RECORD OF DECISION

STANDARD CHLORINE OF DELAWARE SUPERFUND SITE
DELAWARE CITY, NEW CASTLE COUNTY, DELAWARE
OPERABLE UNIT 4

United States Environmental Protection Agency
Region 3
1600 John F. Kennedy Boulevard
Philadelphia, PA 19103-2852

May 2024

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TABLES

FIGURES

APPENDICES

LIST OF KEY ACRONYMS

AOC	Administrative order on consent
AR	Administrative Record
ARAR	Applicable or relevant and appropriate requirements
AST	Above ground storage tanks
CB	Chlorobenzene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Contaminant of Concern
COPEC	Chemical of potential ecological concern
COPC	Chemical of potential concern

CSM	Conceptual site model
DNAPL	Dense nonaqueous phase liquid
DNREC	Delaware Department of Natural Resources and Environmental Control
The EPA	The U.S. Environmental Protection Agency
EPC	Exposure point concentration
FS	Feasibility Study
GETS	Groundwater extraction and treatment system
HHRA	Human health risk assessment
HI	Hazard index
HQ	Hazard quotient
IGR	Interim groundwater remedy
µg/L	Microgram per liter
mg/kg	Milligram per kilogram
mg/L	Milligrams per liter
MCL	Maximum Contaminant Level
Metachem	Metachem Products, LLC
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
OU	Operable Unit
PCB	Polychlorinated biphenyl
RA	Remedial action
RAGS	Risk Assessment Guidance for Superfund
RAO	Remedial Action Objective
RD	Remedial design
RI	Remedial Investigation
ROD	Record of Decision
RSL	Regional Screening Level
SCD	Standard Chlorine of Delaware, Inc.
SLERA	Screening level ecological risk assessment
SVOC	Semivolatile organic compound
TI Waiver	Technical Impracticability Waiter
UCL	Upper confidence limit
UAO	Unilateral Administrative
UU/UE	Unlimited Use/Unrestricted Exposure
VOC	Volatile organic compound

RECORD OF DECISION

STANDARD CHLORINE OF DELAWARE SUPERFUND SITE
OPERABLE UNIT 4

I. DECLARATION

Site Name and Location

The Standard Chlorine of Delaware, Inc. Superfund Site (Site) is located at and near 745 Governor Lea Road in New Castle County, Delaware. Refer to Figure 1 for a map of the Site. The Site is in a heavily industrialized area of New Castle County, Delaware. The Site is approximately three miles northwest of Delaware City, Delaware, west of Route 9 (River Road) and south of Red Lion Creek. The footprint of the contaminated groundwater plume underlies approximately 145 acres of mixed developed and undeveloped upland areas and wetland, including a 23-acre fenced area that is the former location of a chlorobenzene manufacturing plant (Plant) that was owned and operated by Standard Chlorine of Delaware, Inc. (SCD) until December 1998, and then by Metachem Products, LLC (Metachem) until 2002. SCD and then Metachem owned approximately 63 acres (Property), which included the former Plant, a grass covered upland area, and wooded steep slopes and wetland. The National Superfund Database Identification Number for the Site is DED041212473.

Statement and Basis of Purpose

This Record of Decision (ROD) presents the U.S. Environmental Protection Agency's (EPA's) selected final remedial action for operable unit (OU) 4 of the Site (Selected Remedy) which was chosen in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended (CERCLA), 42 U.S.C. §§ 9601 et seq., and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 C.F.R. Part 300. The Selected Remedy addresses contaminated groundwater at the Site.

This ROD is based on the Administrative Record (AR) file for the Site, which was developed in accordance with Section 113(k) of CERCLA, 42 U.S.C. § 9613(k). The AR file is available for review online at https://semspub.epa.gov/src/collection/03/AR67435, at the EPA Region 3 Records Center in Philadelphia, Pennsylvania, and at the Delaware City Public Library in Delaware City, Delaware. The AR file index (Appendix A) identifies each document contained in the AR file upon which the selection of the Selected Remedy is based. The signed ROD will become part of the AR for the Site.

Assessment of the Site

The Selected Remedy is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

Identification of Operable Units

The EPA has organized the cleanup work at the Site into four OUs (Operable Units) as follows:

- **OU1:** Interim action for groundwater, including a subsurface barrier wall and a groundwater extraction and treatment system (GETS). This remedy was constructed by the EPA.
- **OU2:** Final action for contaminated soil and sediment. OU2 is currently in the Remedial Design phase in preparation for implementation.
- **OU3:** Former facility area soils. The EPA constructed this remedy, and it is maintained by DNREC (Delaware Department of Natural Resources and Environmental Control).
- **OU4:** Final action for groundwater. This remedy will address both the shallow Columbia aquifer and underlying, deep Potomac aquifer.

The EPA selected a remedy for what are now known as OU1 and OU2 in a May 9, 1995 ROD for the Site, although that ROD did not refer to operable units. In 2004, the EPA issued a ROD Amendment to add a response action to address the bulk liquid chemicals to be removed from on-site aboveground storage tanks. In 2010, the EPA issued a ROD to select a final remedy for OU3. In 2016, the EPA issued Amendment No. 2 to the 1995 ROD modifying the remedy selected for OU2 and in 2022, the EPA issued Amendment No. 3 to the 1995 ROD selecting a final action for wetlands soil and sediment.

The components of OU1 will be merged with OU4 and become a part of the final groundwater remedy following the signature of this ROD.

Description of Selected Remedy

The Selected Remedy addresses exposure to Site-related groundwater contamination. The EPA has delineated the extent of the Site-related groundwater contamination through the Remedial Investigation/Feasibility Study (RI/FS). The primary contaminants of concern (COCs), as identified in the RI/FS, consist of benzene, numerous chlorobenzene compounds, carbon tetrachloride, toluene, polychlorinated biphenyls (PCBs), dioxins, and metals. Contamination occurs in the shallow Columbia aquifer and deep Potomac aquifer.

The Selected Remedy consists of continued operation of the GETS that was constructed as part of the OU1 Interim Groundwater Remedy (IGR). The IGR is comprised of a subsurface bentonite-clay barrier wall and a GETS to provide hydraulic containment in the vicinity of the former Plant. The area enclosed by the subsurface barrier wall and pumped by the GETS is known as the containment area.

The Selected Remedy also includes ongoing enforcement of Institutional Controls (ICs). A Groundwater Management Zone (GMZ) was established under DNREC authority in an April 2008 Memorandum of Agreement between DNREC's Division of Water and Division of Waste & Hazardous Substances. The GMZ prohibits the installation of new groundwater extraction wells within the area impacted by Site-related groundwater contamination. In 2017 the EPA placed a Notice of Contamination on each of the parcels comprising of the Property to restrict land use. The Notice of Contamination restricts the following activities: installation of groundwater wells or use of groundwater at the Property; any land use other than commercial, light industrial, or open space; any activity that impacts the integrity of remedial components, including but not limited the cap cover system, gas collection and treatment system, stormwater management features, groundwater extraction wells and treatment components, monitoring wells, and subsurface barrier wall; and any construction of buildings on the Property without prior written approval from the EPA. This Notice of Contamination will continue to apply to the Selected Remedy to protect the integrity of infrastructure associated with the Selected Remedy.

In addition to continuation of the actions from the OU1 IGR, the Selected Remedy for OU4 will also include the following new components:

- Expanded groundwater extraction and treatment in the Columbia aquifer north of the containment area;
- A metal sheet pile wall to the north of the containment area to direct groundwater flow toward the new groundwater extraction and treatment system;
- Expansion of groundwater extraction and treatment into the Potomac aquifer;
- An expanded treatment system to handle the increased volume of extracted groundwater, and
- Institutional Controls (ICs). Any future acquisition of the Property must incorporate deed restrictions outlined in the 1995 ROD, the 2010 Operable Unit 3 ROD, and the 2022 Operable Unit 2 ROD Amendment that identify the extent of groundwater contamination and the areas containing contaminated subsurface soils, as well as adhere to other ICs related to use and access restrictions necessary to protection human health, including restricting land and groundwater uses, protecting the integrity of the remedial system components, and preventing construction without prior written approval from the EPA.

This Selected Remedy also includes a Technical Impracticability Waiver evaluation (TI Waiver). A TI Waiver is a subsection of the ROD (included as Appendix D of this ROD) that identifies areas that cannot meet cleanup standards (primarily groundwater Maximum Contaminant Levels [MCLs] in the case of this Site) from an engineering perspective because there is no viable technology to remediate the contamination to the stated cleanup standards. Because of dense non-aqueous phase liquid (DNAPL) beneath portions of the Site, groundwater in the immediate vicinity of that DNAPL will continuously be re-contaminated even if the groundwater is remediated. Removal or destruction of principal threat DNAPL source material is not feasible from an engineering perspective given the depth and scale of DNAPL distribution onsite. For this reason, this ROD establishes a TI Waiver for areas where (a) DNAPL is present, and where (b) due to engineering impracticability, the DNAPL cannot feasibly be removed or treated. When and if additional technologies become available, the EPA may evaluate the feasibility of additional response actions to further address the DNAPL in the TI Waiver zones. A full explanation and maps depicting where the TI Waiver zones are is provided in the EPA's TI Waiver (Appendix D).

The estimated present worth of total costs over a 30-year period for this remedial action is $23,010,225.

<u>Statutory Determinations</u>

The Selected Remedy is protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action (except the areas waived by the TI Waiver that cannot meet MCLs due to engineering impracticability), is cost-effective, and utilizes permanent solutions to the maximum extent practicable.

This Selected Remedy satisfies the preference for treatment as a principal element of the remedy which permanently and significantly reduces the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants.

Because this Selected Remedy will result in hazardous substances remaining onsite above levels that allow for unlimited use and unrestricted exposure (UU/UE), a review will be conducted within five years after commencement of the remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment. Such reviews will be conducted a minimum of every five years thereafter, until the EPA determines that hazardous substances remaining at the Site do not prevent UU/UE.

ROD Data Certification Checklist

The following information is included in the Decision Summary (Part 2) section of this ROD. Additional information can be found in the AR file for the Site.

ROD CERTIFICATION CHECKLIST	
Information	**Location/Page Number**
Contaminants of Concern (COCs) and their respective concentrations	Table 1, Page 43
Baseline risk represented by the COCs	Page 18
Cleanup levels established for COCs and basis for these levels	Table 1, Page 43
How source materials constituting principal threats are addressed	Page 32
Current and reasonably anticipated land use assumptions and current and potential future beneficial uses of groundwater used in the baseline risk assessment and ROD	Page 17
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Estimated capital, annual operation and maintenance (O&M), and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected	Page 35
Key factors that led to selecting the remedy	Page 35

Authorizing Signature

This ROD documents the Selected Remedy for OU4 of the Site. The EPA selected this remedial action with the concurrence of DNREC.

PAUL LEONARD Digitally signed by PAUL LEONARD
Date: 2024.05.21 11:23:41 -04'00'

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Paul Leonard, Director
Superfund and Emergency Management Division
EPA Region 3

RECORD OF DECISION
STANDARD CHLORINE OF DELAWARE SUPERFUND SITE
OPERABLE UNIT 4

II. DECISION SUMMARY

1. Site Name, Location and Description

The Site is located on Governor Lea Road in New Castle County, Delaware. Refer to Figure 1 for a map of the Site. The National Superfund Database Identification Number for the Site is DED041212473. The EPA Region 3 is the lead agency for the Site, and DNREC is the support agency.

The Site is in a heavily industrialized area of New Castle County, Delaware. The Site is approximately three miles northwest of Delaware City, Delaware, west of Route 9 (River Road) and south of Red Lion Creek. The EPA defines the boundaries of a Superfund site as the location of the release(s) of hazardous substances and wherever hazardous substances have come to be located. This includes any associated plume of contaminated groundwater. The footprint of the contaminated groundwater plume underlies approximately 145 acres of mixed developed and undeveloped upland areas and wetland, including a 23-acre fenced area that is the former location of a chlorobenzene manufacturing plant (Plant) that was owned and operated by Standard Chlorine of Delaware, Inc. (SCD) until December 1998, and then by Metachem Products, LLC (Metachem) until 2002. SCD and then Metachem owned approximately 63 acres (Property), which included the 23 acres on which the former Plant was situated, a grass covered upland area, and wooded steep slopes and wetland.

The plume of contaminated groundwater consists of the following contaminants of concern (COCs):

- Numerous chlorobenzene compounds
- Benzene
- Carbon Tetrachloride
- Chloroform
- Toluene
- PCBs
- Dioxins
- Various metals

A chemical-specific list of COCs is provided in Table 1.

Figure 2 maps the extent of the groundwater plume for chlorobenzene, which is the most widespread contaminant. Because other COCs are generally collocated with the chlorobenzene plume, Figure 2 serves as a useful visual to approximate the extent of Site-related contamination.

2. Site History and Enforcement Activities

SCD and Metachem manufactured chlorobenzenes (or CBs) at the Plant from 1966 to 2002 by combining chlorine and benzene, reacting and distilling them at high temperature, and preparing and storing them onsite prior to sale. Some of the CBs were stored in heated aboveground storage tanks (ASTs).

Leakage from pipes and ASTs throughout the Plant drained to Catch Basin #1. A crack in the concrete base of Catch Basin #1 was discovered and repaired in March 1976. The crack resulted in CBs leaking into the subsurface soil and underlying groundwater for an unknown period.

Bulk liquid CBs were often transported offsite by rail for commercial sale. An uncontrolled release of over 5,000 gallons of mono chlorobenzene occurred in September 1981 in the rail car loading area on the west side of the Plant and a drainage ditch. Under the supervision of DNREC, SCD collected a portion of the spilled chemicals and removed contaminated surface soils from the spill area. A limited groundwater investigation revealed the presence of multiple types of chlorinated benzene compounds. SCD then installed a series of recovery wells to capture and treat contaminated groundwater. These wells were brought online in 1986, though they reportedly were shut down repeatedly. The wells were shut down permanently in 2003.

In 1986, an AST collapsed, which resulted in the release of CBs and caused other tanks to fail. The 1986 release totaled over 569,000 gallons of di- and trichlorobenzenes. Following the 1986 release, which impacted soil and sediment in adjacent stream valleys and wetlands, SCD used heavy equipment to collect as much of the spilled CBs as practicable. SCD conducted initial recovery efforts including using wet dredging and a flexible hose to direct contaminated dredge spoils into a lined sedimentation basin constructed just north of the Plant's fence. Contaminated soils were also stored in waste piles next to the wetland. The 1981 and 1986 releases of CB compounds and the resulting contamination of soils, sediments and groundwater led to the listing of the Site on the National Priorities List (NPL) in 1987. An Administrative Order on Consent (AOC) between DNREC and SCD requiring the performance of a Remedial Investigation (RI)/Feasibility Study (FS) by SCD at the Site was issued on January 12, 1988 and amended November 14, 1988.

The objectives of the initial RI, completed in 1992, were to characterize Site conditions, determine the nature and extent of contamination, and assess risks to human health and the environment related to the soils. This initial RI concluded there was a large quantity of DNAPL in the soils of the vadose zone (the zone of unsaturated soils above the water table) and the saturated zones beneath the former Plant. For many years this DNAPL was the source of the plume of dissolved phase CBs originating beneath the Plant and flowing northward in the Columbia aquifer until it discharged into Red Lion Creek and the surrounding wetland. Most of this discharge was cut off by the EPA's installation of a subsurface barrier wall in 2007 as part of the OU1 IGR.

Based on the conclusions of the 1992 RI and the 1995 FS, the EPA issued a ROD for the Site on March 9, 1995. Subsequently, on May 30, 1996, the EPA issued a Unilateral Administrative Order (UAO) for a Remedial Design/Remedial Action (RD/RA) for the Site cleanup.

The COCs identified in the 1995 ROD included benzene, numerous CBs, and toluene. Subsequent investigations identified PCBs, meta-chloronitrobenzene, dioxins, and metals as Site-related contaminants, in addition to the COCs listed in the 1995 ROD.

The remedy selected in the 1995 ROD consisted of two components: an interim remedy for groundwater (IGR) (now identified as OU1) and a final action for spill pathway soils and sediments (now identified as OU2). The IGR required containment of groundwater to minimize continued releases of contaminants. The IGR also required pumping and treating groundwater within the containment area. The 1995 remedy selected for spill pathway soils and sediments was treatment, by either bioremediation or a contingent remedy of low temperature thermal desorption. The remedy also required ICs including deed restrictions and a GMZ.

In December 1998 the Property, including the Plant, was sold to Metachem Products, LLC (Metachem). While operating the Plant, Metachem continued RD activities, including bioremediation treatability studies for addressing contaminated sediments in the OU2 wetland. Metachem submitted the results of a bioremediation study to the EPA in spring of 2001. Based on the results of the bioremediation treatability study, the EPA determined that bioremediation was unlikely to remediate all the contaminated soil and sediment to the performance standards established in the 1995 ROD and began conversations with Metachem to initiate the contingent remedy selected in the 1995 ROD.

The EPA's Removal Action

Metachem filed for bankruptcy on May 10, 2002, and abandoned the Property on May 14, 2002 to the custody and control of the EPA and DNREC. From 2002 through 2006, the EPA and DNREC completed an emergency removal action that included the sale and disposal of hazardous chemicals, decontamination of process equipment, and oversight of the dismantlement of the former Plant. The EPA issued a ROD Amendment in 2004 implementing offsite thermal treatment (incineration) as the remedy for bulk liquid wastes left onsite following abandonment of the Plant. In 2008, the EPA issued an Explanation of Significant Differences to expand the volume of materials to be sent for offsite incineration. There are no original structures remaining from the former Plant.

The EPA's Remedial Actions

The EPA completed construction of the OU1 IGR in 2007. This interim remedy, as described in the 1995 ROD, included the installation of a subsurface barrier wall surrounding the upland portion of the Site. This subsurface barrier wall is comprised of a 36-inch-wide soil and bentonite mix with an average depth of approximately 60 feet below ground surface. The bottom of the wall is keyed into a naturally occurring impermeable clay layer that separates the shallow Columbia aquifer from the deeper Potomac aquifer. DNREC created a GMZ for the Delaware City Industrial Area, including the area surrounding the Site, in April 2008. This IC, called for in the 1995 ROD, places restrictions on the installation of potable and industrial wells within the GMZ to prohibit the use of contaminated groundwater.

In September 2010 the EPA issued a ROD for OU3 addressing the contamination in the vadose zone soils (soils above the water table) and soil gas in the former Plant area through capping, active soil gas collection and treatment, and ICs to restrict future land use. In a 2011 memorandum to the Site file, the EPA modified the 2010 ROD to include soils in the sedimentation basin under the OU3 remedial action. In February 2016, the EPA issued an amendment to the 1995 ROD (2016 ROD Amendment) to address the OU2 waste pile soils that were temporarily staged in the upland area north of the Plant; these waste pile soils were remnants of the original spill response conducted by SCD after the 1987 spill. The remedy selected in the 2016 ROD Amendment was to place OU2 waste pile soils underneath the OU3 Cap.

The EPA completed construction of the OU3 selected remedy in 2017. A 23-acre multi-layer soil and geosynthetic material cap with active soil gas collection and treatment was constructed over the former Plant area and sedimentation basin. The active soil gas collection and treatment system captures soil gas volatilizing from the soil and treats it using granular activated carbon prior to venting it to the atmosphere. The objectives of the OU3 remedial action are to prevent exposure to contaminated soil and soil gas through inhalation, ingestion, or dermal contact; minimize risks to ecological communities exposed directly to the contaminated soil and indirectly via bioaccumulation of contaminated soil in plants and animals; and minimize the further spread of contamination to groundwater, surface water, sediment, and air. The impermeable cap and soil gas collection system prevents vapors from emitting into the atmosphere and prevents surface water from infiltrating through the contaminated soil. DNREC assumed the long-term operation and maintenance of the OU3 remedy in 2018. Figure 1 shows the location of the OU1 subsurface barrier wall and OU3 cap. The area under the OU3 cap was designated as a Waste Management Area (WMA), which is an engineering control prohibiting disturbance and requiring control of contaminated media in that area. In 2017, the EPA placed a Notice of Contamination on each of the parcels comprising of the Property to restrict land use. The Notice of Contamination restricts the following activities: installation of groundwater wells or use of groundwater at the Property; any land use other than commercial, light industrial, or open space; any activity that impacts the integrity of remedial components, including but not limited the cap cover system, gas collection and treatment system, stormwater management features, groundwater extraction wells and treatment components, monitoring wells, and subsurface barrier wall; and any construction of buildings on the Property without prior written approval from the EPA.

The EPA issued a ROD Amendment in September 2022 amending the final remedy for OU2. The remedy selected in the 2022 ROD Amendment includes excavating shallow sediment contaminated with COCs to a depth of two feet; excavating deeper sediment contaminated with primary COCs at concentrations indicative of source material to depths practicable; excavating soil in upland areas contaminated with primary COCs to a depth of seven feet; treating all material onsite with low temperature thermal desorption to achieve preliminary remediation goals for all COCs; metals stabilization as necessary; amending the upper two feet of treated sediment with granular activated carbon and microbes; ICs to restrict land use; and long term monitoring of the wetland, Red Lion Creek, and fish tissue sampled from Red Lion Creek. The EPA is currently in the RD phase for the OU2 remedy.

3. Community Participation

Pursuant to Section 113(k)(2)(B) of CERCLA, 42 U.S.C. § 113(k)(2)(B), the RI/FS reports, the Proposed Plan, and other documents relating to the EPA's Preferred Alternative for OU4 were released to the public for comment on August 3, 2023. These documents were made available to the public online at https://semspub.epa.gov/src/collection/03/AR67435, and electronically at the EPA Administrative Records Room at the EPA's Region 3 office, and in the Delaware City Library in Delaware City, Delaware. The notice of availability of these documents was published in the *New Castle Weekly* on August 2, 2023, *Town Square Live* on August 7, 2023, *Middle Town Transcript* on August 10, 2023, and *Hoy en Delaware* in Spanish on August 23, 2023. A fact sheet detailing the Proposed Plan was mailed to local citizens on August 4, 2023. A public comment period was held from August 3, 2023 until

September 2, 2023.

The EPA held a public meeting at the Delaware City Library, located at 250 5th St. Delaware City, Delaware, 19706, on August 22, 2023 from 6–7:30 PM. During the public meeting, the EPA gave a formal presentation on the EPA's Proposed Plan, followed by a "Question and Answer" session where representatives from the EPA were available to answer any questions regarding the Site and the Proposed Plan. For RODs, responses to all significant comments received during the public comment period, including those raised at the public meeting, are provided in the Responsiveness Summary. The EPA did not receive any questions or comments about the EPA's Preferred Alternative at the public meeting, and the EPA did not receive any comments or questions during the public comment period.

4. Scope of the Selected Remedy

Scope of the Selected Remedy

Site-related groundwater contamination areally extends across approximately 145 acres in the Columbia and Potomac aquifers. The IGR eliminated immediate hazards to human health and the environment via containment. A GMZ was enacted to prohibit consumption of contaminated groundwater. As a part of the IGR, the EPA also installed a 60-foot-deep bentonite-clay subsurface barrier wall to contain contamination within the 23-acre Plant where most of the contamination resides. Six extraction wells and a GETS were implemented to extract and treat contaminated groundwater from within this containment area. The IGR has been in operation since 2007 and has resulted in significant decreases in COCs in the Columbia aquifer north of the subsurface barrier wall. Operation of the IGR will continue under OU4.

While the IGR contains contamination in the vicinity of the former Plant, it does not directly treat contamination in the Potomac aquifer or in the Columbia aquifer beyond the boundaries of the subsurface barrier wall. The Selected Remedy will address contaminated areas of the Columbia aquifer beyond the reach of the existing IGR by expanding groundwater extraction and treatment into those areas and by installing a metal sheet pile wall to direct groundwater flow toward these new extraction wells. The Selected Remedy will also address contamination in the Potomac aquifer with new groundwater extraction wells. An expanded treatment system will be built to handle additional volume of extracted groundwater. Design specifics will be determined during the RD.

Technical Impracticability Waiver

A Technical Impracticability Waiver (TI Waiver) is a document that identifies areas that cannot meet cleanup standards (primarily groundwater MCLs, in the case of this Site) because there is currently no viable technology to remediate the contamination to the stated cleanup standards. Because DNAPL serves as a continuous principal-threat source material, remediated groundwater in the immediate vicinity of sub-surface DNAPL source pools will become re-contaminated by continual dissolution. While the EPA can locate and remediate some DNAPL areas, the EPA cannot effectively remediate all the potential DNAPL pools. For this reason, this ROD includes a TI Waiver for the areas of the Site where: (a) DNAPL is present, and (b) due to engineering impracticability, the DNAPL cannot feasibly be removed or treated. A full explanation is provided in the EPA's 2023 TI Waiver (included as Appendix

D). The nature and extent of DNAPL contamination was characterized in the RI/FS, based on sampling results and visible presence of DNAPL.

Within these TI Waiver zones, applicable or relevant and appropriate requirements (ARARs) are waived because they cannot feasibly be met from an engineering perspective. The TI Waiver zones are limited to the locations within the former Plant and adjacent areas with significant DNAPL concentration in the Columbia aquifer and the Potomac 'A' sands down to 120 feet below mean sea level.

The TI Waiver zones include the following areas that currently have groundwater contamination above MCLs: the Columbia and Potomac aquifers within and underlying the OU1 subsurface barrier wall but outside the footprint of the OU3 cap; the Columbia and Potomac aquifer in the vicinity of the drainage gulley on the west side of the Property; the Columbia aquifer adjacent to the subsurface barrier wall in the vicinity of the Former Air Products Facility at the southwest corner of the Property; the Columbia aquifer underlying the steep wooded area to the north of the OU1 subsurface barrier wall; the Potomac aquifer underlying the foot of the steep wooded area north of the former Plant in the vicinity of Red Lion Creek; and the Potomac aquifer immediately to the east of the OU1 subsurface barrier wall. The locations of these TI Waiver zones are shown in the figures included in Appendix D.

Within the TI Waiver zones, contamination will be contained via the expansion of the GETS to prevent further migration, and ICs (including the GMZ, Notice of Contamination, and deed restrictions to protect the integrity of the remedial components in the case of the sale of the Property) will continue to ensure no human health exposure above acceptable risk standards. ARARs will be met in all areas of the Site outside of the limited TI Waiver zones. If new remedial technologies become available, the EPA will evaluate the feasibility of additional response actions to further address the DNAPL in the TI Waiver zones.

5. Site Characteristics

The footprint of the contaminated groundwater plume underlies approximately 145 acres of mixed developed and undeveloped upland areas and wetland, including a 23-acre fenced area that is the former location of the chlorobenzene manufacturing plant. The surrounding Property is characterized by grass-covered upland area and wooded steep slopes dropping down to Red Lion Creek and wetland. A Site map is included as Figure 1.

Geology and Hydrogeology

There are two aquifers underlying the Site: the surficial Columbia aquifer, and the underlying Potomac aquifer. The Columbia aquifer is heavily impacted by contamination from the former Plant and other industrial activities in the area. Groundwater discharges from the Columbia aquifer into Red Lion Creek, and surface water in Red Lion Creek feeds into the Columbia aquifer. The Columbia and Potomac aquifers are separated by clays of the Merchantville Formation and upper Potomac Formation, which act as geological confining units. These clays are thin or absent in some areas beneath the Site, allowing Site-related contamination to migrate downward into the Potomac aquifer. Site-related contamination has been found in wells screened in the upper portions the Potomac aquifer as deep as approximately 160 feet below ground surface on the Site. Groundwater in the Columbia aquifer at the Site flows north toward Red Lion Creek, which is just above sea level and was tidally influenced before the installation of a tide gate a mile downstream. Groundwater in the upper Potomac aquifer would naturally flow east toward the Delaware River; however, industrial pumping by the Delaware City Refinery results in a southward flow.

Nature and Extent of Contamination

The conceptual site model for the Site is based on groundwater sampling data and an understanding of the Site's geology. A diagram of the conceptual site model and more detailed characterization of Site contamination can be found in the RI/FS.

The primary contaminant releases at the Site were CBs in both liquid and solid forms. Liquid CBs, benzene, nitrobenzene, and other Site-related contaminants were released during the spills described in the Site History section of this ROD. These contaminants flowed over the surface in the following areas:

- In a drainage ditch at the south of the Site, flowing west past the former Air Products Property to an unnamed tributary of Red Lion Creek along the west side of the Property, and
- Across the former Plant area, exiting to the east and west through drainage features into the western, northern, and eastern wetlands, and into Red Lion Creek and its unnamed tributary in the western wetlands.

These spills resulted in liquid contamination leaching into the subsurface via the following transport mechanisms:

- Vertically through the soil vadose to the Columbia aquifer, primarily underlying the former Plant area;
- Horizontally within the Colombia aquifer toward Red Lion Creek, flowing primarily north with the direction of local groundwater;
- Vertically in the vicinity of the northern wetlands, where the confining clay layer is thin or absent in some areas and contamination reached the Potomac aquifer;
- Vertically within the Potomac aquifer, where the groundwater flows southward (the presiding direction of Potomac groundwater on the Site, due to industrial pumping south of the Site), and
- Vertically in areas below the vicinity of the former Plant and adjacent drainage gullies, leaching through thin and absent portions of the Merchantville clay layer and into the underlying Potomac aquifer.

The Columbia and Potomac aquifers were impacted by DNAPL contamination, including CBs, benzene, PCBs, and nitrobenzene in the same general areas. This DNAPL contamination spread via the same migration pathways described above. Most of DNAPL settled on the clay layer separating the Columbia aquifer and the Upper Potomac sands, on the clay intermingled with and underlying the Upper Potomac A-Sand, and in the wetland sediments and underlying matrix material. This DNAPL remains in place and continually dissolves, contributing to ongoing elevated levels of groundwater contamination.

CBs, benzene, nitrobenzene, and other Site-related contaminants were released from former Catch Basin 1 and the sedimentation basin. Because Catch Basin 1 was used as a settling basin to recover product from the Plant's wastewater, it was likely a source for sorbed product and DNAPL contamination in the subsurface.

Elevated levels of PCBs and dioxins were detected in soil near the western drainage gully, and in the Columbia and Potomac aquifers. The PCB Concentration Area was a functional area of the former plant that consolidated PCB wastes. Infiltration from these source areas led to groundwater contamination as demonstrated through data from groundwater sampling summarized in the RI/FS.

The acidification of Site soils due to operational releases of hydrogen chloride, migration onto the Property of contamination from an offsite 2001 sulfuric acid tank collapse spill, and corroded Plant equipment contributed to elevated levels of metals in Site groundwater.

6. Current and Potential Future Land and Resource Uses

As discussed above, the Property is currently under the custody and control of the EPA and DNREC and is only used for remedial activities undertaken by the EPA and its contractors. The Property surrounds a 35-acre grassy upland, which encompasses the former Plant, including the capped area that was installed as a part of OU3. These uplands are about 50 feet above sea level. A 100- to 200- yard-wide buffer of steep, wooded slope separates these uplands from Red Lion Creek, which drains into the Delaware River a mile downstream. Red Lion Creek was historically tidally influenced, but in recent years a tide gate at its mouth has limited tidal influence. The creek is bordered by a wetland vegetated primarily with dense phragmites, an invasive type of reed common in disturbed wetland habitats.

Nearby land use is agricultural and wooded with interspersed industrial properties, notably the Delaware City Refinery across Governor Lea Road a few hundred yards south of the Site. A small businesses complex borders the west side of the Property while the north and east sides of the Property are wooded. The closest residences are located on Hamburg Road nine tenths of a mile from the Site boundary.

The Potomac aquifer is the current source of drinking water for the Delaware City community. However, the GMZ prohibits the installation of potable water wells in the greater industrial area surrounding the Site, specifically, south of Red Lion Creek and between the Delaware River and Highway 1. This area includes the entirety of the SCD Site. The supply wells for the Delaware City municipal water system are not in danger of Site-related contamination. Outside of the GMZ to the north of Red Lion Creek there is three quarters of a mile of wooded and agricultural areas before reaching the first houses. These closest houses are hydraulically upgradient from Site-related contamination.

Future land use in this area is not expected to change from its current industrial use. Some additional industrial development may occur on adjacent properties. Because of the need to maintain the integrity of the Selected Remedies, there are limited options for development on the Property itself. Surface water may be used for future recreation including fishing once the current fish advisory (placed due to contamination coming from multiple area industrial sources, including Site-related groundwater contamination) is lifted. Once groundwater is remediated to cleanup standards, the Potomac and Columbia aquifers outside of the TI Waiver zones could be used for drinking water when and if the GMZ is removed.

7. Summary of Site Risks

During the OU4 RI, a baseline human health risk assessment (HHRA) and screening level ecological risk assessment (SLERA) were conducted to determine the current and potential future effects of contaminated groundwater on human and ecological health in the absence of any cleanup actions at the Site. A baseline risk assessment (before any cleanup) provides the basis for taking a remedial action and indicates the exposure pathway(s) that need to be addressed by the remedial action. This section summarizes the results of the HHRA and SLERA. For more detailed information on human and ecological health, refer to the RI.

a. Human Health Risk Assessment Summary and Identification of Contaminants of Concern

As part of the RI/FS process, the EPA conducted a baseline HHRA to estimate what risks the Site poses if no remedial action is taken. The HHRA provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. The HHRA evaluated the health effects associated with potential exposures to contamination in the Columbia and Potomac aquifers under an unrestricted land use scenario. While the GMZ encompasses the Site and surrounding area and prohibits the installation of new potable water wells in the area impacted by the Site, it is possible that a water supply well could be installed in areas affected by the Site's groundwater contamination in the future when and if groundwater is remediated to beneficial use.

Table 1 lists each COC, its measured exposure point concentration (EPC) during the RI/FS, and a cleanup level/performance standard for each COC.

The HHRA data demonstrate that if groundwater impacted by Site-related contaminants was used as a potable water source, such use would pose a substantial threat to human health. Based on the presented risks, it is expected that human health risk from groundwater exposure would exceed the acceptable Hazard Index (HI) and cancer risk values by substantial amounts. Remedial action is necessary to eliminate these unacceptable exposures. An explanation is provided in more detail below.

Identification of Contaminants of Concern

The selection of contaminants of potential concern (COPCs) is a risk-based screening step to identify chemicals that should be included in the quantitative risk assessment. The selection of COPCs was based on information regarding chemical substances found at the Site including chemical-specific concentrations, occurrence, distribution, and toxicity. COPCs include only those chemicals with positive detections and are limited to those chemicals that exceed the selection criterion. Screening levels were considered based on exposure assumptions for hypothetical future adult or child residents, commercial/industrial workers, and utility workers to be protective of all potential current and future Site uses. The COPCs identified in the HHRA and selected as COCs for this ROD are listed in Table 1.

Risk assessments are conducted using an EPC for each COPC. The EPC represents an estimated concentration to which a receptor is assumed to be continuously exposed while in contact with an environmental medium.

EPCs used in the HHRA are available in Table 1 of this ROD and in Table 3.1 in the RI.

Exposure Assessment

The exposure assessment portion of the risk assessment defines and evaluates the type and magnitude of human exposure to the chemicals present at or migrating from a site. The HHRA considered potential risk associated with hypothetical future residents, commercial/industrial workers, and utility workers. The risk to utility workers was not quantified because the risk posed to hypothetical residents bounds the upper-level risk for the utility worker. Exposure to chemicals via ingestion, dermal contact, inhalation while showering, and inhalation from VI were assessed for both hypothetical future residents and commercial/industrial workers. This was based on exposure from groundwater at the Site and its potential for future residential use. Except for inhalation of volatile contaminants via VI, risks to the commercial/industrial worker were not quantified because the hypothetical resident risks bound the upper-level risk to the worker group.

The maximum detected concentration of each analyte was compared to the current tap water Regional Screening Level (RSL) based on a cancer risk of 1E-06 or noncancer hazard quotient (HQ) of 0.1, whichever was lower. For lead, the DNREC screening value of 5 micrograms per liter (µg/L) was used. Chemicals with maximum detections greater than the screening values were retained as COPCs.

The Site-wide groundwater dataset encompasses as many as 835 samples. To facilitate the calculations and to minimize the potential for results of distal wells to decrease the exposure point concentration relative to the plume center, the EPCs were generally calculated from the historical data for the well with the maximum detection. If the well had fewer than 6 detections, then the maximum detection was used as the exposure point concentration. Otherwise, ProUCL Version 5.00.00 was used to calculate the 95 percent upper confidence limit of the mean concentration for the well.

Toxicity Assessment

The toxicity assessment for the COPCs examines information concerning the potential human health effects of exposure to COPCs. The goal of the toxicity assessment is to provide a quantitative estimate of the relationship between the magnitude and type of exposure and the severity or probability of human health effects for each COPC. Toxicity values (e.g., reference doses, reference concentrations, cancer slope factors, and inhalation unit risks) were obtained from various sources, the EPA and non-EPA, in accordance with the hierarchy outlined in Office of Solid Waste and Emergency Response Directive 9285.7-53. If a value was not found in any of the sources listed in this directive, the value listed in the RSL tables was used.

The toxicity values applied in the HHRA can be found in Table 2 or Attachment E.1.1. of the RI.

Risk Characterization

The EPA sets a target risk range of no greater than 10^{-4} to 10^{-6} for a lifetime excess carcinogenic risk. An excess lifetime cancer risk means the acceptable risk to an individual of developing cancer from exposure over a lifetime to carcinogens at a Site is between 10,000 to 1 (10^{-4}) and 1,000,000 to 1 (10^{-6}). For non-carcinogenic contaminants, the EPA sets a target Hazard Index (HI) of no greater than 1. The hazard quotient (HQ) measures the risk posed by each exposure pathway (i.e., inhalation, ingestion, and dermal contact) of a single non-carcinogenic contaminant at a site, while the HI is the sum of all of the HQ values for the respective receptor (e.g. a future child or adult resident, an industrial or commercial worker, or a utility worker).

The COCs identified in the HHRA include various metals, volatile organic compounds (VOCs), semi volatile organic compounds (SVOCs), PCBs, and dioxins/furans. A chemical-specific list of each COC and its cleanup level/performance standard is provided in Table 1.

b. Ecological Risk Assessment Summary and Identification of Contaminants of Concern

A SLERA was conducted to evaluate the potential effects of groundwater contaminant discharge on ecological receptors. Columbia aquifer groundwater discharges into the transition zone and surface water at the northern portion of the Site, including to Red Lion Creek. The SLERA evaluated potential effects of groundwater contaminants on two communities: organisms that live in the transition zone (hyporheic community) through which groundwater contaminants flow as they are discharged to surface water; and upper trophic level receptors that could consume fish or invertebrates that were exposed to the groundwater contaminants.

Hyporheic Community Receptors

Chemicals detected at concentrations greater than the screening values were retained as chemicals of potential ecological concern (COPEC) and evaluated further. For these COPECs, the 95 percent UCL of the mean concentration was calculated using ProUCL, Version 5.00.00. The SLERA was used to determine which contaminants may pose a threat to the hyporheic community and were selected as COCs for ecological receptors. These COCs include metals, VOCs, SVOCs, PCBs, dioxins, and furans. The COCs for hyporheic community ecological receptors and their cleanup levels are listed in Table 1.

Evaluation of potential ecological risks is inherently uncertain. There is uncertainty as to whether the dataset represents chemical concentrations to which ecological receptors would be exposed. The extent of attenuation that occurs between the monitoring wells (where concentrations are measured) and discharge points is uncertain. For this reason, use of the groundwater results to estimate exposure by ecological receptors is generally conservative.

Upper Trophic Level Receptors

To evaluate potential effects to upper trophic level receptors from groundwater contaminant discharge to surface water, a representative fish-eating bird, the Belted Kingfisher, was used. A food web model used the maximum detected concentration of each bioaccumulative chemical to calculate a daily dose and compared this dose to the No Observed Adverse Effects Level. The ecological quotients that exceeded 1 for bioaccumulative chemicals were retained as food web COPECs. Use of the maximum groundwater detection to represent contaminant discharge to Red Lion Creek is conservative, due to natural attenuation between monitoring wells (where concentrations were measured) and discharge points. To provide a more realistic assessment, the 95 percent UCL of the mean concentration for each upper trophic level COPEC was used as the EPC. Ecological quotients were calculated using the EPCs, and COPECs with ecological quotients exceeding 1 were retained as COCs. COCs and their cleanup levels for upper trophic level receptors are listed in Table 1.

c. Basis for Remedial Action

In summary, the HHRA evaluated the potential health effects associated with use of the contaminated groundwater from the Columbia and Potomac aquifers as a potable water source, and the potential exposure to VOCs via the vapor intrusion pathway. If used as a potable water source, Site-related contaminants in both the Columbia and Potomac aquifers would pose a threat to human health. The SLERA determined that contaminants in groundwater pose an unacceptable risk to hyporheic and upper trophic level ecological receptors.

The EPA determined that remedial actions are necessary to reduce the risks to within or below the EPA's acceptable risk range. Therefore, it is the EPA's determination that implementation of the Selected Remedy for OU4 is necessary to protect human health from current and future exposure through ingestion of drinking water at the Site and to reduce unacceptable risk to ecological receptors.

8. Remedial Action Objectives

Remedial Action Objectives (RAOs) are specific goals to protect human health and the environment. RAOs provide general descriptions of what the cleanup is designed to accomplish and help guide the alternative evaluation process. The following RAOs have been developed for OU4:

Remedial Action Objectives for Human Health

- Prevent exposure to Site-related groundwater contamination, including DNAPL in the Columbia and Potomac aquifers, that would result in a target organ HI greater than 1 for non-carcinogens in the groundwater via the potential exposure routes of inhalation, ingestion, and dermal absorption.
- Prevent exposure to Site-related carcinogens in groundwater at concentrations that would result in a cumulative cancer risk that exceeds 1×10^{-4} (1E-04) via the potential exposure routes of inhalation, ingestion, and dermal contact.
- Restore the Columbia and Potomac aquifers where groundwater is impacted by Site-related contaminants to their maximum beneficial use as sources of potable water in those areas outside of the proposed TI Waiver zones.

These human health-related RAOs will prevent human exposure to Site-related groundwater contamination, thereby eliminating that exposure pathway.

Remedial Action Objective for Environmental Protection

- Reduce risks to ecological receptors exposed to Site-related groundwater contamination by reducing contamination in the Columbia aquifer to the ecological cleanup levels explained in

Section 7 and listed in Table 1 of this Record of Decision.

Remedial Action Objectives for Limiting Further Migration of Contaminants

- Minimize the further spread of contamination via any of the following major migration pathways:
  - DNAPL to groundwater
  - Groundwater from the Columbia aquifer to the Potomac aquifer
  - Groundwater to sediment
  - Groundwater to surface water
  - Groundwater to soil gas
- Treat principal threat waste to the extent practicable.

The RAOs to limit migration of contaminants will ensure contamination at an unacceptable risk does not migrate outside of the WMA and TI Waiver zones. Because ICs will prevent exposure within the WMA and TI Waiver zones, containing contamination from spreading beyond those areas will eliminate all other unacceptable exposure pathways. These RAOs will be achieved by reducing the volume, toxicity, and mobility of Site-related contamination via the GETS, metal sheet pile wall, and subsurface barrier wall described in the Selected Remedy.

9. Summary of Remedial Action Alternatives

CERCLA Section 121, 42 U.S.C. § 9621, mandates that remedial actions be protective of human health and the environment, cost-effective, comply with ARARs, and use permanent solutions and alternative treatment technologies and resource recovery alternatives, to the maximum extent practicable. Section 121(b)(1) also establishes a preference for remedial actions which employ, as a principal element, treatment to permanently and significantly reduce the volume, toxicity, or mobility of the hazardous substances, pollutants and contaminants at a site. CERCLA Section 121(d), 42 U.S.C. § 9621(d), further specifies that a remedial action must attain a level or standard of control of the hazardous substances, pollutants, and contaminants, which at least attains ARARs under federal and state laws, unless a waiver can be justified pursuant to CERCLA Section 121(d)(4), 42 U.S.C. § 9621(d)(4).

Detailed descriptions of the remedial alternatives for addressing the contamination associated with the Site can be found in the 2020 FS report. The construction time for each alternative reflects only the time required to construct or implement the alternative and does not include the time required to design the alternative or procure contracts for its design and construction.

Remedial Alternatives

Remedial alternatives for Standard Chlorine OU4 are presented below. The alternatives are numbered to correspond with alternatives presented in the 2020 FS for the Site.

Table 3: Summary of Remedial Alternatives

Medium	FS Designation	Description
OU4 – Groundwater	Alternative G1	No Action
	Alternative G2	Expanded Groundwater Extraction and Treatment, Groundwater Source Area Containment, ICs, and TI Waiver
	Alternative G3	Groundwater Extraction and Treatment, Groundwater Source Area Containment, Enhanced Bioremediation, Metals Treatment, ICs, and TI Waiver

Common Components to the Alternatives

Each alternative, except the G1 "No Action" alternative, contains some common elements that were considered in the evaluation process. In alternatives G2 and G3, activities currently being conducted as part of the OU1 IGR will be continued and merged with the OU4 remedy to form a final groundwater remedy. Specifically, the subsurface barrier wall would continue to be maintained and monitored to contain the high levels of contamination in the containment area. Operation and maintenance of the existing GETS within the containment area would also be continued to exert an inward gradient within the subsurface barrier wall and contain and treat contamination in that portion of the Site.

Another common component to Alternatives G2 and G3 is the continued enforcement of the existing ICs, the GMZ which prohibits the potable use of groundwater in the contaminated portion of the Columbia and Potomac aquifers, and the Notice of Contamination that protects the integrity of infrastructure associated with the Selected Remedy. In both alternatives, any future acquisition of the Property must incorporate deed restrictions to ensure the integrity of the Selected Remedy as outlined in the Notice of Contamination. Continued maintenance of fencing and signage has also been included to warn visitors and potential trespassers of the hazards associated with the Site. Five-Year Reviews will be conducted to review the Selected Remedy and ensure that the waste that remains in place does not pose unacceptable risk.

The TI Waiver is the final common element to Alternatives G2 and G3, as completely removing all DNAPL contamination from the TI Waiver zones is not feasible from an engineering perspective. The TI Waiver zones would include those areas with extensive, deep pools of DNAPL where it is not feasible from an engineering perspective to remove the DNAPL contamination. Monitoring would be required to ensure hydraulic control to contain contamination within the TI Waiver zones.

Alternative G1: No Action

Estimated Capital Cost: $0
Estimated Annual O&M Cost: $0
Estimated Present Worth Cost: $0
Estimated Construction Timeframe: N/A

The NCP requires that the EPA include a "No Action" Alternative in its remedy selection decision making process. Under the No Action Alternative, no cleanup measures would be implemented. The purpose of the No Action Alternative is to provide a baseline to compare the other clean up alternatives. The No Action Alternative would not meet any of the cleanup objectives described earlier in this section. Furthermore, the No Action Alternative would not provide for the EPA's continued enforcement of the GMZ, Notice of Contamination, or deed restrictions in the case of future sale of the Property. There are no costs to implement, operate, and maintain this Alternative. The IGR under OU1 would not be continued under the No Action Alternative, as there are significant costs (approximately $400,000 a year) to operate and maintain the OU1 system. Because existing contaminated groundwater would remain in place, the EPA would conduct Five-Year Reviews under this Alternative as required by Section 121(c) of CERCLA.

Alternative G2: Expanded Groundwater Extraction and Treatment, Groundwater Source Area Containment, ICs, and TI Waiver

Estimated Capital Cost: $8.8M
Estimated Annual O&M Cost: $800k-850k
Estimated Present Worth Cost: $23.0M
Estimated Construction Timeframe: 2 years

This alternative would remove and treat Site-related contamination from both aquifers. The extraction of groundwater would also help provide hydraulic containment of contamination in the Columbia and Potomac aquifers and reduce contaminant flows to Red Lion Creek and the surrounding wetlands. This alternative depends on the successful completion of the OU2 remedy to address contamination in the Site wetland soils and sediments, because current contamination in the Site wetlands continually dissolves and re-contaminates Site groundwater. The successful completion of the ongoing OU2 cleanup will eliminate that contamination pathway.

This alternative would include continued operation of the existing GETS currently conducted under OU1 to maintain hydraulic control of the Columbia aquifer in the area within the subsurface barrier wall. The GETS would also be expanded to the Potomac aquifer, with extraction wells likely to be located to the east and west of the OU1 containment area. Installation of extraction wells would be avoided immediately under the containment area and the Red Lion Creek area, so as not to draw contamination into the Potomac aquifer in those areas with high contaminant levels in the overlying Columbia aquifer and with a thin or absent confining clay layer. In the Columbia aquifer, the GETS would be expanded to the area north of the containment area; this would help establish hydraulic control and remediate contamination in those portions of the aquifer. Groundwater in areas outside of the TI Waiver zones would be remediated to cleanup standards.

Exact location of the extraction wells would be refined during the design phase of the remediation by taking into consideration factors including those mentioned here. A sheet pile wall would be installed on the eastern edge of the western wetlands for slope stabilization and to direct groundwater flow to the north where the new Columbia extraction wells would be located. To accommodate the additional volume, a second GETS would likely be necessary, as the existing treatment system has limited capacity.

Current ICs, including the GMZ and Notice of Contamination, would be kept in place. Future acquisition of the Property must incorporate deed restrictions outlined in the 1995 ROD, the 2010 Operable Unit 3

ROD, and the 2022 Operable Unit 2 ROD Amendment that identify the extent of groundwater contamination and the areas containing contaminated subsurface soils, as well as adhere to other ICs related to use and access restrictions necessary to protection human health, including restricting land and groundwater uses, protecting the integrity of the remedial system components, and preventing construction without prior written approval from the EPA.

A TI Waiver would also be included, as completely removing all DNAPL contamination from the TI Waiver zones is not feasible from an engineering perspective. The TI Waiver zones would include those areas with extensive, deep pools of DNAPL where it is not feasible from an engineering perspective to remove the DNAPL contamination. Monitoring would be required to ensure hydraulic control to contain contamination within the TI Waiver zones.

Because contaminated groundwater would remain in place, the EPA would conduct Five-Year Reviews under this Alternative as required by Section 121(c) of CERCLA. The O&M components for this alternative would primarily involve maintenance and operation of the groundwater extraction wells and treatment system.

Alternative G3: Groundwater Extraction and Treatment, Groundwater Source Area Containment, Enhanced In-Situ Bioremediation, Metals Treatment, ICs, and TI Waiver

Estimated Capital Cost: $16.2M
Estimated Annual O&M Cost: $650k-700k
Estimated Present Worth Cost: $28.7M
Estimated Construction Timeframe: 2 years

This alternative also would remove and treat contamination from both the Columbia and Potomac aquifers, provide hydraulic containment of contamination in both aquifers, and reduce contaminant flows to Red Lion Creek and the surrounding wetlands. As in Alternative G2, current ICs, including the GMZ and Notice of Contamination, would remain in place. As described for Alternative G2, Alternative G3 also depends on the successful completion of the in-progress OU2 remedy for the same reasons listed above.

This alternative is similar to Alternative G2 except that groundwater from the portion of the Columbia aquifer north of the existing containment area would be treated using enhanced in-situ bioremediation with metals treatment to achieve cleanup standards. Groundwater extraction and treatment would be the same as indicated in Alternative G2 in other areas of the Site to establish hydraulic control. The in-situ bioremediation would likely be in the form of a Permeable Reactive Barrier (PRB) that relies on microorganisms to biodegrade the groundwater contaminants; this specific PRB design is also sometimes known as a bio-wall. The bio-wall would be situated along the southern edge of the Red Lion Creek wetlands area, at the bottom of the slope north of the OU1 containment area. Alternatively, a series of injection wells would be located at the same location for injection of bioremediation amendments. The exact design would be finalized in the Remedial Design phase. While the reducing conditions that would be present under the anaerobic bioremediation process would tend to transform hexavalent chromium to its less toxic trivalent state, bioremediation would not address all Site-related metals contamination present in the Columbia groundwater. Therefore, an additional metals treatment, such as sulfate injections for the generation of insoluble sulfide compounds or a PRB employing zero-valent iron (ZVI) or sulfate, would be used downgradient of the bioremediation treatment area. The metals treatment PRB would be placed downgradient of the bio-wall to minimize the potential for precipitated metal compounds to reduce the permeability of the bio-wall. A metal sheet pile wall would be installed along the eastern edge of the western wetlands to direct groundwater flow to the bio-wall.

As in Alternative G2, because contaminated groundwater would remain in place under Alternative G3, the EPA would conduct Five-Year Reviews under this Alternative as required by Section 121(c) of CERCLA. The O&M components for this alternative would include maintenance and operation of the groundwater extraction wells and treatment system. O&M would also include maintenance of the bio-wall and metals treatment PRB, including replacement of these components as necessary with age.

Current ICs, including the GMZ and Notice of Contamination, would be kept in place. Future acquisition of the Property must incorporate deed restrictions outlined in the 1995 ROD, the 2010 Operable Unit 3 ROD, and the 2022 Operable Unit 2 ROD Amendment that identify the extent of groundwater contamination and the areas containing contaminated subsurface soils, as well as adhere to other ICs related to use and access restrictions necessary to protection human health, including restricting land and groundwater uses, protecting the integrity of the remedial system components, and preventing construction without prior written approval from the EPA.

A TI Waiver would also be included, as completely removing all DNAPL contamination from the TI Waiver zones is not feasible from an engineering perspective. The TI Waiver zones would include those areas with extensive, deep pools of DNAPL where it is not feasible from an engineering perspective to remove the DNAPL contamination. Monitoring would be required to ensure hydraulic control to contain contamination within the TI Waiver zones.

10. Expected Outcomes of Each Alternative

a. Criteria Used to Compare Cleanup Alternatives

The remedial alternatives have been evaluated against the nine decision criteria set forth in the NCP, 40 C.F.R. § 300.430(e)(9)(iii) and listed in Table 4 below. These nine criteria are organized into three categories: threshold criteria, primary balancing criteria, and modifying criteria. Threshold criteria must be satisfied for an alternative to be eligible for selection. Primary balancing criteria are used to weigh major trade-offs among alternatives. Modifying criteria are formally considered after public comment has been received on the Proposed Plan.

In the remedial decision-making process, the EPA describes the relative performance of each alternative against the evaluation criteria and notes how each alternative compares to the other alternatives under consideration. A summary of each of the criteria is presented below, followed by a summary of the relative performance of the alternatives with respect to each of the nine criteria. These summaries provide the basis for determining which alternative provides the “best balance” of trade-offs with respect to the nine criteria. A detailed analysis of alternatives can be found in the FS, which is in the Administrative Record file for the Site.

Table 4: Evaluation Criteria for Superfund Remedial Alternatives

Threshold Criteria	**1. Overall Protection of Human Health and the Environment** determines whether an alternative can adequately protect human health and the environment by eliminating, reducing, or controlling exposures to hazardous substances, pollutants or contaminants to levels that do not pose an unacceptable risk.
	2. Compliance with ARARs evaluates whether an alternative meets Federal and more stringent State environmental laws or facility siting laws, or whether a waiver is justified.
Primary Balancing Criteria	**3. Long-term Effectiveness and Permanence** considers the ability of an alternative to maintain protection of human health and the environment over time.
	4. Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present.
	5. Short-term Effectiveness considers the length of time needed to implement an alternative and the risks the alternative poses to workers, residents, and the environment during implementation.
	6. Implementability considers the technical and administrative feasibility of implementing an alternative, including factors such as the relative availability of goods and services.
	7. Cost includes the estimated capital and annual operation and maintenance costs, as well as present worth cost of an alternative. Present worth cost is the total cost of an alternative over time in today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent.
Modifying Criteria	**8. State/ Support Agency Acceptance** considers whether the State agrees with the EPA's analyses and recommendations, as described in the Feasibility Study and Proposed Plan.
	9. Community Acceptance considers whether the local community agrees with the EPA's analyses and preferred alternative. Comments received on the Proposed Plan are an important indicator of community acceptance.

b. <u>Summary of Comparative Analysis of Alternatives</u>

1. Overall Protection of Human Health and the Environment

The "No Action" alternative (Alternative G1) would not be protective of human health and the environment because it does not include any actions to address the unacceptable risks described in Section VII (Summary of Site Risks) of this ROD. The No Action alternative will not be discussed further in the nine criteria analysis because it does not satisfy the threshold criterion of providing overall protection to human health and the environment.

Both action alternatives would be protective of human health and the environment by eliminating, reducing, or controlling risk through treatment, engineering controls, and ICs. In Alternative G2, groundwater in the Potomac and in the Columbia aquifers with Site-related COCs exceeding their respective cleanup levels would be extracted and treated. In Alternative G3, groundwater in the Potomac aquifer would be extracted and treated, and groundwater in the Columbia aquifer would be treated with a bio-wall and a PRB for metals treatment. In areas with extensive DNAPL contamination, groundwater above the cleanup levels would remain in place for both alternatives; however, in those instances, hydraulic control would be established to prevent further migration of contamination and to limit contamination to those areas addressed by the TI Waiver.

Both alternatives would significantly reduce the overall volume of contamination, as indicated by the high mass of contamination already extracted and treated via the ongoing OU1 system. Treatment of the organic contamination in the Columbia aquifer outside the containment barrier in Alternatives G2 and G3 would improve protection of human health and the environment in that area.

Potential risks remaining after implementation, primarily due to contamination left in place in the TI Waiver zones, would be addressed through ICs in the form of a GMZ, Notice of Contamination, and deed restrictions to protect the integrity of the remedy in the case of future sale of the Property.

2. *Compliance with ARARs*

Section 121(d) of CERCLA, 42 U.S.C. § 9621(d), and the NCP at 40 C.F.R. § 300.430(f)(1)(ii)(B), require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law, which are collectively referred to as "ARARs," unless such ARARs are waived under Section 121(d)(4) of CERCLA, 42 U.S.C. § 9621(d)(4), and the NCP at 40 C.F.R. § 300.430(f)(1)(ii)(C).

"Applicable" requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility-siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. Only those State standards that are identified by a State in a timely manner and that are more stringent than Federal requirements may be applicable.

"Relevant and appropriate" requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility-siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those State standards that are identified by a State in a timely manner and that are more stringent than Federal requirements may be relevant and appropriate.

Under 40 CFR § 300.400(g)(3), the EPA may also identify other advisories, criteria, or guidance "to be considered" for a particular release (TBC Criteria). TBC Criteria are non-promulgated criteria, advisories, or guidance, issued by Federal or State government that are not legally binding and do not have the status of potential ARARs. However, TBC Criteria may be considered during development of remedial alternatives. The EPA may use TBC Criteria in determining the necessary level of cleanup for protection of human health or the environment when ARARs do not exist for particular contaminants.

ARARs for remedial action alternatives can be classified into one of the following three functional groups:

- **Chemical-Specific:** Health-risk-based numerical values or methodologies that establish concentration or discharge limits for particular contaminants. Often, these ARARs are used to determine the extent of site remediation. In general, chemical-specific requirements are set for a single chemical or a closely related group of chemicals. Examples include MCLs, promulgated under the Safe Drinking Water Act (SDWA) and any more stringent Delaware medium-specific concentrations (DE MSCs). Potential Federal and more stringent State chemical-specific ARARs are identified in Appendix B.

- **Location-Specific:** Requirements that restrict remedial actions based on the geographic characteristics of the Site or its immediate environment. Examples of these areas regulated under various Federal laws include floodplains, wetlands, and locations where historically significant cultural resources are present. Potential Federal and more stringent State location-specific ARARs identified are presented in Appendix B.

- **Action-Specific:** Requirements that set controls or restrictions on the design, implementation, and performance levels (including discharge limits) of activities related to the management of hazardous substances, pollutants, or contaminants. These action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate how a selected alternative must be achieved. An example of action-specific ARARs include the substantive requirements of the Resource Conservation and Recovery Act (RCRA) regulations for generation, characterization, and management of hazardous wastes. Potential Federal and more stringent State action-specific ARARs are presented in Appendix B.

Alternatives G2 and G3 would meet the threshold criteria of compliance with ARARs that are not waived by the TI Waiver. The principal ARARs associated with the alternatives include:

- Maximum Contaminant Levels, also known as Drinking Water Standards
- Surface Water Quality Standards
- Wetlands Protection and Mitigation regulations
- Fugitive Air Emissions regulations and Ambient Air Standards
- Hazardous Waste Management regulations

Further detail on all ARARs considered for G2 and G3 can be found in Appendix B of this ROD. A notable exception to compliance with all ARARs is provided for the TI Waiver zones. These areas in the vicinity of the containment area are contaminated with large volumes of DNAPL at inaccessible depths and locations, and, as a result, cannot be remediated due to engineering impracticability. The rationale is detailed in the EPA's Groundwater Restoration Technical Impracticability Evaluation (Appendix D). Therefore, ARARs will not be met in these limited TI Waiver zones. Due to the presence of DNAPL in these areas, it is also unlikely that risk-based cleanup levels will be met due to engineering impracticability. In the TI Waiver Evaluation, the EPA evaluates options for meeting ARARs, and determines that no feasible alternative, from an engineering perspective, exists. More detailed information on which MCLs are being waived and where, can be found in the TI Waiver which is part of the Administrative Record. The WMA underlying the OU3 cap is also excluded from ARARs, as WMAs are managed to contain waste and are not required to remove or remediate waste. Where waste threatens the ground water, as is the case under the OU3 cap, groundwater cleanup standards apply at the edge of the WMA.

3. Long-Term Effectiveness and Permanence

Alternatives G2 and G3 both have the potential to be effective over the long term when combined with the TI Waiver and ICs. While the GETS and containment barrier components in both alternatives would not achieve cleanup goals within the DNAPL-contaminated TI Waiver zones, they would provide required hydraulic control of the contaminant plume, which would prevent further migration of contamination. While a TI waiver will apply to portions of the Site, ICs and establishing hydraulic control of the contaminated portion of the aquifers would eliminate exposure risks.

Alternative G2 would be effective at removing Site-related contaminants from the Columbia aquifer to the north and west of the containment area and would provide hydraulic control of the contaminant plume, but it would not achieve cleanup levels in the TI Waiver zones. Alternative G3 would be effective in addressing Columbia aquifer contamination in groundwater passing through the bioremediation treatment zone. Reducing inorganic contaminant concentrations through a PRB using ZVI or sulfate amendment injections would allow Alternative G3 to mitigate the risks related to these Site contaminants. Alternative G2 would remove the metals-contaminated water and treat it before discharging the treated water to Red Lion Creek. It is estimated that Alternative G2 would result in a slightly greater contaminant reduction than in Alternative G3. Effectiveness of the GETS, the bio-wall, and the metals treatment component would be monitored by collecting and analyzing groundwater samples to determine whether the COC concentrations in the groundwater of both aquifers have been reduced to acceptable levels, meaning they have been reduced to cleanup levels in those areas outside of the WMA and TI Waiver zones. In the case of the GETS, vapor samples also would be collected and analyzed to ensure the continued effectiveness of these systems. The least amount of uncertainty with respect to treatment effectiveness is associated with Alternative G2 because Alternative G3 would require pilot studies to determine design characteristics for the bio-wall and the metals treatment component. Additionally, at some point in the future the bio-wall material would require replacement when treatment effectiveness decreases due to exhaustion of the treatment media.

4. Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative G2 would reduce the mobility, toxicity, and volume of the contaminants in the containment area, the upland portions of the Columbia aquifer, and the Potomac aquifer by extracting (pumping) and treating contaminated groundwater from both aquifers. Mobility reduction in this case will be achieved through hydraulic control of the Columbia and Potomac aquifer plumes.

Alternative G3 includes in situ treatment technologies (bio-wall, metals treatment) that would reduce the volume and toxicity of OU4 contaminants in the northern part of the Site.

Based on the expected outcomes of the two alternatives, it is likely that the two alternatives would produce similar reductions in contaminant toxicity and volume.

5. Short-Term Effectiveness

Short-term risks to construction workers, surrounding communities and the environment are expected to occur from the implementation of Alternatives G2 and G3. These risks include exposure through dermal contact or to dust and vapor during construction activities, as well as continued risks from the current Site conditions before the alternatives are fully implemented. Alternative G3 would be somewhat less effective than Alternative G2 in the short term because of the increased Site activities (bio-wall and PRB construction) required, including digging trenches, which would lead to greater exposures than Alternative G2. Construction workers could potentially be exposed to Site-related contamination through dermal contact and inhalation of dust and vapors during construction of extraction wells, operation of the treatment systems, and sampling of groundwater. Short-term risks associated with Alternatives G2 and G3 can be managed by a combination of ICs, engineering controls, personal protective equipment (PPE), and vapor and dust monitoring and suppression measures to be employed during construction activities. Vapor capture and treatment systems would address any increase in the off gassing of contaminants under both alternatives. Construction duration for both Alternatives G2 and G3 is expected to be similar because of the inclusion of many common components.

6. Implementability

Both Alternatives G2 and G3 are readily implementable based on previous experience at the Site. Groundwater extraction and treatment and the installation of a sheet pile wall along the eastern edge of the western wetlands are common elements of Alternatives G2 and G3. However, Alternative G2 would be more easily implemented, as it lacks the additional pilot studies and treatment technologies included for bioremediation and in situ metals treatment. Activities to maintain the GETS would be similar under Alternatives G2 and G3. The proposed treatment technologies under Alternative G3 (bio-wall, metals treatment component) would require additional characterization sampling, as well as pilot studies to optimize bio-wall placement and other design characteristics. The proposed technologies are readily available and, based on Sites with similar contamination, have performed with high efficiency. With respect to the administrative requirements, both alternatives are equally favorable. Alternatives G2 and G3 could be implemented in similar time frames. It is anticipated that the potential risks of mobilizing contaminants, destruction of habitat, or damaging infrastructure would be somewhat increased by implementing Alternative G3 instead of Alternative G2, due to more invasive construction techniques necessary to install the bio-wall as opposed to additional extraction wells.

7. Cost

The present worth costs for Alternatives G2 and G3, the up-front capital costs, and expected annual O&M or operating costs are presented as follows, assuming a 7% discount rate over a 30-year period:

Table 5: Cost Estimates of Remedial Alternatives

	Alternative G2	Alternative G3
30-Year Present Worth Cost	$23,010,225	$28,675,475
Capital Cost	$8,883,456	$16,167,614
Annual Operating Cost	$806,565	$680,129

The costs for both Alternatives could change once the startup period or the pilot studies are completed because the findings could indicate that certain treatment components could be reduced or need to be expanded to achieve discharge limits (for the GETS) or one or more cleanup levels (in the case of the bio-wall and metals treatment). The costs of Alternative G2 are lower than Alternative G3 and are less subject to change based on the relative lack of certainty in the Alternative G3 remedy.

8. State Acceptance

The EPA has coordinated closely with DNREC in the preparation and evaluation of this ROD. DNREC concurs with the Selected Remedy for OU4 (Appendix C).

9. Community Acceptance

The EPA did not receive any comments or questions regarding the Preferred Alternative (Alternative G2) in the Proposed Plan during the public meeting or public comment period. Were the EPA to have received public comments, they would be addressed in the Responsiveness Summary of this ROD. A transcript of the public meeting is available in the AR.

11. Principal Threat Waste

The NCP at 40 C.F.R. § 300.430(a)(l)(iii)(A) establishes an expectation that the EPA will use treatment to address the principal threats posed by a site wherever practicable. The principal threat concept is applied to the characterization of source materials at a Superfund site. A source material is material that includes or contains hazardous substances, pollutants, or contaminants that act as reservoirs for migration of contamination to groundwater, soil, surface water, or air, or as a source for direct exposure. Principal threat wastes are those source materials considered to be highly toxic or highly mobile, which would present a significant risk to human health or the environment should exposure occur. They include liquids or other highly mobile materials or materials having high concentrations of toxic compounds.

The DNAPL present throughout the containment area and in more limited portions of the Columbia and Potomac aquifers outside of the containment area contribute to groundwater contamination at the Site. This DNAPL is considered principal threat waste. Portions of the DNAPL contamination will dissolve into groundwater and be treated by the extraction and treatment aspect of the Selected Remedy. Due to engineering limitations, some more extensive pools of DNAPL cannot practicably be treated. Those areas are addressed by the TI Waiver. The TI Waiver provides an extensive discussion on this topic. In areas where the TI Waiver will apply, hydraulic control will be established to prevent the migration of principal threat wastes beyond these areas of control. Outside of the TI Waiver zones, Site-related groundwater contamination will be reduced to the stated cleanup standards.

