.1 ft/day in the first aquitard).

Extensive ISS (APR-10). The area included in the extensive ISS remedial component is shown in Figure 20. The hydraulic conductivity in the ISS area was assigned a value of 0.0028 ft/day ($1x10^{-6}$ cm/s) and the initial soil and groundwater concentrations are assigned a value of zero. The ISS treatment area was extended from top of model layer 3 (the middle of the first aquitard, where the APR-9 soil excavation ended) through model layer 7 (the bottom of the intermediate aquifer).

4.3 Scenario simulations

The remedial components described in Section 4.2 were combined in various ways to form seven scenarios or alternatives. The remedial components that were incorporated into each of these seven alternatives are identified in Table 5. The alternatives are compared based on predicted times to achieve concentration targets and predicted average mass discharge to the Hylebos Waterway during the next 100 years. Results are summarized in Table 7.

Figure 21 illustrates calculated arsenic concentrations in the plume core for the upper and intermediate aquifer for alternative CAA1. The initial conditions used to develop these results correspond to the 2008 conditions shown in Figures 7, 8, and 9. Figure 21 shows that the core concentrations decrease by approximately 60% over the first 2 years (from approximately 100,000 ppb to approximately 40,000 ppb). However, concentrations remain above 100 ppb in the plume core for more than 3,000 years in the upper aquifer and for more than 7,000 years in the intermediate aquifer.

The estimated restoration time frames to achieve the arsenic groundwater cleanup level of 5 ug/L is extremely long for all alternatives and potential points of compliance evaluated with the model (see Table 7).[6] For instance, the estimated restoration time frames at the vertical shoreline MWs are greater than 10,000 years for all alternatives. The shortest estimated restoration time frames are 3,100 years and 3,700 years for CAA5 and CAA2, respectively, for a point of compliance of pore water NSDSs. The average mass discharge to the Hylebos Waterway ranges from approximately 2 kg/year for CAA4 to approximately 10 kg/year for CAA1. Predicted time-series concentration plots at the various potential point of compliance locations are included in Appendix B.

[6] The estimated restoration time frames for surface water at locations as close as technically possible to the point or points where groundwater flows into surface water were determined with empirical surface water data rather than the model.

References

DOF. 2013. *Final Remedial Investigation Report for Former Arkema Manufacturing Plant. 2901 & 2920***,** Taylor Way, Tacoma, Washington. September.

Harbaugh, A.W., 2005. MODFLOW-2005, *The U.S. Geological Survey modular ground-water model—the Ground-Water Flow Process*: U.S. Geological Survey Techniques and Methods 6-A16, variously p.

Pacific Groundwater Group and Joel Massmann, 2004. *Bank Remediation Focused Feasibility Study*, ATOFNINA Chemicals, Inc., Tacoma, Washington. March 22, 2004.

Pioneer, 2019. *Feasibility Study Data Gap Investigation Report, Former Arkema Manufacturing Site***,** Prepared for Port of Tacoma, July 2019.

Zheng, Chunmiao & Bennett, Gordon, 2002. *Applied Contaminant Transport Modeling*. second edition, John Wiley & Sons.

Tables

Table 1. Overview of previous models developed for the Arkema site.

Model	Application	Transport	Reactions	High K windows and Low K precipitate zones	Notes/Other
Intera, 1990	Design and predict effects of expedited response actions (e.g., P&T and SPW).	Advection, dispersion, and sorption.	Equilibrium and reversible sorption (retardation approach).	Single window in vicinity of storage tank. Low permeability zone along waterway to represent precipitates.	Five-layer model with upper aquifer, 1st aquitard, intermediate aquifer, 2nd aquitard, and deep aquifer.
Intera, 1994;1995	Estimate arsenic flux to waterway prior SPW.	Advection, dispersion, and sorption.	Same as above.	Four windows associated with stream channels and storage tank.	Three-layer model with single layer for upper aquifer, 1st aquitard, intermediate aquifer.
Boateng/Massmann, 1999	Simulate effects of SPW. Evaluate flow around SPW the wall edges or wings.	No transport.	None.	Layers are assumed homogeneous. No windows included.	First MODFLOW model. Five-layer model. Refined grid spacing.
PGG/Massmann, 2004	Estimate arsenic flux to waterway.	Advection only.	None.	Included windows and added swale beneath sheet pile wall.	Refined grid. Twelve model layers.
Current	Estimate restoration time periods for FS alternatives and estimate arsenic flux to waterway.	Advection, dispersion, and sorption.	Non-linear, reversible sorption using Langmuir isotherms	Includes 6 windows associated with stream channels and other heterogeneities. Modified precipitate zone to reflect 2004-2006 cap construction.	Calibrated to improved water level dataset. First to calibrate to GW arsenic concentrations. Refined grid and layering.

Table 2. Model layers used to describe hydrostratigraphy in the model area.

Hydrogeologic unit	Model Layer	Average elevation of layer top	Average elevation of layer bottom	Average layer thickness	Average hydraulic conductivity	Total arsenic maximum sorption capacity
		(ft MLLW)[1]	(ft MLLW)	(ft)	(ft/day)	(mg/kg)
Shallow aquifer	1	15.7	13.2	2.5	5.0	100
First aquitard	2	13.2	6.3	6.9	0.11	300,3000[2]
First aquitard	3	6.3	3.9	2.3	0.11	300,3000[2]
First aquitard	4	3.9	1.5	2.4	0.11	300,3000[2]
Intermediate aquifer	5	1.5	-0.9	2.4	30	300
Intermediate aquifer	6	-0.9	-3.8	2.9	30	300
Intermediate aquifer	7	-3.8	-6.9	3.1	30	300
Second aquitard	8	-6.9	-9.7	2.9	0.11	3000
Second aquitard	9	-9.7	-13.0	3.3	0.11	3000
Second aquitard	10	-13.0	-16.2	3.1	0.11	3000
Second aquitard	11	-16.2	-19.3	3.1	0.11	3000
Deep aquifer	12	-19.3	-22.4	3.1	60	300
Deep aquifer	13	-22.4	-50.0	27.6	60	300
Undifferentiated	14	-50.0	-130.0	80.0	5.0	300

[1] MLLW elevations are equal to NAVD88 elevations plus 2.46 feet.

[2] The 300 mg/kg value is assigned to locations with higher pH values to reflect effect of pH on arsenic sorption.

Table 3. Parameters used in final calibrated transport model.

Parameter	Calibrated value	Comments/Basis
Bulk density of aquifer materials	100 lbs/ft^3 for all layers	Estimate based on literature values (e.g., Zheng and Bennett, 2002). Relatively low variability among sites with typical range from 90 to 110 lbs/ft3.
Langmuir equilibrium constant, Kl	10 mg/L for all layers	Based on results from laboratory batch adsorption tests (Pioneer, 2019) and refined during model calibration.
Langmuir concentration of available sorption sites, Smax.	Ranges from 100 to 3,000 mg/kg depending on layer and pH conditions. The upper aquifer is assigned a value of 100 mg/kg and the intermediate aquifer is assigned a value of 300 mg/kg. The value assigned to the first and second aquitards is 3,000 mg/kg, except for high pH areas in the first aquitard, where the Smax is set to 300 mg/kg, as shown in Figure 6.	Based on results from laboratory batch adsorption tests (Pioneer, 2019) and refined during model calibration.
Arsenic initial conditions	Ranges from 0 to 250,000 ppb, as illustrated in Figures 7 through 9.	Based on observed concentrations (DOF, 2013; Pioneer, 2019) and model calibration.
Arsenic source strength	Source concentrations equal to 175,000 ppb. Total input equal to 34 kg/year total arsenic from the Former Penite Manufacturing Building and 27 kg/year from Former Penite Pit #2 at locations shown in Figure 6.	Based on observed concentrations (DOF, 2013; Pioneer, 2019) and model calibration.
Aquifer dispersivity	Longitudinal value equal to 5 ft for all layers except the deep aquifer, where a value of 30 ft is used. Transverse dispersivity assigned a value equal to 10% of longitudinal value for all layers.	Estimates based on literature values (e.g., Zheng and Bennett, 2002) and refined during model calibration.

Table 4. Calibration results for transport model.

Upper aquifer			
	Arsenic concentrations in ppb		
	Average	**Maximum**	**Standard deviation**
2008 observed	1,105	250,083	8,327
2017 calculated	801	115,860	5,108
2017 observed	989	101,184	5,819
Intermediate aquifer			
	Arsenic concentrations in ppb		
	Average	**Maximum**	**Standard deviation**
2008 observed	1,764	250,239	14,245
2017 calculated	893	55,222	4,332
2017 observed	710	50,497	5,040

Table 5. Additional remedial components simulated in alternative scenarios.

Alternative	Natural attenuation	Additional remedial components: Subtidal cap extension (EPC-2A)	Focused UA soil removal (APR-2)	Focused low-permeability surface cap (APR-4A)	Focused ISS upgradient of 124+00-2 (APR-6)	Focused PRB in IA (APR-7)	Focused PRB in UA (APR-8)	Vertical barrier walls (APR-5A)	Excavate to 88 mg/kg (APR-9)	Extensive ISS
CAA 1	X									
CAA 2	X	X	X							
CAA 3 w/o Contingent	X	X	X	X						
CAA 3 w/ Contingent	X	X	X	X	X	X	X			
CAA 4 w/o Contingent	X	X	X	X	X			X		
CAA 4 w/ Contingent	X	X	X	X	X	X	X	X		
CAA 5	X	X				X	X		X	X

Table 6. Attenuation factors used to estimate nearshore concentrations based on calculated values at vertical shoreline monitoring wells.

Nearshore sample location type[1]	Well location	Attenuation factor
Angled Shoreline MW	Upper aquifer	30
PPS	Intermediate aquifer	65
PW NSDS	Upper Aquifer	49
PW NSDS	Intermediate aquifer	94

[1]MW: monitoring well; NSDS: nylon-screen diffusion sampler; PPS: pushpoint sampler; PW: pore water

Table 7. Results from simulations of alternative scenarios.

	Predicted Relative Timeframes to Achieve Concentration Targets (years)[1]				Average mass discharge to Hylebos Waterway (kg/year)
	5 ug/L across entire Site	5 ug/L at Vertical Shoreline MWs	5 ug/L at Angled Shoreline MWs/PPSs	5 ug/L at PW NSDS	
CAA 1 (baseline)	>10,000	>10,000	>10,000	>10,000	10.0
CAA 2	>10,000	>10,000	4,588	3,711	9.9
CAA 3 w/o contingent	>10,000	>10,000	7,711	6,505	7.9
CAA 3 w/ contingent	>10,000	>10,000	>10,000	>10,000	4.6
CAA 4 w/o contingent	>10,000	>10,000	>10,000	>10,000	2.1
CAA 4 w/ contingent	>10,000	>10,000	>10,000	>10,000	2.1
CAA 5	>10,000	>10,000	4,040	3,108	3.2

[1]MW: monitoring well; NSDS: nylon-screen diffusion sampler; PPS: pushpoint sampler; PW: pore water

Figures

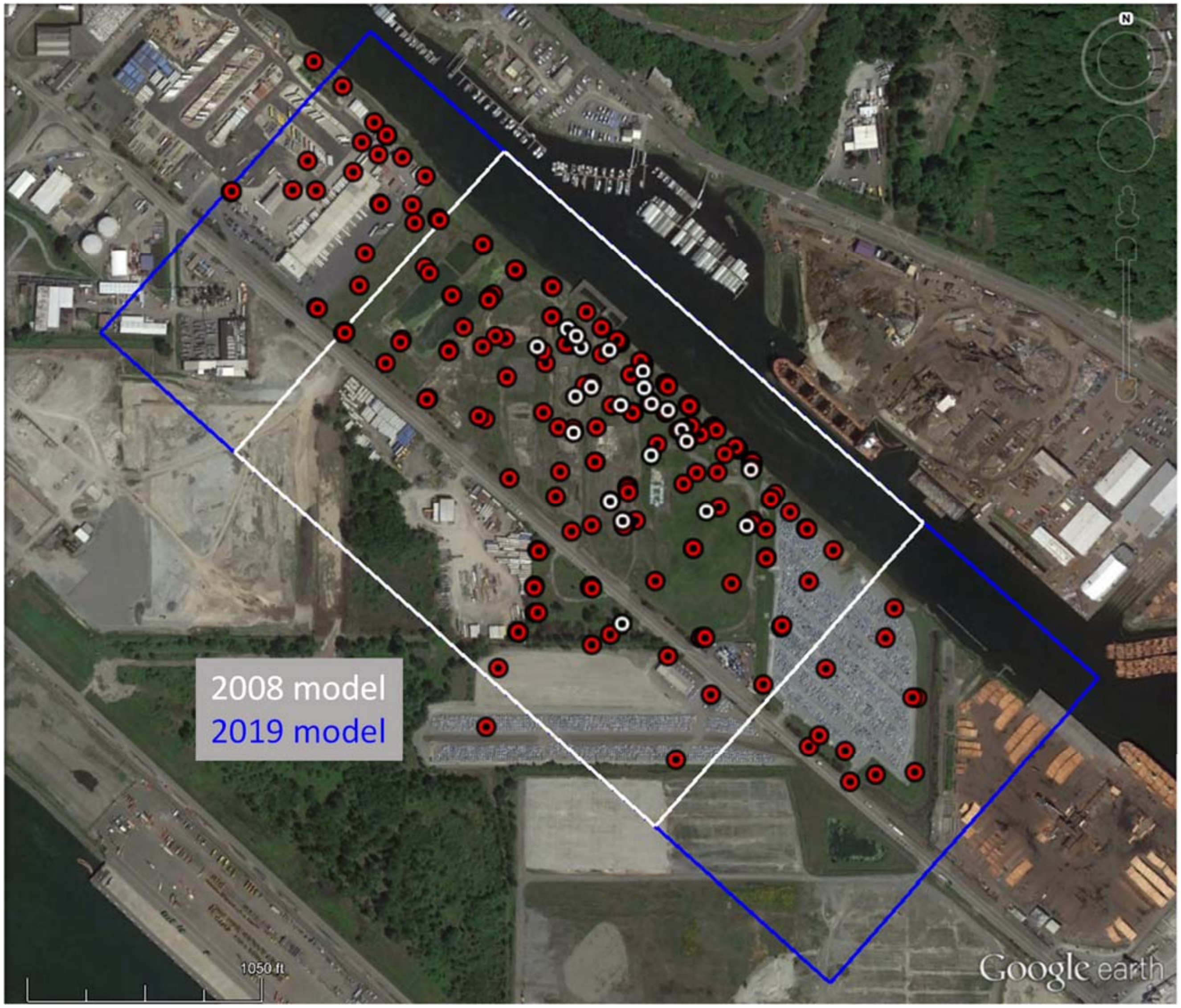


Figure 1. Original (2008) and revised (2019) model boundaries and spatial distribution of current water level calibration targets.

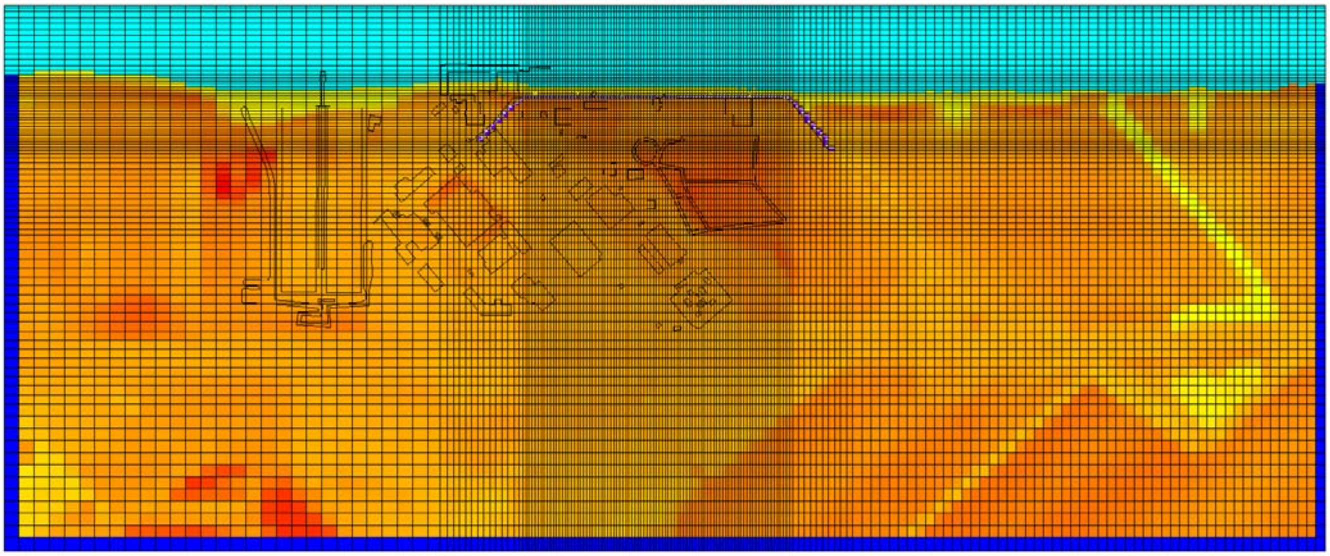


Figure 2. Model surface topography, grid spacing, and hydraulic boundary conditions.

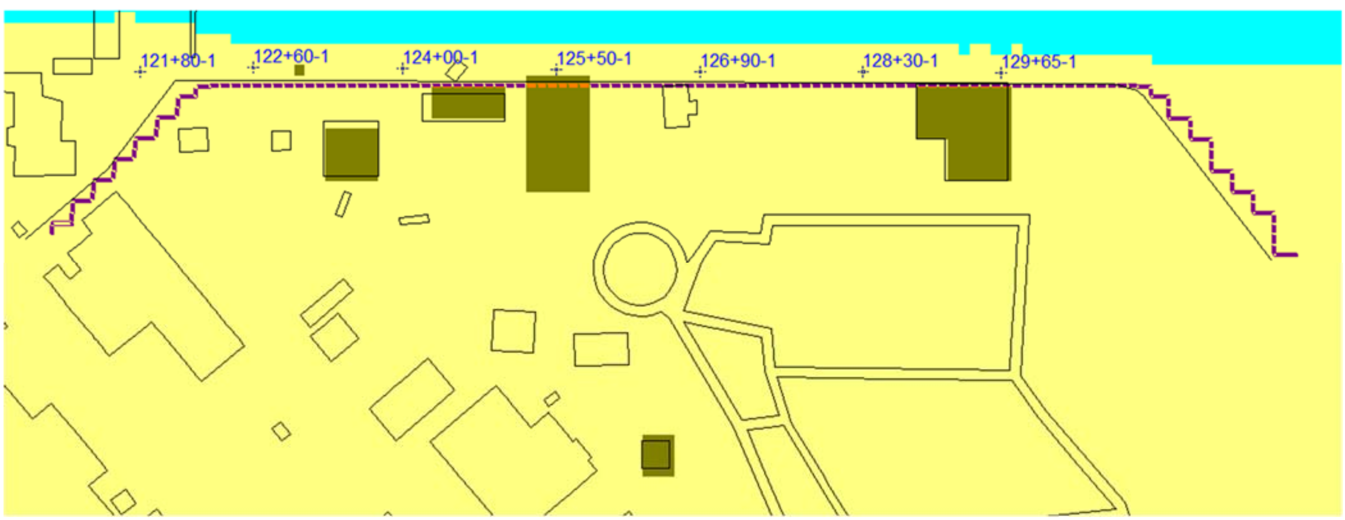


Figure 3. Locations of windows in the first aquitard (layers 2-4) with higher hydraulic conductivity.

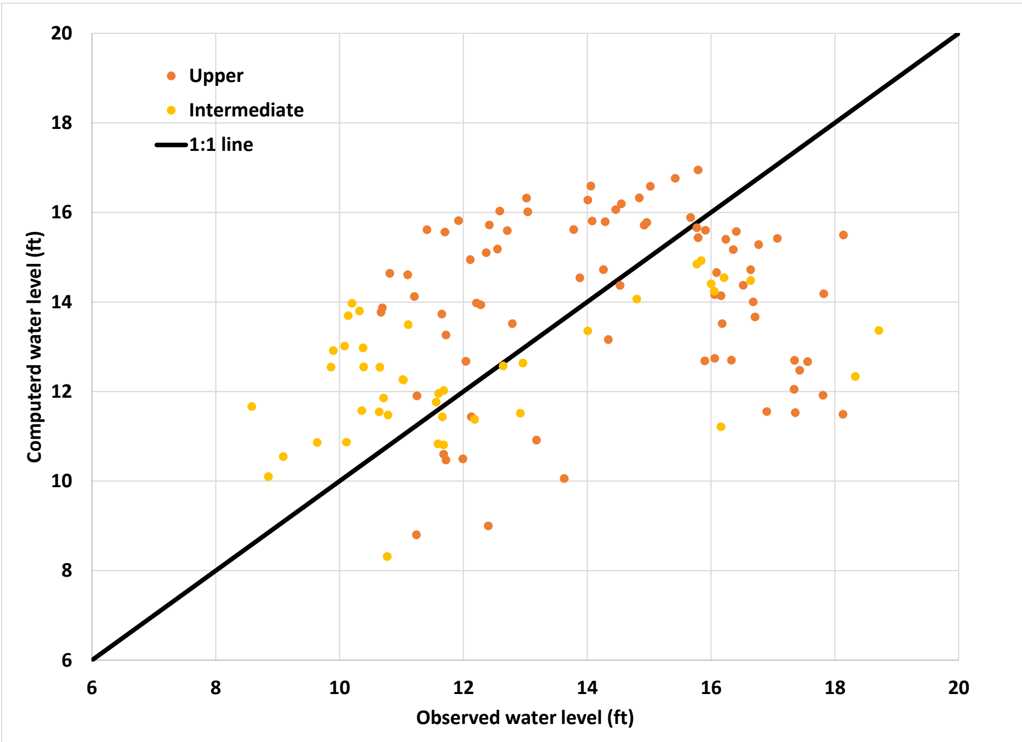


Figure 4. Comparison of observed and calibrated water levels.

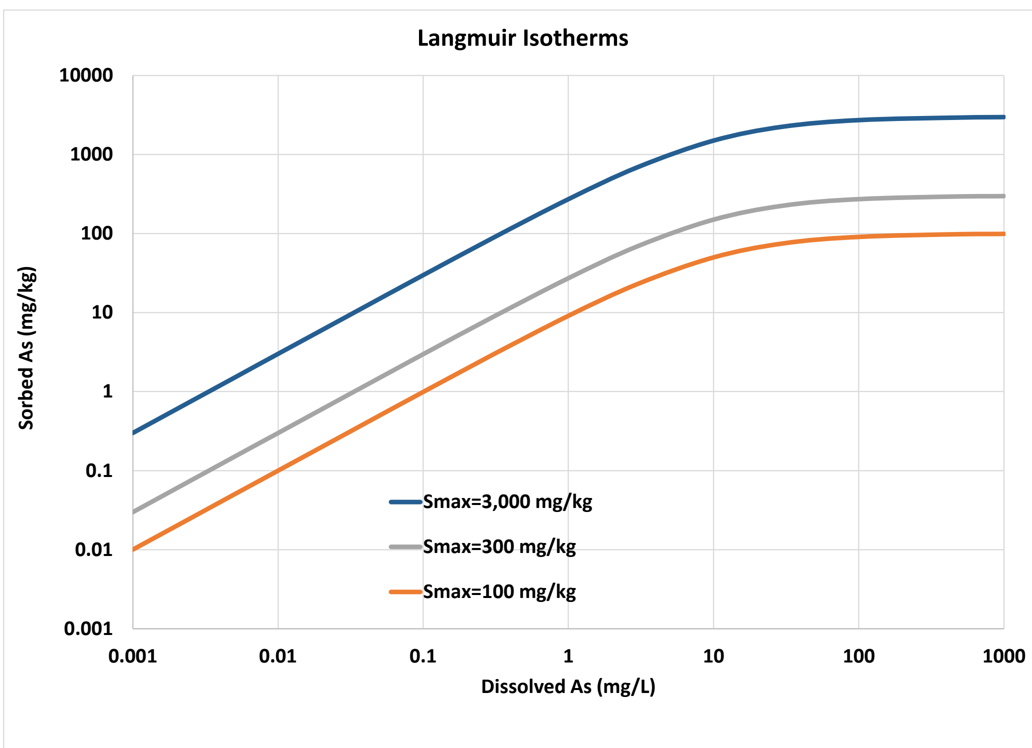


Figure 5. Langmuir isotherms for the range of parameters used in the transport model. The equilibrium constant, Kl, is assigned a value of 10 mg/L for all isotherms.

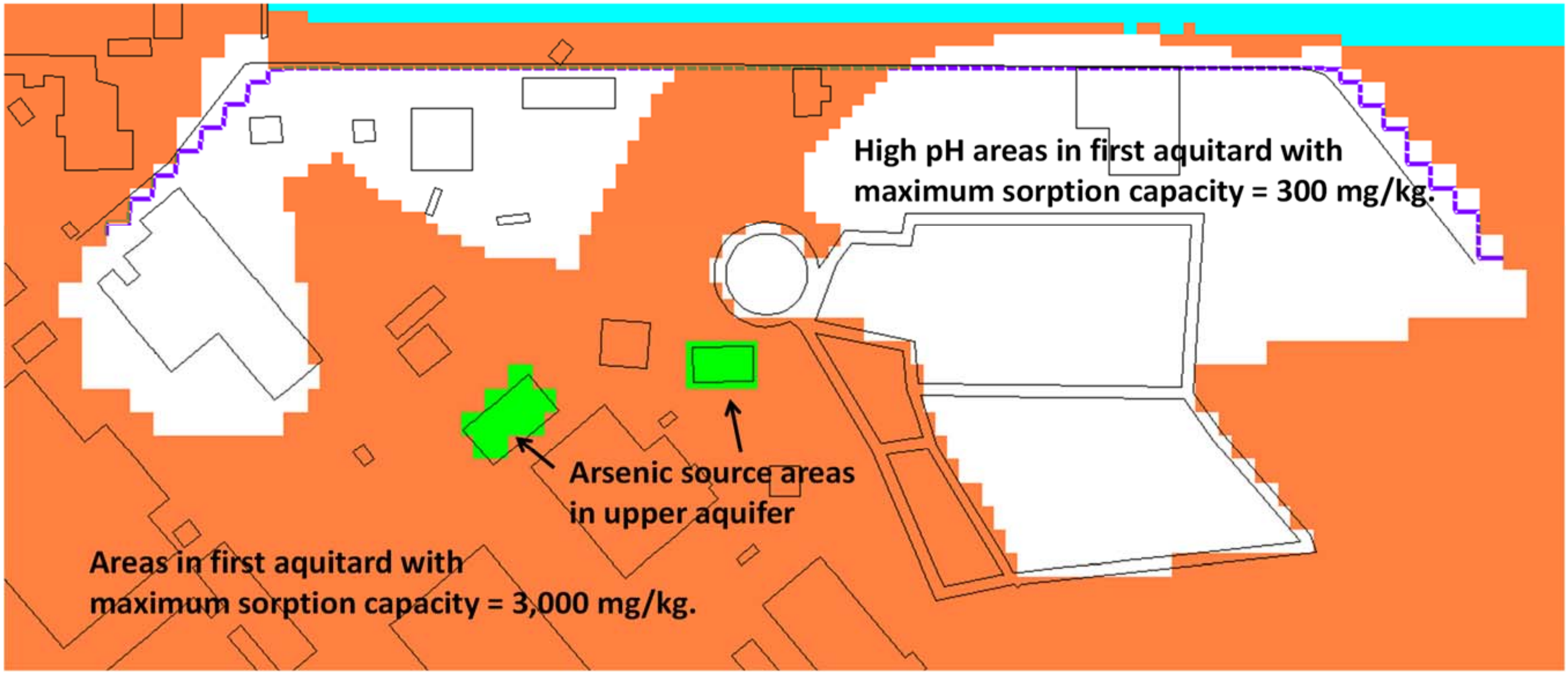


Figure 6. Arsenic source areas in the upper aquifer and maximum sorption capacity values in the first aquitard.

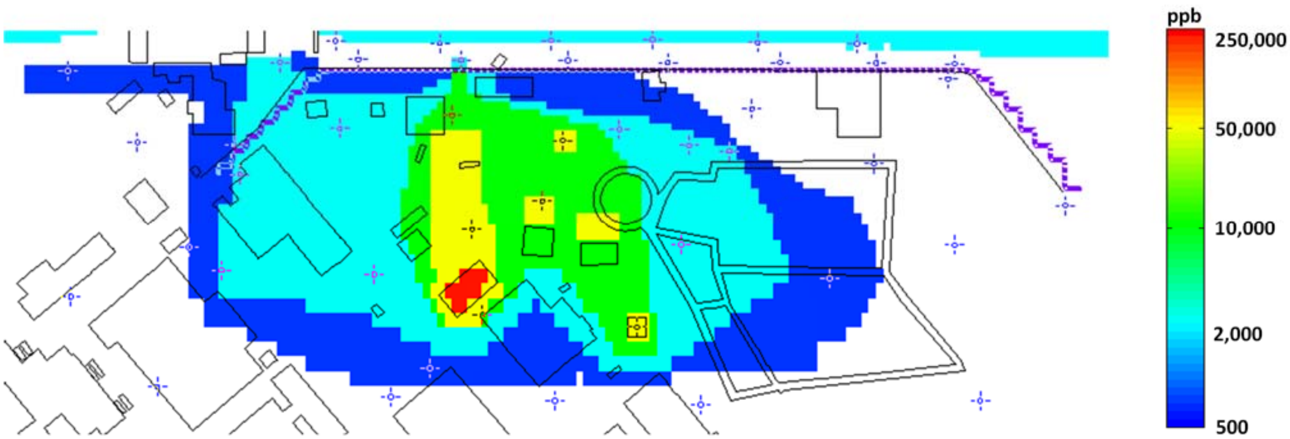


Figure 7. Initial arsenic concentrations for model layers 1 and 2.