Principal threat waste (both DNAPL and soil contamination) is also present in the soil and sediment matrices in the wetland areas along Red Lion Creek. These sources of principal threat waste are being addressed by the OU2 remedial action, and the removal of that principal threat waste will eliminate one of the pathways contributing to groundwater contamination.

12. Selected Remedy

a. Summary of the Rationale for the Selected Remedy

Alternative G2 is the EPA's Selected Remedy. The EPA estimates that extraction and treatment of contaminated groundwater via Alternative G2 will result in a greater contaminant reduction than would Alternative G3. Designing a GETS to withdraw and treat contaminated groundwater from the area north of the containment area will also eliminate the need for pilot tests and require less invasive construction techniques than the implementation of Alternative G3. The Selected Remedy will also provide the least amount of uncertainty with respect to treatment effectiveness. From a cost perspective, Alternative G2 has lower estimated capital and 30-year present value costs than Alternative G3, and less uncertainty in the cost due to better known implementability parameters.

The Selected Remedy will include continued operation of the GETS that is currently being conducted as the OU1 IGR; expanded groundwater extraction and treatment in the Columbia aquifer north of the containment area; a metal sheet pile wall to direct groundwater flow to the north of the containment area; expanded groundwater extraction and treatment in the Potomac aquifer; an expanded treatment system to handle the increased volume of extracted groundwater; and implementation of ICs. The treatment components of the Selected Remedy combined with the existing components of the IGR and the other OUs at the Site, provide a remedial approach that will:

- Limit contaminant migration within the Potomac aquifer;
- Remove and treat contaminants from the Columbia and Potomac aquifers;
- Eliminate further migration of contaminants from the Columbia aquifer to the Potomac aquifer;
- Continue to prevent migration of contaminants from the containment area to the surrounding groundwater, Red Lion Creek, and the Site wetlands; and
- Reduce or eliminate further migration of contaminants from the portions of the Columbia aquifer outside the containment area to Red Lion Creek and the surrounding wetlands.

The Selected Remedy will not remediate all principal threat waste on the Site, as DNAPL and groundwater contamination in the TI Waiver zones would remain in place. However, ICs, including the GMZ Notice of Contamination, and deed restrictions to protect the integrity of remedial components in the case of sale of the Property, will eliminate unacceptable risk by prohibiting the consumption of contaminated groundwater in the TI Waiver zones and protecting the integrity of the Selected Remedy. The Selected Remedy will also provide hydraulic control to ensure cleanup goals are not exceeded anywhere outside of the TI Waiver zones, and ensure that contaminant migration is eliminated.

A long-term monitoring plan will be developed to ensure the Selected Remedy is functioning as designed and that groundwater cleanup levels are being met outside of the TI Waiver zones and the WMA. This monitoring plan will include groundwater monitoring to ensure groundwater concentrations meet cleanup goals.

Through the treatment technologies in the Selected Remedy, these actions will permanently reduce the toxicity, mobility, and volume of the contaminant plume in the groundwater. In the limited TI Waiver zones where principal threat waste remains, contamination will be contained via hydraulic control, and risk will be mitigated through ICs. Under the Selected Remedy existing contaminated groundwater will remain in place in the TI Waiver zones; therefore, the EPA will conduct Five-Year Reviews as required by Section 121(c) of CERCLA.

b. Detailed Description of the Selected Remedy

The Selected Remedy for OU4 is Alternative G2, "Expanded Groundwater Extraction and Treatment, Groundwater Source Area Containment, ICs, and TI Waiver," as described in Section IX above. Under this remedial action, the EPA will:

- Continue operation of the subsurface barrier wall and groundwater extraction and treatment system that is currently being conducted as the OU1 IGR;
- Expand groundwater extraction and treatment in the Columbia aquifer north of the containment area;
- Install a metal sheet pile wall to direct groundwater flow to the north of the containment area;
- Expand groundwater extraction and treatment into portions of the Potomac aquifer;
- Build an expanded treatment system to handle the increased volume of extracted groundwater;
- Keep in place ICs including the Notice of Contamination to protect the integrity of the Selected Remedy, continued enforcement of the GMZ to prevent use and consumption of contaminated groundwater, and additional deed restrictions to protect the integrity of the Selected Remedy in the case of future sale of the Property, and
- Establish a TI Waiver for areas where cleanup standards cannot be met due to infeasibility from an engineering perspective.

The RAOs are listed in Section 12. These RAOs include preventing exposure to Site-related groundwater contamination that would result in unacceptable risk to human or ecological receptors; restoring the Columbia and Potomac aquifer groundwater to its maximum beneficial use as a potable water supply (excluding those areas within the WMA and TI Waiver zones); and eliminating the further spread of contamination, including treatment of principal threat waste to the extent practicable.

The following performance standards shall be used ensure the efficacy of the remedial action. Contaminant-specific cleanup levels are listed for each COC in Table 1.

a. Effluent discharged from the groundwater extraction and treatment system shall meet the substantive requirements of the NPDES program and Delaware discharge limitations. The discharge criteria and frequency of effluent sample analysis will be determined during the RD. The discharge shall result in a cumulative excess carcinogenic risk of less than or equal to $1x10^{-4}$ and a cumulative excess non-carcinogenic target organ HI of less than or equal to 1.

b. Air emissions from the groundwater treatment system resulting from treated groundwater shall meet the substantive requirements of Delaware general air emissions standards, Delaware regulations governing toxic air pollutants, and federal air emissions standards for process vents. In addition, emissions shall result in a cumulative excess carcinogenic risk of smaller than or equal to $1x10^{-4}$ and a cumulative excess non-carcinogenic HI of less than or equal to 1. The EPA guidance document, Control of Air Emissions from Superfund Air Strippers at Superfund

Groundwater Sites (OSWER Directive 9355.0-28, June 15, 1989), shall also be considered in determining the need for air emission controls.

c. All components of the groundwater remedy shall be implemented in accordance with the ARARs delineated in the ARARs Table in Appendix B.

d. Extraction and treatment of groundwater shall continue until MCLs and other ARARs for Site COCs are met and until a cumulative excess carcinogenic risk less than or equal to 1×10^{-4} and target organ HIs less than or equal to 1 are achieved throughout the Site, except for within the WMA and the TI Waiver zones.

e. Within the TI Waiver zones and WMA, hydraulic control shall be established such that the plume does not migrate and groundwater contamination exceeding ARARs does not travel beyond the boundaries of the WMA and TI Waiver zones. A groundwater monitoring program shall be established to ensure this performance standard is met.

These performance standards will ensure that the remedial action achieves RAOs.

c. Cost Estimate for the Selected Remedy

The present worth cost of the Selected Remedy, assuming a 7% discount rate, is estimated to be $23,010,225. This includes an initial Capital Cost of $8,883,456. The EPA estimates the annual operating cost for the Selected Remedy to be highest in the first year, at $954,729, due to startup costs. The EPA estimates the annual operating cost in years 2-30 to be $806,565. The EPA estimates that a long-term groundwater monitoring program to monitor approximately 60 Columbia aquifer wells and 30 Potomac aquifer wells could cost an additional $145,226 during the first five years for biannual sampling, and an additional $95,423 for annual sampling during years 6-30. Five Year Reviews, conducted every five years, would cost an additional estimated $25,872 each. Refer to the FS for extensive cost calculations.

d. Expected Outcomes of Selected Remedy

Following implementation of the Selected Remedy, workers, visitors, and potential trespassers at the Site, as well as ecological receptors, will no longer be exposed to COCs in groundwater at levels that present an unacceptable human health or ecological risk outside the TI Waiver zone and WMA. Land use on the Property will be restricted to light industrial to ensure the integrity and long-term protectiveness of the Selected Remedy, and compatibility of any future re-use of the Property with the Selected Remedy. Use of groundwater beneath the Property will be prohibited via continued enforcement of the GMZ.

The Selected Remedy will reduce the concentration of COCs in groundwater to below the cleanup levels in areas outside the TI Waiver zones and WMA. In areas covered by the TI Waiver or the WMA, hydraulic control will be established to ensure no COCs above cleanup levels migrate outside of those areas. Cleanup levels for groundwater COCs are generally set at the MCL, except where risk-based calculations require a lower cleanup level to ensure protectiveness to human health and ecological receptors. Where a contaminant has an MCL and a risk-based cleanup level, the lower of the two numbers is selected to be conservative. Table 1 lists specific cleanup levels for each COC.

Principal threats, or source material that would present a significant risk to human health or the environment should exposure occur, will be removed outside of the TI Waiver zones and WMA.

Upon achieving cleanup levels, the Property will continue to need the EPA or DNREC oversight due to maintenance needs for the OU1 GETS, WMA, and OU3 cap, and monitoring needs to ensure hydraulic containment within the TI Waiver zones. Groundwater contamination will remain in place above cleanup levels in portions of the Site covered by the TI Waiver, WMA, and elsewhere impacted by Site-related groundwater contamination until cleanup levels are met. Because the aquifer outside of the WMA and TI Waiver zones will be remediated to potable use, portions of the aquifer may become appropriate for drinking water usage.

13. STATUTORY DETERMINATIONS

The OU4 Selected Remedy is protective of human health and the environment; complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action, except where those requirements are waived; is cost-effective, and utilizes permanent solutions to the maximum extent practicable.

Because the Selected Remedy will result in hazardous substances remaining onsite above levels that allow for UU/UE, a review will be conducted within five years after commencement of the remedial action to ensure that the Selected Remedy continues to provide adequate protection of human health and the environment. Such reviews will be conducted a minimum of every five years thereafter, until the EPA determines that hazardous substances remaining at the Site do not prevent UU/UE at the Site.

a. Protection of Human Health and the Environment

Except for the WMA and TI Waiver zones, the OU4 Selected Remedy will achieve protection of human health and the environment by reducing groundwater contamination to cleanup levels at the Site. By achieving the groundwater cleanup levels for Site COCs and meeting the cumulative risk performance standard, the Selected Remedy will eliminate unacceptable exposure levels above an excess cumulative cancer risk of $1x10^{-4}$ and non-cancer risk above an HI of 1 for utility worker, commercial or industrial worker, and future resident adult and child human receptors. Achievement of cleanup levels will restore the aquifer at the Site to its maximum beneficial use, except for within the WMA and TI Waiver zones. Unacceptable risks to ecological receptors will also be reduced to acceptable levels. Regular monitoring, maintenance, and enforcement of use restrictions including the GMZ will ensure ongoing protectiveness of the Selected Remedy.

b. Compliance with Applicable or Relevant and Appropriate Requirements

Any cleanup alternative selected by the EPA must comply with all applicable or relevant and appropriate federal and state environmental requirements or provide the basis upon which such requirement(s) can be waived. *Applicable* requirements are those environmental standards, requirements, criteria, or limitations promulgated under federal or state law that are legally applicable to the remedial action to be implemented at the Site. *Relevant and appropriate* requirements, while not being directly applicable, address problems or situations sufficiently similar to those encountered at the Site that their application is well-suited to the particular circumstance.

The Selected Remedy for OU4 would meet the threshold criteria of compliance with ARARs that are not waived. Major ARARs include, but are not limited to:

- Drinking Water Standards (including the MCL)
- Surface Water Quality Standards
- Wetlands Protection and Mitigation regulations
- Fugitive Air Emissions regulations and Ambient Air Standards
- Hazardous Waste Management regulations

The full list of ARARs is described in Appendix B.

A notable exception to compliance with all ARARs is provided for the TI Waiver zones and WMA. These areas in the vicinity of the OU1 containment area are contaminated with large volumes of DNAPL, and, as a result, cannot be remediated due to engineering impracticability. The rationale is detailed in the EPA's TI Waiver (Appendix D). By definition, a TI Waiver waives ARARs, in this case primarily MCLs. Therefore, ARARs will not be met in these TI Waiver zones. In the TI Waiver Evaluation, the EPA evaluated options for meeting ARARs, and determined that no alternative currently exists that meets engineering feasibility. More detailed information on which MCLs are being waived and where, can be found in the TI Waiver which is part of the Administrative Record.

c. Cost-Effectiveness

The NCP at 40 C.F.R. § 300.430(f)(l)(ii)(D), requires the EPA to evaluate cost-effectiveness by comparing all the alternatives meeting the threshold criteria: protection of human health and the environment; and compliance with ARARs against long-term effectiveness and permanence.

The Selected Remedy is cost-effective in providing overall protection of human health and the environment by limiting the risk posed by Site COCs and meets all other requirements of CERCLA and the NCP at a cost that is proportional to the other alternatives that were evaluated. Further, the Selected Remedy meets the criteria ARAR compliance, except where waived, is readily implementable, provides a high degree of both short- and long-term effectiveness, and is acceptable to the public and the State. The estimated present value of the Selected Remedy is $23,010,225.

d. Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable and Preference for Treatment as a Principal Element

The Selected Remedy is intended to treat contamination and provide a permanent solution to contamination in groundwater. Because it is impracticable from an engineering perspective to remediate all principal threat waste, some waste will remain in place as described in the section discussing the TI Waiver (Appendix D). The Selected Remedy maximizes the amount of principal threat waste that can feasibly be treated.

e. Five Year Review Requirements

Section 121(c) of CERCLA and Section 300.430(f)(4)(ii) of the NCP require review of a remedy if the remedy results in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for UU/UE. Any such review must be conducted no less often than every five years after initiation of the remedial action.

Because hazardous substances will remain at the Site, the review described by Section 121(c) of CERCLA and Section 300.430(f)(4)(ii) of the NCP will be conducted no less often than every five years after initiation of the remedial action.

f. Documentation of Significant Changes

The Proposed Plan was released for public comment on August 3, 2023. The EPA has reviewed all potential repositories for comments submitted during the public comment period and did not receive any public comments. Because there were no public comments, it was determined that no significant changes were necessary or appropriate to the remedy, as originally identified in the Proposed Plan.

III. Responsiveness Summary

A Responsiveness Summary for a selected remedy summarizes the questions and comments received during the public comment period on the EPA's Proposed Plan. The EPA did not receive any written or oral comments during the public comment period, held from August 3, 2023 until September 2, 2023, regarding the remedial alternatives presented in the Standard Chlorine of Delaware OU4 Proposed Plan.

Pursuant to Section I13(k)(2)(B) of CERCLA, 42 U.S.C. § 113(k)(2)(B), the Supplemental RI and FS reports, the Proposed Plan, and other documents relating to the OU4 were released to the public for comment on August 3, 2023. These documents were made available to the public online at https://semspub.epa.gov/src/collection/03/AR67435, and electronically at the EPA Administrative Records Room at the EPA's Region 3 office and in the Delaware City Library in Delaware City, Delaware. The notice of availability of these documents was published in the *New Castle Weekl*y on August 2, 2023, *Town Square Live* on August 7, 2023, *Middle Town Transcript* on August 10, 2023, and *Hoy en Delaware* in Spanish on August 23, 2023. A fact sheet detailing the Proposed Plan was mailed to local citizens on August 4, 2023.

The EPA held a public meeting at the Delaware City Library, located at 250 5th St. Delaware City, Delaware, 19706, on August 22, 2023, from 6–7:30 PM. During the public meeting, the EPA gave a formal presentation on the EPA's Proposed Plan, followed by a "Question and Answer" session where representatives from the EPA answered questions regarding the Site and the Proposed Plan. For RODs, responses to all significant comments received during the public comment period, including those raised at the public meeting, are provided in the Responsiveness Summary. However, the EPA did not receive any comments or questions about the Site during the public comment period.

Given the EPA did not receive any written or oral comments during the public comment period, the EPA determined that no significant changes to the proposed remedy, as originally identified in the

Proposed Plan, were necessary or appropriate.

FIGURE 1 – SITE MAP

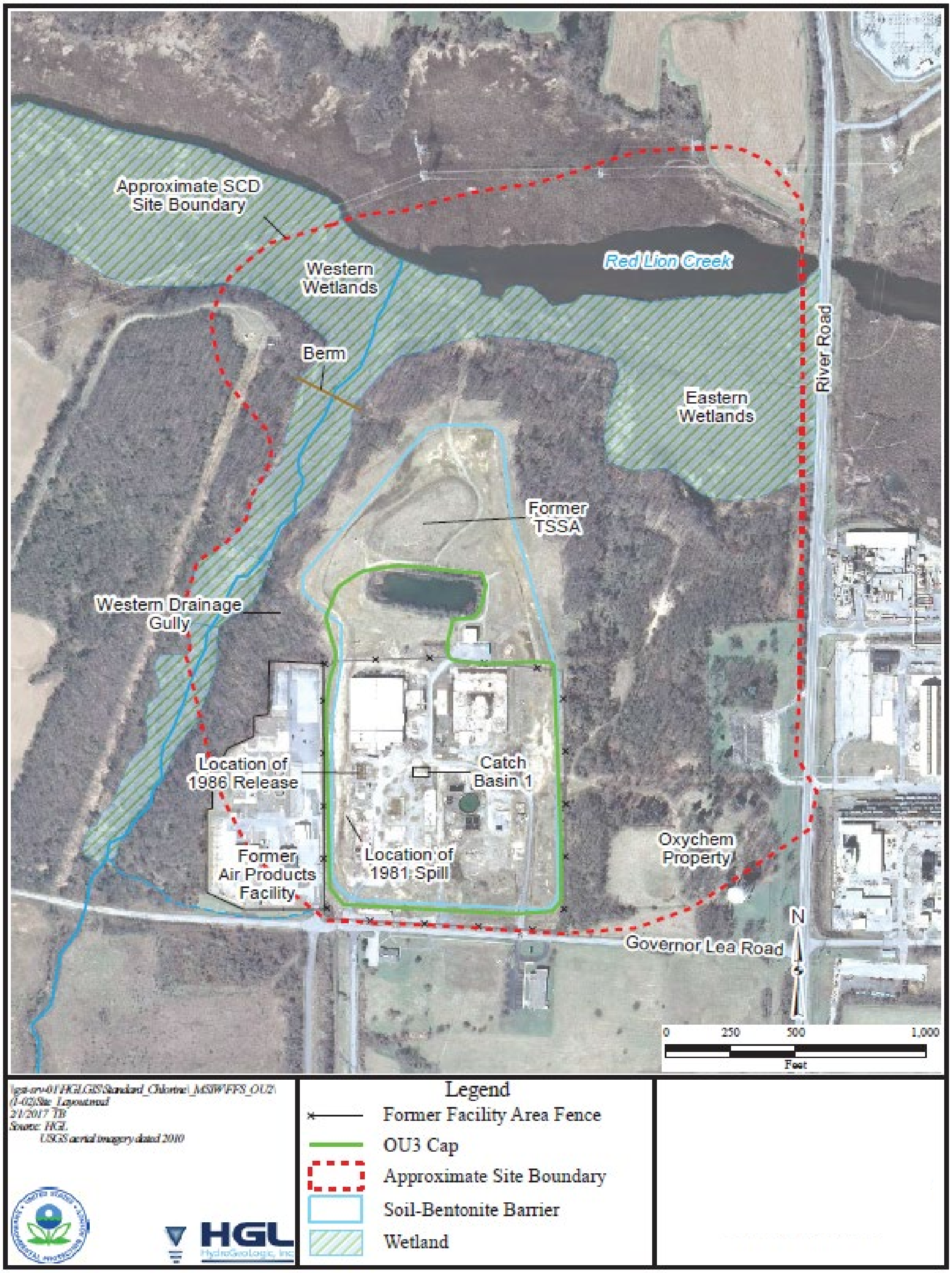
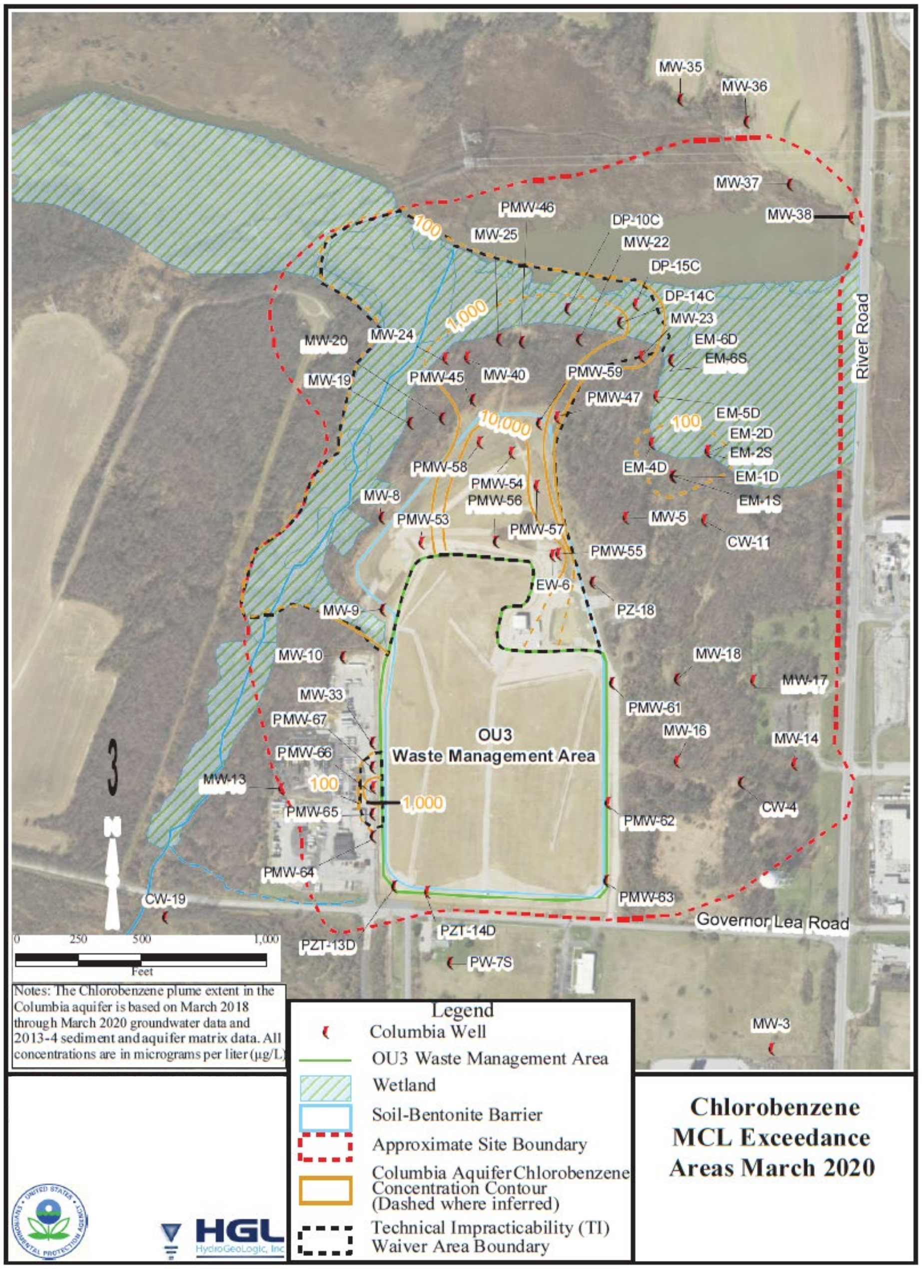


FIGURE 2 – PLUME EXTENT FOR CHLOROBENZENE IN THE COLUMBIA AQUIFER



Chlorobenzene is the most widespread contaminant, and other contaminants are generally collocated with the chlorobenzene. As such, this figure is a useful visual representation of extent of contamination.

FIGURE 3 – EXISTING AND PROPOSED GROUNDWATER EXTRACTION WELLS

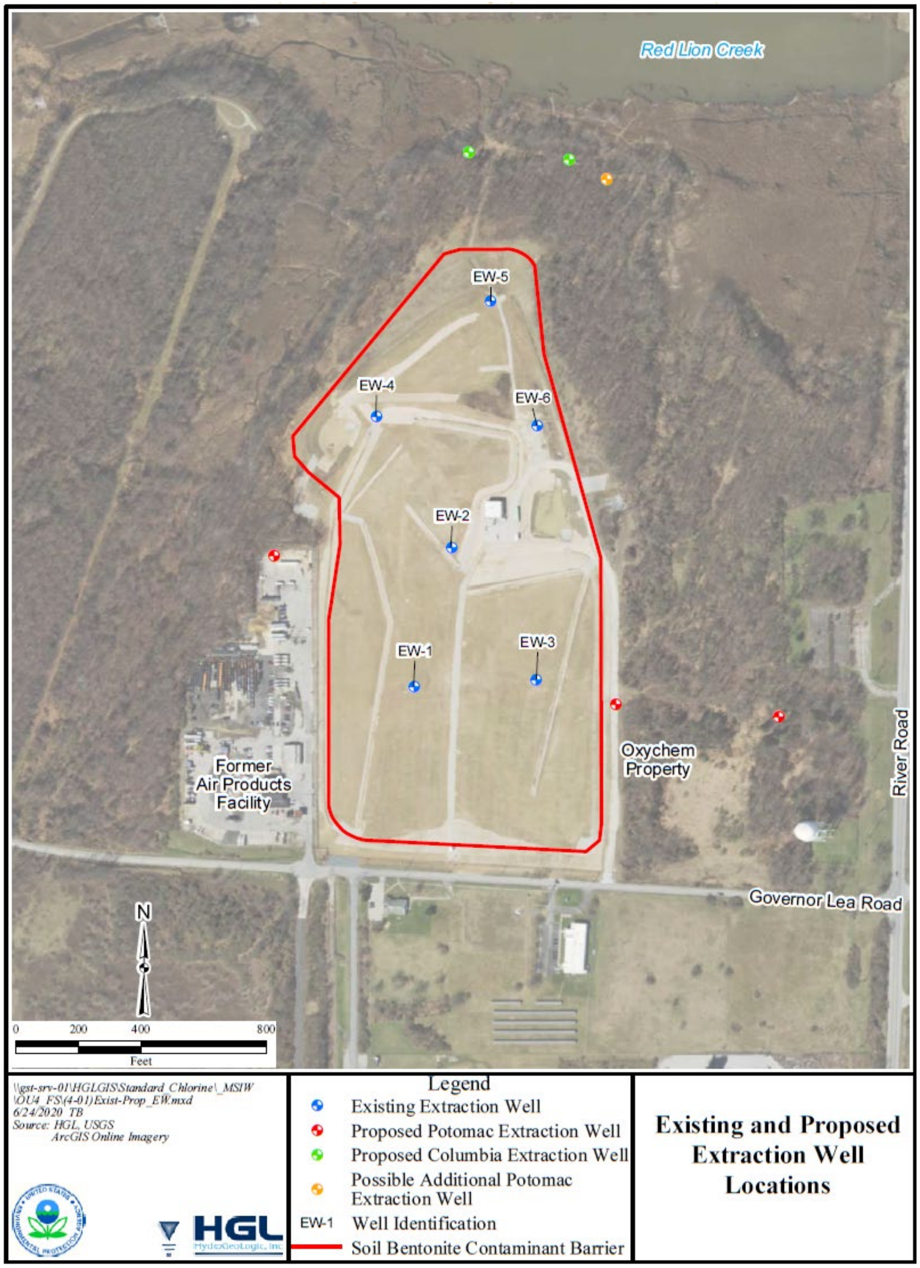


TABLE 1 – List of Cleanup Levels for Each COC

Table 1. Contaminants of Concern and Performance Standards[a]

[a]Once performance standards are achieved for all Site COCs, a risk assessment shall be performed to confirm that exposure to groundwater would result in a cumulative excess carcinogenic risk of less than or equal to $1x10^{-4}$ and a cumulative excess non-carcinogenic target organ HIs of less than or equal to 1.

Chemical	Chemical-specific ARAR (federal MCL)	Estimated Cancer Risk at MCL	Estimated Noncancer HQ at MCL	Exposure Point Concentration - Columbia Aquifer	Comments	Cancer Cleanup Level[1]	Target Organ	Non-Cancer Cleanup Level[2]	Columbia Aquifer Ecological cleanup level	Columbia Aquifer Background Concentration[3]	Columbia Aquifer Cleanup Level[4]
Metals in Groundwater (µg/L)											
Aluminum	--	--	--	12,100	Identified as COC for human health (Columbia) and ecological receptors (hyporheic community).	NA - Not a carcinogen	Neurological	6,700	NA	207	6,700
Arsenic	10	1.9E-04	1.7	16.1	Identified as a COC only for human health (Columbia).	0.27	Skin/vascular system	3.0	NA	4.2	4.2
Barium	2000	--	0.5	1,110	Identified as COC for human health (Columbia) and ecological receptors (hyporheic community).	NA - Not a carcinogen	Kidneys	470	NA	202	470
Beryllium	4	--	0.2	14.6	Identified as a COC only for human health (Columbia).	NA - Not a carcinogen	Intestinal tract	12	NA	1	4
Cadmium	5	--	0.5	7.2	Identified as COC for human health (Columbia) and ecological receptors (hyporheic community).	NA - Not a carcinogen	Kidneys	1.2	NA	1.8	1.8
Chromium, Total	100	2.8E-03	2.2	105	Identified as a COC only for human health (Columbia).	0.19	None reported	44	NA	0.76	0.76
Cobalt	--	--	--	95.5	Identified as COC for human health (Columbia) and ecological receptors (hyporheic community).	NA - Not a carcinogen	Thyroid	3.0	NA	1.7	3
Iron	--	--	--	75,700	Identified as COC for human health (Columbia). Not retained as an ecological COC because was not identified as a COC for sediment in Operable Unit 2.	NA - Not a carcinogen	Intestinal tract	7,000	NA	39,700	39,700
Manganese	--	--	--	26,600	Identified as COC for human health (Columbia) and ecological receptors (hyporheic community).	NA - Not a carcinogen	Neurological	140	NA	437	437
Mercury	2	--	0.4	6.9	Identified as COC for human health (Columbia). Not retained as an ecological COC because was not identified as a COC for sediment in Operable Unit 2.	NA - Not a carcinogen	Immune system	1.9	NA	Not detected	0.026

Chemical	Chemical-specific ARAR (federal MCL)	Estimated Cancer Risk at MCL	Estimated Noncancer HQ at MCL	Exposure Point Concentration - Columbia Aquifer	Comments	Cancer Cleanup Level[1]	Target Organ	Non-Cancer Cleanup Level[2]	Columbia Aquifer Ecological Cleanup Level	Columbia Aquifer Background Concentration[3]	Columbia Aquifer Cleanup Level[4]
Nickel	--	--	--	534	Identified as a COC only for human health (Columbia).	NA - Not a carcinogen	Body and organ weights	130	NA	14.7	130
Silver	--	--	--	14.3	Identified as a COC only for human health (Columbia).	NA - Not a carcinogen	Skin	47	NA	Not detected	47
Thallium	2	--	10	16	Identified as a COC only for human health (Columbia).	NA - Not a carcinogen	Hair	0.10	NA	2.9	2.9
Vanadium	--	--	--	22.9	Identified as a COC only for human health (Columbia).	NA - Not a carcinogen	Hair	43	NA	1.05	43
Organic Compounds in Groundwater (µg/L)											
2-Chlorophenol	-	--	--	260	Identified as a COC only for human health (Columbia).	NA - Not a carcinogen	Reproduction	23	NA	NA	23
4-Chloroaniline	--	--	--	254	Identified as a COC only for human health (Columbia).	1.9	Spleen	76	NA	NA	1.8
1,2-Dichlorobenzene	600	--	0.6	1,100,000	Identified as COC for human health (Columbia) and ecological receptors (hyporheic community and upper trophic level receptors).	NA - Not a carcinogen	Body weight	380	0.7	NA	0.7
1,3-Dichlorobenzene	--	--	--	88,000	Identified as COC for only ecological receptors (hyporheic community and upper trophic level receptors).	NA	NA	NA	150	NA	150
1,4-Dichlorobenzene	75	1.7E-05	0.09	1,400,000	Identified as COC for human health (Columbia) and ecological receptors (hyporheic community and upper trophic level receptors).	23	Liver	8.8	26	NA	8.8
2,4-Dichlorophenol	--	--	--	87	Identified as a COC only for human health (Columbia).	NA - Not a carcinogen	Immune system	15	NA	NA	15
1,2,3,4-Tetrachlorobenzene	--	--	--	15,500	Identified as COC for only ecological receptors (hyporheic community and upper trophic level receptors).	NA	NA	NA	1.8	NA	1.8

Chemical	Chemical-specific ARAR (federal MCL)	Estimated Cancer Risk at MCL	Estimated Noncancer HQ at MCL	Exposure Point Concentration - Columbia Aquifer	Comments	Cancer Cleanup Level[1]	Target Organ	Non-Cancer Cleanup Level[2]	Columbia Aquifer Ecological Cleanup Level	Columbia Aquifer Background Concentration[3]	Columbia Aquifer Cleanup Level[4]
1,2,4,5-Tetrachlorobenzene	--	--	--	63,700	Identified as COC for human health (Columbia) and ecological receptors (hyporheic community and upper trophic level receptors).	NA - Not a carcinogen	Kidneys	0.21	3	NA	0.24
2,3,4,6-Tetrachlorophenol	--	--	--	51	Identified as a COC only for human health (Columbia).	NA - Not a carcinogen	Liver	22	NA	NA	22
1,2,3-Trichlorobenzene	--	--	--	67,000	Identified as COC for human health (Columbia) and ecological receptors (hyporheic community and upper trophic level receptors).	NA - Not a carcinogen	Liver, thyroid, body weight	0.75	8	NA	0.75
1,2,4-Trichlorobenzene	70	5.5E-05	1.9	470,000	Identified as COC for human health (Colulmbia) and ecological receptors (hyporheic community and upper trophic level receptors).	6.4	Adrenal system and urinary system	43	24	NA	6
2,4,6-Trichlorophenol	--	--	--	12	Identified as a COC only for human health (Columbia).	NA - not a carcinogenic COC	Reproduction	3.0	NA	NA	3
Acetone	--	--	--	16,000	Identified as a COC only for human health (Columbia).	NA - Not a carcinogen	Kidneys	2,200	NA	NA	2,600
Benzene	5	4.6E-06	0.08	51,600	Identified as COC for human health (Columbia) and ecological receptors (hyporheic community).	5.7	Blood	35	370	NA	5
bis(2-ethylhexyl)phthalate	6	2.6E-06	0.04	98	Identified as a COC only for human health (Columbia).	0.45	Liver	17	NA	NA	6
Carbon tetrachloride	5	5.8E-06	0.08	430	Identified as a COC only for human health (Columbia).	4.4	Liver	6.5	NA	NA	4.2
Chlorobenzene	100	--	0.4	660,000	Identified as COC for human health (Columbia) and ecological receptors (hyporheic community).	NA - Not a carcinogen	Liver and kidneys	31	1.3	NA	1.3
Chloroform	80	4.4E-05	0.5	1,600	Identified as COC for human health (Columbia) and ecological receptors (hyporheic community).	7.4	Liver	19	NA	NA	9

Chemical	Chemical-specific ARAR (federal MCL)	Estimated Cancer Risk at MCL	Estimated Noncancer HQ at MCL	Exposure Point Concentration - Columbia Aquifer	Comments	Cancer Cleanup Level[1]	Target Organ	Non-Cancer Cleanup Level[2]	Columbia Aquifer Ecological Cleanup Level	Columbia Aquifer Background Concentration[3]	Columbia Aquifer Cleanup Level[4]
Chloromethane	--	--	--	910	Identified as a COC only for human health (Columbia).	NA - Not a carcinogen	Neurological	440	NA	NA	440
Dioxin-Like PCBs	0.5	> 1	460,000	0.000147	Identified as COC for human health (Columbia).	6.4E-08	Reproduction and development	2.7E-07	NA	NA	6.4E-08
Dioxins/Furans	0.00003	9.9E-04	40	0.0000024	Identified as COC for human health (Columbia) and ecological receptors (hyporheic community).	1.6E-07	Reproduction and development	1.9E-07	3.1E-09	NA	3.1E-09
Methylene chloride	5	1.3E-07	0.04	3,300	Identified as a COC only for human health (Columbia).	200	Liver	12	NA	NA	5
Naphthalene	--	--	--	64	Identified as a COC only for human health (Columbia).	18	Body weight	NA - Not a non-cancer COC	NA	NA	17
Nitrobenzene	--	--	--	2,200	Identified as COC for human health (Columbia) and ecological receptors (hyporheic community).	110	Blood	19	66.8	NA	19
PCBs - high risk	0.5	1.3E-04	--	0.66	Identified as a COC for human health (Columbia).	0.018	NA	NA - Not a non-cancer COC	NA	NA	0.018
PCBs - total	0.5	Not a human health COC	Not a human health COC	Not a human health COC	Identified as COC for ecological receptors (hyporheic community and upper trophic level receptors)	NA	NA	NA	7.4E-05	NA	7.4E-05
Pentachlorobenzene	--	--	--	4,700	Identified as COC for human health (Columbia) and ecological receptors (upper trophic level receptors).	NA - Not a carcinogen	Liver and kidneys	0.29	6	NA	0.29
Pentachlorophenol	1	6.3E-05	0.1	460	Identified as a COC only for human health (Columbia).	0.22	Liver	0.86	NA	NA	0.079
Toluene	1000	--	0.8	2,700	Identified as a COC only for human health (Columbia).	NA - Not a carcinogen	Kidneys	150	NA	NA	180
Trichloroethene	5	5.1E-06	0.7	1,600	Identified as a COC only for human health (Columbia).	5.4	Development and immune system	2.9	NA	NA	1

Chemical	Chemical-specific ARAR (federal MCL)	Estimated Cancer Risk at MCL	Estimated Noncancer HQ at MCL	Exposure Point Concentration - Potomac Aquifer	Comments	Cancer Cleanup Level[1]	Target Organ	Non-cancer Cleanup Level[2]	Potomac Aquifer Ecological Cleanup Level[5]	Potomac Aquifer Background Concentration[3]	Potomac Aquifer Cleanup Level[4]
Metals in Groundwater (µg/L)											
Chromium, Total	100	2.8E-03	2.2	4.9	Identified as a COC only for human health (Potomac).	0.20	None reported	Not a non-cancer COC for the Potomac	NA	Not detected	0.2
Iron	--	--	--	23,300	Identified as COC for human health (Potomac). Not retained as an ecological COC because was not identified as a COC for sediment in Operable Unit 2.	NA - Not a carcinogen	Intestinal tract	14,000	NA	19,000	19,000
Manganese	--	--	--	21,800	Identified as COC for human health (Potomac) and ecological receptors (hyporheic community).	NA - Not a carcinogen	Neurological	140	NA	195	195
Organic Compounds in Groundwater (µg/L)											
2-Chlorophenol	-	--	--	23.5	Identified as a COC only for human health (Potomac).	NA - Not a carcinogen	Reproduction	30	NA	NA	30
4-Chloroaniline	--	--	--	809	Identified as a COC only for human health (Potomac).	2.0	Spleen	76	NA	NA	2.0
1,2-Dichlorobenzene	600	--	0.6	21,900	Identified as COC for human health (Potomac) and ecological receptors (hyporheic community and upper trophic level receptors).	NA - Not a carcinogen	Body weight	570	NA	NA	0.7
1,2-Dichloroethane	5	7.7E-06	0.07	110	Identified as a COC only for human health (Potomac).	3.5	Kidneys and neurological	22	NA	NA	3.6
1,4-Dichlorobenzene	75	1.7E-05	0.09	31,000	Identified as COC for human health (Potomac) and ecological receptors (hyporheic community and upper trophic level receptors).	23	Liver	150	NA	NA	24
1.4-Dioxane	--	--	--	31	Identified as a COC only for human health (Potomac).	4.2	NA - not a non-cancer COC	NA	NA	NA	4.3
2,4-Dichlorophenol	--	--	--	19.3	Identified as a COC only for human health (Potomac).	NA - Not a carcinogen	Immune system	11	NA	NA	11

Chemical	Chemical-specific ARAR (federal MCL)	Estimated Cancer Risk at MCL	Estimated Noncancer HQ at MCL	Exposure Point Concentration - Potomac Aquifer	Comments	Cancer Cleanup Level[1]	Target Organ	Non-cancer Cleanup Level[2]	Potomac Aquifer Ecological Cleanup Level[5]	Potomac Aquifer Background Concentration[3]	Potomac Aquifer Cleanup Level[4]
1,2,4,5-Tetrachlorobenzene	--	--	--	103	Identified as COC for human health (Potomac) and ecological receptors (hyporheic community and upper trophic level receptors).	NA - Not a carcinogen	Kidneys	0.43	NA	NA	0.43
1,2,3-Trichlorobenzene	--	--	--	995	Identified as COC for human health (Potomac) and ecological receptors (hyporheic community and upper trophic level receptors).	NA - Not a carcinogen	Liver, thyroid, body weight	1.2	NA	NA	1.2
1,2,4-Trichlorobenzene	70	5.5E-05	1.9	3,786	Identified as COC for human health (Potomac) and ecological receptors (hyporheic community and upper trophic level receptors).	6.5	Adrenal system and urinary system	43	NA	NA	6.7
Benzene	5	4.6E-06	0.08	65,100	Identified as COC for human health (Potomac) and ecological receptors (hyporheic community).	5.8	Blood	35	NA	NA	5
bis(2-ethylhexyl)phthalate	6	2.6E-06	0.04	6.5	Identified as a COC only for human health (Potomac).	0.46	Liver	28	NA	NA	6
Bromodichloromethane	80	9.8E-05	0.2	5.9	Identified as a COC only for human health (Potomac).	4.4	NA - not a non-cancer COC	NA	NA	NA	4.5
Chlorobenzene	100	--	0.4	73,700	Identified as COC for human health (Potomac) and ecological receptors (hyporheic community).	NA - Not a carcinogen	Liver and kidneys	51	NA	NA	1.3
Chloroform	80	4.4E-05	0.5	620	Identified as COC for human health (Potomac) and ecological receptors (hyporheic community).	7.5	Liver	31	NA	NA	10
Dioxin-Like PCBs	0.5	> 1	460,000	0.0000025	Identified as COC for human health (Potomac).	6.5E-08	Reproduction and development	3.6E-07	NA	NA	6.5E-08
Dioxins/Furans	0.00003	9.9E-04	40	0.00000079	Identified as COC for human health (Potomac) and ecological receptors (hyporheic community).	1.6E-07	Reproduction and development	2.5E-07	NA	NA	3.1E-09
Indeno(1,2,3-c,d)pyrene	--	--	--	3.5	Identified as a COC only for human health (Potomac).	0.052	NA - not a non-cancer COC	NA	NA	NA	0.066
Methylene chloride	5	1.3E-07	0.04	240	Identified as a COC only for human health (Potomac).	200	Liver	19	NA	NA	5

Chemical	Chemical-specific ARAR (federal MCL)	Estimated Cancer Risk at MCL	Estimated Noncancer HQ at MCL	Exposure Point Concentration - Potomac Aquifer	Comments	Cancer Cleanup Level[1]	Target Organ	Non-cancer Cleanup Level[2]	Potomac Aquifer Ecological Cleanup Level[5]	Potomac Aquifer Background Concentration[3]	Potomac Aquifer Cleanup Level[4]
Naphthalene	--	--	--	18	Identified as a COC only for human health (Potomac).	18	NA - not a non-cancer COC	NA	NA	NA	19
Nitrobenzene	--	--	--	3,300	Identified as COC for human health (Potomac) and ecological receptors (hyporheic community).	110	Blood	19	NA	NA	19
Tetrachloroethene	5	2.2E-07	0.06	68	Identified as a COC only for human health (Potomac).	NA - not a carcinogenic COC	Neurological	26	NA	NA	5
Toluene	1000	--	0.8	1,000	Identified as a COC only for human health (Potomac).	NA - Not a carcinogen	Kidneys	310	NA	NA	310
Trichloroethene	5	5.1E-06	0.7	16	Identified as a COC only for human health (Potomac).	5.5	Development and immune system	2.9	NA	NA	1

1. Cleanup level is based on target risk of 5.4×10^{-6}. Please see 2020 Feasibility Study for identification of carcinogenic COCs and target risk.
2. Cleanup level is based on target organ hazard index of 1 divided by the number of COCs with target organ toxicity.
3. Potomac aquifer background concentration listed only if metal is a contaminant of concern for that aquifer.
4. Cleanup level is the lowest of the risk-based levels and MCL. If this value is less than the background value, the background concentration is the cleanup level.
5. The final ecological risk assessment for Standard Chlorine OU4 only considers the discharge of groundwater from the Columbia Aquifer to the transition zone and surface water to be a complete exposure pathway for ecological receptors; there is no ecological exposure to contaminants present in the Potomac aquifer, therefore there are no ecological cleanup levels identified for the Potomac Aquifer.

NA = not applicable

TABLE 2 – Summary of Target Organs, Hazard Indices, and Primary Risk Drivers for Non-Carcinogenic Risk – Human Health Baseline Risk Assessment

Target Organ	Hazard Index	Primary Risk Drivers
Columbia Aquifer		
Neurological	62 (child)/38 (adult)	Manganese, aluminum
Skin	3 (child)/2 (adult)	Arsenic and silver
Vascular System	3 (child)/2 (adult)	Arsenic
Kidneys	36,867 (child)/23,095 (adult)	Barium, cadmium, 1,2,4,5-tetrachlorobenzene, pentachlorobenzene, acetone, toluene, and chlorobenzene
Gastrointestinal Tract	6 (child)/4 (adult)	Iron and beryllium
Thyroid	9,067 (child)/5,515 (adult)	Cobalt and 1,2,3-trichlorobenzene
Immune system	184 (child)/146 (adult)	Mercury, 2,4-dichlorophenol, and trichloroethene
Body and organ weights	9,053 (child)/5,714 (adult)	Nickel, naphthalene, 1,2,3-trichlorobenzene, and 1,2-dichlorobenzene
Hair	80 (child)/48 (adult)	Thallium and vanadium
Liver	14,288 (child)/9.341 (adult)	2,3,4,6-Tetrachlorophenol, bis(2-ethylhexyl)phthalate, pentachlorobenzene, pentachlorophenol, 1,2,3-trichlorobenzene, 1,4-dichlorobenzene, carbon tetrachloride, chlorobenzene, chloroform, and methylene chloride
Reproduction	497 (child)/305 (adult)	2,4,6-Trichlorophenol, 2-chlorophenol, dioxin-like PCBs, and dioxins/furans
Spleen	3 (child)/2 (adult)	4-Chloroaniline
Blood	775 (child)/561 (adult)	Nitrobenzene and benzene
Adrenal system	4,952 (child)/3,011 (adult)	1,2,4-Trichlorobenzene
Development	674 (child)/447 (adult)	Trichloroethene, dioxin-like PCBs, and dioxins/furans
Urinary system	0 (child)/7,734 (adult)	1,2,4-Trichlorobenzene
No observed effects	925 (child)/560 (adult)	Chromium and 1,2-dichlorobenzene
Potomac Aquifer		
Neurological	51 (child)/32 (adult)	Manganese, tetrachloroethene, and 1,2-dichloroethane
Kidneys	59 (child)/102 (adult)	1,2,4,5-tetrachlorobenzene, toluene, 1,2- dichloroethane, and chlorobenzene
Gastrointestinal tract	2 (child)/1 (adult)	Iron
Thyroid	134 (child)/82 (adult)	1,2,3-Trichlorobenzene
Immune system	2 (child)/2 (adult)	2,4-Dichlorophenol and trichloroethene
Body and organ weights	134 (child)/86 (adult)	1,2,3-Trichlorobenzene and 1,2-dichlorobenzene
Liver	409 (child)/315 (adult)	1,2,3-Trichlorobenzene, 1,4-dichlorobenzene, chlorobenzene, chloroform, and methylene chloride
Reproduction	10 (child)/6 (adult)	2-Chlorophenol, dioxin-like PCBs, and dioxins/furans
Spleen	11 (child)/6 (adult)	4-Chloroaniline
Blood	992 (child)/716 (adult)	Nitrobenzene and benzene
Adrenal system	40 (child)/24 (adult)	1,2,4-Trichlorobenzene
Development	11 (child)/7 (adult)	Trichloroethene, dioxin-like PCBs, and dioxins/furans
Urinary system	0 (child)/62 (adult)	1,2,4-Trichlorobenzene
No observed effects	18 (child)/11 (adult)	1,2-Dichlorobenzene

APPENDIX A

ADMINISTRATIVE RECORD INDEX

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION III

1600 John F. Kennedy Blvd.

Philadelphia, Pennsylvania 19103

STANDARD CHLORINE OF DELAWARE, INC.

OU 4 REMEDIAL ACTION ADMINISTRATIVE RECORD FILE

INDEX OF DOCUMENTS

AVAILABLE 8/3/2023, UPDATED 5/8/2024

https://semspub.epa.gov/src/collection/03/AR67435

Introduction

The “Administrative Record” is the collection of documents which form the basis for the U. S. Environmental Protection Agency’s (EPA) selection of a response action at a Superfund site. Superfund is the name given to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) which can be found in Title 42 of the U.S. Code (U.S.C.) at Sections 9601 through 9675. Response actions under Superfund can be either “removal actions” or “remedial actions.” As the EPA decides what to do at the site of a release of hazardous substances, the EPA compiles documents concerning the site and EPA’s decision into an “Administrative Record File.” Documents may be added to the Administrative Record File from time to time. Once the EPA Regional Administrator or the Regional Administrator’s delegate signs the decision document memorializing the selection of an action, the documents which form the basis for the selection of an action are known as the “Administrative Record.” An Administrative Record file is required by CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA).

The Administrative Record will be available for public review during normal business hours in an electronic computer imaged format at the selected repository and by appointment only at the Environmental Protection Agency (EPA), Region 3 office which is located at the address given on the cover page. The Administrative Record is treated as a non-circulating reference document. Individuals may review documents contained in the Administrative Record, according to the procedures at the local repository and at the EPA Region 3 office. The Administrative Record will be maintained at the repository until further notice. EPA may send additional documents to the repository as work progresses at the Site. The EPA may hold formal public comment periods at certain stages of the response process. The public is urged to use the formal public comment periods to submit written comments to the EPA regarding the actions at the Site.

Except as explained below, this index and the record were compiled in accordance with the EPA’s Revised Guidance on Compiling Administrative Records for CERCLA Response Actions, EPA/OSRE/OEM/OSRTI (September 20, 2010), and/or in accordance with Superfund Removal Procedures Public Participation Guidance for On-Scene Coordinators: Community Relations and the Administrative Record, OSWER 9360.3-05 (July 1992), and/or the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR Part 300. Consistent with 40 CFR Sections 300.805 (a) (2), and 300.810 (a) (2), Region 3 has listed, in the Administrative Record Index (or in bibliographies of documents listed in the Index), guidance documents which may form a basis for the selection of this response action (EPA Guidance Documents, Non-Site Specific). Unless the guidance documents indexed were generated specifically for the Site, the guidance documents may not be present in the Administrative Record. However, it should be noted that the EPA does maintain an extensive collection of Superfund response action guidance documents available in electronic format on the EPA website at: https://www.epa.gov/superfund/superfund-policy-guidance-and-laws.

Additionally, the EPA guidance related to Superfund cleanup enforcement may be found on the website at the following address:
http://cfpub.epa.gov/compliance/resources/policies/cleanup/superfund.
This page is titled, "Superfund Cleanup Policies and Guidance."

The Administrative Record is listed in chronological order with the earliest dated document at the top and followed by documents which may be "Undated."

Documents in the Administrative Record File have been redacted due to the presence of confidential business information, personal identifiable information, and/or other privileged materials. The redactions are evident from the face of the document and the word "Redacted" appears in the title on the index.

The Documents in the Standard Chlorine OU 1 & OU 2 Remedial Action Administrative Record File dated 4/8/2008, the Standard Chlorine OU 2 Remedial Action Administrative Record File dated 3/2/2016, and the Standard Chlorine OU 2 Remedial Action Administrative Record File dated 9/8/2022 are included in this Administrative Record and are incorporated herein by reference.

STANDARD CHLORINE
OF DELAWARE INC

OU 4 REMEDIAL ACTION ADMINISTRATIVE RECORD FILE
INDEX OF DOCUMENTS
Updated 5/8/2024

In CHRONOLOGICAL Order

DOC ID	DOC DATE	TITLE	PAGE COUNT	ADDRESSEE NAME	AUTHOR NAME
100621	03/09/1995	RECORD OF DECISION (ROD)	138		VOLTAGGIO,THOMAS,C (EPA)
2316159	06/01/2016	REDACTED OU 4 FINAL REMEDIAL INVESTIGATION REPORT	1359	(EPA)	(HYDROGEOLOGIC INC (HGL))
2349463	06/26/2020	OU 4 FEASIBILITY STUDY REPORT	471	(EPA)	(HYDROGEOLOGIC INC (HGL))
2349464	06/26/2020	OU 4 GROUNDWATER RESTORATION TECHNICAL IMPRACTICABILITY EVALUATION	234	(EPA)	(HYDROGEOLOGIC INC (HGL))
2317219	06/21/2021	THIRD FIVE YEAR REVIEW REPORT	34		DIETZ,LINDA,R (EPA)
2317279	09/01/2021	FACT SHEET: EPA ANNOUCES PROPOSED REMEDIAL ACTION PLAN (PRAP)	5		(EPA)
2319719	09/16/2021	OU 2 PROPOSED REMEDIAL ACTION PLAN (PRAP) FOR RECORD OF DECISION (ROD) AMENDMENT	36		(EPA)
2352327	08/01/2023	FACT SHEET: EPA ANNOUNCES PROPOSED CLEANUP PLAN	5		(EPA)
2378593	08/02/2023	PUBLIC NOTICE: PROPOSED CLEANUP PLAN AVAILABLE FOR PUBLIC COMMENT	1		(EPA)|(NEW CASTLE WEEKLY)
2350889	08/03/2023	OU 4 PROPOSED REMEDIAL ACTION PLAN (PRAP)	55		(EPA)
2378594	08/07/2023	PUBLIC NOTICE: PROPOSED CLEANUP PLAN AVAILABLE FOR PUBLIC COMMENT	1		(EPA)|(TOWN SQUARE LIVE)
2378592	08/10/2023	PUBLIC NOTICE: PROPOSED CLEANUP PLAN AVAILABLE FOR PUBLIC COMMENT	1		(EPA)|(MIDDLETOWN TRANSCRIPT)
2378590	08/22/2023	OU 4 PROPOSED REMEDIAL ACTION PLAN (PRAP) PUBLIC MEETING TRANSCRIPT	62		(LEXITAS LEGAL)
2378591	08/23/2023	AVISO PÚBLICA: PLAN DE LIMPIEZA PROPUESTO DISPONIBLE PARA COMENTARIO PÚBLICO	1		(EPA)|(HOY EN DELAWARE)
2378595	05/02/2024	DNREC CONCURRENCE WITH OU 4 RECORD OF DECISION (ROD)	1	HINKLE,CHRISTOPHER (EPA)	RATSEP,TIMOTHY (DE DEPT OF NATURAL RESOURCES & ENVIRONMENTAL CONTROL (DNREC))

APPENDIX B – Applicable or Relevant and Appropriate Requirements (ARARs) and Standards to Be Considered (TBC)
Standard Chlorine of Delaware OU4 Superfund Site

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
Chemical-Specific ARARs				
A. Groundwater and/or Drinking Water				
Safe Drinking Water Act (SDWA) MCLs	40 CFR §§ 141.11-.12 and 141.61-62	Relevant and Appropriate	MCLs are enforceable standards for public drinking water supply systems which have at least 15 service connections or are used by at least 25 persons.	Groundwater at the Site is located within a Class II aquifer, which is a potential source of drinking water. Therefore, MCLs are the cleanup levels for groundwater.
Delaware Regulations Governing Control of Water Pollution as amended.	Delaware Administrative Code, Title 7, Chapter 7201, §§ 3 – 9.	Applicable	Contain water quality regulations for discharges into surface and groundwater.	The substantive provisions are applicable to stormwater runoff into the unnamed tributary and Red Lion Creek. Also, applicable discharge of treated groundwater into surface water. If the selected remedy utilizes the existing GETS, the DNREC requirements for discharge under a NPDES permit equivalence limits will have to be met.
B. Surface Water				
CWA: NPDES Requirements	CWA, Section 402: 33 U.S.C.§1342, 40 CFR Parts 122-125	Applicable	NPDES Permit Equivalence will need to be established for any surface water discharges from any groundwater extraction and treatment or stormwater outfalls.	The substantive provisions of these requirements are applicable to any portion of the remedy that may affect the water quality in the nearby Red Lion Creek. Water discharges will be sampled and analyzed IAW the NPDES permit equivalence in place at the Site. Discharge limits shall be met for all onsite discharge to surface water including stormwater and water treated by the GETS.
Delaware Water Quality Standards	Delaware Administrative Code, Title 7, Chapter 7401 §§ 3.0-6.0, 8.0-9.0	Applicable	Standards are established in order to regulate the discharge into state waters in order to maintain the integrity of the water.	The standards are applicable to the extent activities involve discharge of treated groundwater to surface water.
C. Air				
National Emission Standards for Hazardous Air Pollutants: Site Remediation, promulgated under Section 112 of the Clean Air Act of 1970, as amended (CAA), 42 U.S.C. § 7412	40 C.F.R. Part 63, Subpart GGGGG -- §§ 63.7884-.7887; 63.7890(a)-(b); 63.7891(b); 63.7893(b); 63.7910(a)-(b); 63.7912-.7913; 63.7920; 63.7922; 63.7923(a); 63.7935(a), (g), (h)(1)-(2), (i), (j); 63.7937(b)(1), (c)(1); 63.7938(b), (c)(1)-(3), (d); 63.7941(c), (d), (f), (k); 63.7943(a)-(c); 63.7944 (a)-(c); 63.7945(a); and 63.7946-.7947	Applicable	This subpart establishes national emissions limitations and Maximum Achievable Control Technology (MACT) standards for hazardous air pollutants (HAPs) emitted from site remediation activities. This subpart also establishes requirements to demonstrate initial and continuous compliance with the emissions limitations and work practice standards.	The COCs identified at the Site are designated HAPs. Any vapor emissions during the remedial action will be controlled and monitored in accordance with the substantive provisions of these regulations. No permit will be obtained.

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
Ambient Air Quality Standards	Delaware Administrative Code, Title 7, Chapter 1103, §§ 1.0, 3.0, and 11.0 and Chapter 1106	Applicable	Establishes ambient air quality standards	Substantive requirements are applicable to the selected remedy to the extent it creates a potential to release or emit hazardous air pollutants during implementation of the remedial action.
Chemical Specific ARARs				
D. Wastes				
TSCA	40 CFR Part 761.61(4)(i)(B)	Applicable	Section 761.61(4)(i)(B), which applies to self-implementing on-site cleanup and disposal of PCB remediation waste, provides cleanup levels for PCB-impacted soil for low occupancy areas as well as on-site capping and institutional control requirements.	The citation relates to the Site, which is a low occupancy area, because it provides cleanup levels for PCBs in soil to depth to 25 ppm.
DRGHW	See items 1 through 6 below. The DRGHW provisions that are a part of Delaware's federally authorized program would apply instead of the federal RCRA regulations. Additionally, any provision that is not a part of the authorized program, but that is more stringent than the federal requirement, would also be applicable.	Applicable	Regulate the transportation, management, treatment, and disposal of hazardous wastes.	See items 1 through 6 below.

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
I. Identification and Listing of Hazardous Wastes	Delaware Administrative Code, Title 7, Chapter 1302, §§ 261.20-.34	Applicable	Provides regulations for identifying and characterizing hazardous wastes.	Some of the Site soils and sediments may be hazardous and would be treated as hazardous wastes. Waste for offsite disposal would be managed and disposed of consistent with its characterization.
2. Standard Applicable to Generators of Hazardous Waste	Delaware Administrative Code, Title 7, Chapter 1302, §§ 262.11-34, .40-.44	Applicable	Establishes standards for generators of hazardous wastes including waste determination, manifests, and pre-transport requirements.	Any generation of a hazardous waste during the remedial action will comply with the relevant substantive standards.
3. Requirement for Use and Management of Containers	Delaware Administrative Code, Title 7, Chapter 1302, §§ 264.171-.173 and 264.175-.179	Applicable	Establishes use, management, and design requirements for containers used to store hazardous waste.	The applicable substantive provisions of this subpart are applicable for temporary storage containers and on- site treatment systems. Remedial action that involves storage on-site must meet the substantive requirements for containers.
4. Standard for owners and operators of facilities that store or treat hazardous waste in waste piles	DRGHW Part 264 Subpart **L** (§§ 264.250 - 264.259) 40 CFR Part 264 Subpart L (§§ 264.250 -264.259)	Applicable	Requirements for storage or treatment of hazardous waste in waste piles.	The substantive provisions of this subpart are applicable to any soil and sediment that is excavated and stored in waste piles prior to or during treatment.
5. Air emission standards for process vents for owners and operators of facilities that treat or dispose of hazardous waste.	DRGHW Part 264, Subpart AA (§§ 264.1030 - 264.1034) 40 CFR Subpart AA (§§ 264.1030-1034)	Applicable	Applies to process vent associated with air stripping operations that treat hazardous wastes.	The substantive requirements of this subpart are applicable to treatment options that result in air emissions of VOCs.
6. Standard applicable to transporters of Hazardous Waste	DRGHW Part 263, Subpart C (§ 263.30-263.31) 40 CFR Part 263, Subpart C (§ 263.30- 263.31)	Applicable	Establishes the notice and clean up requirements for hazardous waste discharged during transportation.	The substantive provisions of this subpart would be applicable to the transport of residual waste related to the treatment of soils and sediments, if such waste is spilled during transportation.

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
Location-Specific ARARs				
Coastal Zone Management Act of 1972; Reauthorization Amendments of 1990; as amended.	16 U.S.C. § 1451, 1452,1455b; 15 CFR Part 923.23	Applicable	Requires that Federal entities conducting or supporting activities directly affecting the coastal zone, conduct or support those activities in a manner that is consistent with the approved appropriate State coastal zone management program.	The Site is located within a coastal zone; therefore, the substantive requirements are applicable. RAs are required to be consistent, to the extent practicable, with Delaware's coastal zone management program. The EPA must notify Delaware of its determination that the actions are consistent to the extent practicable.
Delaware Coastal Zone Act; Delaware Regulations Governing the Coastal Zone	Delaware Administrative Code, Title 7, Chapter 108	Applicable	Establishes management policies related to a wide range of coastal, beach, wetlands, woodlands, and other natural areas.	The Site is located within the state's coastal zone; therefore, the substantive requiren1ents are applicable. RAs are required to be consistent, to the extent practicable, with Delaware's coastal zone management program. The EPA must notify Delaware of its determination that the actions are consistent to the extent practicable.
Procedures for Implementing the National Environmental Policy Act Statement of Procedures on Floodplain Management and Wetlands Protection	40 CFR 6, Subparts A through C	To Be Considered	Executive Order 1990 - Protection of Wetlands – to avoid to the extent possible the long- and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands.	This requirement is applicable for construction activities that extend through an area of wetlands. Actions will be needed to address and avoid the potential short-term and long-term adverse effects to wetlands.
Delaware Coastal Management Program Federal Consistency Policies and Procedures	Delaware Administrative Code, Title 7, Chapter 5104 §§ 2, 3, 5	Applicable	The Federal Coastal Zone Management Act of 1972, as amended, provides that each federal agency conducting or supporting activities, whether within or outside the coastal zone, affecting any land or water use or natural resource of the coastal zone, must do so in a manner which is, to the maximum extent practicable., consistent with Delaware's Coastal Management Program.	The Site is located within the state's coastal zone; therefore, the substantive requirements are applicable. RAs are required tobe consistent, to the extent practicable, with Delaware's Coastal Management Program. The EPA must notify Delaware of its determination that the actions are consistent to the extent practicable.
Delaware Wetlands Regulations	Delaware Administrative Code, Title 7, Chapter 7502	Applicable	Regulations to preserve and protect the productive public and private wetlands and to prevent their despoilation and destruction consistent with the historic right of private ownership of lands.	The substantive requirements are applicable for construction activities that extend through an area of wetlands. Actions will be needed to address and avoid the potential short-term and long-term adverse effects to wetlands.
The National Historical Preservation Act and regulation	36 C.F.R. §§800.4 and 800.10 40 C.F.R. § 6.301(b)(c)	Applicable	Requires the identification of historic properties potentially affected by the agency undertaking and the assessment of both the effects on the historic property and ways to avoid, minimize, or mitigate such effects. Historic property is any district, site, building, structure, or object included in or eligible for the National Register of Historic Places, including artifacts, records, and material remains related to such a property.	The EPA does not currently have any information that there are historic properties at the Site. If a determinization is made that there are historic properties on or near the Site, action will be taken to mitigate any adverse effects on those properties resulting from the remedial activities.

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
Action-Specific ARARs				
A. General/Miscellaneous				
Endangered Species Act	50 C.F.R. §§ 17.11	Applicable	Prohibits the taking of any fish or wildlife appearing on any list of threatened or endangered species published by the U.S. Secretary of the Interior pursuant to the federal Endangered Species Act, and defines actions which constitute taking.	Applicable to all alternatives if endangered species are found within the Site. As of May 2023, resource agencies have not identified any endangered species at the Site. The EPA will be required to take threatened and endangered species into consideration before remedial action.
Migratory Bird Treaty Act	50 C.F.R. § 10.13	Applicable	Prohibit, the unlawful taking, possession or sale of any migratory bird, including any part, nest, or egg of any such bird, native to the U.S. or its territories.	Remediation activities might be performed while migratory birds are present. Appropriate action, will be taken during the remedial action to ensure that no on-Site migratory bird, or their nests are adversely affected.
Implementation Policy for Groundwater Management Zone/Groundwater Exclusion Zone, Memorandum of Agreement	No legal citation. April 10, 2008 Memorandum of Agreement for the Delaware City Industrial Area. Policy document source: DNREC.gov.	To Be Considered	A Memorandum of Agreement within DNREC establishing the authorities of each Division to create groundwater ICs (GMZs or Groundwater Exclusion Zones).	Applicable to ICs to be implemented at the Site.
B. Water				
CWA: Delaware National Pollutant Discharge Elimination System Requirements.	40 CFR Part 123; Delaware Administrative Code, Title 7, Chapter 720I §§ 6.15-.16.	Applicable	Establishes effluent limitations for discharges to waters of Delaware and the United States.	Those groundwater treatment alternatives that involve the discharge of treated water will be required to comply with the substantive requirement, of these discharge standards.

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
Delaware Regulations Governing Construction and Use of Water Wells	Delaware Administrative Code, Title 7, Chapter 730I, §§ 3.0-10.0	Applicable	Minimum requirement, are prescribed governing the location, design, installation, use, disinfection, modification, repair, and sealing of all wells and associated pumping equipment as well as certain requirements for the protection of potable water supply wells.	Substantive requirements are applicable to well construction activities (from the initial penetration or excavation of the ground through development, equipment installation and abandonment) on Site.
Delaware Statue Regarding Licensing of Water Well Contractors, Drillers, Pump Installers, Septic Tank Installers, Liquid Waste Treatment Plant Operators and Liquid Waste Haulers	Delaware Administrative Code, Title 7, Chapter 7302 § 4.0	Applicable	Sets forth requirements for the licensing of water well drillers, prevention of pollution of underground waters, submittal of well construction records, and well sealing notification.	The substantive requirements of these regulations are applicable for any remedy that involves the installation or sealing of a well, or the injection of materials into an existing well.
CWA Stormwater Program	40 CFR §I 22.26(c) and (d)	Applicable	This regulation sets forth application requirements for discharge of stormwater from industrial and construction activities.	Alternatives involving remedial construction would be designed and implemented to comply with the substantive provisions of the cited requirements and/or the requirements of the construction general permit for stormwater, such as best management practices.
Delaware Sediment and Stormwater Regulations	Delaware Administrative Code, Title 7, Chapter 5101 §§ 3.0- 7.0	Applicable	Requires implementation of storm water control measures to prevent injury to health, safety, or property.	Stormwater controls shall be implemented and maintained during construction of the remedy. Only the substantive requirement must be met.
C. Air				
Regulations Governing the Control of Air Pollution	Delaware Administrative Code, Title 7, Chapter 1119 and 1124, §§ 8.0 and 50.0	Applicable	Sets forth odor or volatile organic compound (VOC) emission levels.	Remedial alternatives that pose the potential for emission during implementation of the remedy would need to meet the requirements for odor and VOC emissions.

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
E. Hazardous Waste				
RCRA and DRGHW	Delaware Administrative Code, Title 7, Chapter 1302	Applicable	These provisions govern the accumulation time for hazardous wastes and management of containers.	These requirements will be followed for extracted DNAPL and if a groundwater treatment remedy that generates hazardous sludge is selected as the remedy.

Notes:

ARAR- Applicable or Relevant and Appropriate Requirements
CAA - Clean Air Act
CERCLA- Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR-Code of Federal Regulations
CWA- Clean Water Act
DNAPL -Dense non-aqueous phase liquid
DNREC - Delaware Department of Natural Resources and Environmental Control Governing Hazardous Substance Cleanup
DRGHW - Delaware Regulations Governing Hazardous Waste
The EPA - The (U.S.) Environmental Protection Agency
GETS - Groundwater extraction and treatment system
GMZ - Groundwater Management Zone
HSWA - Hazardous and Solid Waste Amendments of 1984
IAW - In accordance with
IC- Institutional Controls.
MCL - Maximum Contaminant Level
NCP - National Oil and Hazardous Substances Pollution Contingency Plan
NPDES - National Pollutant Discharge Elimination System
NPL- National Priorities List
OU4 - Operable Unit 4
PCB - Polychlorinated biphenyl
RA - Remedial action
RCRA - Resource Conservation and Recovery Act
SCD - Standard Chlorine of Delaware
SDWA - Safe Drinking Water Act
SVE- Soil vapor extraction
TBC - To be considered
TSCA- Toxic Substances Control Act
VOC - Volatile Organic Compound

APPENDIX C

DNREC CONCURRENCE LETTER

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL
DIVISION OF WASTE AND HAZARDOUS SUBSTANCES
RICHARDSON & ROBBINS BUILDING
89 KINGS HIGHWAY
DOVER, DELAWARE 19901

DIRECTOR'S OFFICE

PHONE
(302) 739-9400

May 2, 2024

Mr. Chris Hinkle
Remedial Project Manager
US EPA Region III
Four Penn Center
1600 John F. Kennedy Boulevard
Philadelphia, PA 19103-2029

RE: State of Delaware Concurrence for Standard Chlorine of Delaware / Metachem (OU-4) Record of Decision (DE-0053)

Dear Mr. Hinkle:

Thank you for the opportunity of reviewing and commenting on the US EPA's selected remedy and Record of Decision for the Standard Chlorine of Delaware / Metachem Superfund site near Delaware City, Delaware. The State of Delaware hereby concurs with the Record of Decision for the Standard Chlorine of Delaware Inc. Superfund Site Operable Unit 4.

Please call if you have any questions or concerns about this concurrence.

Sincerely,

Mindy B.C. Anthony
for Timothy Ratsep

Timothy T. Ratsep
Director

pc: Paul W. Will, Program Manager II, Remediation Section
Amy E. Bryson, Program Manager II, Remediation Section

TAK/TTR/GLM:jmv
TAK24042.doc
DE-0053 II H3

APPENDIX D

TECHNICAL IMPRACTICABILITY WAIVER

GROUNDWATER RESTORATION TECHNICAL IMPRACTICABILITY EVALUATION
STANDARD CHLORINE OF DELAWARE, INC. SUPERFUND SITE
OPERABLE UNIT 4 (OU4)
NEW CASTLE COUNTY, DELAWARE

Prepared for:

U.S. Environmental Protection Agency Region 3
1650 Arch Street
Philadelphia, PA 19103

Prepared by:

HydroGeoLogic, Inc.
9 Tanner Street, Suite 101
Haddonfield, NJ 08033

EPA Contract EP-S3-07-05
Work Assignment 022RICO03H6

June 2020

Revised by EPA June 2023

HGL
HydroGeoLogic, Inc

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GROUNDWATER RESTORATION TECHNICAL IMPRACTICABILITY EVALUATION STANDARD CHLORINE OF DELAWARE, INC. SUPERFUND SITE OPERABLE UNIT 4 (OU4) NEW CASTLE COUNTY, DELAWARE

1.0 INTRODUCTION

This Technical Impracticability Evaluation has been developed in accordance with the *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration* (EPA, 1993). It will be shown in this document that Applicable or Relevant and Appropriate Requirements (ARARs) cannot all be met for certain Contaminants of Concern (COCs) in certain areas of the Standard Chlorine of Delaware (SCD) Site (Site). In the case of this Site, federal Maximum Contaminant Levels (MCLs) cannot be met in the proposed TI Waiver zones due to technical impracticability.

It a requirement under CERCLA that ARARs, which include meeting the federal MCLs, shall be met for NPL cleanup sites. However, six ARAR waivers are provided by CERCLA §121(d)(4) including the "Technical Impracticability Waiver" which waives ARARs in the case of documented "technical impracticability from an engineering perspective".

This Groundwater Restoration Technical Impracticability (TI) Waiver has been developed for Operable Unit (OU) 4 (OU4) of the Standard Chlorine of Delaware Site. The TI Waiver was prepared in conjunction with the Feasibility Study (FS) for OU4 of the SCD Site (HGL, 2020) completed by HydroGeoLogic, Inc. (HGL) under Contract Number EP-S3- 07-05 with U.S. Environmental Protection Agency (EPA) Region 3, Work Assignment 022RICO03H6, and revised by EPA in 2023. This TI Evaluation has been prepared using data and information from the Remedial Investigation (RI) Report (HGL, 2016a), the FS Report (HGL, 2020), OU1 Interim Remedy Implementation Reports (HGL, 2017a, 2018, 2019a), and groundwater sampling events through April, 2021.

1.0 REPORT PURPOSE

The purpose of this TI Evaluation is to evaluate the technical impracticability of achieving groundwater Applicable or Relevant and Appropriate Requirements (ARARs), from an engineering perspective at the SCD Site. A description of the applicable TI Waiver "zones" and for which COCs it applies is provided in Section 1.2.

This evaluation addresses the technical impracticability of achieving ARARs used to establish cleanup levels for current or potentially drinkable ground water (MCLs or non-zero MCLGs established under the Federal Safe Drinking Water Act).

This report is being submitted as a "front-end" TI Evaluation, in accordance with Section 4.2 of the TI guidance document (EPA, 1993). This TI Evaluation is considered integral to the forthcoming OU4 final groundwater remedy, as the front-end TI Evaluation is an acknowledgement that none of the preferred remedial alternatives will result in complete achievement of the ARARs proposed to be waived by this TI Evaluation.

This front-end TI decisions is being made before implementing the overall Site remedy and is supported by extensive Site characterization data and evaluation of potential remedial alternatives.

These data and information are presented in the RI and FS for the Site.

Data collected during the RI and FS indicate the presence of dense non-aqueous phase liquid (DNAPL) in the Site. This TI Evaluation will outline why the nature of DNAPL contamination on the Site, in addition to other complications, preclude a remedial alternative to restore MCLs that meets engineering feasibility. This TI Evaluation presents the data necessary to support this evaluation.

1.1 REPORT ORGANIZATION

The TI Evaluation is organized as follows:

- Section 1 provides introductory material and details the organization of the document. This section also identifies the ARARs for which a TI waiver is requested and discusses the spatial areas for which the TI waiver is requested.
- Section 2 provides background information including Site characteristics, history, and contamination. This section also presents a conceptual site model (CSM), including the regional and Site-specific geology and hydrogeology, the nature and extent of Site COCs in soil and groundwater, identification of source areas, fate and transport of contaminants at concentrations above MCLs, and potential receptors.
- Section 3 describes source control measures and analyzes the current remedial action performance.
- Section 4 evaluates the restoration potential of the Site. Potentially applicable remedial technologies are discussed for each portion of the TI Waiver zones. Rationale is provided for why ARARs cannot be fully met within the proposed TI Waiver zones. Alternative Remedial Strategies (ARS) are provided to achieve the Remedial Action Objectives (RAOs) of the Site, prevent further spread of contamination, and contain existing contamination.
- Section 4 provides a summary of cost estimates for remedial alternatives as presented in the FS Report.
- The proposed ARS is presented in Section 5, along with a summary and conclusion of the TI Evaluation.

1.2 SPATIAL EXTENT OF PROPOSED TI WAIVER ZONES

The TI Waiver zones are proposed for areas with significant DNAPL contamination where groundwater cannot be restored to MCLs. The rationale for the extent of these zones is presented later in this TI Evaluation.

There are eight proposed TI Waiver zones. The TI Waiver zones are split apart because the nature and extent of contamination, as well as the engineering feasibility of various remedial alternatives, varies by location within the Site.

There are four TI Waiver zones in the Columbia aquifer: zones C1, C2, C3, and C4. The Potomac aquifer also has four TI Waiver zones, zones P1, P2, P3, and P4. **Figure 1a** refers to the horizontal extent of the Columbia aquifer TI zones, while **Figure 1b** refers to their vertical extent. **Figure 2a** depicts the horizontal extent of the Potomac aquifer TI zones, while **Figure 2b** depicts their vertical extent.

Zone C1 encompasses the Columbia aquifer within the OU1 slurry wall to the north of the WMA. It would be unnecessary to propose a TI Waiver zone for the southern half of the containment area enclosed by the slurry wall and capped as a part of OU3, as that area is designated as a WMA, where ARARs do not apply to the underlying groundwater. As with the other Columbia aquifer TI Waiver zones, the vertical extent of the proposed TI Waiver zone goes to the top of the Merchantville Clay or the top of the Potomac A sands, about 30 feet below mean sea level (MSL).

Zone C2 refers to the portion of the Columbia aquifer underlying the steep, wooded area to the north of the slurry wall between the former facility area and the Northern Wetlands along Red Lion Creek. The vertical extent of zone C2 goes to about 30 feet below MSL, where the Potomac A sands begin. Zone C2 extends to the southern end of Red Lion Creek and its associated wetland area, where contaminated groundwater flow meets uncontaminated groundwater flow from the north. The shallow portions of surface water, soils, sediments, and associated contaminated porewater of the Site wetlands from 0 to 4 feet below ground surface in this region are addressed by OU2 and are not included in the TI Waiver.

Zone C3 refers to a small area immediately west of the slurry wall in the area known as the Western Drainage Gully, where former contaminant spills flowed overground and sunk into the soils and groundwater. Zone C3 extends down to the Merchantville Clay, about 30 feet below MSL. Zone C4 refers to a zone near the area known for the former Air Products facility, where spills formerly occurred. Zone C4 also extends down to the Merchantville Clay, 30 feet below MSL.

The Potomac aquifer TI Waiver zones, zones P1, P2, P3, and P4 are bound by the top of the Potomac aquifer to the bottom of the Potomac aquifer ‘A’ sands, 120 feet below mean sea level. Zone P1 refers to the area immediately underlying zone C1. As with the Columbia aquifer, the portion of the Potomac aquifer underlying the OU3 capped area is encompassed by the WMA.

Zone P2 encompasses the Potomac underlying zone C2 where DNAPL and contaminated groundwater have migrated from the Columbia aquifer into the Potomac. In this region, the confining clay layer under the Columbia aquifer is thin and absent in many places, and there is direct hydraulic communication between the Columbia and Potomac aquifers. Zone P2 extends to 120 feet below MSL. Zone P2 extends as far north as the area underlying Red Lion Creek, where it meets uncontaminated groundwater flow from further north.

Zone P3 encompasses the area underlying the Western Drainage Gully, in the Potomac aquifer ‘A’ sands, which are about 30 to 120 feet below MSL. Zone P4 encompasses the area of the Potomac A sands immediately east of the slurry wall in the Potomac aquifer at depths from 30 to 120 feet below MSL.

The depth of the bottom of the TI Waiver zones is defined as 120 feet below mean sea level, which is the depth of the bottom of the Potomac ‘A’ sands in this portion of the aquifer. The depth below surface elevation varies by overlying topographical terrain but varies from about 140–160 feet below surface elevation. Proposed TI Waiver zones were only drawn around areas where ARARs cannot be met through proposed remedial alternatives, only in areas with DNAPL that cannot be reliably removed or treated. Contaminated groundwater downgradient of those DNAPL areas will be remediated. MCL exceedances in areas that can feasibly be remediated to achieve all ARARs were excluded from the TI Waiver zones, as a TI Waiver is only necessary for specific areas where certain ARAR(s) cannot be met.

Note that the TI waiver zone does not apply to groundwater underlying the Waste Management

Area (WMA) (the area within the slurry wall and under the cap). However, it should be noted that contaminant concentrations in groundwater samples collected from most wells underlying the WMA have typically been among the highest observed at the Site. Therefore, the exclusion of the WMA is because the ARARs do not need to be met in groundwater underlying the WMA, not for a lack of contamination.

Because of lack of sample data from under the containment area and limited data points within the Potomac aquifer plume, no data could be generated for Potomac aquifer contaminants within the slurry wall, encompassed by TI Waiver zone P1, which is outside the WMA but inside the bentonite slurry wall that was installed as a part of the IGR. However, because of very high contaminant concentrations within the WMA, it is inferred that these contaminants are leaching from there into the Potomac aquifer underlying this area. Therefore, the P1 zone is included as a TI waiver zone for all COCs.

Table 1.1: Zones covered by the TI Waiver. These zones are depicted in Figures 1.2, 1.2a, 1.3, and 1.3a

Zone	Areas Covered	Reference Figure
C1	The Columbia aquifer within the containment area (the containment area established by the Interim Groundwater Remedy [IGR]) but outside of the Waste Management Area	Figure 1.2a is an aerial map showing the horizontal spatial extent of the proposed Columbia aquifer TI Waiver zones; Figure 1.2b shows the vertical extent
C2	The Columbia aquifer north of the containment area, within the area of DNAPL contamination	Figure 1.2a is an aerial map showing the horizontal spatial extent of the proposed Columbia aquifer TI Waiver zones; Figure 1.2b shows the vertical extent
C3	The Columbia aquifer west of the containment area and north of the rail yard, within the area of DNAPL contamination	Figure 1.2a is an aerial map showing the horizontal spatial extent of the proposed Columbia aquifer TI Waiver zones; Figure 1.2b shows the vertical extent
C4	The Columbia aquifer west of the containment area near the rail yard, within the area of DNAPL contamination	Figure 1.2a is an aerial map showing the horizontal spatial extent of the proposed Columbia aquifer TI Waiver zones; Figure 1.2b shows the vertical extent
P1	Upper Potomac aquifer under the containment area, but outside the Waste Management Area	Figure 1.2a is an aerial map showing the horizontal spatial extent of the proposed Columbia aquifer TI Waiver zones; Figure 1.2b shows the vertical extent
P2	Upper Potomac aquifer north of the containment area, within the area of DNAPL contamination	Figure 1.2a is an aerial map showing the horizontal spatial extent of the proposed Columbia aquifer TI Waiver zones; Figure 1.2b shows the vertical extent
P3	Upper Potomac aquifer west of the containment area, within the area of DNAPL contamination	Figure 1.2a is an aerial map showing the horizontal spatial extent of the proposed Columbia aquifer TI Waiver zones; Figure 1.2b shows the vertical extent
P4	Upper Potomac aquifer east of the containment area, within the area of DNAPL contamination	Figure 1.2a is an aerial map showing the horizontal spatial extent of the proposed Columbia aquifer TI Waiver zones; Figure 1.2b shows the vertical extent

Table 1.2: Each contaminant and the areas for which the TI Waiver will apply.

Contaminant of Concern	MCL (ug/L)	Area to be waived	ARAR to be Waived
Benzene	5	C1, C2, C3, P1, P2, P3, P4	MCL
Carbon Tetrachloride	5	C1, C2, P1	MCL
Chlorobenzene	100	C1, C2, C4, P1, P2, P3, P4	MCL
Total trihalomethanes (TTHM)	80	C1, P1, P2, P4	MCL
1,2-Dichlorobenzene	600	C1, C2, C4, P1, P2, P3, P4	MCL
1,4-Dichlorobenzene	75	C1, C2, C3, C4, P1, P2, P3, P4	MCL
1,2,4-Trichlorobenzene	70	C1, C2, C4, P1, P2, P4	MCL
Total PCBs	0.5	C2, C3, P1	MCL
Beryllium	4	C1, P1	MCL

Chromium	100	C1, P1	MCL
Thallium	2	C1, C2, C3, P1, P2, P4	MCL

Table 1.3: Contaminants to be waived, organized by TI waiver zone.

Zone	COCs to be Waived
C1	Benzene, carbon tetrachloride, chlorobenzene, total trihalomethanes, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, beryllium, chromium, thallium
C2	Benzene, carbon tetrachloride, chlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, total PCBs, thallium
C3	Benzene, total PCBs, 1,4-dichlorobenzene, thallium
C4	Chlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene
P1	Benzene, carbon tetrachloride, chlorobenzene, total trihalomethanes, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, total PCBs, beryllium, chromium, thallium
P2	Benzene, chlorobenzene, total trihalomethanes, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, thallium
P3	Benzene, chlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene,
P4	Benzene, chlorobenzene, total trihalomethanes, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, thallium

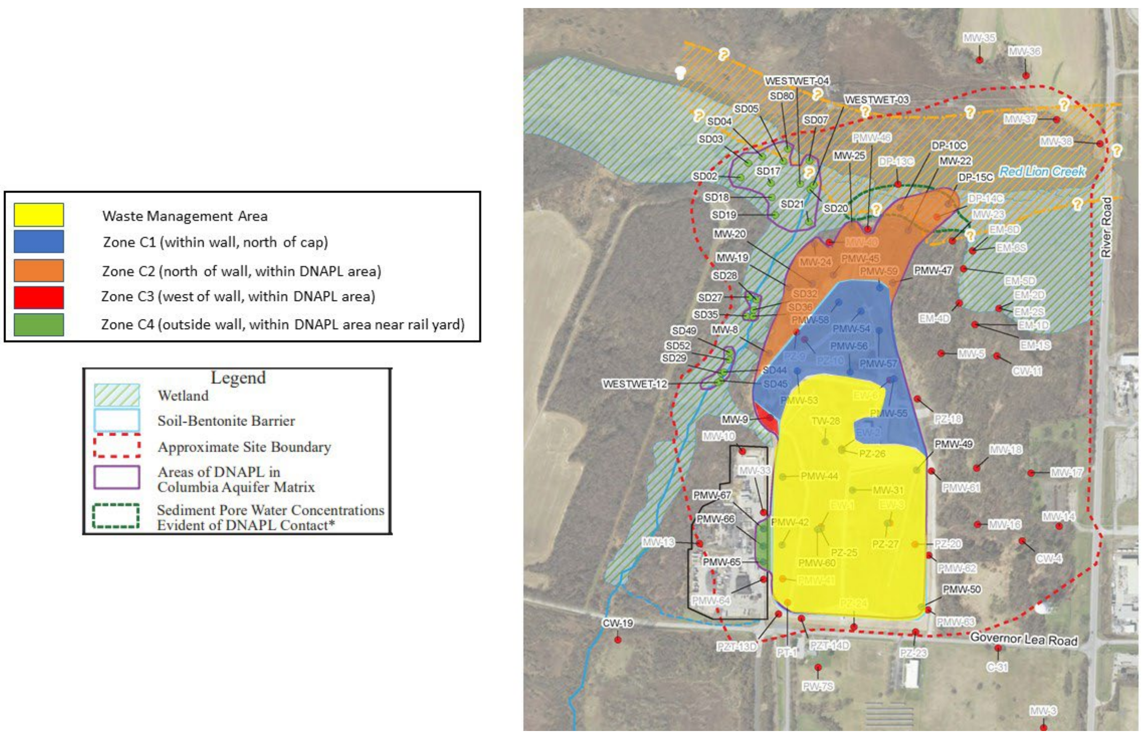

Figure 1a. Columbia aquifer TI waiver zones. Dots represent Columbia aquifer wells, where red dots indicate a lack of DNAPL and blue dots indicate DNAPL presence.

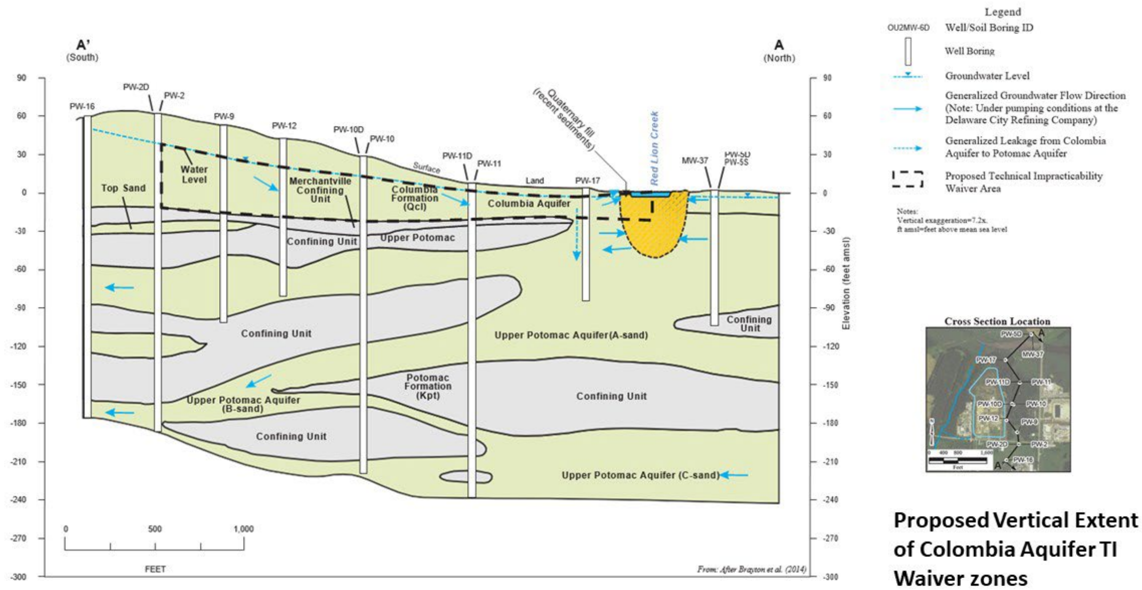

Figure 1b. Columbia aquifer TI waiver zone vertical extent, which goes down to the top of the first confining unit.

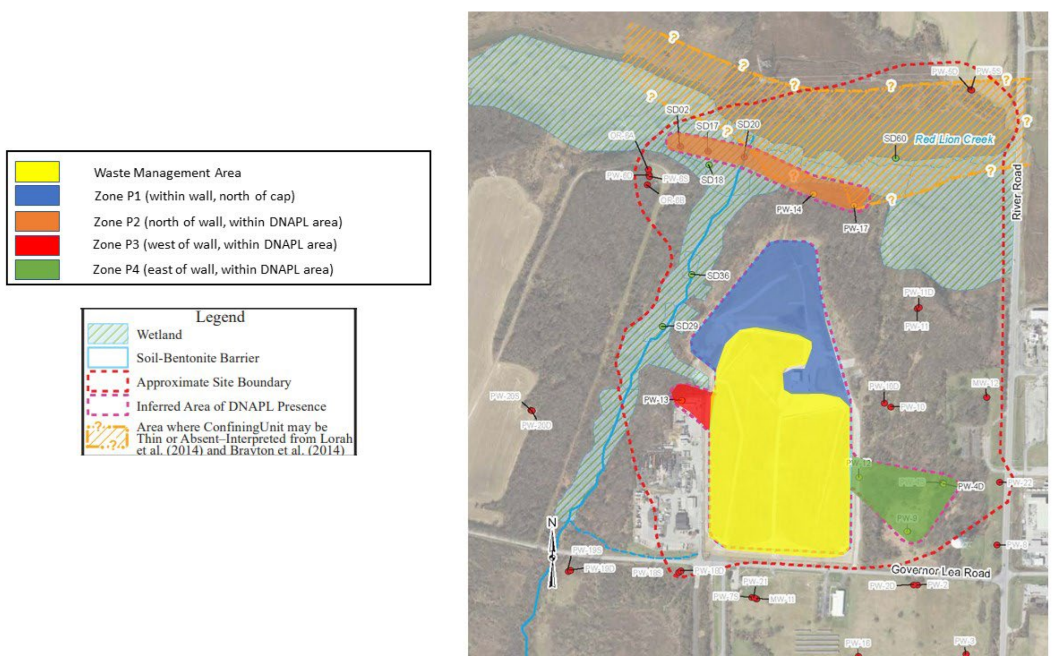

Figure 2a. TI waiver zones for the Potomac aquifer. Red dots indicate DNAPL concentrations below effective solubility (indicating lack of DNAPL), while yellow dots indicate DNAPL concentrations above effective solubility (indicating the presence of DNAPL).

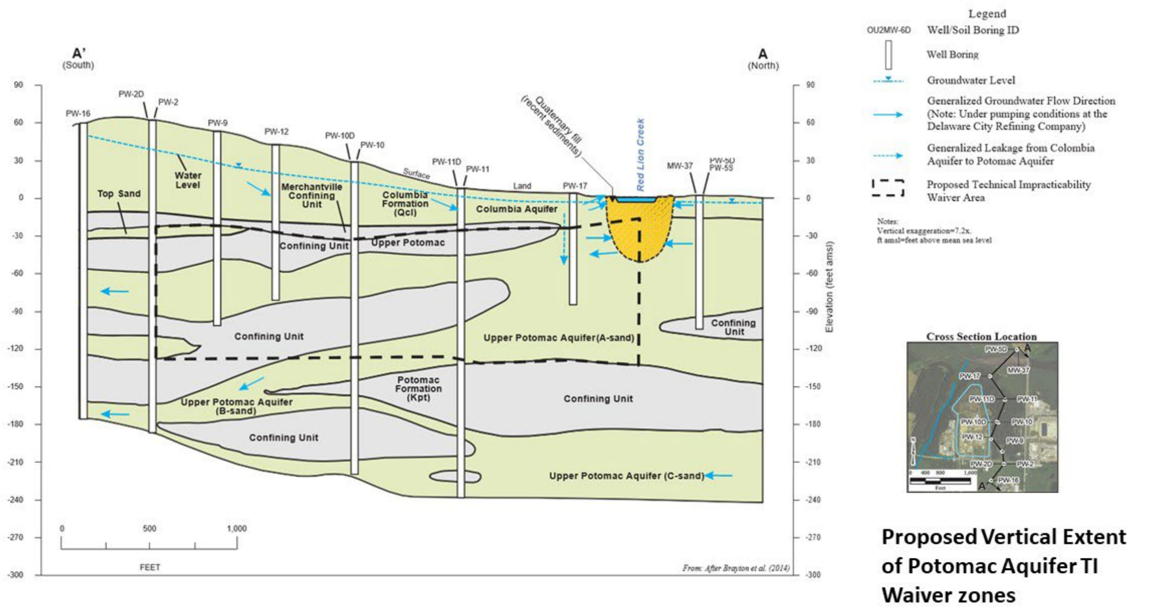

Figure 2b. Vertical extent of TI waiver zones in the Potomac aquifer.

2.0 SITE BACKGROUND

The following subsections provide a summarized view of the Site background. Additional background material can be found in the June 2016 RI Report prepared by HGL (HGL, 2016a). The Site has been divided into four OUs:

- OU1: Interim Groundwater Remedy (IGR) for the Columbia aquifer
- OU2: Final remedy for spill-impacted soils and sediments and associated contaminated porewater of the Site wetlands from 0 to 4 feet (ft) below ground surface (bgs).
- OU3: Final remedy for soil and soil gas in and to the immediate north of the former manufacturing facility area, and
- OU4: Final groundwater remedy.

OU4, the subject of this TI Evaluation, includes the long-term remediation of contaminated groundwater. The two components of OU4 groundwater are contaminated groundwater within the Columbia aquifer and contaminated groundwater within the Potomac aquifer. In addition, off-facility vapor intrusion (VI) is also considered to be part of OU4. While surface water is not explicitly part of OU4, it is directly impacted by OU4 contaminated groundwater that discharges to it.

The OU1 IGR was implemented in 2006 and 2007 to minimize the off-site migration of groundwater contamination and prevent the contamination of groundwater entering the Site from the south. The IGR includes a groundwater containment area formed by a 5,290-foot long soil bentonite slurry wall (slurry wall) that extends to an average depth of approximately 70 ft bgs. A groundwater extraction and treatment system (GETS) is being used to establish inward and upward hydraulic gradients within the containment area and removes contaminants from within the containment area as part of the IGR. EPA regularly tests the efficacy of the slurry wall to ensure it maintains an inward gradient. As part of this routine resting, EPA found a leak in the slurry wall in 2015. The leak was repaired, and EPA will continue to monitor the slurry wall to ensure its efficacy.

Given the widespread presence of DNAPL within the containment area, it is not expected that the continued operation of the GETS will result in the achievement of MCLs in that area. It is anticipated that the OU1 IGR will be incorporated into the final OU4 remedy to assist in the continued containment of the contaminants within the containment area. Because neither the GETS nor other investigated treatment options (to be discussed later in this document) will be able to restore groundwater within the containment area to MCLs within a reasonable timeframe (, a TI waiver is necessary for that portion of the Columbia aquifer.

Off-facility soils and sediments outside of OU3 and contaminated by past spills are covered under OU2, for which a remedy was finalized in a 2022 ROD Amendment (Amendment No. 3 to the 1995 ROD), an. The soils and sediments included in OU2 act as sources for ongoing contamination of Columbia aquifer groundwater; however, these soils and sediments in the northern and western wetlands are to be remediated to the extent practicable as a part of OU2. The OU3 remedy includes a 23.2-acre multilayer protective cap with an incorporated soil vapor recovery and treatment system within the containment area. This cap reduces infiltration of precipitation into most of the containment area and therefore reduces the load on the GETS and the transport of contamination from the OU3 vadose zone soils to the underlying groundwater. However, intrusive activities (drilling, excavating, direct push technology [DPT] borings) in the OU3 area must be minimized/prohibited to maintain cap integrity. Wastes, including heavily contaminated material previously stored in the former sedimentation basin and the former Temporary Soil Storage Area (TSSA), which was a lined and capped temporary pile of contaminated sediments made during the construction of the IGR, were consolidated into the subgrade of the OU3 cap and combined with contaminated waste material from the various site spills to form a WMA., ARARs will not be met in groundwater underlying this WMA. Pertinent Site features, including the footprint of the OU3 cap, are shown on Figure 2.1.

2.1 SITE LOCATION AND DESCRIPTION

The Site is located on approximately 145 acres near the intersection of Governor Lea Road and River Road, approximately 3 miles northwest of Delaware City in New Castle County, Delaware (**Figure 1.1**). Approximately 23 acres of the Site form the approximate footprint of the former SCD/Metachem manufacturing facility. The surrounding area is a mixture of industrial facilities, farmland, and undeveloped properties, although there are residential and commercial properties located to the north and west about one mile from the Site.

Land to the immediate east of the SCD property fence line is owned by OxyChem and is largely undeveloped. Land to the immediate west of the SCD property fence line was previously used by Air Products, Inc. for the packaging and distribution of liquid hydrogen. The property has since been sold and now is leased to multiple commercial operations including a staging location for a trucking company and an unrelated truck repair shop. Across Governor Lea Road is property and buildings that are now owned by Governor Lea Road LLC. Farther to the south is a refinery that is currently owned and operated by the Delaware City Refining Corporation (DCRC). The refinery has deep production wells; pumping of these wells affects the flow direction of the Potomac aquifer (HGL, 2016a).

The SCD facility was built in 1965 on approximately 46 acres of farmland purchased from the Diamond Alkali Company. Production of chlorinated benzene compounds commenced the following year and continued until the plant's closure in 2002. These compounds included chlorobenzene (CB), dichlorobenzene (DCB), and trichlorobenzene (TCB) and were manufactured at the SCD facility until its closure in May 2002. In addition, chlorinated nitrobenzene was manufactured from the expansion of the SCD facility in the early 1970s until the late 1970s. More heavily chlorinated compounds, including tetrachlorobenzenes (TeCBs), pentachlorobenzene (PeCB), hexachlorobenzene (HCB), polychlorinated biphenyls (PCBs), and dioxins, were generated as byproducts of the manufacturing process (Weston, 1993).

The Site was formally added to the National Priorities List (NPL) on July 22, 1987. The Site has been assigned Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) number DED041212473.

2.2 SITE GROUNDWATER DESCRIPTION

Groundwater at the SCD is located within Class II aquifers, indicating it is a current or potential source of drinking water. The Potomac aquifer is classified as II-A (currently used), and the Columbia aquifer is classified as II-B (potential for use) (EPA, 1988a). There are two wellhead protection areas within one mile of the SCD groundwater contaminant plume. These are the:

- Artisan's Village wellfield area located approximately two-thirds of a mile north/northwest of the northern extent of the Columbia aquifer portion of the plume; and

- Little People Child Development Center (Little People) well located approximately one mile west of the western edge of the Potomac aquifer portion of the plume.

The Artisan's Village wellhead protection area is upgradient of the contamination plume in the Potomac aquifer. The four production wells in the Artisan's Village wellfield serve approximately 200,000 residents (DNREC, 2003). Depending on the pumping activity at Delaware City Refining Company (DCRC), the Panda Early Education well, which serves the clients and staff of the day-care center, is either side-gradient (when DCRC is pumping) or upgradient (when DCRC is not pumping) from the Potomac portion of the contaminant plume. As such, neither is expected to be affected by the plume. In addition to the wells associated with these wellhead protection areas, there are production wells located on the DCRC property that are used for industrial purposes (HGL, 2016a). Locations of these wells are shown on Figure 2.2. The Little People well is screened in the Upper Potomac aquifer ells (AV-1 through AV-4) are screened in the Upper Potomac aquifer (Brayton et al, 2014). DCRC production well R-15 has the greatest impact on flow direction within the contaminated portion of the Potomac aquifer at the Site (the A-Sand). Because of a state-established Groundwater Management Zone (GMZ), no new potable water wells are permitted at, or in the immediate area of, the Site. While there is no current human exposure to contaminated groundwater, the goal of the OU4 remedy is to restore, where technically practicable, the aquifers to beneficial use and meet MCLs.

2.3 GEOLOGIC AND HYDROGEOLOGIC INFORMATION

2.3.1 Topography

As part of the remedy for OU3, a cap was built over the former facility area, the sedimentation basin, and the area between the two. Wastes from the original spills, previously stored in the sedimentation basin and TSSA, were spread across the OU3 area (which already contained waste materials from the original spills) to form the subbase for the cap construction. The OU3 cap is vegetated and was constructed with 4 to 4.5 percent slopes and includes perimeter swales and other surface water control features which feed into two stormwater ponds. The remainder of the containment area slopes slightly (approximately 0.5 to 1 percent) to the edges of the containment area to minimize precipitation infiltration within the containment area. Beyond the containment area, ground surface in the northern portion of the Site drops steeply to near sea level at Red Lion Creek. The northwestern portion of the Site slopes steeply westward to the unnamed tributary of Red Lion Creek. Another prominent, but less steep, drainage is located to the east. To the south of the Site elevation increases gradually from west to east until near River Road.

The land between the OU3 cap and Red Lion Creek remains undeveloped except for single-lane gravel roads and IGR components. Only the portion of the Site outside of the containment area remains wooded (Figure 2.1). Near Red Lion Creek and its unnamed tributary, the terrain slopes sharply downward to wetland areas surrounding these two water bodies (HGL, 2016a). A historical topographic map of the Site is presented as Figure 2.3.

2.3.2 Geology

The soils underlying the SCD facility, forested uplands, and wetlands are deep, well-drained soils, which are susceptible to erosion on sloping areas. The wetland areas within the Site consist of mixed alluvial land and marsh. These soils lack uniform characteristics and have been influenced in the past by tidal fluctuations in Red Lion Creek and the Delaware River. Tide gates at the mouth of the Red Lion Creek have limited tidal influences in the past and have been repaired recently after being nonfunctional for a few years. The final cover of the OU3 area is vegetated with a mix of grasses..

The Site is in the Atlantic Coastal Plain physiographic province and is approximately 8 to 12 miles southeast of the fall line demarcating the boundary between the Atlantic Coastal Plain physiographic province and the Piedmont physiographic province (Figure 2.5). The Atlantic Coastal Plain is characterized by a wedge of unconsolidated sediments including gravel, sand, silt, and clay ranging in age from Cretaceous to Quaternary. These sediments dip southeastward at generally less than 1 degree and overlie basement rock made of metamorphic, igneous, and consolidated sedimentary rocks. These basement rocks outcrop as a part of the eastern Piedmont along the fall line, while sediments of the Atlantic Coastal Plain thicken toward the Atlantic Ocean.

Sediments of the Atlantic Coastal Plain were generally deposited through fluvial, deltaic, and marine environments. Reworking of sediments through modern and ancestral erosion has resulted in unconformities by down cutting through Cretaceous-aged sediment, and the later deposition of new deposits.

The Site is underlain by the Quaternary aged Columbia Formation, followed by the Cretaceous-aged Merchantville and Potomac Formations, and finally a basement of Paleozoic and older metamorphic rock and saprolite (Figure 2.6). The basement rock is estimated to be approximately 750 feet bgs in the area of the Site (HGL, 2016a).

The Columbia Formation consists of coarse to fine-grained quartz sands with a characteristic orange to yellow color. Varying amounts of gravel are present in the formation, and a gravel and sand layer is a key marker bed at the base of the formation. The Columbia Formation has occasional lenses of silty clay or clayey silt, and occasional lithified sands can be observed owing to iron oxide cements (Jengo et al., 2013). On the Site, the Columbia Formation ranges from 8 to 84 feet in thickness, with a general decrease in thickness observed moving north toward Red Lion Creek and beyond.

The Merchantville Formation is a shallow marine sediment deposit predominantly composed of material ranging from dark blue-gray to green-gray glauconitic, micaceous clay to silty/sandy clay. The average thickness of the Merchantville Formation on the Site is 10.2 feet, though it is discontinuous and can range in thickness from 0 to 22 feet (Black & Veatch, 2007). An evaluation of the borehole data indicated the absence of the Merchantville Formation over a large portion of the center of the Site (Figure 2.7). Paleochannels that incise the Merchantville Formation have been identified by Degnan and Brayton (2010), Brayton et al. (2014), and Jengo et al. (2013), both on the Site and to the east and west of the Site. These paleochannels may be attributed to the ancestral Red Lion Creek and its tributaries to the ancestral Delaware River, as well as a large north-south trending glacial lake dam erosional channel locally called the Reybold paleochannel. In these areas, the Merchantville Formation is absent, and sometimes the paleochannels formed into the underlying Potomac Formation have been refilled with Columbia Formation sediment. In these areas, the Columbia Formation is directly underlain by Potomac Formation clays and sands (Figures 2.7 and 2.8) (Brayton et al., 2014).

The Potomac Formation underlies areas of the Columbia and Merchantville formations (Figure 2.8). The Potomac consists of nonmarine silts, clays, and sands, deposited in an aggrading alluvial plain creating a heterogeneous, stratigraphically complex layering of sediments where deposits are discontinuous and variable in thickness and extent. The Potomac Formation in the area of the Site has been divided into three subformations designated by the prefixes upper, middle, and lower. Each is approximately 250 feet thick (Brayton et al., 2014). The Upper Potomac Formation consists of variegated red, gray, purple, yellow, and white clays and silts interbedded locally with three relatively thick silty sand units designated the “A-Sand,” “B- Sand,” and “C-Sand” (Figure 2.8). These sand units are separated by localized confining units and are discussed further in Section 2.3.2.2.

2.3.3 Hydrogeology

2.3.3.1 Regional Hydrogeology

The Atlantic Coastal Plain aquifer system is recharged through rainfall and snowmelt. Most of the water that reaches the water table in the surficial aquifer discharges to local streams (Cushing et al., 1973). Some of the groundwater discharges to larger streams and rivers and, in coastal zones, may discharge to wetlands, tidal rivers, or estuaries (Brayton et al., 2014). A relatively small portion of groundwater recharge becomes part of a deeper flow system that includes confined aquifers that extend downdip toward the Atlantic Ocean (Shedlock et al., 2007).

The flow system within the surficial aquifer is unconfined and controlled mainly by topography and surface water features. The surficial aquifer discharges to small streams and creeks. Groundwater in the surficial aquifer is recharged by infiltration of precipitation. Some water from the surficial aquifer recharges underlying aquifers in areas where layers of the Potomac Formation subcrop or outcrop, or where overlying confining units are thin or absent (Brayton et al., 2014).

The regional flow system within the confined aquifers of the Potomac Formation is characterized by slow southeast flow, controlled mainly by hydrostratigraphy. Most of the regional recharge occurs to the northwest of the Site where the upper Potomac aquifer subcrops under Quaternary surficial sediments, primarily the Columbia Formation. The middle and lower Potomac aquifers tend to contact basement rocks in an onlapping unconformable pattern (Benson, 2006; McKenna et al., 2004) and are likely recharged by leakage through confining layers. Fleck and Vroblesky (1996) modeled groundwater flow in the Maryland and Delaware Coastal Plain and estimated average regional flow rates of approximately 0.1 to 0.2 feet per day in the aquifers. Pumping of the aquifers affects both flow rates and flow directions. Vertical groundwater flow gradients in the area are downward from the Columbia aquifer to the Potomac aquifer, and downward between sand layers within the Potomac Formation. Flow between the Columbia and Potomac formations is possible where confining units are thin or absent (Brayton et al., 2014).

2.3.3.2 OU4 Hydrogeology

The Columbia aquifer, consisting of sands and gravels of the Columbia Formation, is the uppermost aquifer at the Site. The upper boundary of the Columbia aquifer represents the localized water table and generally occurs at depths ranging from near ground surface (near the wetlands at Red Lion Creek) to approximately 45 feet bgs in the On-Facility Area (Black & Veatch, 2007). Across much of the Site, the Columbia Formation is underlain by clays and silts from the Merchantville and Potomac formations. Samples collected as part of a geotechnical analysis conducted during the OU1 RD showed that the clays from these formations had porosities of approximately 0.35 and permeabilities ranging from 1.3×10^{-7} to 8.9×10^{-9} square centimeters (cm^2). Silty sands recovered from these formations had porosities of approximately 0.41 and permeabilities ranging from 3.7×10^{-4} to 7.0×10^{-6} cm^2 (Black & Veatch, 2005). These clays and silts form a shallow aquitard, but they are thin or absent from certain areas of the Site including areas to the northeast of the slurry wall, as depicted on Figure 2.9. The elevation of the top of the shallow aquitard, which consists of both Merchantville and Potomac Formation clays and silts, is provided as Figure 2.9. Note that there are several apparent lows in the aquitard surface at the southeastern portion of the Site (Figure 2.9). Gravel mixed with the clay commonly tops the aquitard, indicating high-energy alluvial deposition. Therefore, the depicted lows at the southeastern portion of the Site might not be localized depressions, as shown, but could continue laterally. The borehole data, however, are insufficient to map the lateral expressions of the low areas. Similarly, there is insufficient borehole data to provide a full understanding of the thickness of the aquitard across the Site. However, a map of the minimum observed thickness of the low permeability layer separating the Columbia and Potomac aquifers was presented with the OU1 RD (Black & Veatch, 2005) and has been updated to show more recent Potomac aquifer well installations (Figure 2.9a). Limitations on drilling through contaminated portions of the Columbia aquifer into the Potomac prevented the addition of any data within much of the Site boundary. It should be noted that many of the borings that were used to develop the thickness data were stopped soon after contact with the clay to prevent potential migration of Columbia aquifer contamination into what was then thought to be an uncontaminated Potomac aquifer. As a result, the thicknesses indicated within the containment area and in some upland portions of the Site to the north and west of the containment area might underrepresent the actual aquitard thickness. No clay was observed at locations where a zero (0) is indicated.

Tables 2.1 and 2.2 provide the measured groundwater elevations from December 2007 to January 2015 (Brayton et al., 2014). The flow direction of the unconfined Columbia aquifer generally conforms to topography under natural conditions, with flow generally moving north toward Red Lion Creek (Figure 2.10). The saturated thickness of the Columbia aquifer at the Site varies between 10 and 40 feet. The average groundwater hydraulic gradient under natural conditions in the Columbia aquifer ranges from 0.003 feet/foot to 0.007 feet/foot to the north- northwest (Black & Veatch, 2007). Site water levels may slightly fluctuate due to seasonal precipitation changes. Minimal tidal influence was observed in shallow Columbia aquifer wells near Red Lion Creek (Lorah et al., 2014), but the tide gate on the Delaware River has since been repaired.

The hydraulic conductivity of the Columbia aquifer is estimated to range from 5 to 134 feet per day but has been observed as high as 184 to 441 feet per day (Black & Veatch, 2007). The water level in Red Lion Creek is lower than the adjacent groundwater table in the Columbia aquifer (1 to 2 ft above mean sea level [amsl]), indicating that there is discharge from the Columbia aquifer into Red Lion Creek and the unnamed tributary (HGL, 2020; Lorah et al., 2014).

The slurry wall constructed as part of the OU1 IGR was installed to prevent, to the extent possible, the off-site migration of site contaminants from the most heavily contaminated portions of the Columbia aquifer to the Red Lion Creek and to prevent uncontaminated groundwater from moving into the most heavily contaminated areas. Before the installation of the IGR slurry wall, Site groundwater elevations in the Columbia aquifer ranged from approximately 16.5 feet amsl in the south to approximately 3 ft amsl in areas adjacent to Red Lion Creek. As expected, the pumping associated with the GETS has lowered the average groundwater elevations within the containment area. The water levels measured in November 2019 (Figure 2.10) indicate that the groundwater elevations within the containment area ranged from approximately 6.2 to 6.6 ft amsl at the southern end to approximately 3.7 to 4.1 ft amsl at the northern end (HGL, 2019b). This compares to containment area groundwater elevations ranging from a maximum of over 15 ft amsl to minimums of near 5 ft amsl in this area before the slurry wall was installed (Figure 2.11). The slurry wall diverts groundwater flow around the facility portion of the Site so that the water flows toward the east and west before resuming a more northerly route toward Red Lion Creek (HGL, 2017a).

Lorah, et al. (2014) performed a detailed examination of the hydrology in the area of the wetlands near Red Lion Creek. Their study found that groundwater discharge to the northern marshes occurs approximately at the 1.3-ft-amsl elevation (Figure 2.12). Vertical gradients from the Columbia aquifer across Red Lion Creek were also examined by Lorah, et al. (2014). Figure 2.13 depicts the conceptualized upward vertical gradients at Red Lion Creek and the surrounding wetlands (from Lorah et al. 2014). Shallow upward vertical gradients also are present throughout much of the Western, Northern, and Eastern Wetlands, as well as along Red Lion Creek. These upward gradients from the shallow portion of the Columbia aquifer represent a potential source of contamination to Red Lion Creek and all of the wetlands areas.

Lorah et al. (2014) also estimated the volumetric groundwater fluxes to Red Lion Creek, which indicated that at least half of the net recharge to the subwatershed of Red Lion Creek comes from groundwater, which would largely be derived locally from the Columbia aquifer. This assessment indicates a potentially significant contaminant transport pathway from the Columbia aquifer to Red Lion Creek.

The Merchantville Formation consists of dark gray to black micaceous clays and silty clays. Regionally, the Merchantville acts as a confining unit separating the Columbia aquifer and upper Potomac aquifers. Due to the siltier characteristic, the Merchantville Formation may allow more groundwater leakage over time, as compared to the tighter clay in the Potomac Formation. The Merchantville Formation is absent in some areas of the Site. In these areas, the Columbia aquifer is underlain by either clayey sediments of the Potomac Formation or by silty-sand (Figure 2.8) material. Below these upper units is a sequence of interbedded clays, silts, and sands that eventually forms the upper Potomac aquifer (Black & Veatch, 2007). Within the containment area at the SCD Site, the clay/silty-clay layer associated with the Merchantville and/or the Upper Potomac Formations generally acts as an aquitard to restrict groundwater flow between the Columbia and upper Potomac aquifers, but as depicted on Figure 2.8, some recharge to the Potomac aquifer takes place. The locations of significant communication between the Potomac and Columbia aquifers have not been determined fully but will be in areas where the Merchantville Formation is absent, and the upper portions of the Potomac Formation are permeable (such as in the area near PW-17 and the PW-5 well pair).

Monitoring wells screened within the upper Potomac aquifer were installed in 2007. Gamma logs and vertical water-quality profiling were conducted on selected wells. At two of the locations, the wells were installed with a screened interval set below existing Merchantville clay, but above

Potomac clay. This thin discontinuous sand zone (described by Brayton et al., 2014 as “upper Potomac top sand”) has been found to be similar in water chemistry to the unconfined Columbia aquifer, and water levels have behaved similar to Columbia wells, indicating that the Merchantville clay is not an effective confining unit (Brayton, et al., 2014).

The additional explorations resulted in the identification of three upper Potomac aquifers named by Brayton et al. (2014) as A-Sand, B-Sand, and C-Sand (Figure 2.8). The A-Sand ranges in thickness from 10 to 70 feet and is present below the upper Potomac confining unit (Figure 2.8). This upper Potomac confining unit, however, is not present near Red Lion Creek (wells PW-17 and PW-5, Figure 2.8). A pumping test conducted by U.S. Geological Survey (USGS) in 2010 indicated that transmission also was occurring between the Columbia and Potomac aquifers in the containment area but only near extraction well EW-5. The B- and C-Sands are noted by Brayton et al. (2014) as being thinner than the A-Sand. The B-Sand is below a second localized Potomac confining unit. This second confining unit has been documented as being between 40 and 60 feet thick. The B-Sand has been found to be 10 to 15 feet thick. The C-Sand lies below a third localized Potomac confining unit and has been shown to be less than 10 feet in thickness (Brayton et al., 2014). There is hydraulic communication between the A-, B- and C-Sands as their confining units are not laterally continuous (Figure 2.8).

The Merchantville Formation and upper Potomac Formation clays reduce groundwater flow between the Columbia and upper Potomac aquifers throughout much of the Site. However, downward vertical gradients exist between the Columbia and Potomac aquifers. Site-related contaminants have been detected at concentrations greater than their effective solubilities in wells screened in the Potomac aquifer to the west, east, and north of the former plant area indicating that DNAPL is present at depths of at least 150 feet. Taken together, these results indicate that transmission of both DNAPL and dissolved contamination has occurred or is occurring between the Columbia and Potomac aquifers.

Based on conversations with DNREC, recent usage records indicate that a refinery located to the south of the Site pumped an average of approximately 387,000 gallons of water per day from the Potomac aquifer well R-15 for industrial production purposes in 2018 (DNREC, 2019). Pumping from this well has been shown to directly impact the flow of Potomac aquifer groundwater at the Site (Brayton et al., 2014). During a period of limited groundwater pumping, owing to a change in the ownership of DCRC, water levels were measured to estimate natural groundwater flow conditions in the Potomac aquifer. A potentiometric contour map showing these conditions from Brayton et al. (2014) is presented as Figure 2.14. This figure shows that groundwater flow under close to ambient conditions is generally to the east, toward the Delaware River. Figure 2.15 shows that the potentiometric conditions in the Potomac aquifer under normal pumping conditions at DCRC is generally toward the south. Hydraulic heads in the upper Potomac aquifer sands are affected by changes in stage of Red Lion Creek due to precipitation, as well as minimally affected by tidal changes. The tidal influence is further reduced by the tide control structure on Red Lion Creek (Brayton et al., 2014). Additionally, the active pumping of the Potomac aquifer to the south increases the downward vertical gradient from the Columbia aquifer to the Potomac aquifer.

2.4 CONTAMINANT SOURCE AND HISTORY OF RELEASES

Three major documented releases occurred at SCD in the 1970s and 1980s (Black & Veatch, 2005) and are listed below:

- An unknown volume of various off-product chemicals was released from Catch Basin 1 leaks that were discovered in March 1976;
- A September 1981 release of approximately 5,000 gallons of CB were released from a railroad tank car; and
- Releases from multiple storage tanks in January 1986 totaling approximately 569,000 gallons of volatile organic compounds (VOCs).

The locations of these releases are all within the portion of the containment area that is covered by the OU3 cap. These locations are depicted on Figure 2.1. Additional details of these releases and other ongoing sources of groundwater contamination are presented in the following subsections.

Additionally, an unknown volume of waste material and wastewater was released from leaks in a wastewater treatment plant (WWTP) discharge line that ran from the WWTP east, under River Road, through the Oxychem Property, and into the Delaware River. Contamination related to the leaks from this line contributed to the need for remedial activities conducted at the Oxychem property to the east of River Road and has been identified during well installation activities conducted to the west of River Road. The material from this release is thought to have contributed to groundwater contamination in both the Columbia aquifer and the upper sands of the Potomac aquifer. Discoveries of decomposed drums, contaminant-filled drainpipes, and solid chlorinated benzene materials during the IGR implementation indicate that other releases occurred as the result of plant operations and waste disposal activities [HGL, 2013]). Note that the contaminants released are either dense non-aqueous phase liquids (DNAPLs) or solids at ambient temperatures in their pure forms.

2.4.1 Catch Basin 1 Release and Related Remedial Activities

In March 1976, SCD determined that Catch Basin 1, part of the facility's wastewater treatment plant (WWTP) (Figure 2.1) had been leaking materials into the subsurface. Catch Basin 1 was a settling basin used to recover product from the facility's wastewater. According to the 1992 RI report, the catch basin was repaired at that time, but the contaminated soil surrounding the catch basin was left in place. This finding was confirmed during subsurface soil sampling conducted as part of the 2006 OU3 RI (Black & Veatch, 2007). Releases from Catch Basin 1 are thought to be a major source of highly chlorinated compound contamination (including TeCBs, PeCB, HCB, and PCBs) in subsurface soil and groundwater (Weston, 1993). Based on high concentrations of TeCBs and PeCBs found at isolated spots in the Western Wetlands (HGL, 2016a), it is likely that other, undocumented, releases of these compounds also occurred during the plants operational period.

2.4.2 1981 Release and Related Remedial Activities

In September 1981, an accident that occurred during the loading of a railroad tank car resulted in the release of approximately 5,000 gallons of CB. This release occurred on the rail siding located along the western boundary of the SCD Site (Figure 2.1). Chemicals from this release flowed into the drainage ditch that ran north and south along the rail siding. The spilled materials then flowed into the drainage ditch that runs in front of the Former Air Products Property and discharges into the unnamed tributary in the Western Wetlands (Figure 2.1). As part of the response action, SCD collected a portion of the spilled chemicals and removed surface soils from the spill area and the drainage ditch located in front of the Former Air Products Property. The excavated soil was disposed of at a permitted off-Site disposal facility. This removal action was performed under the supervision of DNREC. SCD also conducted a limited subsurface investigation of the area to determine the potential for migration of the spilled CB into the underlying groundwater. Based on the results of this investigation, SCD and DNREC concluded that the potential existed for groundwater contamination to occur (Weston, 1992).

As a follow-up to the soil cleanup and sampling efforts, SCD installed groundwater monitoring wells at various locations on the SCD property. Analysis of the samples collected from these wells revealed that the groundwater was contaminated with multiple types of chlorinated benzene compounds. Based on these analyses, it was determined that the primary source of the high-chlorine-content benzene compounds was the March 1976 Catch Basin 1 leak (Weston, 1993).

2.4.3 1986 Release and Related Remedial Activities

In January 1986, a 375,000-gallon tank located near the western boundary of the SCD Site collapsed and damaged three nearby tanks (Figure 2.1). The tank failures resulted in the release of approximately 569,000 gallons of various VOCs, including paradichlorobenzene and TCB compounds. As the spilled materials, which normally were heated so that they would remain in a liquid state, cooled, some of the material solidified on the ground. This allowed SCD to recover and reprocess some of the spilled chemicals (HGL, 2016a).

A portion of the spilled chemicals traveled northward to the northwest corner of the SCD facility and flowed down a drainage gully into the wetlands surrounding the unnamed tributary to Red Lion Creek (Figure 2.1). Chemicals also flowed eastward across the SCD property and into the facility's eastern drainage ditch (Figure 2.1). These chemicals then traveled northward to the facility's eastern weir. No historical data pertaining to the northeastern spill pathway outside of the fence line are available, but sediments in the eastern wetland area were sampled in 2013 and 2014, and chlorinated benzene compounds were found at elevated concentrations near the shore-line (HGL, 2016a).

In an attempt to minimize the spread of contaminants from the Western Wetlands into Red Lion Creek, SCD constructed a berm (Figure 2.1) and a silt fence across the mouth of the wetlands. The silt fence has deteriorated and is no longer functional. Contaminated sediments were also excavated from the wetlands area to the north of the silt fence and placed in a lined Sedimentation Basin (Figure 2.1) located to the north of the manufacturing area. Soils that were heavily contaminated as a result of the spill were placed into soil piles constructed northwest of the sedimentation basin. During the construction of the IGR, the soil piles along with heavily contaminated slurry wall trench spoils from the former rail siding area were consolidated into a lined and capped TSSA (HGL, 2013) (Figure 2.1). Despite the initial spill response activities, much of the sediment and subsurface soil in the Western Wetlands and the wetlands bordering Red Lion Creek at the north end of the Site remain heavily contaminated with chlorobenzene compounds and other site-related contaminants (HGL, 2016a).

As part of RI activities, the PRP collected water samples from between the two layers of the sedimentation basin liner and found that contaminants had permeated at least the upper layer. Based on the age of the liner system and the detected contamination, it was suggested in a document? (Weston) (1992) that contamination had migrated from the pond into the underlying soil and groundwater.

The sedimentation basin was emptied during the construction of the OU3 cap, and the remaining contaminated sediments were incorporated into the subgrade when that portion of the cap was constructed and the cap was extended to cover the former sedimentation basin. The TSSA was excavated and the wastes from the TSSA were transported to the OU3 area and incorporated into the cap subgrade throughout the OU3 area. Liner material from the sedimentation basin and TSSA were recovered to the extent possible and sent off Site for proper disposal (HGL, 2017b).

2.4.4 DNAPL Sources

As part of the 2016 RI, HGL surveyed groundwater from Columbia and Potomac-screened wells to determine where DNAPL was likely to be present or groundwater had recently come in contact with DNAPL in the two aquifers. In the Columbia aquifer this assessment was completed using the following lines of evidence:

1) Visible presence of DNAPL,
2) Use of the 1 percent rule as described in Kueper and Davies (2009), and
3) DNAPL presence assessment provided in Lorah, et al. (2014), which also used the 1 percent rule.

For the purposes of the FS and this TI Waiver Evaluation, the areas where groundwater was determined to have had recent contact with DNAPL were refined to show areas where DNAPL is present by using only the following occurrences as evidence:

1) Visible presence of DNAPL,
2) Contaminants detected at concentrations greater than their respective soil saturation limits in wetlands sediment or underlying aquifer matrix, and
3) Contaminants detected in groundwater samples at concentrations greater than their respective effective solubilities.

While DNAPL screening assessments presented in the RI Report were made in part using 1 percent of the laboratory solubilities as an indicator that groundwater had been exposed to DNAPL, it is acknowledged that the actual DNAPL released was a multicomponent liquid. The solubility in water of each chemical component of the DNAPL mixture is lower than its laboratory solubility. To more accurately estimate the effective solubilities of each component of the DNAPL, knowledge of the composition of the DNAPL is needed. The method for computing the effective solubilities (using Raoult's Law) is described in Kueper and Davies (2009).

In 2009 a sample of DNAPL recovered from extraction well EW-1 was tested, and the following composition reported in the July through December 2009 RA implementation status report (HGL, 2010):

- 1,2-DCB, 29.5 percent;
- 1,4-DCB, 26.4 percent;
- CB, 22 percent;
- 1,2,4-TCB, 18.2 percent;
- 1,3-DCB, 2.2 percent;
- 1,2,3-TCB, 1.4 percent; and

- 0.3 percent of other compounds (benzene, 1,2,4,5-TeCB, 1,2,3,4-TeCB, PeCB, HCB, bis-(2-ethylhexyl)phthalate, 2,4,6-trichlorophenol, 2,3,4,6-tetrachlorophenol, and pentachlorophenol).

Utilizing this information, effective solubilities were calculated and are provided in Table 2.3. To determine the effective solubilities of the DNAPL components that were included in the 0.3 percent of the liquid that was not speciated, a conservative value of 0.3 percent was used for each compound. As indicated on Table 2.3, effective solubilities calculated for the DNAPL are substantially lower than the associated laboratory solubilities.

The molecular weights of all but one (benzene) of the components of the recovered product are greater than that of water, and the product has therefore been identified as DNAPL.

An assessment of the extent of the DNAPL zone is presented below.

2.4.5 DNAPL Assessment of the Columbia Aquifer

Visible DNAPL has been observed at the following well locations:

- TW-5
- MW-31
- TW-28
- PMW-42
- PZ-29
- PT-1

- PZ-25

Three of these locations are near the southwest corner of the Site near zone C4 where the 1981 railroad tank car spill occurred, and separate-phase material was reported to have flowed into the Former Air Products Property drainage ditch and north along the former rail siding (zones C3 and P3). Well TW-5 was sealed during IGR construction activities. PZ-29, while still in existence, is no longer accessible for sampling because the casing has bent.

The comparison of groundwater concentrations to effective solubilities is provided in Table 2.4 This comparison was performed using Calculation Method 3, provided in Keuper and Davies (2009). The following site-related contaminants have been detected above effective solubilities:

- 1,2,3,4-TeCB
- 1,2,4,5- TeCB,
- HCB,
- nitrobenzene,
- 1,2,3-TCB,
- 1,2,4-TCB,
- 1,2-DCB,
- 1,3-DCB,
- 1,4-DCB, and
- CB.

Site contaminants were detected at concentrations greater than their effective solubilities at 32 well locations in the Columbia aquifer (Table 2.4). This includes all but one of the wells that were sampled within the containment area.

Additionally, concentrations of at least one site contaminant exceeded soil saturation limits in aquifer matrix/deeper sediment samples collected from 23 of 52 locations in the Western Wetlands during the 2013 through 2014 wetlands sampling event (Table 2.5). These exceedances indicate that DNAPL present at these 23 locations.

No such exceedances were observed in matrix samples collected during this event from the Northern Wetlands, Eastern Wetlands, or in subsurface samples collected from locations within Red Lion Creek.

Figure 2.17 presents the inferred extents of DNAPL in the Columbia aquifer based upon the results of these analyses. Removal and treatment of these DNAPL-contaminated sediments are included in the Selected Remedy for OU2. This material will be addressed by the OU2 wetland remedy. The goal of the OU2 remedy is to remove as much principal threat waste as practicable from the wetlands. Because these areas will be remediated, EPA will not be proposing a TI waiver in the Western and Northern wetlands.

Where DNAPL remains in the subsurface, the remaining DNAPL will continuously diffuse into the groundwater. Unless the DNAPL is physically removed from the subsurface, it will remain a continuing source and will prevent the attainment of MCLs in the Columbia aquifer in the immediate vicinity of the DNAPL, even where other remediation techniques are applied. Therefore, removal or treatment of DNAPL is critical; the viability of removing of treating DNAPL is discussed later in this TI Waiver Evaluation, in the section discussing Evaluation of Restoration Potential of the Site.

It should be noted that DNAPL presence is inferred to the north of the slurry wall at the north end of the Site where the confining unit is thin or absent (Figures 2.7, 2.9, and 2.16). The absence of a confining unit in this northern area means that DNAPL has moved vertically into the Potomac aquifer. DNAPL is also likely to have preferentially moved from the areas of initial discharge to the lows in the top of the confining unit and possibly areas where the confining unit is absent (e.g., near extraction well EW-5).

2.4.6 <u>DNAPL Assessment of the Potomac Aquifer</u>

Lorah et al. (2014) performed a comparison of contaminant concentrations in the Potomac aquifer wells with evidence of DNAPL contact (PW-14 and PW-17) to those in MW-25, a proximal Columbia aquifer well. Their comparison utilized the molar ratios of chlorinated benzenes. This comparison confirmed that there is little difference in the Columbia and Potomac aquifer contaminant mixtures in the northern portion of the Site. This information supports the conclusion that the DNAPL contamination in the northern portion of the Site in the Columbia and Potomac aquifers is likely from the same source. As indicated on Figures 2.21 and 2.22, a breach of the clay material between the Columbia and Potomac aquifers has not been identified in the southern portion of the SCD property, the Former Air Products Property, the area between Governor Lea Road and the DCRC property, or on the Oxychem property.

Contaminants detected in wells screened in the Potomac aquifer were compared to their effective solubilities to assess the potential presence of DNAPL. The following chemicals have been detected at least once at a level greater than their effective solubilities:

- 1,2,3-TCB,
- 1,2-DCB,

- 1,4-DCB,
- 1,2,4,5-TeCB,
- 1,2,3,4-TeCB,
- CB,
- Nitrobenzene, and
- benzene.

Although benzene has a specific gravity less than that of water, it was included with the DNAPL because likely moved as a result of co-solvency with the other compounds on the list. Samples collected from monitoring wells PW-4D, PW-9, PW-12, PW-13, PW-14, and PW-17, all screened in the A-Sand and depicted on Figure 2.18, have had concentrations of at least one site contaminant greater than its effective solubility.

Additionally, samples were collected from seven borings (Figure 2.18) installed during the 2013 through 2014 wetlands sampling event to depths consistent with the Potomac A-Sand (greater than 25 feet below the wetlands surface). In three of the seven borings, site contaminants (i.e., 1,4-dichlorobenzene, 1,2,3-trichlorobenzene, and 1,2,4-trichlorobenzene) were present at concentrations greater than their respective saturation limits. This indicates that DNAPL is present in the Potomac A-Sand at those locations. Based on the frequency with which the DNAPL-indicative concentrations were found, it is probable that the DNAPL is widespread in the Potomac A-Sand and is acting as a source of contamination for Potomac aquifer groundwater.

Although no wells or borings have been placed into the portion of the A-Sand underlying the containment area, it is believed that DNAPL is present throughout much of this portion of the Site as well. The evidence behind this conclusion includes:

- DNAPL-indicative contaminant concentrations throughout the overlying containment area;
- Evidence of hydrologic communication between the Columbia aquifer and the Potomac aquifer near extraction well EW-5 in the containment area; and
- DNAPL-indicative contaminant concentrations observed in multiple A-Sand screened wells located to the immediate north, west, and east of the containment area.

Combining this area with those where direct evidence has been observed, the lateral extent of the inferred DNAPL in the Potomac aquifer A-Sand is presented on Figure 2.18.

As is the case in the Columbia aquifer, if dissolved contamination in Potomac A-Sand areas immediately adjacent to locations where DNAPL exists is remediated, unless the DNAPL is removed or contained, it will diffuse into the lower concentration groundwater of the remediated areas. Unless the DNAPL is physically removed or destroyed, it will remain a continuing source and will prevent the attainment of MCLs in the Potomac aquifer. Therefore, removal or treatment of DNAPL is paramount to achieving ARARs. The viability of DNAPL treatment or removal in the Potomac aquifer is discussed later, in the section discussing Evaluation of Restoration Potential for the Site.

It should be noted that no evidence of DNAPL has been found during sampling of the monitoring wells screened in the Potomac B-Sand or C-Sand, and thus, these areas are excluded from the TI Wavier.