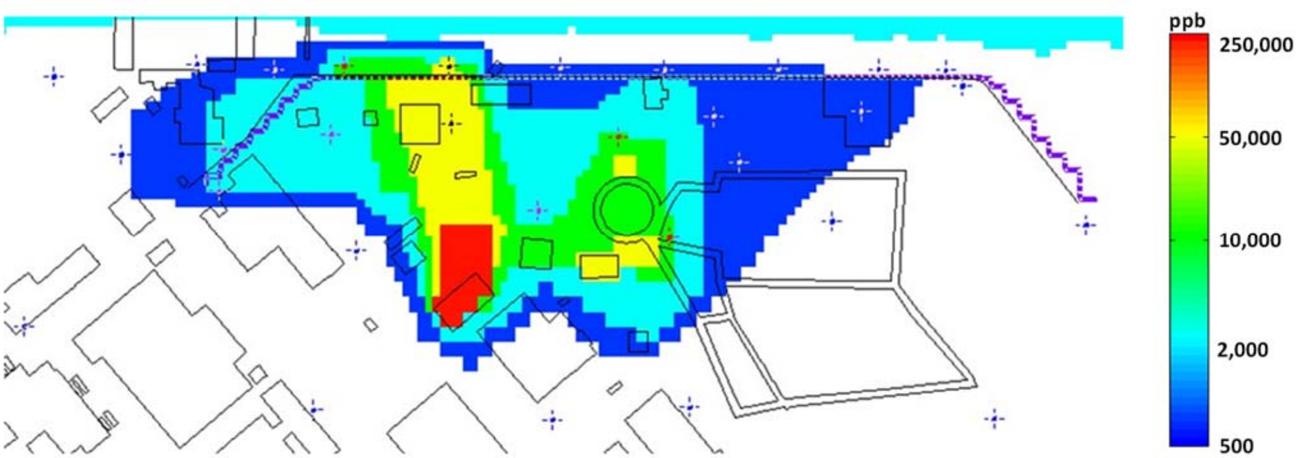


Figure 8. Initial arsenic concentrations for model layers 3 through 7.

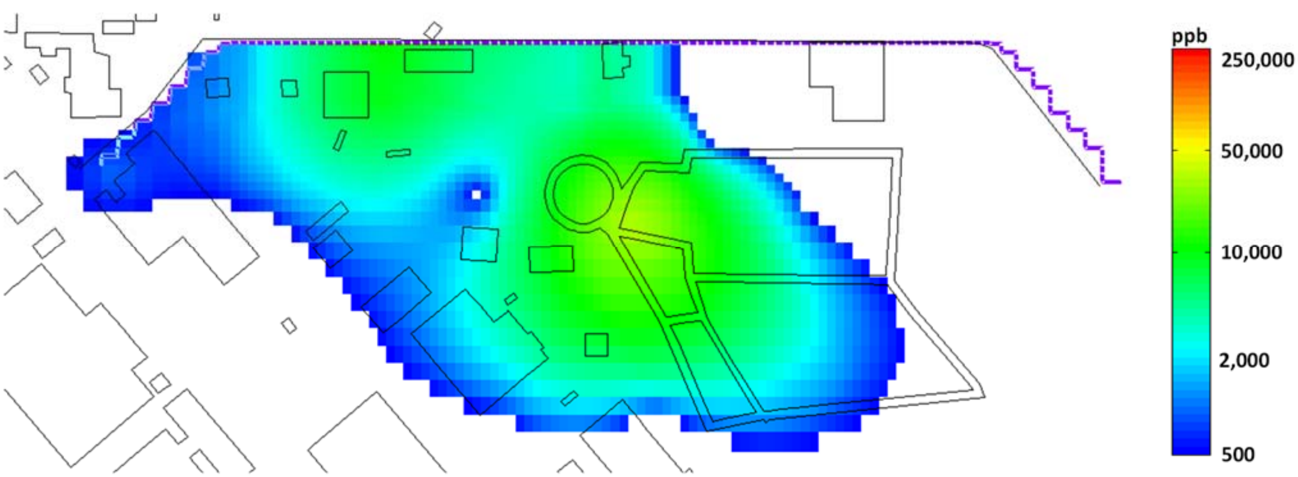


Figure 9. Initial arsenic concentrations for model layer 8.

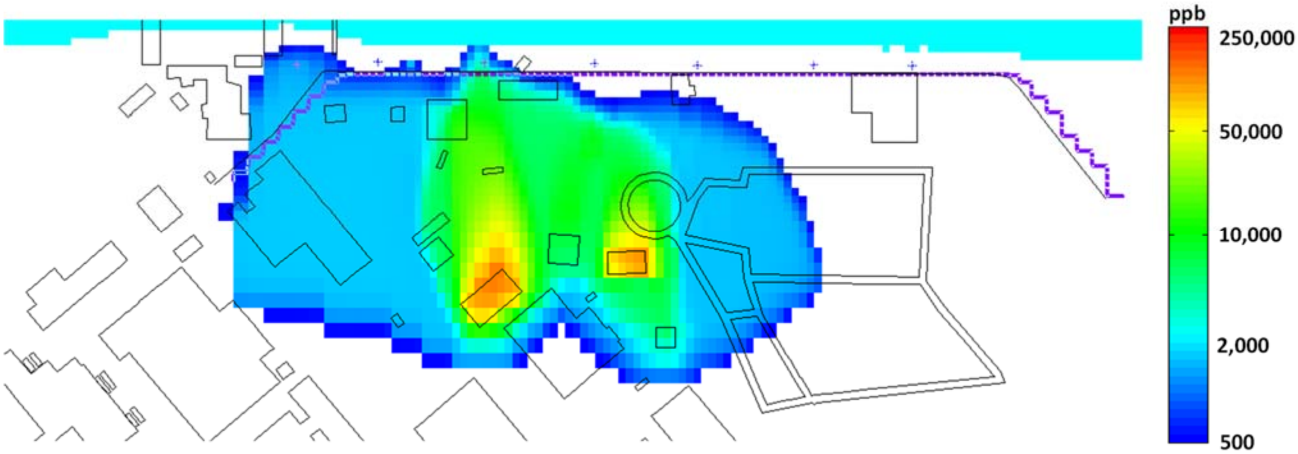


Figure 10. Calculated arsenic concentrations for 2017 in upper aquifer.

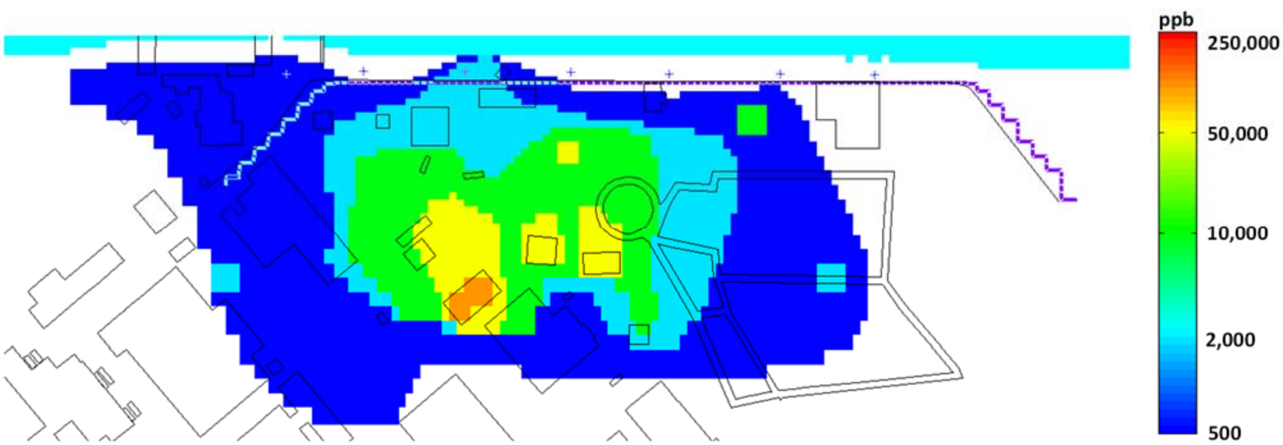


Figure 11. Observed arsenic concentrations for 2017 in upper aquifer.

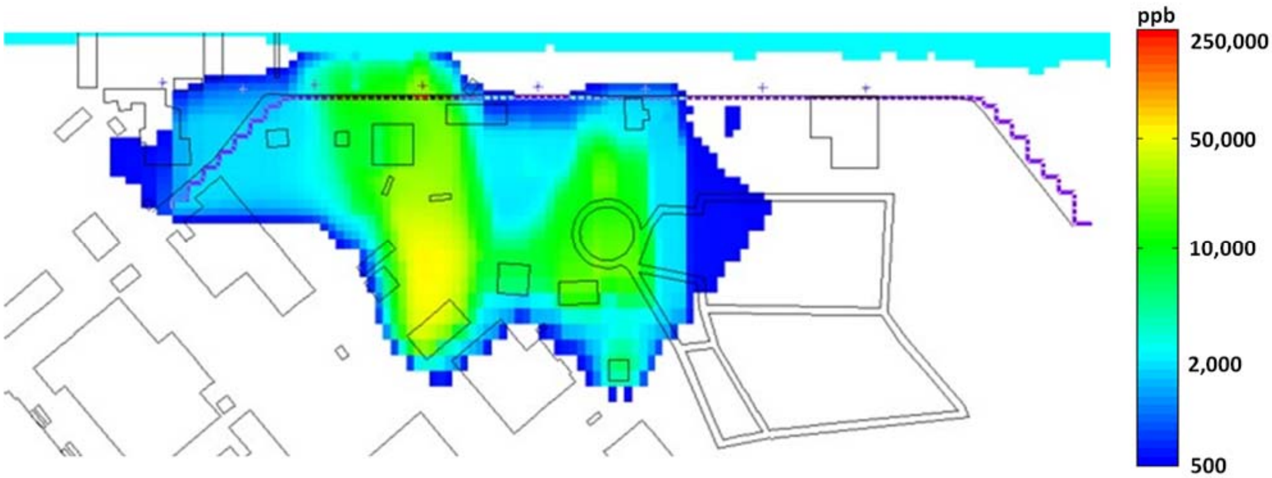


Figure 12. Calculated arsenic concentrations for 2017 in intermediate aquifer.

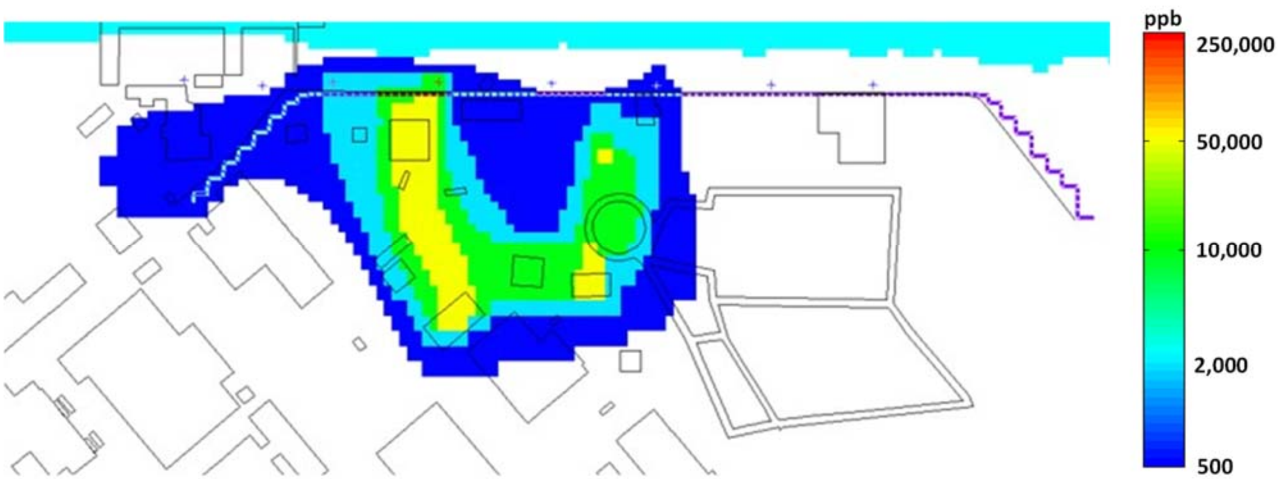


Figure 13. Observed arsenic concentrations for 2017 in intermediate aquifer.

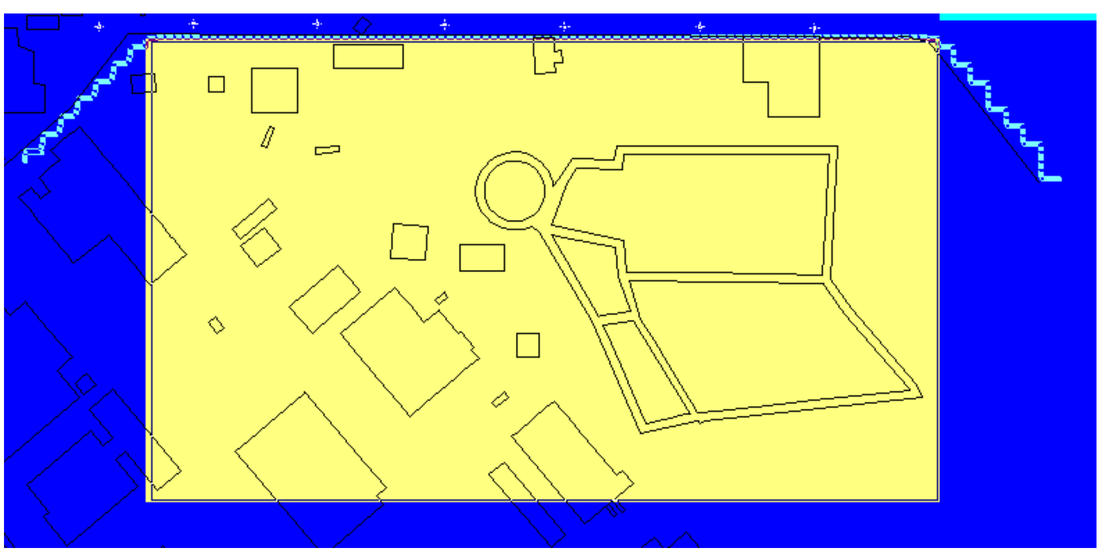


Figure 14. Area included in water balances described in Section 4.1.

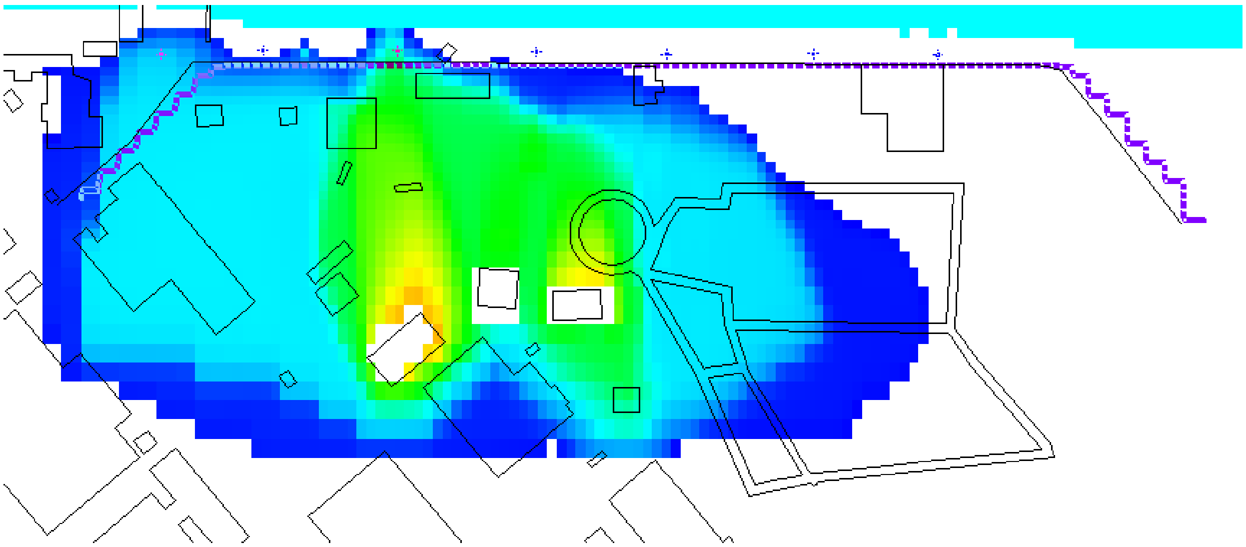


Figure 15. Locations where initial soil and groundwater concentrations are set to zero in the focused UA soil removal component. The zero-concentration locations are shown in white.

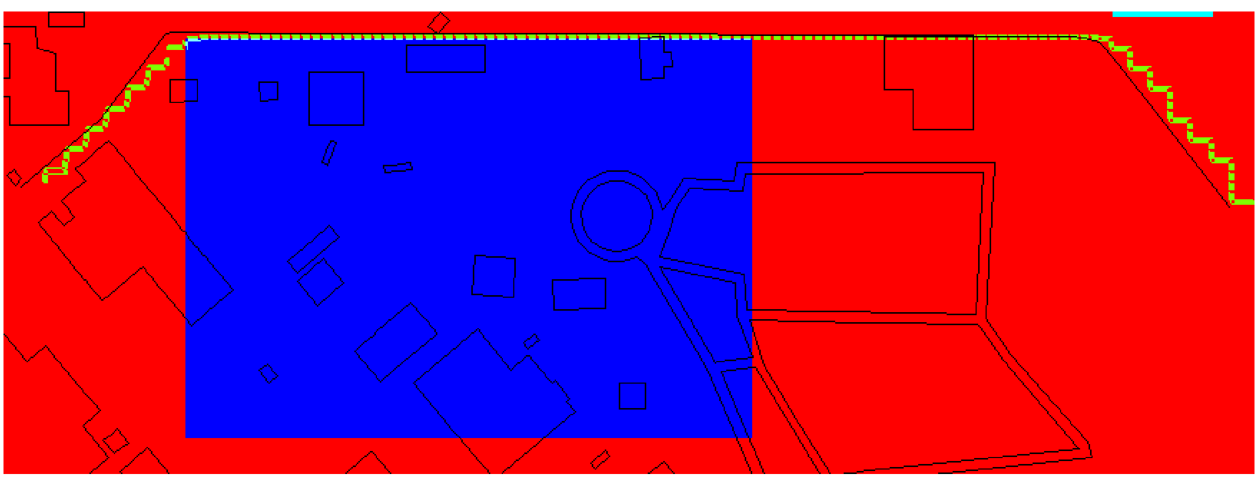


Figure 16. Location of the low-permeability surface cap. The recharge rate is reduced to 1% of the value used in the base-case simulation for the area shown in blue.

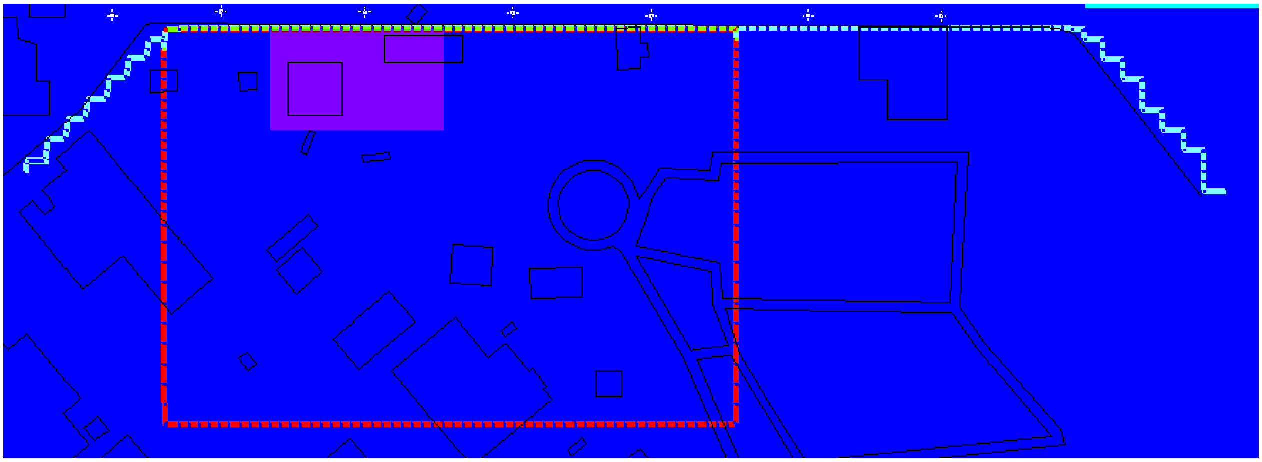
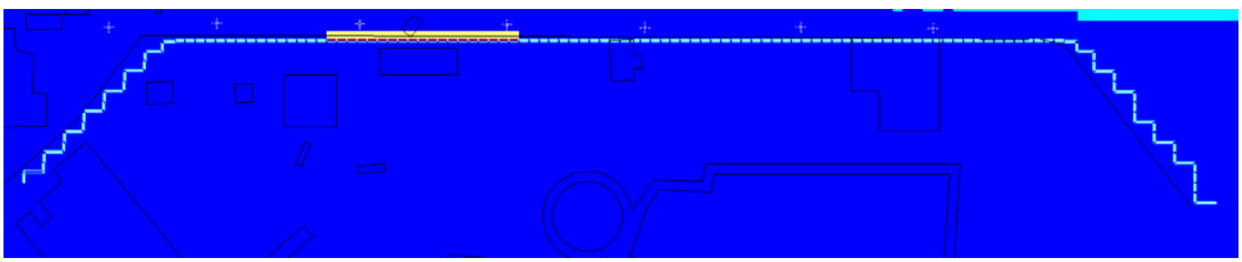
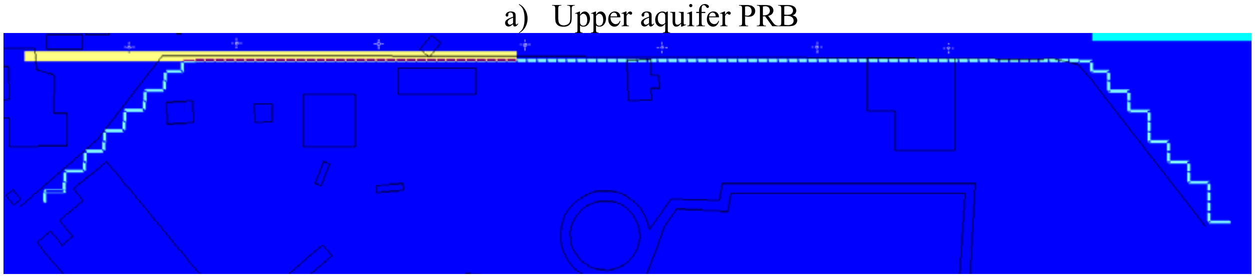


Figure 17. Locations of the focused ISS treatment zone upgradient of 124+00-2 and the vertical barrier walls. The ISS area is shown in purple and the vertical barrier walls are shown as red dashed lines.



a) Upper aquifer PRB



b) Intermediate aquifer PRB

Figure 18. Locations of permeable reactive barriers (PRBs). PRB areas are shown in yellow.

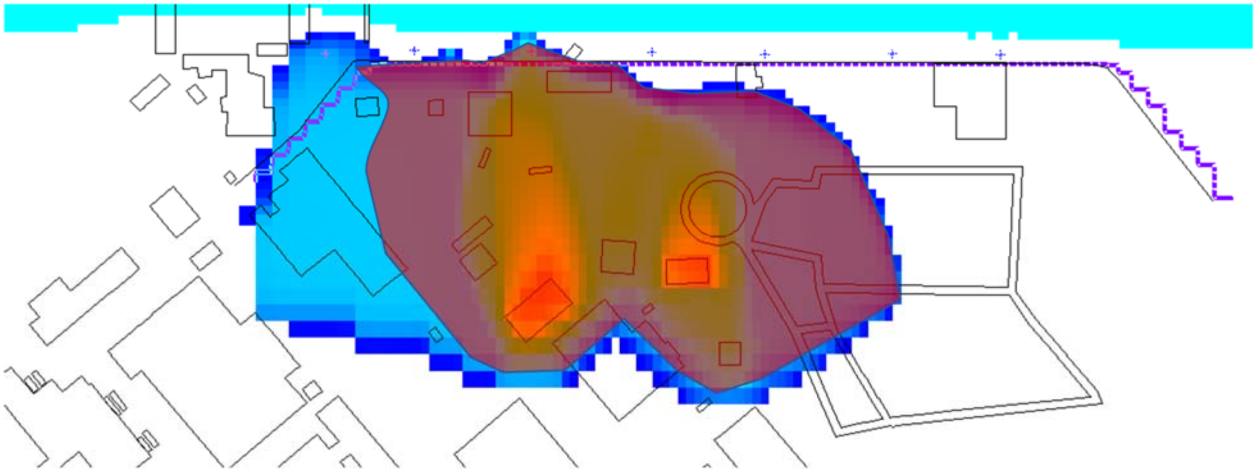


Figure 19. Location of area included in the component with excavation to 88 mg/kg. Excavation area is shown in red overlay.

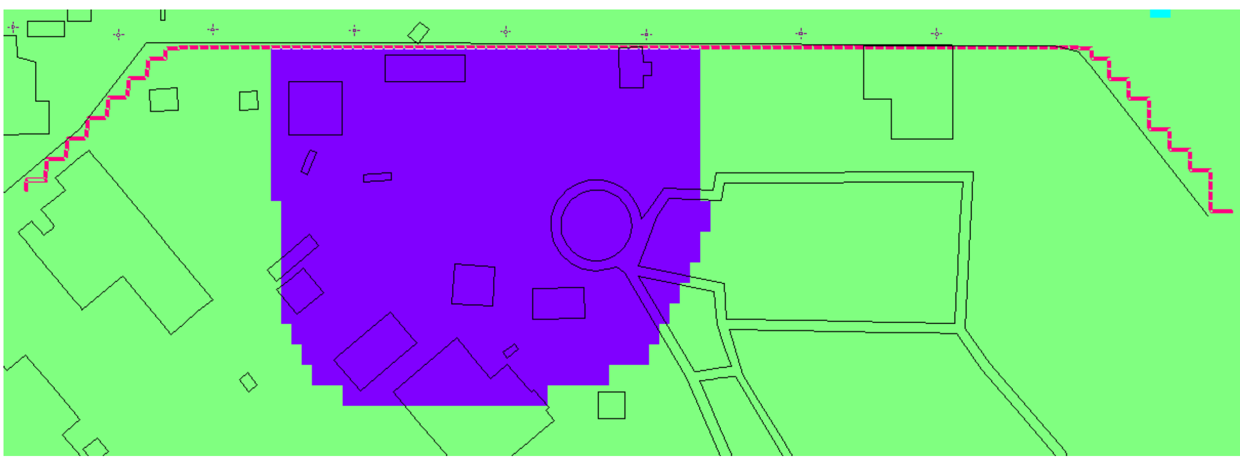


Figure 20. Location of area included in the extensive ISS component. The ISS area is shown in purple.