2.5 CONTAMINANT DISTRIBUTION, TRANSPORTATION, AND FATE

2.5.1 Conceptual Site Model

Figure 2.16 presents the generalized graphical CSM for the Site. The generalized release locations are depicted as well as conceptual contaminant flow paths. The primary releases at the Site were CBs in both liquid and solid forms. Elevated levels of PCBs and dioxins have been found in soil at the southeastern portion of the Site. In addition, elevated levels of PCBs have been found near the location of the former warehouse, in the eastern drainage ditch, and in the Columbia and Potomac aquifers. Liquid CBs, benzene, nitrobenzene, and/or other Site-related contaminants have flowed over the surface in the following areas:

- In a drainage ditch at the south of the Site, flowing west past the Former Air Products Property to an unnamed tributary of Red Lion Creek (overlying zones C3, C4, and P3);
- Across the former facility portion of the Site (including the area overlying zones C1 and P1, which lie within the footprint of the former facility area), exiting to the east and west through drainage features into the western, northern, and Eastern Wetlands, and into Red Lion Creek and its unnamed tributary in the Western Wetlands;

These spills resulted in liquid contamination leaching down into the following subsurface areas:

- Vertically through the vadose zone of the Columbia aquifer, primarily underlying the former facility area (including the WMA and zone C1)
- Horizontally within the Colombia aquifer toward Red Lion Creek, flowing primarily north with the direction of local groundwater through zone C2
- Vertically in the vicinity of the Northern Wetlands, where the confining clay layer is thin and absent in some areas, and contamination reached the Potomac aquifer in this area (the vicinity of zone P2)
- Vertically within the Potomac aquifer, where southward flow of groundwater (the presiding direction of Potomac groundwater on the Site, due to industrial pumping south of the Site), drawing contamination into zones P1, P3, and P4
- Vertically in areas below the vicinity of the WMA, zone C1, and the former air products facility and adjacent drainage gullies, leaching through thin and absent portions of the Merchantville Clay Layer into zones P1, P3, and P4; however

Figure 2.16 illustrates how Site contaminants have been mobilized from their original release points toward pumping well locations

Vapor-phase contamination, including CBs and benzene, exists on the Site in areas where residual contamination is present in soil and sediment and overlain by unsaturated material or the soil surface and in areas where the Columbia aquifer is so heavily contaminated that direct volatilization to soil gas occurs. These areas compose most of the Site area, but because the Potomac Formation does not have an unsaturated zone in the Site area, no accumulation of vapor-phase contamination is expected to occur in that aquifer.

Dissolved and dense non-aqueous phase liquid (DNAPL) contamination, including CBs, benzene, PCBs, and nitrobenzene, also affect the Columbia and Potomac aquifers, in the same areas and via the same pathways as described above. Dissolved contamination also is discharged from groundwater to the surface in the wetlands near Red Lion Creek and directly into the creek. DNAPL is found primarily on the clay layer separating the Columbia aquifer and the Upper

Potomac sands in zones C1, C2, C3, and C4, on the clay intermingled with and underlying the Upper Potomac A-Sand in zones P1, P2, P3, and P4, and in the wetlands sediments and underlying matrix material, which falls under the jurisdiction of OU2, and is not addressed by this TI Waiver

CBs, benzene, nitrobenzene, and other Site-related contaminants were released from former Catch Basin 1 and the sedimentation basin. In these areas, contamination moves in the subsurface and affects the same media as the separate-phase release. Because Catch Basin 1 was used as a settling tank to remove DNAPL from the facility's wastewater treatment system, it was likely a source for sorbed product and DNAPL contamination in the subsurface.

The PCB Concentration Area, as depicted on Figure 2.16, was a functional area of the former plant that consolidated PCB wastes. Infiltration from these source areas lead to subsurface soil and groundwater contamination as demonstrated through data from recent groundwater sampling.

Elevated levels of metals are thought to primarily result from the acidification of site soils (because of operational releases of hydrogen chloride and migration of a 2001 sulfuric acid tank collapse at the DCRC [formerly Motiva] property) but also from corroded equipment observed in the former SCD facility (HGL, 2016a).

Exchange of groundwater between the Columbia aquifer and Potomac aquifer occurs in some areas of the Site, particularly near and under Red Lion Creek (in the vicinity of TI Waiver zones C2 and P2), where the confining unit is absent. Reactions observed in piezometer PZ-29 (near extraction well EW-5) during a 2010 USGS pumping test conducted confirmed that the two aquifers communicate hydraulically in that area as well (Brayton et al., 2014). This exchange forms a pathway for contamination to reach the deeper aquifers. Additionally, the absence of a confining unit allows DNAPL to move from the Columbia aquifer to the deeper Potomac aquifer.

2.5.2 Groundwater Contamination

Data acquired primarily from 2008 through 2021 were used to assess the nature and extent of contamination in OU4 groundwater. Due to the limited historical data for PCBs and dioxins/furans in groundwater, samples for these parameters were collected in 2015. For inorganics, limited data exists for the Potomac aquifer; therefore, data collected by Black & Veatch in 2004 and data collected by the USGS from 2007 through 2010 were used. The following sections provide a discussion of the types and extent of contamination present as well as a discussion of exceedances of pertinent screening levels. These are dissolved plumes, or areas with DNAPL in the immediate vicinity of dissolved contamination.

2.5.3 VOCs and SVOCs in Groundwater

Chlorobenzenes in groundwater are present at high concentrations in the Columbia aquifer and at select locations in the Potomac aquifer. The discussions that follow describe the nature and distribution of VOCs in both aquifers.

VOCs and SVOCs in the Columbia Aquifer

As indicated in the 2016 RI Report, chlorobenzenes were detected in the Columbia aquifer samples collected between 2008 and 2015. The most frequently detected contaminants were VOCs and include CB and 1,4-DCB, followed by 1,2-DCB and 1,3-DCB.

Figure 2.19 shows the distribution of total VOCs and SVOCs in wells screened within the

Columbia aquifer. Although the RI Report only incorporated data from samples collected through 2015, VOC and SVOC data from more recent sampling (conducted in March 2018) were used on this figure and contoured to show the most current site conditions. The 2018 data indicate that concentrations of VOCs and SVOCs are elevated throughout most of the containment area, including total VOC and SVOC concentrations of over 100,000 ppb in areas within the containment area. More recent data (April 2021) confirm that the current distribution of these contaminants remains very similar. Relatively low concentrations of organic contaminants were detected in samples collected from wells located in the extreme southern portion of the containment area.

Generally, VOC and SVOC concentrations in samples collected from immediately outside the containment area were at least an order of magnitude lower than concentrations in adjacent portions within the containment areas, and have shown significant decreases in time since the slurry wall was installed. This suggests that the slurry wall has been effective in containing site-related groundwater contamination (HGL, 2019a).

Although lower than the concentrations inside the containment area, concentrations of contaminants exceed MCLs in all but one of the wells to the north and west of slurry wall. In addition, DNAPL-indicative concentrations were found in all wells in this area except MW-23, PMW-46, and MW-40. This DNAPL-level contamination, mostly from chlorinated benzene compounds, was excluded from the containment area because of constructability issues and the lack of an aquitard in the northern portion of the Site (Black & Veatch, 2005). The area in question is adjacent to the Northern and Western Wetlands, and based on groundwater flow direction, it is likely serving as a continuing source for sediment and surface water contamination.

Elevated concentrations (up to 10 milligrams per liter [mg/L]) above MCLs of site contaminants have been detected in three wells (PMW-65, PMW-66, and PMW-67), which were installed along the eastern edge of the Former Air Products Property (immediately west of the containment area) during the construction of the OU3 remedy. It should be noted that these three wells are bounded to the south and north by PMW-64 and MW-33, respectively. Data from these wells suggest that the area in which the PMW-65, PMW-66, and PMW-67 installed contain a somewhat immobile quantity of DNAPL that was trapped outside the containment area during slurry wall construction. This area is included in a TI Waiver zone C4.

VOCs and SVOCs in the Potomac Aquifer

Chlorobenzenes have also been detected in Potomac aquifer groundwater. The majority of these contaminant detections have been in wells screened in the A-Sand of the Potomac. It should be noted that in areas where substantial contaminant levels have been detected in a well screened in the A-Sand, no corresponding well was installed in the B-Sand or C-sand because of concerns about allowing further migration of contamination.

As with the Columbia aquifer, chlorinated benzenes represent the most prevalent contaminants in the Potomac aquifer. The most frequently detected VOC contaminant is CB, followed by 1,4-DCB and 1,2-DCB. The most frequently detected SVOCs include 4-chloroanaline followed by 2-chorophenol and phenol, which have been identified as potential degradation products of compounds that are known Site contaminants (Heijman et al, 1993; Howard, 1989). 1,2,3,4- TeCB and 1,2,4,5-TeCB also have been detected at relatively high frequencies.

The data for total VOCs and SVOCs in the Potomac aquifer are shown on Figures 2.20 and 2.20a. Figure 2.20 shows the total VOCs and SVOCs for the A-Sand, while Figure 2.20a shows the results for samples collected from wells screened in the B-Sand and C-Sand.

On the eastern side of the Site two of the three wells with the most elevated concentrations occur at PW-12 and PW-4D. These locations are directly east of the former drum cleaning area and former facility wastewater treatment plant. In the area of PW-12, the Merchantville Formation also appears to be absent, but borehole logs indicate that 23 ft of Potomac clay was encountered between the Columbia aquifer and the Potomac Formation A- sand (Figure 2.21). Well PW-4S, coincident with location PW-4D, is screened within the “top sand” of the Potomac Formation (Figure 2.22). Highly chlorinated benzenes are absent at this location; however, methyl tertiary butyl ether (MTBE) is present. MTBE is a gasoline additive and is not associated with the Site. Groundwater samples collected from PW-22, located to the east of PW-4D, have had increasing site-related contaminant (benzene, CB, and all three DCB compounds) concentrations indicating the potential migration of these contaminants to the east. Both benzene and CB concentrations in PW-22 were greater than their respective MCLs during the 2018 through 2021 sampling events although only data through March 2019 have been documented in a report at this point (HGL, 2018 and 2019a). The COC 1,4-DCB also was present at a concentration greater than its MCL in the March 2020 PW-22 sample.

The other well with elevated contaminant concentrations in the A-Sand east of the former facility is PW-9 (Figure 2.20 and Figure 2.22). The contamination in this area may be contiguous with that at PW-12 and PW-4D (Figure 2.20). It should be noted that at PW-9 over 6 ft of Merchantville clay is present, suggesting that the contamination in this area moved within the A- Sand to this location from areas where the clay is thin or absent. However, clay is not completely absent in any of the borings in this area. The contamination at PW-9 and PW-4D may have moved into this area through the paleochannels that have eroded the aquitard on the SCD or Oxychem property. The location of these paleochannels cannot be determined with the current boring data, but their presence is suggested by lows in the aquitard surface (Figure 2.20) and high-energy depositional paleo-environments, as indicated by gravels deposited above the Merchantville clay, which could have incised the clay (Brayton et al., 2014).

Under pumping conditions, flow is generally toward the south at PW-9. Neither PW-2 nor PW-8, A-Sand wells located to the south and east of PW-9 respectively, have shown evidence of significant migration of the contamination found at PW-9.

Figure 2.23 depicts the total VOCs and SVOCs concentration in wells PW-4D, PW-9, and PW-12 over time. All the data are from after the slurry wall was installed. All the observed concentrations in these wells are high enough to indicate that the water at these well locations has been in contact with DNAPL. Concentrations in well PW-9 have been relatively stable compared to wells PW-4D and PW-12. Because of a shutdown during 2010 and 2011, there was minimal groundwater pumping at the refinery located to the south of the Site. During this period, flow in the Potomac aquifer was inferred from groundwater elevations to be from west to east, and concentrations at the most contaminated well (PW-12) generally decreased (Brayton et al., 2014). This decrease cannot be readily explained because no contamination has been detected in the A-sand well (PW-10) located to the north of PW-12, and no deeper drilling has occurred in the area to the west of PW-12.

To the north of the former facility, PW-14 and PW-17 have had detections of site-related contaminants at very high concentrations (Figure 2.20). Concentrations in the shallower Columbia aquifer are similarly elevated in these areas (Figure 2.19). Although a substantial clay layer was observed during the drilling of PW-14, there was little evidence of the Merchantville or Upper Potomac Formation clays in the area of PW-17. Groundwater flow in the Potomac aquifer is expected to be toward the south in the area of PW-14 and PW-17 under industrial pumping conditions and to the east-southeast during minimal pumping periods. This indicates that there is less potential for dissolved-phase flow to the north in the Potomac aquifer. Taken together, this information leads to the conclusion that the observed contamination arrived at PW-14 and PW-17 either from the Western Wetlands or by travelling north through the Columbia aquifer to the PW-17 area and then dropping into the Potomac aquifer in the area where the clay is thin or absent (Figure 2.20). Prior to 2019, contamination had not been detected in the northernmost Potomac aquifer wells (PW-5S and PW-5D), which are located north of Red Lion Creek (HGL, 2018). CB was detected at 2.3 µg/L in PW-5D in March 2019 (HGL, 2019a), and five chlorobenzene compounds were detected (at concentrations as high as 2.1 µg/L) in a duplicate sample collected during the 2020 sampling event. None of these contaminants were detected in the associated parent sample.

Trends in Groundwater VOC and SVOC Contamination

To identify trends in contaminant concentrations in the Potomac aquifer, Mann-Kendall trend analyses were performed for the eight wells where sufficient detections exist to make the analyses meaningful.

- PW-4D
- PW-6S
- PW-9
- PW-12
- PW-13
- PW-14
- PW-17
- PW-22

No analyses were performed for the 23 Potomac-screened wells where site-related contaminants have either never been detected or detected in only one or two sampling rounds.

The results of the Potomac well analyses showed significant increasing trends in wells PW-9, PW-13, and PW-22. The remaining wells either showed no trend or, in the case of PW-14, a possible decreasing trend.

As mentioned in Section 2.5.3.1.2, the limited results from well PW-22, which is located to the east of PW-4D, have shown increased contamination concentrations during each sampling round since it was installed. The March 2020 contaminant concentration reading in the PW-22 well was 2,659 µg/L, over an order of magnitude lower than what was observed at PW-4D in the same sampling round. However, the March 2020 result is more than three times the concentration of 810 µg/L observed in the March 2019 sampling event (HGL, 2019a).

To identify trends in VOC and SVOC contaminant concentrations in the Columbia aquifer, Mann-Kendall analyses trend analyses were performed on the available data from 12 wells located outside the containment area and six wells located within the containment area. For the wells located outside the containment area, significant decreasing contaminant concentration trends were observed in nine of twelve wells with two wells (PMW-47 and MW-20) showing a possible decreasing trend and the other well (MW-22) not showing any definite trend. This seems to support the observation that the IGR is reducing or eliminating the migration of contaminants out of the containment area sources to the areas where wells with declining trends are located. With respect to the wells within the containment area, three showed possible or significant increasing trends, one showed a significant decreasing trend, and the remaining two showed no discernible trend (HGL, 2019a). These results tend to support the hypothesis that while the pumping and treating of groundwater is removing contamination, it is not substantially reducing the groundwater contaminant concentrations within the containment area. The results of the trend analyses for both aquifers are summarized on Table 2.8.

Groundwater VOC and SVOC Contaminant Mass and Distribution

Groundwater contamination is widespread across the Site. All the groundwater within the 35- acre containment area is considered to require remediation. The portion of the containment area underlying the OU3 multi-layer cap (about 23.2 acres) is considered a WMA, but groundwater from the WMU can contact the groundwater in the remainder of the containment area. Separately, it is estimated that Columbia aquifer groundwater underlying approximately 13.6 acres of upland area and 18.7 acres of wetlands to the outside of the containment area does not meet the MCLs. Groundwater data is not available for the portion of the Site occupied by Red Lion Creek. However, given the COC concentrations found in the Northern and Western Wetlands, it is estimated that groundwater underlying approximately 4 acres of the creek exceeds PRGs. Assuming an average effective porosity (n) of 0.3 and, based on recent groundwater elevation readings, average aquifer thicknesses of 22 ft in the containment area, 19 ft in the remaining upland areas and 17 ft in wetlands and Red Lion Creek areas, it is estimated that approximately 663,000 cubic yards (cy) of Columbia aquifer groundwater has contamination at concentrations greater than the PRGs and MCLs. This figure includes approximately 129,000 cy of groundwater underlying the Western and Northern Wetlands, approximately 126,000 cy of groundwater underlying upland areas outside of the containment area, and approximately 36,000 cy underlying Red Lion Creek. Using the historical average GETS influent concentration prior to cap construction activities (90 milligrams per liter [mg/L]) within the containment area and an approximated average of recent groundwater sampling data for treatment area wells outside the containment area (30 mg/L), a mass of over 66,000 pounds of dissolved contaminants in the Columbia aquifer is achieved. Although contamination exists through a portion the Eastern Wetlands groundwater as well, the concentrations found there are more than an order of magnitude lower than those observed in the other contaminated areas of the Site. As a result, it is not expected that this contamination would greatly impact the total contaminant mass in the Columbia aquifer.

Based on several years of sampling data groundwater to the east of the containment area now meets MCLs and human-health based PRGs. Additionally, although there have been sporadic detections of Site contaminants north of Red Lion Creek, none of these detections have exceeded MCL or human health based PRGs. As a result, although the groundwater in these areas has been considered during development of remedial alternatives and was included in the development of the Site footprint, it has not been included in the volume and mass calculations for the Site.

Similarly, although contamination has been detected in Columbia aquifer groundwater underlying the Eastern Wetlands as well, the concentrations found there are more than an order of magnitude lower than those observed in the other contaminated areas of the Site. A portion of the Eastern Wetlands groundwater volume was included in the contaminated groundwater volume calculation, but given the observed contaminant concentrations, the mass of contamination would not greatly impact the total contaminant mass in the Columbia aquifer and was thus omitted from that calculation. Red Lion Creek surface water is being addressed as part of OU2 and was therefore omitted from the volume and mass calculations for OU4.

The widespread presence of DNAPL across the Site means that the actual total mass of contaminants requiring treatment is much higher than that attributable to the dissolved contamination. During the 1986 tank collapse, approximately 569,000 gallons of di- and trichlorobenzene compounds were released. Although no substantive records about the initial company response results are available, conversations with EPA personnel have indicated that as much as 90% of the released amount was recovered during initial cleanup efforts. Using the molecular weights and mass fractions of the 2009 DNAPL sample constituents (Table 2.3), an approximate DNAPL density of 1,297 grams per liter (11.05 pounds per gallon) was derived for the released mixture. Using an 80% recovery rate for the initial 1986 release response, it is estimated that approximately 1.42M pounds of di- and trichlorobenzene compounds remained in the soil, sediment, and groundwater from that release. However, the lack of records about the volume of contaminant releases from other site operations (e.g., undocumented spills and onsite waste disposal, releases from the leaks in Catch Basin 1 and the wastewater treatment plant discharge line) make an accurate accounting of the total amount of contamination released at the Site difficult at best. If an average of just 0.1 inch of DNAPL is present across base of the containment area and the external area bounded by wells and aquifer matrix samples where DNAPL-indicative concentrations have been observed, the added mass of Columbia aquifer contamination would exceed 548,000 pounds. Combined with the dissolved portion of contamination yields a Columbia aquifer contaminant mass estimate of 619,000 pounds.

Calculation of the volume of contaminated groundwater in the Potomac aquifer is complicated by multiple factors including:

- Lack of groundwater data in the portion of the aquifer beneath the containment area; and
- Undefined thicknesses of interspersed water bearing sands and non-water bearing clays.

To account for these and other uncertainties, it was assumed that:

- All the water in the portion of the Potomac aquifer A-Sand that underlies the containment area is contaminated at levels greater than the PRGs;
- The combined average porosity (n) of the affected Potomac aquifer soils is 0.2;
- Contamination from the Site has only impacted the portion of the Potomac aquifer extending from approximately 25 ft below mean sea level (bmsl) to approximately 110 ft bmsl (the A-Sand); and
- Lateral limits of site-related Potomac aquifer contamination have been defined by past sampling events.

Based on this information, the estimated extents of the Potomac aquifer portion of the contaminant plume was mapped using ArcMap®. Using this plot, the approximate area where dissolved contamination exists in the Potomac aquifer was estimated to be approximately 82.5 acres. It should be noted that the area in which Potomac aquifer contamination occurs does not completely overlap the area where Columbia aquifer occurs. As a result, the area over which Site contamination has impacted groundwater cannot be arrived at through the use of only one or the other number. Using the 82.5 acres figure, the volume of Site-related contaminated groundwater in the Potomac aquifer requiring remediation was estimated to be approximately 2.5M cy. Using the median of the 2018 groundwater sampling data from the proposed Potomac aquifer TI waiver area (54 mg/L) (HGL, 2018), a mass of approximately 230,000 pounds of dissolved contaminants in the Potomac aquifer is achieved. As with the Columbia aquifer, the inferred presence of DNAPL across much of the Potomac portion of the Site increases the estimated total mass of contaminants requiring treatment by a substantial amount. Using one- quarter of the average DNAPL thickness and the same density that was used in the Columbia aquifer calculations above, the area bounded by wells where DNAPL-indicative concentrations have been observed, and the assumptions listed for the calculation of the dissolved contaminant volume and mass, the mass of Potomac aquifer contamination attributable to DNAPL contamination would be approximately 124,000 pounds. Combined with the dissolved portion of contamination yields a Potomac aquifer contaminant mass estimate of 354,000 pounds.

2.5.4 TAL Metals in Groundwater

Metals in the Columbia Aquifer

Unfiltered metals samples were collected from the Columbia aquifer wells between 2008 and 2010 and in 2021. Two wells, MW-13 and MW-36, were identified as background locations. MW-13 is located west of the Site on the Former Air Products Property, and MW-36 is located north of Red Lion Creek (Figure 2.19). Neither of these locations has shown evidence of being affected by Site-related contaminants. The analytical results for the samples collected from these wells were pooled to form the background dataset. To assess whether the metal detections reported for the Site wells reflect background conditions, the Site data were compared to these background data.

The following contaminants were detected at concentrations greater than their respective MCLs in on-site wells in the most recent data:

- Beryllium

- Chromium
- Thallium

Beryllium and total chromium slightly exceeded their respective MCLs in zone C1 north of the WMA. Thallium exceeded its MCL in multiple wells in the Columbia aquifer, much of it within the DNAPL contamination zones. Because the concentrations of all three of these metals were several times higher within these zones as in the background concentrations, it can be concluded that these MCL exceedances are caused by site-related contamination.

Metals in the Potomac Aquifer

Thallium has been detected in zones P2 (well PW-14) and P4 (well PW-4S) at about eight times above the MCL and significantly above background concentrations, which did not exceed the MCL in any locations in the Potomac. Other metals, including chromium and beryllium, were not detected above MCLs in the Potomac aquifer.

2.5.5 Polychlorinated Biphenyls in Groundwater

Polychlorinated Biphenyls in the Columbia Aquifer

PCB samples were collected from wells across the SCD Site and on neighboring properties in March and September 2008 and in March 2015. The data for PCBs in Columbia aquifer well samples is presented in Table D.4 of the RI Report (HGL, 2016a). Figure 2.27 depicts the maximum observed total PCB congener concentrations (in 1000s of picograms per liter [pg/L]) in each well sampled in 2008. PCBs were detected at concentrations exceeding the MCL in nine wells out of 26 Columbia aquifer wells sampled in 2008. The areas where the highest PCB detections occurred and exceeded MCLs are near the footprint of the former warehouse (now covered by the OU3 cap and part of the WMA), to the north of the slurry wall (zone C2) and west of the containment area in zone C3. These areas coincide with areas of elevated concentrations of VOCs and SVOCs in the Columbia aquifer.

Polychlorinated Biphenyls in the Potomac Aquifer

Samples collected from two wells, PW-12 and PW-17, were tested in March 2015 for PCBs. These wells are screened in the Potomac aquifer A-Sand at locations that have had high levels of total VOCs and SVOCs (Figure 2.20). The results of the PCB testing are provided in Table D.9 of the RI Report (HGL, 2016a). Numerous PCB congeners were detected in both PW-12 and PW-17, with the highest concentrations at PW-17 as indicated by a total PCB concentration of approximately 343,000 pg/L.

There were no exceedances of MCLs for total PCBs in these samples. As the most contaminated Potomac aquifer wells were sampled for PCBs, the results from these wells may represent the highest levels of PCBs in the Potomac aquifer; however, no data has been collected for the Potomac aquifer under the former facility portion of the Site. Due to groundwater movements within the slurry wall, it is likely that PCBs have contaminated portions of the Potomac aquifer within the containment area below the former facility portion of the site (zone P1).

2.6 POTENTIAL ROUTES OF MIGRATION

Figure 2.31 depicts the migration pathways and exposure media (shaded) of significance to OU4. These pathways are as follows:

- DNAPL to groundwater
- Subsurface soil and aquifer matrix to groundwater,
- Groundwater to sediment and surface water,
- Sediment to groundwater (which is being addressed in OU2)
- Sediment to surface water (which is being addressed in OU2)
- Groundwater to soil gas, and
- Groundwater to surface water.

Each of the contaminant migration pathways is described in the following sections.

2.6.1 DNAPL to Groundwater

When the site-related contaminants were spilled or leaked, most of the materials were either recovered as a solid, infiltrated into the soil, or moved via overland flow into drainages and eventually to the wetlands and surface water toward the northern end of the Site. Both liquid- phase DNAPL and dissolved-phase contaminants were released. The DNAPL migrated vertically through the vadose zone and into the Columbia aquifer, eventually hitting local poorly permeable layers, including the Merchantville clay and Upper Potomac clay, or stopping in areas where capillary pressures were higher than the downward pressures of the DNAPL. The DNAPL that reached the clay layer moved along these clays, following the topography of the clay surface toward low spots or areas where the clay is missing (e.g., near EW-5 or at the northeast portion of the Site). In areas where the clay is missing, the DNAPL continued downward into the Upper Potomac Formation A-Sand and down to the clay that is interspersed throughout and underlies the A-Sand. In addition, finely divided DNAPL droplets were dispersed through some of the saturated zone and were trapped in the smaller aperture pathways. The residual DNAPL remains a source for contamination in groundwater and soil vapor in those areas of the Columbia aquifer highlighted in Sections 2.5.2.1 and Figure 2.17. Residual DNAPL remains a source for contamination in groundwater and soil vapor in those areas of the Potomac aquifer highlighted in Sections 2.5.2.2 and Figure 2.18

2.6.2 Subsurface Soil and Aquifer Matrix to Groundwater

Contamination in soil represents a continuing source of contamination for groundwater outside of OU3 in the western drainage gully (Figure 2.1). A multilayer cap was constructed as part of the OU3 remedy. This remedy has eliminated the infiltration of precipitation through the contaminated vadose zone soil in OU3 and eliminated the movement of contamination through infiltration from vadose zone soil to groundwater. However, the contaminated soil and aquifer matrix outside of the area to be capped (near the western drainage gully and in the Western and Northern Wetlands) represents an ongoing source.

During periods of rainfall, infiltrating precipitation outside of OU3 contacts the contaminated surface and subsurface soils, allowing a portion of the contaminants to dissolve into the water. Although some of the dissolved contamination is adsorbed by the deeper vadose zone soils, the remaining dissolved contaminants continue downward and reach the groundwater.

Some of the processes that will affect this migration of contaminants from soil to groundwater are discussed in the following sections.

2.6.2.1 Sorption

The migration of a contaminant from the soil to the underlying groundwater is affected by the physical and chemical properties of the contaminant and the soil system. The mobility of contaminants caused by infiltrating precipitation will be retarded by the sorption properties of each contaminant and will be increased by the solubility of each contaminant. Once soil contamination has been transported to groundwater, the mobility of each contaminant is affected by how that contaminant behaves within the groundwater system.

Sorption (and desorption) can be defined as the interaction of a contaminant with a solid [soil] (EPA, 1990). This interaction affects the mobility of contaminants in the subsurface. The degree to which contaminants interact with soil will affect the mobility of the contaminant. At the Site, the contaminants present are primarily uncharged weakly polar chlorinated benzenes. These organic compounds interact with soil organic matter through a process known as "hydrophobic sorption," which can be explained as the affinity of organic compounds for phases other than water (EPA, 1990). Ionic nonpolar chemicals, such as metals, tend to interact with charged and polar surfaces of the soil matrix, such as clays (EPA, 1990).

For the CBs and nonpolar organic contaminants such as PCBs, the degree to which the contaminant is sorbed onto organic matter, as opposed to remaining in inorganic soils or the water matrix, is determined by the contaminant's distribution coefficient (K_d), which describes the partitioning between liquids and solids (Freeze and Cherry, 1979). The K_d for organic chemicals is calculated as the product of the organic carbon partition coefficient (K_{oc}) and the fraction of organic carbon (f_{oc}) present. K_{oc} values for major Site-related contaminants are provided in Table 2.11. The K_{oc} values for Site-related contaminants range over three orders of magnitude, with PCBs and dioxins having the highest values. K_{oc} levels generally increase relative to the chlorination level of a compound. The fraction of organic carbon in the media also directly affects K_d. At the Site, areas of sandy aquifer matrix and soil will tend to have lower organic carbon content and thus less sorption capacity than the clays. The areas with the highest sorptive capacity are the layers of peat that were found in the matrix underlying the Western Wetlands during the 2013 through 2014 wetlands subsurface sampling event. These layers (generally located approximately 10 to 16 ft bgs) have higher f_{oc} values than other portions of the Site. As expected, some of the highest aquifer matrix contaminant concentrations found during subsurface sampling were in those peat layers.

For polar inorganics (metals), distribution coefficients are a function of numerous properties of the soil as well as of the contaminant itself, including its charge and complex state, the clay content of the matrix and the surface charge on clays, and the pH and ionic strength of the water (EPA, 1990 and 1992). The portion of the Columbia aquifer located at the Site is largely sand with little clay above the top of the Potomac Formation. Additionally, the pH of the Columbia aquifer groundwater at the Site is rather low (4.0 to 5.0 observed in GETS influent and groundwater samples). Taken together, these factors indicate that metals in the site soils and matrix are not likely to have strong sorption tendencies in the Columbia Formation but could sorb to the Merchantville and Potomac clays underlying the Columbia. There are no metals analytical data for the aquifer matrix underlying the wetlands areas or in the Potomac Formation.

2.6.3 Dissolution

Dissolution is the process by which a chemical moves into an aqueous solution. The solubility of organic chemicals is inversely related to the K_{oc}. Solubility is a measure of a chemical's ability to associate with water, which is polar, while K_{oc} is a measure of a chemical's ability to associate with organic matter, which tends to be nonpolar. Table 2.11 provides both the solubilities and K_{oc} values for site-related organic contaminants covered by this TI Waiver. The solubilities are highest for the non-chlorinated site contaminants and generally decrease as the level of chlorination in the chemical increases.

2.6.3.1 Migration Within Groundwater

When contaminants were spilled or leaked from their containers, some of the contamination would have rapidly volatilized; however, while the SCD facility was operating at least 575,000 gallons of benzene, nitrobenzene, and chlorinated benzenes spilled. Most of the material was either recovered as a solid or infiltrated into the soil and groundwater as DNAPL. A portion of the DNAPL became dissolved contamination when it encountered Site groundwater and moved together with the flow of the aquifer in which it was located. In the case of the Columbia aquifer, this would be north to Red Lion Creek. Groundwater in the Potomac aquifer tends to flow east to southeast depending on pumping at the DCRC facility production well R-15.

The information currently available indicates that there is some connection between the Columbia and Potomac aquifers at the Site, as the Merchantville and Potomac clays are absent in some areas (highlighted on Figure 2.7) and Site-related contamination has been detected in the Potomac aquifer.

Groundwater flow in the Columbia aquifer is generally to the north from the SCD Site and has been shown to discharge into Red Lion Creek and adjacent wetlands. According to Lorah et al. (2014), groundwater discharge accounts for a minimum of 47 percent of the total discharge for the subwatershed of Red Lion Creek at the Site. Representative groundwater contour maps that illustrate flow in the Columbia aquifer after and before the implementation of the IGR are presented as Figures 2.10 and 2.11, respectively. Red Lion Creek is a significant hydrological divide for the Columbia aquifer. Because of this, and past sampling results showing minimal to no contamination in wells MW-34 through MW-39, groundwater is not expected to move significantly northward past Red Lion Creek.

Groundwater flow in the upper Potomac aquifer has been determined to be generally to the south during normal pumping conditions at DCRC and predecessor refineries (Brayton et al, 2014). A representative groundwater contour map that illustrates flow under pumping conditions in the upper Potomac aquifer is presented as Figure 2.15.

Advection and dispersion are the primary processes affecting the movement of a chemical within the groundwater system. Advection is the movement of a chemical with the bulk fluid flow. Dispersion is the spreading of the leading edge of the plume due to spatial variation in the aquifer characteristics, fluid mixing, and diffusion. Within groundwater, the migration rates of dissolved chemicals range widely because different chemicals experience different degrees of adsorption. Chemicals will not move as rapidly as the groundwater because of adsorption of the chemicals onto the subsurface media. This process is known as retardation. For organic compounds, a retardation factor may be estimated using the organic carbon content of a chemical (K_{oc}), as well as the bulk density and void fraction of the subsurface matrix. Site-specific values of these factors are presented on Table 2.11. Chemicals with high K_{oc} values, such as SVOCs, will have higher retardation factors than organics characterized by low K_{oc} values, such as VOCs. Thus, SVOCs at the SCD Site should take more time than VOCs to travel a given distance. Because of the complexities of the physio-chemical interactions between inorganic compounds and subsurface materials, it is difficult to estimate the extent of retardation for an inorganic compound.

These transport mechanisms spread the contamination throughout the Columbia aquifer and into the Potomac aquifer at the Site before the containment area was constructed. The portions of the Columbia aquifer within the containment area and between the containment area and Red Lion Creek contain elevated concentrations of contaminants, primarily benzene and chlorinated benzenes. As evidenced by groundwater sampling data and GETS influent data (HGL, 2019a, 2019b), concentrations of multiple contaminants (benzene, CB, 1,2-DCB, 1,4-DCB, 1,2,4-TCB) were transported through the Columbia aquifer and remain orders of magnitude greater than their respective MCLs within most of the containment area. PCBs were detected at concentrations exceeding the MCL in nine wells out of 31 Columbia aquifer wells sampled in 2008 or 2015.

The slurry wall and GETS control the migration of groundwater in the Columbia aquifer by preventing the groundwater from the most contaminated area from migrating northward. With a few exceptions, contaminant concentrations in groundwater immediately outside of the containment area are substantially lower than those within the containment area. This indicates that the slurry wall has been effective in preventing further migration of site-related groundwater contamination in the Columbia aquifer. However, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, benzene, carbon tetrachloride, and chlorobenzene are still present to the north and west of the containment area at concentrations that are orders of magnitude greater than their respective MCLs (HGL, 2016a, 2018, 2019a). This is largely the result of residual product from the initial release and contaminant migration that occurred prior to the implementation of the IGR.

The migration of such a substantial mass of multiple COCs through the Columbia and downward into the Potomac aquifer has made attainment of MCLs impracticable throughout large volumes of Site groundwater in both aquifers.

2.7.1 Migration from Groundwater to Sediment

Groundwater flow in the Columbia aquifer at the Site is toward Red Lion Creek and the surrounding wetlands (Figures 2.10 and 2.11). Locally upward flow in the shallow portion of the Columbia aquifer through the northern wetland sediments at the Site has been suggested by Lorah et al. (2014) (Figure 2.13). Most of the contaminants in groundwater are likely to become absorbed to the organic material of the sediment because highly chlorinated compounds have a high affinity for the solid phase in soils and sediments and a low solubility in porewater (Lorah et al., 2014). Sorption and desorption are dominant processes in the wetland sediments. Benzene and CB, because of their low K_{oc}, high solubility, and low density might ascend to the surface and evaporate. Based on recent laboratory studies showing that native microbial populations can degrade Site contaminants (Lorah et al., 2014), it is believed that some portion of the original Site contamination has degraded through biological processes. However, volatilization and biological degradation are currently incapable of removing all the site-related contaminants from the groundwater that enters the area. As a result, discharging contaminated groundwater is a significant ongoing source of contamination to the sediments of Red Lion Creek and the adjacent wetlands.

2.7.2 Migration from Sediment to Groundwater

The organic-rich wetland sediments act as a reservoir and ongoing source of contamination to groundwater and pore water as highly chlorinated compounds may have sorbed to the wetland sediments during the initial contamination and through ongoing contact with contaminated groundwater. Theoretical concentrations were calculated by Lorah et al. (2014) for groundwater to estimate the equilibrium desorption of contaminants into Site groundwater. Lorah et al. (2014) found that predicted concentrations were comparable to the measured concentrations of contaminants in Site groundwater, which may indicate a large amount of sorbed mass in sediments. The sediments may act as a secondary source of contamination to groundwater through desorption primarily in the Northern and Western Wetlands. Additionally, DNAPL present in the sediments and aquifer matrix in the Western Wetlands (Figures 2.17 and 2.18) could act as an ongoing source of contamination to the groundwater. Addressing this contaminant migration pathway is one of the remedial action objectives of the OU2 remedy and is therefore not the focus of OU4.

2.7.3 Migration from Groundwater and Sediment to Surface Water

The Columbia aquifer discharges to the eastern, western, and Northern Wetlands as well as to Red Lion Creek (Figures 2.12 and 2.13). The discharge of groundwater to Red Lion Creek contributes to the transport of contaminants from groundwater to surface water at the Site. The volumetric groundwater fluxes calculated by Lorah et al. (2014) indicate that a large volume of water is discharged to Red Lion Creek; therefore, the mass of contaminants transported from groundwater to Red Lion Creek could be significant. However, as discussed in Section 2.5.5, concentrations of contaminants in Red Lion Creek have generally been low.

Surface water samples were collected from four locations adjacent to the shoreline of the Eastern Wetlands in 2008 and 2009, with detections of total VOCs and SVOCs ranging from 10.7 µg/L to over 5,000 µg/L. Benzene and multiple chlorinated benzene compounds exceeded MCLs in three of these sample locations. Given these detections and the sample proximity to the shoreline, groundwater could be acting as a source of contamination to surface water. Water in Red Lion Creek is monitored on a semiannual basis at a location immediately downstream from the Site. Apart from one anomalously high sample result, collected in March 2014 (Tables D.11 and D.12 in Appendix D of the RI Report [HGL, 2016a]), total VOCs and SVOCs at this downstream location generally have remained low to nondetect with no MCL exceedances. However, DNREC has put in place a fish advisory for bioaccumulative contaminants (PCBs, dioxins, and furans) for Red Lion Creek as part of the institutional controls (ICs) to protect the public from Site contamination. As discussed in Section 2.5.6, substantial contamination exists in sediments in the Northern and Western Wetlands, and this contamination could be partly responsible for the contaminant detections in the surface water.

To achieve Water Quality Criteria (WQC) in the Red Lion Creek and unnamed tributary surface water, it will be necessary to

1) Implement the OU2 remedy to treat the sediment and aquifer matrix contamination that contacts surface water, and prevent the flow of contaminated groundwater to these water bodies; and/or
2) Provide for the treatment of all contaminated groundwater and surface water that enters these to water bodies.

2.7.4 Migration from Groundwater to Soil Gas

The principal contaminants for the groundwater to soil gas pathway include chlorinated benzenes and benzene. These contaminants also are present as DNAPL at the Site. VOCs in groundwater and as DNAPL will volatilize to soil gas and result in the potential for VI into the GETS building, neighboring buildings, or future buildings at the Site.

3.0 SOURCE CONTROL MEASURES AND REMEDIAL ACTION PERFORMANCE

3.1 OU1 IGR REMEDY

The subsurface soil-bentonite slurry wall (slurry wall) and the associated GETS were constructed as part of the IGR under OU1. The IGR was implemented to prevent the migration of site-related groundwater contamination within the Columbia Aquifer and from the Columbia Aquifer to the Potomac Aquifer. The IGR was not intended as a standalone remedy to cleanup groundwater to MCLs. Installed in 2006/2007, the slurry wall is 5,290 feet long, surrounds approximately 35 acres, and extends to an average depth of approximately 70 ft (Figure 2.1), keyed into the Merchantville Clay Layer. Where feasible, spoils from the slurry wall construction trench were incorporated into the soil-bentonite slurry. Where contaminant levels in the trench spoils precluded their use in the slurry, the spoils were stored in a temporary soil storage area (TSSA). All the waste, contaminated soil, and sediments from the TSSA was subsequently incorporated into the sub-base of the OU3 cap during cap construction.

The OU1 IGR was installed years after the ongoing spills on the former process facility. Based on investigations done as part of the RI and FS, high concentrations of COCs including DNAPL have migrated away from the original former process facility into other portions of the Columbia aquifer and Potomac aquifer, throughout the eight proposed TI Waiver zones. Therefore, the OU1 IGR can control contamination in the proposed TI Waiver zone C1 and the underlying zone P1, but the source material in the other TI Waiver zones needs to be addressed by other means.

3.1.1 Groundwater Extraction and Treatment System

The GETS was completed in June 2007 as part of the IGR and is being used to lower the groundwater elevation within the area surrounded by the slurry wall, treat contaminated water within this containment area, and reduce the potential for contamination in the Columbia Aquifer to spread to the Potomac Aquifer. Additionally, the GETS treated approximately 450,000 gallons of contaminated water from the lined sedimentation basin during the OU3 construction activities.

The GETS includes six extraction wells, a treatment system building, conveyance piping and a groundwater treatment system as specified in the IGR design documents (Black & Veatch, 2005). The GETS withdraws contaminated groundwater from the portion of the Columbia Aquifer that lies within the slurry wall and treats extracted groundwater using an air stripper, green sand filtration, and two 2,500-pound granular activated carbon (GAC) filters. Off- gas from the air stripper is treated using two 10,000-pound GAC vessels before being discharged to the atmosphere. Treated groundwater is discharged outside the slurry wall and flows to Red Lion Creek under a National Pollutant Discharge Elimination System (NPDES) permit equivalence. Treated water meets all MCLs and the NPDES equivalence discharge limits (which take into account the Delaware Regulations Governing the Control of Water Pollution and the Delaware Surface Water Quality Standards). Wastes generated during the operation of the GETS (e.g., spent carbon, spent bag filters, backwash sludge) is transported and disposed of off-site in accordance with all applicable Resource Conservation and Recovery Act (RCRA) requirements. The treated off-gas meets the requirements of the air permit equivalence that was provided by DNREC. Since its construction, the GETS has extracted and treated over 125.8 million (M) gallons of contaminated Columbia aquifer groundwater from within the containment area. As a result, more than 79,500 pounds of site-related organic contaminants have been removed for the Columbia aquifer (HGL, 2019b).

Even with the removal of these contaminants, and somewhat decreased GETS influent concentrations since the beginning of system operation, containment area groundwater contaminant levels remain as much as 800 times MCLs (HGL, 2019b). Tests done as a part of the RI have shown that the slurry wall and GETS have been effective at containing the contamination within the slurry wall, which helps control contamination from spreading further. However, the very high remaining groundwater contaminant concentrations even after more than ten years years indicates that the GETS and IGR alone cannot restore groundwater to ARARs.

While the OU1 GETS system can control the further spread of contamination, it cannot address the existing source material that falls outside of the OU1 slurry wall and GETS footprint area.

3.2.1 OU2 REMEDY

Amendment No. 3 to the 1995 ROD was issued in September 2022 and specifies the Selected Remedy for OU2. The Selected Remedy, which is currently in the remedial design phase, will remove a significant source of contamination that currently leaches into the Columbia and Potomac aquifers from the soil matrix in the Western Wetlands, primarily within 10 feet of the ground surface.

The Selected Remedy combines elements of the contingent remedy selected in the 1995 ROD, excavation and on-site treatment via low temperature thermal desorption (LTTD), with bioremediation, metals stabilization and ICs. Removal and treatment of the principal threat waste in the wetland will eliminate an ongoing source of contamination to sediment, groundwater, and surface water. The Selected Remedy includes targeting sediment and underlying saturated media that exhibit concentrations of benzene and chlorinated benzene compounds indicative of the presence of DNAPL. The average depth of excavation for this material is estimated to be 10 feet. Additionally, sediment from other areas of the wetland that exhibit concentrations of benzene and chlorinated benzene compounds in excess of the Remedial Action Level of 33 mg/kg total benzene and chlorinated benzenes and/or 4 mg/kg chromium will be excavated to a depth of 2 feet, treated, and placed back in the wetland. All material will be treated to achieve remediation goals.

The Selected Remedy also includes excavating contaminated soil from the western drainage gully and the area where the waste pile soils were once stored to a depth of 7 feet. All excavated material will be dewatered and treated onsite using LTTD. If inorganic contaminants are detected at concentrations harmful to ecological receptors, that material will be blended with a metals stabilization agent. Treated material will be used to backfill the areas that were excavated. In the wetland, the final two feet (approximate) of backfill material will be blended with organic matter and bioaugmented granular activated carbon (GAC). This bioaugmented GAC will include the addition of microbes that are capable of degrading the organic contaminants present in groundwater. Creating a bioreactive zone on the surface of the wetland will provide for long term permanence of the remedy via bioremediation of residual contamination from groundwater.

Land use restrictions will be implemented through ICs to minimize the potential for human exposure to contamination and protect the integrity of the remedy. The ICs will include use, access, and deed restrictions for those parcels where Site-related soil and sediment contamination are located.

By removing source material in the Western Wetlands, OU3 will limit that pathway for contamination, which currently contributes to contamination in TI Waiver zones C2 and P2. However, OU3 does not address source material DNAPL already within zones C2, P2, and the other proposed TI Waiver zones.

3.2.2 OU3 REMEDY CONSTRUCTION

A multilayer cap has been constructed to remedy contamination levels in the groundwater. Primary construction activities were completed in April 2017, although repairs to surface water control features were completed in August 2017. The layers of the cap consist of:

- 6-inch topsoil layer to promote vegetation and infiltration
- 18-inch protective soil layer
- Geocomposite drainage layer
- Barrier geomembrane layer
- Geosynthetic clay liner (GCL) layer
- 12-inch sand gas venting layer
- Other various geosynthetics

The cap is tied into the existing vertical groundwater slurry wall on the east, west, and south boundaries of the Site. The northern boundary of the cap does not extend as far as the northern boundary of the slurry wall. An active gas collection system is being used to extract and treat VOCs that migrate from the soil and groundwater underlying the capped area and prevent gaseous contamination from leaking out from under the capped area. The collected VOCs are treated using GAC and the resulting off-gas is discharged to the atmosphere in accordance with the provisions of air permit equivalences provided by DNREC.

The OU3 cap reduces the spread of groundwater contamination in the Columbia aquifer by decreasing infiltration and isolating contaminants from surface water runoff. The infiltration reduction achieved by the cap also reduces the further migration of contaminants from OU3 soils to the Columbia aquifer groundwater. Because of the potential for Columbia aquifer contamination to migrate to the Potomac aquifer, installation of the OU3 cap should reduce the potential for dissolved phase groundwater contaminants to spread to the lower aquifer. The existing GETS will continue to help decrease groundwater contamination levels as well.

It should be noted that the OU3 cap area has been designated as a WMA. This designation was made because waste materials from the TSSA and the sedimentation basin were spread across the footprint of the OU3 cap as part of the OU3 cap subgrade construction. As a result of this WMA designation, ARARs do not have to be met in groundwater underlying the area and no TI Waiver will be sought for the OU3 cap footprint area.

As with the other remedial actions so far, even though the OU3 cap can help contain further spread of contamination, it does not address the source material that exists within the proposed TI Waiver zones.

3.2.3 ONGOING SAMPLING ACTIVITIES

In addition to the remedial activities described above, the following routine sampling activities are conducted at the Site:

- Monthly aqueous samples of influent, treated effluent, and samples of the treatment system off-gas are collected to assess contaminant removal, characterize performance of the GETS, monitor vapor and liquid phase carbon life and assess compliance of the system with permit equivalences.

- Quarterly water level measurements of Columbia aquifer monitoring and extraction wells are made to monitor the hydraulic gradient across the slurry wall.
- Quarterly water level measurements of select Potomac aquifer monitoring wells are made to monitor the hydraulic gradient between the Potomac and Columbia aquifers in the portion of the Site surrounding the containment area.
- Annual sampling of Columbia and Potomac aquifer groundwater monitoring wells is performed under OU1.
- Semiannual sampling of stormwater outfalls and the GETS discharge is performed to determine how remedial activities have affected PCB discharges from the Site.
- Annual sampling of stormwater outfalls is performed to determine metals discharges from the Site
- Sampling of the OU3 gas collection system influent and effluent is being performed by DNREC to test the effectiveness of collection and treatment. This sampling will continue on a monthly basis to monitor vapor phase carbon life and compliance of the system with the air permit equivalence.

Potomac aquifer groundwater monitoring wells PW-23 and PW-24 were installed on the east side of Route 9 in November 2022. The purpose of these wells is to assess whether Site-related contaminants are present east of PW-22. However, analytical results of PW-23 and PW-24 indicate that there is no contamination in this area east of River Road. While groundwater monitoring will be continued, it will only serve as a measurement tool, and does not contribute to remediation of the Site.

4.0 RESTORATION POTENTIAL OF THE SITE

This section evaluates the restoration potential for groundwater at the Site and presents information demonstrating that groundwater restoration is technically impracticable within the proposed TI Waiver zones. The following sections discuss the source material, previous remedial actions, and other potential remedial technologies. Each potential remedial technology is evaluated for its suitability in each TI Waiver zone.

4.1 Overview

A key factor in evaluating potential remedial strategies is the presence of DNAPL on the Site. DNAPL has been directly observed at many locations in the Site and is interpreted to exist across a wide area.

As previously noted, the presence of DNAPL in the Site in both the Columbia and Potomac aquifers at depths of up to 120 feet below MSL strongly supports the judgement that groundwater restoration within the DNAPL zone is technically impracticable.

DNAPL deposits are located in the following areas, as detailed in the Feasibility Study (HGL, 2020) and Remedial Investigation (HGL, 2016).

- TI Waiver Zone C1, in the Columbia aquifer north of the cap but within the slurry wall.

- TI Waiver Zone C2, in the Columbia aquifer north of the slurry wall.
- TI Waiver Zone C3, in the Columbia aquifer immediately west of the slurry wall in the area known as the western drainage gully.
- TI Waiver Zone C4, in the Columbia aquifer immediately west of the slurry wall near the rail yard.
- TI Waiver Zone P2, in the Potomac aquifer north of the slurry wall underlying the wetlands in the Potomac "A" sands, from the top of the saturated Potomac aquifer to 120 feet below mean sea level.
- TI Waiver Zone P3, in the Potomac aquifer immediately west of the slurry wall underlying the area known as the western drainage gully in the Potomac "A" sands from the top of the saturated Potomac aquifer to 120 feet below mean sea level.
- TI Waiver Zone P4, in the Potomac aquifer to the east of the slurry wall in the Potomac "A" sands from the top of the saturated Potomac aquifer to 120 feet below mean sea level.

The lack of groundwater wells in Zone P1 means that DNAPL has not been directly observed in TI Waiver zone P1. However, it is inferred that DNAPL is present in the Potomac in TI Waiver zone P1 based on the CSM and the presence of DNAPL in adjacent portions of the Potomac aquifer. Because the confining clay layer beneath the WMA is thin and absent in places, and the DNAPL and other contaminant concentrations are very high within the WMA where the original contaminant releases occurred, it is inferred that contamination flowed directly downward into the Potomac in this location. Additionally, the presence of DNAPL in the adjacent Zone P3 and Zone P4 indicates that contamination would have flowed through Zone P1 to reach Zone P3 and P4. It can be deduced that concentrations of contaminants in P1 should be higher or similar to concentrations in Zone P3 and P4 . Because the largest contaminant spills occurred in the area overlying zone P1, it is inferred that the DNAPL contaminating other portions of the Potomac migrated through zone P1 and that DNAPL remains in that zone.

The nature of the DNAPL releases at the Site exacerbates the remediation limitations typically seen at DNAPL sites. The source material was released in ongoing leaks and spills over many years, and migrated along various pathways over a long period of time and across a wide area. According to the TI guidance document (EPA, 1993), a widespread DNAPL release such as this one substantially increases the difficulty of groundwater restoration and thus provides support in favor of a TI decision.

An automated DNAPL extraction system was piloted as a part of the Feasibility Study (HGL, 2020) in areas with the highest contaminant concentration and known DNAPL presence. However, DNAPL recovery rates were irregular and very low, which means DNAPL collection would not remove a significant quantity of DNAPL relative to the total mass present onsite (HGL, 2020). The total estimated mass of DNAPL in the Columbia aquifer is about 550,000 pounds and in the Potomac aquifer it is about 120,000 pounds (HGL, 2020), which vastly exceeds the negligible amounts recovered in the pilot testing.

Nonetheless, the following remedial technologies are evaluated for their potential use in remediating the Site.

4.2 Excavation and Ex-situ Treatment of DNAPL

Excavation and treatment of DNAPL source-material is often used where removal through extraction wells is not feasible. The excavation approach is being taken by EPA in OU2 in the wetlands to the north and west of the proposed TI Waiver zones, as proposed in the OU2 Rod Amendment (EPA, 2022).

DNAPL is widespread across 50 acres in both the Columbia and Potomac aquifers. DNAPL extends down to the Potomac A sands, about 30-160 feet below surface level depending on the exact location and the height of the overlying topographical terrain. The combination of depth and extent of contamination precludes excavation and treatment of DNAPL; in the western wetlands where principal threat DNAPL source material is being excavated and treated as a part of OU2, most of the contamination lies within 10 feet of the surface, which is a much more feasible engineering option.

An additional factor precluding recovery of DNAPL in OU4 is the OU3 landfill cap which cannot be perforated. This precludes the drilling of additional DNAPL extraction wells or excavation of DNAPL in the 23-acre footprint underlying the cap, which coincides with the highest concentrations of contamination.

Zone C1 is encompassed within the slurry wall surrounding the WMA, which means any attempts to excavate DNAPL would not achieve long-term success, because the large mass of DNAPL and the aqueous phase contaminant plume from dissolving DNAPL in the WMA would re-contaminate the C1 TI Waiver zone. DNAPL excavation and treatment in zone C2 would be impracticable due to the large area of about 15 acres of steep, wooded terrain. The Merchantville confining unit separating the Columbia from the Potomac aquifer is also thin and absent in zone C2, and DNAPL contamination extends down to about 30 feet below MSL (90 feet below ground surface), a depth which would be impracticable to excavate. Zones C3 and C4 are smaller, but the depth of DNAPL (about 30 feet below MSL, or 40 feet below ground surface) and immediate proximity to the slurry wall would not allow for excavation without damaging the slurry wall.

In the Potomac aquifer, DNAPL is widespread to 120 feet below MSL, which is about 30-160 feet below ground service. The depth and widespread contamination across over 40 acres in zones P1, P2, P3, and P4 renders excavation of DNAPL impracticable.

For these reasons, the engineering that would be necessary to address the principal threat DNAPL waste in the proposed TI Waiver zones is deemed impracticable, which eliminates excavation and ex-situ treatment of the source material as a potential remediation alternative.

4.3 Physical Barriers

Vertical barriers are usually constructed along the perimeter of the contamination using low permeability materials that extend from ground surface down to a competent aquitard, low permeability soil, or bedrock. Soil-bentonite slurry walls are most often used for vertical containment. Other vertical containment options include thin walls, deep soil mixing, grout walls, sheet pile walls and vertical liners (ITRC, 2009). These structures are often used in conjunction with covers/caps and treatment technologies such as in situ treatment and groundwater collection and treatment systems. Vertical barriers can also be used to redirect groundwater away from contaminated material or towards a treatment area.

Physical barriers do not address source material, because they do not reduce the volume of contaminants in groundwater or DNAPL. However, physical barriers could be used in conjunction with another remediation method, such as pump-and-treat, to reduce contaminant concentrations and achieve ARARs. However, as described in the previous section, high mass loads of DNAPL are present in all eight of the proposed TI Waiver zones, and there is no feasible engineering alternative that allows removal or treatment of that DNAPL. Therefore, the use of physical barriers would not allow for achieving ARARs within the proposed TI Waiver zones.

However, physical barriers can be used to limit the size of the proposed TI Waiver zones by containing the existing source material DNAPL. Because of the lack of a key-in area due to the thin and sporadic distribution of the Merchantville Clay layer, physical barriers are not possible to the northeast of the WMA along the northeastern portion of zone C2. Physical barriers could be used to control the spread of contamination in portions of zone C2 that have a key-in area. Zones C1 and P1 are already contained within the OU1 slurry wall, which is performing as intended, which means additional containment would be redundant and unnecessary.

Zones C3, C4, and P3 are all near the rail yard and western drainage gully. Physical containment in the form of a barrier wall could be effective in these areas to control the existing DNAPL source material. Therefore, physical containment is retained as a potential remedial strategy in this area as well as in portions of zone C2. However, as previously explained, it would only serve to prevent the further migration of source material and would not restore ARARs within the TI Waiver zones. Therefore, technology incorporating physical barriers would not eliminate the need for TI Waiver zones.

4.4.1 <u>Groundwater Extraction Wells</u>

A hydraulic barrier is a hydraulic boundary, usually created by pumping, that works by means of influencing the flow of groundwater such that the migration of contamination is controlled. A hydraulic barrier generally can feature one or more extraction wells or interceptor trench to prevent the downgradient flow of groundwater. A hydraulic barrier could be implemented in any of the eight TI Waiver zones, and has already been implemented within the OU1 slurry wall, which encompasses zones C1. This existing GETS is working as intended, and has resulted in a significant decreasing trend in aqueous phase contamination outside of the slurry wall. However, contaminations within the slurry wall have not changed significantly since the groundwater pumping began in 2007. There are also existing wells in the Columbia and Potomac aquifer in areas within the TI Waiver zones, which demonstrates that extraction and treatment would be feasible in these areas to provide hydraulic containment.

However, the presence of high levels of DNAPL in throughout the TI Waiver zones means extraction and treatment of aqueous-phase contamination would not achieve ARARs, because the DNAPL would slowly diffuse into the groundwater in the immediate vicinity of the DNAPL, providing a constant source of contamination. While groundwater extraction and treatment may remove small amounts of DNAPL mass via dissolution, this is a very slow and inefficient process that would not address such a large volume of source material as is present at the SCD Site. Therefore, hydraulic containment is retained as a potential remedial strategy for all of the TI

Waiver zones, but it cannot result in meeting ARARs in any of the eight TI Waiver zones due to its inability to treat source material DNAPL. This means that hydraulic containment or groundwater extraction wells does not preclude the need for a TI Waiver. Beyond the immediate area of DNAPL contamination, containment can prevent continued contaminant migration, and therefore areas beyond the extend of DNAPL contamination will be remediated and are not included in the TI Waiver zones.

4.4.2 In Situ Enhanced Bioremediation

Bioremediation is a process in which microorganisms degrade or transform contaminants found in soil and/or groundwater, converting them to less toxic or innocuous end products. Aerobic bioremediation takes place in the presence of oxygen, and anaerobic bioremediation takes place in the absence of oxygen.

Natural bioremediation relies on indigenous microorganisms under existing site conditions and is likely to occur to some extent regardless of what remedial technology is employed. Enhanced bioremediation is a process in which site conditions are modified to enhance the desired microbial activity. To stimulate and enhance microbial activity, microorganisms (bioaugmentation); nutrients, organic substrates, and other amendments (biostimulation); and oxygen (bioventing) can be added to the system. Solutions such as surfactants can be utilized to enhance desorption of the target compounds. The remedial time frame for this technology depends on the microbial community, the target contaminants and their concentrations, and the presence/absence of a continuing source term, such as DNAPL. Also, bioremediation of contaminants depends on the contact of the treating microbes with the contaminants. Consequently, because microbes would only act on the surface area of DNAPL agglomerations, bioremediation treatment effectiveness could be limited, or the approach could be rendered ineffective in areas where DNAPL is present.

Enhanced bioremediation of benzene, CB, and CB isomers can be implemented under aerobic and anaerobic conditions. However, in addition to the preferential degradation of benzene under aerobic conditions, biodegradation of the lower chlorinated compounds (CB and the DCBs) proceeds faster under aerobic conditions (Wenderoth et al., 2003), especially in the case of CB and 1,4-DCB (Dermietzel and Vieth, 2002). Lorah et al. (2014) also observed aerobic degradation of trichlorobenzene in bench scale studies conducted at the Site, but biodegradation of the more highly chlorinated compounds (TCBs, TeCBs, PeCB, and HCB) can be expected to progress more rapidly, or exclusively, under anaerobic conditions. Half-lives under anaerobic conditions are high and degradation by-products of 1,2-DCB, 1,4-DCB, and 1,2,4-TCB include CB and 1,4-DCB, which extends the time frame to attain MCLs. The biodegradation pathways for chlorinated benzenes under aerobic conditions have shorter half-lives and more stable end products.

In situ bioremediation is most frequently implemented through the injection of amendments and/or microbial cultures into the subsurface. Two alternative passive bioremediation applications might be feasible for the treatment of portions of the Site downgradient of the containment area. These approaches (bioreactive zones and biowalls) theoretically treat the dissolved contamination that passes through them as the result of natural groundwater flow. While these approaches might result in treated water passing downgradient to the Red Lion Creek, its unnamed tributary, and the surrounding wetlands, neither approach would directly treat the dissolved or DNAPL contamination that is present, and would remain, upgradient of the implementation locations. Even in combination with other cleanup methods (such as GETS), the DNAPL would persist in the proposed TI Waiver zones, rendering this solution impracticable.

lies Biowalls and other forms of bioreactive zones are another alternative, but again, these are a form of containment that would not treat the DNAPL contamination that is present at the Site. Most of the compounds observed in the Columbia and Potomac aquifers are amenable to biodegradation. However, the widespread presence of DNAPL would handicap the effectiveness of bioremediation because bioremediation of DNAPL itself is not technically practicable from an engineering standpoint, the DNAPL would remain as a continuing source and MCLs would not be achieved in the immediate vicinity of the DNAPL. Within the DNAPL zone, scattered pockets of the soil/groundwater matrix free from DNAPL contamination exist; however, it would not be practicable to remediate the groundwater in those pockets, as they are surrounded by the larger DNAPL zone and would become continually recontaminated by the immediately adjacent DNAPL. Outside of the DNAPL zones beyond the boundaries of the TI Waiver, bioremediation remains a viable remedial alternative.

Due to the depth, extent, and high concentrations of the contaminant plume in the Potomac aquifer, the effectiveness of in situ groundwater bioremediation injections would be limited. The DNAPL that is present in the Potomac A-Sand would back-diffuse into these areas and recontaminate them. Proper placement of a potential biowall in the Potomac aquifer would be dependent on identifying steady-state flow direction in that aquifer. The dependence of Potomac aquifer flow direction and gradient on DCRC production makes such placement uncertain. DCRC pumping is not controlled by the EPA, and as has been observed in recent years, this pumping can be decreased or halted depending on the profitability of the refinery. Such changes in pumping, and therefore flow direction, unreliable.

The Bioremediation would not reliably address the source material (DNAPL) and therefore would fail to meet MCLs within the proposed TI Waiver zones.

Implementation of bioremediation within the proposed TI Wavier zones is severely handicapped. Bioremediation of the primary Site contaminants (chlorobenzene compounds) involves removal of chlorines from the benzene ring to which they are attached. This dechlorination would increase the chloride concentrations in the groundwater. High chloride levels (in excess of 500 mg/L) have been observed in the portion of the Columbia aquifer located to the north of the containment area and are thought to be attributable to dechlorination of Site contaminants. Such high chloride levels could lead to desiccation failure of the containment barrier if the technology were to be used within or immediately adjacent to the containment area. This could result in some of the highest concentration contaminants being released to the surrounding groundwater before treatment can be achieved. Even if the desiccation issue could be overcome, injections performed in the OU3 area would likely have to be performed using directional drilling techniques to avoid damage to the cap. Using this approach would make it infeasible to achieve complete amendment distribution throughout the containment area. For these reasons, enhanced bioremediation is not recommended for use in within, or immediately adjacent to, the containment area.

Biowalls and bioreactive zones could not be implemented to address contamination in the Potomac aquifer because of the depth of the contamination, the variability of the groundwater flow direction, and, in the case of bioreactive zones, the lack of a local surface water discharge point. In the Colombia aquifer, installation of bioreactive zones or biowalls would be handicapped by the lack of a tie-in layer below many portions of the Colombia aquifer, which would allow contamination to bypass the biowall. If implementation were achieved, the ineffectiveness of bioremediation against the high mass load of DNAPL renders this option infeasible

4.4.3 <u>In-situ Chemical Oxidation</u>

In-situ chemical oxidation (ISCO) typically involves the introduction of an oxidant into contaminated water via injection to initiate an oxidation (redox) reaction involving one of the site contaminants. Oxidation reactions can chemically convert hazardous contaminants to nonhazardous or less toxic compounds and elements through the transfer of electrons from the contaminant to the oxidant. As a result, the organic contaminant is broken down, with water, carbon dioxide, chlorides (in the case of chlorinated compounds), and other less toxic chemicals as the end products of the reaction. When using ISCO, oxidants are injected into the subsurface as a solution, mixed into the ground as a solid, or, in the case of ozone, injected as a gas. Oxidants commonly used include hydrogen peroxide, potassium/sodium permanganate, sodium persulfate, or ozone. In some cases, co- amendments (such as iron in Fenton's reagent reactions) are added to catalyze the reaction.

The primary benefits to the chemical oxidation approach are its fairly short treatment time and the destruction of organic contaminants. Potential drawbacks for this technology include:

- Potential generation of more toxic contaminants;
- Volatilization of organic chemicals due to the exothermic nature of the reactions;
- Potential regulatory issues associated with underground injection control;
- Oxidant delivery problems due to reactive transport; and
- Short persistence of some oxidants due to fast reaction rates in the subsurface.

The following paragraphs provide a review of the applicability of ISCO to the each of the proposed TI Waiver zones.

Because of the potential for ISCO to undergo exothermic oxidation reactions and generate increased chloride levels that could adversely impact the existing OU1 slurry wall, it would t be infeasible to apply this technology near the slurry wall or within the containment area. Chlorinated compounds would likely cause desiccation of the containment slurry wall and increase the slurry wall permeability. This eliminates its applicability in zones C1, C3, C4, P1, P3, and P4, all of which are in very close proximity to the slurry wall.

Portions of zone C2 lie away from the slurry wall. In these zones, ISCO injections could help address benzene and the various chlorinated benzene compounds. ISCO would not address other site COCs. The technical implementability of ISCO in zone C2 is complicated by potential adverse effects. ISCO would cause geochemical changes in the aquifer by altering the oxidative state and the pH. This can change the solubility of many inorganic species and result in precipitation of soluble mineral species. Imbalances in pH can also mobilizes heavy metals, while organics and other compounds such as nitrite and iron may be mobilized due to the formation of reaction by-products or by degradation of parent compounds. ISCO can also cause permeability reduction due to the formation of insoluble precipitates or process residuals during the oxidation process. Furthermore, ISCO injections would need to avoid the areas close to the OU1 slurry wall where much of the source material lies, which means the remaining DNAPL source material would continue to re-contaminate the surrounding area via dissolution. The large footprint of zone C2 (more than ten acres), steep wooded terrain, and depth (including uninterrupted hydraulic communication with the underlying Potomac aquifer) further exacerbates implementibility issues in zone C2.

For zone P2, ISCO is not implementable due to the depths of DNAPL concentration up to 120 feet below MSL (about 150 feet below ground surface in this area). Efficacy of ISCO depends on maximizing contact between the injections and the source material. To treat the Potomac aquifer outside the footprint of the containment area, the injection points would have to be installed using drill rigs instead of DPT rigs because of the depth to contamination. Although portions of the Merchantville Confining Unit are thin or absent in some areas of P2, drill points would need to be double cased to prevent introducing new migration pathways from the Columbia into the Potomac aquifer. The combination of a need for a high density of injection points and the depth and complication of drilling into the Potomac aquifer makes ISCO infeasible for the Potomac.

4.4.4 Sparging/Soil Vapor Extraction

The target contaminant groups for AS/SVE are VOCs. AS/SVE is best suited for well drained, high-permeability soil (sand and gravel) with low organic carbon content. AS/SVE systems are typically less effective against DNAPL and SVOCs, and they are ineffective when addressing metals.

AS/SVE is a well-established technology that has been used at many sites with similar conditions (geology, depth, and extent of contamination) to treat many of the contaminants present on the Site. Contamination in the Columbia aquifer outside the containment slurry wall could be treated with multiple vertical or horizontal wells with minimal potential for aquifer clogging. Up to 30 AS wells and 10 SVE wells could be necessary to treat the Columbia aquifer north of the containment slurry wall (zone C2), assuming a 20 ft radius of influence for each well.