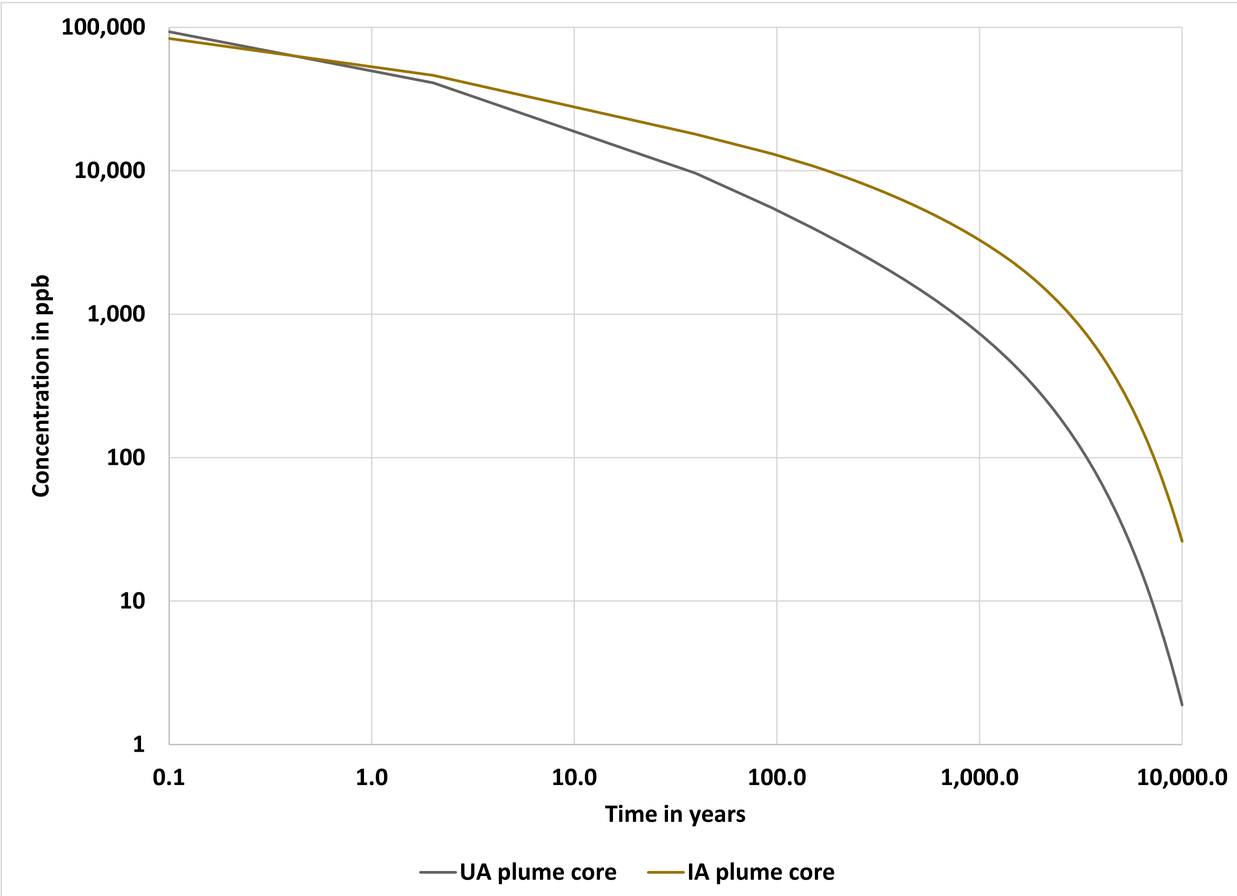


Figure 21. Calculated concentrations in the plume core for the upper and intermediate aquifers.

Appendix A

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Table 1: Attenuation Factors for Predicting Future Dissolved Arsenic Concentrations at Shoreline POC Locations Based on Vertical Shoreline MW Model Results

Category	Vertical Shoreline MW Segment Info						Angled Shoreline MW/PPS Segment Info						Pore Water NSDS Segment Info						Attenuation Factors	
	Segment ID [1]	Segment Distance (feet)	Sample Location within Segment	Dissolved Arsenic Conc. (ug/L)	Segment Distance * Conc. (feet*ug/L)	Segment Weighted Conc. [2] (ug/L)	Segment ID [1]	Segment Distance (feet)	Sample Location within Segment	Dissolved Arsenic Conc. (ug/L)	Segment Distance * Conc. (feet*ug/L)	Segment Weighted Conc. [2] (ug/L)	Segment ID [1]	Segment Distance (feet)	Sample Location within Segment	Dissolved Arsenic Conc. (ug/L)	Segment Distance * Conc. (feet*ug/L)	Segment Weighted Conc. [2] (ug/L)	Vertical Shoreline MWs to Angled Shoreline MWs/PPSs [3]	Vertical Shoreline MWs to Pore Water NSDSs [4]
2018 Upper Aquifer Results	1A	165	5B1-1R	1,360	224,400								3A	128	119+25-0-DS	2.8	357			
	1B	202	121+80-1	1,850	373,700		2A	458	122+60-0	9.7	4,433		3B	165	120+75-0-DS	4.2	693			
	1C	120	122+60-1	26	3,132								3C	165	122+60-0-DS	13	2,129			
	1D	147	124+00-1	1,100	161,700	742	2B	150	124+00-0	8.1	1,217	25	3D	150	124+00-0-DS	5.0	744	15	**30**	**49**
	1E	147	125+50-1	81	11,863		2C	142	125+50-0	101	14,342		3E	142	125+50-0-DS	44	6,205			
	1F	150	126+90-1	95	14,280		2D	142	126+90-0	30	4,217		3F	142	126+90-0-DS	31	4,388			
	1G	135	128+30-1	16	2,120		2E	165	128+30-0	13	2,178		3G	165	128+30-0-DS	8.8	1,454			
2017 Upper Aquifer Results	1A	165	5B1-1R	1,040	171,600															
	1B	202	121+80-1	735	148,470		2A	458	122+60-0	9.7	4,447		3A-3C	458	122+60-0-DS	5.6	2,579			
	1C	120	122+60-1	15	1,800															
	1D	147	124+00-1	3,130	460,110	750	2B	150	124+00-0	7.7	1,148	21	3D	150	124+00-0-DS	4.6	683	12	36	65
	1E	147	125+50-1	83	12,142		2C	142	125+50-0	75	10,607		3E	142	125+50-0-DS	39	5,595			
	1F	150	126+90-1	30	4,515		2D	142	126+90-0	25	3,522		3F	142	126+90-0-DS	20	2,868			
	1G	135	128+30-1	7.9	1,071		2E	165	128+30-0	14	2,310		3G	165	128+30-0-DS	3.4	559			
2018 Intermediate Aquifer Results	4A	120	5B1-2R	0.88	106		5A	130	119+25-ST1	9.9	1,290		6A	130	119+25-ST1-DS	33	4,316			
	4B	142	120+75-2	139	19,738		5B	215	120+75-ST1	48	10,213		6B	215	120+75-ST1-DS	32	6,880			
	4C	105	121+80-2	1,560	163,800															
	4D	108	122+60-2	2,850	307,800	11,102	5C	172	123+25-ST1	189	32,508	60	6C	172	123+25-ST1-DS	547	93,998	118	185	**94**
	4E	142	124+00-2	76,200	10,820,400															
	4F	150	125+50-2	706	105,900		5D	180	125+00-ST1	21	3,726		6D	180	125+00-ST1-DS	44	7,830			
	4G	146	126+90-2	909	132,714		5E	177	126+80-ST1	19	3,292		6E	177	126+80-ST1-DS	15	2,690			
	4H	135	128+30-2	625	84,375		5F	150	128+50-ST1	70	10,478		6F	150	128+50-ST1-DS	35	5,250			
2017 Intermediate Aquifer Results	4A	120	5B1-2R	0.80	96		5A	130	119+25-ST1	7.9	1,023									
	4B	142	120+75-2	65	9,216		5B	215	120+75-ST1	279	59,985		6A'	417	120+75-ST1-DS	3.2	1,322			
	4C	105	121+80-2	82	8,579															
	4D	108	122+60-2	3,340	360,720	5,896	5C	172	123+25-ST1	155	26,660	90						4.9	**65**	1,194
	4E	142	124+00-2	39,200	5,566,400															
	4F	150	125+50-2	375	56,250		5D	180	125+00-ST1	21	3,834		6B'	390	125+00-ST1-DS	6.4	2,488			
	4G	146	126+90-2	1,130	164,980		5E	177	126+80-ST1	2.3	409									
	4H	135	128+30-2	92	12,380		5F	150	128+50-ST1	3.1	465		6C'	252	128+50-ST1-DS	5.6	1,419			

Notes:

Conc.: concentration; MW: monitoring well; NSDS: nylon-screen diffusion sampler; POC: point of compliance; PPS: pushpoint sampler

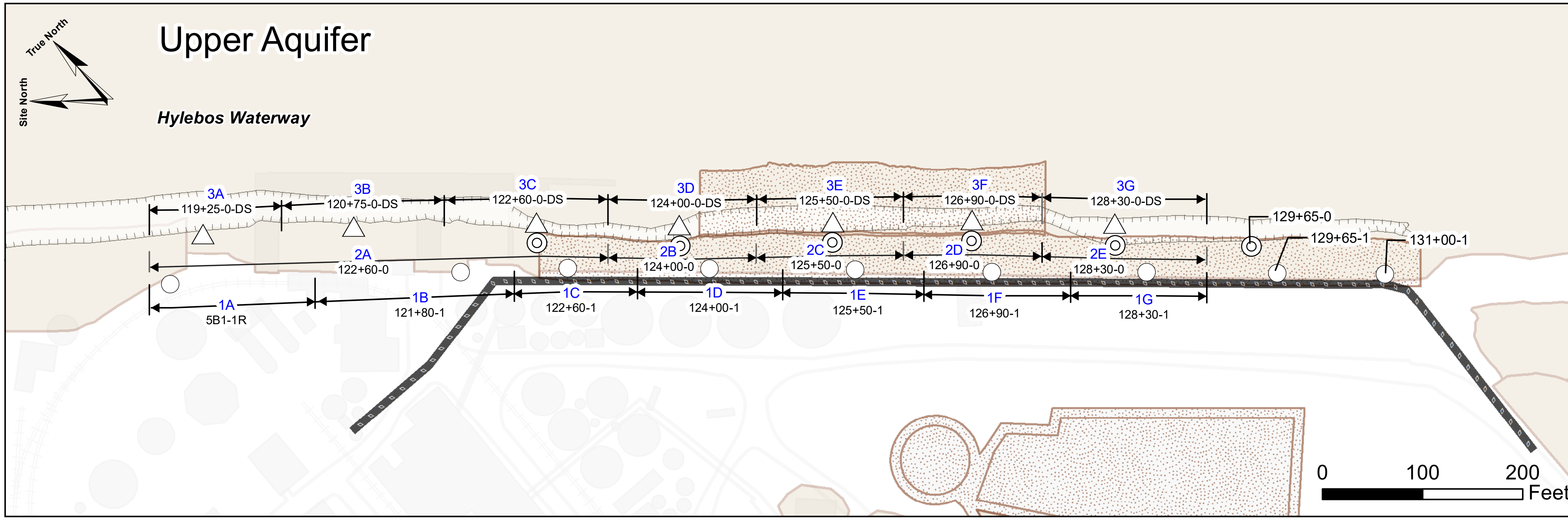
The attenuation factors in bold red font (i.e., the most conservative attenuation factors) were used to predict future dissolved arsenic concentrations at shoreline POC locations based on vertical shoreline MW model results.

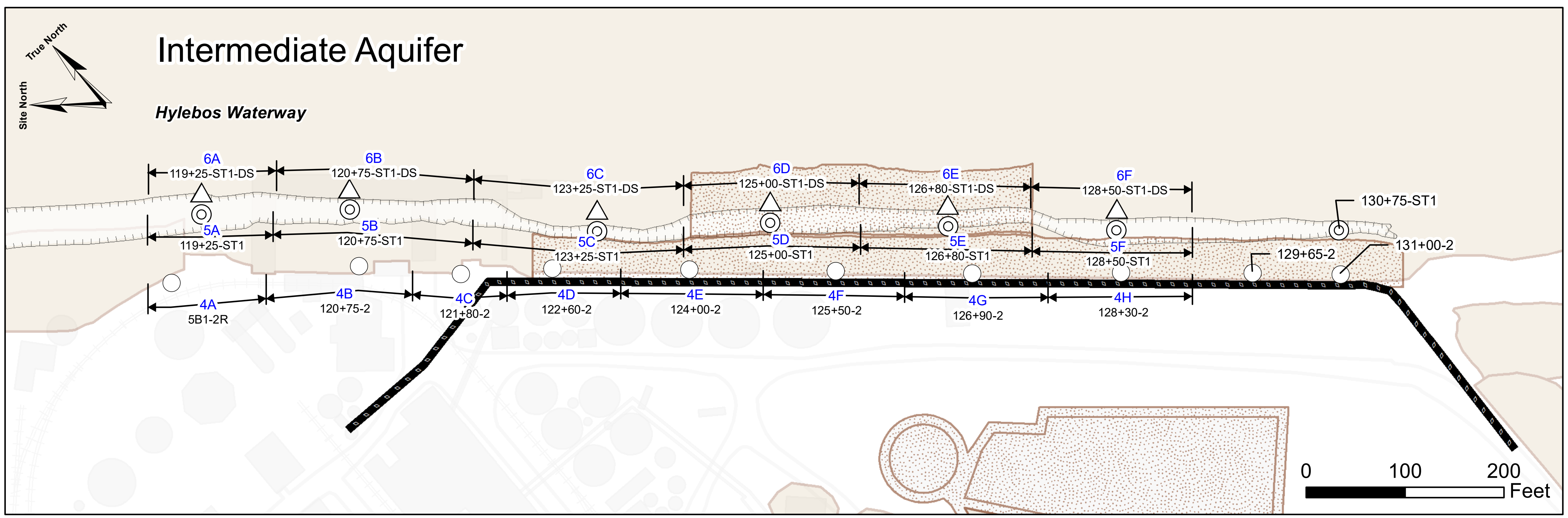
(1) See Figures 1 and 2 for segment locations and sample locations within each segment.

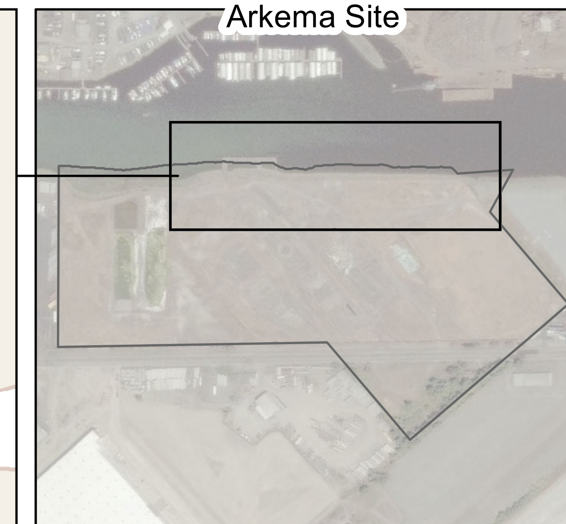
(2) The segment weighted concentration equals the sum of all segment distance times concentration in the previous column divided by the sum of the segment distances.

(3) The Vertical Shoreline MWs to Angled Shoreline MWs/PPSs attenuation factor equals the segment weighted concentration for vertical shoreline MWs divided by the segment weighted concentration for Angled Shoreline MWs/PPSs.

(4) The Vertical Shoreline MWs to Angled Shoreline MWs/PPSs attenuation factor equals the segment weighted concentration for vertical shoreline MWs divided by the segment weighted concentration for pore water NSDSs.







Legend

Sample Type
- Monitoring Well
- Upper Aquifer Angled Shoreline Monitoring Well / Intermediate Aquifer PPS
- Upper / Intermediate Aquifer Pore Water NSDS

Completed Remedial Actions
- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features
- Historical Infrastructure
- Intermediate Aquifer Outcrop
- RI/FS Site Boundary

Notes:
J: Estimated concentration
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-Some pore water and surface water samples were co-located. The symbols for these samples were adjusted slightly for visibility.

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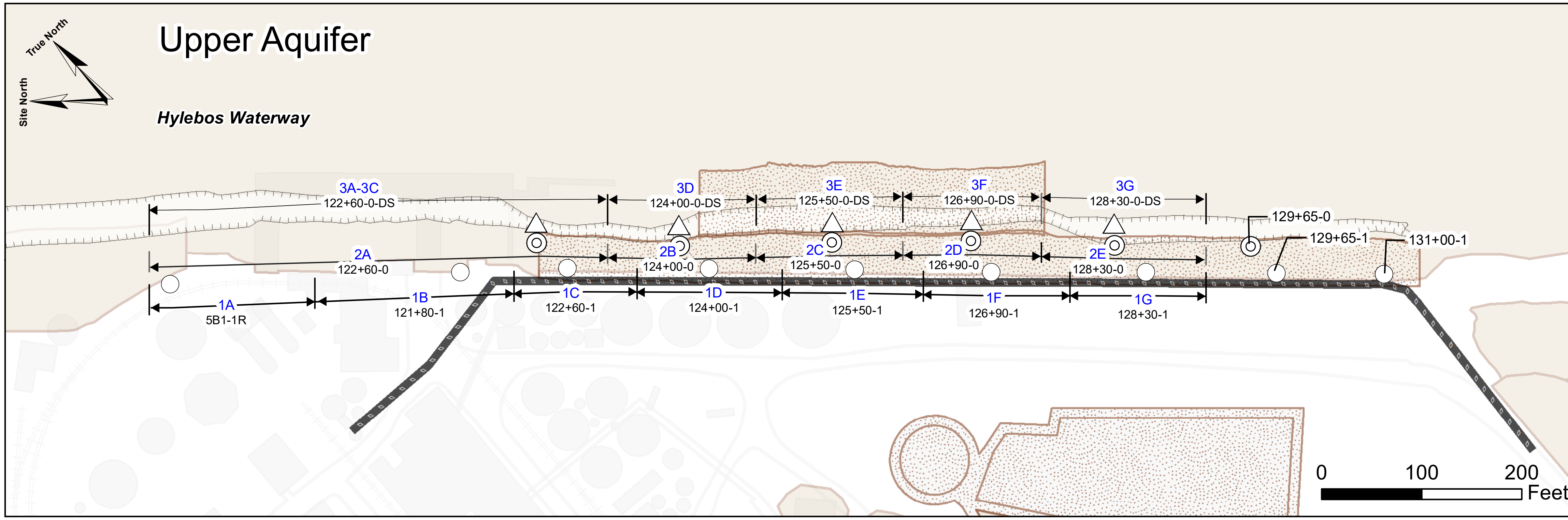
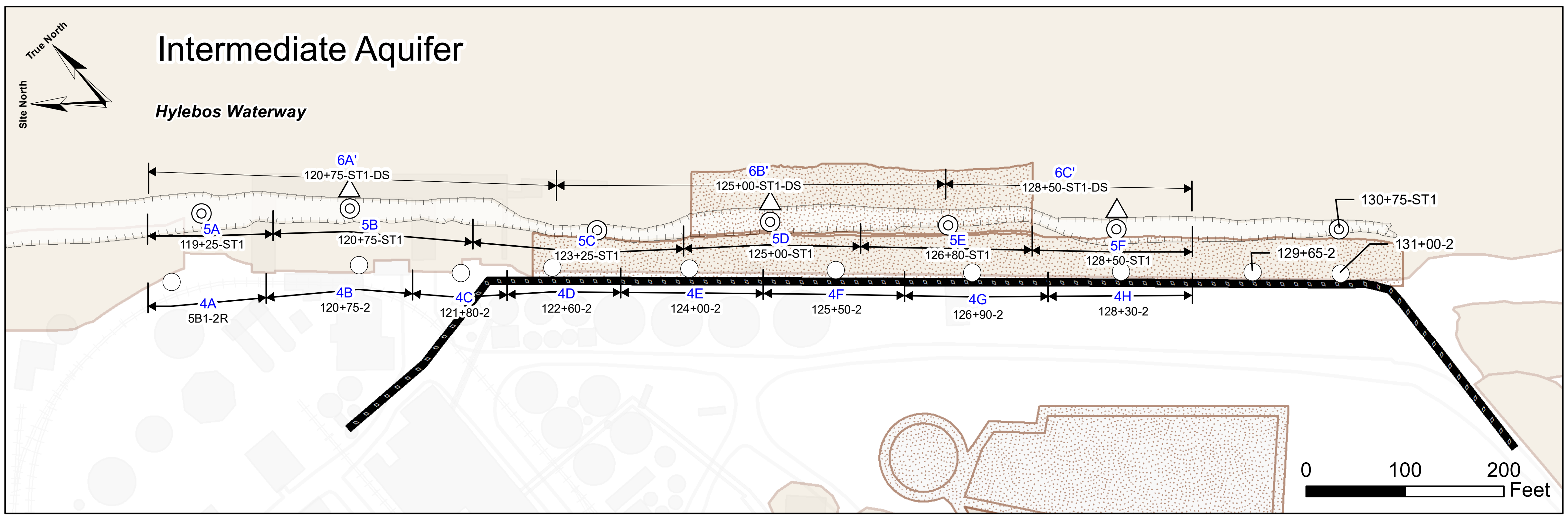
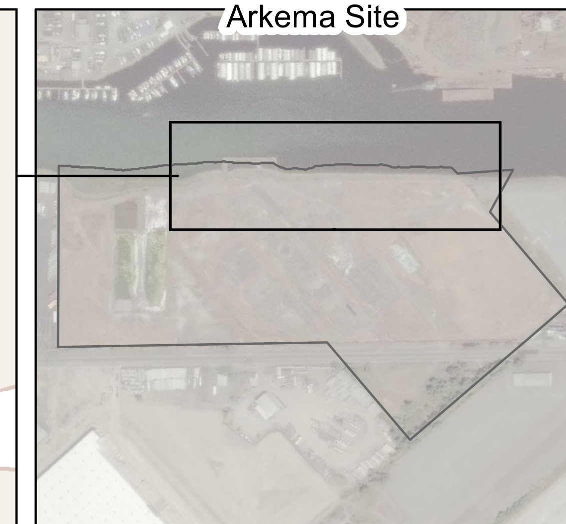
Segments Used to Calculate 2018 Shoreline Attenuation Factors
FS Report
Former Arkema Manufacturing Site

Figure 1







Legend

Sample Type

- Monitoring Well
- Upper Aquifer Angled Shoreline Monitoring Well / Intermediate Aquifer PPS
- Upper / Intermediate Aquifer Pore Water NSDS

Completed Remedial Actions

- Soil / Sediment Removal
- Soil / Sediment Cap
- Sheet Pile Wall

Other Features

- Historical Infrastructure
- Intermediate Aquifer Outcrop
- RI/FS Site Boundary

Notes:
J: Estimated concentration
-Geospatial data were provided by other consultants or georeferenced from reports by other consultants. All locations are approximate.
-Some pore water and surface water samples were co-located. The symbols for these samples were adjusted slightly for visibility.

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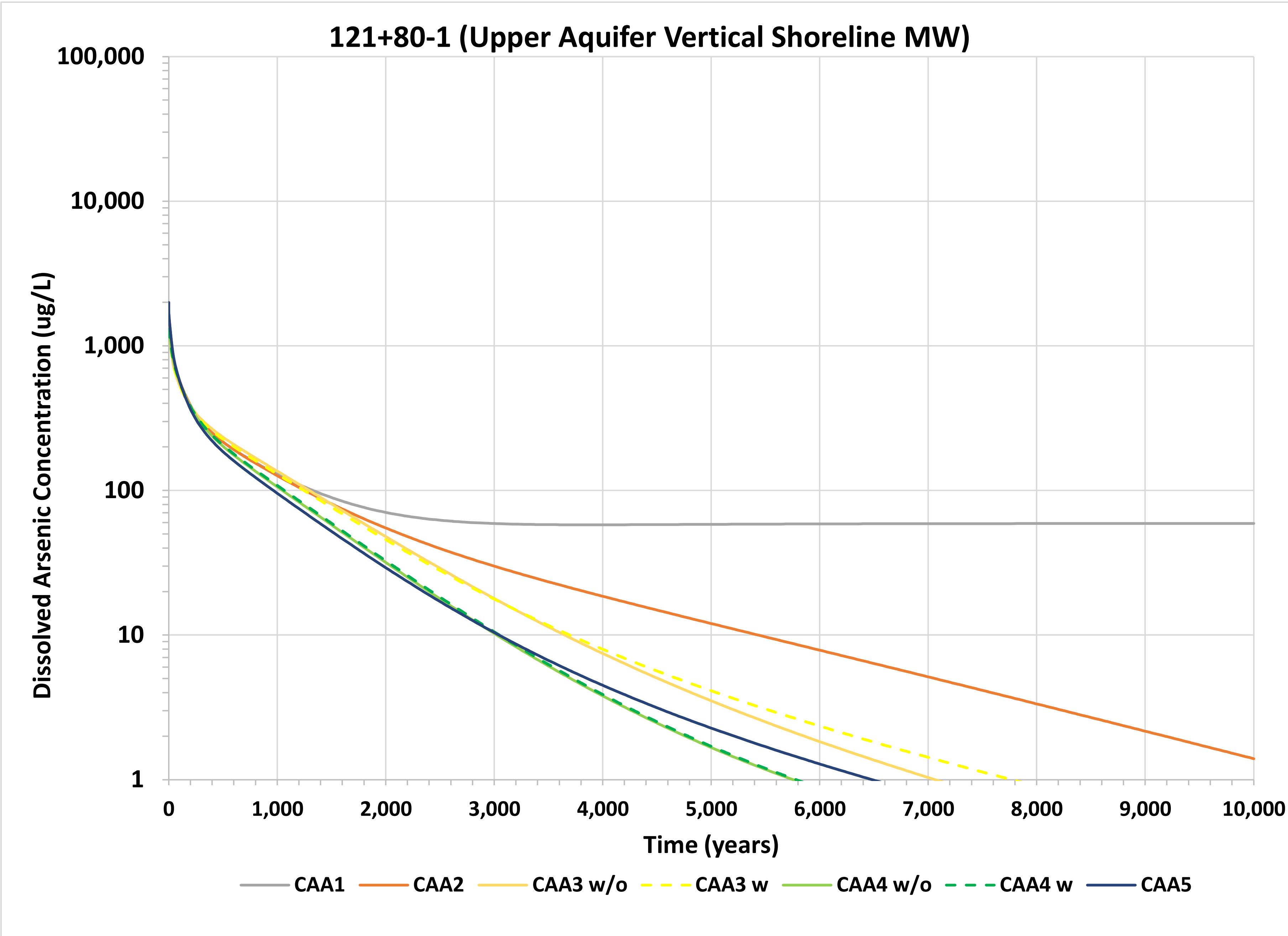
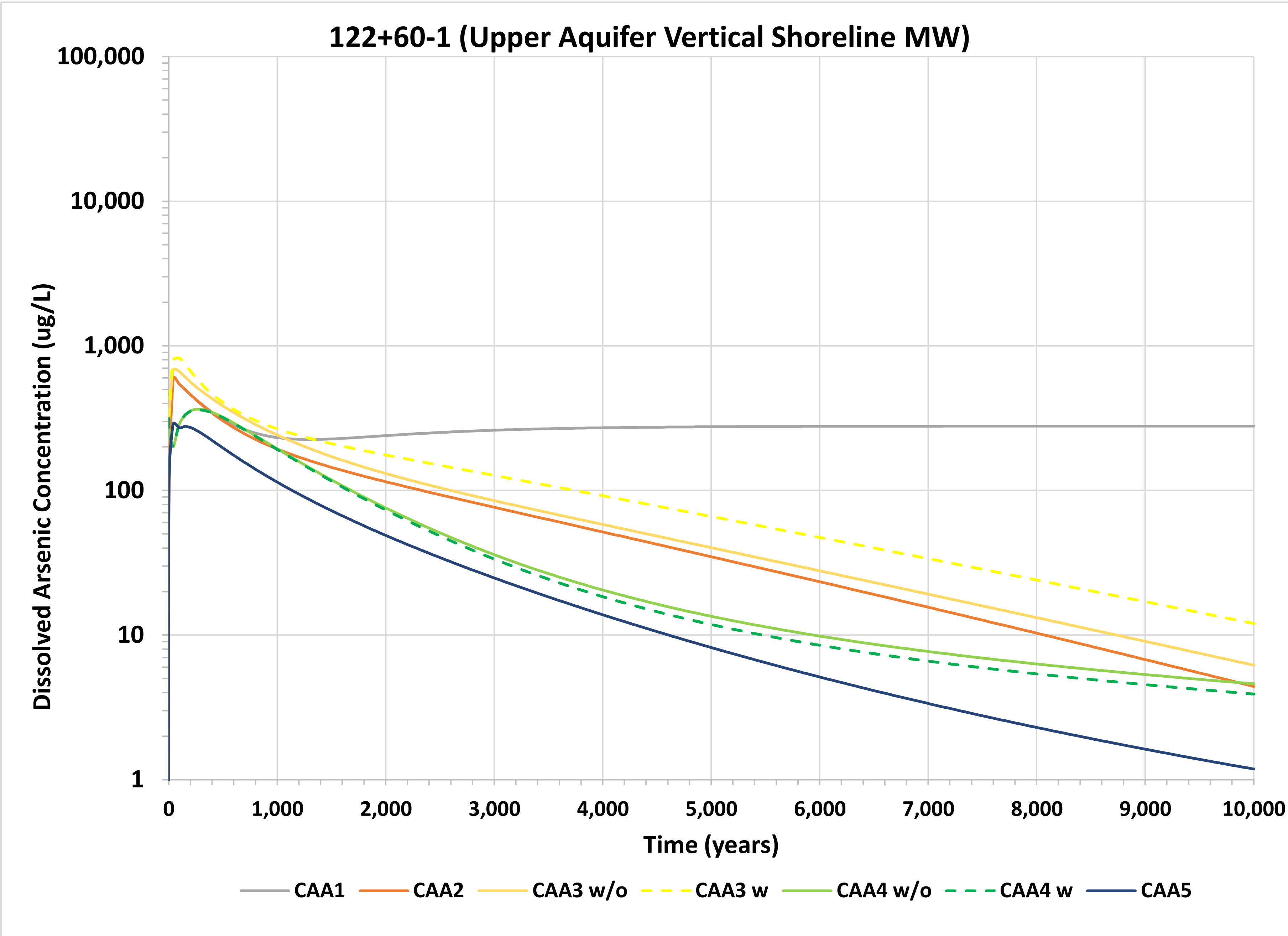
Segments Used to Calculate 2017 Shoreline Attenuation Factors
FS Report
Former Arkema Manufacturing Site