However, AS/SVE is not regarded as an effective treatment of DNAPL. DNAPL concentrates in areas above low-permeability zones, and pools above confining layers, including the Merchantville Clay Layer at the Site. Sparged air in the Columbia aquifer would likely bypass these DNAPL areas, leaving the DNAPL mass untreated.

An additional complication for using AS/SVE to treat the groundwater in the Potomac aquifer is the presence of confining units. These units would restrict vertical flow of volatilized compounds and could direct contaminant migration into previously uncontaminated areas, further exacerbating contamination on the Site.

For these reasons, AV/SVE would not treat the source material DNAPL Therefore, the continued presence of DNAPL would support the need for a TI Waiver zone encompassing the DNAPL.

4.4.5 In Situ Thermal Desorption

With In Situ Thermal Desorption (ISTD), the soil and groundwater are heated to temperatures above the boiling points of the contaminants, enhancing volatilization of adsorbed VOCs and SVOCs. ISTD can be achieved by several methods, including hot air or steam enhanced extraction, electrical resistance heating (ERH), and thermal conduction heating. Any volatilized compounds are typically removed using an SVE system. Off-gas is usually treated via carbon adsorption, catalytic oxidation, or thermal oxidation before being discharged to the atmosphere. Alternatively, a condenser can be used to separate the contaminants from the air stream and capture them for reuse or disposal as a liquid. This combination of SVE and ISTD, sometimes referred to as thermally enhanced SVE, is a relatively well-established technology that can achieve remediation of a wider range of organic contamination in a shorter time frame than SVE alone.

When DNAPL is heated, it will vaporize and travel upward. However, the vaporized DNAPL can re-condense and form new pools of DNAPL, which poses the risk of mobilization and further spread of contamination. In addition to the problem of vertical DNAPL mobilization, an important component to ISTD is ensuring that the source material is heated to the appropriate temperature. Because the bulk of the source material (DNAPL) is pooled in the Columbia aquifer against the Merchantville Clay Layer in zones C2, C3, and C4, it would not be feasible to design a system that provides sufficient heat to the bottom layers of DNAPL pools in these zones.

For zone C1, in addition to the noted challenges of treating pooled DNAPL with thermal desorption, thermal desorption in this zone could damage the OU3 cap and the OU1 remedy. Thermal treatment would need to stay away from the slurry wall and the WMA, which would render it ineffective at treating the source material. Furthermore, as previously noted, zone C1 is in direct hydraulic communication with the WMA, meaning any portion of C1 that is treated via thermal desorption would be re-contaminated by source material in the WMA.

Within the proposed TI Waiver zones in the Potomac aquifer, thermal desorption technology would require the installation of a large number of electrodes and/or thermal conduction wells, as well as electrical supply lines sufficient to handle the current needed to heat the subsurface. This would result in a need to introduce new potential migration pathways by drilling through the confining layer. More importantly, any vaporized source material would be blocked by the confining layers, which would result in ineffective collection of vapors. As in the Columbia aquifer TI Waiver zones, mobilization of DNAPL could exacerbate contamination by causing further migration. Although portions of P2 underly areas with a thin or absent confining layer, the nearby flow of Red Lion Creek through this area would complicate the capture of any vaporized contaminant. Mobilization and further spread of DNAPL is another concern in zone P2.

An additional concern is that thermal heating would compromise the OU1 slurry wall, which is an important part of the existing IGR, and will become an important part of the final OU4 remedy. The heat front from ISTD dissipates within approximately 10 feet of the heat zone, which means to protect the slurry wall from heat damage, the heat zone should be kept a minimum of 10 feet from the slurry wall. This adds another layer of infeasibility for the TI Waiver zones C3, C4, P3, and P4.

For all of these reasons, ISTD is not a suitable technology to treat the source material DNAPL to meet ARARs within the proposed TI zone.,.

4.4.6 <u>Permeable Reactive Barriers</u>

Permeable Reactive Barriers (PRBs) are installed across the flow path of a contaminant plume. Because they are built to be more permeable than the surrounding geology, PRBs treat the contaminants while allowing the treated water to pass. PRBs can be constructed using ZVI, GAC, chelators (ligands selected for their specificity for a given metal), peat, sorbents, or other treatment media (FRTR, 2002). PRBs have been used to remediate both organic and inorganic contaminants. Not only would ZVI address many of the metal contaminants in the Columbia groundwater, it also would be useful in the dechlorination of chlorinated benzene compounds with the presence of a catalyst. However, it should be noted that ZVI is less effective against the resulting benzene (Plagentz et al., 2006).

Zone C1 is managed within the OU1 slurry wall, which means a PRB would not be be of added benefit for zone C1. Based on the hydrogeology of the Site, most of the contamination flows from the Columbia aquifer down to the Potomac aquifer, while some contamination flows to Red Lion Creek and the Western Wetlands. Therefore, the most likely place for installation of a PRB would be along, or just to the north of, the haul road that runs along the wetlands at the north end of the Site. This could be used in or near zones C2, C3, and C4. The depth of the Potomac aquifer, and the need to drill through the Merchantville Confining Unit which would introduce new migration pathways, renders the use of PRBs in zones P2, P3, and P4 as not feasible. Zone P1 is not suitable for a PRB because it underlies the OU1 slurry wall containment area.

PRBs are retained a potential remedial technology in the Columbia aquifer in zones C2, C3, and C4. However, PRBs do not remediate source material DNAPL to ARAR levels. Therefore, PRBs can be used to control further migration of contamination, but TI Waiver zones are still necessary in all of the proposed areas because of the presence of DNAPL source material.

4.5 SUMMARY OF APPLICABLE REMEDIAL TECHNOLOGIES

The Remedial Action Objectives (RAOs) for the Site are as follows, and must be met by any selected remedial technologies.

- Prevent exposure to Site-related groundwater contamination and DNAPL in the Columbia and Potomac aquifers that would result in a target organ HI greater than 1 for non-carcinogens in the groundwater via the potential exposure routes of inhalation, ingestion and dermal absorption.
- Prevent exposure to Site-related carcinogens in groundwater at concentrations that would result in a cumulative cancer risk in excess of $1x10^{-4}$ (1E-04) via the potential exposure routes of inhalation, ingestion, and dermal contact.
- Meet the ARARs for the Site.in areas outside of the proposed TI waiver zones
- Restore the Columbia and Potomac aquifer groundwater to its beneficial use as a potable water supply in those areas where waste does not remain in place and areas outside of the proposed TI Waiver.
- Prevent unacceptable risks to ecological communities exposed to Site-related groundwater contamination, including that in sediment and surface water.
- Minimize the further spread of contamination via any of the following major migration pathways:
    - DNAPL to groundwater
    - Groundwater from the Columbia aquifer to the Potomac aquifer
    - Groundwater to sediment
    - Groundwater to surface water
    - Groundwater to soil gas
- Treat principal threat waste to the extent practicable.
- Where restoration of the groundwater will not be met:
    - Prevent the continued migration of contamination
    - Reduce the volume and concentrations of contaminants

For the reasons detailed above, restoration to ARARs is not possible in the proposed TI Waiver zones. However, if DNAPL can be reliably contained, then the downgradient plume can be remediated to ARARs. This section discusses how migration of contamination from the DNAPL to the downgradient aqueous plume can be prevented in each of the TI zones.

Zone C1

ICs including DNREC’s Groundwater Management Zone, access agreements and restrictive covenants to prevent exposure to contaminated groundwater. A physical barrier already exists as a part of the OU1 IGR, and will be incorporated in the OU4 final groundwater remedy, which contains the further spread of contamination from zone C1. Groundwater extraction and treatment already performed as a part of OU1 will also be included in the OU4 final groundwater remedy; the groundwater extraction and treatment will result in reduced contaminant volume and concentration within this TI zone.

Zone C2

ICs including DNREC's Groundwater Management Zone, access agreements and restrictive covenants to prevent exposure to contaminated groundwater. A physical barrier, such as a sheet pile wall, can be incorporated in portions of zone C2 that have a key-in layer in the Merchantville Clay layer, especially along the western edge of zone C2. Groundwater extraction and treatment can also be incorporated to establish hydraulic control, which coupled with the sheet pile wall, will prevent contamination from migrating outside of this TI zone. Groundwater extraction and treatment can also be used to treat dilute contamination in the vicinity of the TI zone. PRBs are also a suitable remedial technology. Alternatively, to treat contaminated groundwater in this zone, enhanced in-situ bioremediation could be used in place of or in addition to groundwater extraction and treatment. In situ enhanced bioremediation could address the aqueous phase groundwater contaminant plume. These technologies reduce contaminant volume and mobility within the TI zone, and reduce contaminant volume and concentration downgradient of the TI zone, restricting the contamination from migrating outside of the TI zone.

Zone C3

ICs including DNREC’s Groundwater Management Zone, access agreements and restrictive covenants to prevent exposure to contaminated groundwater. Groundwater extraction and treatment can be used to establish hydraulic control and prevent the aqueous phase contaminant plume from migrating outside of this TI zone. Extraction and treatment will also reduce the volume and mobility of contamination, both within and downgradient of the TI zone. A physical barrier such a sheet pile wall can also be incorporated, as could a PRB. In situ enhanced bioremediation could address the aqueous phase groundwater contaminant plume, further reducing the volume of contamination and concentrations.

Zone C4

ICs including a Groundwater Management Zone, access agreements and restrictive covenants to prevent exposure to contaminated groundwater. Groundwater extraction and treatment can be used to establish hydraulic control and prevent the spread of an aqueous phase contaminant plume, which will prevent contaminants from migrating outside of the TI zone. Extraction and treatment will reduce the volume/concentration and mobility of contamination. In situ enhanced bioremediation could address the aqueous phase groundwater contaminant plume. These technologies can minimize the spread of further contamination.

Zone P1

ICs including Groundwater Management Zone, access agreements and restrictive covenants to prevent exposure to contaminated groundwater. Groundwater extraction and treatment can be used to reduce the volume of contamination within this TI zone. It will also reduce the volume and concentration of contamination downgradient of this TI zone by cutting off the primary source material, and prevent contamination from migrating outside of the proposed TI zone in the future by establishing hydraulic control.

Zone P2

ICs including Groundwater Management Zone, access agreements and restrictive covenants to prevent exposure to contaminated groundwater. Groundwater extraction and treatment can be used to reduce volume and mobility of contamination within this TI zone, and to reduce downgradient contaminant volume and concentrations by cutting off the primary source material. This will result in an overall reduction in contaminant mobility and will prevent contamination from migrating outside of the TI zone.

Zone P3

ICs including Groundwater Management Zone, access agreements and restrictive covenants to prevent exposure to contaminated groundwater. Groundwater extraction and treatment can be used to reduce volume and mobility of contamination within this TI zone, and reduce downgradient contaminant volume and concentrations by cutting off the primary source material. This will result in an overall reduction in contaminant mobility and will prevent contamination from migrating outside of the TI zone.

Zone P4

ICs including Groundwater Management Zone, access agreements and restrictive covenants to prevent exposure to contaminated groundwater. Groundwater extraction and treatment can be used to reduce volume and mobility of contamination within this TI zone, and reduce downgradient contaminant volume and concentrations by cutting off the primary source material. This will result in an overall reduction in contaminant mobility and will prevent contamination from migrating outside of the TI zone.

4.6 ALTERNATIVE REMEDIAL STRATEGIES

It was demonstrated in the previous sections that potential remedial technologies will not be able to achieve compliance with the MCLs for those identified portions of the Potomac and Columbia aquifers within the DNAPL zone where potential remedial technologies would not fully remediate the DNAPL contamination. However, expanded pumping and treatment of contaminated groundwater from the Potomac aquifer and treatment of the contaminated portions of the Columbia aquifer that are outside the containment area, in addition to physical barriers in certain locations, can be combined with the existing remedial actions performed under the OU1 IGR to produce an ARS that achieves the following:

- Limit contaminant migration within the Potomac aquifer;
- Remove and/or treat contaminants from the Columbia and Potomac aquifers outside of the immediate vicinity of DNAPL concentration in the identified TI Waiver zones;
- Limit further migration of contaminants from the Columbia aquifer to the Potomac aquifer;
- Continue to prevent migration of contaminants from the containment area to Red Lion Creek and the surrounding wetlands; and
- Reduce or eliminate further migration of contaminants from the portions of the Columbia aquifer outside the containment area to Red Lion Creek and the surrounding wetlands

The following sections provide two remedial alternatives, sharing some common elements, that could be implemented to achieve the aforementioned remedial action objectives.

4.6.1 ARS 1: Expanded Groundwater Extraction and Treatment, Groundwater Source Area Containment, and ICs

This ARS includes continued use of the slurry wall, the OU3 cap, and continued extraction and treatment of the contaminated groundwater from within the containment area. However, the existing GETS would be expanded to accommodate additional flow from the Potomac aquifer. Additional extraction wells, likely in the areas of monitoring wells MW-22 and MW-25, would be added to treat Columbia aquifer contamination located to the north of the containment area. While the expanded treatment system would be able to handle some of the additional extracted water, a second GETS would be required to treat the entire flow. Not only would these additional Columbia aquifer wells reduce the mass of contaminants in groundwater and the downward flow of contamination into the Potomac aquifer, but they would also limit or cut off the migration of contamination to the Red Lion Creek and its wetlands.

Additionally, groundwater extraction from these locations could pull back some of the groundwater contamination that is already in the wetlands along the south side of Red Lion Creek. To be successful, this ARS would rely on removal and treatment (to be conducted as part of OU2) of portions of the wetlands where DNAPL is present to reduce volume, toxicity, and mobility of contamination in the Columbia aquifer. Also, as part of OU2, bioreactive zones like those pilot-studied at the Site by the USGS will be used to address contaminated groundwater that discharges in Red Lion Creek, the unnamed tributary, or surface water in the surrounding wetlands.

To maximize the volume of contaminated groundwater that is captured by the extraction wells near MW-25 and MW-22, a sheet pile wall would be installed along the eastern edge of the Western Wetlands (in the vicinity of the western edge of TI Waiver zones C2, C3, and C4) to direct water towards the wells. This sheet pile wall would also limit the volume of contaminated Columbia aquifer groundwater that would otherwise enter the Western Wetlands. Because of the high groundwater chloride levels and low pH, this sheet pile wall likely would have to be replaced at some point during the remedy life.

The Site fence surrounding OU3 would be used to restrict access to the OU3 remedy and the GETS. Institutional controls (ICs) would be used to limit the potential for human exposure to site contaminants. The proposed ICs include:

- Site use limitations that could be implemented through the continued enforcement of DNREC's GMZ, employment of CPCNs to the north of Red Lion Creek, and the use of zoning ordinances and restrictive covenants. The GMZ includes the area of known and suspected Site-related groundwater contamination;

- Access agreements to allow continued operation and maintenance of the GETS and collection of performance and compliance monitoring samples; and
- Continued use and maintenance of warning signs to limit unauthorized access to the Site.

This ARS would remove and treat contamination from both aquifers and allow for achievement of ARARs outside of the TI waiver zones, provide for containment of contaminated groundwater in the Columbia aquifer within the current slurry wall, and reduce the toxicity and/or mobility of principal threat waste by establishing hydraulic control within the TI waiver zones. The continued use of ICs would protect human health.

4.6.2 ARS 2: Groundwater Extraction and Treatment, Groundwater Source Area Containment, Enhanced Bioremediation, Metals Treatment, and ICs

This ARS is similar to the approach outlined for ARS 1 except that groundwater from the portion of the Columbia aquifer north of the existing containment area would be treated using a biowall and metals treatment instead of extraction and treatment. As such, it is much less likely that a second GETS would be needed, and if one is needed, it would have a smaller capacity. Groundwater extraction and treatment would employ the same methods as other areas of the Site.

The Site fence surrounding OU3 would be used to restrict access to the OU3 remedy and the GETS. The same ICs would be used to limit the potential for human exposure to site contaminants. As in ARS 1, this ARS would rely on removal and treatment (to be conducted as part of OU2) of portions of the wetlands where DNAPL is present to reduce volume, toxicity, and mobility of contamination in the Columbia aquifer. Also, as in ARS 1, bioreactive zones (to be installed as part of an OU2 remedy) would be used to address contaminated groundwater that discharges in Red Lion Creek, the unnamed tributary, or the surrounding wetlands.

To address the organic contamination to the north of the containment area, in situ bioremediation, implemented using a biowall, would be used. The most likely place for installation of a biowall would be along, or just to the north of, the haul road that runs along the wetlands at the north end of the Site. Unfortunately, placement of the wall in the wetlands is impractical from a constructability standpoint and because there is a greater area where the clay layer between the Columbia and Potomac aquifers is missing. Replacement or amendment of the media in the biowall would likely be necessary at some point prior to achieving cleanup goal. To maximize the volume of contaminated groundwater that passes through the biowall for treatment, a sheet pile wall would be installed along the eastern edge of the Western Wetlands to direct water towards the biowall. This sheet pile wall would also limit the volume of contaminated Columbia aquifer groundwater that would otherwise enter the Western Wetlands. Because of the high groundwater chloride levels and low pH, this sheet pile wall likely would have to be replaced at some point during the remedy life.

Because bioremediation would not address metals contamination present in the Columbia groundwater, an additional metals treatment, such as sulfate injections for the generation of insoluble sulfide compounds or a PRB employing ZVI or sulfate, would be used downgradient of the bioremediation treatment area. The metals treatment would be placed downgradient of the biowall to minimize the potential for precipitated metals compounds to reduce the permeability of the biowall. While this reduction in permeability could also occur in the PRB, it would be less expensive to reinstall the PRB media than to rebuild the microbial community in the biowall.

This ARS would remove and treat contamination from both aquifers, and the extraction of groundwater would help provide hydraulic containment of contamination in the Potomac aquifer. The biowall and PRB would provide treatment of the contaminants located north of the containment area. However, this approach might require additional treatment measures (in the form of sulfate injections) to address inorganic contamination that is already downgradient of the proposed biowall and PRB locations. Additionally, the biowall and PRB would not prevent the downward migration of contamination into the Potomac in areas where the low permeability layer is missing (such as in the northeast portion of the Site near well PW-17). The continued use of ICs listed in ARS 1 would help protect human health.

5.0 COST ESTIMATES OF REMEDIAL ALTERNATIVES

The total cost for the remedial action includes capital and O&M costs, both direct and indirect. Capital costs consist of the direct costs for items such as labor, materials, equipment, and services plus the indirect costs for engineering management, permits, startup, and contingencies. A 20% contingency was utilized in all capital cost estimates for the alternatives, which is the middle of the range provided in EPA's guidance document (EPA, 2000). O&M costs are the annual post-construction costs necessary to maintain the remedy. O&M costs include such items as operating labor, maintenance, auxiliary materials, and energy.

A present worth analysis is used to evaluate expenditures that occur over different time periods by discounting all future costs to a common base year. In accordance with EPA guidance, present worth estimates are calculated at a 7% discount rate over 30 years (EPA, 2000), with 2020 as a base year. Because the expected treatment duration, as calculated in Section 3.5, would be much longer than 30 years, the actual costs would be higher than the provided present worth estimates.

The cost estimates in this report are order-of-magnitude level estimates, which are based on a variety of information including quotes from suppliers, generic unit costs, vendor information, conventional cost estimating guides, and professional judgment.

ARS 1: COST ESTIMATE

This section presents the present worth analysis for ARS 1. Primary uncertainties that could impact the total cost of this alternative include:

- The number and locations of the new extraction wells;
- The need for an ion exchange system to address metals that are not currently removed to levels consistent with the PRGs;
- The need to design and construction of the second GETS. For costing purposes, a second GETS has been assumed;
- Costs for acquisition of land or a permanent easement for placement of a second GETS; and
- The degree of increases in electrical costs and the material required for the well casings, conveyance piping, and treatment system components.

These uncertainties will be addressed during the RD stage.

Expansion of the existing GETS would include the following elements (approximate capital costs provided in parentheses):

- Addition of one tray to the air stripper to improve VOC removal ($2,000);
- Addition of two multi-media sand/anthracite filters to improve metals removal and system throughput ($8,000);

- Addition of extra bag filter units to each of the three existing filter banks to improve throughput ($6,000);
- Expansion and reprogramming of the control system to handle the added equipment ($120,000);
- Inclusion of a filter press to improve solids handling ($30,000);
- Addition of a third liquid-phase GAC unit to increase hydraulic residence time and maintain or extend the time between carbon changeouts ($7,000);
- Addition of a third vapor phase GAC unit to maintain or extend the time between carbon changeouts ($20,000);
- Replacement of the effluent pump with one to handle higher flow rates ($2,000);
- Possible addition of an ion exchange system to address metals that are not currently removed to levels consistent with the PRGs ($200,000); and
- Expansion of the treatment building footprint and relocation of equipment to accommodate some of the added treatment components (approximately $120,000).
- Treated water discharge would be via the existing discharge line.

The installation of the five additional extraction wells and conveyance piping would add between $650,000 and $710,000 to the upgrade total. A large portion of this cost stems from the need to use 316 stainless steel for the piping, well casing, and well screens to address compatibility issues and ensure that the system remains functional over the remedy lifespan. Also, past experience indicates that double-cased wells would be required for the Potomac aquifer extraction wells on the Oxychem property. With design, project management, and construction management added in, capital costs for the upgrade of the existing GETS and installation of new extraction wells would total between $1.2M and $1.4M.

The estimated cost of the second GETS (including design, project management, and construction management costs) would be in the $3M to $3.1M range based on the cost of the original treatment system construction. This would be in addition to aforementioned costs to operate the existing GETS after it has been upgraded to handle the added flow from the Columbia and the portion of the Potomac aquifer underlying the Former Air Products Property.

Site preparation costs including the installation of the sheet pile wall along the Western Wetlands edge would add another $2.9M to the costs.

Based on these cost data, it is estimated that ARS 1 would require the following:

- A capital expenditure of approximately $8.8M, which includes construction oversight, upgrading and expanding the existing GETS, and designing and constructing the second GETS;
- A combined cost of $800,000 to $850,000 for O&M of the two GETSs for each year of operation; and

- An additional cost of $100,000 to $150,000 for system startup, commissioning, and optimization that will occur during the first year of GETS operation.

Additional costs of approximately $25,000 (incurred every 5 years) would be incurred for each FYR that would be required until PRGs are met for all Site-related contaminants. Finally, approximately $145,000/year for the first 5 years and then $95,000/year thereafter for long-term maintenance (LTM), associated reporting, and project management. The LTM program would include approximately 60 Columbia aquifer wells and 30 Potomac aquifer wells including the extraction wells. These would be sampled semiannually for the first five years and with a possible switch to annual sampling thereafter. Table 5.1 presents the cost summary associated with ARS 1. The total estimated present worth cost (2019 dollars) is approximately $23M. Detailed and backup data regarding the cost estimate are presented in Appendix A.

5.1 ARS 2: COST ESTIMATE

The estimate of costs for ARS 2 is affected by the same uncertainties identified for ARS 1 regarding the expansion of the GETS or the possibility of constructing a second GETS. Because this alternative would have two fewer extraction wells, and less conveyance piping, it is estimated that the GETS expansion costs would be in the $1.1M to $1.2M range including the installation of extraction wells. For costing purposes, a second GETS (with somewhat reduced operating costs compared to the one included in ARS 1) has been assumed.

As estimated in Section 4.2.4.3, capital costs for a biowall would be approximately $5.1M to address the organic contamination to the north and west of the containment area. Replacement or amendment of the media in the biowall might be necessary at some point prior to achieving cleanup goal, but this is uncertain at this point.

The metals treatment, a PRB employing ZVI, would cost an additional $2.5M to construct. It is expected that replacement of the ZVI (or sulfate amendment) and disposal of the spent media would cost approximately $450,000 every 10 years.

Overall, it is estimated that ARS 2 would require the following (Table 5.2):

- A capital expenditure of $16.2M, which includes construction oversight, the costs of biowall and PRB installation and maintenance, upgrading and expanding the existing GETS, and designing and constructing the second GETS;
- A combined cost of $650,000 to $700,000 for O&M of the two GETSs for each year of operation.
- An additional cost of $100,000 to $150,000 for system startup, commissioning, and optimization that will occur during the first year of GETS operation.
- Approximately $25,000 (incurred every 5 years) for each Five-Year Review; and
- Approximately $145,000/year for the first 5 years and then $95,000/year thereafter for LTM, associated reporting, and project management.

The total estimated present worth cost (2019 dollars) is approximately $28.7M. Detailed and backup data regarding the cost estimate are presented in Appendix A.

6.0 PROPOSED ALTERNATE REMEDIAL STRATEGY

The TI waiver zones would be considered for the portion of the Columbia aquifer within the containment area but outside of the OU3 cap, the portion of the Potomac aquifer that underlies the containment area and those portions of the Potomac aquifer, and other portions of the Columbia aquifer where DNAPL or DNAPL-indicative concentrations of site contaminants are present. Within the affected area of the Columbia aquifer, the TI Waiver would apply from the groundwater surface to the bottom of the Columbia aquifer, where the Merchantville Clay Layer begins, approximately 30 feet below mean sea level. Within the affected area of the Potomac aquifer, the TI waiver would apply to the Potomac ‘A’ Sands, from the top of the Potomac aquifer to a depth of 120 ft below mean sea level. Refer to Section 1.0, including Figures 1a, 1b, 2a, and 2b for explanations and figures of the proposed TI waiver zones.

A TI Waiver is necessary because from an engineering perspective, it is impracticable, from an engineering perspective to restore groundwater concentrations to MCLs within the proposed zones containing DNAPL. However, either of the proposed ARSs would restore groundwater concentrations to MCLs in other portions of the Site outside of the TI Waiver zones, and either of the proposed ARSs would establish hydraulic control to prevent Site-related contamination from spreading further.

While both of the listed ARSs would be effective in reducing Site risks, ARS 1 is considered the preferrable remedy. It is estimated that extraction and treatment of contaminated groundwater would result in a greater contaminant reduction than the proposal in ARS 2. Designing a GETS to withdraw and treat contaminated groundwater from the area north of the containment area would also eliminate the need for pilot tests and require less destruction of existing habitat than the implementation of ARS 2. From a cost perspective, ARS 1 has the lower estimated capital and 30-year present value costs than ARS 2. For these reasons, ARS 1 is selected as the proposed remedy.

The treatment components of the ARS combined with the existing components of the IGR and OU3 remedy and the selected OU2 remedy, provide a remedial approach that would be used to:

- Limit contaminant migration within the Potomac aquifer;
- Remove and/or treat contaminants from the Columbia and Potomac aquifers;
- Limit further migration of contaminants from the Columbia aquifer to the Potomac aquifer;
- Continue to prevent migration of contaminants from the containment area to the surrounding groundwater, Red Lion Creek, and the Site wetlands; and
- Reduce or eliminate further migration of contaminants from the portions of the Columbia aquifer outside the containment area to Red Lion Creek and the surrounding wetlands.

ARS 1 includes ICs that would prevent use of the contaminated groundwater. ICs would remain in place for protection of the GETS and the bioreactive zones (to be installed as a part of OU2). The GETS, combined with the bioreactive zones included in OU2 and combined with the MNA portion of the ARS 1 remedy, would permanently reduce concentrations of the Site COCs within the containment area, the Potomac aquifer, Red Lion Creek and its unnamed tributary, portions of the Western and Northern Wetlands, and areas with low levels of contamination. This ARS provides overall protection of human health and the environment from contamination in the

Columbia aquifer outside the containment area through the use of ICs and the continued degradation of contaminants in portions of the Eastern Wetlands.

The ARS is expected to comply with ARARs identified for the GETS operation and construction, and the transportation and disposal of contaminated soils and other Site wastes. It also would comply with relevant potential chemical- and location-specific ARARs. An erosion and sediment control plan would be prepared to protect the downgradient wetland area during the construction of the ARS components.

The proposed ARS is expected to achieve high long-term effectiveness at reducing contaminant concentrations to below MCLs outside of the DNAPL-contaminated areas proposed for this TI Waiver. Hydraulic control and ICs will be used to protect human health and contain the contaminated plume from migrating into Red Lion Creek and elsewhere offsite. The proposed combination of remedial techniques has a precedent of successful use at sites with the similar COCs and concentrations, and coupled with the proposed TI Waiver, can allow the Site to be successfully contained and remediated.

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Table 1.3
Applicable or Relevant and Appropriate Requirements and To Be Considered Material

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
Chemical Specific ARARs				
A. Groundwater and/or Drinking Water				
Safe Drinking Water Act (SDWA) MCLs	42 U.S.C. § 300f et seq. 40 CFR §§ 141.11-.12 and 141.61-.62	Relevant and Appropriate	MCLs are enforceable standards for public drinking water supply systems which have at least 15 service connections or are used by at least 25 persons.	These requirements are not directly applicable since groundwater in the vicinity of the SCD is not used as private drinking water supply. However, since groundwater at the SCD is located within a Class II aquifer, which is a potential source of drinking water, the MCLs have been incorporated into the PRGs that were developed for the SCD groundwater.
Delaware Hazardous Substance Cleanup Act	Delaware Administrative Code, Title 7, Chapter 91	Applicable	Lays out procedures for the cleanup of hazardous waste sites and provides uniform risk-based remediation standards for the protection of human health and the environment.	Applicable in evaluation of remedial alternatives which address risk-based criteria or when setting standards for cleanups.
Delaware Regulations Governing Hazardous Substance Cleanup. Amended July 2015	Delaware Administrative Code, Title 7, Chapter 1375, §§ 11, 12, 13 and 7 , Chapter 91	Applicable	Establishes cleanup criteria for hazardous waste sites. Lays out the criteria for evaluation and implementation of remedial actions and outlines the procedure for site closure.	The substantive provisions are applicable for the development of the remedial objectives and alternatives.
Delaware Regulations Governing Control of Water Pollution as amended 9/1/12	Delaware Administrative Code, Title 7, Chapter 7201, §§ 3 - 9	Applicable	Contain water quality regulations for discharges into surface and groundwater.	The substantive provisions are applicable to stormwater runoff into the unnamed tributary and Red Lion Creek. Also, applicable to discharge of treated groundwater into surface water. If the selected remedy utilizes the existing GETS, the DNREC requirements for discharge under a NPDES permit equivalence limits would have to be met.
B. Surface Water				
CWA: Ambient Water Quality Criteria	CWA, § 402: 33 U.S.C. § 1342	Applicable	The objective of the CWA is to restore and maintain the chemical, physical and biological integrity of the nation's waters by preventing point and nonpoint pollution sources and maintaining the integrity of wetlands.	Applicable to point source discharges from or during construction of remedial components associated with OU4.

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
CWA: NPDES Requirements	CWA, Section 402: 33 U.S.C. §1342, 40 CFR Parts 122-125	Applicable	NPDES Permit Equivalence will need to be established for any surface water discharges from any groundwater extraction and treatment or stormwater outfalls.	The substantive provisions of these requirements are applicable to any portion of the remedy that may affect the water quality in the nearby Red Lion creek. Sediment and erosion control features will need to be implemented before start of intrusive construction activities. Water discharges will be sampled and analyzed IAW the NPDES permit equivalence in place at the Site. Discharge limits shall be met for all onsite discharge to surface water including stormwater and water treated by the GETS.
Delaware Water Quality Standards	Delaware Administrative Code, Title 7, Chapter 7401	Applicable	It is the policy of the Department to maintain within its jurisdiction over surface waters of the State of Delaware satisfactory quality consistent with public health and public recreation purposes, the propagation and protection of fish and aquatic life, and other beneficial uses of the water.	The discharge of treated groundwater would be required to meet the guidelines established for protection of aquatic life.
C. Air				
Clean Air Act (CAA): National Ambient Air Quality Standards	42 U.S.C Section 7401 40 CFR Part 50	Relevant and Appropriate	This regulation sets forth national primary ambient air quality standards that define levels of air quality which the Administrator judges are necessary, with an adequate margin of safety, to protect the public health. Defines emissions limitations for sulfur oxides, particulate matter, carbon monoxide, ozone, nitrogen oxide, and lead.	Any construction and/or excavation activities as well as any treatment alternative that would result in the emission of site contaminants to the air will follow the substantive requirements of these regulations.
CAA: National Emissions Standards for Hazardous Air Pollutants	40 CFR Part 61	Applicable	Provides emission standards for 8 contaminants, including benzene and vinyl chloride. Identifies 25 additional contaminants as having serious health effects but does not provide emission standards for these contaminants.	Any construction and/or excavation activities as well as any treatment alternative that would result in the emission of site contaminants to the air will comply with the substantive requirements of these regulations.

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
State of Delaware Implementation Plans for Attainment and Maintenance of National Ambient Air Quality Standards	40 CFR Part 52, Subpart I	Applicable	These regulations establish ambient air and emissions standards at the state level and set forth the permitting requirements for equipment and construction activities that might discharge air contaminants into the atmosphere. The regulations are applicable to air strippers, SVE systems, and soil gas capture systems.	The substantive requirements of these regulations will be met in case vapor phase carbon will be used to treat the air stripper off-gas before discharge to the atmosphere.
Delaware Ambient Air Quality Standards	Delaware Administrative Code, Title 7, Chapter 1103	Applicable	Establishes ambient air quality standards.	These standards will be applicable if vapor phase carbon is used to treat the air stripper off-gas before discharge to the atmosphere.
Chemical Specific ARARs				
D. Wastes				
TSCA	40 CFR Part 761 (particularly §§ 1, 3, 61, 70, 75, 202-218, 265, 272, 274)	Applicable	Establishes restrictions on the disposal of bulk PCB remediation wastes.	This portion of TSCA will be applicable if any soils excavated from the Site contain PCBs at concentrations greater than 25 ppm. This concentration assumes that the Site is a low occupancy area as defined in 40 CFR 761.3.
DRGHW	SEE ITEMS 1 THROUGH 6 BELOW The DRGHW provisions that are a part of Delaware's federally authorized program would apply instead of the federal RCRA regulations. Additionally, any provision that is not a part of the authorized program, but that is more stringent than the federal requirement, would also be applicable.	Applicable	Regulate the transportation, management, treatment, and disposal of hazardous wastes.	SEE ITEMS 1 THROUGH 6 BELOW

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
Regulations promulgated pursuant to the RCRA; HSWA	SEE ITEMS 1 THROUGH 6 BELOW Federal RCRA regulations would not apply for those regulations where Delaware has the authority from EPA to administer. Federal citations are also included in items 1 through 6 below because any federal regulations that are imposed under the HSWA, which are not a part of Delaware's authorized program, and which are immediately effective, would apply.	Applicable	Regulates the management of hazardous waste, to ensure the safe disposal of wastes, and to provide for resource recovery from the environment by controlling hazardous wastes "from cradle to grave."	SEE ITEMS 1 THROUGH 6 BELOW
1. Identification and Listing of Hazardous Wastes	DRGHW Part 261 40 CFR Part 261	Applicable	Identifies solid wastes that are regulated as hazardous wastes.	This part of the regulations will be used to determine which materials must be managed as hazardous wastes.
2. Standards Applicable to Generators of Hazardous Waste	DRGHW Part 262 subpart A (§§ 262.10-262.12) and § 262.34; 40 CFR Part 262. subpart A (§§ 262.10-262.12 and § 262.34)	Applicable	Establishes standards for generators of hazardous wastes, including waste determination and requirements regarding accumulation time.	The substantive standards of the listed sections would be applicable to the residual waste generated by the treatment of soils and sediments if the waste generated by the treatment system(s) is a RCRA-hazardous waste.

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
3. Requirements for Use and Management of Containers	DRGHW Part 264 Subpart I (§§ 264.170 - 264.179) 40 CFR Part 264 Subpart I (§§264.170-264.179)	Applicable	Requirements for storage of hazardous waste in storage containers.	The applicable substantive provisions of this subpart are applicable for temporary storage containers and on-site treatment systems.
4. Standards for owners and operators of facilities that store or treat hazardous waste in waste piles	DRGHW Part 264 Subpart L (§§ 264.250 - 264.259) 40 CFR Part 264 Subpart L (§§ 264.250 – 264.259)	Applicable	Requirements for storage or treatment of hazardous waste in waste piles.	The substantive provisions of this subpart are applicable to any soil and sediment that is excavated and stored in waste piles prior to or during treatment.
5. Air emission standards for process vents for owners and operators of facilities that treat or dispose of hazardous waste.	DRGHW Part 264, Subpart AA (§§ 264.1030 – 264.1034) 40 CFR Subpart AA (§§ 264.1030-1034)	Applicable	Applies to process vents associated with air stripping operations that treat hazardous wastes.	The substantive requirements of this subpart are applicable to treatment options that result in air emissions of VOCs.
6. Standards applicable to transporters of Hazardous Waste	DRGHW Part 263, Subpart C (§ 263.30-263.31) 40 CFR Part 263, Subpart C (§ 263.30-263.31)	Applicable	Establishes standards for the cleanup of hazardous waste discharged during transportation.	The substantive provisions of this subpart would be applicable to residual waste generated by the treatment of soils and sediments, if such waste is spilled on site during transportation.

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
Location-Specific ARARs				
Coastal Zone Management Act of 1972; Reauthorization Amendments of 1990; last amended February 1, 2010	16 U.S.C. § 1451, 1452, 1453, 1456; 15 CFR Part 923	Applicable	Requires that Federal entities conducting or supporting activities directly affecting the coastal zone, conduct or support those activities in a manner that is consistent with the approved appropriate State coastal zone management program.	The Site is located within a coastal zone; therefore, the substantive requirements are applicable. RAs are required to be consistent, to the extent practicable, with Delaware's coastal zone management program. EPA must notify Delaware of its determination that the actions are consistent to the extent practicable.
Delaware Coastal Zone Act; Delaware Regulations Governing the Coastal Zone	Delaware Administrative Code, Title 7, Chapter 108; Delaware Coastal Zone Act Regulations of May 11, 1999, amended on August 2, 2017	Applicable	Establishes management policies related to a wide range of coastal, beach, wetlands, woodlands, and other natural areas.	The Site is located within the state's coastal zone; therefore, the substantive requirements are applicable. RAs are required to be consistent, to the extent practicable, with Delaware's coastal zone management program. EPA must notify Delaware of its determination that the actions are consistent to the extent practicable.
Procedures for Implementing the National Environmental Policy Act Statement of Procedures on Floodplain Management and Wetlands Protection	40 CFR 6, Subparts A through C	Applicable	Executive Order 11990 - Protection of Wetlands - to avoid to the extent possible the long- and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands.	This requirement is applicable for construction activities that extend through an area of wetlands. Actions will be needed to address and avoid the potential short-term and long-term adverse effects to wetlands.
Delaware Coastal Management Program Federal Consistency Policies and Procedures	Delaware Administrative Code, Title 7, Chapter 5104	Applicable	The Federal Coastal Zone Management Act of 1972, as amended, provides that each federal agency conducting or supporting activities, whether within or outside the coastal zone, affecting any land or water use or natural resource of the coastal zone, must do so in a manner which is, to the maximum extent practicable, consistent with Delaware's Coastal Management Program.	The Site is located within the state's coastal zone; therefore, the substantive requirements are applicable. RAs are required to be consistent, to the extent practicable, with Delaware's Coastal Management Program. EPA must notify Delaware of its determination that the actions are consistent to the extent practicable.

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
Delaware Wetlands Regulations	Delaware Administrative Code, Title 7, Chapter 7500	Applicable	Regulations to preserve and protect the productive public and private wetlands and to prevent their despoilation and destruction consistent with the historic right of private ownership of lands.	The substantive requirements are applicable for construction activities that extend through an area of wetlands. Actions will be needed to address and avoid the potential short-term and long-term adverse effects to wetlands.
Preservation of Historical and Archeological Data Act (or Archeological and Historic Preservation Act of 1974)	16 U.S.C.§ 469	Applicable	Requires that Federal agencies act to recover, protect, and preserve any significant scientific, prehistorical, historical, or archeological data that may be irreparably lost or destroyed as a result of the alteration of terrain caused by Federal activities.	EPA does not currently have any information that there are any significant scientific, prehistorical, historical, or archeological data at the Site. If EPA discovers that such data are present at the Site, actions will be taken to comply with the substantive requirements of this act.
The National Historical Preservation Act and regulations	16 U.S.C. §§ 469 and 470; 36 CFR Part 800	Applicable	Requires that Federal agencies take actions to avoid adverse effects in historic properties.	EPA does not currently have any information that there are historic properties at the Site. If a determination is made that there are historic properties on or near the Site, action will be taken to mitigate any adverse effects on those properties resulting from the remedial activities.

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
Action-Specific ARARs				
A. General/Miscellaneous				
CERCLA of 1980 and Superfund Amendments and Reauthorization Act of 1986	NCP, 40 CFR Part 300, Subpart E	Applicable	This subpart establishes methods and criteria for determining the appropriate extent of response authorized by CERCLA and CWA Section 311(c), when there is a release of a hazardous substance into the environment, or when there is a release into the environment of any pollutant or contaminant that may present an imminent and substantial danger to the public health or welfare of the United States.	As this is an NPL Site, this requirement is applicable to RAs conducted at the Site.
Delaware Land Use Restrictive Covenants (Uniform Environmental Covenants Act)	Delaware Administrative Code, Title 7, Chapter 1375, § 12.7.5.4; Title 7, Delaware Code, Chapter 79, Subchapter II	Applicable	To provide the required restrictions on land use to protect the integrity of the remedy as well as human health and the environment.	Applicable to ICs to be implemented at the Site.

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
Implementation Policy for Groundwater Management Zone/Groundwater Exclusion Zone, Memorandum of Agreement	No legal citation. April 10, 2008 Memorandum of Agreement for the Delaware City Industrial Area. Policy document source: https://onlinedocs.dnrec.delaware.gov/docfinity/servlet/repository?j_username=DNRECAPI&j_password=API@dnrec2012&id=8a8a81ef37b6a22c0137b98790114b92&clearRedaction=false&annotate=true&thumb=false&pdf=true.	Applicable	A Memorandum of Agreement within DNREC establishing the authorities of each Division to create groundwater ICs (GMZs or Groundwater Exclusion Zones).	Applicable to ICs to be implemented at the Site.
B. Water				
CWA Delaware National Pollutant Discharge Elimination System Requirements	40 CFR Parts 122 through 125 Delaware Administrative Code, Title 7, Chapter 7201 § 6.	Applicable	Establishes effluent limitations for discharges to waters of Delaware and the United States.	Those groundwater treatment alternatives that involve the discharge of treated water will be required to comply with the substantive requirements of these discharge standards.
Surface Water Discharge Section: Regulations Governing the Control of Water Pollution	Delaware Administrative Code, Title 7, Chapter 7201	Applicable	These regulations seek to prevent, manage, and/or control the pollution from activities that affect or have the reasonable potential to affect the quality of surface water and groundwater.	These standards are applicable to discharge to surface water from remediation activities. Only the substantive requirements must be met.

Table 1.1 (continued)
Applicable or Relevant and Appropriate Requirements and To Be Considered Material

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
Delaware Regulations Governing Construction and Use of Water Wells	Delaware Administrative Code, Title 7, Chapter 7301	Applicable	Minimum requirements are prescribed governing the location, design, installation, use, disinfection, modification, repair, and sealing of all wells and associated pumping equipment as well as certain requirements for the protection of potable water supply wells.	The substantive requirements of these regulations are applicable for any remedy that involves the installation or sealing of a well, or the injection of materials into an existing well.
Delaware Statute Regarding Licensing of Water Well Contractors, Drillers, Pump Installers, Septic Tank Installers, Liquid Waste Treatment Plant Operators and Liquid Waste Haulers	Delaware Administrative Code, Title 7, Chapter 7302	Applicable	Sets forth requirements for the licensing of water well drillers, prevention of pollution of underground waters, submittal of well construction records, and well sealing notification.	The substantive requirements of these regulations are applicable for any remedy that involves the installation or sealing of a well, or the injection of materials into an existing well.
Storm Water Discharges Requirements Delaware Sediment and Stormwater Regulations	40 CFR §122.26 Delaware Administrative Code, Title 7, Chapter 5101	Applicable	Requires implementation of storm water control measures to prevent injury to health, safety, or property.	Stormwater controls shall be implemented and maintained during construction of the remedy. Only the substantive requirements must be met.
C. Air				
Regulations Governing the Control of Air Pollution	Delaware Administrative Code, Title 7, Chapters 1102, 1103, 1119 and 1124	Applicable	Sets forth the permit requirements if odor or VOC emissions exceed a specific threshold amount. Establishes the hazardous air pollutant discharge regulations.	Any construction and/or excavation activities as well as any treatment alternative that would result in the emission of SCD contaminants to the air will comply with the substantive requirements of these regulations.
D. Injection				
SDWA: Underground Injection Control	40 CFR Parts 144 and 146	Applicable	Prohibits underground injection unless requirements are met	The substantive requirements of these regulations will be followed for any remedy that involves the injection of any amendment in the Columbia or Potomac aquifer.

ARAR	Legal Citation	ARAR Class	Requirement Synopsis	Applicability to Proposed Remedies
E. Hazardous Waste				
RCRA and DRGHW	Delaware Administrative Code, Title 7, Chapter 1302	Applicable	These provisions govern the accumulation time for hazardous wastes and management of containers.	These requirements will be followed for extracted DNAPL and if a groundwater treatment remedy that generates hazardous sludge is selected as the remedy.

Notes:
ARAR – Applicable or Relevant and Appropriate Requirements
CAA – Clean Air Act
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR – Code of Federal Regulations
CWA – Clean Water Act
DNAPL – dense non-aqueous phase liquid
DNREC – Delaware Department of Natural Resources and Environmental Control
DRGHSC- Delaware Regulations Governing Hazardous Substance Cleanup
DRGHW – Delaware Regulations Governing Hazardous Waste
EPA – (U.S.) Environmental Protection Agency
GETS – groundwater extraction and treatment system
GMZ – Groundwater Management Zone
HSWA – Hazardous and Solid Waste Amendments of 1984
IAW – in accordance with
IC – Institutional Control
MCL – Maximum Contaminant Level
NCP – National Oil and Hazardous Substances Pollution Contingency Plan
NPDES – National Pollutant Discharge Elimination System
NPL – National Priorities List
OU4 – Operable Unit 4
PCB – polychlorinated biphenyl
RA – remedial action
RCRA – Resource Conservation and Recovery Act
SCD – Standard Chlorine of Delaware
SDWA – Safe Drinking Water Act
SVE – soil vapor extraction
TBC – to be considered
TSCA – Toxic Substances Control Act
VOC – Volatile Organic Compound

Table 2.1
Groundwater Elevations for February 2014 - December 2019

Well Number	Inside/ Outside of Wall	Groundwater Elevation, feet																		
		2/20/2014	4/17/2014	6/23/2014	8/14/2014	10/8/2014	1/16/2015	4/1/2015	5/15/2015	1/6/2016	3/1/2016	5/19/2016	6/22/2016	9/6/2016	11/9/2016	1/12/2017	3/2/2017	4/5/2017	5/31/2017	7/12/2017
MW-10	Out	10.04	9.90	no data	9.68	9.45	11.69	12.42	10.72	12.32	10.88	10.44	10.51	10.45	10.31	10.09	9.85	9.95	10.13	9.87
MW-13	Out	14.80	14.67	no data	14.67	14.20	16.74	17.35	14.65	17.33	15.69	15.39	15.55	15.46	15.39	15.22	14.99	no data	no data	no data
MW-14	Out	11.66	12.28	12.96	12.41	12.00	11.56	12.50	12.41	10.62	11.96	12.12	12.40	12.29	12.08	11.73	11.66	11.71	no data	no data
MW-16	Out	12.20	12.85	13.56	12.95	12.48	11.98	13.04	12.95	12.08	12.43	12.65	12.96	12.82	12.63	12.23	12.24	12.32	12.33	no data
MW-17	Out	10.19	10.76	11.33	10.73	10.28	9.71	10.57	10.73	9.72	10.03	10.23	10.52	10.33	10.16	9.87	9.89	10.09	no data	9.79
MW-18	Out	10.47	10.81	11.61	10.93	10.46	9.96	11.11	10.93	10.01	10.34	10.64	10.88	10.61	10.46	10.19	10.25	10.55	10.41	10.06
MW-19	Out	3.03	3.09	2.77	2.41	1.89	2.56	3.26	3.27	2.82	3.16	2.91	2.87	2.68	2.68	2.56	2.46	2.76	2.79	2.44
MW-20	Out	2.94	3.10	2.83	2.44	1.79	2.54	3.28	3.20	3.92	3.19	2.86	2.92	2.76	2.70	2.53	2.48	2.76	2.83	2.49
MW-21	Out	2.55	2.68	2.49	2.25	1.82	2.28	2.83	2.73	no data	no data	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
MW-22	Out	2.66	2.76	2.56	2.38	1.88	2.40	2.90	2.79	2.54	2.81	2.67	2.61	2.60	2.51	2.40	2.31	2.53	2.52	2.20
MW-23	Out	2.00	2.06	1.95	1.82	1.31	1.80	2.11	2.13	1.66	2.02	1.98	1.93	1.88	1.66	1.82	1.75	1.94	1.89	1.68
MW-24	Out	1.50	1.66	1.73	1.39	0.81	1.25	1.71	1.47	0.38	1.59	1.48	1.55	1.28	1.34	1.20	1.14	1.41	1.41	1.18
MW-25	Out	1.89	2.02	1.88	1.71	1.18	1.71	2.13	2.11	1.86	2.50	1.91	1.85	1.85	1.84	1.68	1.63	1.85	1.83	1.60
MW-31	In	9.58	9.83	9.78	9.36	8.81	9.32	10.50	10.44	10.34	10.83	no data[1]	no data[1]	no data[1]	9.93	9.14	8.13	7.94	8.41	8.46
MW-33	Out	no data	12.92	no data	12.88	12.51	12.82	13.55	13.44	13.78	14.18	13.80	13.95	13.87	13.70	13.34	12.92	13.22	13.42	13.31
MW-40	Out	2.11	2.20	2.04	2.82	1.13	1.83	2.32	2.40	1.98	2.24	2.04	2.07	1.95	1.96	1.79	1.73	1.96	2.01	1.11
MW-5	Out	6.38	6.68	6.80	6.27	5.92	5.81	6.79	6.73	no data[1]	6.27	6.52	6.60	6.25	6.26	6.01	6.11	6.51	no data	5.70
MW-8	Out	5.20	5.35	5.21	4.84	4.27	4.93	5.61	5.51	5.56	5.81	5.46	5.50	5.44	5.26	5.10	4.84	5.06	5.20	4.90
MW-9	Out	8.78	8.93	8.74	8.45	7.97	8.50	9.26	9.55	no data[1]	9.94	15.40	9.54	9.62	9.34	8.59	8.21	8.38	8.53	8.31
PMW-41	In	11.76	12.01	12.16	10.18	9.57	11.41	12.70	12.73	11.02	11.45	10.84	10.87	11.25	10.81	9.97	9.08	8.56	8.96	9.13
PMW-42	In	10.76	11.01	11.03	12.05	11.66	10.46	11.71	11.75	10.75	11.20	no data[1]	no data[1]	10.49	10.49	9.66	8.73	8.44	8.70	8.85
PMW-43	Out	14.41	14.66	14.66	14.37	13.75	14.26	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PMW-44	In	9.56	9.82	9.76	9.39	9.00	9.34	10.41	10.40	10.27	10.78	no data	no data	10.57	10.01	9.30	8.37	8.25	8.62	8.66
PMW-45	Out	2.84	3.01	2.83	2.47	1.80	2.54	3.21	3.12	1.75	3.10	2.88	2.90	2.80	2.70	2.52	2.42	2.67	2.78	2.44
PMW-46	Out	2.34	2.49	2.32	2.13	0.21	2.11	2.62	0.92	2.27	2.58	2.40	2.41	2.28	2.29	2.13	2.07	2.21	2.28	1.96
PMW-47	Out	3.92	4.20	4.08	3.71	2.82	3.72	4.46	4.29	5.07	4.38	4.22	4.26	4.26	4.02	3.71	3.56	3.79	3.99	3.68
PMW-48	Out	10.46	11.01	11.60	10.90	10.39	10.10	11.07	10.96	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PMW-49	In	9.26	9.51	9.42	9.01	8.57	9.05	10.22	10.13	10.06	10.68	10.46	9.04	9.36	9.77	9.05	8.03	7.97	8.53	8.38
PMW-50	In	10.73	10.84	10.78	10.34	9.89	10.19	11.52	10.72	10.86	11.21	10.72	10.58	11.02	10.60	9.69	8.76	8.43	8.68	8.90
PMW-53	In	6.77	7.23	7.12	6.74	6.15	6.99	7.94	7.84	7.49	6.22	7.66	7.99	8.69	7.55	7.05	6.18	6.61	7.36	7.16
PMW-54	In	5.27	5.85	5.53	5.12	4.38	5.59	6.59	6.45	6.70	7.47	6.52	6.74	7.22	6.54	5.54	4.79	5.09	6.02	5.76
PMW-55	In	6.97	7.62	7.31	6.95	6.53	7.37	8.48	8.81	no data[1]	9.65	8.00	8.30	8.88	7.94	7.28	6.42	6.59	6.75	7.43
PMW-56	In	6.93	7.34	7.31	6.92	6.46	7.09	8.14	8.05	7.64	9.36	7.98	8.36	8.96	7.97	7.32	6.42	6.56	7.42	7.20
PMW-57	In	5.79	6.22	6.09	5.72	4.86	5.97	6.99	6.94	7.20	7.72	6.85	7.08	7.65	6.81	no data	5.41	5.53	6.47	6.22
PMW-58	In	5.47	5.84	5.74	5.37	4.69	5.63	6.61	6.67	no data[1]	no data[1]	6.56	6.80	7.30	6.52	5.73	5.04	5.17	6.02	5.79
PMW-59	In	4.77	5.17	5.01	4.64	3.99	4.83	5.75	5.83	5.68	6.12	5.63	5.74	6.08	5.51	4.86	4.39	4.52	5.21	4.95
PT-1	In	12.55	12.81	12.89	12.48	11.99	12.28	13.61	14.85	11.23	11.71	11.17	11.26	11.61	9.36	8.47	7.63	7.35	7.42	7.68
PZ-1	Out	16.96	16.39	17.76	17.48	16.97	17.10	17.91	17.61	no data[1]	18.79	18.64	18.94	no data	18.61	18.26	17.80	18.25	18.28	no data
PZ-10	In	6.54	6.84	6.86	6.50	6.12	6.65	7.61	7.62	no data[1]	8.65	5.79	7.89	8.54	7.53	6.93	6.07	6.24	8.08	6.86
PZ-12	Out	3.13	3.34	3.14	2.80	2.18	2.85	3.53	3.42	no data[1]	3.47	3.16	3.32	3.20	2.95	2.85	2.73	2.96	3.09	2.77
PZ-14	In	5.01	5.43	5.24	4.87	4.24	5.12	6.05	6.16	no data[1]	6.44	5.94	6.07	6.49	5.86	5.12	4.60	4.73	5.49	5.26
PZ-15	Out	3.48	3.71	3.55	3.21	2.45	3.24	2.84	3.18	no data[1]	3.88	3.66	3.78	3.70	3.50	3.24	3.10	3.32	no data	3.16
PZ-16	Out	4.66	4.99	4.91	4.50	3.83	4.42	5.25	4.98	no data[1]	5.12	4.98	5.05	5.06	4.79	4.46	4.31	4.56	4.70	4.36
PZ-17	Out	7.00	7.34	7.58	6.96	5.91	6.38	7.42	7.37	no data[1]	6.83	7.14	7.31	6.91	6.86	6.57	6.76	7.14	6.75	6.32
PZ-18	Out	8.15	8.42	8.90	8.20	7.56	7.36	8.46	8.27	7.46	7.81	8.21	8.45	7.92	7.96	7.61	7.91	8.35	7.83	7.37
PZ-19	In	8.16	8.53	8.46	8.05	7.51	8.19	9.33	9.26	no data[1]	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZ-20	In	10.30	10.46	10.39	9.93	9.54	9.87	11.15	11.00	10.62	11.03	no data[1]	10.67	9.65	10.36	9.50	8.43	8.18	8.62	8.75
PZ-21	Out	12.97	13.64	14.36	13.79	13.41	13.08	13.88	13.84	11.05	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZ-22	Out	15.14	15.76	16.49	16.04	15.49	15.40	16.09	16.03	no data[1]	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned

*Piezometer located adjacent to extraction well.

no data [1] - no data due to access issues related to OU-3 remedy construction activities

Note: The elevations taken in June 2016 will be used for July 2016

Table 2.1 (contnued)

Groundwater Elevations for February 2014 - December 2019

Well Number	Inside/ Outside of Wall	Groundwater Elevation, feet																		
		2/20/2014	4/17/2014	6/23/2014	8/14/2014	10/8/2014	1/16/2015	4/1/2015	5/15/2015	1/6/2016	3/1/2016	5/19/2016	6/22/2016	9/6/2016	11/9/2016	1/12/2017	3/2/2017	4/5/2017	5/31/2017	7/12/2017
PZ-23	Out	16.31	16.86	17.58	17.19	16.75	16.63	17.23	17.24	no data[1]	17.42	17.56	17.78	17.80	17.60	17.18	16.99	no data	17.12	17.07
PZ-24	Out	17.26	17.76	18.39	18.04	17.56	17.59	18.18	18.14	no data[1]	18.60	18.64	18.92	18.94	18.72	18.37	18.09	18.09	18.25	18.17
PZ-25*	In	9.94	8.30	8.25	7.96	7.41	no data	11.07	9.71	no data[1]	no data[1]	no data[1]	no data[1]	no data[1]	10.73	9.74	8.91	7.05	7.40	7.51
PZ-26*	In	8.56	9.07	8.81	8.90	8.38	8.64	9.71	8.96	8.82	10.61	no data[1]	no data[1]	10.08	9.45	8.74	7.36	7.34	8.25	8.15
PZ-27*	In	9.79	9.87	9.95	9.49	8.91	9.62	10.89	9.59	no data[1]	10.99	no data[1]	no data[1]	9.97	10.15	9.33	8.34	7.97	8.50	8.57
PZ-28*	In	6.82	7.36	7.19	6.78	6.24	7.13	8.08	8.00	no data[1]	9.38	7.67	9.00	8.69	7.48	7.03	6.03	6.52	7.50	7.28
PZ-3	Out	15.42	15.68	15.77	15.55	14.82	15.32	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZ-4	Out	11.36	11.58	11.48	11.14	10.61	11.13	11.86	11.58	no data[1]	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZ-5	Out	8.87	9.03	8.88	8.56	8.22	8.58	8.39	8.55	no data[1]	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZ-7	Out	7.94	8.08	7.90	7.64	7.09	7.69	8.36	8.29	no data[1]	8.77	8.28	8.39	8.42	8.17	7.98	7.62	7.86	7.97	7.71
PZ-9	Out	3.98	4.08	3.83	3.39	2.94	3.53	4.31	4.23	no data[1]	4.32	3.92	4.03	3.82	3.72	3.57	3.46	3.75	3.93	3.55
PZT-10D	Out	15.94	16.28	16.45	16.24	15.77	15.90	no data	no data	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-11D	Out	16.97	17.41	17.78	17.50	16.99	17.12	no data	16.98	no data[1]	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-12D	Out	17.25	17.74	18.30	17.97	17.42	17.51	18.18	18.02	18.37	18.70	18.72	19.01	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-1D	In	10.49	10.75	10.73	10.31	9.86	10.24	11.43	10.53	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-1S	In	10.38	10.65	10.64	10.21	9.66	10.12	11.34	10.43	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-2D	In	11.25	11.50	12.03	11.11	10.59	10.95	12.16	10.74	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-2S	In	11.20	11.45	11.48	11.05	15.43	10.90	12.10	10.22	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-3D	In	13.03	13.30	13.39	13.02	12.23	12.76	48.74	13.23	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-3S	In	13.00	13.26	13.33	12.97	12.23	12.73	47.93	13.01	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-41S	In	11.92	12.17	12.21	11.80	11.18	11.60	12.85	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-42S	In	10.81	11.07	11.08	10.65	10.11	10.53	11.74	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-4D	In	12.22	12.44	12.51	12.06	11.49	11.85	13.09	13.01	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-4S	In	12.25	12.49	12.55	12.12	11.51	11.95	13.14	13.06	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-5D	In	11.71	11.91	11.93	11.50	11.05	11.28	13.54	12.72	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-5S	In	11.78	11.79	12.00	11.58	11.05	11.37	12.62	12.66	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-6D	In	11.30	11.46	11.46	11.02	10.56	10.82	12.12	11.60	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-6S	In	11.33	11.50	11.49	11.07	10.65	10.86	12.16	11.66	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-7D	In	10.43	10.59	10.51	10.05	8.56	10.00	11.26	10.37	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-7S	In	10.40	10.58	10.49	10.03	9.46	9.97	11.24	10.33	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-8D	Out	13.70	13.91	13.92	13.59	12.93	13.52	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
PZT-9D	Out	14.95	15.19	15.24	14.98	14.35	14.82	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
TW-28	In	8.69	9.02	8.99	8.58	8.02	10.67	9.72	8.73	9.94	10.62	no data[1]	no data[1]	no data[1]	9.31	8.63	7.50	7.50	8.15	8.07
PMW-60	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	10.88	no data[1]	10.48	10.86	7.37	6.56	6.58	5.30	8.75	5.77
PMW-61	Out	NA	NA	NA	NA	NA	NA	NA	NA	NA	10.33	10.64	10.91	10.64	10.74	no data	10.26	10.58	10.36	10.08
PMW-62	Out	NA	NA	NA	NA	NA	NA	NA	NA	NA	13.53	13.73	14.01	13.93	13.70	13.25	13.20	13.30	13.36	13.22
PMW-63	Out	NA	NA	NA	NA	NA	NA	NA	NA	NA	15.74	15.92	16.14	16.10	16.36	15.95	15.78	15.79	15.81	15.83
PMW-64	Out	NA	NA	NA	NA	NA	NA	NA	NA	NA	17.07	16.77	17.00	16.86	16.69	16.32	16.14	16.29	16.49	16.36
PMW-65	Out	NA	NA	NA	NA	NA	NA	NA	NA	NA	16.38	16.07	16.32	15.97	15.99	15.66	15.48	15.60	15.77	15.68
PMW-66	Out	NA	NA	NA	NA	NA	NA	NA	NA	NA	15.71	15.40	15.63	15.52	15.31	14.86	15.10	14.90	15.01	14.99
PMW-67	Out	NA	NA	NA	NA	NA	NA	NA	NA	NA	14.81	14.43	14.58	14.51	14.33	14.00	13.83	13.93	14.03	14.01
PZT-13D	Out	NA	NA	NA	NA	NA	NA	NA	NA	NA	18.41	18.18	18.45	18.33	17.12	17.79	17.54	17.69	17.92	17.73
PZT-14D	Out	NA	NA	NA	NA	NA	NA	NA	NA	NA	18.57	18.44	18.75	18.22	18.46	18.07	17.80	17.86	18.04	17.94
EW-1	In	-5.05	10.49	0.05	9.82	9.39	9.96	11.13	-0.42	no data	no data	no data[1]	no data[1]	no data[1]	no data[1]	no data	no data	no data	8.60	no data
EW-2	In	3.11	9.10	3.40	8.55	7.96	8.69	9.79	1.09	no data	no data	no data[1]	no data[1]	no data[1]	no data[1]	no data	-2.76	-3.57	6.60	no data
EW-3	In	3.99	10.22	4.16	9.69	9.23	9.68	10.92	1.58	no data	no data	no data[1]	no data[1]	no data[1]	no data[1]	no data	-0.42	-0.90	8.60	no data
EW-4	In	5.29	7.40	5.60	5.92	5.03	7.16	8.10	3.80	no data	8.37	no data[1]	2.05	-2.42	0.83	no data	-4.18	-0.37	7.52	no data
EW-5	In	-12.25	5.82	-14.75	3.90	3.54	5.57	6.57	-3.00	no data	6.09	5.40	5.67	no data[1]	4.90	no data	-17.39	-14.45	4.48	no data
EW-6	In	no data	4.18	-3.56	2.85	no data	3.94	5.06	no data	no data	5.42	no data[1]	-2.68	-3.45	no data[1]	no data	-3.88	3.15	4.30	no data

*Piezometer located adjacent to extraction well.

no data [1] - no data due to access issues related to OU-3 remedy construction activities

Note: The elevations taken in June 2016 were used for July 2016

Table 2.1 (continued)
Groundwater Elevations for February 2014 - December 2019

Groundwater Elevation, feet													
9/18/2017	**11/16/2017**	**1/19/2018**	**3/1/2018**	**5/30/2018**	**7/2/2018**	**9/1/2018**	**11/19/2018**	**1/3/2019**	**3/7/2019**	**5/6/2019**	**7/11/2019**	**9/4/2019**	**11/5/2019**
9.69	6.70	9.53	9.80	9.75	9.46	9.18	9.64	10.13	10.23	9.80	9.75	9.36	9.22
14.90	14.80	14.53	no data	15.24	no data	no data	15.28	15.78	15.77	15.77	no data	no data	no data
no data	11.08	10.66	11.00	no data	no data	no data	11.94	12.89	13.48	no data	no data	no data	no data
11.88	11.56	11.16	11.49	no data	no data	12.13	12.72	13.43	14.04	no data	13.96	no data	12.55
9.44	9.24	8.90	9.35	10.22	10.17	9.82	10.21	11.12	11.59	11.78	11.40	10.77	10.11
9.77	9.44	9.19	9.81	no data	no data	10.00	10.60	11.54	12.00	12.14	11.61	11.02	10.38
2.27	2.55	2.25	2.58	no data	no data	2.06	2.78	3.18	3.37	2.97	2.70	2.24	2.33
2.32	2.35	2.31	2.58	no data	no data	2.20	1.80	3.37	3.38	3.05	2.77	2.38	2.40
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
2.08	2.13	2.11	2.36	2.39	2.06	2.13	2.70	3.03	2.97	3.08	2.68	2.41	2.42
1.58	1.62	1.62	1.78	no data	1.56	1.72	2.29	1.81	2.25	2.65	2.21	2.17	2.11
1.11	1.18	1.05	1.26	no data	no data	1.31	1.85	2.16	1.95	2.30	2.00	1.84	1.69
1.53	1.54	1.53	1.71	no data	no data	1.60	2.14	2.34	2.21	2.48	2.12	1.99	1.94
8.19	7.91	7.70	7.41	6.62	6.41	5.97	6.36	6.33	6.91	6.37	6.64	6.21	5.71
13.12	12.91	12.65	12.99	13.31	13.05	12.81	13.29	13.84	13.94	13.59	13.70	13.29	12.91
1.64	1.70	1.63	1.82	no data	no data	1.65	2.17	2.82	2.43	3.53	2.18	2.00	2.01
5.41	5.27	5.27	6.06	no data	no data	no data	6.44	7.00	7.13	6.96	6.44	5.87	5.81
4.75	4.71	4.67	4.84	no data	no data	4.21	4.70	5.10	5.27	4.94	4.66	4.21	4.28
8.20	8.03	7.94	8.15	no data	7.64	7.29	7.86	8.24	8.41	7.91	7.84	7.36	7.32
9.03	8.74	8.45	8.11	7.36	7.24	6.79	6.88	6.93	7.63	7.22	7.56	7.33	6.64
8.73	8.41	8.16	7.75	7.03	6.84	6.39	6.55	6.52	7.27	6.84	7.21	6.94	6.29
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
8.29	8.21	8.02	7.64	no data	no data	6.47	6.83	6.82	7.38	6.87	7.15	6.79	6.28
2.27	2.32	2.28	2.52	no data	no data	2.19	2.73	3.27	3.27	no data	2.76	2.38	2.37
no data	1.96	1.92	2.12	2.20	no data	1.93	2.47	2.79	2.75	2.82	2.49	2.27	2.25
3.47	3.43	3.37	3.21	no data	no data	2.22	3.77	4.18	4.28	4.07	3.80	3.38	3.31
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
8.15	7.84	7.62	7.43	6.55	6.35	5.97	6.47	6.44	6.93	6.31	6.56	6.11	5.58
8.77	8.43	8.14	7.85	7.09	6.94	6.46	6.57	6.57	7.27	6.83	7.11	6.88	6.17
6.79	6.71	6.59	6.25	5.47	5.36	4.98	6.01	5.62	8.91	5.44	5.59	5.47	4.90
5.48	5.39	5.25	4.92	4.51	4.35	4.06	4.87	4.61	4.91	4.62	4.61	4.14	4.01
6.99	6.90	6.71	6.25	5.45	5.46	5.29	5.72	5.37	5.68	5.32	5.91	4.78	4.57
7.01	6.71	6.52	6.32	5.58	5.42	5.10	5.74	5.66	5.97	5.48	5.75	5.01	4.82
6.01	5.60	5.72	5.41	4.96	4.80	4.56	5.15	5.08	5.34	5.03	5.13	4.48	4.30
5.65	5.42	5.31	5.06	4.66	4.50	4.24	4.87	4.78	5.07	4.74	4.81	4.25	4.07
4.77	4.60	4.54	4.88	4.21	3.99	3.76	4.42	4.44	4.70	4.46	4.45	3.84	3.72
7.54	7.24	8.64	8.41	7.67	6.94	7.05	7.16	7.22	7.97	7.54	7.64	7.57	6.88
17.90	17.58	17.06	17.42	18.19	18.07	17.82	18.32	19.17	19.67	19.61	19.68	19.15	18.41
6.68	6.38	6.31	6.03	no data	no data	4.95	5.65	5.51	5.81	5.35	5.52	4.94	4.73
2.60	2.59	2.57	2.80	2.94	no data	no data	3.02	3.51	3.52	no data	no data	2.65	2.66
5.04	4.91	4.81	4.70	no data	no data	no data	4.61	4.62	4.85	4.60	4.52	4.00	3.85
3.00	2.97	2.94	3.11	no data	no data	no data	3.34	3.77	3.82	3.64	3.38	2.97	1.94
4.16	4.04	4.04	4.34	no data	no data	no data	4.52	4.91	5.06	4.84	4.53	4.06	4.00
6.02	5.84	5.78	6.63	no data	no data	6.25	7.04	7.69	7.88	7.74	7.14	6.57	6.44
7.02	6.68	5.67	7.92	no data	no data	7.40	8.23	8.91	9.18	9.06	8.40	7.80	7.57
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
8.59	8.27	8.01	7.68	6.71	6.73	6.28	6.49	6.46	7.12	6.68	6.92	6.63	5.98
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned