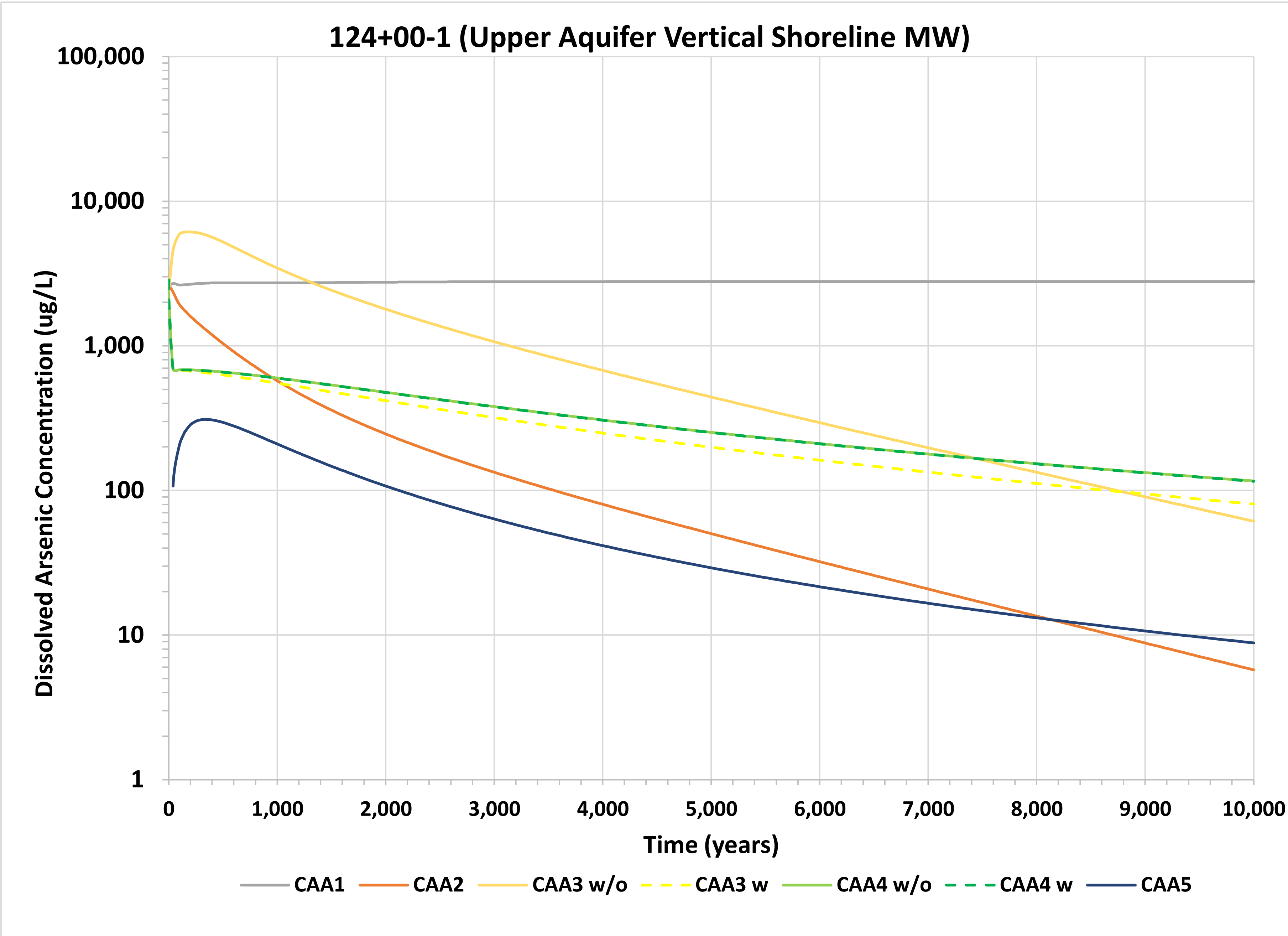
Figure 2

Appendix B

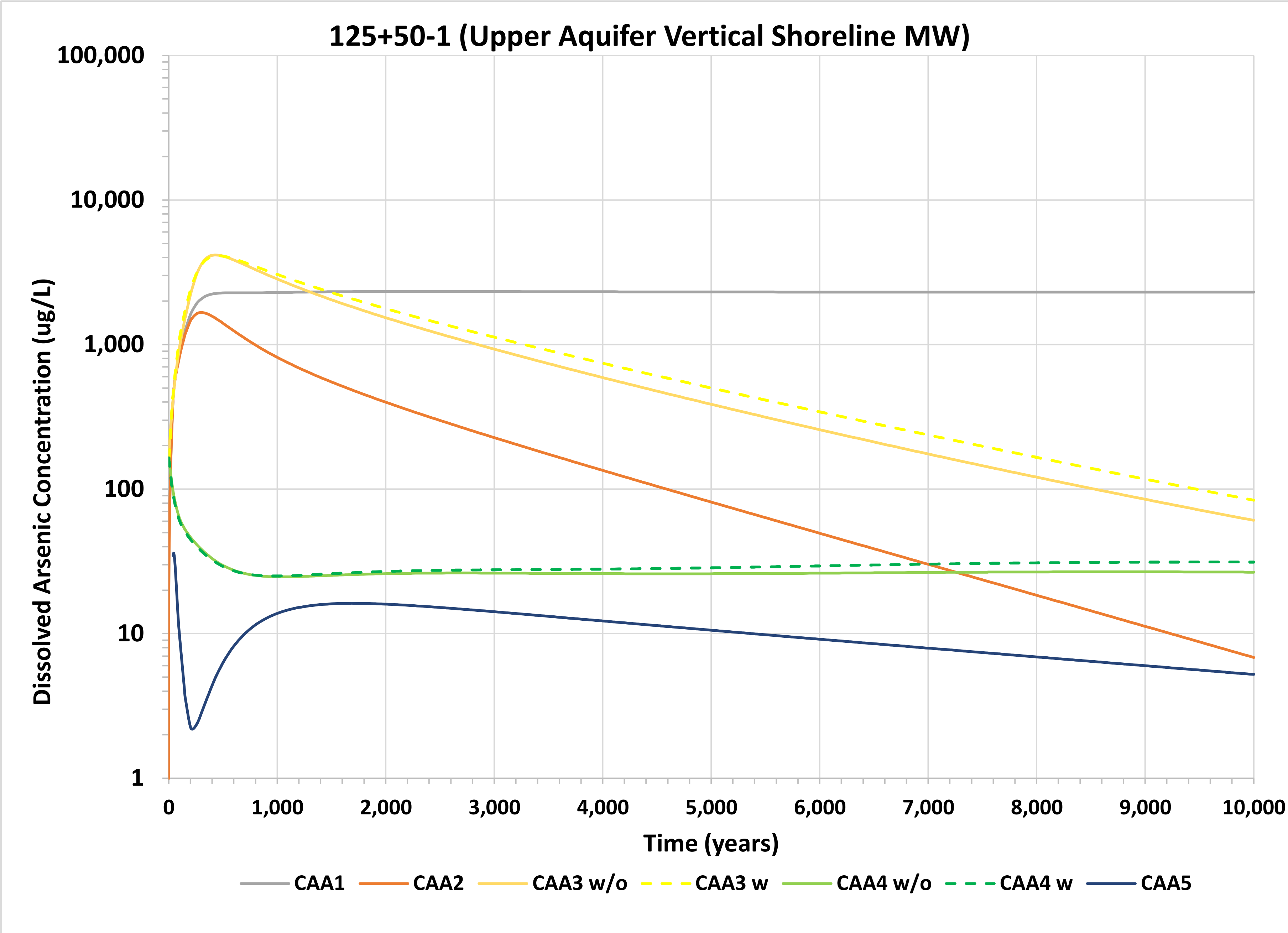


121+80-1 (Upper Aquifer Vertical Shoreline MW)
100,000
10,000
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

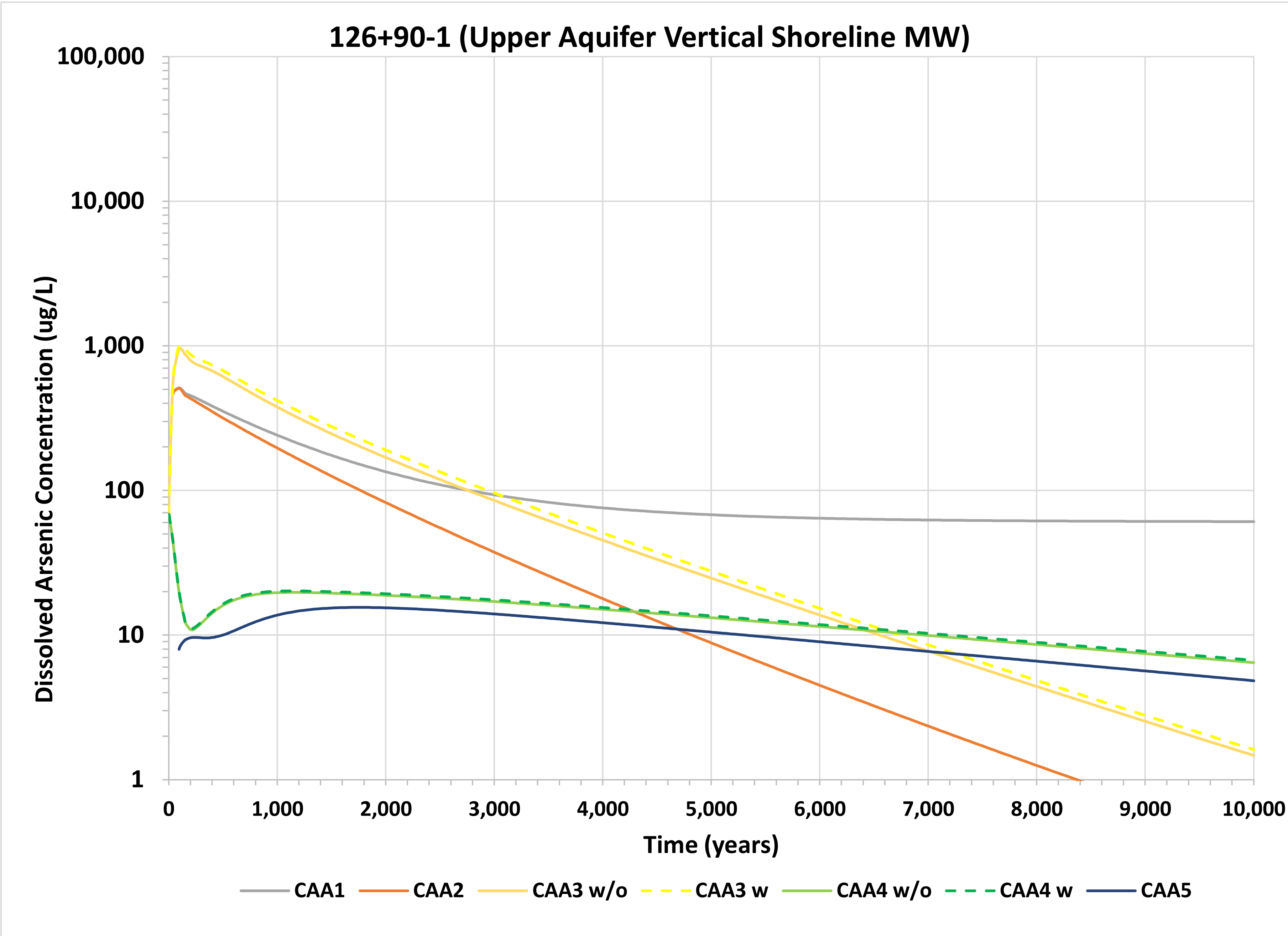

122+60-1 (Upper Aquifer Vertical Shoreline MW)
Dissolved Arsenic Concentration (ug/L)
100,000
10,000
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

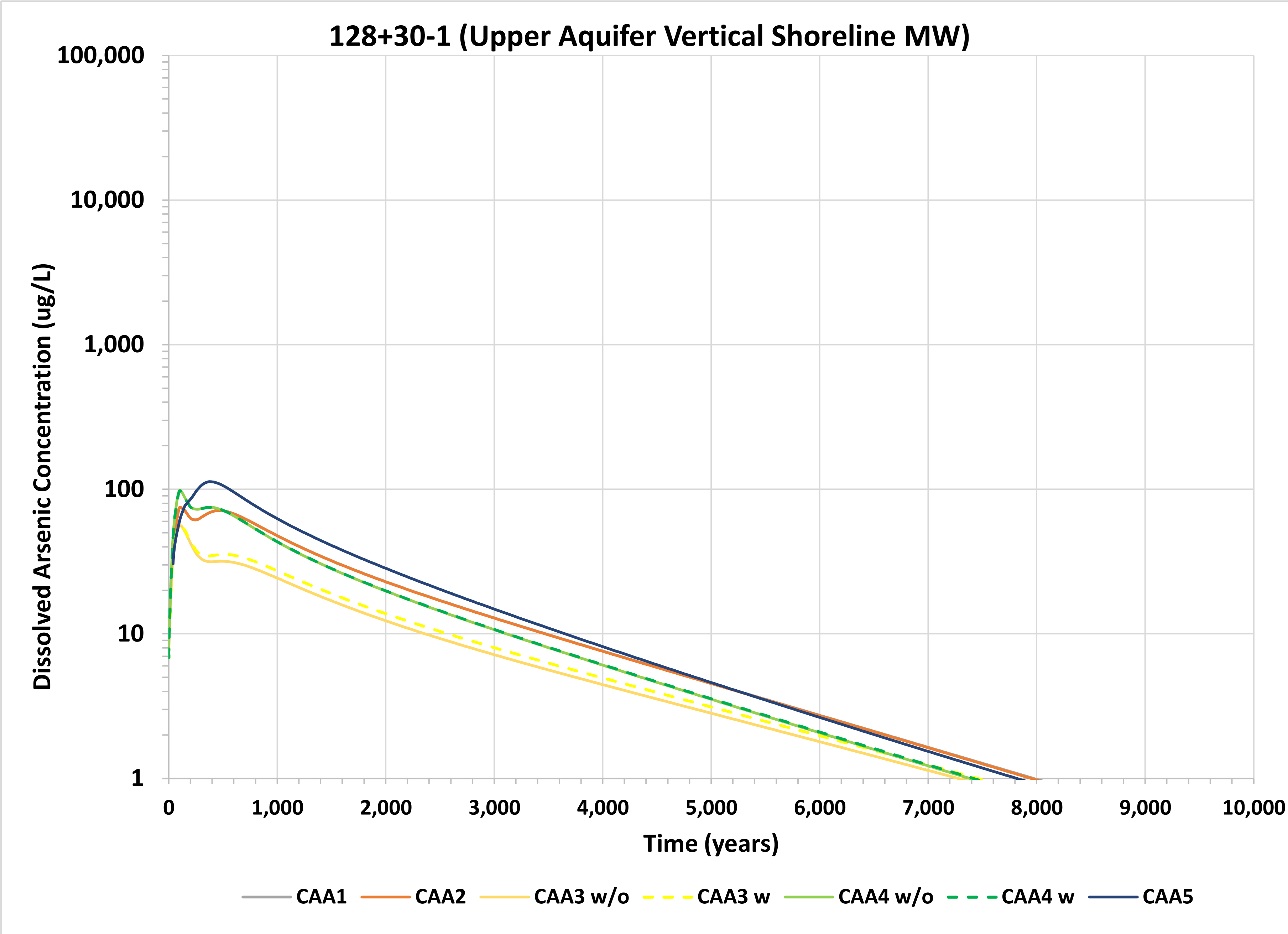


124+00-1 (Upper Aquifer Vertical Shoreline MW)
Dissolved Arsenic Concentration (ug/L)
100,000
10,000
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

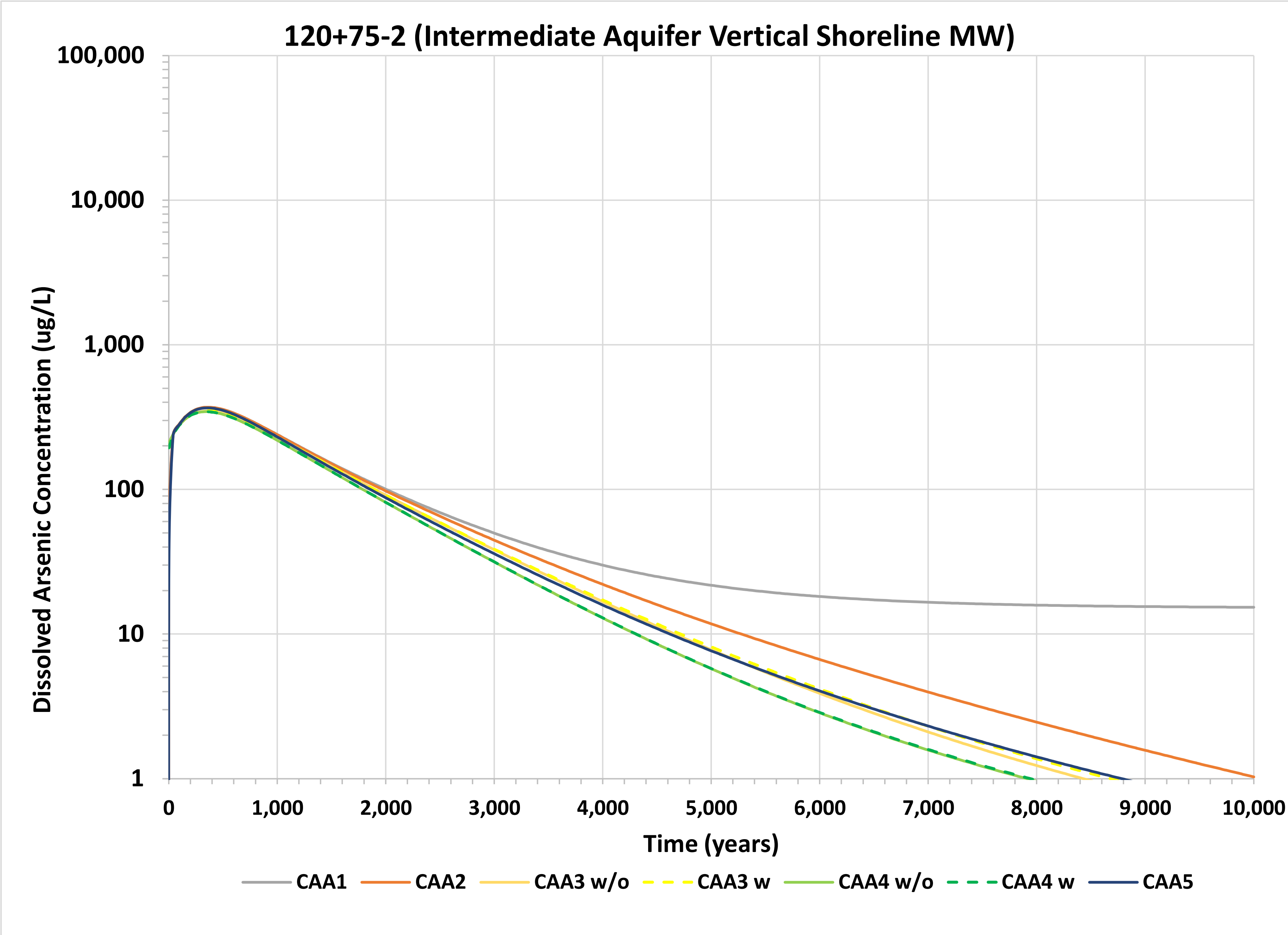


125+50-1 (Upper Aquifer Vertical Shoreline MW)
100,000
10,000
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

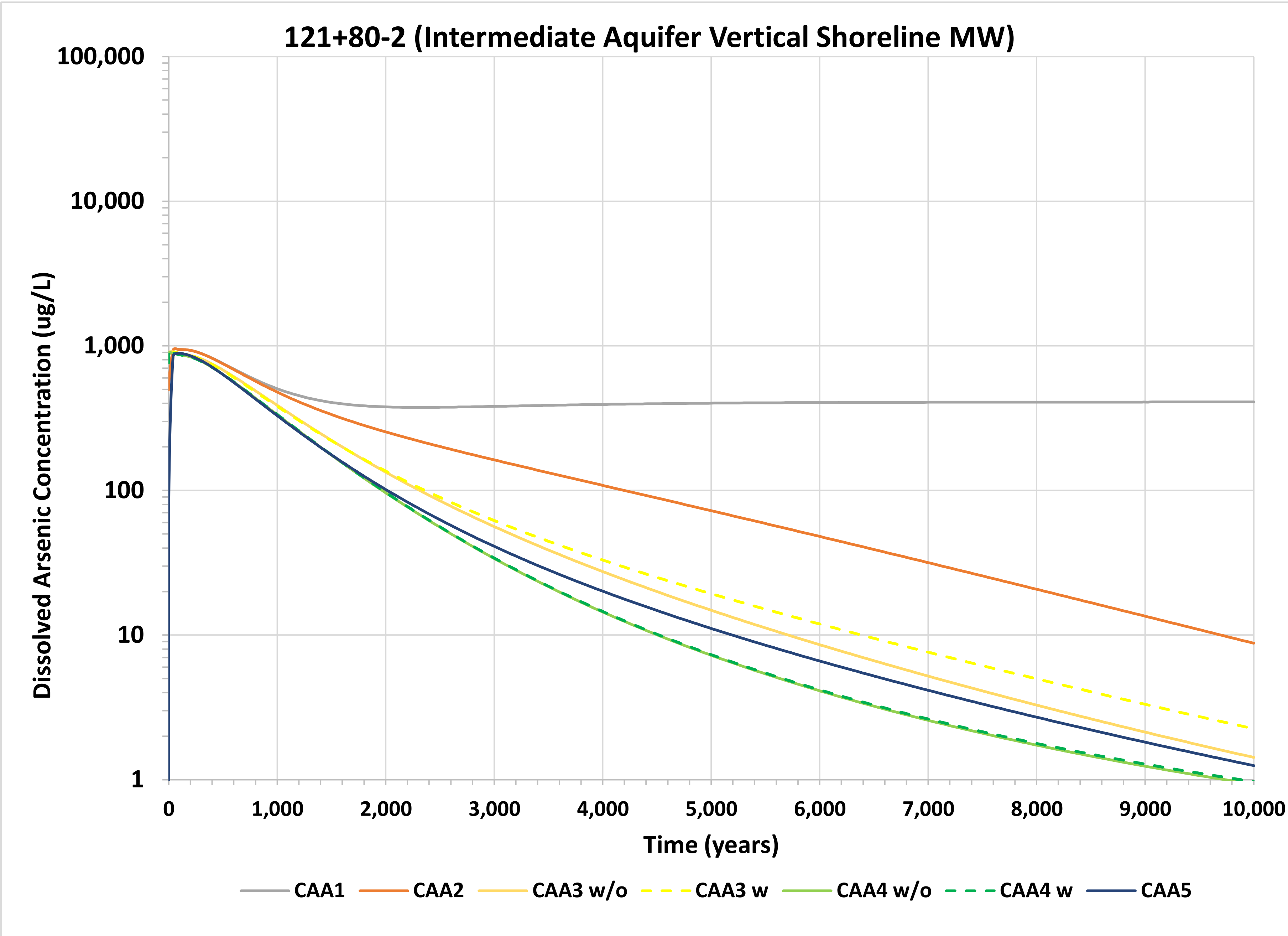

126+90-1 (Upper Aquifer Vertical Shoreline MW)
Dissolved Arsenic Concentration (ug/L)
100,000
10,000
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

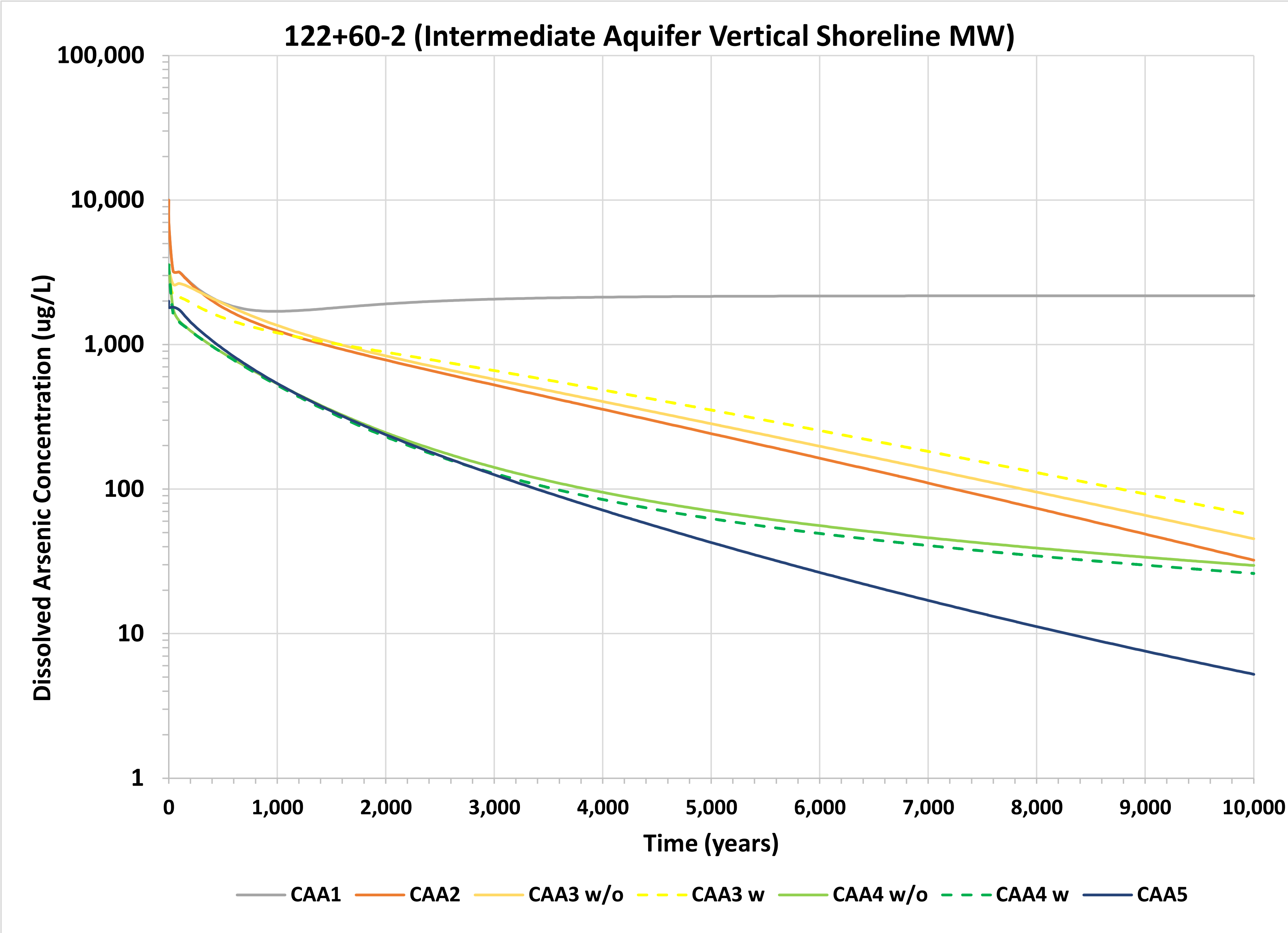


128+30-1 (Upper Aquifer Vertical Shoreline MW)
Dissolved Arsenic Concentration (ug/L)
100,000
10,000
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

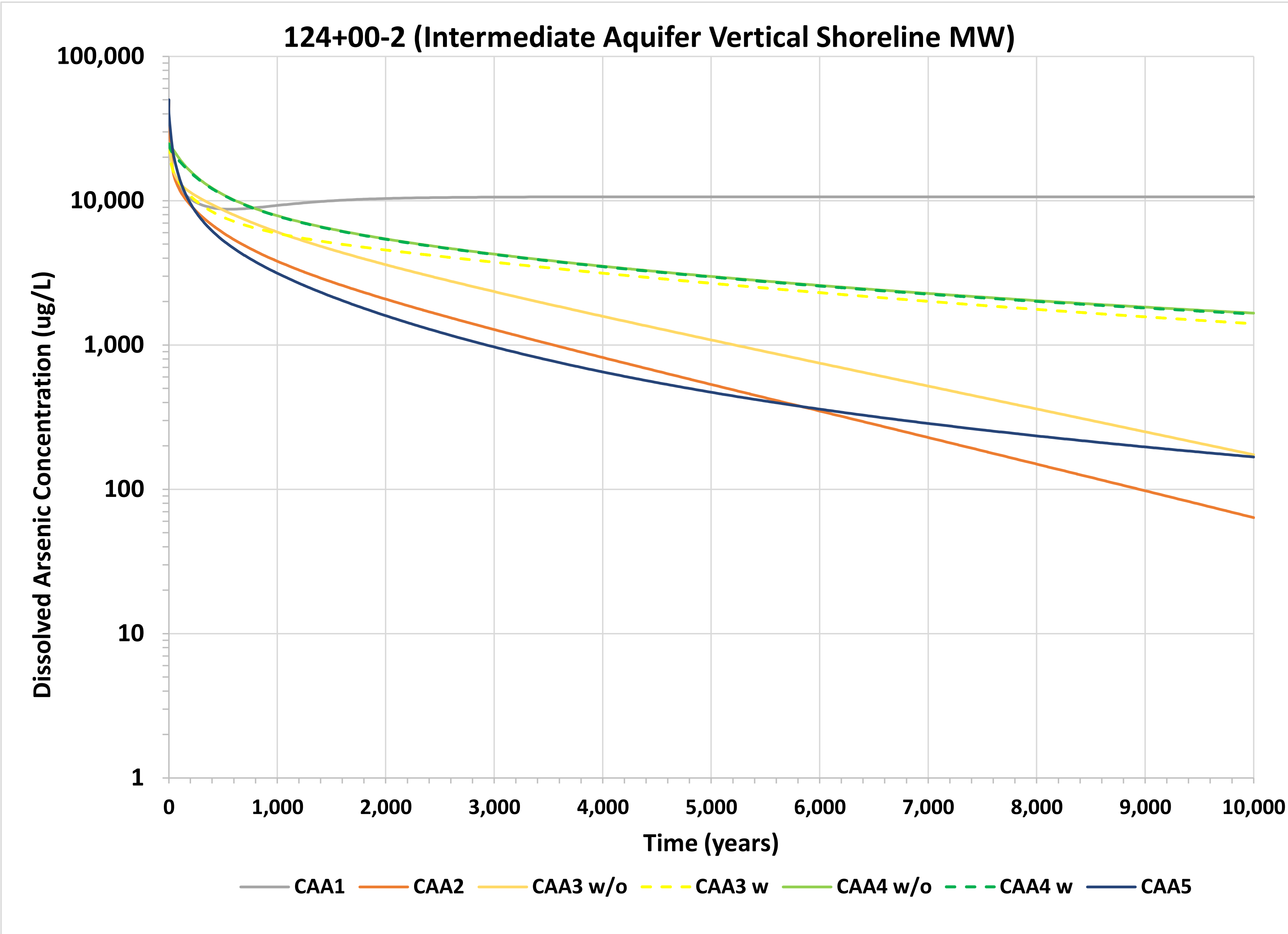


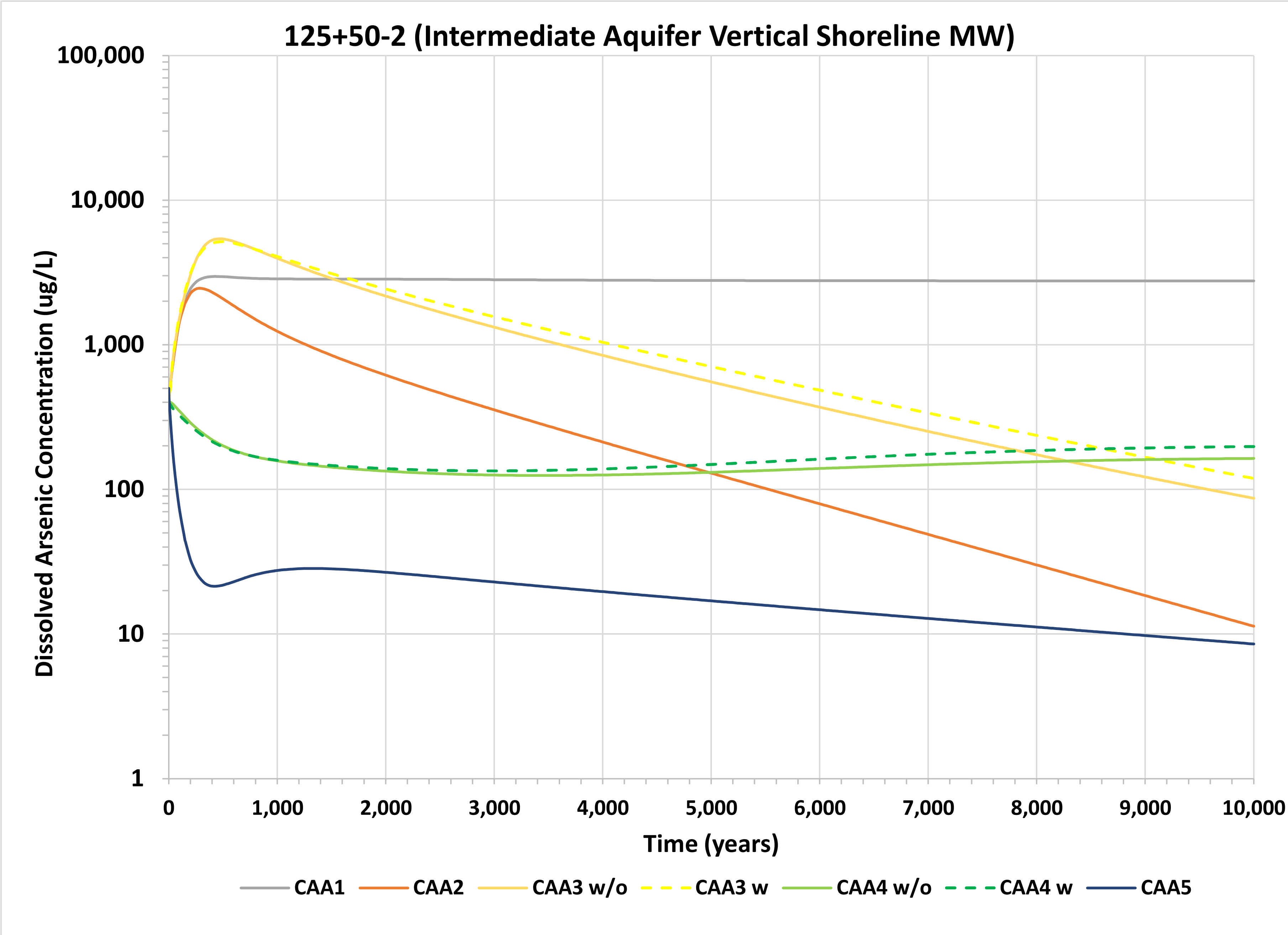
120+75-2 (Intermediate Aquifer Vertical Shoreline MW)
100,000
10,000
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

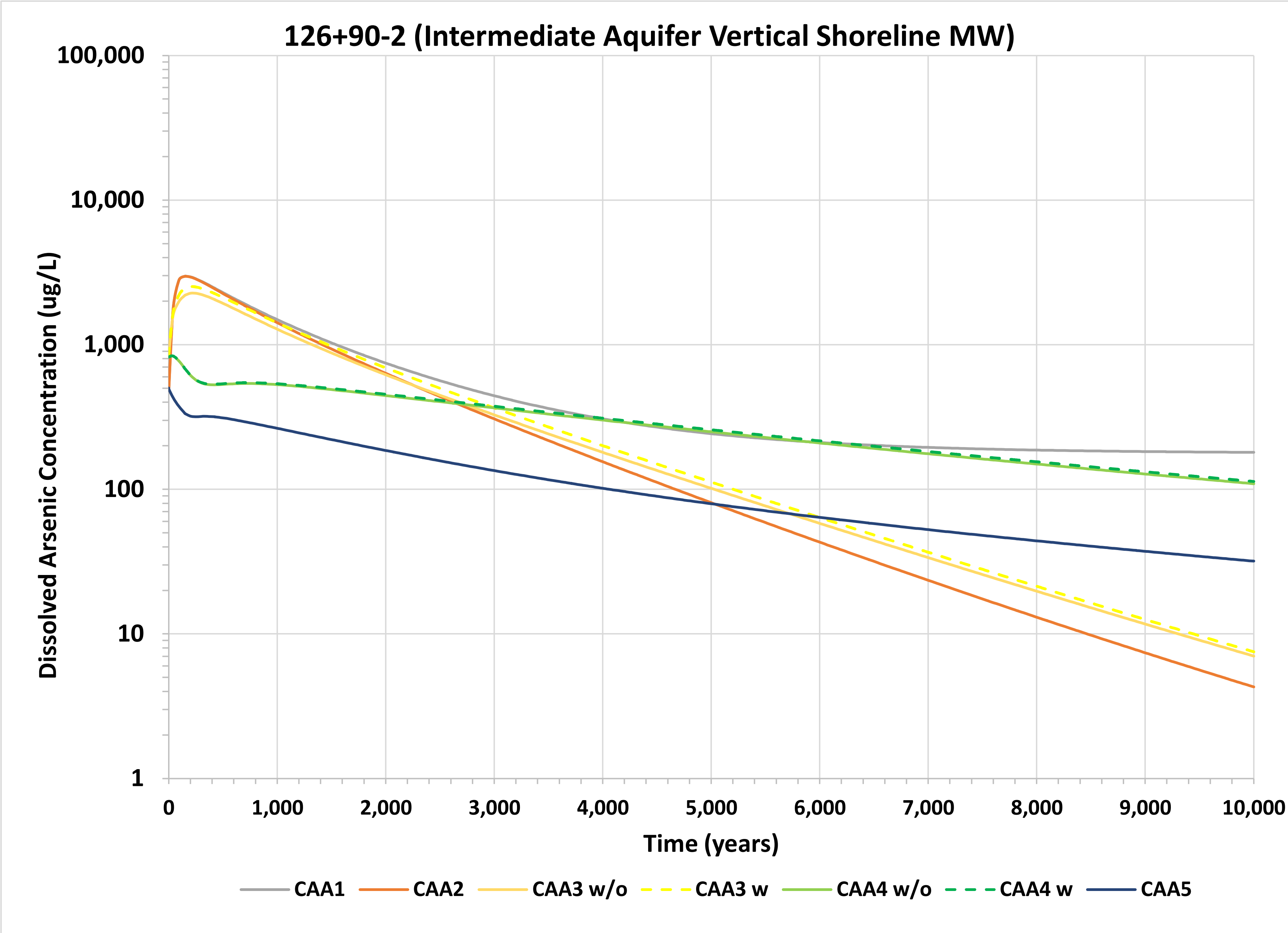

121+80-2 (Intermediate Aquifer Vertical Shoreline MW)
Dissolved Arsenic Concentration (ug/L)
100,000
10,000
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

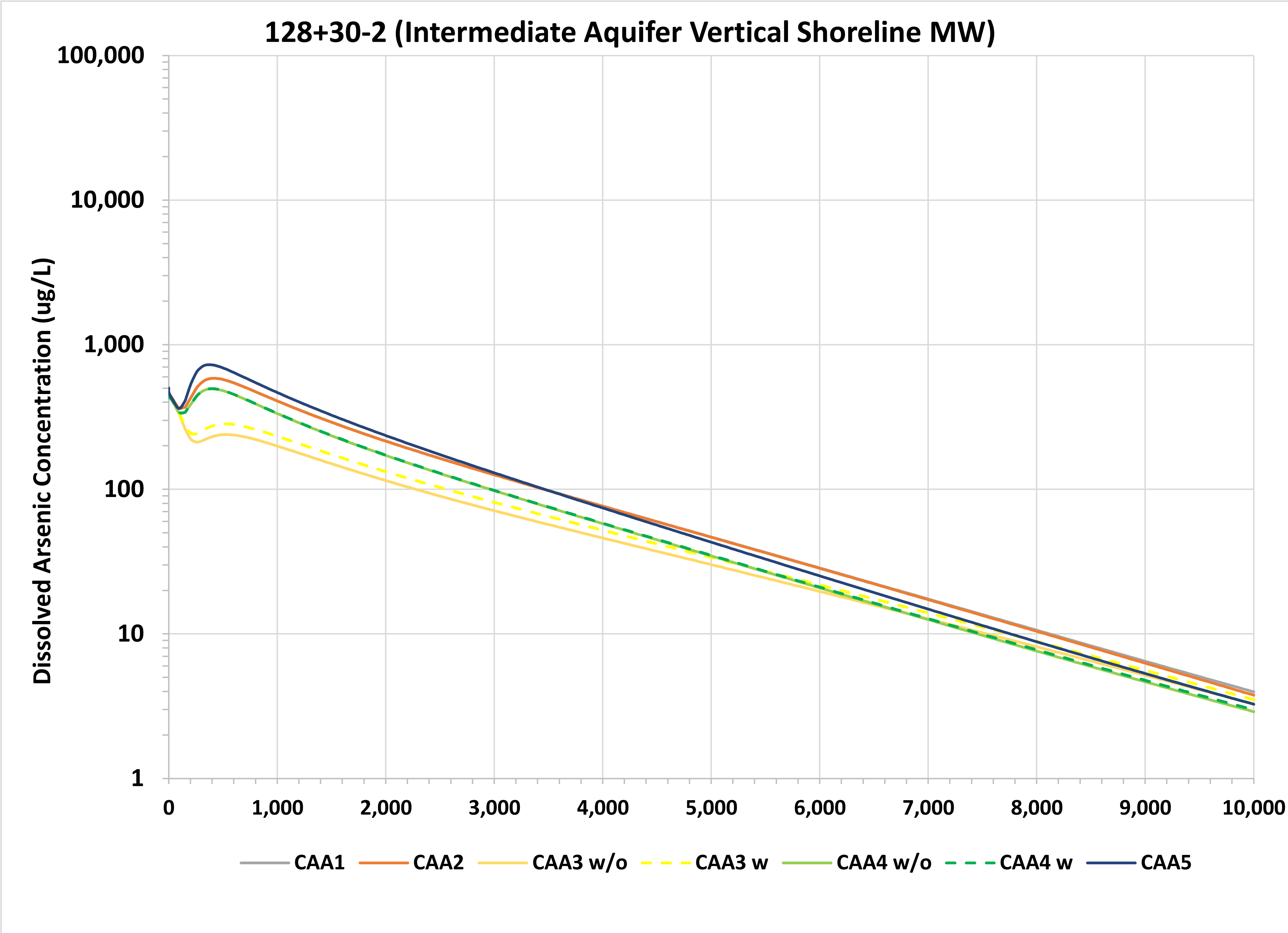


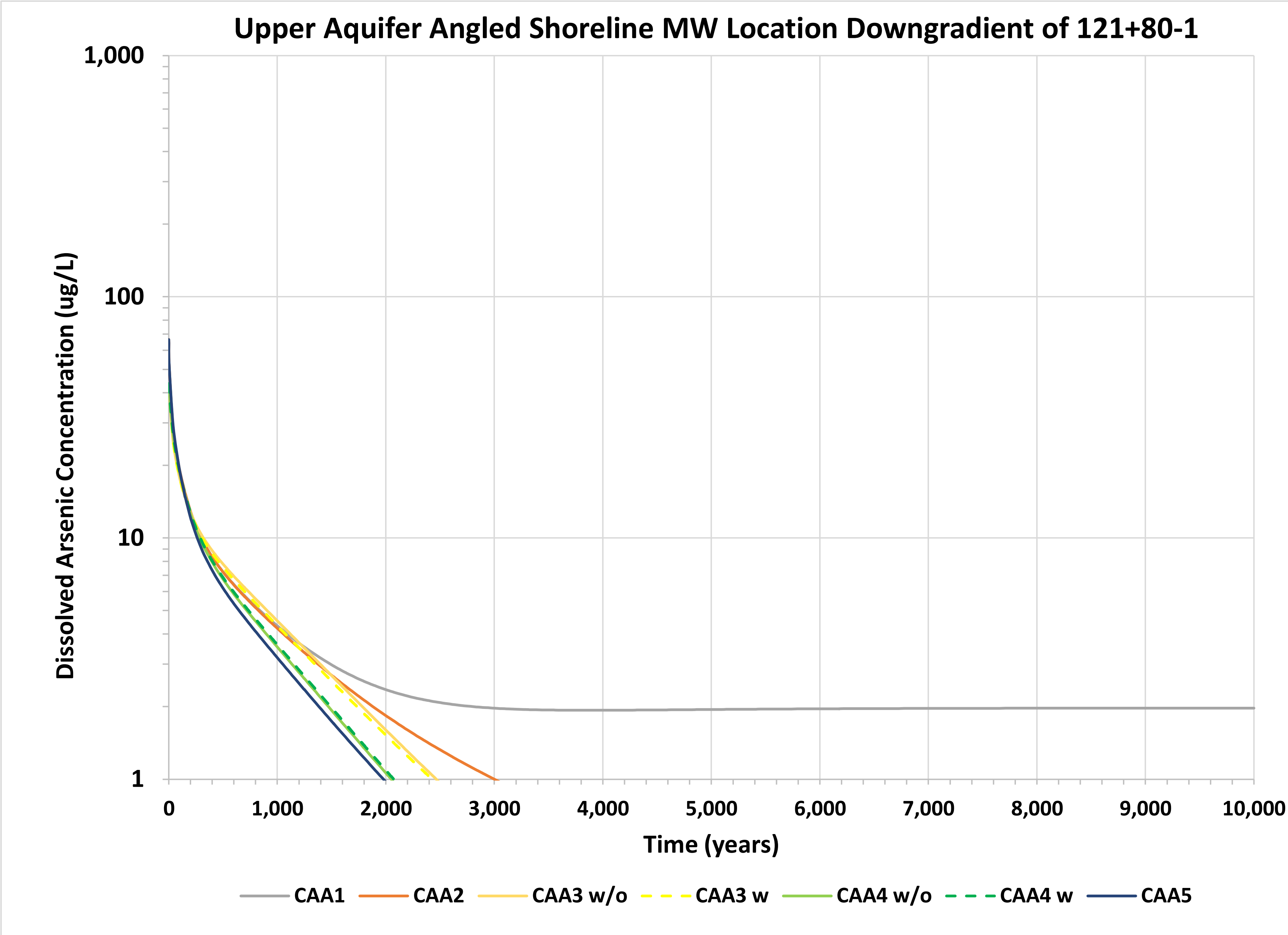
122+60-2 (Intermediate Aquifer Vertical Shoreline MW)
100,000
10,000
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5


124+00-2 (Intermediate Aquifer Vertical Shoreline MW)
100,000
10,000
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

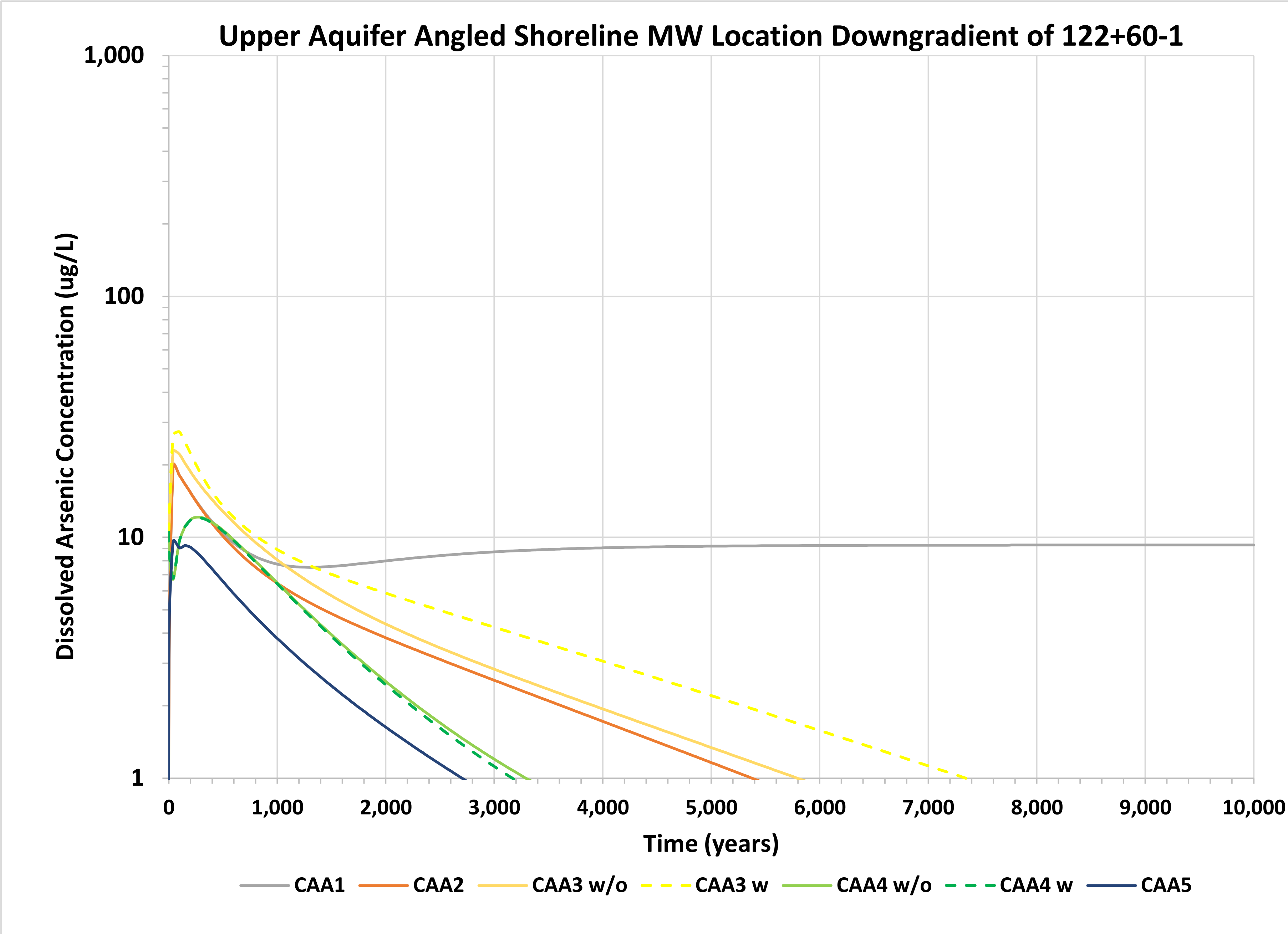

125+50-2 (Intermediate Aquifer Vertical Shoreline MW)
100,000
10,000
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5


126+90-2 (Intermediate Aquifer Vertical Shoreline MW)
100,000
10,000
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

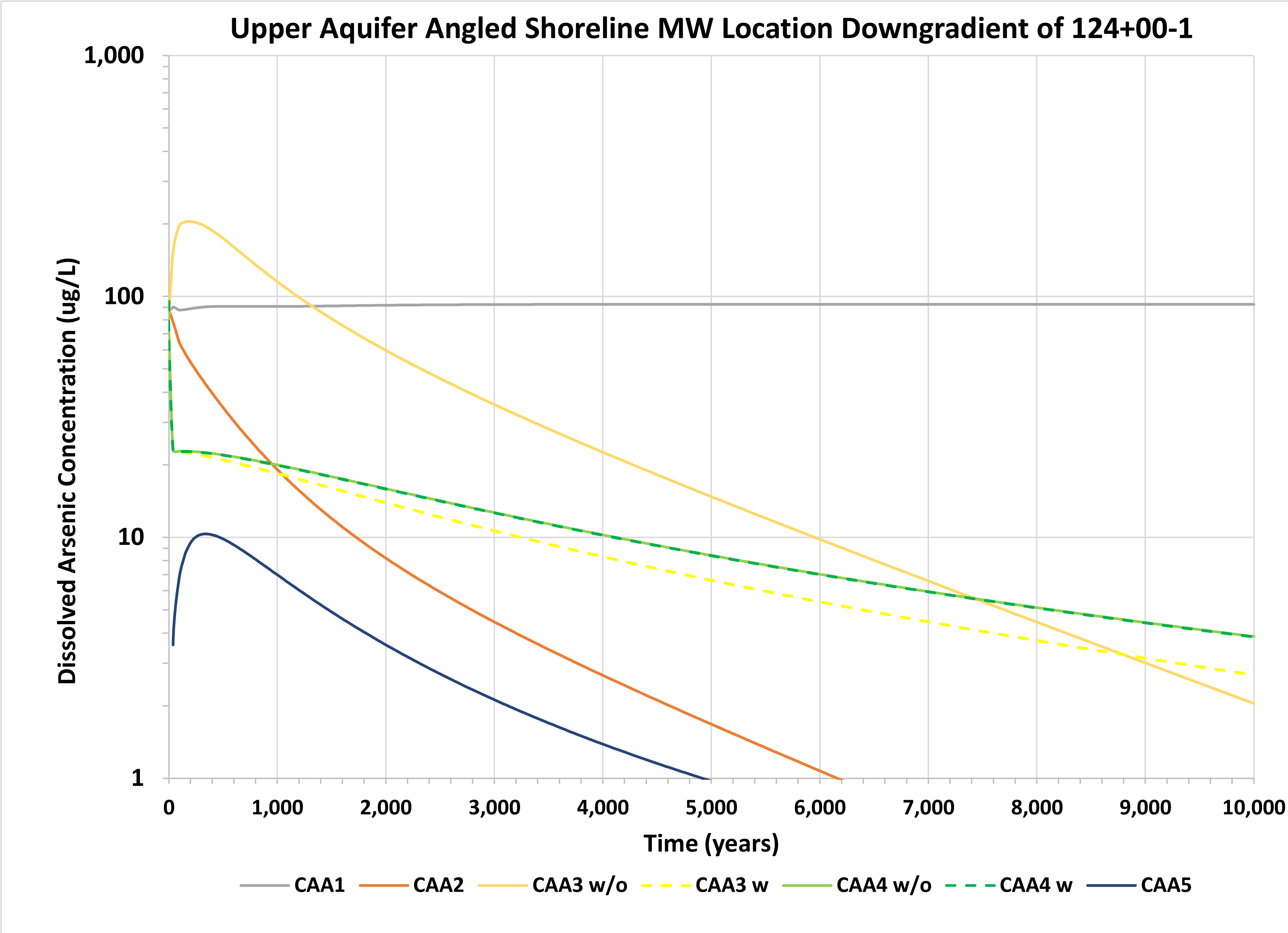

128+30-2 (Intermediate Aquifer Vertical Shoreline MW)
Dissolved Arsenic Concentration (ug/L)
100,000
10,000
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5



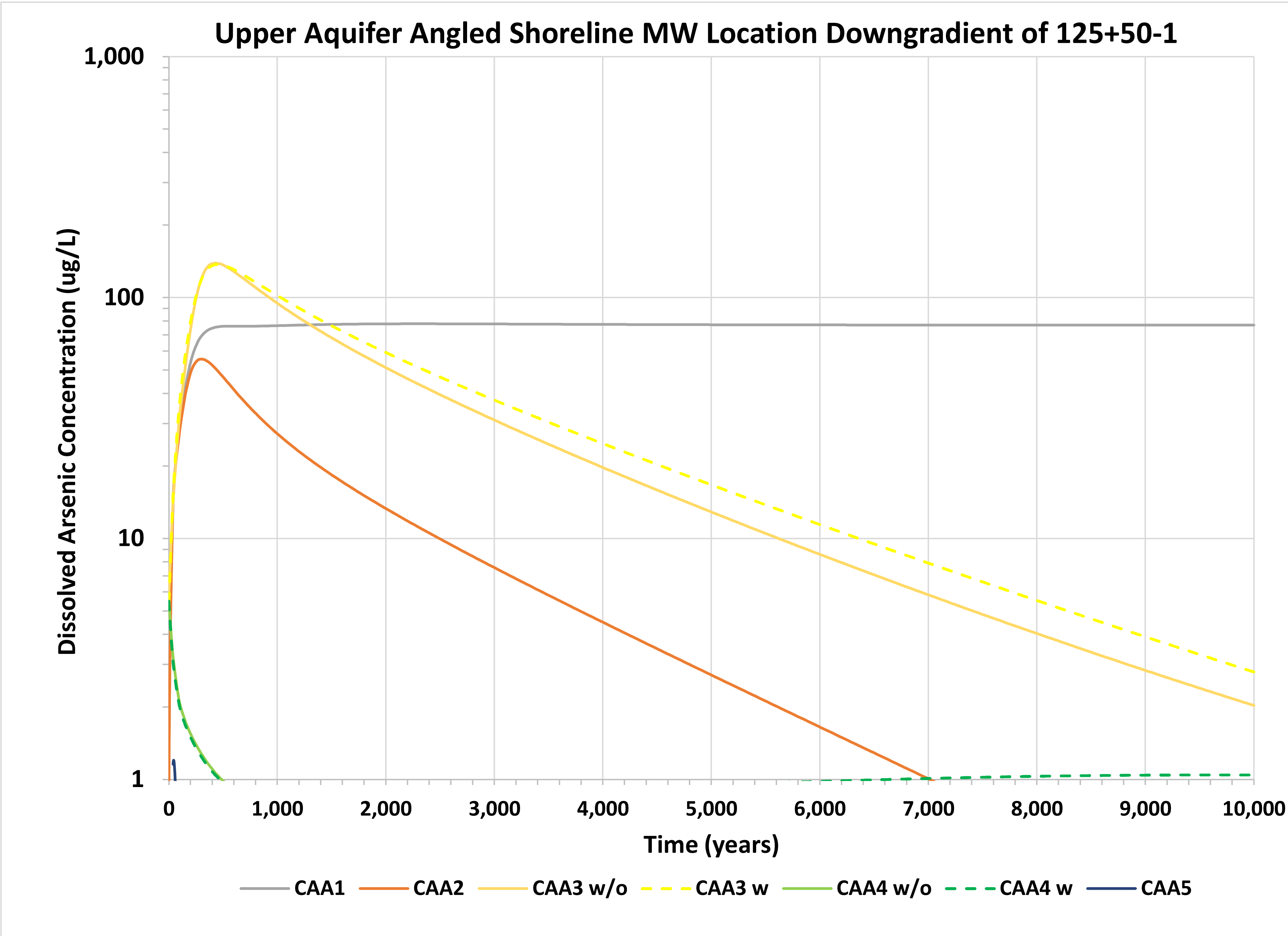
Upper Aquifer Angled Shoreline MW Location Downgradient of 121+80-1
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5