Table 2.1 (continued)
Groundwater Elevations for February 2014 - December 2019

Groundwater Elevation, feet													
9/18/2017	11/16/2017	1/19/2018	3/1/2018	5/30/2018	7/2/2018	9/1/2018	11/19/2018	1/3/2019	3/7/2019	5/6/2019	7/11/2019	9/4/2019	11/5/2019
16.82	16.50	15.97	16.15	no data	no data	no data	17.13	18.06	18.82	no data	18.99	18.56	no data
17.93	17.63	17.06	17.36	18.12	17.21	17.95	18.33	19.20	19.92	20.07	20.03	19.57	18.66
7.39	7.10	6.96	6.52	6.03	5.56	5.69	5.59	5.57	6.34	6.24	6.44	6.43	6.07
7.65	7.65	7.47	7.03	6.12	no data	5.52	6.33	5.98	6.47	5.91	6.12	5.62	5.25
8.17	8.10	7.84	7.30	6.50	6.32	5.87	6.34	6.11	6.73	6.24	6.47	6.11	5.59
6.74	6.83	6.70	6.23	5.46	5.33	4.98	6.11	5.56	5.85	5.43	5.59	5.19	4.91
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
7.61	7.51	7.44	7.60	no data	no data	no data	7.40	7.74	7.87	7.44	no data	no data	6.86
3.28	3.33	3.25	3.47	3.72	3.24	2.98	3.59	4.23	4.28	3.84	3.56	3.07	3.14
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned	abandoned
7.91	7.62	7.45	7.20	6.38	6.19	5.81	6.47	6.33	6.79	6.24	6.41	5.89	5.59
5.62	5.32	8.18	8.26	6.72	6.62	6.11	6.56	6.35	7.11	6.68	7.20	6.92	6.27
9.70	9.42	9.04	9.91	10.70	10.59	10.13	10.68	11.63	12.11	12.21	11.76	11.13	no data
12.97	12.61	12.17	12.44	13.34	13.47	13.11	13.43	14.37	15.04	15.35	15.05	14.54	13.59
15.60	15.24	14.61	14.81	15.71	no data	15.59	15.87	16.80	17.53	17.82	17.66	17.16	16.19
16.12	15.85	no data	15.92	16.50	16.20	16.01	16.63	17.27	17.44	17.22	17.32	16.82	16.36
15.44	15.19	no data	15.27	15.79	15.50	15.28	15.84	16.46	16.59	16.34	16.46	15.95	15.56
14.78	14.56	14.15	14.49	14.98	14.74	14.50	15.02	15.62	15.72	15.46	15.58	15.13	14.70
13.82	13.57	13.20	13.54	13.98	13.71	13.48	13.96	14.52	14.62	14.36	14.36	14.01	13.62
17.47	17.16	16.73	17.13	17.88	17.61	17.45	18.12	18.84	19.23	19.08	19.16	18.61	17.97
17.66	17.38	16.86	17.20	17.73	17.84	17.62	18.09	18.89	18.84	19.44	19.49	18.99	18.20
no data	-2.02	8.15	-2.82	no data	no data	no data	6.52	-5.55	-3.01	-3.41	7.15	6.88	6.23
no data	6.00	6.67	-0.79	no data	no data	-3.14	5.49	-0.51	no data	-0.64	-0.69	-0.99	-1.48
no data	-0.70	8.01	-5.29	no data	-5.34	-6.65	6.48	-5.08	-4.32	-4.93	-5.74	-5.83	-6.46
no data	6.86	6.64	-0.91	no data	-3.27	-3.32	11.28	-2.68	-3.22	-3.25	-2.59	1.53	-3.26
no data	3.88	5.13	-12.36	no data	-13.50	no data	4.73	-9.29	-11.46	-12.45	-12.70	-6.25	3.83
no data	3.45	6.58	0.00	no data	no data	no data	no data	-3.54	-3.85	-4.59	5.80	-5.90	no data

Table 2.2
Groundwater Elevations for December 2007 - December 2013

Well Number	Inside/ Outside of Wall	Groundwater Elevation (feet)												
		12/19/07	01/17/08	02/21/08	03/19/08	04/21/08	05/22/08	06/19/08	07/22/08	08/14/08	09/18/08	10/12/08	11/11/08	12/10/08
MW-5	Out	no data	5.46	5.75	6.08	5.74	6.12	5.61	5.29	5.25	5.33	5.03	5.10	5.48
MW-8	Out	no data	no data	no data	5.38	5.27	5.40	5.18	4.99	4.95	4.98	4.74	4.83	5.04
MW-9	Out	no data	no data	no data	9.34	9.21	9.09	8.90	8.73	no data	8.65	8.39	8.43	8.64
MW-10	Out	no data	9.99	10.15	10.24	10.05	10.20	10.01	9.81	9.80	9.78	9.54	no data	8.55
MW-13	Out	no data	14.62	14.76	14.88	14.65	14.92	14.77	14.61	14.63	14.55	14.33	no data	14.29
MW-14	Out	10.98	10.96	11.02	11.20	11.22	11.37	11.35	11.17	11.08	no data	10.76	10.63	10.98
MW-16	Out	11.48	11.42	11.51	11.72	11.70	11.87	11.81	11.65	11.56	no data	11.23	11.12	11.39
MW-17	Out	9.08	9.06	9.24	9.44	9.33	9.57	9.42	9.21	9.14	no data	8.85	8.71	9.12
MW-18	Out	9.38	9.35	9.52	9.82	9.64	9.91	9.71	9.46	9.38	no data	9.09	9.03	9.38
MW-19	Out	2.81	no data	no data	3.03	2.76	3.14	2.63	2.33	2.30	2.36	2.20	2.31	2.72
MW-20	Out	2.77	no data	2.90	3.01	2.72	4.1*	2.65	2.39	2.34	2.40	2.16	2.29	2.67
MW-21	Out	2.38	no data	2.42	2.57	2.42	2.56	2.22	1.98	1.96	1.94	1.87	1.96	2.18
MW-22	Out	2.37	2.31	2.47	2.62	2.47	2.62	2.23	2.02	2.00	2.02	1.94	2.04	2.25
MW-23	Out	1.79	1.72	2.85	1.97	1.87	1.94	1.70	1.53	1.54	1.55	1.51	1.55	1.66
MW-24	Out	1.27	no data	1.17	1.47	1.29	1.35	1.02	0.83	0.78	0.83	0.68	0.66	2.75
MW-25	Out	1.70	no data	1.78	1.90	1.76	1.89	1.64	1.45	1.46	1.49	1.35	1.49	1.62
MW-31	In	10.29	no data	no data	10.43	10.43	10.38	10.43	10.33	10.22	10.06	9.80	no data	9.75
MW-33	Out	no data	no data	13.11	13.24	13.06	13.22	13.17	12.96	12.93	12.90	12.61	no data	12.58
MW-40	Out	0.88	no data	1.99	2.09	1.93	2.13	1.82	1.64	1.62	1.67	1.46	1.61	1.78
PMW-41	In	12.12	no data	12.30	12.36	12.29	12.37	12.35	12.22	12.17	11.96	11.74	11.63	11.66
PMW-42	In	11.27	no data	11.46	11.50	11.45	11.49	11.48	11.38	11.30	11.13	10.86	10.77	10.77
PMW-43	Out	14.22	no data	14.40	14.55	14.34	14.59	14.49	14.31	14.28	14.24	15.45	11.84	14.02
PMW-44	In	10.19	no data	10.35	10.32	10.34	10.32	10.33	10.23	10.13	9.91	9.73	9.64	9.70
PMW-45	Out	2.98	2.56	2.80	2.92	2.68	2.96	2.58	2.37	2.32	2.37	2.14	2.21	2.54
PMW-46	Out	2.10	2.02	2.19	2.31	2.20	2.32	2.00	1.83	1.79	0.20	1.43	0.21	0.38
PMW-47	Out	3.87	3.78	4.01	4.13	3.95	4.14	3.84	3.63	3.55	3.56	3.35	3.34	3.65
PMW-48	Out	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	9.91	no data
PMW-49	In	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	10.17	no data
PMW-50	In	11.09	11.24	11.28	11.32	11.25	11.27	11.26	11.15	11.10	10.93	10.65	10.53	10.59
PMW-53	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-54	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-55	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-56	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-57	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-58	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-59	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PZ-1	Out	16.54	16.83	16.87	17.01	16.92	17.16	17.09	16.96	16.92	16.81	16.61	16.40	16.46
PZ-3	Out	15.26	no data	15.42	15.55	15.31	15.62	15.51	15.34	15.33	15.26	13.94	14.82	no data
PZ-4	Out	11.30	no data	11.50	11.59	11.41	11.57	11.46	11.27	11.24	11.20	10.94	10.87	11.06
PZ-5	Out	9.04	no data	9.18	9.19	9.05	9.19	9.01	8.82	8.79	8.75	8.50	8.50	8.74
PZ-7	Out	8.01	no data	8.13	8.13	8.03	8.18	7.98	7.81	7.78	7.78	7.53	7.59	7.79
PZ-9	Out	3.73	3.62	3.89	3.99	3.72	4.05	3.63	3.41	3.34	3.50	3.11	no data	2.81
PZ-10	In	1.58*	7.54	no data	7.58	7.63	7.47	7.56	7.44	7.30	7.12	7.01	6.88	7.01
PZ-12	Out	2.53	2.85	3.09	3.22	3.00	3.22	2.89	2.68	2.61	2.65	2.42	2.46	2.77
PZ-14	In	5.65	5.64	5.78	5.76	5.73	5.71	5.65	5.52	5.36	5.27	5.14	5.08	5.27
PZ-15	Out	3.36	3.56	3.60	3.64	3.42	3.63	3.30	3.09	3.03	3.05	2.84	2.86	3.15
PZ-16	Out	1.51*	4.39	4.66	4.78	4.60	4.82	4.51	4.26	4.16	4.21	3.97	3.96	4.27
PZ-17	Out	6.08	5.95	6.27	6.60	6.22	6.64	6.16	5.85	5.84	5.88	5.54	5.53	5.96
PZ-18	Out	6.98	6.88	7.26	7.49	7.11	7.60	7.07	6.79	6.80	5.84	6.47	6.44	5.88
PZ-19	In	9.16	9.28	9.27	9.23	9.27	9.21	9.25	9.13	9.02	8.87	8.65	8.52	8.59
PZ-20	In	11.03	10.87	10.92	10.96	10.89	10.91	10.91	10.80	10.74	10.61	10.28	10.19	10.23
PZ-21	Out	12.61	2.54*	12.58	12.77	12.78	12.92	12.89	12.79	12.70	12.57	12.37	no data	12.24
PZ-22	Out	15.17	14.92	14.90	15.03	15.12	15.24	15.28	15.20	15.12	14.99	14.77	14.63	14.58
PZ-23	Out	16.23	16.13	16.11	16.21	16.29	16.45	16.47	16.42	16.35	16.18	14.99	15.81	15.76
PZ-24	Out	16.72	17.15	17.12	17.22	17.30	17.42	17.43	17.36	17.30	17.20	16.96	16.81	16.74
PZ-25**	In	10.84	no data	10.98	11.02	10.99	10.98	11.00	10.90	10.83	10.64	10.38	10.27	10.30
PZ-26**	In	9.71	9.77	9.84	9.69	9.82	9.48	9.79	9.70	9.35	9.09	8.09	9.08	9.14
PZ-27**	In	10.67	10.73	10.79	10.80	10.76	10.77	10.78	10.67	10.60	10.38	10.12	10.01	10.08
PZ-28**	In	8.00	no data	8.12	7.80	8.10	7.78	8.06	7.95	7.74	7.46	7.36	7.39	7.49
TW-28	In	9.61	no data	no data	9.58	9.73	9.60	9.72	9.61	9.45	9.20	9.09	9.01	9.06

Notes:

*Denotes questionable reading based on difference from average and trend for location.

**Piezometer located adjacent to extraction well.

***Groundwater elevations collected bimonthly starting October 2013..

[1]C-31, PMW-51, PZ-6, PZ-8, PZ-11, PZ-11, PZ- 13, PZ-29, and PZ-30 are omitted from this table because they have not provided data since October 2011.

Table 2.2 (continued)
Groundwater Elevations for December 2007 - December 2013

Well Number	Inside/ Outside of Wall	Groundwater Elevation (feet)											
		01/14/09	02/17/09	03/18/09	04/15/09	05/13/09	06/10/09	07/16/09	08/13/09	09/15/09	10/14/09	11/09/09	12/23/09
MW-5	Out	5.59	5.39	5.29	5.51	5.98	5.73	5.50	5.31	5.58	5.61	5.80	6.33
MW-8	Out	5.18	5.10	5.05	5.07	5.43	5.33	4.45	4.86	5.12	4.97	5.15	5.43
MW-9	Out	8.82	8.71	8.65	8.66	9.02	8.96	9.44	8.52	8.79	8.84	8.78	9.12
MW-10	Out	9.94	9.75	9.75	no data	10.16	10.11	9.89	10.14	9.93	9.92	9.92	no data
MW-13	Out	14.60	14.35	15.31	no data	14.79	14.75	14.58	14.67	14.69	14.67	14.67	no data
MW-14	Out	10.73	10.73	no data	no data	11.18	11.37	11.30	no data	11.18	11.12	no data	11.71
MW-16	Out	11.18	11.18	no data	no data	11.63	11.79	11.74	no data	11.63	11.55	no data	12.22
MW-17	Out	8.87	8.87	no data	no data	9.42	9.49	9.38	no data	9.29	9.22	no data	9.94
MW-18	Out	9.15	9.15	no data	no data	9.77	9.76	9.60	no data	9.59	9.48	no data	10.32
MW-19	Out	2.81	2.53	2.49	2.88	3.14	2.74	2.46	2.41	2.67	2.41	2.75	3.18
MW-20	Out	2.80	2.55	2.51	no data	3.14	2.78	2.56	2.29	2.65	2.40	2.72	3.15
MW-21	Out	3.25	2.15	2.17	2.49	2.53	2.39	5.03*	2.16	2.16	1.97	2.26	2.63
MW-22	Out	2.35	2.22	2.22	2.63	2.54	2.38	2.04	2.30	2.22	1.04*	2.33	2.70
MW-23	Out	1.73	1.63	1.69	1.87	1.90	1.79	1.57	1.79	1.68	1.57	1.76	2.00
MW-24	Out	0.85	0.74	0.86	0.93	1.12	0.80	0.79	0.72	0.87	0.71	0.96	1.61
MW-25	Out	1.71	1.61	1.50	1.71	1.88	1.74	1.53	1.21	1.63	1.51	1.71	1.97
MW-31	In	10.03	10.08	9.93	9.73	10.10	10.37	10.30	9.88	10.11	10.16	10.02	10.26
MW-33	Out	12.92	12.70	12.64	no data	13.07	13.13	12.99	12.90	13.00	12.80	13.01	no data
MW-40	Out	1.91	1.79	1.77	1.83	2.14	1.91	1.66	1.58	1.81	1.66	1.89	2.20
PMW-41	In	11.92	11.84	11.74	no data	11.91	12.11	12.11	11.80	11.98	11.86	11.91	12.19
PMW-42	In	11.04	11.10	10.93	no data	11.04	11.33	11.26	10.92	11.12	10.98	10.99	10.26
PMW-43	Out	14.18	14.00	13.86	no data	14.34	14.33	14.26	13.98	14.30	14.11	14.29	14.61
PMW-44	In	9.95	10.00	9.89	no data	10.02	10.20	10.19	9.82	10.00	9.86	9.95	10.19
PMW-45	Out	2.66	2.51	2.47	2.56	2.98	2.77	2.53	2.24	2.56	2.47	2.64	3.04
PMW-46	Out	0.47	0.34	1.95	2.15	2.31	2.22	1.87	0.32*	1.97	1.78	0.47*	2.41
PMW-47	Out	3.77	3.70	3.66	3.73	4.09	3.96	3.68	3.46	3.73	3.59	3.79	4.18
PMW-48	Out	10.31	10.15	10.03	no data	9.93	9.91	9.75	9.59	9.77	9.66	9.95	10.50
PMW-49	In	10.51	10.54	10.41	no data	9.86	10.06	9.92	8.68*	9.84	9.64	9.75	10.04
PMW-50	In	10.87	10.89	10.71	no data	10.83	11.14	11.03	10.71	10.93	10.78	10.83	11.10
PMW-53	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-54	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-55	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-56	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-57	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-58	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-59	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PZ-1	Out	16.61	16.35	16.32	16.20	16.67	16.90	16.84	16.54	16.81	16.62	16.75	17.08
PZ-3	Out	15.18	14.84	14.79	no data	15.31	15.41	15.26	14.19*	15.32	15.05	15.27	15.58
PZ-4	Out	11.29	11.19	11.07	no data	11.45	11.46	11.33	11.02	11.31	11.15	11.33	11.64
PZ-5	Out	8.94	8.84	8.75	8.77	9.11	9.11	8.88	8.62	8.88	8.69	8.89	9.19
PZ-7	Out	7.94	7.87	7.79	7.81	8.14	8.10	7.88	7.65	7.90	7.71	7.90	8.19
PZ-9	Out	3.81	3.59	3.50	3.61	4.13	3.05	3.55	2.50	3.64	3.42	3.79	4.05
PZ-10	In	7.22	7.33	7.27	7.07	7.36	7.47	7.45	8.06*	7.19	7.06	7.14	7.40
PZ-12	Out	2.92	2.82	2.78	2.84	3.23	3.09	2.83	2.55	2.83	2.66	2.90	3.30
PZ-14	In	5.45	5.46	5.42	5.32	5.67	5.78	5.55	5.19	5.40	5.26	5.38	5.69
PZ-15	Out	3.31	3.21	3.18	3.25	3.61	3.49	3.23	2.94	3.22	3.05	3.28	3.68
PZ-16	Out	4.45	4.35	4.29	4.36	4.74	4.67	4.42	4.11	4.39	4.24	4.47	4.89
PZ-17	Out	6.10	5.89	5.80	5.95	6.50	6.30	6.11	5.81	6.17	6.00	6.37	6.92
PZ-18	Out	7.00	6.76	6.66	6.83	7.40	7.23	7.06	5.81	7.16	7.00	7.38	7.96
PZ-19	In	8.92	8.93	8.83	8.66	9.01	9.23	9.12	8.71	8.94	8.77	8.86	9.08
PZ-20	In	10.53	10.56	10.39	no data	10.56	10.81	10.76	10.34	10.62	9.98*	10.49	10.73
PZ-21	Out	12.44	12.38	12.23	9.84*	12.64	12.86	12.84	12.48	12.69	12.64	12.78	13.21
PZ-22	Out	14.76	14.58	14.57	12.86*	14.85	15.12	15.17	14.80	14.99	14.95	15.04	15.37
PZ-23	Out	15.92	15.85	15.74	15.66	15.93	16.23	16.32	15.95	16.14	16.10	16.10	16.38
PZ-24	Out	16.89	16.70	16.68	16.54	16.82	17.14	17.24	16.90	17.08	17.02	17.06	no data
PZ-25**	In	10.58	10.63	10.47	10.24	10.62	10.87	10.82	10.23	10.64	10.49	10.53	10.60
PZ-26**	In	9.42	9.35	9.35	9.16	9.51	9.72	9.67	9.27	9.48	9.30	9.36	9.52
PZ-27**	In	10.39	10.40	10.24	10.02	10.44	10.63	10.57	10.07	10.49	10.27	10.35	10.45
PZ-28**	In	7.77	7.83	7.77	no data	7.88	8.10	7.96	7.40	7.69	7.54	7.61	7.73
TW-28	In	no data	9.40	9.27	9.11	9.44	9.70	9.52	9.19	9.40	9.24	9.31	9.54

Notes:

*Denotes questionable reading based on difference from average and trend for location

**Piezometer located adjacent to extraction well

***Groundwater Elevations collected bimonthly starting October 2013.

[1] C-31, PMW-51, PZ-6, PZ-8, PZ-11, PZ-11, PZ- 13, PZ-29, and PZ-30 have been hidden from this table because they have not provided data since October 2011.

Table 2.2 (continued)
Groundwater Elevations for December 2007 - December 2013

Well Number	Inside/ Outside of Wall	Groundwater Elevation (feet)											
		01/13/10	02/23/10	03/16/10	04/14/10	05/18/10	06/17/10	07/26/10	08/26/10	09/22/10	10/20/10	11/18/10	12/14/10
MW-5	Out	6.62	6.69	7.24	7.19	6.73	6.35	6.10	5.73	5.56	5.98	6.00	5.81
MW-8	Out	5.53	5.52	5.62	5.79	5.59	6.21	5.05	5.05	4.74	5.18	5.03	4.96
MW-9	Out	9.20	9.22	9.59	9.45	9.33	9.08	8.83	8.70	8.43	9.11	8.96	8.64
MW-10	Out	no data	no data	no data	no data	10.47	10.22	9.99	no data	9.65	9.99	9.95	9.83
MW-13	Out	no data	no data	no data	no data	15.27	15.03	14.93	no data	14.54	14.85	17.8*	14.63
MW-14	Out	12.20	12.28	12.74	13.35	13.23	12.80	12.29	11.90	11.54	11.66	no data	11.26
MW-16	Out	12.70	12.78	13.29	14.00	13.73	13.32	12.77	12.37	12.03	12.14	no data	11.75
MW-17	Out	10.40	10.40	10.92	11.44	11.21	10.78	10.31	9.89	9.59	9.75	no data	9.41
MW-18	Out	10.76	10.75	11.41	11.83	11.51	11.08	10.63	10.16	9.89	10.03	no data	9.73
MW-19	Out	3.18	3.94	3.95	3.41	3.04	2.70	2.47	2.33	2.18	2.61	2.61	2.62
MW-20	Out	3.21	3.40	3.85	3.42	3.08	2.79	2.50	2.39	2.21	2.64	2.57	2.55
MW-21	Out	2.69	3.11	3.34	2.97	2.77	2.50	2.23	2.12	2.01	2.32	2.24	2.33
MW-22	Out	2.75	3.23	3.32	3.01	2.89	2.51	2.33	2.20	2.03	2.44	2.37	2.44
MW-23	Out	2.08	2.47	2.49	2.27	2.17	1.94	1.83	1.76	1.57	1.90	1.80	1.87
MW-24	Out	1.73	1.98	2.36	2.09	1.98	1.79	1.62	1.54	1.36	1.69	1.61	1.62
MW-25	Out	2.01	2.08	2.41	2.17	2.00	1.82	1.62	1.57	1.46	1.74	1.69	1.71
MW-31	In	10.41	10.35	10.68	10.82	10.91	10.78	10.34	10.20	9.83	10.28	9.82	9.69
MW-33	Out	no data	no data	no data	no data	13.66	13.44	13.24	no data	12.84	13.16	13.10	12.90
MW-40	Out	2.26	2.30	2.68	no data	2.22	2.02	1.80	1.72	1.59	1.90	1.83	1.82
PMW-41	In	12.41	12.42	12.66	12.91	13.01	12.83	12.40	12.27	11.95	12.19	11.98	11.73
PMW-42	In	11.49	11.51	11.71	11.93	12.07	11.89	11.46	11.33	11.01	11.30	11.02	10.81
PMW-43	Out	14.87	14.74	15.21	15.33	15.14	14.87	14.70	14.49	14.23	14.55	14.48	14.24
PMW-44	In	10.33	10.31	10.60	10.73	10.85	10.74	10.25	10.14	9.80	10.16	9.85	9.65
PMW-45	Out	3.13	3.12	3.67	3.37	3.06	2.81	2.50	2.40	2.84	2.60	2.51	2.51
PMW-46	Out	2.45	1.04	2.98	1.11	3.90	2.28	0.42	1.94	1.78	2.16	2.07	2.11
PMW-47	Out	4.33	4.39	4.80	4.72	4.49	4.24	3.89	3.72	3.50	3.91	3.75	3.76
PMW-48	Out	10.97	10.95	11.70	12.08	11.74	11.27	10.82	10.34	10.08	10.18	10.10	9.89
PMW-49	In	10.12	10.07	10.34	10.54	10.71	10.48	10.04	9.87	9.49	10.03	9.49	9.37
PMW-50	In	11.27	11.24	11.48	11.72	11.84	11.68	11.25	11.12	10.76	11.08	10.81	10.57
PMW-53	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-54	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-55	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-56	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-57	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-58	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-59	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PZ-1	Out	17.40	17.53	18.00	18.30	18.32	18.03	17.71	17.43	17.12	17.30	17.15	16.91
PZ-3	Out	15.87	15.77	16.31	16.42	16.29	16.07	15.84	15.58	15.29	15.62	15.51	15.26
PZ-4	Out	11.83	11.72	12.09	12.14	11.96	11.78	10.47	11.33	11.11	11.43	11.37	11.19
PZ-5	Out	9.32	9.35	9.70	9.59	9.44	9.21	8.96	8.82	8.55	8.97	8.79	8.74
PZ-7	Out	8.28	8.30	8.62	8.50	8.37	8.14	7.93	7.81	7.59	7.97	7.85	7.81
PZ-9	Out	4.20	4.21	4.82	4.45	4.09	3.72	3.47	3.35	3.18	3.62	3.53	3.46
PZ-10	In	7.54	7.56	7.80	7.92	8.09	7.89	7.37	7.32	7.32	7.44	6.89	6.95
PZ-12	Out	3.42	3.42	3.96	3.70	3.45	3.20	2.85	2.73	2.53	2.93	2.83	2.83
PZ-14	In	5.81	5.90	6.21	6.24	6.25	6.04	5.59	5.42	5.15	5.66	5.11	5.34
PZ-15	Out	3.81	3.86	4.36	4.15	3.92	3.67	3.32	3.17	2.97	3.37	3.24	3.25
PZ-16	Out	5.09	5.14	5.59	5.53	5.26	4.99	4.63	4.44	4.21	4.61	4.45	4.13
PZ-17	Out	7.28	7.22	7.90	7.94	7.43	7.03	6.74	6.34	6.16	6.38	6.52	6.31
PZ-18	Out	8.38	8.33	9.13	9.17	8.60	8.17	7.89	7.42	7.26	7.36	7.55	6.28
PZ-19	In	9.19	9.17	9.46	9.60	9.75	9.59	9.11	8.94	8.58	9.16	8.53	8.53
PZ-20	In	10.89	10.85	11.16	11.35	11.47	11.30	10.88	10.71	10.35	10.77	10.37	10.22
PZ-21	Out	13.68	13.86	14.36	14.92	14.85	14.44	13.88	13.50	13.16	13.24	13.00	12.83
PZ-22	Out	15.81	16.10	16.53	17.05	no data	16.71	16.17	15.84	15.53	15.52	15.31	15.13
PZ-23	Out	16.83	17.14	17.50	18.01	18.14	17.80	17.31	17.00	16.67	16.67	16.48	16.31
PZ-24	Out	17.71	no data	18.33	18.82	18.97	18.67	18.23	17.95	17.63	17.66	17.50	17.29
PZ-25**	In	10.77	10.77	11.03	11.23	11.53	11.32	10.90	10.64	10.36	10.81	10.32	10.26
PZ-26**	In	9.64	no data	9.88	10.06	10.30	10.15	9.68	9.44	9.01	9.68	8.97	9.08
PZ-27**	In	10.60	10.57	10.85	11.04	11.30	11.04	10.70	10.43	9.97	10.56	10.04	10.01
PZ-28**	In	7.95	7.88	8.13	8.22	8.54	8.38	7.88	7.76	7.38	7.95	7.31	7.46
TW-28	In	9.67	9.67	9.93	10.07	10.22	10.06	9.60	9.46	9.46	9.57	9.06	9.04

Notes:

*Denotes questionable reading based on difference from average and trend for location.

**Piezometer located adjacent to extraction well.

***Groundwater elevations collected bimonthly starting October 2013.

[1]C-31, PMW-51, PZ-6, PZ-8, PZ-11, PZ-11, PZ- 13, PZ-29, and PZ-30 are omitted from this table because they have not provided data since October 2011.

Table 2.2 (continued)
Groundwater Elevations for December 2007 - December 2013

Well Number	Inside/ Outside of Wall	Groundwater Elevation (feet)											
		1/13/2011	2/23/2011	3/15/2011	4/14/2011	5/11/2011	6/22/2011	7/20/2011	8/18/2011	9/14/2011	10/20/2011	11/16/2011	12/8/2011
MW-5	Out	5.76	5.83	6.24	6.20	6.36	6.06	5.85	5.81	no data	6.23	5.84	6.43
MW-8	Out	4.97	5.03	5.21	5.34	5.37	4.98	4.8	4.78	5.17	5.01	5.12	5.22
MW-9	Out	8.58	8.54	8.81	8.94	8.91	8.56	8.38	8.38	8.75	8.62	8.72	8.98
MW-10	Out	9.79	9.77	10.03	10.13	10.14	9.75	9.59	9.61	9.98	9.89	9.91	10.17
MW-13	Out	14.50	14.56	14.82	14.88	14.96	14.67	14.56	14.59	15.1	14.99	14.89	15.16
MW-14	Out	11.15	11.09	11.23	11.50	12.57	12.50	11.53	11.65	11.87	12.21	12.02	12.01
MW-16	Out	11.63	11.53	11.70	11.95	13.05	13.02	12.01	12.18	12.37	12.71	12.49	12.56
MW-17	Out	9.33	9.33	9.54	9.70	10.77	10.66	9.67	10.04	10.06	10.48	10.24	10.36
MW-18	Out	9.62	9.63	9.91	10.01	11.11	10.99	9.98	10.21	10.4	10.67	10.59	10.59
MW-19	Out	2.53	2.73	3.03	3.04	2.99	2.71	2.36	2.38	2.9	2.68	2.66	3.44
MW-20	Out	2.55	2.73	3.05	3.04	3.00	2.59	2.39	2.41	2.9	2.67	2.69	3.08
MW-21	Out	2.18	2.35	2.56	2.67	2.56	2.23	2.05	2.13	2.43	2.37	2.35	2.71
MW-22	Out	2.27	2.44	2.64	2.76	2.62	2.27	2.11	2.21	2.51	2.48	2.48	2.91
MW-23	Out	1.77	1.88	2.00	2.07	2.01	1.78	1.68	1.75	no data	1.93	1.93	2.25
MW-24	Out	1.59	1.72	1.86	1.91	1.93	1.63	1.49	1.49	1.83	1.77	1.66	1.86
MW-25	Out	no data	1.76	1.92	1.97	1.93	1.66	1.55	1.4	1.85	1.78	1.76	1.99
MW-31	In	9.43	9.37	9.47	9.82	9.92	9.54	9.35	9.24	9.71	9.61	9.92	9.76
MW-33	Out	no data	12.81	13.02	13.20	13.32	12.99	12.82	12.77	13.29	13.23	13.16	13.35
MW-40	Out	1.82	2.97	2.13	2.20	2.18	1.83	1.69	1.72	2.04	1.94	1.95	3.13*
PMW-41	In	11.58	11.39	11.58	11.88	12.03	11.73	11.56	11.38	11.9	11.97	12.04	11.98
PMW-42	In	10.67	10.45	10.61	10.92	10.98	10.75	10.56	10.39	10.88	10.92	11.06	10.94
PMW-43	Out	14.09	14.07	14.36	14.54	14.69	14.36	14.22	14.18	14.79	17.73*	14.6	14.65
PMW-44	In	9.50	9.34	9.48	9.80	9.89	9.54	9.39	9.24	9.63	9.43	9.86	9.76
PMW-45	Out	2.48	2.67	2.90	2.97	2.93	2.54	2.38	2.37	2.82	2.53	2.65	2.82
PMW-46	Out	2.06	2.16	2.42	2.46	2.42	2.09	1.91	1.98	2.29	2.22	2.22	2.5
PMW-47	Out	3.67	3.79	4.02	4.15	4.16	3.77	3.59	3.59	3.96	3.84	3.88	3.99
PMW-48	Out	9.79	9.73	10.07	12.14	10.48	10.38	10.18	10.06	10.59	10.58	10.25	10.43
PMW-49	In	9.09	9.03	9.19	9.51	9.57	9.20	9.04	8.94	9.37	9.26	9.58	9.43
PMW-50	In	10.37	10.23	10.45	10.74	10.82	10.49	10.3	10.12	10.68	10.64	11.71*	10.76
PMW-53	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-54	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-55	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-56	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-57	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-58	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-59	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PZ-1	Out	16.80	16.62	16.81	16.99	17.25	17.12	16.98	16.88	17.58	17.63	15.5*	17.47
PZ-3	Out	15.19	15.03	15.37	15.52	15.67	15.37	15.25	15.22	15.94	14.81	15.66	15.74
PZ-4	Out	11.16	11.07	11.35	11.50	11.58	11.22	11.05	11.01	11.47	11.39	11.37	11.46
PZ-5	Out	8.69	8.63	8.89	9.04	9.02	8.67	8.49	8.48	8.84	8.72	8.82	9.02
PZ-7	Out	7.75	7.70	7.93	8.08	8.04	7.72	7.55	7.58	7.88	7.77	7.87	8.05
PZ-9	Out	3.46	3.63	3.98	4.01	4.01	3.54	3.33	3.32	3.89	3.62	3.63	3.93
PZ-10	In	6.72	6.69	6.73	6.13	7.11	6.77	6.57	6.48	6.73	6.63	7.11	6.83
PZ-12	Out	2.83	2.98	3.21	3.30	3.26	2.83	2.67	2.68	3.1	2.94	2.97	3.09
PZ-14	In	5.07	5.19	5.25	5.52	5.61	5.14	4.93	4.96	no data	5.05	5.48	5.21
PZ-15	Out	3.23	3.34	3.55	3.67	3.66	no data	3.08	3.08	3.45	3.32	3.37	3.48
PZ-16	Out	4.36	4.51	4.74	4.84	4.86	4.52	4.31	4.32	4.68	4.56	4.57	4.71
PZ-17	Out	6.30	6.34	6.75	6.73	6.94	6.67	6.45	6.4	6.89	6.83	6.4	6.82
PZ-18	Out	7.27	7.29	7.75	7.66	7.91	7.77	7.54	7.45	7.95	7.95	7.37	7.89
PZ-19	In	8.24	8.24	8.19	8.60	8.68	8.26	8.08	8.01	8.38	8.24	8.7	8.46
PZ-20	In	10.01	9.93	10.08	10.34	10.46	10.08	9.9	9.78	10.32	10.19	10.45	10.33
PZ-21	Out	12.77	12.56	12.68	12.95	13.27	13.27	13.06	12.91	13.43	13.5	13.56	13.29
PZ-22	Out	15.05	14.71	14.86	15.16	15.45	15.50	15.33	15.15	15.66	15.85	15.74	15.61
PZ-23	Out	16.22	15.81	16.00	16.27	16.57	16.64	25.46*	16.29	16.79	17.04	16.95	16.78
PZ-24	Out	17.20	16.91	16.99	17.27	17.54	no data	17.4	17.27	17.82	18.05	17.94	17.78
PZ-25**	In	9.96	9.98	9.92	10.34	10.50	10.05	9.87	9.83	10.19	10.2	no data	10.06
PZ-26**	In	8.72	8.63	8.64	9.04	9.24	no data	8.56	8.63	no data	8.74	no data	8.84
PZ-27**	In	9.63	9.66	9.98	9.98	10.19	9.62	9.58	9.64	9.98	9.65	10.38	9.89
PZ-28**	In	7.07	7.21	7.10	no data	7.60	7.09	6.91	6.93	7.08	7	7.54	7.22
TW-28	In	8.75	8.74	8.74	9.10	9.21	8.81	8.62	8.65	no data	8.8	9.19	8.98

Notes:

*Denotes questionable reading based on difference from average and trend for location.

**Piezometer located adjacent to extraction well.

***Groundwater elevations collected bimonthly starting October 2013.

[1]C-31, PMW-51, PZ-6, PZ-8, PZ-11, PZ-11, PZ- 13, PZ-29, and PZ-30 are omitted from this table because they have not provided data since October 2011.

Table 2.2 (continued)
Groundwater Elevations for December 2007 - December 2013

Well Number	Inside/ Outside of Wall	Groundwater Elevation (feet)										
		1/17/2012	2/16/2012	3/1/2012	4/25/2012	5/30/2012	7/2/2012	8/8/2012	9/20/2012	10/10/2012	11/14/2012	12/12/2012
MW-5	Out	6.38	6.33	6.37	6.11	5.88	5.66	5.39	5.42	5.37	5.56	5.38
MW-8	Out	5.24	5.09	5.00	4.93	4.74	4.62	4.44	4.52	4.52	4.85	4.76
MW-9	Out	8.85	8.66	8.54	8.48	8.22	8.18	7.96	8.04	7.98	8.25	8.22
MW-10	Out	10.08	9.90	no data	9.72	no data	9.42	9.25	9.35	9.25	9.52	9.47
MW-13	Out	15.60	14.83	no data	14.57	no data	no data	no data	14.32	14.22	14.46	14.25
MW-14	Out	12.12	12.04	11.93	11.72	11.48	11.28	11.07	10.89	10.82	10.98	10.80
MW-16	Out	12.61	12.54	12.46	12.23	11.98	11.75	11.54	11.31	11.25	11.42	11.23
MW-17	Out	10.26	10.18	10.13	9.90	9.67	9.46	9.22	9.06	9.01	9.20	9.00
MW-18	Out	10.60	10.55	10.52	10.24	10.02	9.76	9.51	9.35	9.28	9.46	9.25
MW-19	Out	2.92	2.75	2.67	2.60	2.36	2.23	2.03	2.13	2.16	2.55	2.40
MW-20	Out	2.90	2.76	2.68	2.59	2.40	2.24	2.05	2.17	2.20	2.55	2.42
MW-21	Out	2.49	2.40	2.34	2.34	2.07	1.94	1.79	1.85	1.89	2.10	2.11
MW-22	Out	2.57	2.47	2.43	2.44	2.14	2.04	1.86	1.94	1.96	2.18	2.20
MW-23	Out	1.94	1.88	1.85	1.83	1.64	1.57	1.43	1.50	1.53	1.66	1.64
MW-24	Out	1.63	1.51	1.35	1.32	1.12	1.01	0.91	0.98	1.02	1.14	1.01
MW-25	Out	1.85	1.78	1.74	1.71	1.53	1.44	1.34	1.41	1.45	1.62	1.60
MW-31	In	10.74*	9.45	-0.77*	9.06	8.82	8.72	8.59	8.45	8.42	8.78	8.87
MW-33	Out	13.32	13.12	no data	12.80	no data	12.57	12.43	12.51	12.42	12.68	12.47
MW-40	Out	2.04	1.95	1.89	1.85	1.72	1.59	1.45	1.56	2.58	1.82	1.73
PMW-41	In	12.02	11.76	11.51	11.29	11.06	10.91	10.79	10.68	10.65	10.92	10.91
PMW-42	In	10.96	10.71	10.46	10.26	10.01	9.90	9.13	no data	9.62	9.89	9.98
PMW-43	Out	14.78	14.54	14.36	14.16	14.00	13.95	13.75	13.84	no data	14.02	13.78
PMW-44	In	9.78	9.53	9.31	9.15	8.91	8.81	8.64	8.57	9.85	8.82	8.91
PMW-45	Out	2.82	2.70	2.62	2.57	2.34	2.22	no data	2.13	2.17	2.48	2.37
PMW-46	Out	2.30	2.20	2.14	2.14	1.91	1.84	1.68	1.75	1.75	1.95	1.94
PMW-47	Out	4.00	3.88	3.83	3.79	3.53	3.40	3.17	3.23	3.22	3.50	2.49
PMW-48	Out	10.77	10.75	10.74	10.46	10.22	9.97	9.71	9.60	9.54	9.70	9.45
PMW-49	In	9.39	9.14	8.91	7.76	8.51	8.43	8.29	8.11	8.10	8.48	8.55
PMW-50	In	10.74	10.47	10.18	9.97	9.71	9.65	9.50	9.35	9.28	9.63	9.67
PMW-53	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-54	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-55	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-56	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-57	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-58	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PMW-59	In	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PZ-1	Out	10.45*	17.45	17.22	16.79	16.83	16.69	16.48	16.43	16.34	16.51	16.28
PZ-3	Out	15.86	15.61	15.42	15.19	15.00	14.97	14.77	14.78	14.74	14.96	14.73
PZ-4	Out	11.55	11.32	11.18	11.04	10.87	10.81	10.64	10.75	10.69	10.92	10.83
PZ-5	Out	8.95	8.73	8.64	8.58	8.30	8.28	8.04	8.12	8.06	8.35	8.33
PZ-7	Out	8.00	7.82	7.72	7.69	7.42	7.39	7.18	7.29	7.24	7.48	7.49
PZ-9	Out	3.90	3.73	3.63	3.56	3.32	3.16	2.96	3.11	3.11	3.51	3.37
PZ-10	In	6.99	6.73	6.59	6.57	6.27	6.17	5.94	5.87	5.91	6.28	6.34
PZ-12	Out	3.11	2.98	2.93	2.87	2.63	2.51	2.30	2.39	2.42	2.75	2.67
PZ-14	In	5.29	5.12	5.04	5.01	4.74	3.67	4.35	4.35	4.40	4.75	4.84
PZ-15	Out	3.48	3.36	3.33	3.26	3.02	2.91	2.69	2.75	2.77	3.07	3.03
PZ-16	Out	4.75	4.63	4.61	4.51	4.25	4.12	3.86	3.89	3.91	4.18	4.13
PZ-17	Out	6.99	6.94	7.01	6.67	6.48	6.26	5.96	5.99	5.93	6.14	5.91
PZ-18	Out	8.07	8.05	8.11	7.71	7.54	7.33	6.06	7.00	6.92	7.06	6.69
PZ-19	In	8.49	8.23	8.06	7.97	7.70	7.61	7.38	7.25	7.28	7.64	7.79
PZ-20	In	no data	10.03	9.76	9.57	9.32	9.26	9.24	8.96	8.90	9.29	9.35
PZ-21	Out	no data	13.46	13.51	13.30	13.07	12.84	12.63	12.46	12.38	12.52	12.34
PZ-22	Out	15.99	15.93	15.73	15.54	15.32	15.10	14.90	14.74	14.68	14.75	14.60
PZ-23	Out	17.14	17.06	16.85	16.66	16.45	16.25	16.04	15.92	15.89	15.88	15.75
PZ-24	Out	15.40*	17.97	17.76	17.53	17.37	17.16	17.00	16.86	16.82	16.83	16.69
PZ-25**	In	10.07	9.84	9.58	9.49	9.20	9.04	8.93	8.79	8.80	9.08	9.42
PZ-26**	In	8.79	8.59	8.44	8.29	8.01	7.74	7.64	7.54	7.53	7.88	8.28
PZ-27**	In	9.88	9.60	9.43	9.18	8.93	8.89	8.92	8.67	8.44	8.84	9.09
PZ-28**	In	7.33	7.09	6.92	6.87	6.60	6.51	6.31	6.24	6.26	6.64	6.83
TW-28	In	9.00	8.74	8.55	8.44	8.19	8.10	7.90	7.75	7.79	8.10	8.24

Notes:

*Denotes questionable reading based on difference from average and trend for location.

**Piezometer located adjacent to extraction well.

***Groundwater elevations collected bimonthly starting October 2013.

[1]C-31, PMW-51, PZ-6, PZ-8, PZ-11, PZ-11, PZ- 13, PZ-29, and PZ-30 are omitted from this table because they have not provided data since October 2011.

Table 2.2 (continued)
Groundwater Elevations for December 2007 - December 2013

Well Number	Inside/ Outside of Wall	Groundwater Elevation (feet)										
		1/22/2013	2/19/2013	3/21/2013	4/15/2013	5/8/2013	6/12/2013	7/25/2013	8/27/2013	9/12/2013	10/21/2013***	12/11/2013
MW-5	Out	5.94	5.64	5.72	6.00	5.73	6.03	6.12	5.60	5.67	5.43	5.57
MW-8	Out	4.86	5.06	5.14	5.05	5.13	5.02	5.07	5.01	4.96	5.06	5.09
MW-9	Out	8.26	8.38	8.57	8.55	8.58	8.67	8.65	8.60	8.57	8.61	8.75
MW-10	Out	9.53	9.58	9.78	9.75	9.75	no data	9.89	9.80	9.70	9.70	9.85
MW-13	Out	14.42	14.40	14.45	14.49	14.49	no data	no data	14.68	14.65	15.41	14.45
MW-14	Out	13.41	13.47	13.43	13.52	13.54	13.58	14.23	14.10	14.28	13.70	no data
MW-16	Out	13.78	13.81	13.78	13.91	13.92	13.97	14.6	14.45	14.69	14.05	no data
MW-17	Out	12.25	12.23	12.18	12.33	12.29	12.39	12.9	12.70	13.00	12.31	no data
MW-18	Out	12.33	12.24	12.19	12.41	12.31	12.47	12.94	12.67	13.07	12.26	no data
MW-19	Out	2.70	2.63	2.76	2.77	2.76	2.73	2.67	2.55	2.43	2.52	2.55
MW-20	Out	2.68	2.65	2.76	2.77	2.77	2.72	2.69	2.57	2.48	2.57	2.55
MW-21	Out	2.19	2.24	2.40	2.41	2.39	2.34	2.29	2.20	2.12	2.19	2.26
MW-22	Out	2.27	2.30	2.48	2.46	2.45	2.43	2.35	2.27	2.19	2.30	2.40
MW-23	Out	1.72	1.74	1.83	1.83	1.82	1.83	1.78	1.74	1.67	1.73	1.78
MW-24	Out	1.21	1.23	1.31	1.32	1.32	1.25	1.27	1.24	1.17	1.24	1.22
MW-25	Out	1.67	1.67	1.81	1.81	1.81	1.75	1.74	1.68	1.62	1.71	1.7
MW-31	In	8.47	8.96	9.37	9.02	9.40	9.22	9.55	9.78	9.84	9.97	9.83
MW-33	Out	12.59	12.63	12.73	12.74	12.77	no data	13.1	13.00	12.91	12.77	12.67
MW-40	Out	1.88	1.87	2.96	1.96	1.95	1.88	1.88	1.81	1.73	1.81	1.78
PMW-41	In	10.75	11.03	11.38	11.22	11.43	11.34	11.79	11.86	11.86	11.87	11.72
PMW-42	In	9.60	10.08	10.46	10.23	10.49	9.36	10.77	10.89	10.95	11.03	10.88
PMW-43	Out	13.96	13.95	14.05	14.07	14.11	14.17	14.50	14.42	14.31	14.08	13.96
PMW-44	In	8.58	9.01	7.59	9.12	9.40	9.24	9.59	9.72	9.78	9.90	9.82
PMW-45	Out	2.56	2.57	2.69	2.71	2.73	2.68	2.66	2.53	2.48	2.55	2.52
PMW-46	Out	1.02	2.10	2.03	2.24	2.21	2.18	2.12	1.96	0.37	2.07	2.09
PMW-47	Out	3.54	3.64	3.83	3.78	3.84	3.79	3.80	3.76	3.68	3.72	3.76
PMW-48	Out	9.88	9.72	9.69	9.96	9.80	10.05	10.50	10.36	10.19	9.79	9.54
PMW-49	In	9.19	8.63	9.05	8.66	9.08	8.93	9.19	9.44	9.50	9.63	9.54
PMW-50	In	9.45	9.80	10.17	9.94	10.21	9.98	10.52	10.65	10.73	10.79	10.71
PMW-53	In	6.31	6.76	7.13	6.66	7.20	6.77	6.90	7.3	7.37	7.58	7.5
PMW-54	In	4.81	5.48	5.66	5.23	5.80	5.27	5.44	5.85	5.8	6.03	6.04
PMW-55	In	6.39	7.12	7.41	6.81	no data	6.92	7.16	7.73	8.35	8.00	7.96
PMW-56	In	6.32	6.86	7.27	6.82	7.32	6.93	7.11	7.43	7.53	7.72	7.69
PMW-57	In	5.30	4.81	6.14	5.71	6.17	5.76	5.94	6.25	6.3	6.46	6.46
PMW-58	In	4.93	5.41	5.79	5.38	5.84	5.42	5.59	5.86	5.92	6.08	6.07
PMW-59	In	4.37	2.79	5.01	4.69	5.05	4.73	4.84	5.04	5.03	5.14	5.16
PZ-1	Out	16.42	16.47	16.58	16.59	16.67	16.71	17.18	17.23	17.18	16.85	16.57
PZ-3	Out	14.91	14.94	15.02	15.03	15.08	15.18	15.51	15.36	15.35	15.09	14.99
PZ-4	Out	10.89	10.96	11.09	11.10	11.14	11.15	11.37	11.27	11.22	11.11	11.14
PZ-5	Out	8.31	8.47	8.69	8.64	8.69	8.76	9.33	8.72	8.68	8.71	8.84
PZ-7	Out	7.51	7.59	7.80	7.77	7.79	7.85	7.81	7.77	7.73	7.77	7.91
PZ-9	Out	3.62	3.60	3.68	3.77	3.77	3.72	3.69	3.54	3.47	3.57	no data
PZ-10	In	5.93	6.46	6.84	6.43	6.87	6.54	6.69	6.94	7.04	7.22	1.19
PZ-12	Out	2.81	2.85	3.01	2.99	3.01	2.95	2.94	2.86	2.79	2.86	2.85
PZ-14	In	4.57	5.03	5.28	4.93	5.31	4.98	5.1	5.33	5.33	5.47	5.49
PZ-15	Out	3.13	3.20	3.37	3.32	3.37	3.31	3.31	3.25	3.19	3.25	3.26
PZ-16	Out	4.29	4.34	4.49	4.49	4.51	4.52	4.54	4.49	4.42	4.39	4.41
PZ-17	Out	6.50	6.18	6.25	6.54	6.26	6.62	6.77	6.44	6.28	5.99	6.07
PZ-18	Out	7.47	7.15	7.14	7.53	7.15	7.61	7.83	7.43	7.27	6.91	6.96
PZ-19	In	7.36	7.87	8.29	7.84	8.31	8.02	8.26	8.56	8.64	8.82	8.75
PZ-20	In	9.07	9.46	9.84	9.50	9.88	9.79	10.08	10.33	10.38	10.46	10.37
PZ-21	Out	12.49	12.57	12.55	12.66	12.71	12.72	13.36	13.38	13.29	12.90	12.48
PZ-22	Out	14.69	14.79	14.81	14.87	14.96	14.95	15.56	15.55	15.60	15.23	14.79
PZ-23	Out	15.81	15.95	15.97	16.02	16.10	16.10	16.67	16.81	16.77	16.44	15.99
PZ-24	Out	16.77	-9.08	16.93	16.96	17.07	15.34	17.54	17.73	17.71	17.37	16.94
PZ-25**	In	8.77	9.51	9.92	9.31	9.93	9.46	9.89	10.34	10.39	10.50	9.94
PZ-26**	In	7.59	8.36	8.59	8.17	8.74	8.33	8.7	9.04	9.04	9.28	9.17
PZ-27**	In	8.58	9.26	9.41	12.00	9.64	9.23	9.54	10.08	10.11	10.23	9.92
PZ-28**	In	6.18	6.89	7.14	6.70	7.32	6.80	6.96	7.44	7.50	7.71	7.67
TW-28	In	7.87	8.33	8.73	8.36	8.78	8.50	8.81	9.03	9.06	9.27	9.18

Notes:

*Denotes questionable reading based on difference from average and trend for location.

**Piezometer located adjacent to extraction well.

***Groundwater elevations collected bimonthly starting October 2013.

[1]C-31, PMW-51, PZ-6, PZ-8, PZ-11, PZ-11, PZ- 13, PZ-29, and PZ-30 are omitted from this table because they have not provided data since October 2011.

Table 2.3
Effective Solubilities for DNAPL Sample Acquired from Extraction Well EW-1

Chemical	Molecular Weight (g/mol)	Density (g/L)	Mass Fraction	Molar Fraction	Laboratory Solubility (mg/L)	Reference	Effective Solubility (mg/L)
1,2-dichlorobenzene	150	1,288	0.295	0.28	156	(1)	44.05
1,4-dichlorobenzene	150	1,248	0.264	0.25	81	(1)	20.47
chlorobenzene	110	1,106	0.220	0.29	498	(1)	143.00
1,2,4-trichlorobenzene	180	1,459	0.182	0.15	49	(1)	7.11
1,3-dichlorobenzene	147	1,306	0.022	0.02	125	(2)	2.69
1,2,3-trichlorobenzene	180	1,453	0.014	0.01	18	(1)	0.20
1,3,5-trichlorobenzene	180	1,456	0.003	0.004	6.0	(4),(5)	0.026
benzene	78	876	0.003	0.004	1,800	(1)	7.75
1,2,3,4-tetrachlorobenzene	216	1,700	0.003	0.004	5.9	(3),(6)	0.025
1,2,4,5-tetrachlorobenzene	216	1,858	0.003	0.004	0.60	(1)	0.003
pentachlorobenzene	250	1,834	0.003	0.004	0.83	(1)	0.004
hexachlorobenzene	285	2,044	0.003	0.004	0.0062	(1)	0.000027

DNAPL = dense nonaqueous phase liquid
RSL= Regional Screening Level
g/mol=grams per mole
mg/L=milligrams per liter
(1) EPA RSL Chemical Specific Parameters Table (November 2018)
(2) Miller MM et al.; J Chem Eng Data 29:184-90 (1984)
(3) Yalkowsky, S.H.; Handbook of Aqueous Solubility Data (2003)
(4) http://toxnet.nlm.nih.gov/cgi-bin/sis/search/r?dbs+hsdb:@term+@rn+@rel+108-70-3
(5) https://pubchem.ncbi.nlm.nih.gov/compound/1_3_5-trichlorobenzene#section=Density
(6) https://pubchem.ncbi.nlm.nih.gov/compound/1_2_3_4-tetrachlorobenzene#section=Density

Table 2.4
DNAPL Constituents Detected in Select Columbia Aquifer Wells as a Percentage of Effective Solubility - September 2014

	Chemical											
	1,2,3,4-TETRACHLOROBENZENE[1]	1,2,4,5-TETRACHLOROBENZENE	HEXACHLOROBENZENE	NITROBENZENE	PENTACHLOROBENZENE	1,2,3-TRICHLOROBENZENE	1,2,4-TRICHLOROBENZENE	1,2-DICHLOROBENZENE	1,3,5-TRICHLOROBENZENE[2]	1,3-DICHLOROBENZENE[3]	1,4-DICHLOROBENZENE	CHLOROBENZENE
Effective Solubility (µg/L)	25	3	0.027	2,100	4	200	7,110	44,050	26	2,690	20,470	143,000
Well												
DP10C	0%	0%	0%	0%	0%	30%	1%	2%	0%	0%	3%	1%
DP14C	0%	0%	0%	12%	0%	41%	2%	6%	0%	0%	8%	2%
DP15C	0%	230%	0%	18%	0%	265%	12%	10%	0%	0%	13%	2%
EM1D	0%	0%	0%	0%	0%	10%	1%	1%	0%	1%	1%	1%
EM1S	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
EM2D	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
EM2S	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%
EM4D	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
EM4S	0%	0%	0%	0%	0%	0%	0%	2%	0%	4%	3%	1%
EM5D	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
EM5S	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
EM6D	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
EM6S	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
PZT10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
PZT8D	0%	277%	0%	0%	0%	45%	7%	4%	0%	2%	1%	1%
MW3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MW5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MW8	0%	1200%	0%	0%	0%	600%	56%	5%	0%	29%	27%	1%
MW9	0%	533%	0%	0%	0%	375%	37%	2%	0%	45%	17%	2%
MW10	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MW13	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MW14	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MW16	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MW17	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MW18	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MW19	0%	667%	0%	0%	0%	85%	35%	1%	0%	25%	7%	0%
MW20	0%	117%	0%	0%	0%	55%	6%	0%	0%	2%	2%	0%
MW21	0%	967%	0%	10%	0%	475%	30%	23%	0%	45%	28%	3%
MW22	0%	600%	0%	3%	0%	105%	11%	9%	0%	10%	15%	2%
MW23	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%
MW24	0%	2400%	0%	0%	0%	950%	114%	10%	0%	45%	40%	4%
MW25	0%	1433%	0%	23%	0%	1450%	93%	59%	0%	193%	93%	13%
MW31	0%	190%	0%	1%	0%	1150%	52%	116%	0%	108%	259%	57%
MW33	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MW34	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MW36	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MW37	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
MW40	0%	0%	0%	0%	0%	4%	0%	0%	0%	0%	0%	0%
PMW42	0%	1267%	0%	0%	0%	800%	101%	77%	0%	63%	32%	42%
PMW43	0%	0%	0%	0%	0%	6%	0%	0%	0%	0%	0%	0%
PMW44	0%	2900%	0%	0%	0%	1150%	134%	45%	0%	126%	68%	62%
PMW45	0%	767%	0%	0%	0%	500%	62%	17%	0%	74%	36%	13%
PMW46	0%	0%	0%	0%	0%	7%	0%	0%	0%	2%	1%	0%
PMW47	0%	933%	0%	0%	0%	180%	14%	25%	0%	12%	17%	1%
PMW48	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
PMW49	0%	733%	0%	2%	0%	0%	11%	10%	0%	17%	26%	8%
PMW50	0%	833%	0%	0%	0%	12%	3%	1%	0%	3%	6%	0%
PMW53	0%	1233%	0%	0%	0%	750%	69%	30%	0%	67%	38%	34%
PMW54	0%	467%	0%	18%	0%	285%	23%	34%	0%	67%	64%	17%

Table 2.4

DNAPL Constituents Detected in Select Columbia Aquifer Wells as a Percentage of Effective Solubility - September 2014

	Chemical											
Effective Solubility (µg/L)	1,2,3,4-TETRACHLOROBENZENE[1]	1,2,4,5-TETRACHLOROBENZENE	HEXACHLOROBENZENE	NITROBENZENE	PENTACHLOROBENZENE	1,2,3-TRICHLOROBENZENE	1,2,4-TRICHLOROBENZENE	1,2-DICHLOROBENZENE	1,3,5-TRICHLOROBENZENE[2]	1,3-DICHLOROBENZENE[3]	1,4-DICHLOROBENZENE	CHLOROBENZENE
	25	3	0.027	2,100	4	200	7,110	44,050	26	2,690	20,470	143,000
Well												
PMW55	0%	1400%	0%	9%	0%	90%	21%	25%	0%	26%	49%	13%
PMW56	0%	833%	0%	13%	0%	700%	66%	70%	0%	160%	137%	24%
PMW57	0%	2200%	0%	37%	0%	500%	68%	48%	0%	67%	83%	9%
PMW58	0%	1100%	0%	3%	0%	600%	77%	52%	0%	86%	59%	36%
PMW59	0%	1600%	0%	105%	0%	1200%	89%	70%	0%	212%	112%	10%
PMW60*	128%	1467%	0%	0%	0%	70%	24%	66%	0%	160%	78%	65%
PMW61*	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
PMW62*	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
PMW63*	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
PMW64*	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
PMW65*	88%	277%	0%	0%	35%	80%	5%	2%	0%	3%	1%	0%
PMW66*	32%	213%	0%	0%	0%	55%	7%	6%	0%	2%	1%	1%
PMW67*	34%	277%	0%	0%	0%	70%	8%	7%	0%	3%	2%	1%
PW7S	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
PZ18	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
PZ25	0%	326667%	44444%	0%	0%	4900%	1210%	409%	0%	409%	977%	168%
PZ26	0%	1200%	0%	52%	0%	0%	60%	70%	0%	138%	147%	91%
PZ27	0%	1633%	0%	12%	0%	1400%	65%	77%	0%	37%	43%	3%
TW28	0%	1300%	0%	0%	0%	250%	21%	16%	0%	28%	24%	13%

* - Sample data from March 2017

Laboratory Solubilities used in effective solubility calculations taken from January 2015 Regional Screening Level Parameter Table except for the following:

1) http://www.ilo.org/dyn/icsc/showcard.display?p_card_id=0676

2) http://toxnet.nlm.nih.gov/cgi-bin/sis/search/r?dbs+hsdb:@term+@rn+@rel+108-70-3

3) http://toxnet.nlm.nih.gov/cgi-bin/sis/search/r?dbs+hsdb:@term+@rn+@rel+541-73-1

µg/L=micrograms per liter

Shaded cells = Concentrations indicative of NAPL Presence

TeCB=tetrachlorobenzene DCB=dichlorobenzene

TCB=trichlorobenzene CB=chlorobenzene

Table 2.5
Wetlands Aquifer Matrix Samples with COC concentrations exceeding Csat

Compound	Sample Number	Chemical	Concentration (mg/kg)	Csat (mg/kg)	Depth Interval
1,4-DICHLOROBENZENE	MC13-SD22	1,4-DICHLOROBENZENE	330	280	11-13 ft
CHLOROBENZENE	MC13-SD22	CHLOROBENZENE	1600	760	11-13 ft
1,2-DICHLOROBENZENE	MC13-SD27	1,2-DICHLOROBENZENE	390	380	9-11 ft
1,3-DICHLOROBENZENE	MC13-SD27	1,3-DICHLOROBENZENE	190	170	9-11 ft
1,4-DICHLOROBENZENE	MC13-SD27	1,4-DICHLOROBENZENE	770	280	9-11 ft
1,2,3,4-TETRACHLOROBENZENE	MC13-SD28	1,2,3,4-TETRACHLOROBENZENE	1000	17	10-12 ft
1,2,4,5-TETRACHLOROBENZENE	MC13-SD28	1,2,4,5-TETRACHLOROBENZENE	190	2.1	10-12 ft
1,3-DICHLOROBENZENE	MC13-SD28	1,3-DICHLOROBENZENE	180	170	10-12 ft
1,4-DICHLOROBENZENE	MC13-SD28	1,4-DICHLOROBENZENE	820	280	10-12 ft
CHLOROBENZENE	MC13-SD28	CHLOROBENZENE	4300	760	10-12 ft
HEXACHLOROBENZENE	MC13-SD28	HEXACHLOROBENZENE	6.5	0.059	10-12 ft
PENTACHLOROBENZENE	MC13-SD28	PENTACHLOROBENZENE	140	1.4	10-12 ft
1,2,4,5-TETRACHLOROBENZENE	MC13-SD29	1,2,4,5-TETRACHLOROBENZENE	4.5	2.1	10-12 ft
1,2,4,5-TETRACHLOROBENZENE	MC13-SD29	1,2,4,5-TETRACHLOROBENZENE	3.5	2.1	16-18 ft
1,4-DICHLOROBENZENE	MC13-SD29	1,4-DICHLOROBENZENE	680	280	16-18 ft
CHLOROBENZENE	MC13-SD29	CHLOROBENZENE	980	760	16-18 ft
1,4-DICHLOROBENZENE	MC13-SD32	1,4-DICHLOROBENZENE	2400	280	10-12 ft
CHLOROBENZENE	MC13-SD32	CHLOROBENZENE	6000	760	10-12 ft
1,2,3-TRICHLOROBENZENE	MC13-SD36	1,2,3-TRICHLOROBENZENE	160	150	10-12 ft
1,4-DICHLOROBENZENE	MC13-SD36	1,4-DICHLOROBENZENE	1000	280	10-12 ft
1,2,3-TRICHLOROBENZENE	MC13-SD36	1,2,3-TRICHLOROBENZENE	1500	150	14-16 ft
1,2,4-TRICHLOROBENZENE	MC13-SD36	1,2,4-TRICHLOROBENZENE	6200	400	14-16 ft
1,2-DICHLOROBENZENE	MC13-SD36	1,2-DICHLOROBENZENE	1100	380	14-16 ft
1,3-DICHLOROBENZENE	MC13-SD36	1,3-DICHLOROBENZENE	470	170	14-16 ft
1,4-DICHLOROBENZENE	MC13-SD36	1,4-DICHLOROBENZENE	6700	280	14-16 ft
1,2,4-TRICHLOROBENZENE	MC13-SD44	1,2,4-TRICHLOROBENZENE	460	400	10-12 ft
1,4-DICHLOROBENZENE	MC13-SD44	1,4-DICHLOROBENZENE	710	280	10-12 ft
1,2,3-TRICHLOROBENZENE	MC13-SD44	1,2,3-TRICHLOROBENZENE	360	150	14-16 ft
1,2,4-TRICHLOROBENZENE	MC13-SD44	1,2,4-TRICHLOROBENZENE	1100	400	14-16 ft
1,2-DICHLOROBENZENE	MC13-SD44	1,2-DICHLOROBENZENE	820	380	14-16 ft
1,3-DICHLOROBENZENE	MC13-SD44	1,3-DICHLOROBENZENE	180	170	14-16 ft
1,4-DICHLOROBENZENE	MC13-SD44	1,4-DICHLOROBENZENE	2200	280	14-16 ft
CHLOROBENZENE	MC13-SD44	CHLOROBENZENE	1400	760	14-16 ft
1,4-DICHLOROBENZENE	MC13-SD45	1,4-DICHLOROBENZENE	720	280	10-12 ft
CHLOROBENZENE	MC13-SD45	CHLOROBENZENE	1700	760	10-12 ft
1,4-DICHLOROBENZENE	MC13-SD45	1,4-DICHLOROBENZENE	320	280	14-16 ft
1,4-DICHLOROBENZENE	MC13-SD49	1,4-DICHLOROBENZENE	1400	280	10-12 ft
CHLOROBENZENE	MC13-SD49	CHLOROBENZENE	1800	760	10-12 ft
1,2,3,4-TETRACHLOROBENZENE	MC13-SD52	1,2,3,4-TETRACHLOROBENZENE	21	17	10-12 ft
1,2,4,5-TETRACHLOROBENZENE	MC13-SD52	1,2,4,5-TETRACHLOROBENZENE	6.5	2.1	10-12 ft
PENTACHLOROBENZENE	MC13-SD52	PENTACHLOROBENZENE	1.6	1.4	10-12 ft
1,2,4,5-TETRACHLOROBENZENE	MC13-SD52	1,2,4,5-TETRACHLOROBENZENE	3	2.1	15-17 ft
1,2,3-TRICHLOROBENZENE	MC14-SD02	1,2,3-TRICHLOROBENZENE	190	150	25-27 ft
1,2,3-TRICHLOROBENZENE	MC14-SD02	1,2,3-TRICHLOROBENZENE	160	150	25-27 ft
1,2,4-TRICHLOROBENZENE	MC14-SD02	1,2,4-TRICHLOROBENZENE	960	400	25-27 ft
1,2,4-TRICHLOROBENZENE	MC14-SD02	1,2,4-TRICHLOROBENZENE	670	400	25-27 ft
1,4-DICHLOROBENZENE	MC14-SD02	1,4-DICHLOROBENZENE	600	280	25-27 ft
1,4-DICHLOROBENZENE	MC14-SD02	1,4-DICHLOROBENZENE	420	280	25-27 ft
1,2,3-TRICHLOROBENZENE	MC14-SD02	1,2,3-TRICHLOROBENZENE	220	150	4-8 ft
1,2,3-TRICHLOROBENZENE	MC14-SD02	1,2,3-TRICHLOROBENZENE	1900	150	4-8 ft
1,2,4-TRICHLOROBENZENE	MC14-SD02	1,2,4-TRICHLOROBENZENE	550	400	4-8 ft
1,2,4-TRICHLOROBENZENE	MC14-SD02	1,2,4-TRICHLOROBENZENE	2100	400	4-8 ft
1,2-DICHLOROBENZENE	MC14-SD02	1,2-DICHLOROBENZENE	620	380	4-8 ft