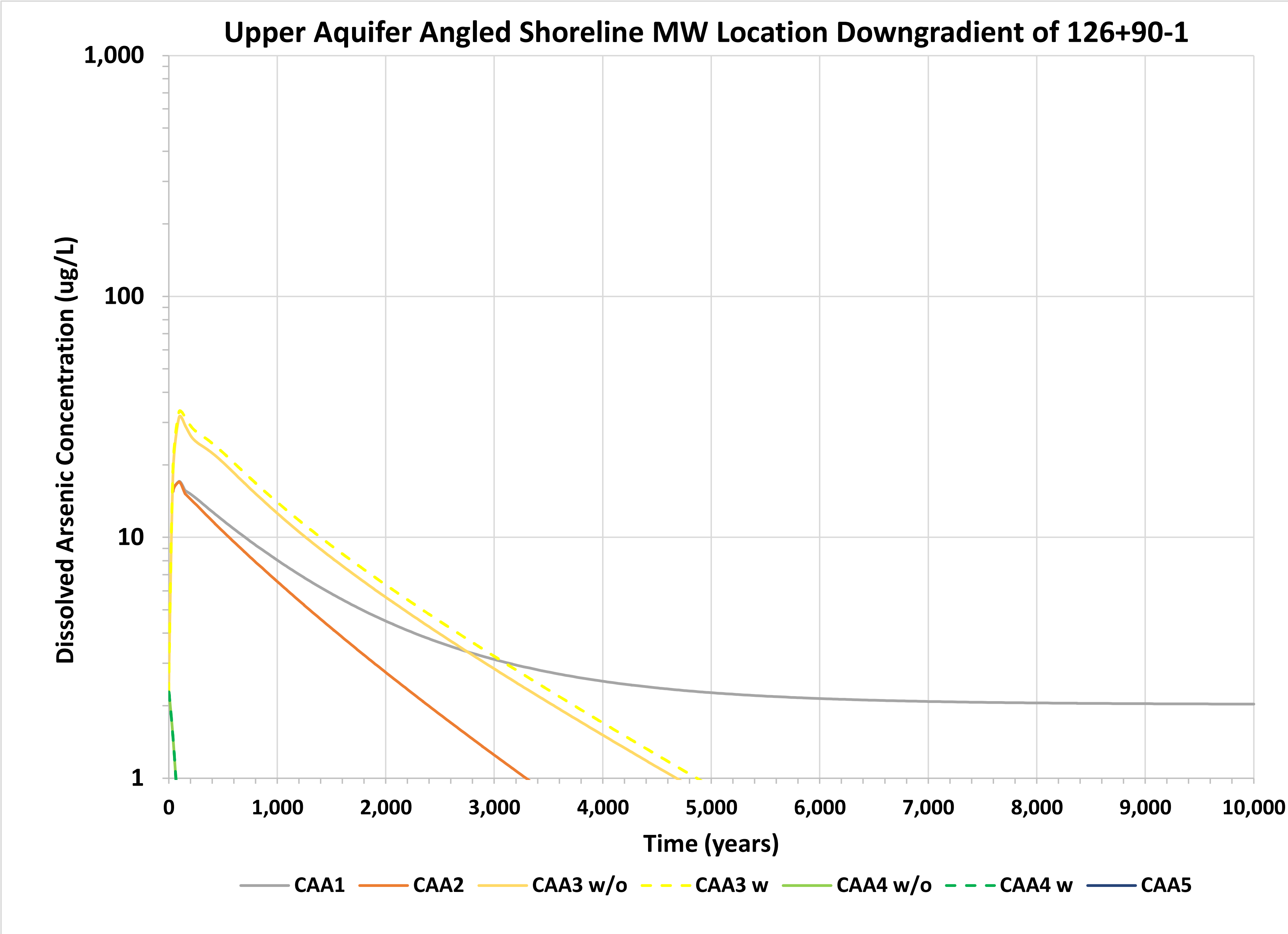
Upper Aquifer Angled Shoreline MW Location Downgradient of 122+60-1
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

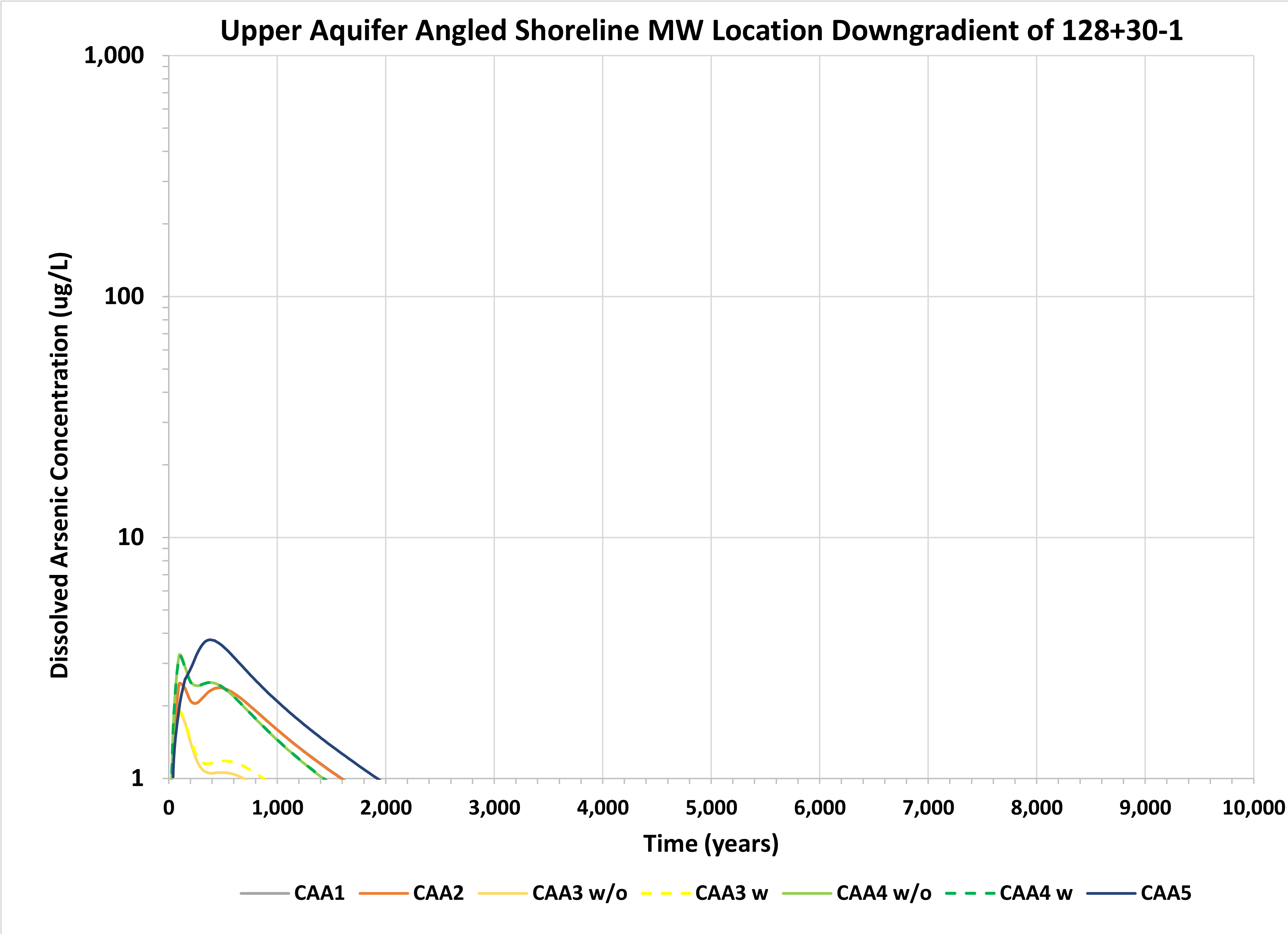


Upper Aquifer Angled Shoreline MW Location Downgradient of 124+00-1
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

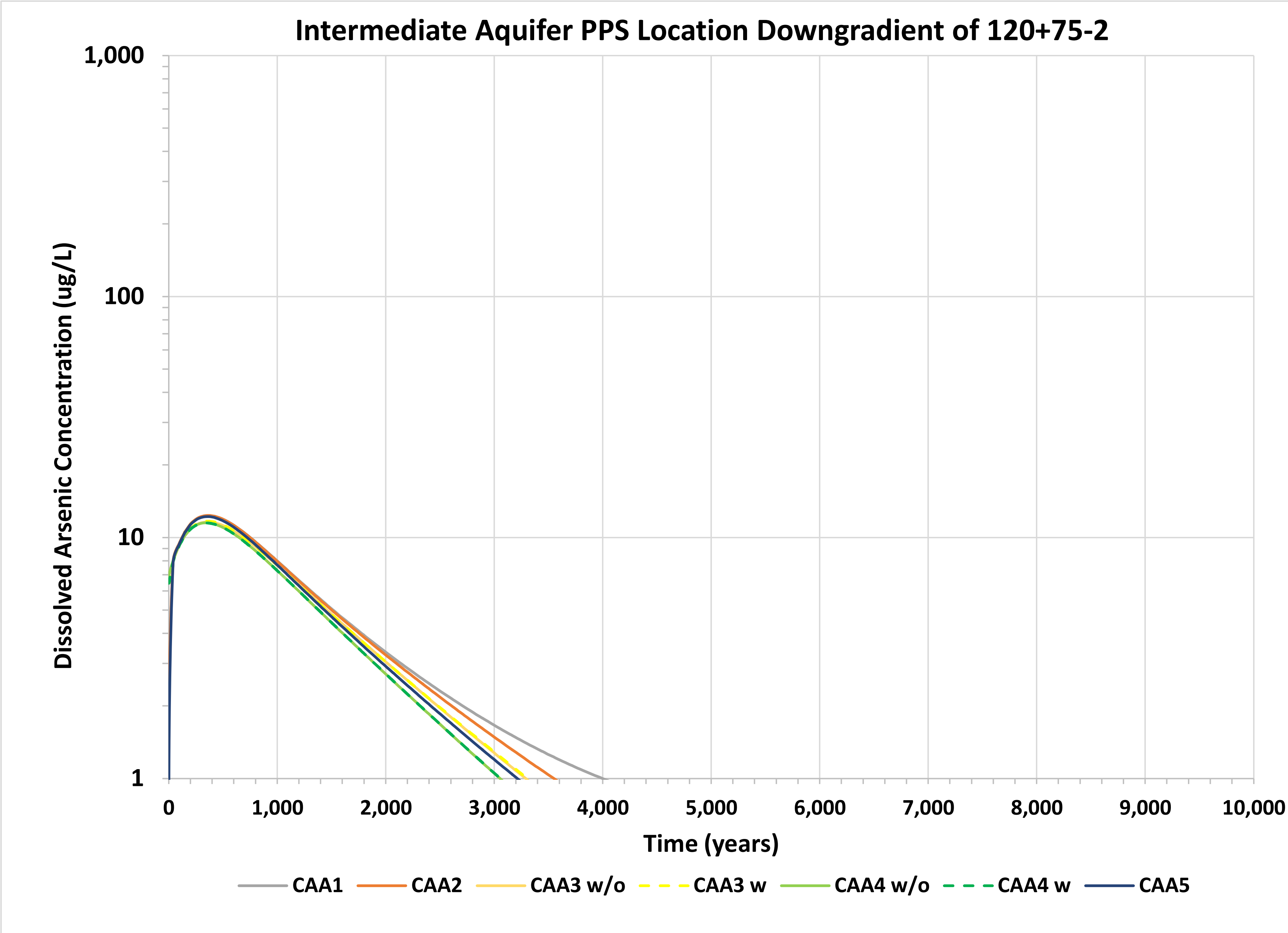


Upper Aquifer Angled Shoreline MW Location Downgradient of 125+50-1
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

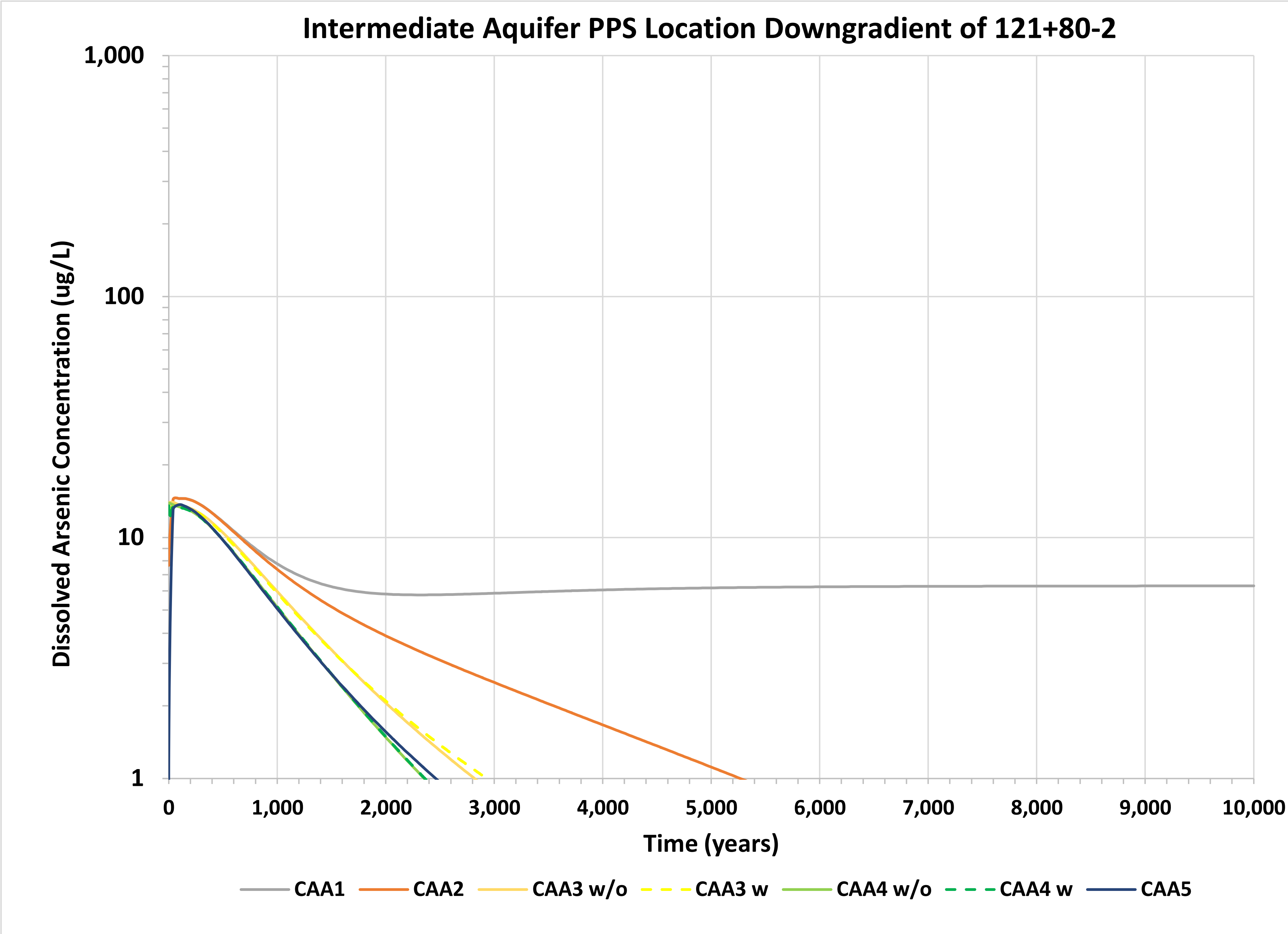

Upper Aquifer Angled Shoreline MW Location Downgradient of 126+90-1
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5



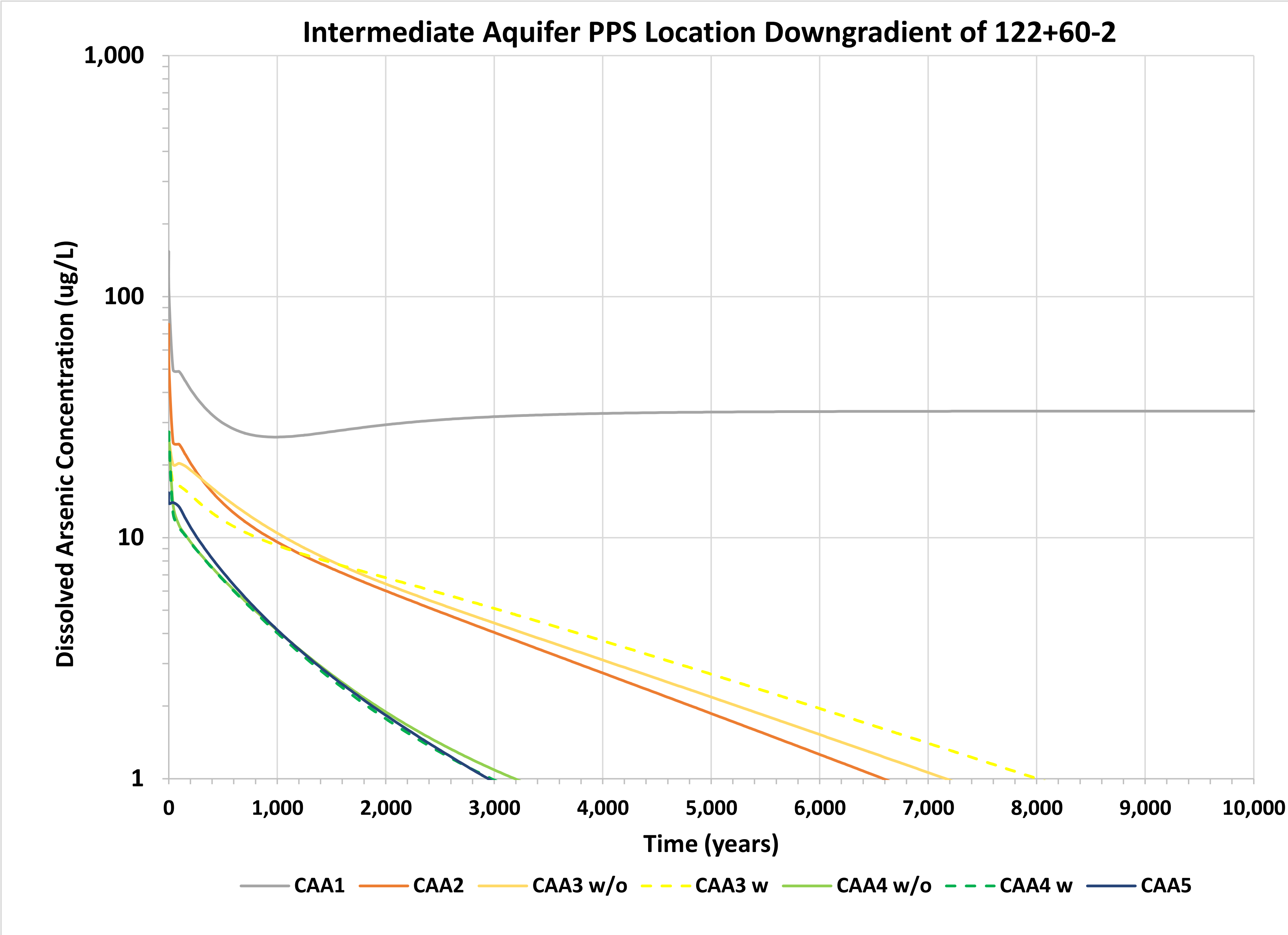
Upper Aquifer Angled Shoreline MW Location Downgradient of 128+30-1
Dissolved Arsenic Concentration (ug/L)
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5



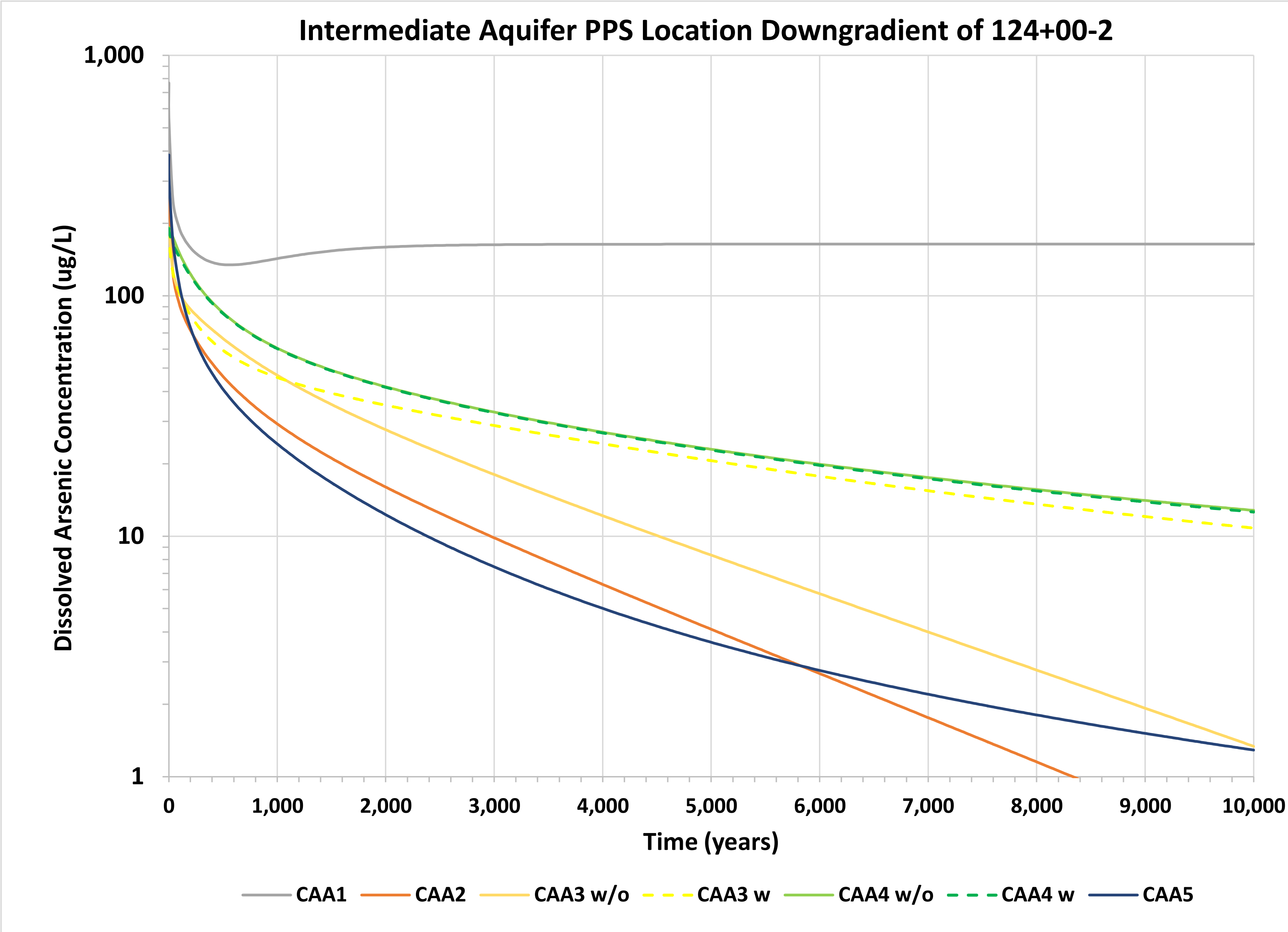
Intermediate Aquifer PPS Location Downgradient of 120+75-2
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5



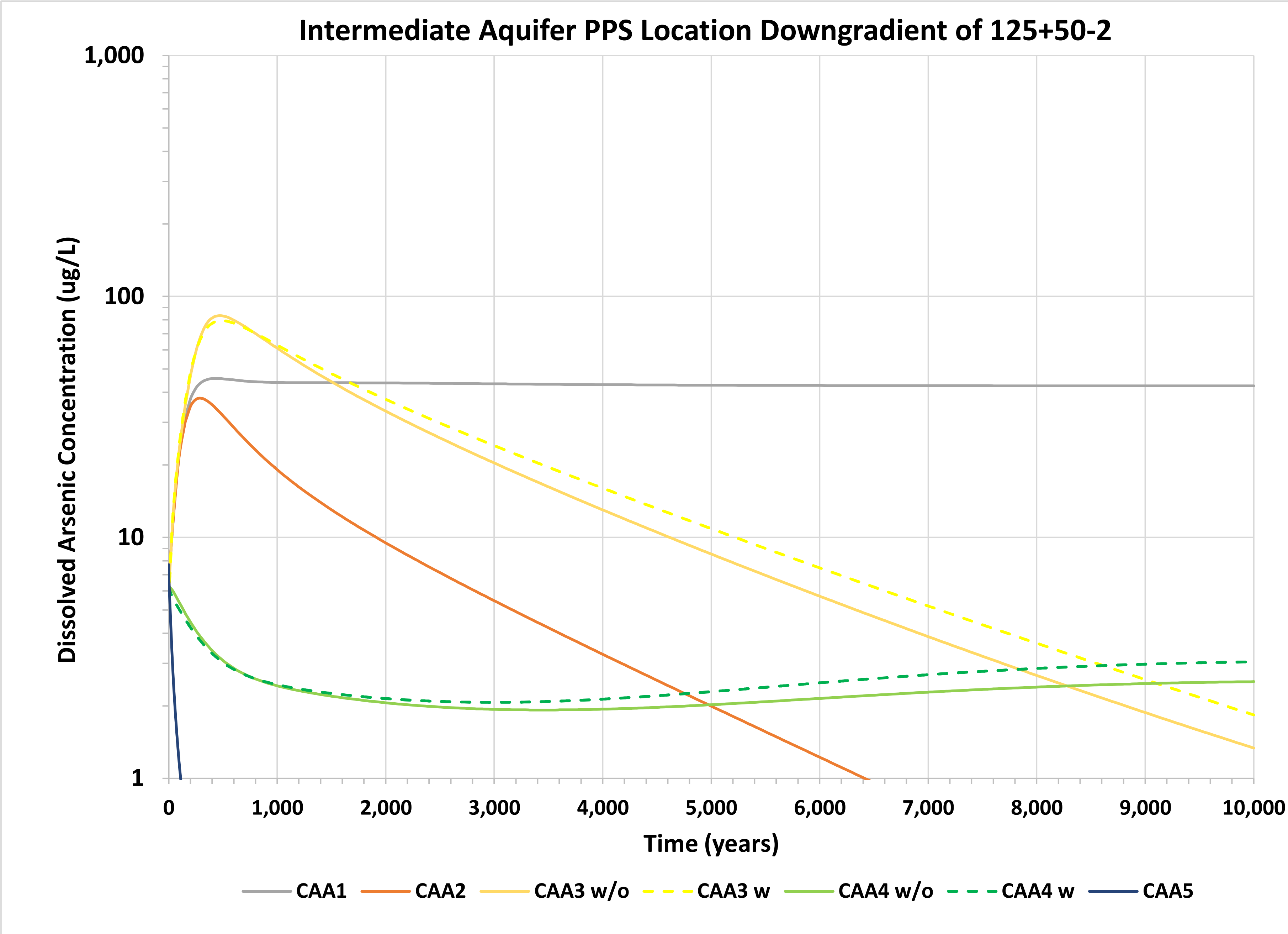
Intermediate Aquifer PPS Location Downgradient of 121+80-2
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