Table 2.5
Wetlands Aquifer Matrix Samples with COC concentrations exceeding Csat

Compound	Sample Number	Chemical	Concentration (mg/kg)	Csat (mg/kg)	Depth Interval
1,3-DICHLOROBENZENE	MC14-SD02	1,3-DICHLOROBENZENE	360	170	4-8 ft
1,4-DICHLOROBENZENE	MC14-SD02	1,4-DICHLOROBENZENE	990	280	4-8 ft
1,4-DICHLOROBENZENE	MC14-SD02	1,4-DICHLOROBENZENE	8200	280	4-8 ft
CHLOROBENZENE	MC14-SD02	CHLOROBENZENE	1800	760	4-8 ft
CHLOROBENZENE	MC14-SD03	CHLOROBENZENE	1100	760	5-7 ft
1,2,3-TRICHLOROBENZENE	MC14-SD04	1,2,3-TRICHLOROBENZENE	210	150	10-12 ft
1,4-DICHLOROBENZENE	MC14-SD04	1,4-DICHLOROBENZENE	2400	280	10-12 ft
CHLOROBENZENE	MC14-SD04	CHLOROBENZENE	3200	760	5-7 ft
CHLOROBENZENE	MC14-SD05	CHLOROBENZENE	3500	760	6-8 ft
CHLOROBENZENE	MC14-SD07	CHLOROBENZENE	810	760	5-8 ft
1,4-DICHLOROBENZENE	MC14-SD17	1,4-DICHLOROBENZENE	530	280	28-30 ft
1,4-DICHLOROBENZENE	MC14-SD17	1,4-DICHLOROBENZENE	310	280	28-30 ft
1,2,3-TRICHLOROBENZENE	MC14-SD17	1,2,3-TRICHLOROBENZENE	370	150	9-11 ft
1,2,4-TRICHLOROBENZENE	MC14-SD17	1,2,4-TRICHLOROBENZENE	970	400	9-11 ft
1,4-DICHLOROBENZENE	MC14-SD17	1,4-DICHLOROBENZENE	1500	280	9-11 ft
1,4-DICHLOROBENZENE	MC14-SD18	1,4-DICHLOROBENZENE	440	280	5-7 ft
CHLOROBENZENE	MC14-SD18	CHLOROBENZENE	1100	760	5-7 ft
1,2,3-TRICHLOROBENZENE	MC14-SD19	1,2,3-TRICHLOROBENZENE	420	150	5-7 ft
1,2,4-TRICHLOROBENZENE	MC14-SD19	1,2,4-TRICHLOROBENZENE	570	400	5-7 ft
1,3-DICHLOROBENZENE	MC14-SD19	1,3-DICHLOROBENZENE	190	170	5-7 ft
1,4-DICHLOROBENZENE	MC14-SD19	1,4-DICHLOROBENZENE	7600	280	5-7 ft
1,2,3-TRICHLOROBENZENE	MC14-SD20	1,2,3-TRICHLOROBENZENE	340	150	16-18 ft
1,2,4-TRICHLOROBENZENE	MC14-SD20	1,2,4-TRICHLOROBENZENE	1500	400	16-18 ft
1,4-DICHLOROBENZENE	MC14-SD20	1,4-DICHLOROBENZENE	1100	280	16-18 ft
1,4-DICHLOROBENZENE	MC14-SD20	1,4-DICHLOROBENZENE	300	280	26-28 ft
1,3-DICHLOROBENZENE	MC14-SD21	1,3-DICHLOROBENZENE	190	170	10-12 ft
CHLOROBENZENE	MC14-SD21	CHLOROBENZENE	2300	760	10-12 ft
CHLOROBENZENE	MC14-SD21	CHLOROBENZENE	1100	760	5-8 ft
CHLOROBENZENE	MC14-SD80	CHLOROBENZENE	840	760	5-7 ft
1,2,4,5-TETRACHLOROBENZENE	WestWet-03	1,2,4,5-TETRACHLOROBENZENE	11	2.1	5-7 ft
1,4-DICHLOROBENZENE	WestWet-03	1,4-DICHLOROBENZENE	690	280	5-7 ft
PENTACHLOROBENZENE	WestWet-03	PENTACHLOROBENZENE	3.2	1.4	5-7 ft
1,2,3-TRICHLOROBENZENE	WestWet-04	1,2,3-TRICHLOROBENZENE	980	150	5-7 ft
1,2,4,5-TETRACHLOROBENZENE	WestWet-04	1,2,4,5-TETRACHLOROBENZENE	25	2.1	5-7 ft
1,2,4-TRICHLOROBENZENE	WestWet-04	1,2,4-TRICHLOROBENZENE	2600	400	5-7 ft
1,4-DICHLOROBENZENE	WestWet-04	1,4-DICHLOROBENZENE	2500	280	5-7 ft
CHLOROBENZENE	WestWet-04	CHLOROBENZENE	1200	760	5-7 ft
PENTACHLOROBENZENE	WestWet-04	PENTACHLOROBENZENE	3.4	1.4	5-7 ft

Csat = Soil Saturation Limit

mg/kg=milligrams per kilogram

ft = feet

Table 2.6
VOC Detection Summary for Columbia Aquifer Groundwater (2008-2014 Data)

Analyte Name	2015 - January Tap Water RSL (µg/L)	2015 - January MCLs (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Detected Number[1]	Number Greater than RSL	Number Greater than MCL
1,1,1-TRICHLOROETHANE	800	200	ND	ND	0	0	0
1,1,2,2-TETRACHLOROETHANE	0.076	--	ND	ND	0	0	NA
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	5,500	--	ND	2,200	1	0	NA
1,1,2-TRICHLOROETHANE	0.041	5	ND	ND	0	0	0
1,1-DICHLOROETHANE	2.7	--	ND	6,200	1	1	NA
1,1-DICHLOROETHYLENE	28	7	ND	3,600 J	1	1	1
1,2,3-TRICHLOROBENZENE	0.7	--	1.2 J	67,000 D	402	402	NA
1,2,4-TRICHLOROBENZENE	0.4	70	1.1 J	470,000 D	537	537	398
1,2-DIBROMO-3-CHLOROPROPANE (DBCP)	0.00033	0.2	58 J	1,300	6	6	6
1,2-DIBROMOETHANE	0.0075	0.05	ND	ND	0	0	0
1,2-DICHLOROBENZENE	30	600	1.4 J	1,100,000 D	604	537	390
1,2-DICHLOROETHANE	0.17	5	ND	95	1	1	1
1,2-DICHLOROPROPANE	0.44	5	91 J	2,200	2	2	2
1,3,5- TRICHLOROBENZENE	--	--	0.43 J	160	14	NA	NA
1,3-DICHLOROBENZENE	--	--	1.1 J	88,000	546	NA	NA
1,4-DICHLOROBENZENE	0.48	75	1.2 J	1,400,000 D	607	607	487
2-BUTANONE	560	--	850 J	16,000	4	3	NA
2-HEXANONE	3.8	--	430 J	5,600	4	4	NA
4-METHYL-2-PENTANONE	120	--	ND	ND	0	0	NA
ACETONE	1,400	--	5.3 J	16,000	14	1	NA
BENZENE	0.45	5	0.53 J	60,000 J	449	449	429
BROMODICHLOROMETHANE	0.13	80	4.3 J	3,400	3	3	1
BROMOFORM	9.2	80	ND	1,700	1	1	1
BROMOMETHANE	0.75	--	4.9 J	1,200 J	7	8	NA
CARBON DISULFIDE	81	--	ND	ND	0	0	NA
CARBON TETRACHLORIDE	0.45	5	1.5 J	430	84	55	31
CHLOROBENZENE	7.8	100	0.056 J	660,000 D	608	579	479
CHLOROBROMOMETHANE	8.3	--	ND	3,200	1	1	NA
CHLOROETHANE	2,100	--	ND	5,800	1	1	NA
CHLOROFORM	0.22	80	2 J	1,600	66	68	26

Table 2.6
VOC Detection Summary for Columbia Aquifer Groundwater (2008-2014 Data)

Analyte Name	2015 - January Tap Water RSL (µg/L)	2015 - January MCLs (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Detected Number[1]	Number Greater than RSL	Number Greater than MCL
CHLOROMETHANE	19	--	1.1	910 J	11	2	NA
CIS-1,2-DICHLOROETHENE	3.6	70	ND	2,200 J	1	1	1
CIS-1,3-DICHLOROPROPYLENE	--	--	95 J	240 J	3	NA	NA
CYCLOHEXANE	1300	--	3.3 J	9,300 J	7	1	NA
DIBROMOCHLOROMETHANE	0.17	80	ND	ND	0	0	0
DICHLORODIFLUOROMETHANE	20	--	ND	ND	0	0	NA
ETHYLBENZENE	1.5	700	1,300 J	2,500	2	2	2
ISOPROPYLBENZENE (CUMENE)	45	--	ND	2,800	1	1	NA
m,p-Xylene	--	--	ND	5,800	1	NA	NA
METHYL ACETATE	2,000	--	9.9 J	1,400 J	3	0	NA
METHYL TERT-BUTYL ETHER	14	--	0.26 J	330	143	46	NA
METHYLCYLOHEXANE	--	--	1.8 J	11	5	NA	NA
METHYLENE CHLORIDE	11	5	2 J	3,300	16	7	10
o-Xylene	19	--	ND	2,000 J	1	1	NA
STYRENE (MONOMER)	120	100	ND	ND	0	0	0
TETRACHLOROETHYLENE	4.1	5	2.4 J	2,200	7	5	4
TOLUENE	110	1,000	0.87 J	2,700	19	3	2
TRANS-1,2-DICHLOROETHENE	36	100	ND	ND	0	0	0
TRANS-1,3-DICHLOROPROPENE	--	--	2.5 J	1,800	3	NA	NA
TRICHLOROETHYLENE	0.28	5	1.1 J	1,600	17	17	6
TRICHLOROFLUOROMETHANE	110	--	1.3 J	8.8 J	3	0	NA
VINYL CHLORIDE	0.019	2	ND	3,600	1	1	1
XYLENES, O & M	--	--	ND	ND	66	NA	NA

Notes: RSL=Regional Screening Level, MCL=Maximum Contaminant Level, g/L=microgram per liter, J=estimated, D=result reported from the diluted analysis, ND=Not Detected, NA=Not Applicable, --=No Screening Value

1) Detections in normal sample/duplicate pair counted as one detection

Table 2.7
SVOC Detection Summary for Columbia Aquifer Groundwater (2008-2014 Data)

Analyte Name	2015 - January Tap Water RSL (µg/L)	2015 - January MCLs (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Detected Number[1]	Number Greater than RSL	Number Greater than MCL
1,2,3,4-TETRACHLOROBENZENE	--	--	0.53 J	17,000	424	NA	NA
1,2,4,5-TETRACHLOROBENZENE	0.17	--	0.57 J	76,000 J	449	449	NA
1,4-DIOXANE	0.78	--	6,600 J	6,600 J	6	1	NA
2,2'-OXYBIS(1-CHLOROPROPANE)	0.36	--	ND	ND	0	0	NA
2,3,4,6-TETRACHLOROPHENOL	24	--	0.58 J	51	16	1	NA
2,4,5-TRICHLOROPHENOL	120	--	0.91 J	15 J	36	0	NA
2,4,6-TRICHLOROPHENOL	1.2	--	0.7 J	12 J	9	6	NA
2,4-DICHLOROPHENOL	4.6	--	0.79 J	87	127	92	NA
2,4-DIMETHYLPHENOL	36	--	ND	ND	0	0	NA
2,4-DINITROPHENOL	3.9	--	ND	ND	2	0	NA
2,4-DINITROTOLUENE	0.24	--	ND	ND	0	0	NA
2,6-DINITROTOLUENE	0.048	--	ND	ND	0	0	NA
2-CHLORONAPHTHALENE	75	--	ND	12	1	0	NA
2-CHLOROPHENOL	9.1	--	0.84 J	260	165	72	NA
2-METHLYPHENOL	93	--	ND	41	1	0	NA
2-METHYLNAPHTHALENE	3.6	--	0.4 J	31 J	22	2	NA
2-NITROANILINE	19	--	ND	ND	0	0	NA
2-NITROPHENOL	--	--	0.74 J	21	45	NA	NA
3,3`-DICHLOROBENZIDINE	0.12	--	ND	3.3 J	1	1	NA
3-NITROANILINE	--	--	ND	ND	0	NA	NA
4,6-DINITRO-2-METHYLPHENOL	0.15	--	1.3 J	1.7 J	3	2	NA
4-BROMOPHENYL PHENYL ETHER	--	--	ND	ND	0	NA	NA
4-CHLORO-3-METHYLPHENOL	140	--	6.6	47	3	0	NA
4-CHLOROANILINE	0.36	--	0.95 J	470	75	75	NA
4-CHLOROPHENYL PHENYL ETHER	--	--	ND	ND	0	NA	NA
4-METHLYPHENOL	190	--	0.75 J	120	18	0	NA
4-NITROANILINE	3.8	--	ND	ND	0	0	NA

Table 2.7
SVOC Detection Summary for Columbia Aquifer Groundwater (2008-2014 Data)

Analyte Name	2015 - January Tap Water RSL (µg/L)	2015 - January MCLs (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Detected Number[1]	Number Greater than RSL	Number Greater than MCL
4-NITROPHENOL	--	--	1.4 J	24	22	NA	NA
ACENAPHTHENE	53	--	8.1 J	60	5	1	NA
ACENAPHTHYLENE	--	--	ND	ND	0	NA	NA
ACETOPHENONE	190	--	0.74 J	0.87 J	2	0	NA
ANTHRACENE	180	--	0.58 J	11	4	0	NA
ATRAZINE	0.3	3	0.6 J	23 J	14	14	4
BENZALDEHYDE	190	--	ND	2.8 J	1	0	NA
BENZO[A]ANTHRACENE	0.034	--	3 J	4.7 J	2	2	NA
BENZO[A]PYRENE	0.0034	0.2	ND	3.6 J	3	1	1
BENZO[B]FLUORANTHENE	0.034	--	1.5 J	3 J	5	3	NA
BENZO[G,H,I]PERYLENE	--	--	ND	3.7 J	3	NA	NA
BENZO[K]FLUORANTHENE	0.34	--	0.56 J	2.1 J	6	4	NA
BENZYL BUTYL PHTHALATE	16	--	1 J	3.5 J	22	0	NA
BIPHENYL	0.083	--	0.56 J	2 J	2	2	NA
BIS(2-CHLOROETHOXY)METHANE	5.9	--	ND	3.9 J	1	0	NA
BIS(2-CHLOROETHYL) ETHER	0.014	--	ND	ND	0	0	NA
BIS(2-ETHYLHEXYL) PHTHALATE	5.6	6	0.45 J	98	129	31	28
CAPROLACTAM	990	--	ND	2.1 J	1	0	NA
CARBAZOLE	--	--	ND	ND	0	NA	NA
CHRYSENE	3.4	--	3.3 J	4.6 J	2	1	NA
DIBENZ[A,H]ANTHRACENE	0.0034	--	ND	ND	2	0	NA
DIBENZOFBRAN	0.79	--	0.66 J	22 J	4	3	NA
DIETHYL PHTHALATE	1500	--	0.63 J	40	15	0	NA
DIMETHYL PHTHALATE	--	--	ND	1.8 J	1	NA	NA
DI-N-BUTYL PHTHALATE	90	--	0.49 J	17 J	71	0	NA
DI-N-OCTYL PHTHALATE	20	--	ND	2.2 J	1	0	NA
FLUORANTHENE	80	--	0.63 J	28	7	0	NA

Table 2.7
SVOC Detection Summary for Columbia Aquifer Groundwater (2008-2014 Data)

Analyte Name	2015 - January Tap Water RSL (µg/L)	2015 - January MCLs (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Detected Number[1]	Number Greater than RSL	Number Greater than MCL
FLUORENE	29	--	0.59 J	22	7	0	NA
HEXACHLOROBENZENE	0.049	1	0.61 J	150	7	7	5
HEXACHLOROBUTADIENE	0.3	--	ND	ND	0	0	NA
HEXACHLOROCYCLOPENTADIENE	3.1	50	ND	ND	1	0	0
HEXACHLOROETHANE	0.69	--	0.94 J	2.9 J	3	3	NA
INDENO[1,2,3-CD]PYRENE	0.034	--	ND	3.2 J	3	1	NA
ISOPHORONE	78	--	ND	ND	0	0	NA
NAPHTHALENE	0.17	--	0.43 J	64	82	82	NA
NITROBENZENE	0.14	--	0.52 J	2,200	296	296	NA
N-NITROSODI-N-PROPYLAMINE	0.011	--	ND	ND	0	0	NA
N-NITROSODIPHENYLAMINE	12	--	ND	1.6 J	1	0	NA
PENTACHLOROBENZENE	0.32	--	0.51 J	4,700 J	196	196	NA
PENTACHLOROPHENOL	0.04	1	2 J	460	9	9	9
PHENANTHRENE*	12	--	0.56 J	85	15	2	NA
PHENOL	580	--	0.61 J	67 J	103	0	NA
PYRENE	12	--	0.59 J	8.2	8	0	NA

Notes: RSL=Regional Screening Level, MCL=Maximum Contaminant Level, *=Delaware Department of Natural Resources and Environmental Control RSL, g/L=micrograms per liter, J=estimated, ND=Not Detected, NA=Not Applicable, --=No Screening Value
1) Detections in normal sample/duplicate pair counted as one detection

Table 2.8
Mann-Kendall Groundwater Contaminant Long-Term Trend Analysis

Well ID	Monitored Aquifer	Well Location	Total COCs Concentration Trend	Trend Probability (%)
PW-4D	Potomac	Outside Wall	No Trend	52.7
PW-6S	Potomac	Outside Wall	No Trend	62.2
PW-9	Potomac	Outside Wall	Significant Increasing Trend	98.8
PW-12	Potomac	Outside Wall	No Trend	52.7
PW-13	Potomac	Outside Wall	Significant Increasing Trend	98.5
PW-14	Potomac	Outside Wall	Possible Decreasing Trend	91.9
PW-17	Potomac	Outside Wall	No Trend	86.2
PW-22	Potomac	Outside Wall	Significant Increasing Trend	99.9
MW-22	Columbia	Outside Wall	No Trend	81.1
MW-23	Columbia	Outside Wall	Significant Decreasing Trend	100.0
MW-25	Columbia	Outside Wall	Significant Decreasing Trend	99.6
PMW-46	Columbia	Outside Wall	Significant Decreasing Trend	99.5
MW-20	Columbia	Outside Wall	Possible Decreasing Trend	94.4
MW-19	Columbia	Outside Wall	Significant Decreasing Trend	100.0
MW-8	Columbia	Outside Wall	Significant Decreasing Trend	100.0
MW-9	Columbia	Outside Wall	Significant Decreasing Trend	100.0
MW-33	Columbia	Outside Wall	Significant Decreasing Trend	100.0
PMW-47	Columbia	Outside Wall	Possible Decreasing Trend	91.4
MW-5	Columbia	Outside Wall	Significant Decreasing Trend	100.0
PMW-45	Columbia	Outside Wall	Significant Decreasing Trend	100.0
TW-28	Columbia	Inside Wall	Significant Decreasing Trend	100.0
MW-31	Columbia	Inside Wall	No Trend	63.7
PMW-42	Columbia	Inside Wall	Significant Increasing Trend	95.9
PMW-44	Columbia	Inside Wall	No Trend	50.9
PMW-41	Columbia	Inside Wall	Possible Increasing Trend	93.0
PMW-50	Columbia	Inside Wall	Significant Increasing Trend	99.3

Table 2.9
Metals Detection Summary for Columbia Aquifer Groundwater (2008-2010 Data)

Analyte Name	2018 - November Tap Water RSL (µg/L)	2019 - March MCLs (µg/L)	Background Value or Maximum Background (µg/L)[3]	Minimum (µg/L)	Maximum (µg/L)	Detected Number[2]	Number Greater than RSL	Number Greater than MCL
ALUMINUM (FUME OR DUST)	2,000	--	207	30.2 J	18,100 J	196	72	NA
ANTIMONY	0.78	6	--	ND	2.1 J	1	1	0
ARSENIC	0.052	10	4.2	2.3 J	20.3	56	34	13
BARIUM	380	2,000	201.9*	11.2 J	1,230	193	41	0
BERYLLIUM	2.5	4	1*	0.16 J	19.7	145	68	49
CADMIUM	0.92	5	1.8	0.084 J	7.2	73	22	4
CALCIUM METAL	--	--	22145*	1530 J	105,000	248	NA	NA
CHROMIUM	--	100	0.76	0.58 J	131	105	NA	2
COBALT	0.6	--	1.7	0.78 J	137	183	177	NA
COPPER	80	1,300	2.2	0.86 J	69.2	108	0	0
IRON	1,400	--	39,733*	43.8 J	90,700 J	227	30	NA
LEAD	5 [1]	15	--	1.6 J	45	58	0	9
MAGNESIUM	--	--	12,021*	815 J	55,900	247	NA	NA
MANGANESE	43	--	436.7*	5.5 J	26,600	248	189	NA
MERCURY	0.063	2	--	0.032 J	6.9	16	0	3
NICKEL	39	--	14.67*	0.93 J	615	188	45	NA
POTASSIUM	--	--	6,780	472 J	9,650 J	244	NA	NA
SELENIUM	10	50	5	2.5 J	29.3 J	92	22	0
SILVER	9.4	--	--	0.49 J	14.3	30	2	NA
SODIUM	--	--	24,700	2710 J	815,000	250	NA	NA
THALLIUM	0.02	2	2.9	1 J	16 J	24	14	22
VANADIUM (FUME OR DUST)	8.6	--	1.045	0.39 J	22.9 J	57	3	NA
ZINC	600	--	13.82*	3.6 J	475 J	184	0	NA

1) DNREC screening value used.
2) Only one value of normal/duplicate pairs counted
* Value was calculated using ProUCL and represents the 95% Upper Simultaneous Limit (USL) or the Kaplan-Meier USL
All other values are the maximum background value.
3) Background value is the 95% USL. If insufficient detections to calculate a 95% USL, the background value is the maximum background detection.

Table 2.9a
March 2018 and September 2018 Potomac Aquifer Background Well Data - Metals

Location		Potomac Wells to the North of Red Lion Creek				Potomac Wells to the Southwest and West of the Site																Maximum Concentration* (µg/l)
Location ID		PW-5S		PW-5D		PW-20D		PW-20S		PW-19D*		PW-19D		PW-19S		PW-18S						
CLP Sample ID		MC0568		MC0567		MC0540		MC0554		MC0536		1809013-03		MC0537		1809013-04		1809013-01				
Date		3/6/2018		3/6/2018		3/8/2018		3/8/2018		3/8/2018		9/20/2018		3/9/2018		9/19/2018		9/19/2018				
Field QC		Normal		Normal		Normal		Normal		Normal		Normal		Normal		Duplicate		Duplicate				
Analyte Name	**Units**	**Result**	**Flag**	**Result**	**Flag**	**Result**	**Flag**	**Result**	**Flag**	**Result**	**Flag**	**Result**	**Flag**	**Result**	**Flag**	**Result**	**Flag**	**Result**	**Flag**			
Aluminum	µg/l			165		23.8		178		7530				76.8		288		323				**323**
Antimony	µg/l																					
Arsenic	µg/l																	1.1				**1**
Barium	µg/l	26.3		111		76.4		66.0		133				72.1								**111**
Beryllium	µg/l																					
Cadmium	µg/l																					
Calcium	µg/l	7630		14500		11700		9190		14500		14500		11800		12800		13200				**14500**
Chromium	µg/l									14.8												
Cobalt	µg/l									3.7												
Copper	µg/l									9.0												
Iron	µg/l			558		8350		11800		14400		8580		6490		9650		10400				**11800**
Lead	µg/l			1.0						2.9						1.1		1				**1**
Magnesium	µg/l	2510		4450		3310		3130		3810		3540		3990		4160		4290				**4450**
Manganese	µg/l	11.6		18.0		75.7		114		142		58.9		105		130		136				**136**
Mercury	µg/l																					
Nickel	µg/l	1.5		2.6						12.0						1.7						**3**
Potassium	µg/l			2090		2880		2310		4050		3180		2770		2780		2870				**3180**
Selenium	µg/l																					
Silver	µg/l																					
Sodium	µg/l	5830		7200		3710		3040		4160		4260		3200		5940		6250				**7200**
Thallium	µg/l																					
Vanadium	µg/l									18.6												
Zinc	µg/l	2.2		4.6		2.9				72.7		14.8		3.6								**15**

J = Analyte present. Reported value might not be accurate or precise.
A blank cell in the result column indicates the analyte was not detected in that sample.
µg/L = micrograms per liter
* - Data from the March 2018 PW-19D sample was omitted from calculation because of multiple outliers related to turbidity issues with the sample.

Table 2.10
Toxicity Equivalence Factors for Groundwater Samples from the Colombia and Potomac Aquifers

Location	Data Year	Full Dioxin/PCB Data Set?	TEQs from Substitution (pg/L)			KM TEQ pg/L	
			U = 0	U = 1/2 DL	U = DL	Sample KM TEQ	Qualifier
COLUMBIA AQUIFER							
MW-10	2008	PCBs Only	Insufficient Detections to Calculate				
MW-13	2008	PCBs Only					
MW-13	2008	PCBs Only					
MW-19	2008	PCBs Only	5.85	5.98	6.10	5.86	
MW-20	2008	PCBs Only	70.86	70.86	70.86	70.86	
MW-22	2008	PCBs Only	113.27	113.27	113.27	113.27	
MW-23	2008	PCBs Only	9.07	9.24	9.40	9.10	
MW-24	2008	PCBs Only	0.03	5.00	9.97	Not calculated	
MW-25	2015	Full Dioxin/PCB Data	14.40	15.56	16.72	14.48	
MW-25	2008	PCBs Only	146.60	147.91	149.22	146.89	
MW-31	2008	PCBs Only	14.73	14.74	14.76	14.73	J
MW-5	2008	PCBs Only	19.48	19.49	19.49	19.49	
MW-8	2008	PCBs Only	22.10	22.10	22.11	22.10	
MW-9	2008	PCBs Only	34.32	34.32	34.33	34.32	
PMW-42	2008	PCBs Only	6.80	6.98	7.15	6.82	
PMW-43	2008	PCBs Only	0.04	0.90	1.75	Not calculated	
PMW-44	2015	Full Dioxin/PCB Data	0.08	2.53	4.98	1.94	J
PMW-44	2008	PCBs Only	0.07	4.81	9.54	Not calculated	
PMW-44	2008	PCBs Only	0.10	2.86	5.63	Not calculated	
PMW-45	2008	PCBs Only	0.00	1.43	2.85	Not calculated	
PMW-47	2008	PCBs Only	0.02	1.66	3.30	2.54	J
PMW-48	2008	PCBs Only	0.01	5.17	10.33	Not calculated	
PMW-49	2008	PCBs Only	0.02	1.48	2.95	2.34	J
PMW-50	2008	PCBs Only	0.04	0.76	1.48	0.87	J
PMW-51	2008	PCBs Only	0.00	1.75	3.50	Not calculated	
TW-28	2008	PCBs Only	11.56	11.56	11.57	11.57	
POTOMAC AQUIFER							
PW-12	2015	Full Dioxin/PCB Data	0.05	2.39	4.72	1.92	J
PW-12 Duplicate	2015	Full Dioxin/PCB Data	0.06	2.48	4.90	1.92	J
PW-17	2015	Full Dioxin/PCB Data	3.34	4.86	6.39	3.47	J

All results are in picograms per liter
TEQ=Toxicity Equivalence Factor
U=not detected
KM=Kaplan-Meier
DL=Detection Limit
2,3,7,8-TCDD RSL= 0.6 pg/l

RSL = January 2015 EPA Regional Screening Level
PCB=Polychlorinated Biphenyl
U.S. EPA=Environmental Protection Agency
Shaded Results Greater than RSL
J=estimated

Table 2.11
Physical and Chemical Properties of Select Groundwater Contaminants

Contaminant	**Molecular Weight**	**Density**	**Partition Coefficient**	**Water Partition Coefficient**	**Water Solubility**
Analyte	**(g/mol)**	**(g/cm^3)**	**K_{oc}** (L/kg)	**log K_{ow}** (L/kg)	**S** **(mg/L)**
BENZENE	7.8E+01	0.8765	1.5E+02	2.1E+00	1.8E+03
CHLOROBENZENE	1.1E+02	1.1058	2.3E+02	2.8E+00	5.0E+02
DICHLOROBENZENE, 1,2-	1.5E+02	1.3059	3.8E+02	3.4E+00	1.6E+02
DICHLOROBENZENE, 1,4-	1.5E+02	1.2475	3.8E+02	3.4E+00	8.1E+01
TRICHLOROBENZENE, 1,2,4-	1.8E+02	1.459	1.4E+03	4.0E+00	4.9E+01

Data from EPA Region 3 January 2015 Regional Screening Level Parameter Table
g/mol=grams per mol
g/cm^3=grams per centimeter cubed
Koc=organic carbon-water partition coefficient
L/kg=liters per kilogram
mg/L=milligrams per liter

Table 5.1
Cost Estimate
Alternative ARS 1 - Groundwater Extraction and Treatment, Groundwater Source Area Containment, and Monitored Natural Attenuation
Feasibility Study Report, OU4, SCD Superfund Site, New Castle, DE

Phase Name	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6-10	Year 11-15	Year 16-20	Year 21-25	Year 26-30	Total
Remedial Action (RA)											
Expansion of existing GETS	$ 713,790										$ 713,790
Second GETS	$ 3,069,107										$ 3,069,107
Installation of extraction wells	$ 480,576										$ 480,576
Site Preparation	$ 969,332	$ 969,332	$ 969,332								$ 2,907,996
Site Restoration			$ 161,957								$ 161,957
Oversight (Labor)	$ 516,677	$ 516,677	$ 516,677								$ 1,550,030
Post RA Implementation											
Long-term monitoring	$ 145,226	$ 145,226	$ 145,226	$ 145,226	$ 145,226	$ 477,114	$ 477,114	$ 477,114	$ 477,114	$ 477,114	$ 3,111,697
O&M	$ 954,729	$ 806,565	$ 806,565	$ 806,565	$ 806,565	$ 4,032,825	$ 4,032,825	$ 4,032,825	$ 4,032,825	$ 4,032,825	$ 24,345,113
Five-Year Review						$ 25,872	$ 25,872	$ 25,872	$ 25,872	$ 25,872	$ 129,360
Subtotal	$ 6,849,436	$ 2,437,799	$ 2,599,756	$ 951,791	$ 951,791	$ 4,535,811	$ 4,535,811	$ 4,535,811	$ 4,535,811	$ 4,535,811	**$ 36,469,626**
Escalated for Inflation*	$ 6,849,436	$ 2,474,366	$ 2,678,334	$ 995,267	$ 1,010,196	$ 5,036,024	$ 5,425,228	$ 5,844,511	$ 6,296,198	$ 6,782,794	**$ 43,392,354**
Present Value Estimate*	$ 6,849,436	$ 6,401,342	$ (1,749,490)	$ 812,434	$ 770,674	$ 3,141,847	$ 2,413,217	$ 1,853,564	$ 1,423,702	$ 1,093,529	**$ 23,010,255**

* A yearly inflation rate of 1.50% is used along with a 7% discount rate.

Table 5.2
Cost Estimate
Alternative ARS 2 - Groundwater Extraction and Treatment, Groundwater Source Area Containment, Enhanced Bioremediation (Biowall), Metals Treatment (PRB), and Monitored Natural Attenuation
Feasibility Study Report, OU4, SCD Superfund Site, New Castle, DE

Phase Name	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6-10	Year 11-15	Year 16-20	Year 21-25	Year 26-30	Total
Remedial Action (RA)											
Expansion of existing GETS	$ 294,525	$ 294,525									$ 589,050
Second GETS	$ 1,425,708	$ 1,425,708									$ 2,851,417
Installation of extraction wells	$ 407,742										$ 407,742
Biowall	$ 2,545,670	$ 2,545,670									$ 5,091,339
PRB	$ 1,274,594	$ 1,274,594									$ 2,549,189
Site Preparation	$ 969,332	$ 969,332	$ 969,332								$ 2,907,996
Site Restoration			$ 220,851								$ 220,851
Oversight (Labor)	$ 516,677	$ 516,677	$ 516,677								$ 1,550,030
Post RA Implementation											
Long-term monitoring	$ 151,053	$ 151,053	$ 151,053	$ 151,053	$ 151,053	$ 503,485	$ 503,485	$ 503,485	$ 503,485	$ 503,485	$ 3,272,689
O&M	$ 828,293	$ 680,129	$ 680,129	$ 680,129	$ 680,129	$ 3,400,647	$ 3,400,647	$ 3,400,647	$ 3,400,647	$ 3,400,647	$ 20,552,047
PRB amendment replacement						$ 450,000		$ 450,000		$ 450,000	$ 1,350,000
Five-Year Review						$ 25,872	$ 25,872	$ 25,872	$ 25,872	$ 25,872	$ 129,360
Subtotal	$ 8,413,594	$ 7,857,688	$ 2,538,042	$ 831,182	$ 831,182	$ 4,380,004	$ 3,930,004	$ 4,380,004	$ 3,930,004	$ 4,380,004	**$ 41,471,711**
Escalated for Inflation*	$ 8,413,594	$ 7,975,553	$ 2,614,754	$ 869,149	$ 882,186	$ 4,878,049	$ 4,700,754	$ 5,661,175	$ 5,455,417	$ 6,570,025	**$ 48,020,659**
Present Value Estimate*	$ 8,413,594	$ 7,453,788	$ 2,283,828	$ 709,485	$ 673,016	$ 3,001,841	$ 2,090,717	$ 1,770,967	$ 1,233,440	$ 1,044,800	**$ 28,675,475**

* A yearly inflation rate of 1.50% is used along with a 7% discount rate.

TI WAIVER FIGURES

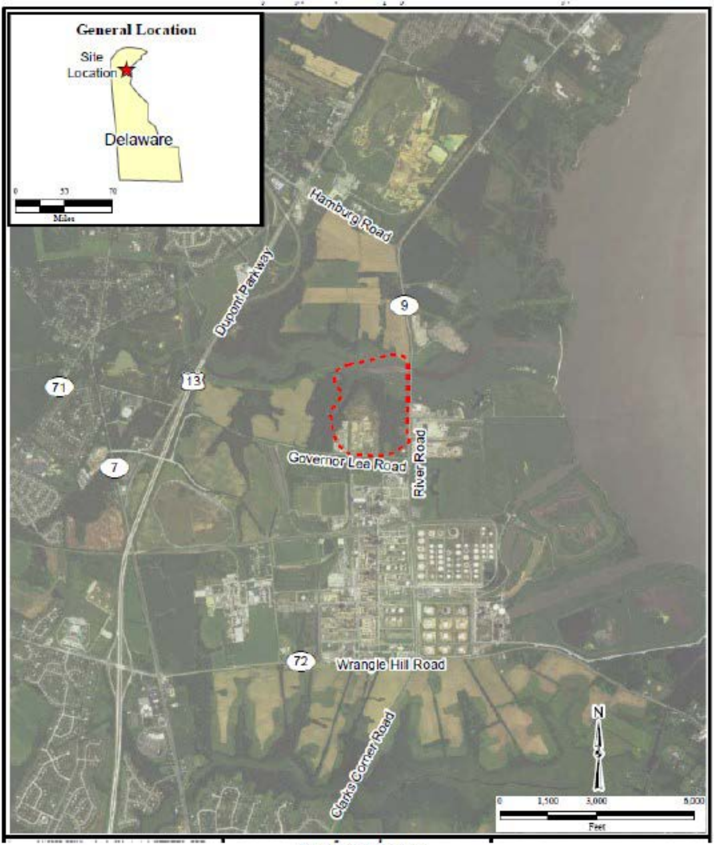


Figure 1 Site Location

Proposed TI Waiver Zones and COC MCL Exceedance Maps

Standard Chlorine of Delaware Superfund Site

Hotspot of contamination above MCL
Waste Management Area
Zone C1
Zone C2
Zone C3
Zone C4

Legend
Wetland
Soil-Bentonite Barrier
Approximate Site Boundary
Areas of DNAPL in Columbia Aquifer Matrix
Sediment Pore Water Concentrations Evident of DNAPL Contact*

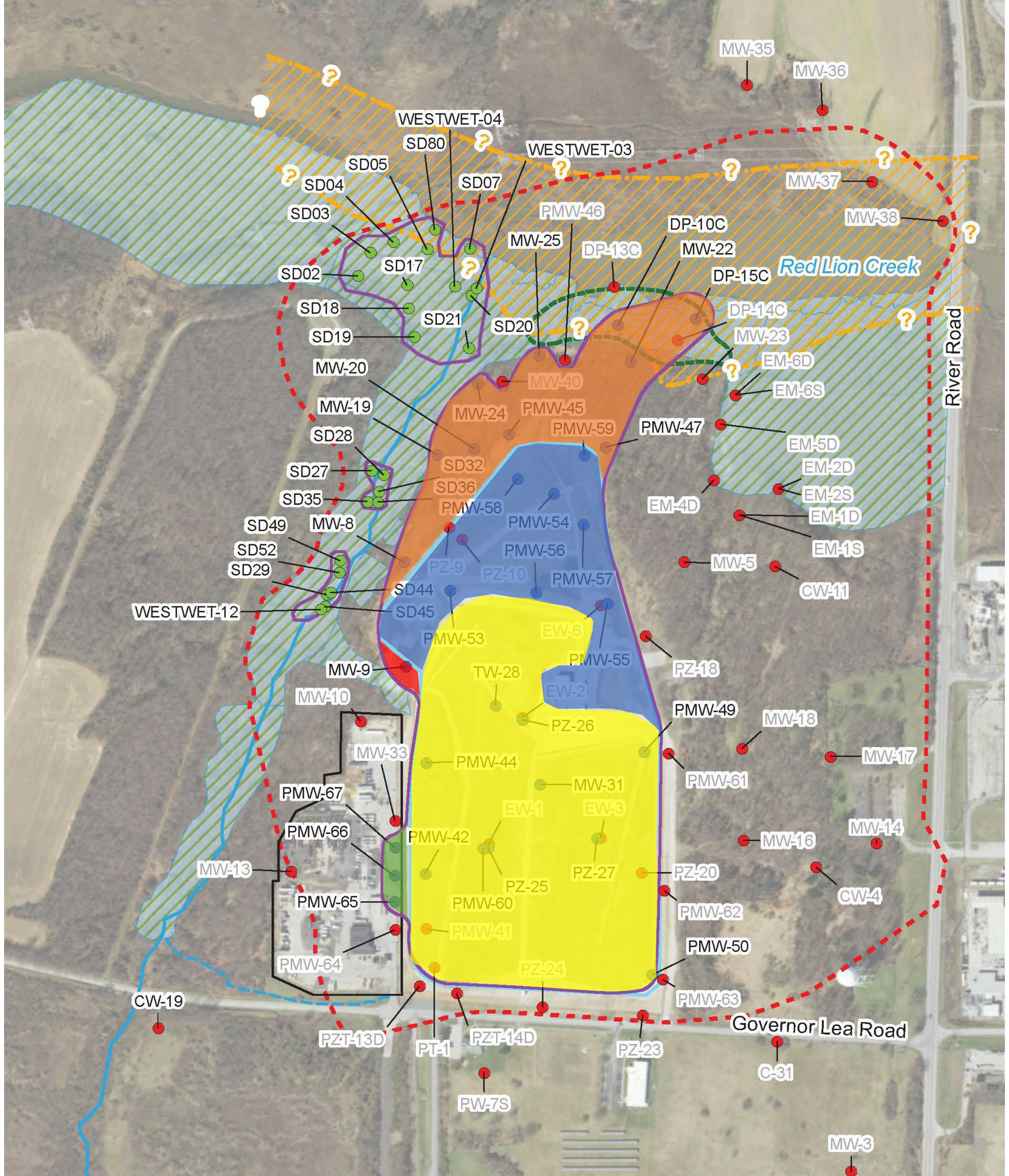
Figure 1a. Proposed Horizontal Extent of Columbia Aquifer TI Waiver Zones

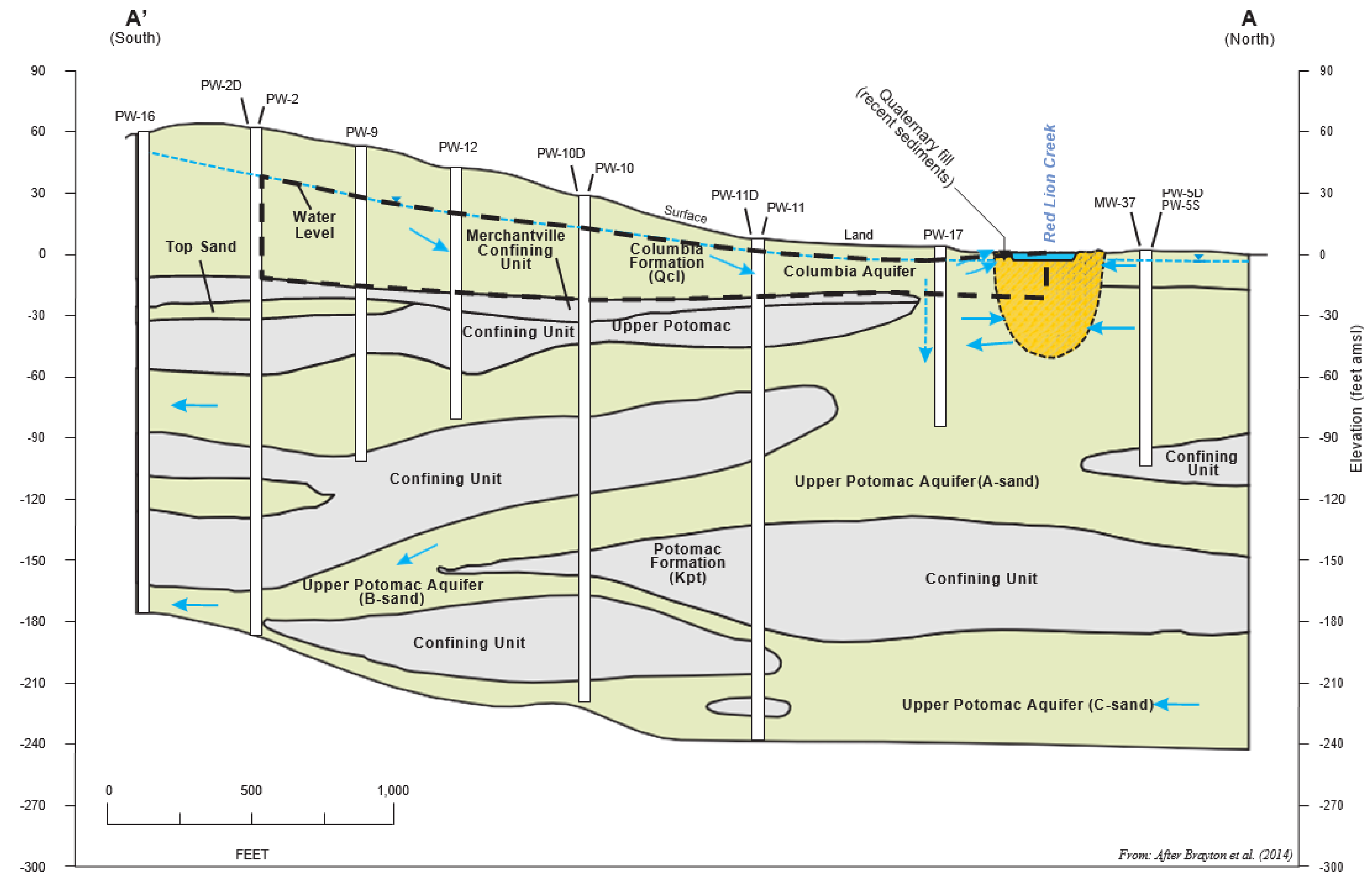
Columbia Well

Sediment Sample Locations toAquifer Matrix Sample Locations Concenttion greater than C_{sat}

Columbia Well Concentration Greater than Effective Solubility

Area where Confining Unit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)





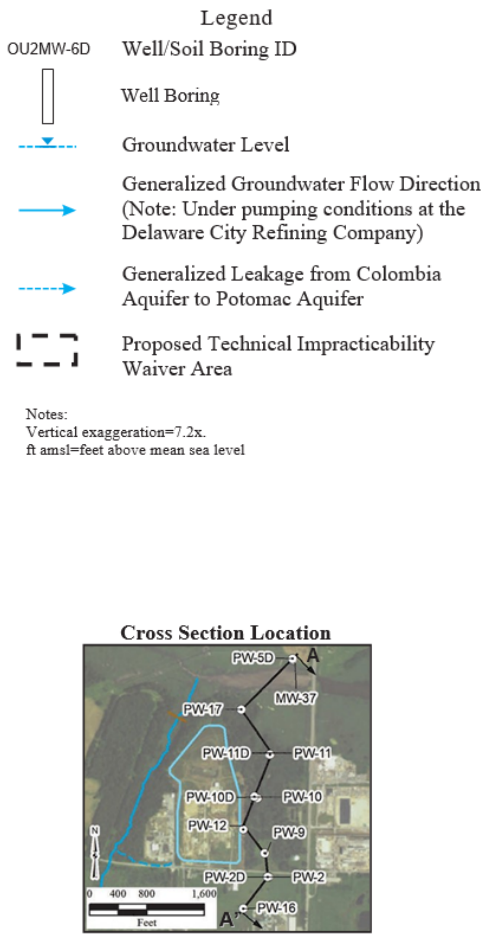


Figure 1b. Proposed Vertical Extent of Colombia Aquifer TI Waiver zones

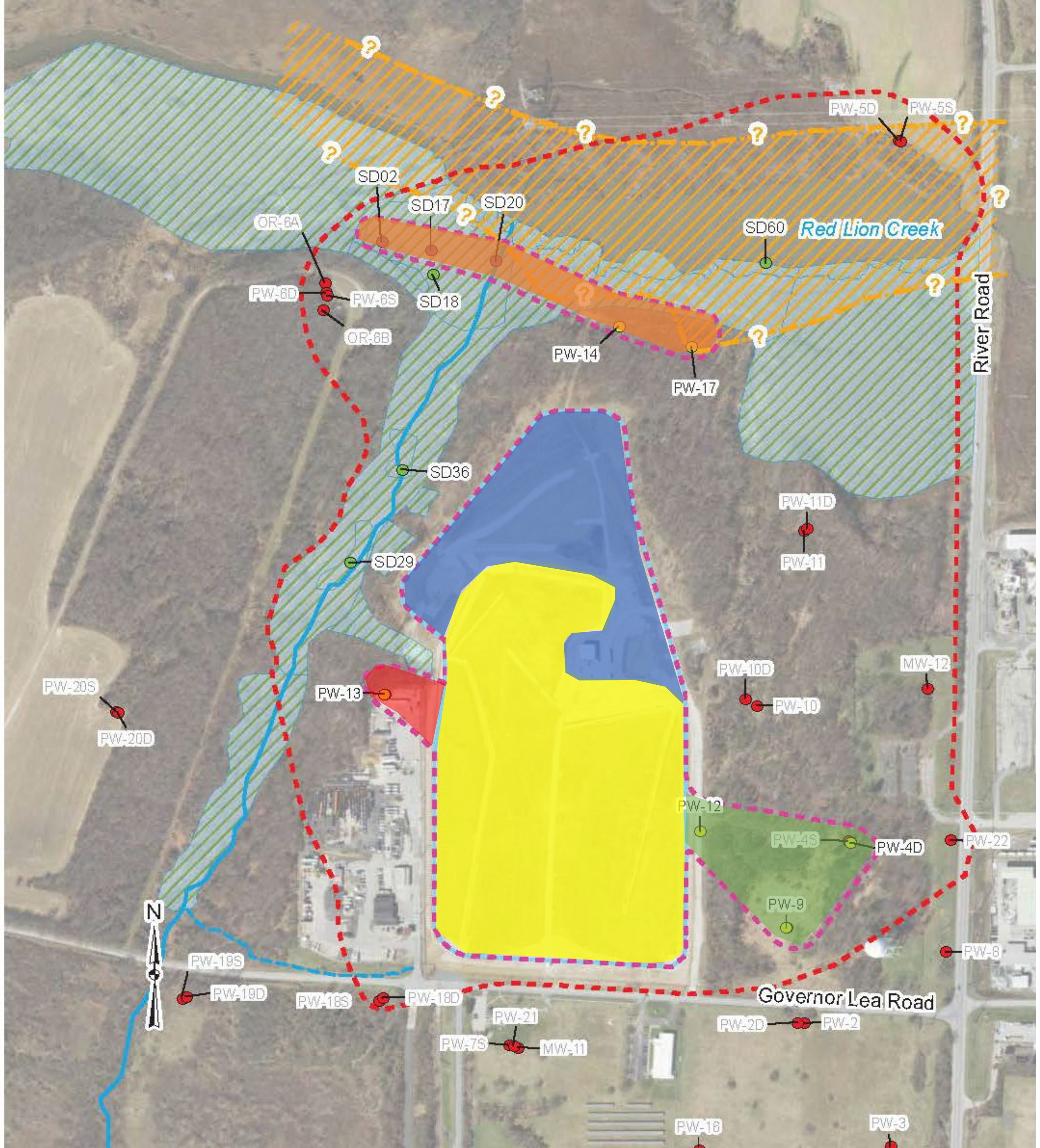
- Hotspot of contamination above MCL
- Waste Management Area
- Zone P1
- Zone P2
- Zone P3
- Zone P4

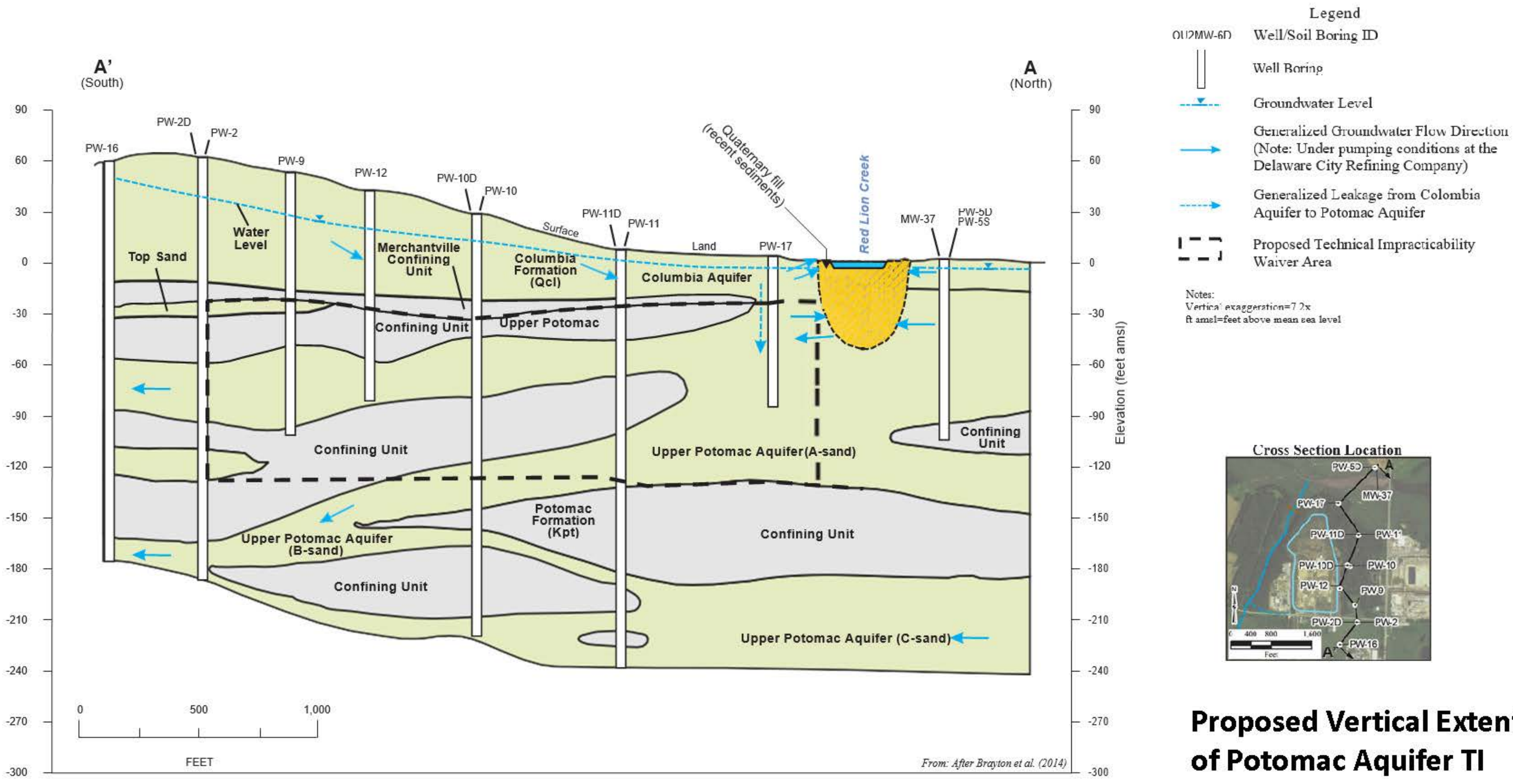
Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Inferred Area of DNAPL Presence
- Area where ConfiningUnit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)

Figure 2a. Proposed Horizontal Extent of Potomac Aquifer TI Waiver Zones

- Potomac Well
- Aquifer Matrix Sample Locations
- Aquifer Matrix Sample Locations Concentration greater than C_{sat}
- Potomac Well Concentrations Greater than Effective Solubility





Proposed Vertical Extent of Potomac Aquifer TI Waiver zones

Columbia Aquifer

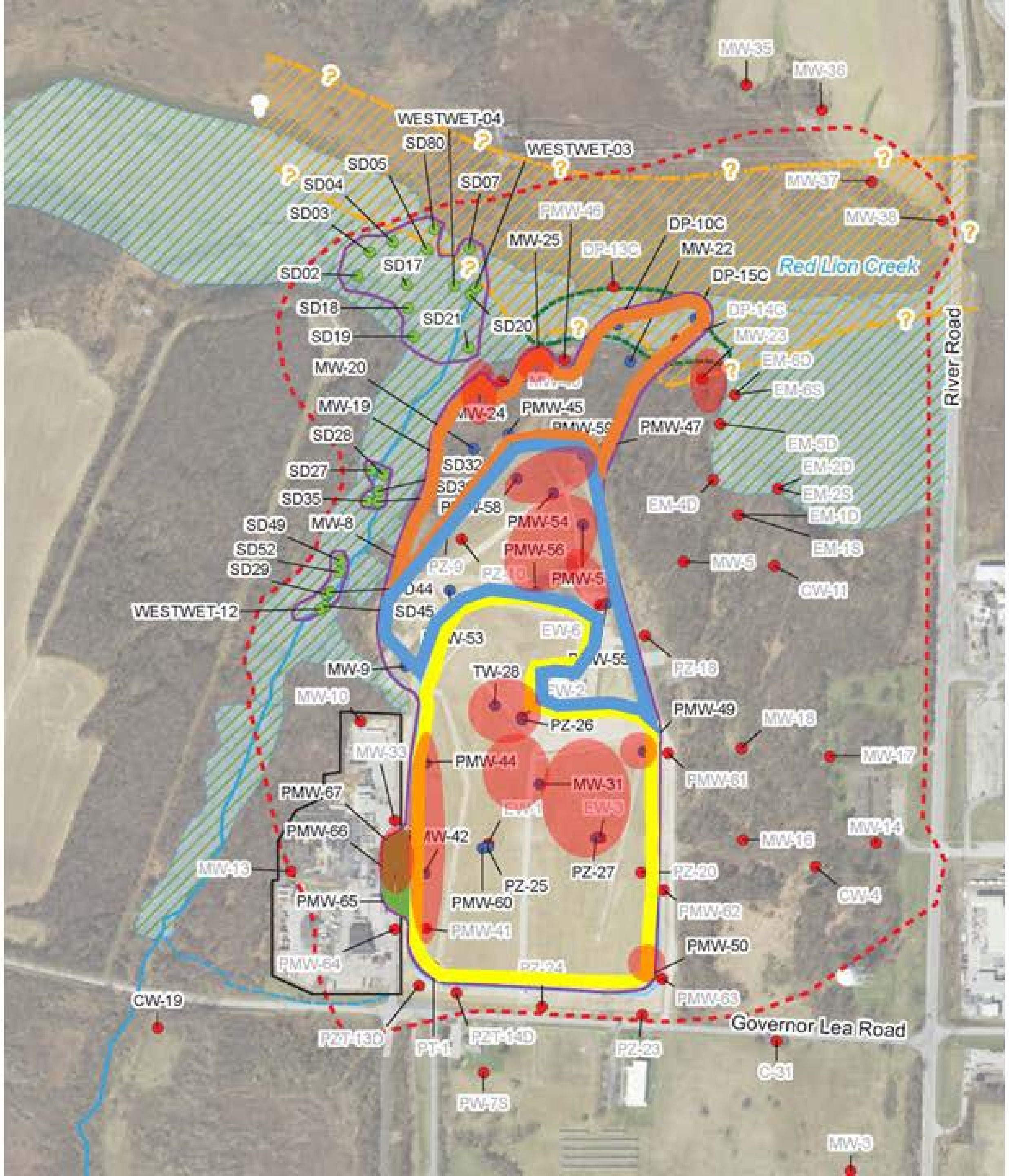
1,2,4-Trichlorobenzene

- Columbia Well
- Sediment Sample Locations toAquifer Matrix Sample Locations Concenttion greater than C_{sat}
- Columbia Well Concentration Greater than Effective Solubility
- Area where Confining Unit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)

Hotspot of contamination above MCL	
Waste Management Area	
Zone C1	
Zone C2	
Zone C3 (no waiver required)	
Zone C4	

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Areas of DNAPL in Columbia Aquifer Matrix
- Sediment Pore Water Concentrations Evident of DNAPL Contact*



Potomac Aquifer

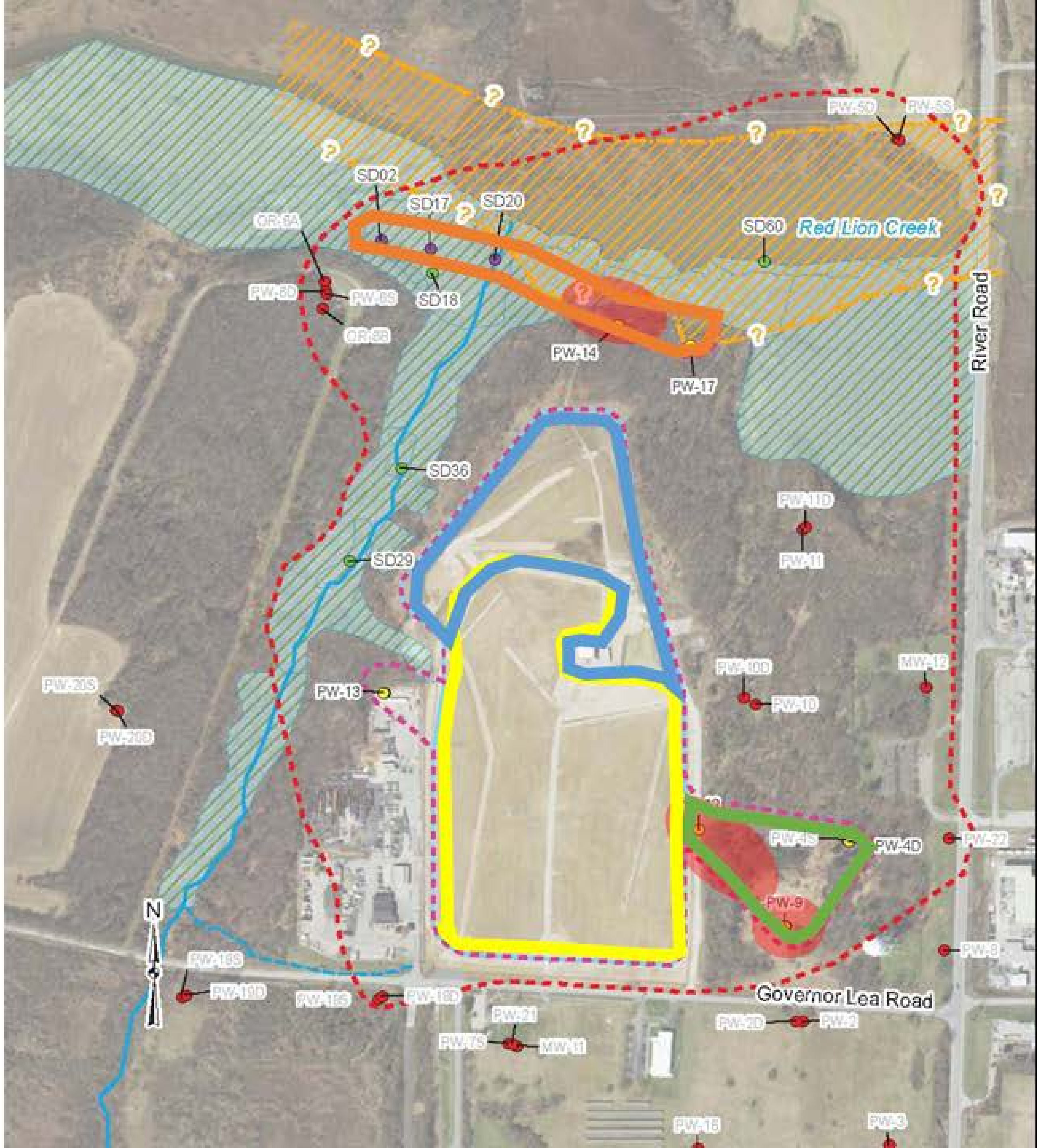
1,2,4-Trichlorobenzene

- Potomac Well
- Aquifer Matrix Sample Locations
- Aquifer Matrix Sample Locations Concentration greater than C_{sat}
- Potomac Well Concentrations Greater than Effective Solubility

Hotspot of contamination above MCL	
Waste Management Area	
Zone P1 (contamination inferred)	
Zone P2	
Zone P3 (no waiver required)	
Zone P4	

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Inferred Area of DNAPL Presence
- Area where ConfiningUnit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)



Columbia Aquifer

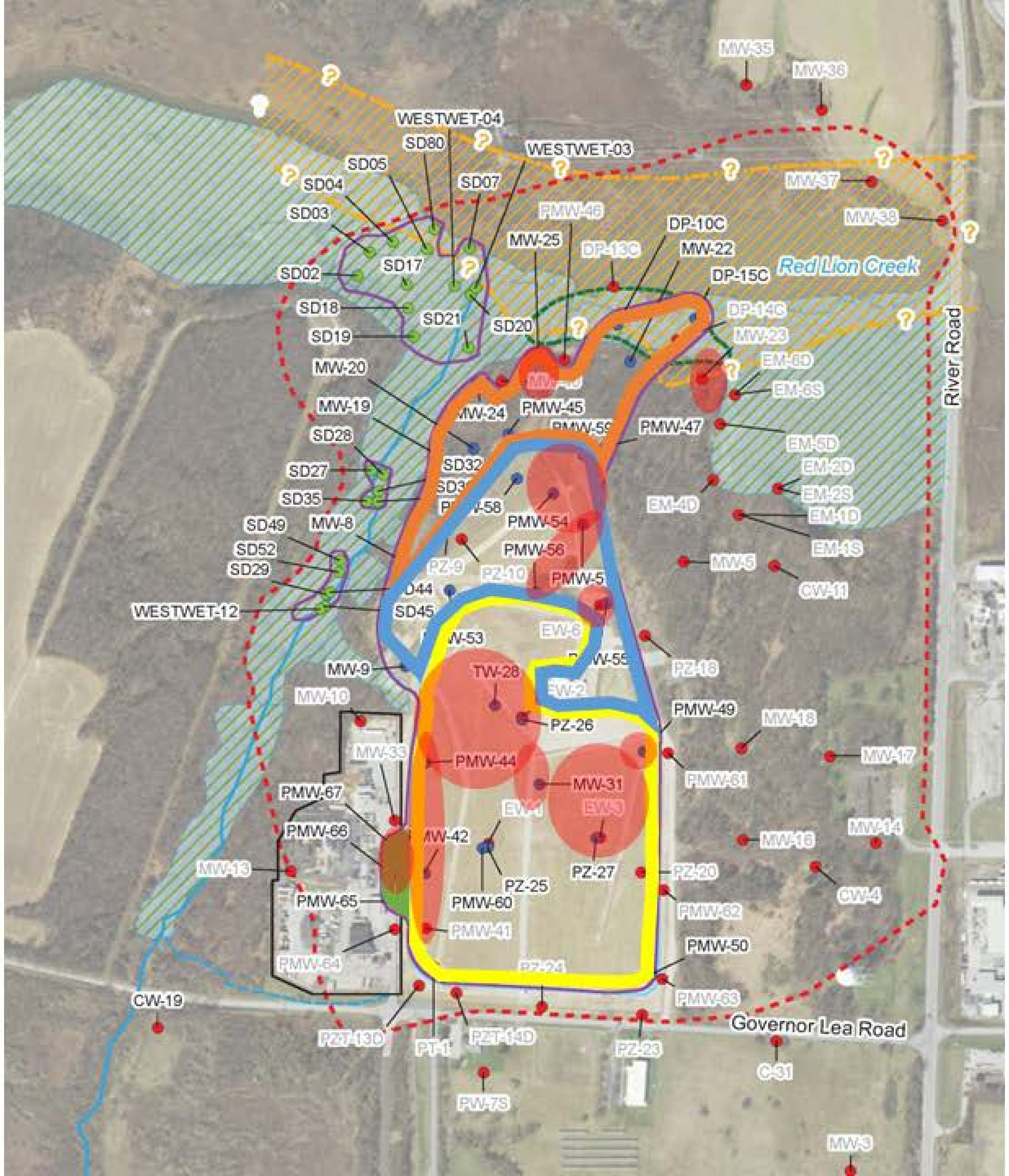
1,2-dichlorobenzen

- Columbia Well
- Sediment Sample Locations toAquifer Matrix Sample Locations Concenttion greater than C_{sat}
- Columbia Well Concentration Greater than Effective Solubility
- Area where Confining Unit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)

	Hotspot of contamination above MCL
	Waste Management Area
	Zone C1
	Zone C2
	Zone C3 (no waiver required)
	Zone C4