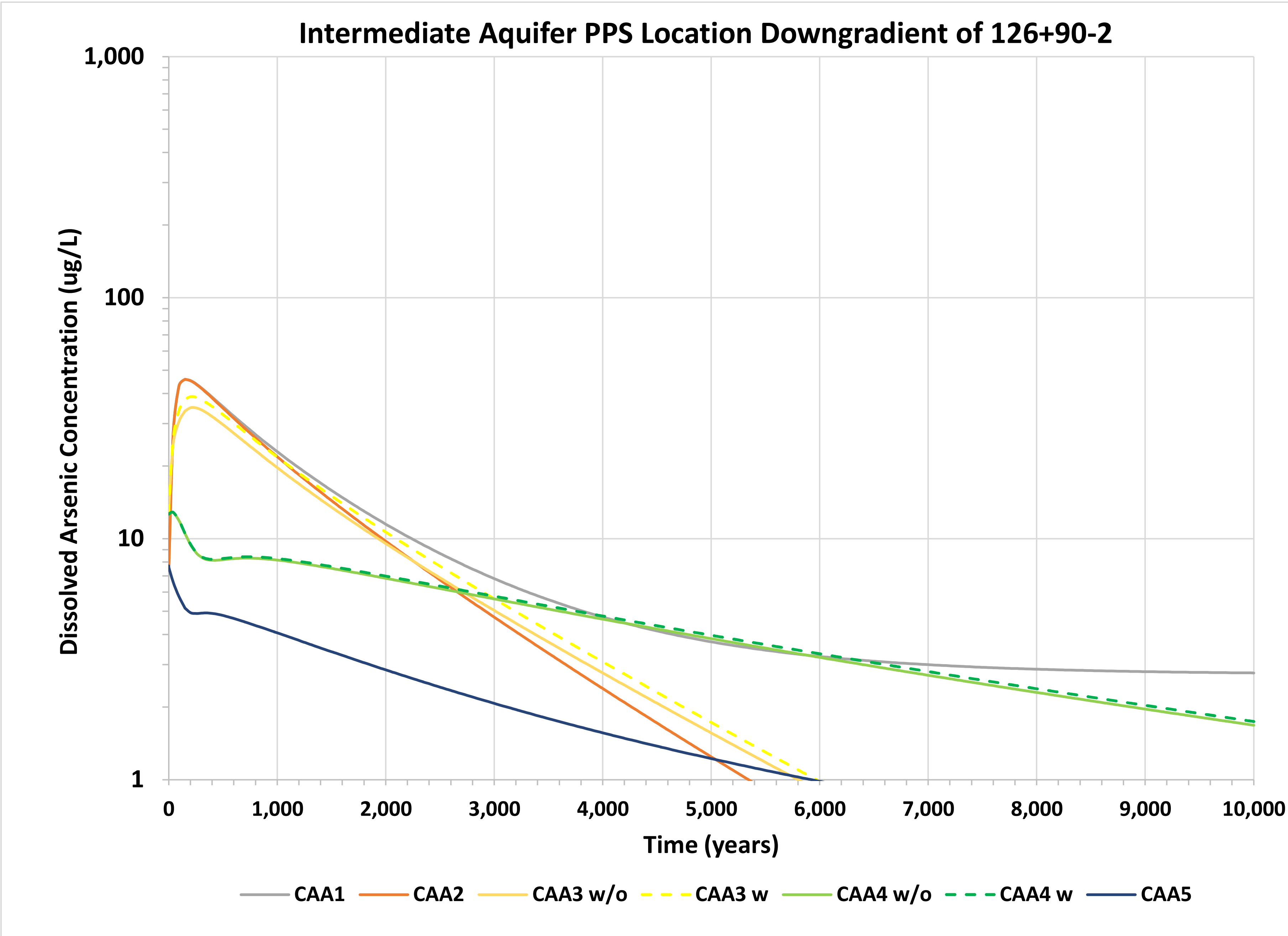


Intermediate Aquifer PPS Location Downgradient of 122+60-2
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

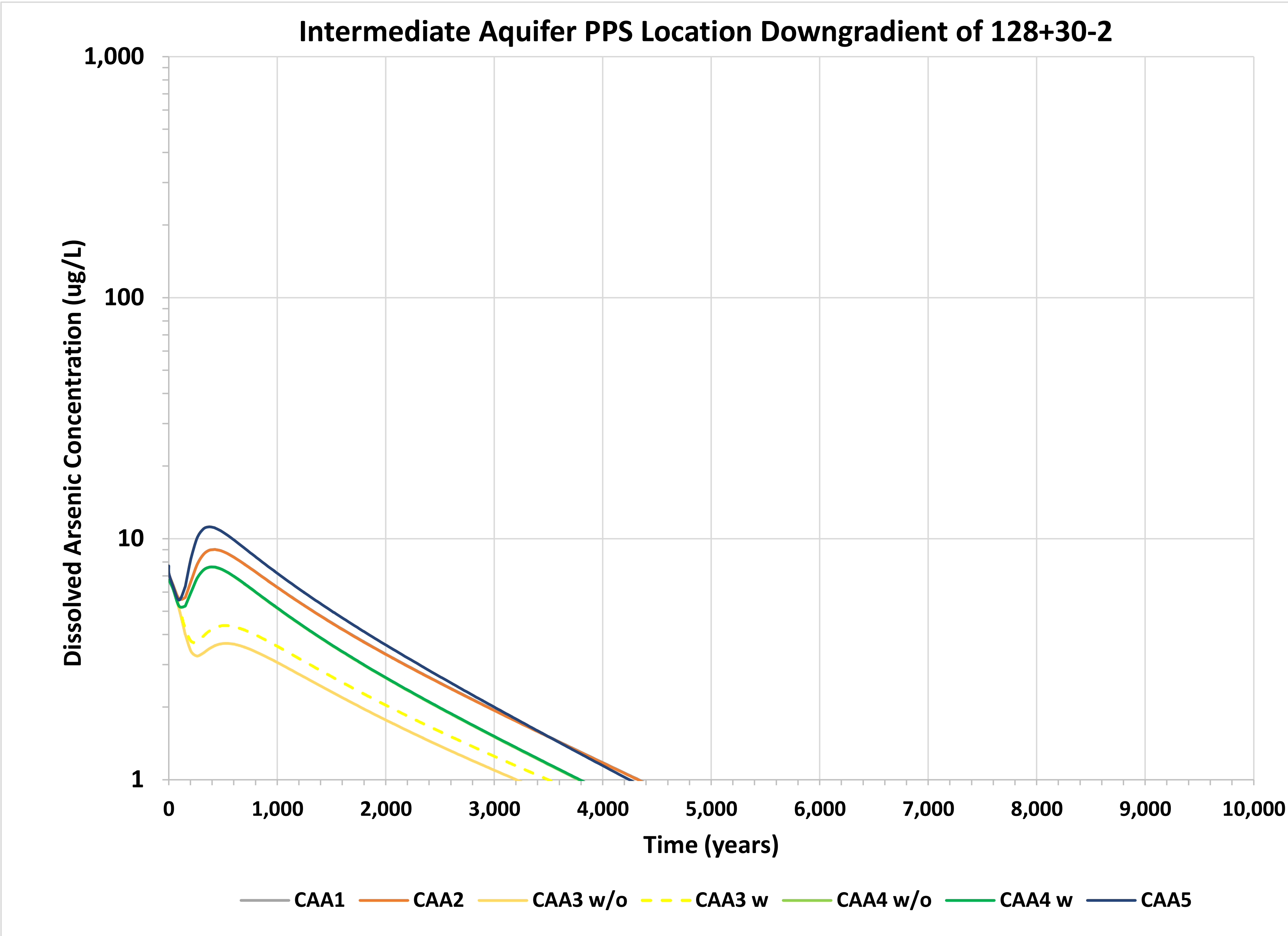


Intermediate Aquifer PPS Location Downgradient of 124+00-2
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

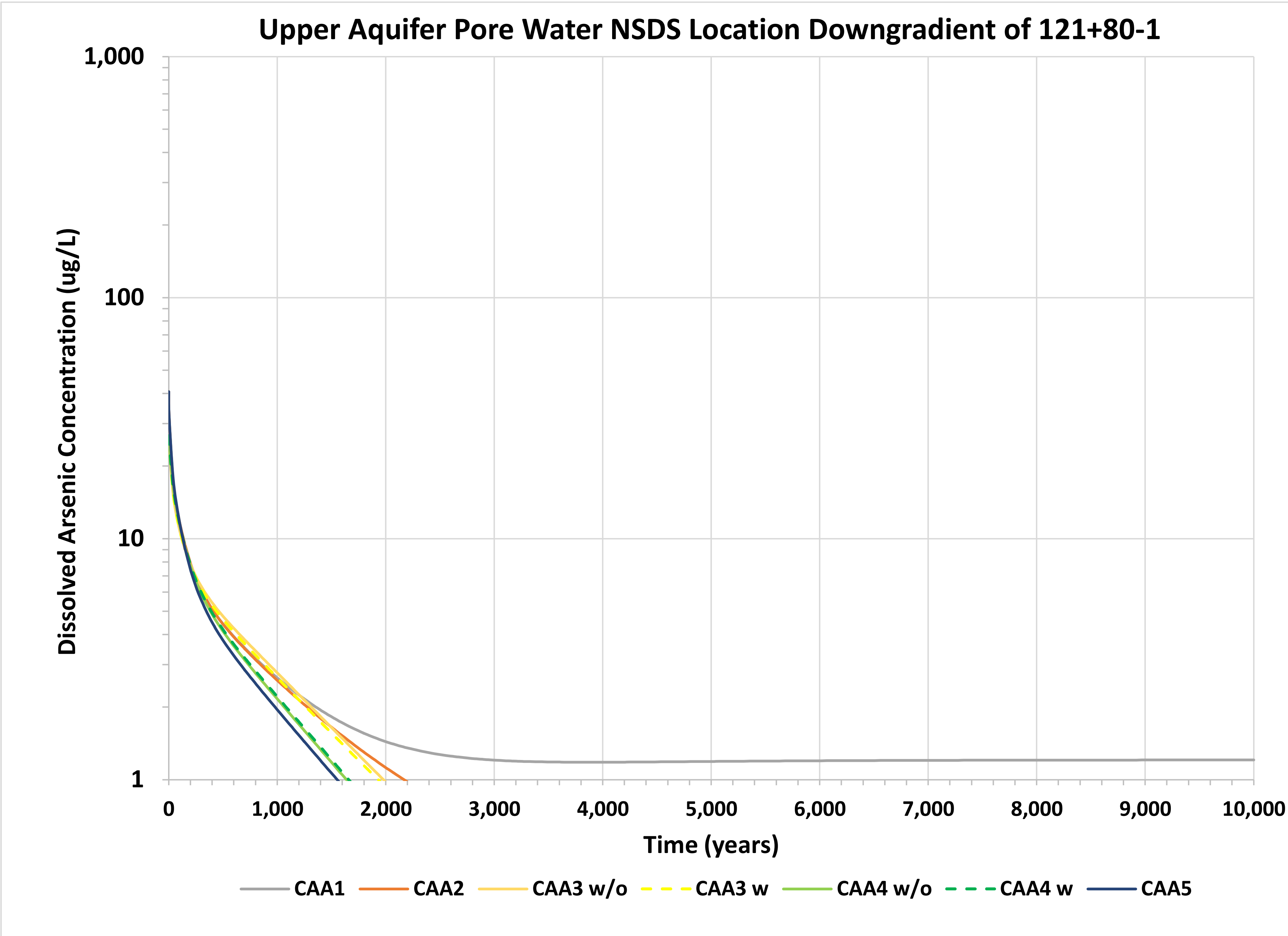

Intermediate Aquifer PPS Location Downgradient of 125+50-2
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5



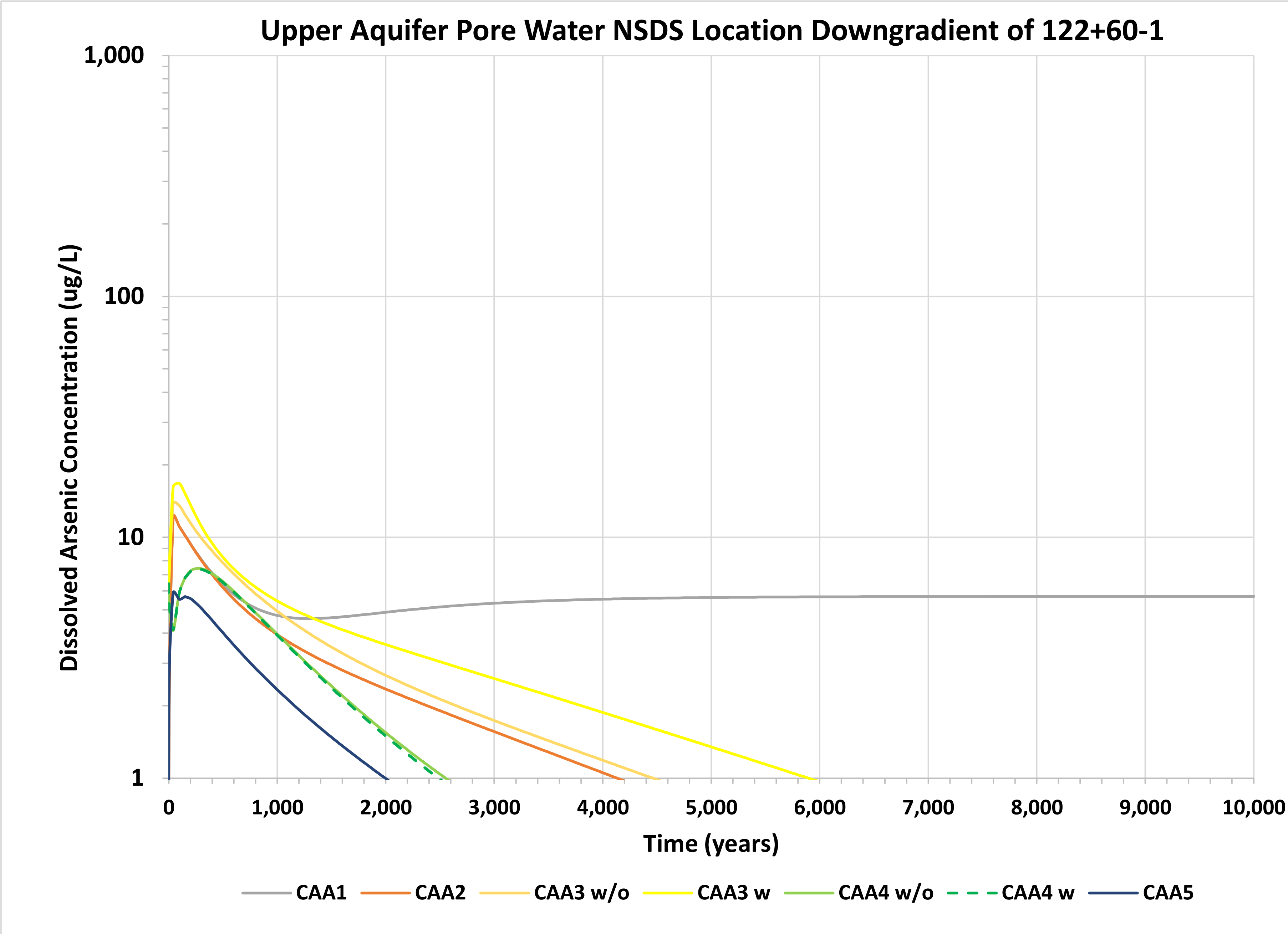
Intermediate Aquifer PPS Location Downgradient of 126+90-2
Dissolved Arsenic Concentration (ug/L)
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

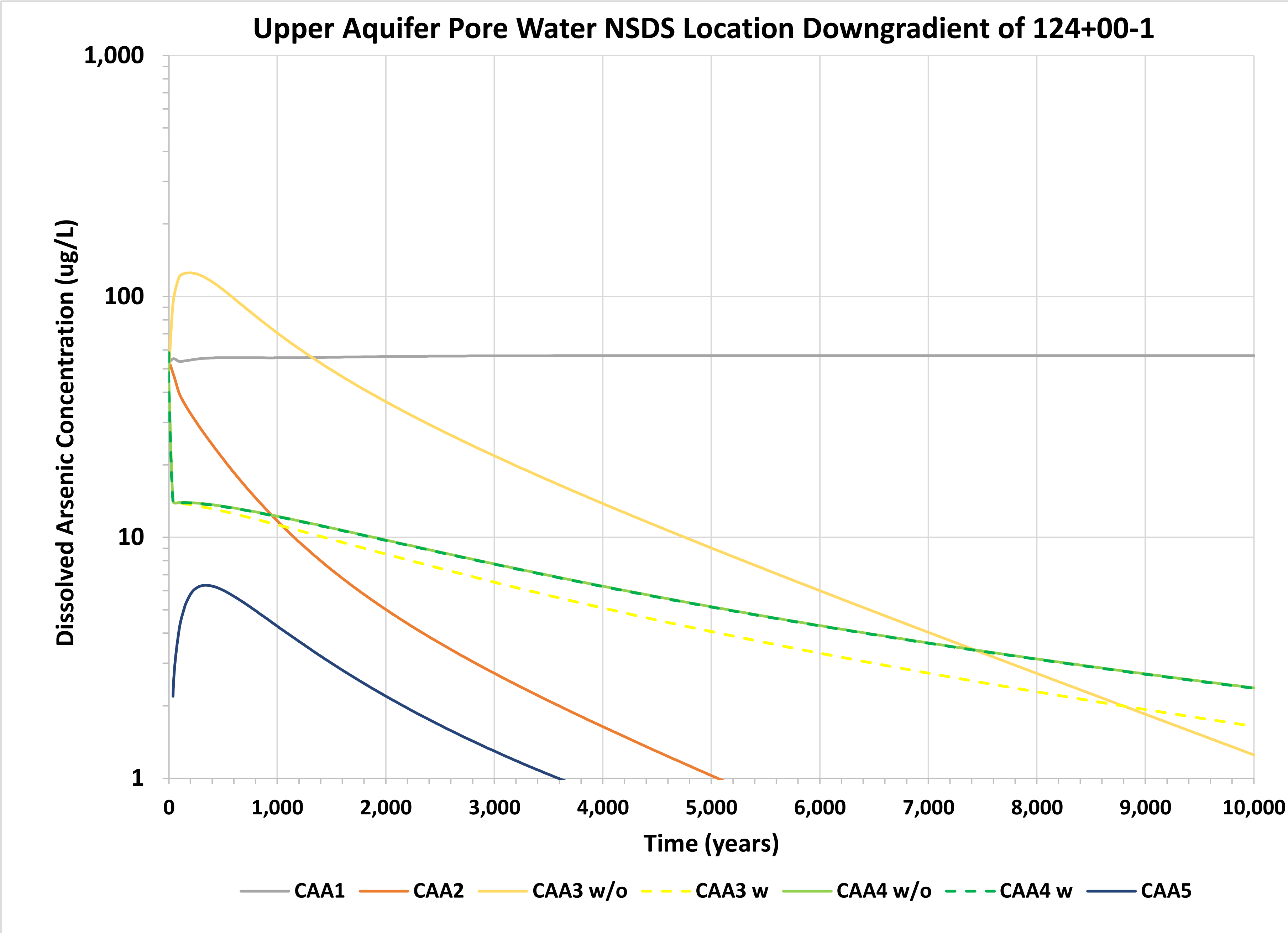


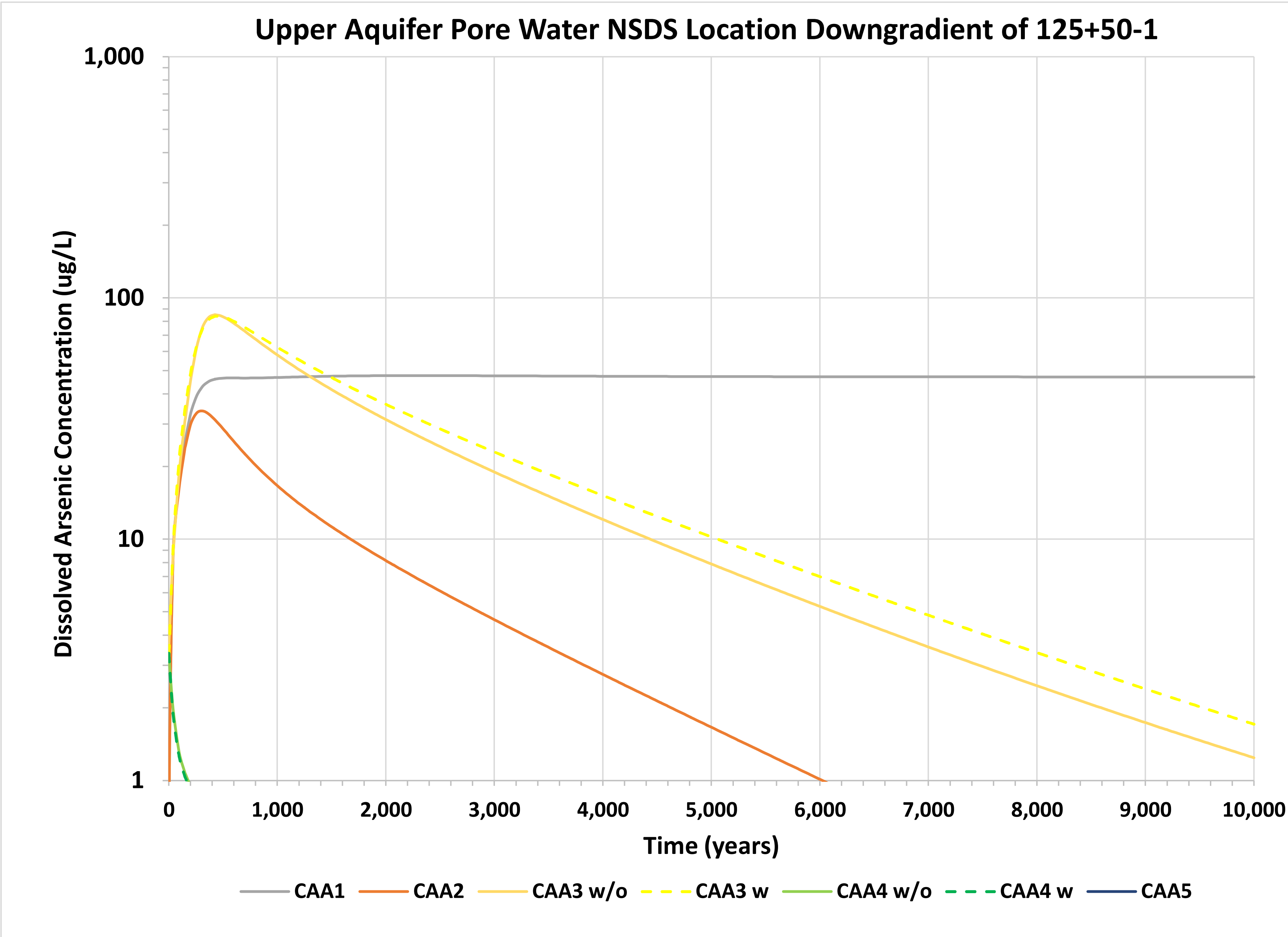
Intermediate Aquifer PPS Location Downgradient of 128+30-2
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

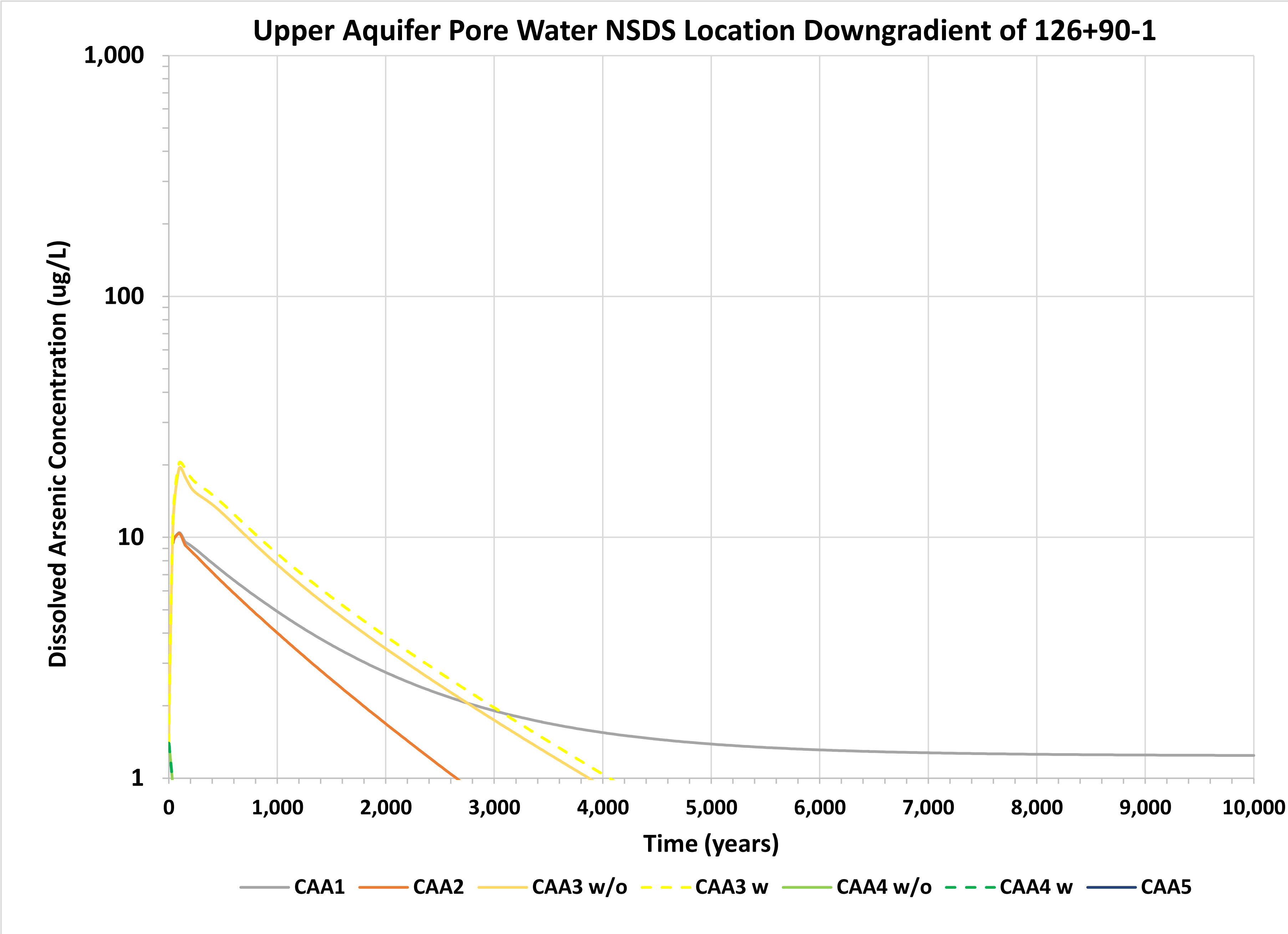


Upper Aquifer Pore Water NSDS Location Downgradient of 121+80-1
Dissolved Arsenic Concentration (ug/L)
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

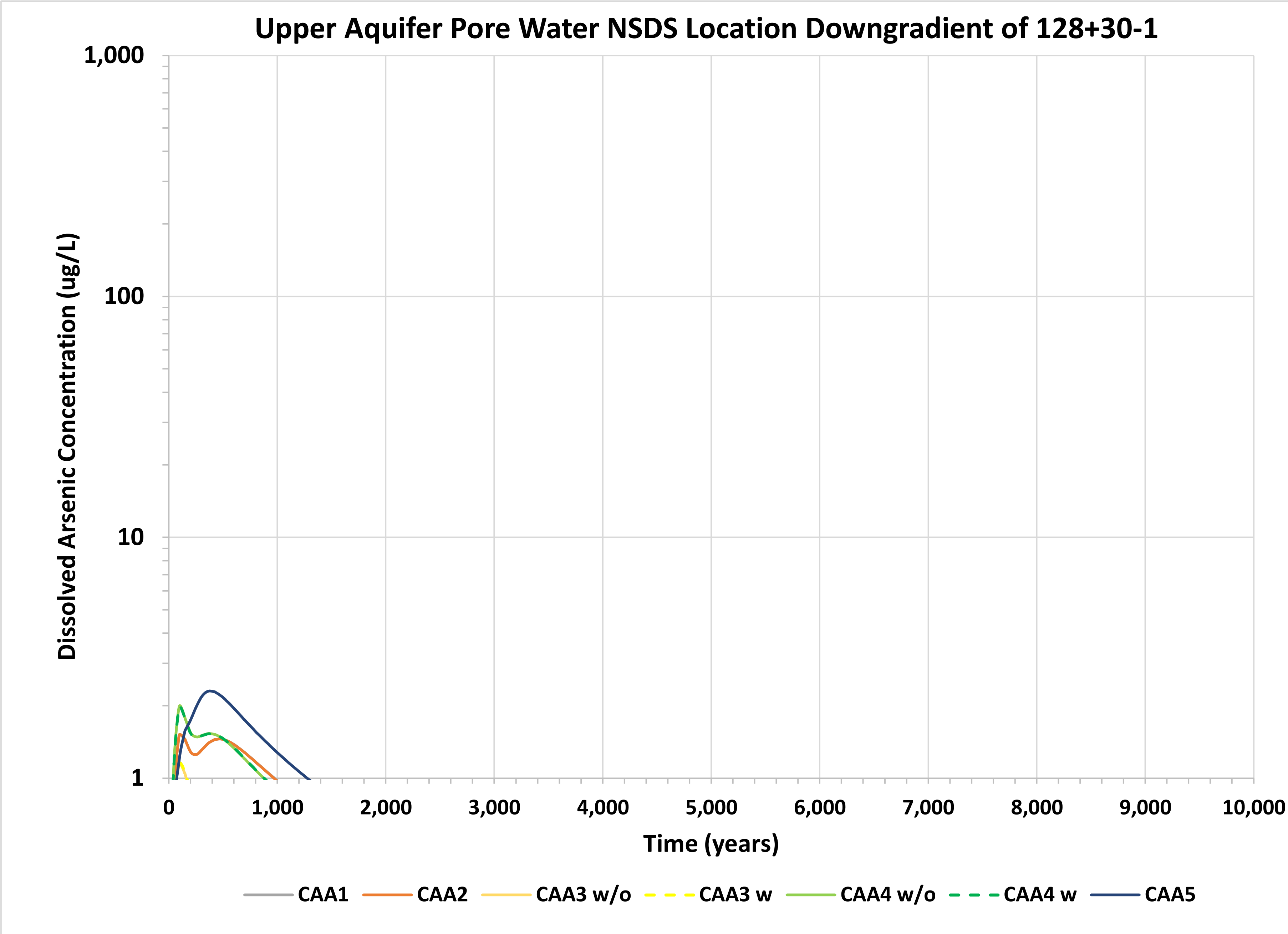

Upper Aquifer Pore Water NSDS Location Downgradient of 122+60-1
Dissolved Arsenic Concentration (ug/L)
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

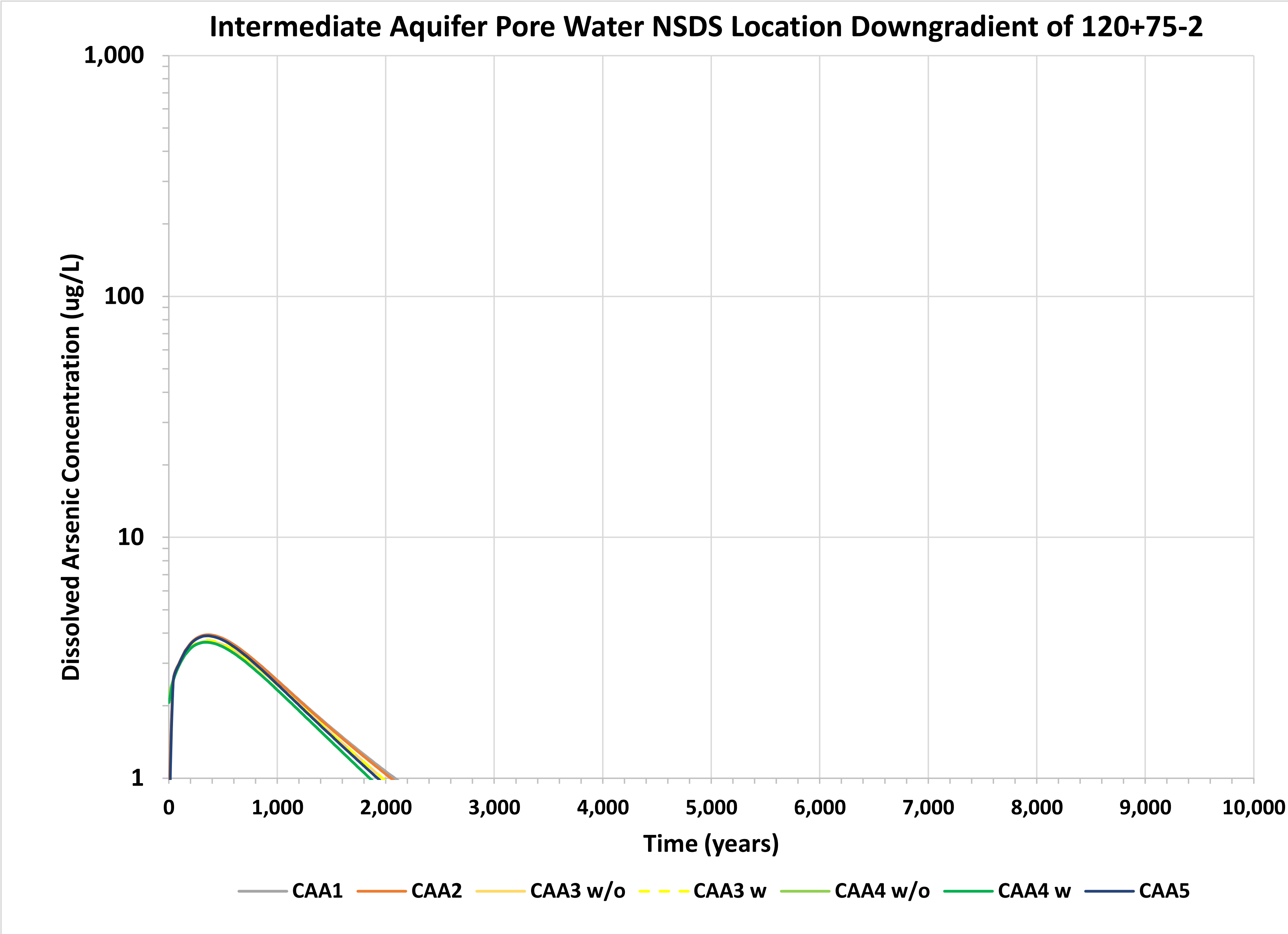

Upper Aquifer Pore Water NSDS Location Downgradient of 124+00-1
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5


Upper Aquifer Pore Water NSDS Location Downgradient of 125+50-1
Dissolved Arsenic Concentration (ug/L)
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

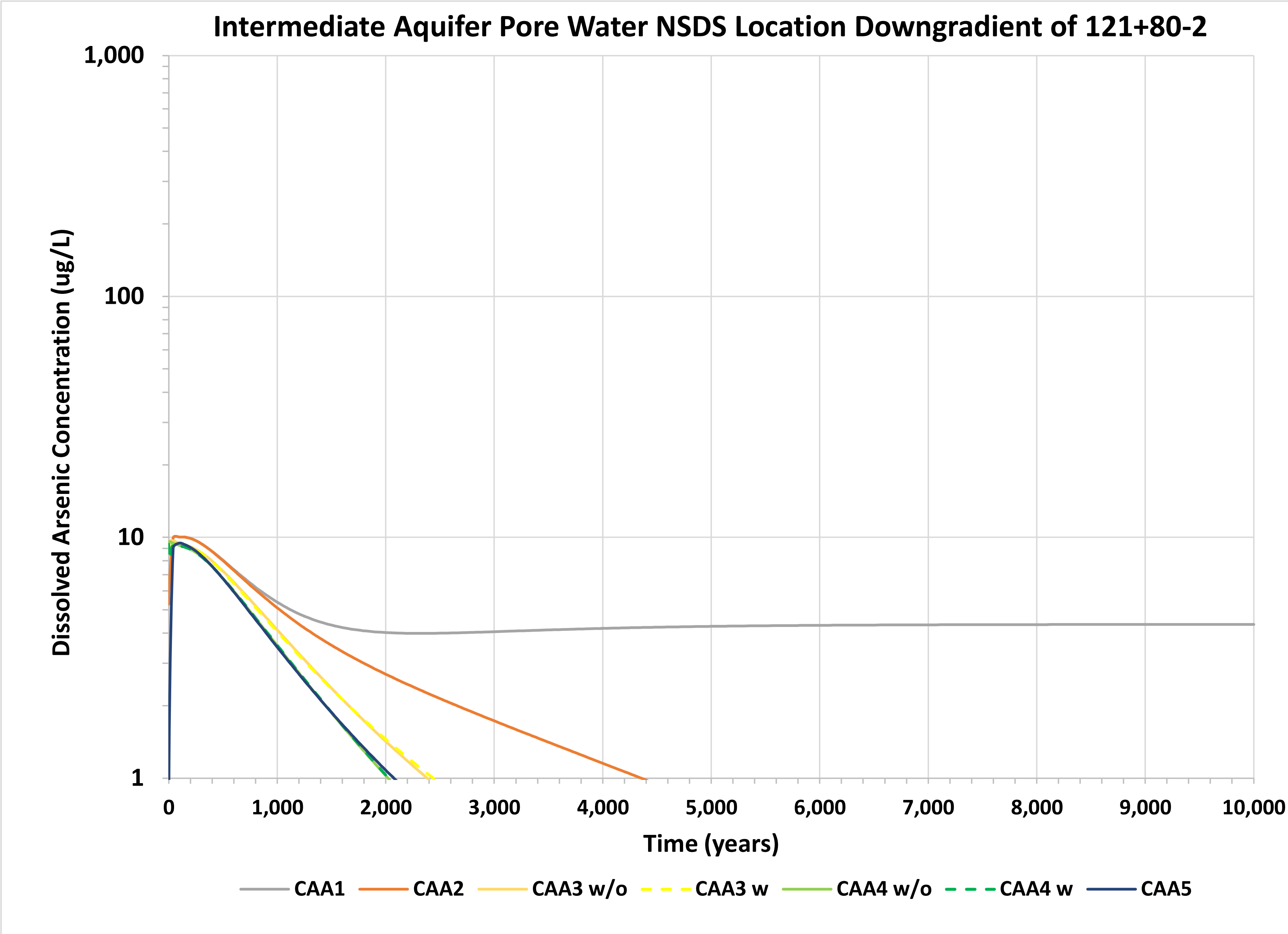


Upper Aquifer Pore Water NSDS Location Downgradient of 126+90-1
Dissolved Arsenic Concentration (ug/L)
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

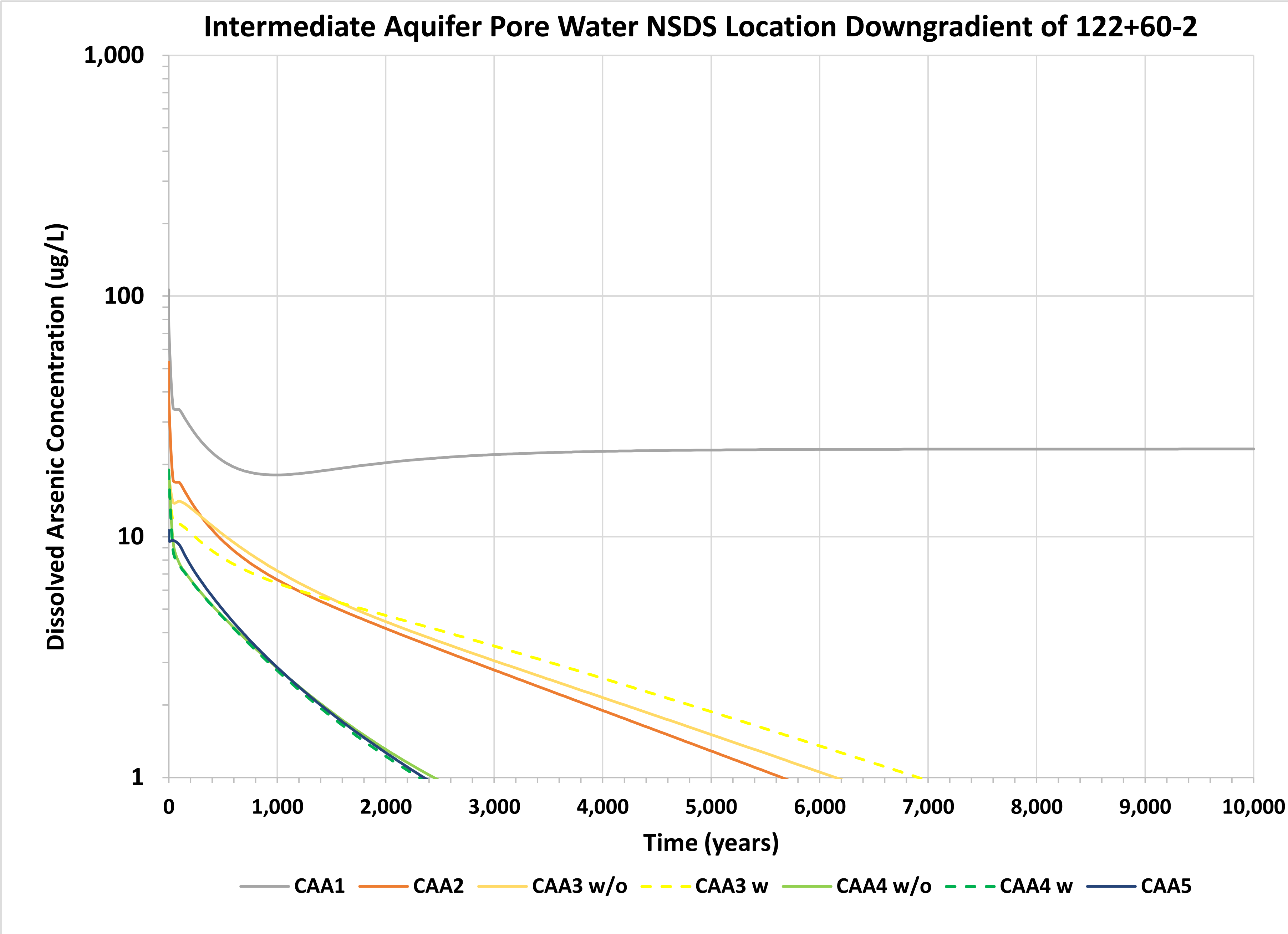

Upper Aquifer Pore Water NSDS Location Downgradient of 128+30-1
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5



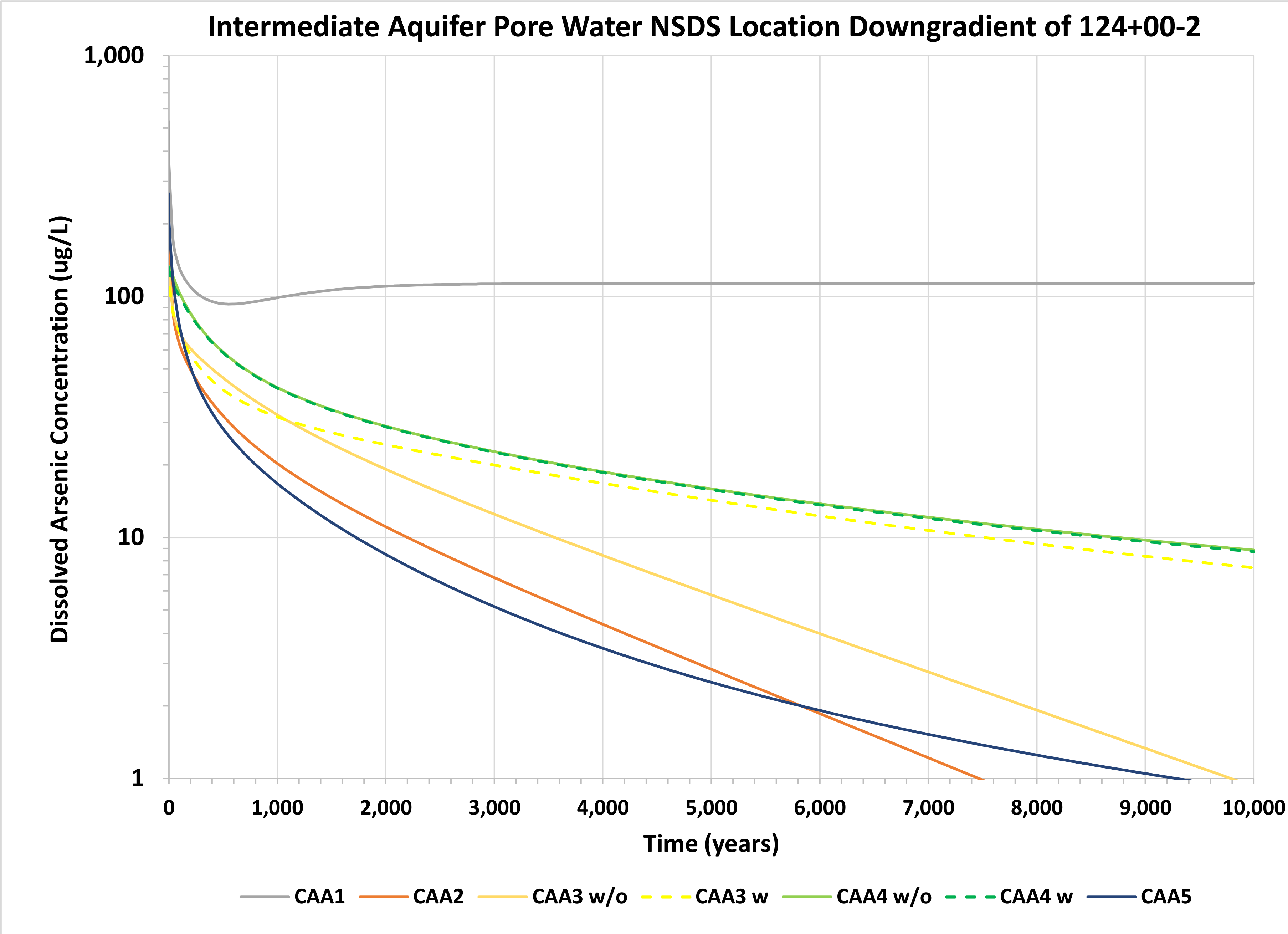
Intermediate Aquifer Pore Water NSDS Location Downgradient of 120+75-2
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Dissolved Arsenic Concentration (ug/L)
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5



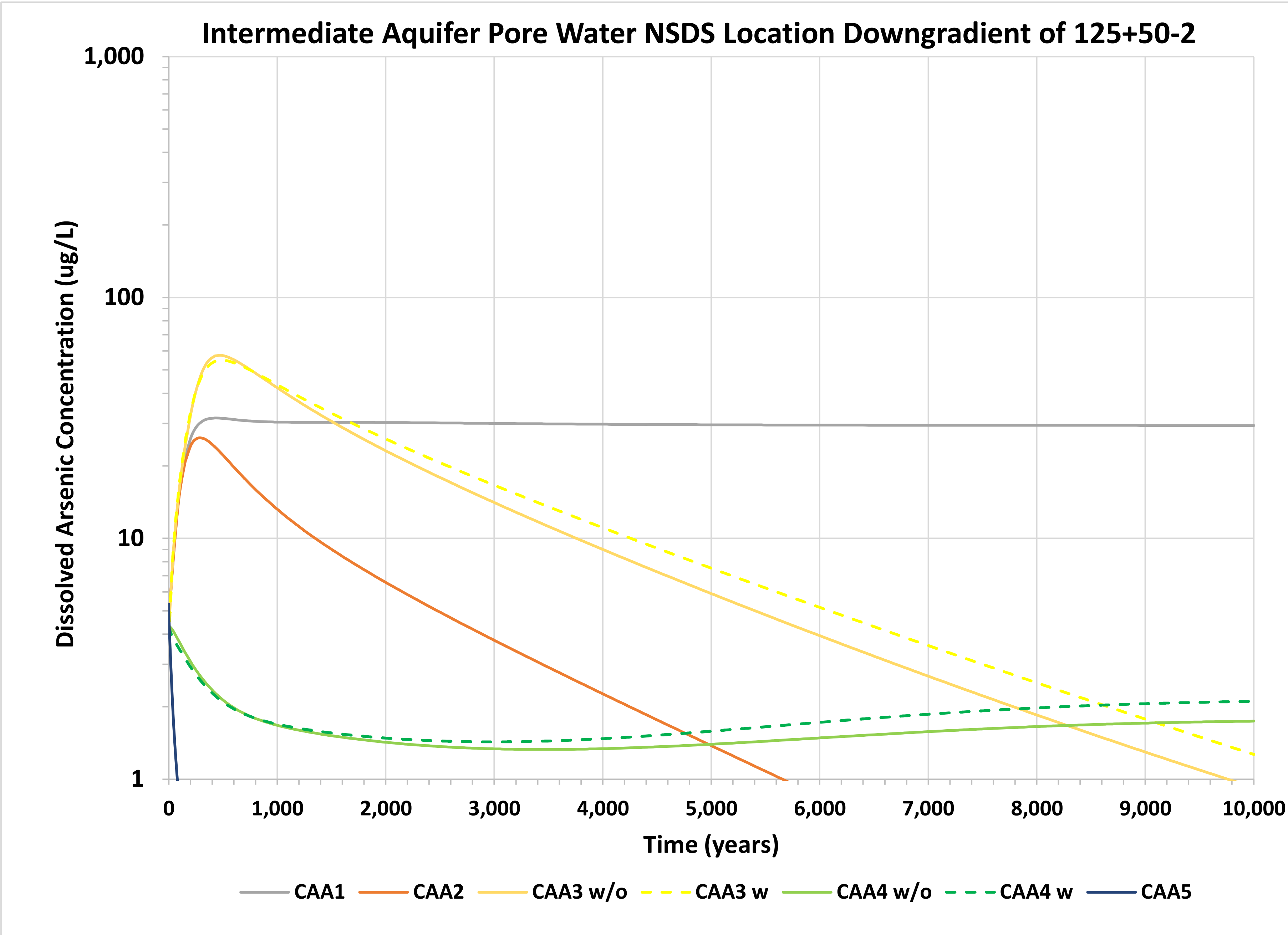
Intermediate Aquifer Pore Water NSDS Location Downgradient of 121+80-2
Dissolved Arsenic Concentration (ug/L)
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

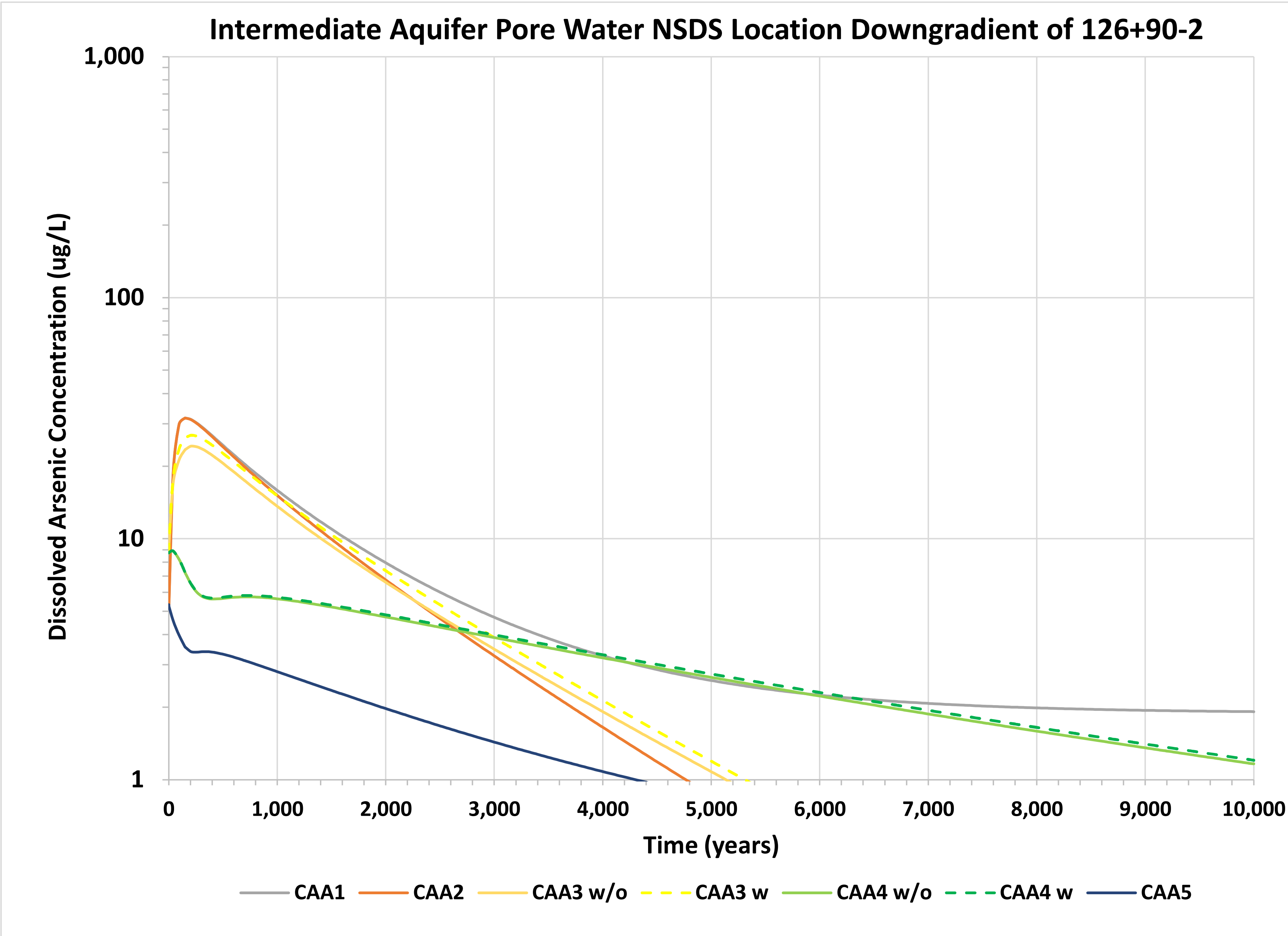


Intermediate Aquifer Pore Water NSDS Location Downgradient of 122+60-2
Dissolved Arsenic Concentration (ug/L)
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5

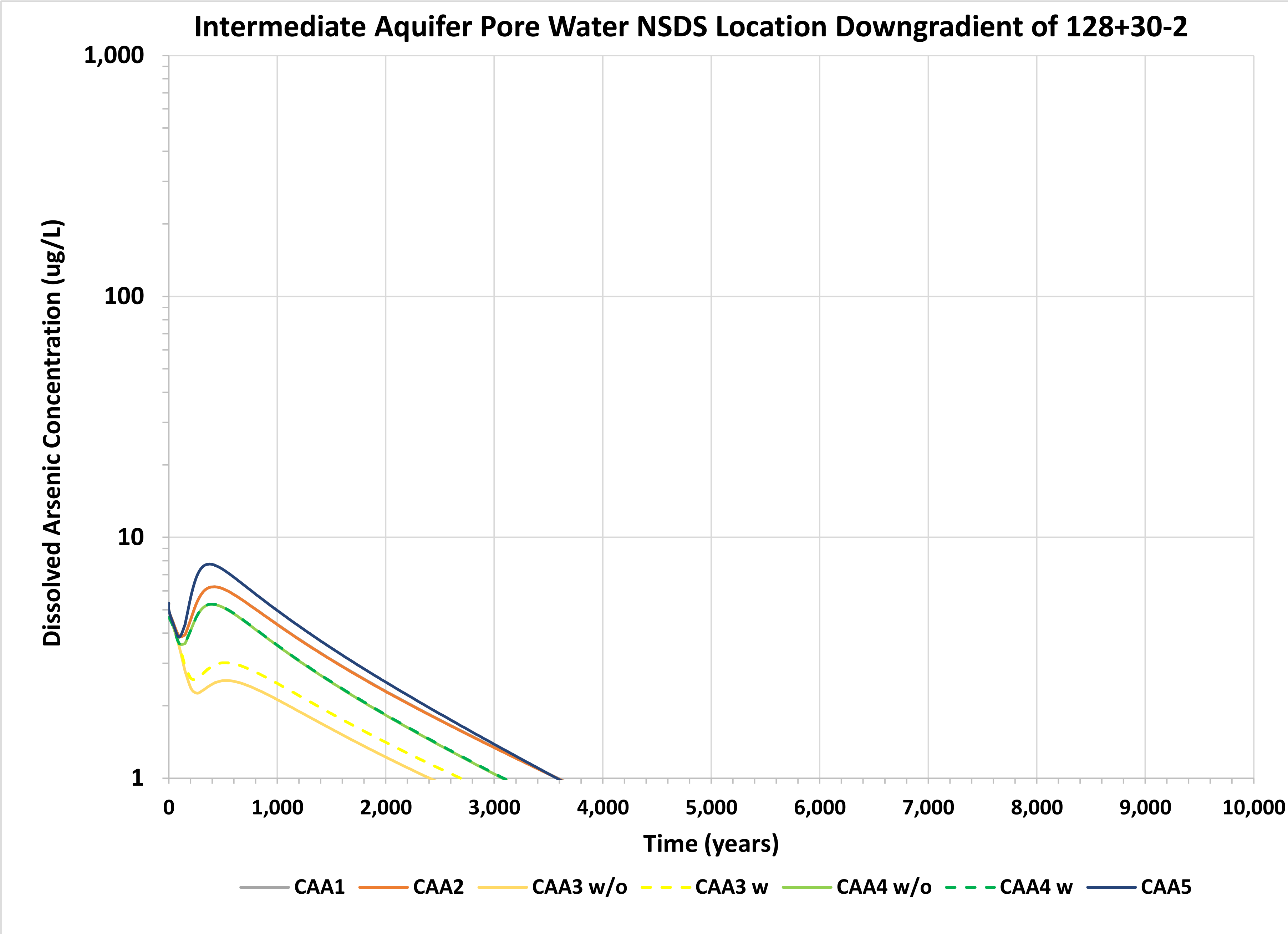


Intermediate Aquifer Pore Water NSDS Location Downgradient of 124+00-2
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5


Intermediate Aquifer Pore Water NSDS Location Downgradient of 125+50-2
1,000
100
10
1
Dissolved Arsenic Concentration (ug/L)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5



Intermediate Aquifer Pore Water NSDS Location Downgradient of 126+90-2
Dissolved Arsenic Concentration (ug/L)
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5


Intermediate Aquifer Pore Water NSDS Location Downgradient of 128+30-2
Dissolved Arsenic Concentration (ug/L)
1,000
100
10
1
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Time (years)
CAA1
CAA2
CAA3 w/o
CAA3 w
CAA4 w/o
CAA4 w
CAA5