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Areas of DNAPL in Columbia Aquifer Matrix
- Sediment Pore Water Concentrations Evident of DNAPL Contact*



Potomac Aquifer

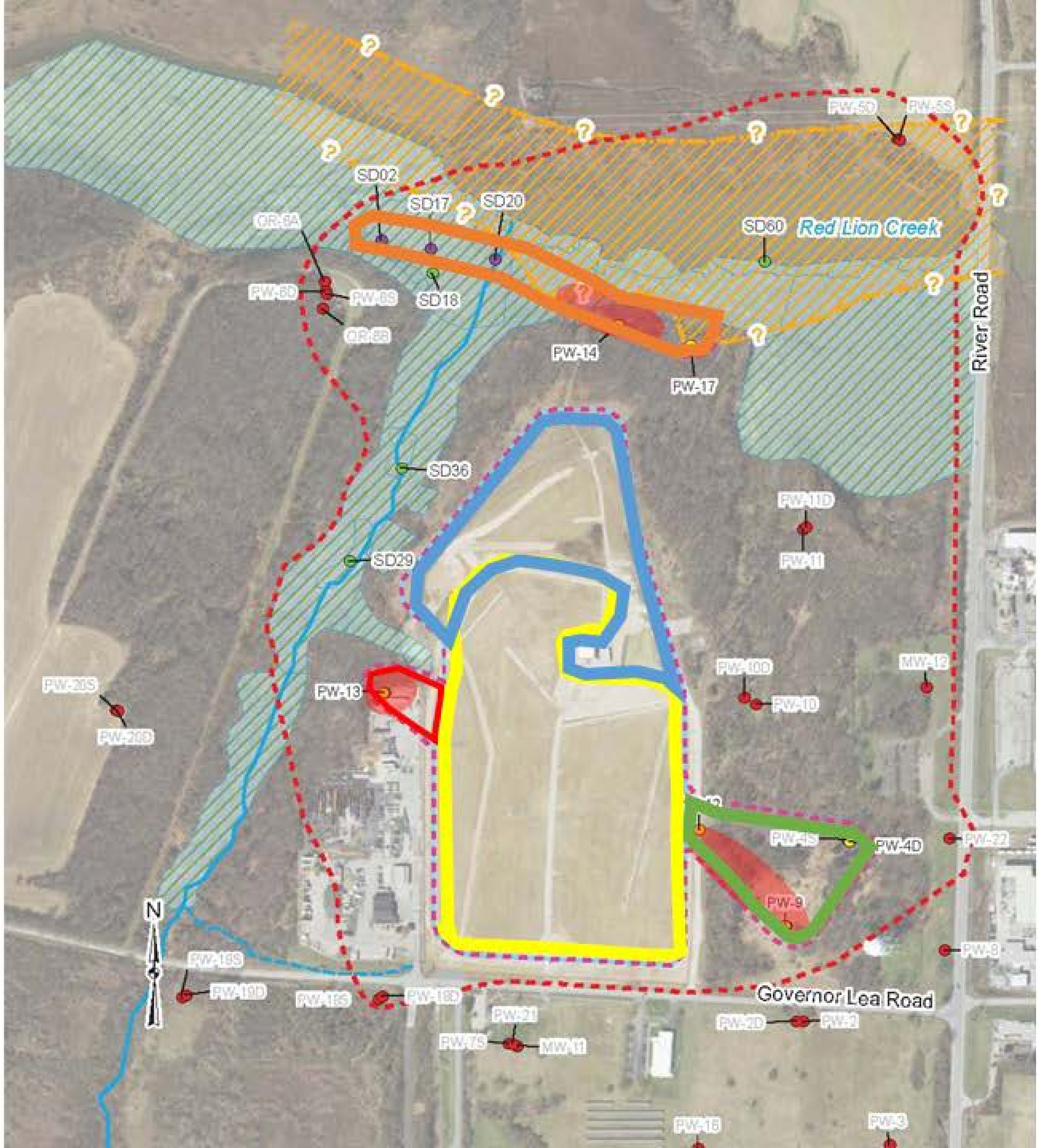
1,2-dichlorobenzene

- Potomac Well
- Aquifer Matrix Sample Locations
- Aquifer Matrix Sample Locations Concentration greater than C_{sat}
- Potomac Well Concentrations Greater than Effective Solubility

	Hotspot of contamination above MCL
	Waste Management Area
	Zone P1 (contamination inferred)
	Zone P2
	Zone P3
	Zone P4

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Inferred Area of DNAPL Presence
- Area where ConfiningUnit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)



Columbia Aquifer

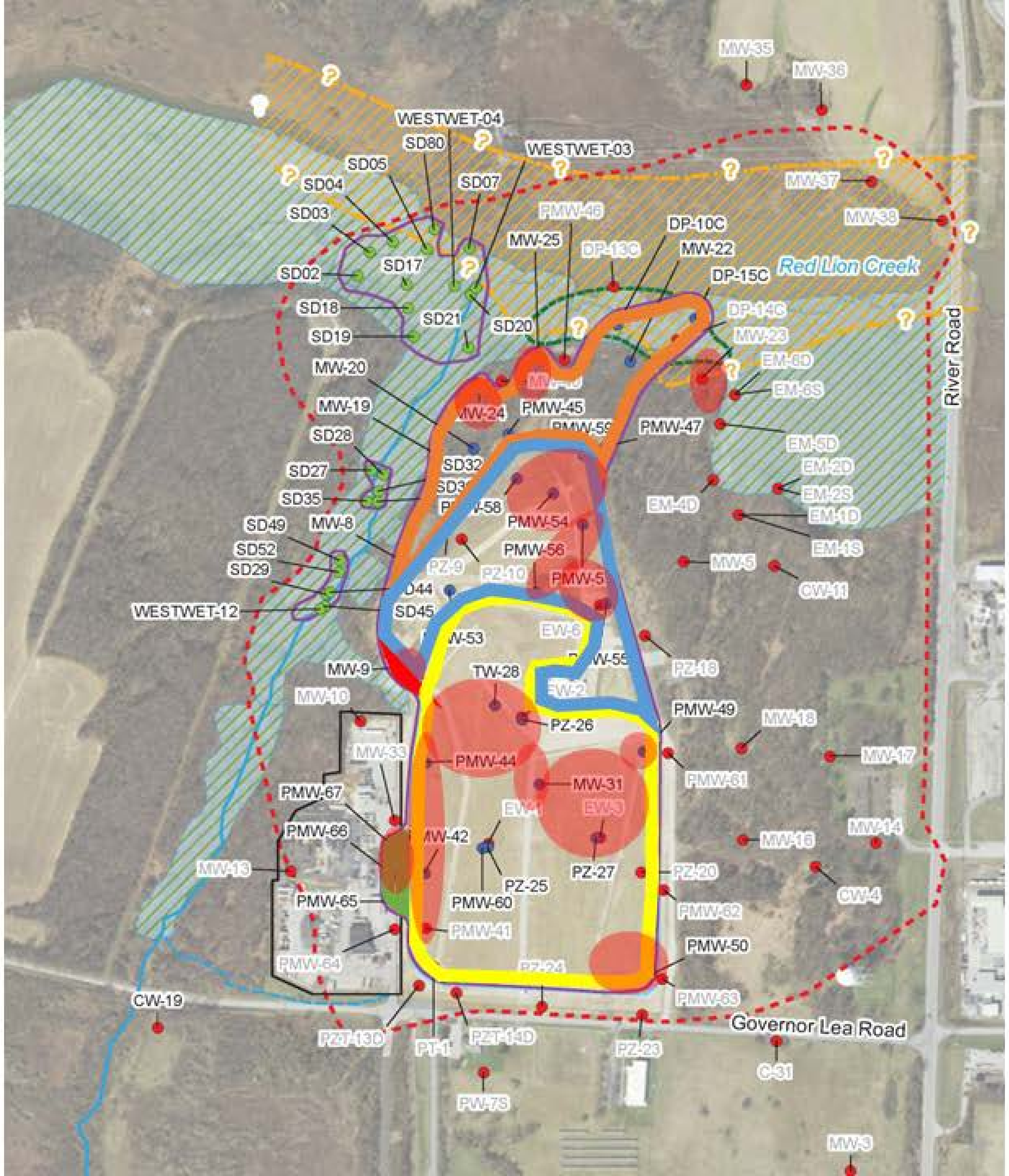
1,4-dichlorobenzene

- Columbia Well
- Sediment Sample Locations toAquifer Matrix Sample Locations Concentiion greater than C_{sat}
- Columbia Well Concentration Greater than Effective Solubility
- Area where Confining Unit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)

- Hotspot of contamination above MCL
- Waste Management Area
- Zone C1
- Zone C2
- Zone C3
- Zone C4

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Areas of DNAPL in Columbia Aquifer Matrix
- Sediment Pore Water Concentrations Evident of DNAPL Contact*



Potomac Aquifer

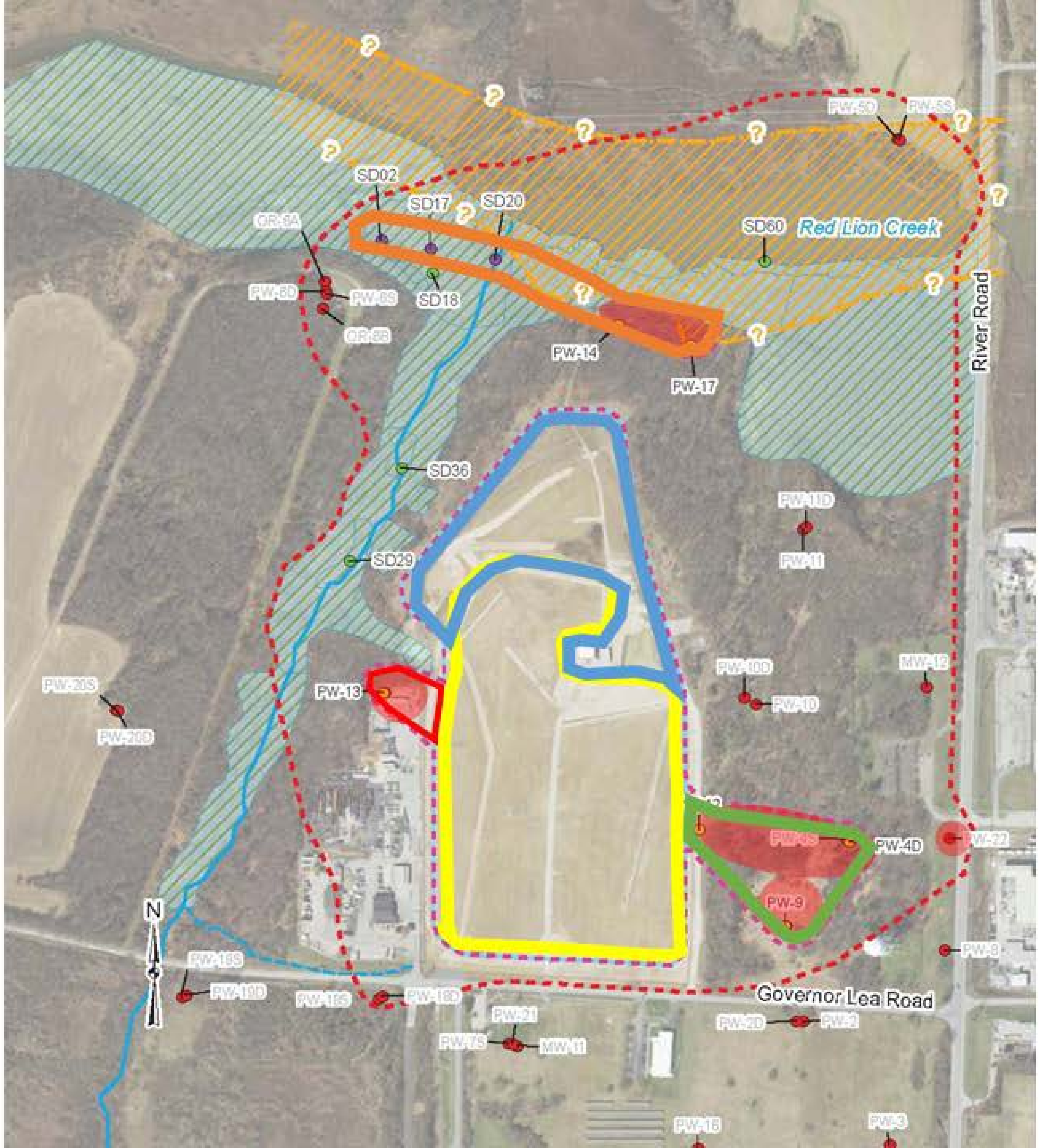
1,4-dichlorobenzene

- Potomac Well
- Aquifer Matrix Sample Locations
- Aquifer Matrix Sample Locations Concentration greater than C_{sat}
- Potomac Well Concentrations Greater than Effective Solubility

	Hotspot of contamination above MCL
	Waste Management Area
	Zone P1 (contamination inferred)
	Zone P2
	Zone P3
	Zone P4

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Inferred Area of DNAPL Presence
- Area where ConfiningUnit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)



Columbia Aquifer

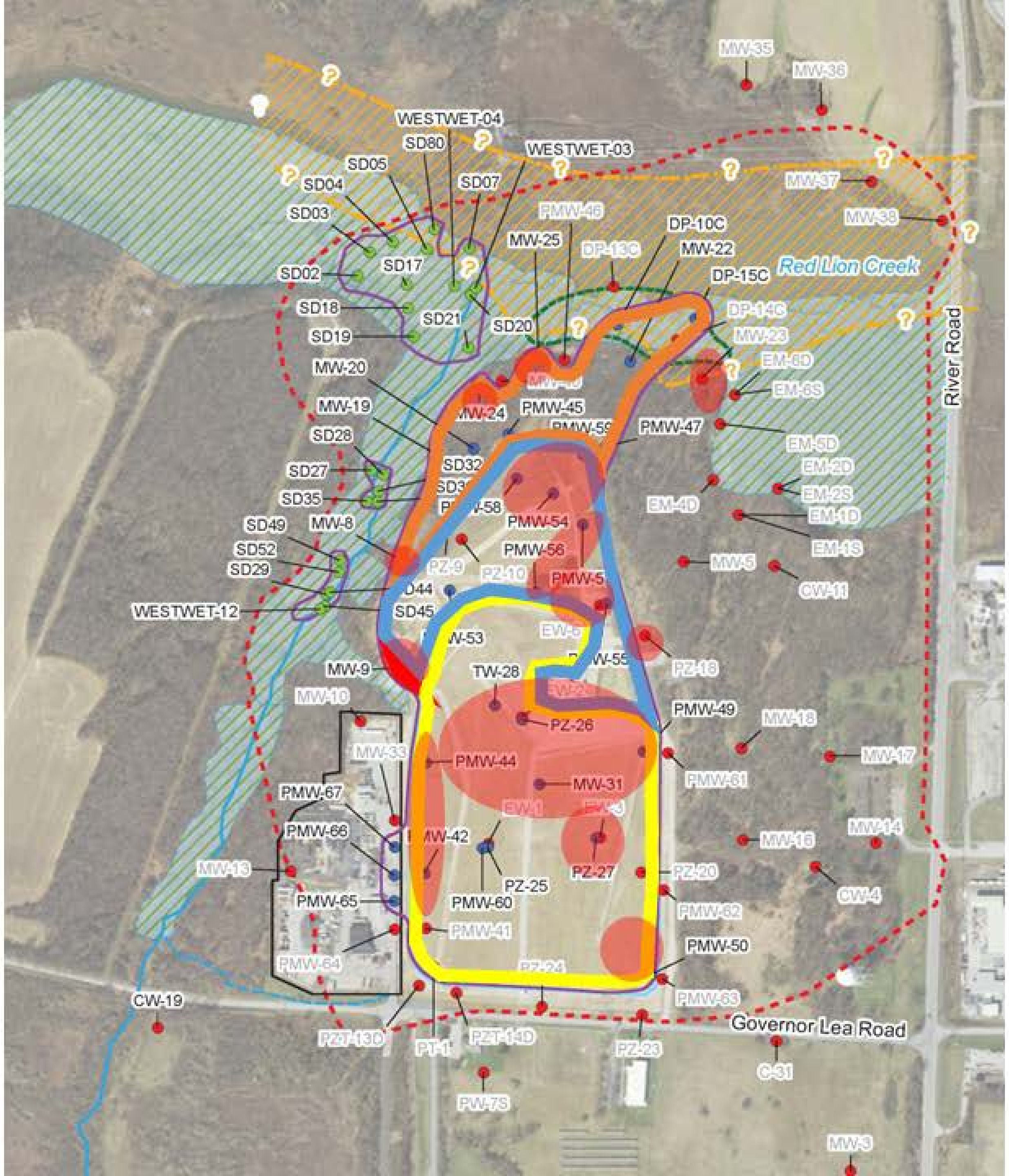
Benzene

- Columbia Well
- Sediment Sample Locations toAquifer Matrix Sample Locations Concentrion greater than C_{sat}
- Columbia Well Concentration Greater than Effective Solubility
- Area where Confining Unit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)

	Hotspot of contamination above MCL
	Waste Management Area
	Zone C1
	Zone C2
	Zone C3
	Zone C4 (no waiver required)

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Areas of DNAPL in Columbia Aquifer Matrix
- Sediment Pore Water Concentrations Evident of DNAPL Contact*



Potomac Aquifer

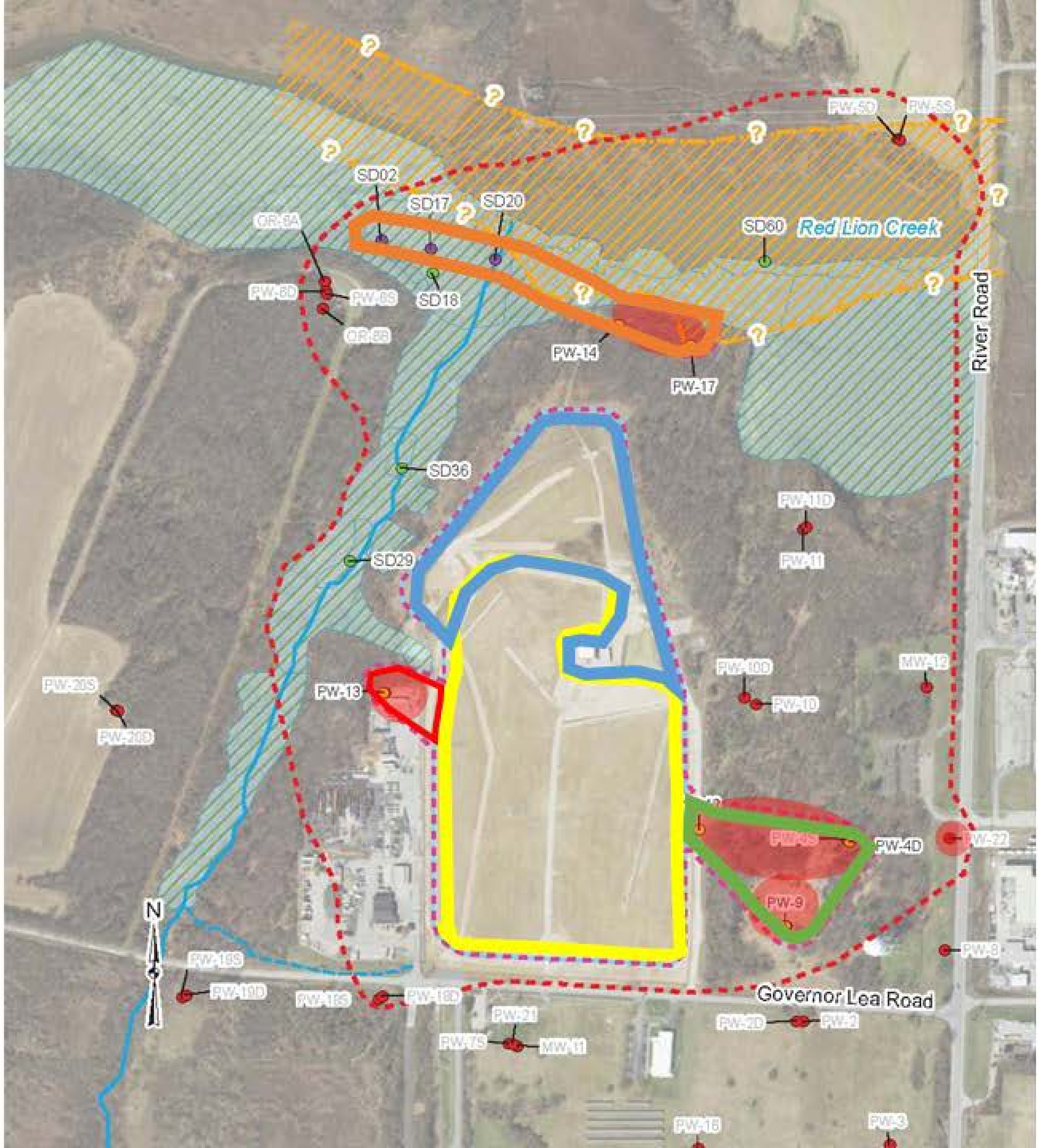
Benzene

- Potomac Well
- Aquifer Matrix Sample Locations
- Aquifer Matrix Sample Locations Concentration greater than C_{sat}
- Potomac Well Concentrations Greater than Effective Solubility

Symbol	Description
(pink fill)	Hotspot of contamination above MCL
(yellow outline)	Waste Management Area
(blue outline)	**Zone P1** (contamination inferred)
(orange outline)	Zone P2
(red outline)	Zone P3
(green outline)	Zone P4

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Inferred Area of DNAPL Presence
- Area where ConfiningUnit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)



Columbia Aquifer

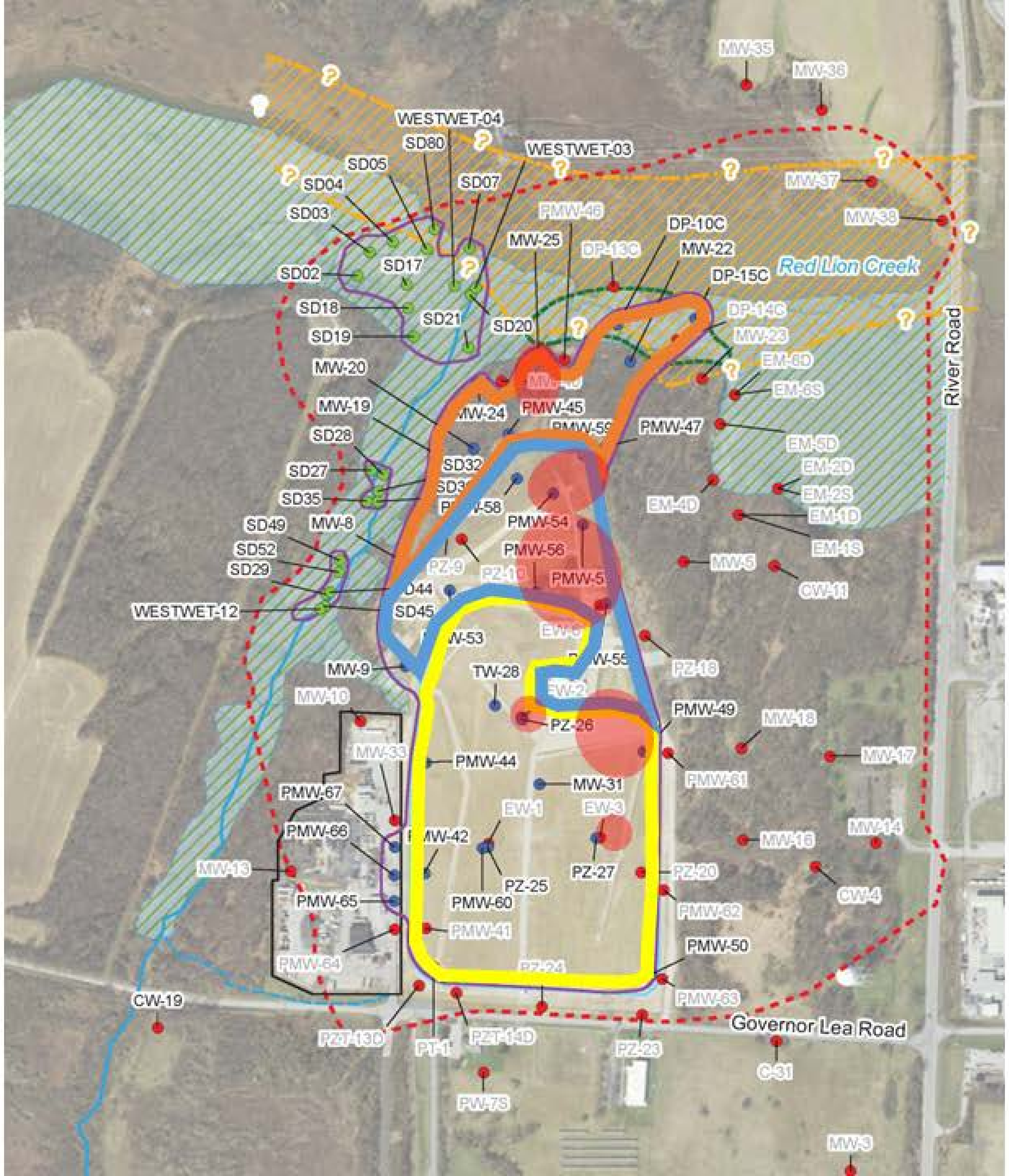
Carbon tetrachloride

- Columbia Well
- Sediment Sample Locations toAquifer Matrix Sample Locations Concentiton greater than C_{sat}
- Columbia Well Concentration Greater than Effective Solubility
- Area where Confining Unit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)

	Hotspot of contamination above MCL
	Waste Management Area
	Zone C1
	Zone C2
	Zone C3 (no waiver required)
	Zone C4 (no waiver required)

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Areas of DNAPL in Columbia Aquifer Matrix
- Sediment Pore Water Concentrations Evident of DNAPL Contact*



Potomac Aquifer

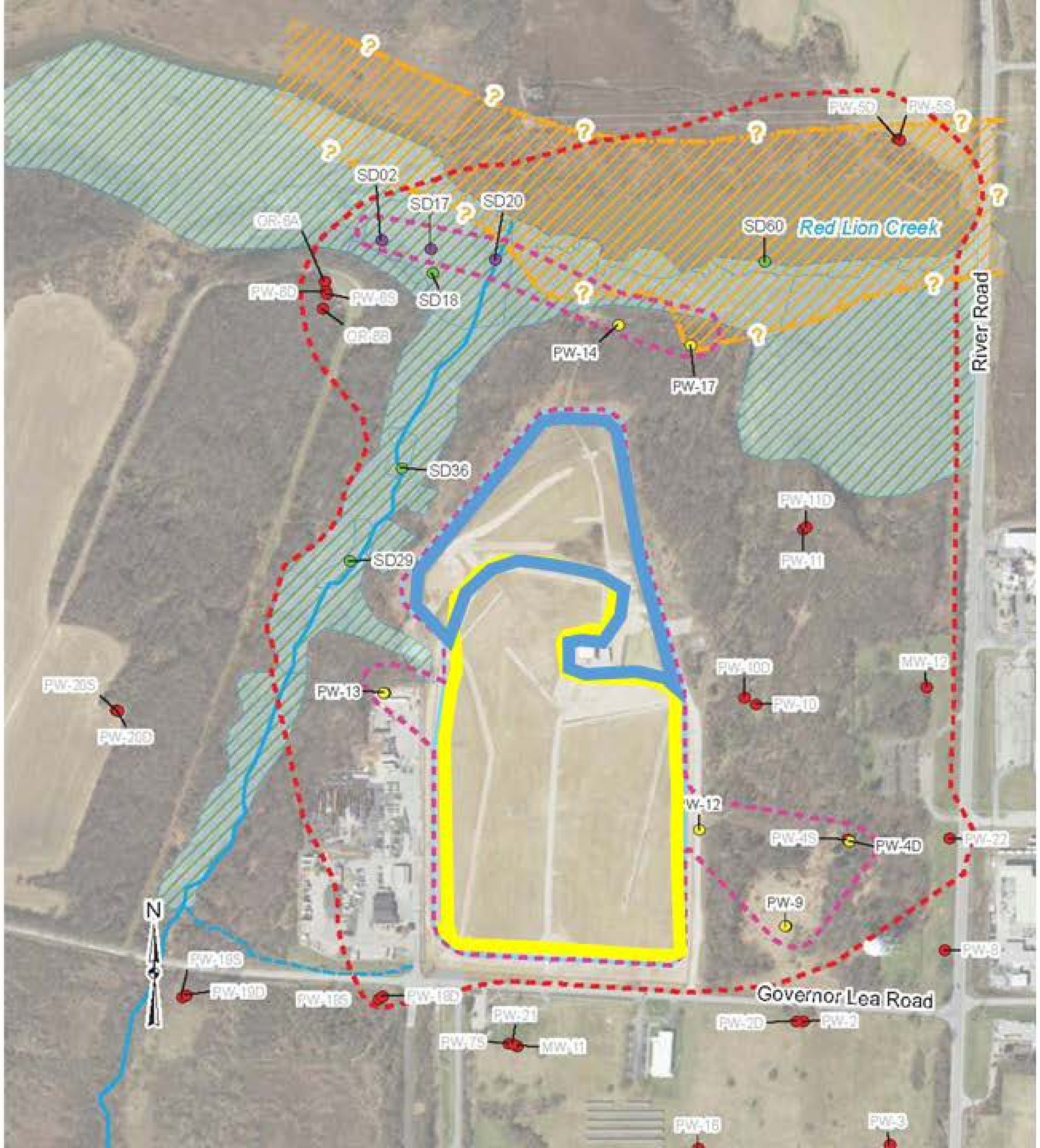
Carbon tetrachloride

- Potomac Well
- Aquifer Matrix Sample Locations
- Aquifer Matrix Sample Locations Concentration greater than C_{sat}
- Potomac Well Concentrations Greater than Effective Solubility

	Hotspot of contamination above MCL
	Waste Management Area
	Zone P1 (contamination inferred)
	Zone P2 (no waiver required)
	Zone P3 (no waiver required)
	Zone P4 (no waiver required)

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Inferred Area of DNAPL Presence
- Area where ConfiningUnit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)



Columbia Aquifer

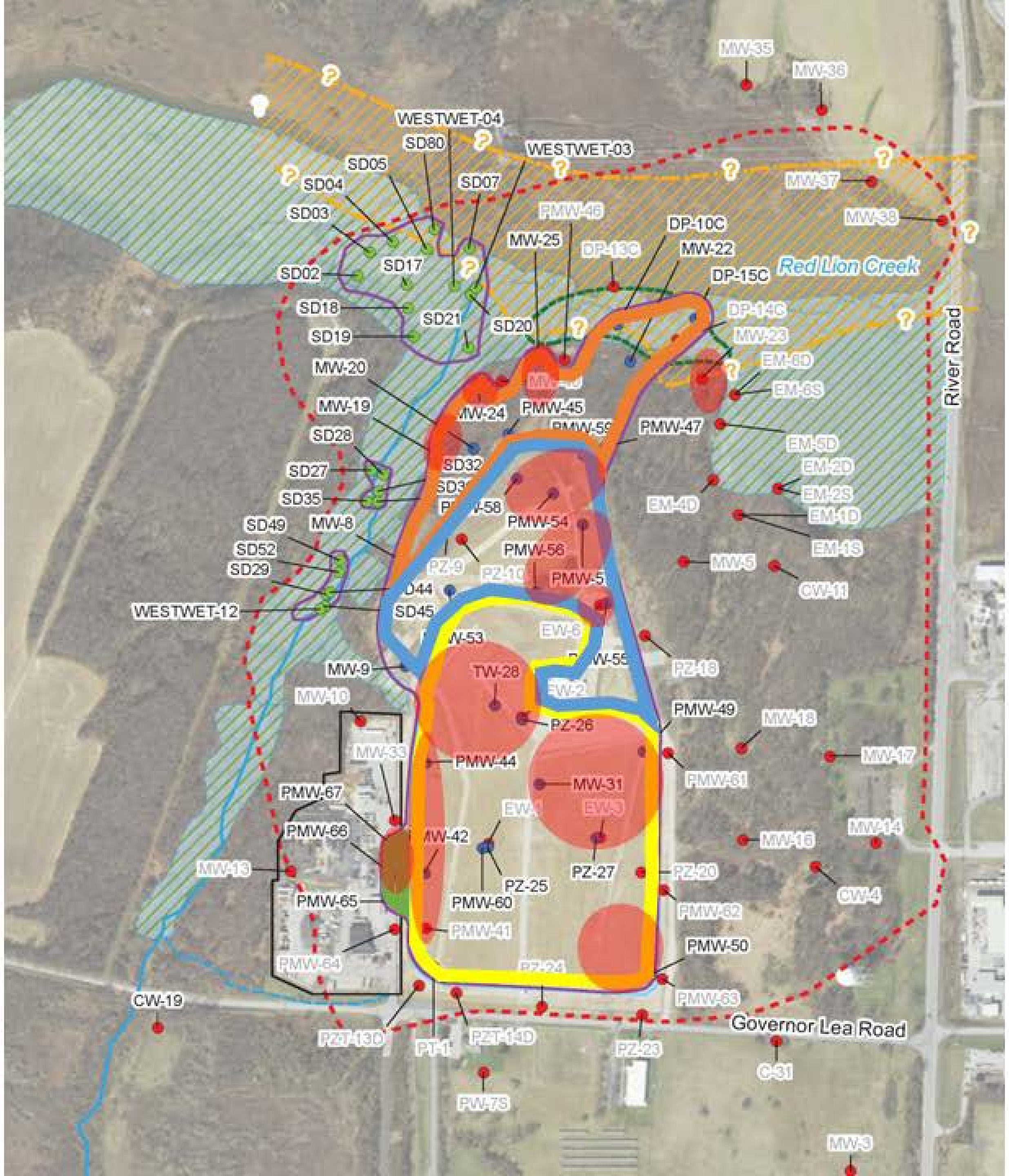
Chlorobenzene

- Columbia Well
- Sediment Sample Locations toAquifer Matrix Sample Locations Concentiton greater than C_{sat}
- Columbia Well Concentration Greater than Effective Solubility
- Area where Confining Unit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)

	Hotspot of contamination above MCL
	Waste Management Area
	Zone C1
	Zone C2
	Zone C3 (no waiver required)
	Zone C4

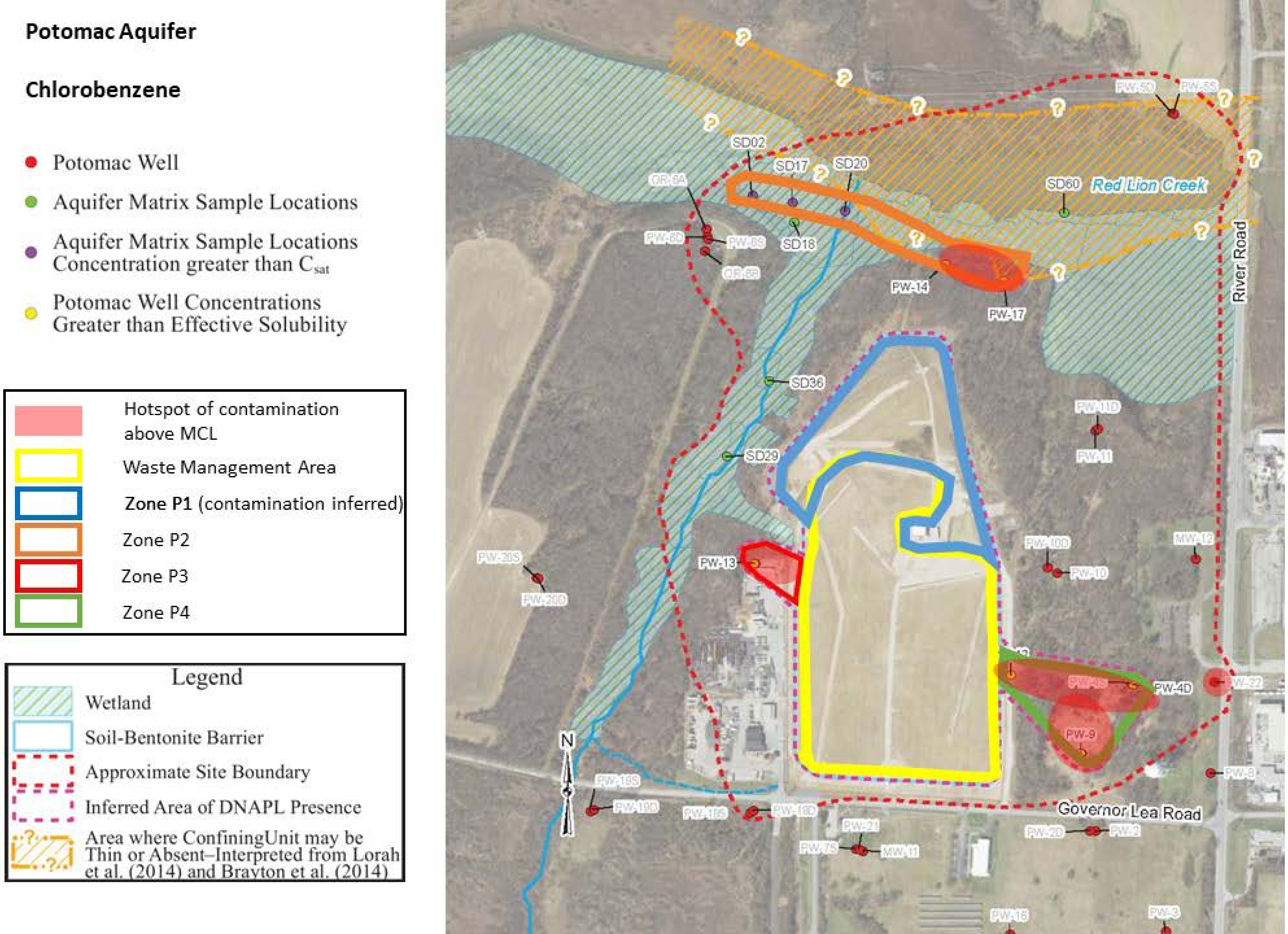
Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Areas of DNAPL in Columbia Aquifer Matrix
- Sediment Pore Water Concentrations Evident of DNAPL Contact*



Potomac Aquifer

Chlorobenzene

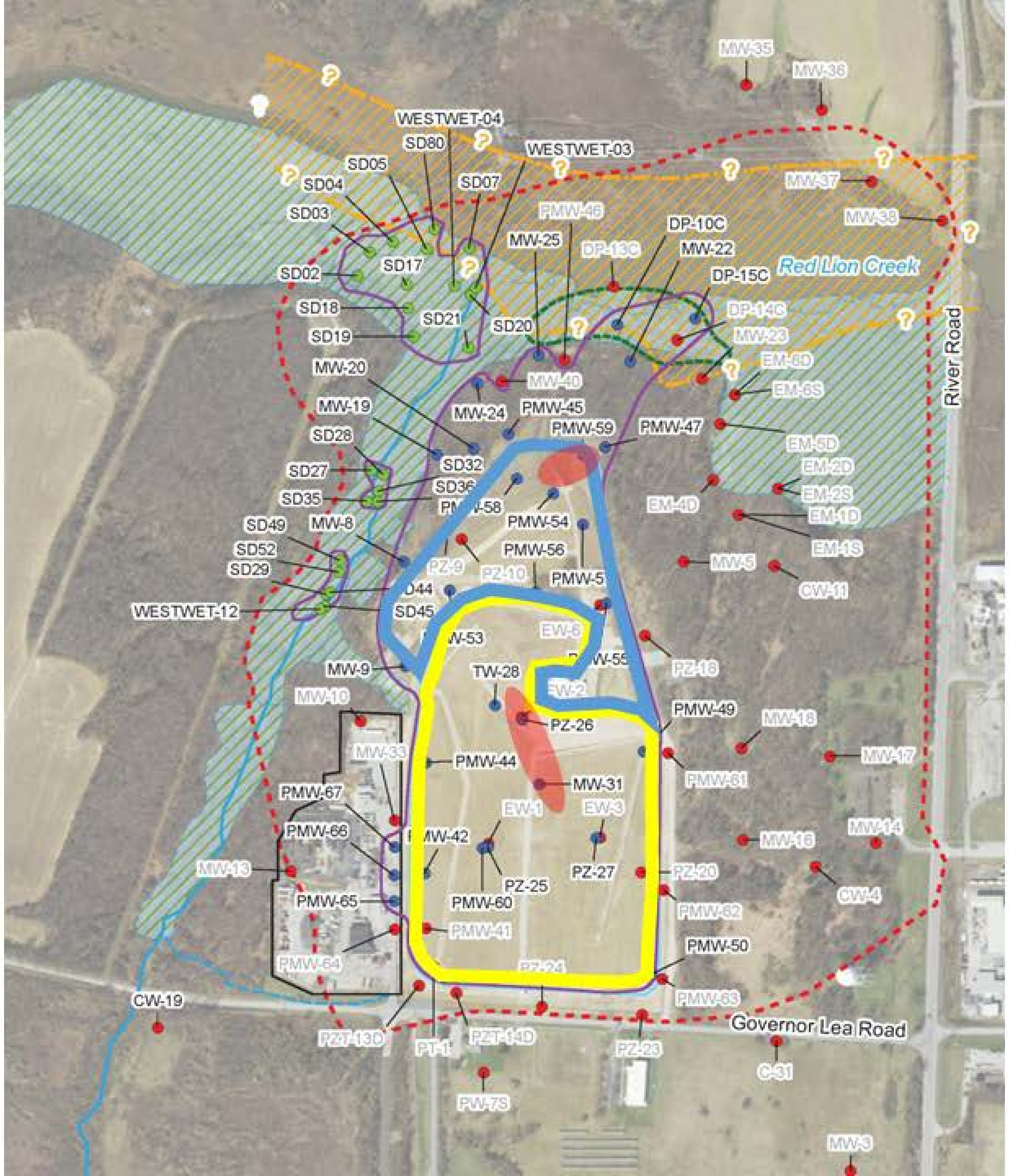


Columbia Aquifer

Total trihalomethanes

- Columbia Well
- Sediment Sample Locations to Aquifer Matrix Sample Locations Concentration greater than C_{sat}
- Columbia Well Concentration Greater than Effective Solubility
- Area where Confining Unit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)

	Hotspot of contamination above MCL
	Waste Management Area
	Zone C1
	Zone C2 (no waiver required)
	Zone C3 (no waiver required)
	Zone C4 (no waiver required)



Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Areas of DNAPL in Columbia Aquifer Matrix
- Sediment Pore Water Concentrations Evident of DNAPL Contact*

Potomac Aquifer

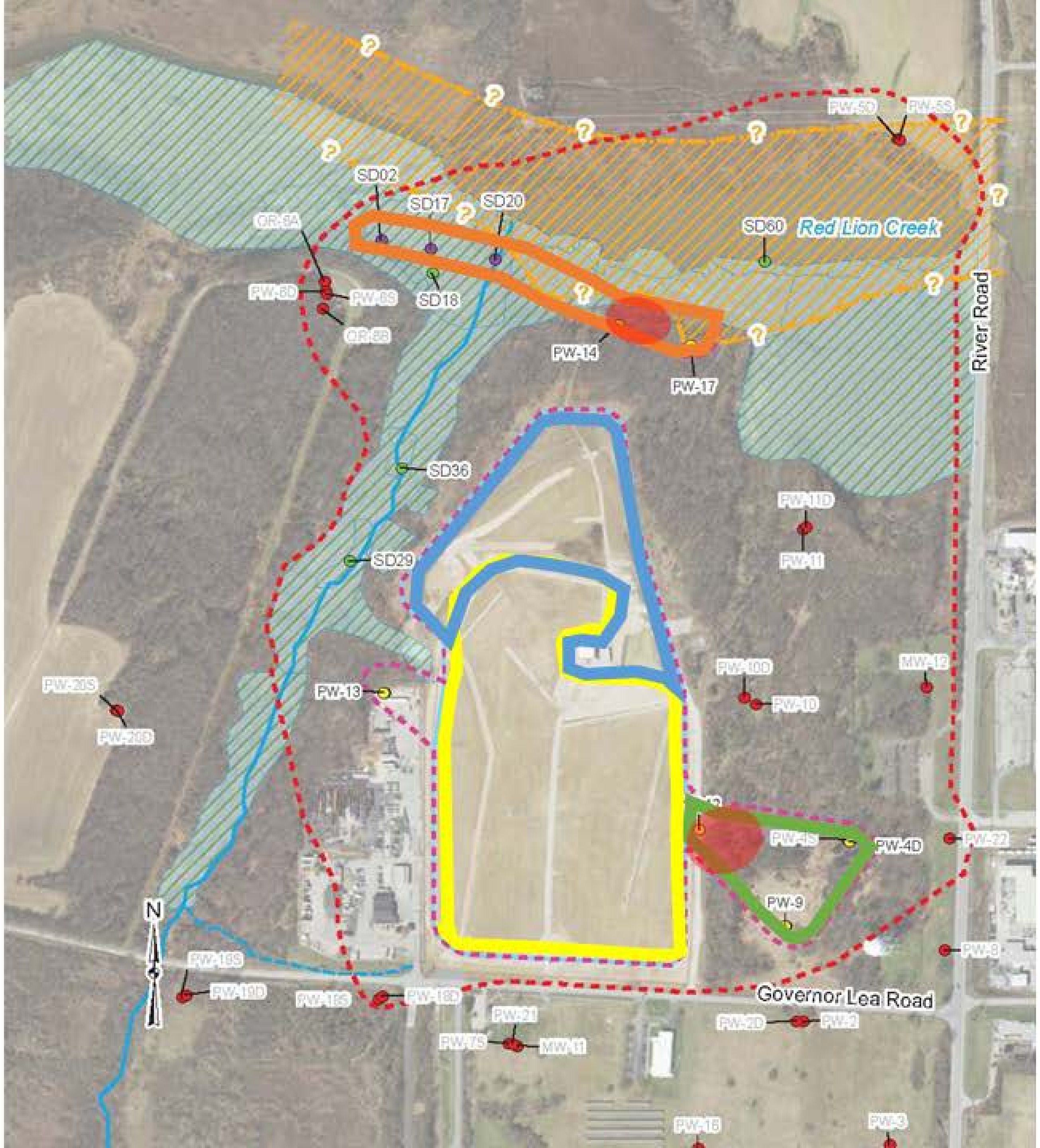
Total Trihalomethanes

- Potomac Well
- Aquifer Matrix Sample Locations
- Aquifer Matrix Sample Locations Concentration greater than C_{sat}
- Potomac Well Concentrations Greater than Effective Solubility

Symbol	Description
Pink fill	Hotspot of contamination above MCL
Yellow outline	Waste Management Area
Blue outline	**Zone P1** (contamination inferred)
Orange outline	Zone P2
Red outline	Zone P3 (no waiver required)
Green outline	Zone P4

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Inferred Area of DNAPL Presence
- Area where ConfiningUnit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)



Columbia Aquifer

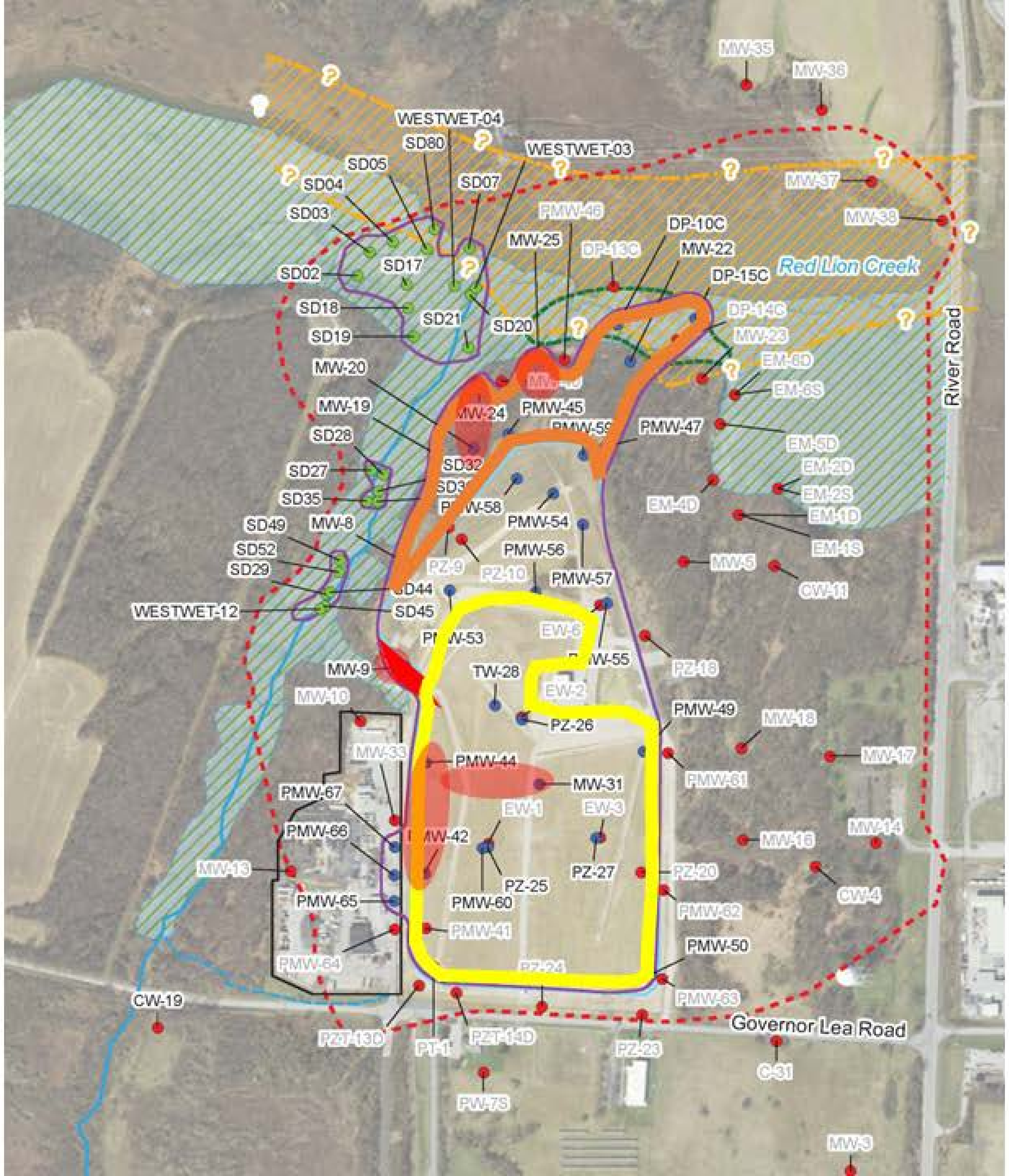
PCBs

- Columbia Well
- Sediment Sample Locations toAquifer Matrix Sample Locations Concentiton greater than C_{sat}
- Columbia Well Concentration Greater than Effective Solubility
- Area where Confining Unit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)

(pink fill)	Hotspot of contamination above MCL
(yellow outline)	Waste Management Area
(blue outline)	Zone C1 (no waiver required)
(orange outline)	Zone C2
(red outline)	Zone C3
(green outline)	Zone C4 (no waiver required)

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Areas of DNAPL in Columbia Aquifer Matrix
- Sediment Pore Water Concentrations Evident of DNAPL Contact*



Potomac Aquifer

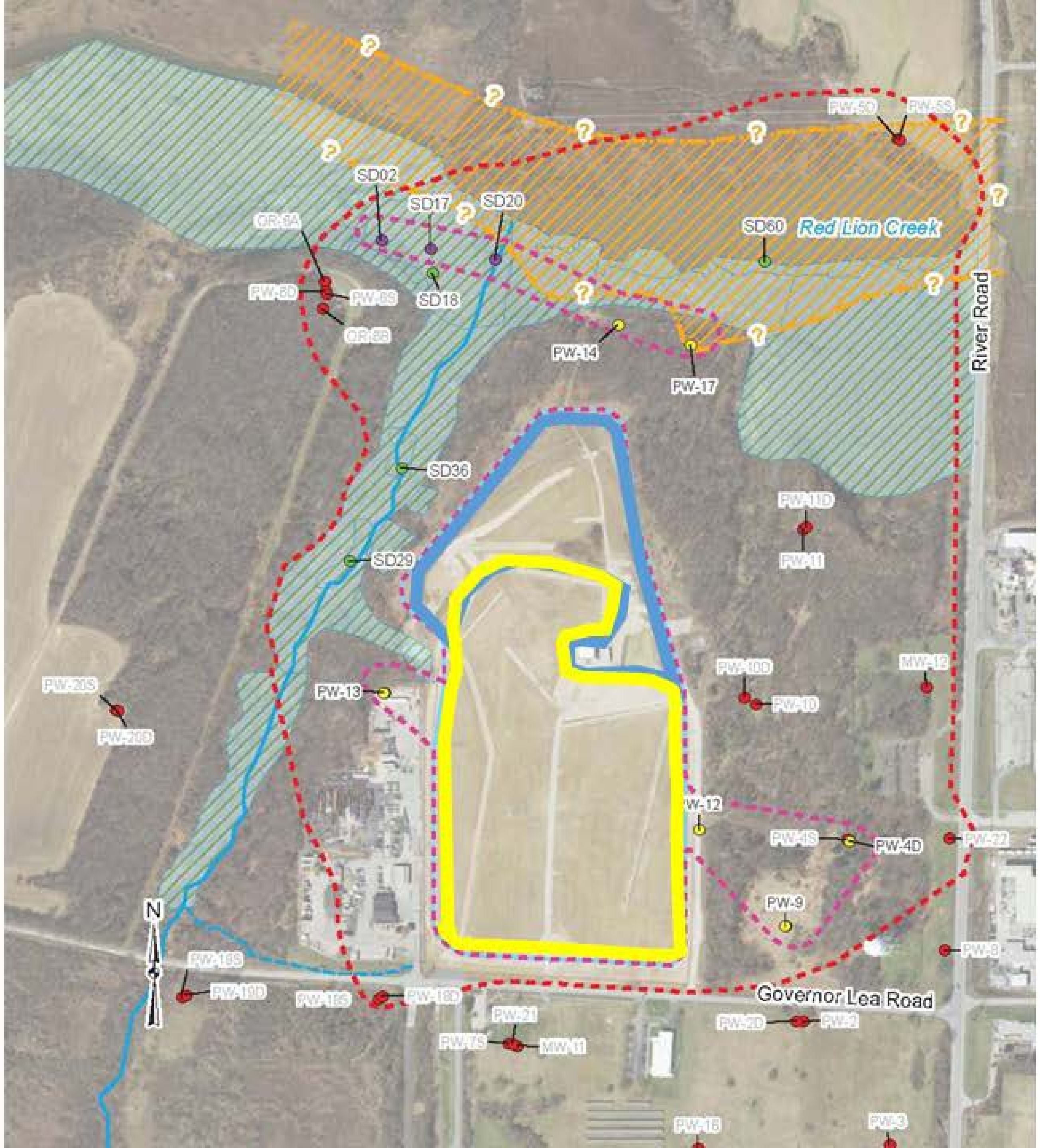
PCBs – no exceedances

- Potomac Well
- Aquifer Matrix Sample Locations
- Aquifer Matrix Sample Locations Concentration greater than C_{sat}
- Potomac Well Concentrations Greater than Effective Solubility

	Hotspot of contamination above MCL
	Waste Management Area
	Zone P1 (contamination inferred)
	Zone P2 (no waiver required)
	Zone P3 (no waiver required)
	Zone P4 (no waiver required)

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Inferred Area of DNAPL Presence
- Area where ConfiningUnit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)



Columbia Aquifer

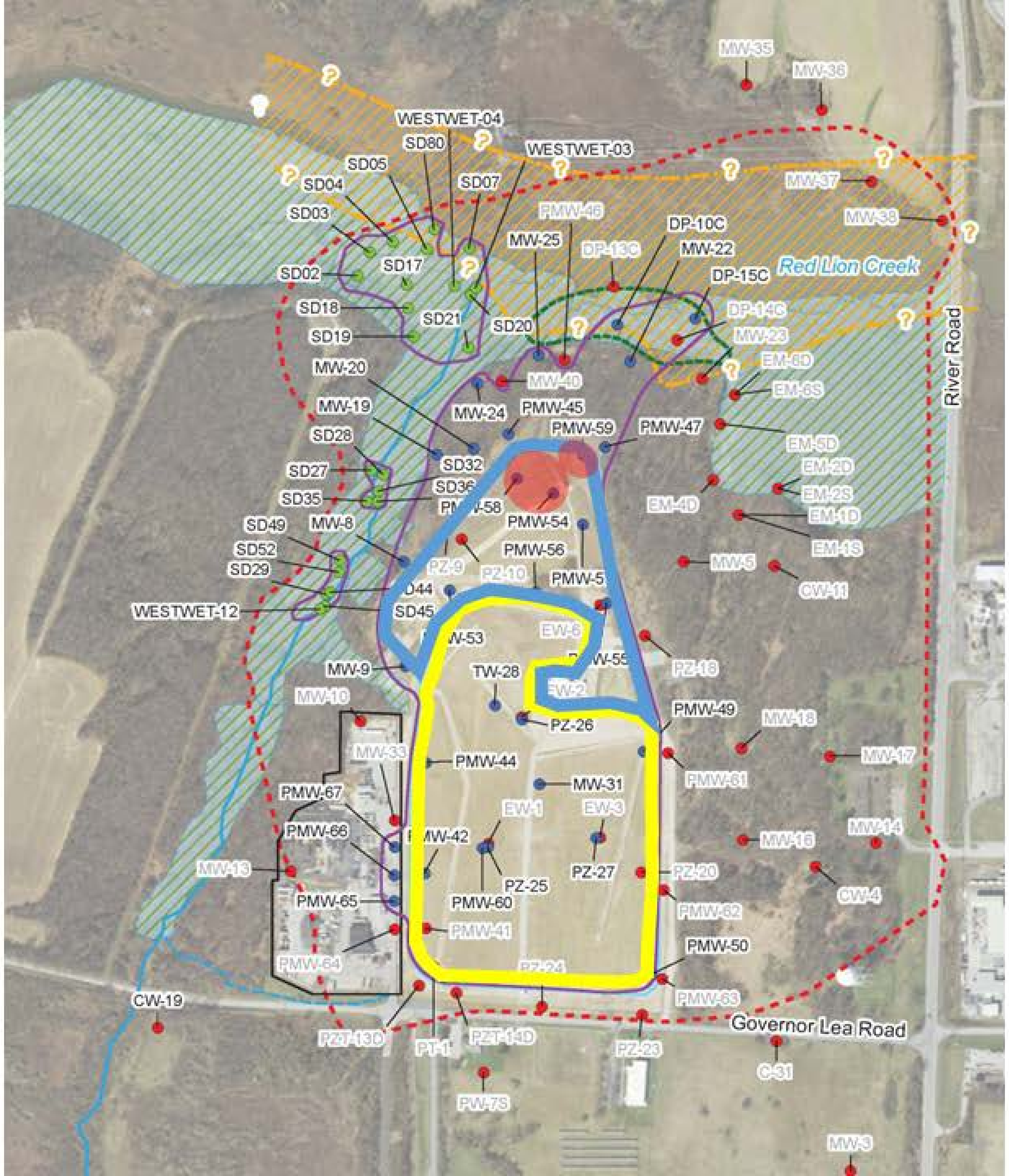
Beryllium

- Columbia Well
- Sediment Sample Locations toAquifer Matrix Sample Locations Concention greater than C_{sat}
- Columbia Well Concentration Greater than Effective Solubility
- Area where Confining Unit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)

	Hotspot of contamination above MCL
	Waste Management Area
	Zone C1
	Zone C2 (no waiver required)
	Zone C3 (no waiver required)
	Zone C4 (no waiver required)

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Areas of DNAPL in Columbia Aquifer Matrix
- Sediment Pore Water Concentrations Evident of DNAPL Contact*



Potomac Aquifer

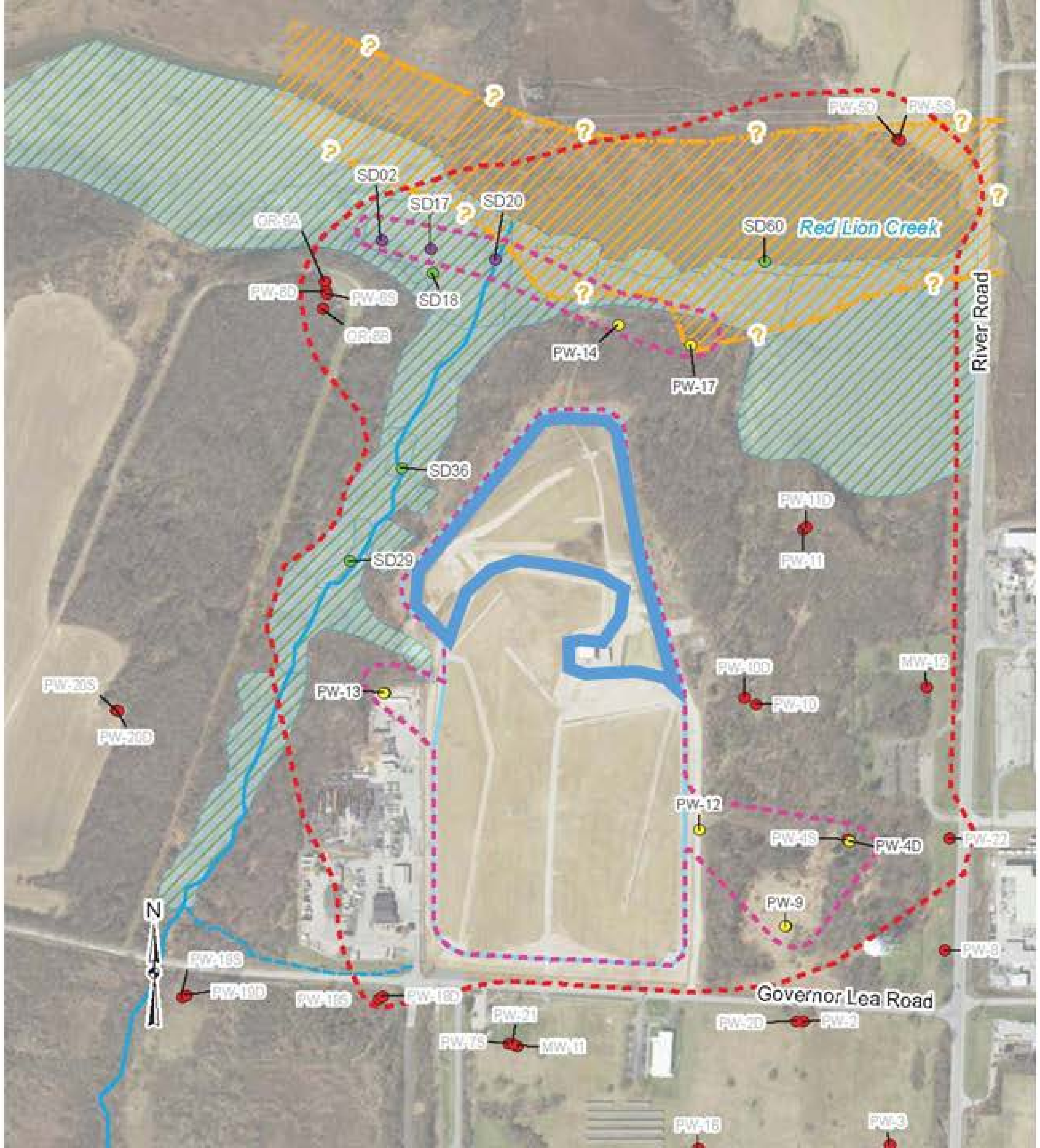
Beryllium

- Potomac Well
- Aquifer Matrix Sample Locations
- Aquifer Matrix Sample Locations Concentration greater than C_{sat}
- Potomac Well Concentrations Greater than Effective Solubility

	Hotspot of contamination above MCL
	Waste Management Area
	Zone P1 (contamination inferred)
	Zone P2 (no waiver required)
	Zone P3 (no waiver required)
	Zone P4 (no waiver required)

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Inferred Area of DNAPL Presence
- Area where ConfiningUnit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)



Columbia Aquifer

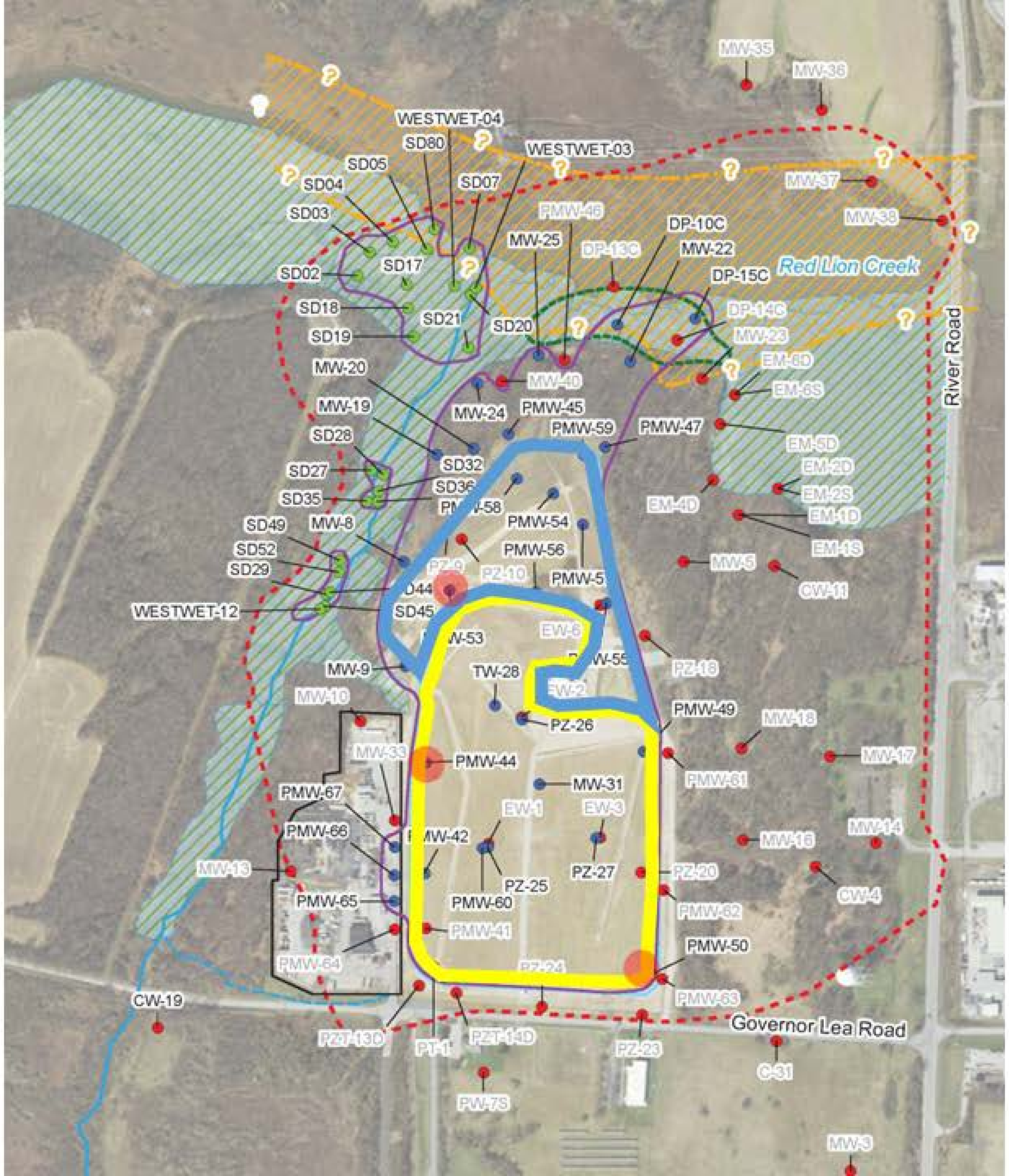
Chromium

- Columbia Well
- Sediment Sample Locations toAquifer Matrix Sample Locations Concentiion greater than C_{sat}
- Columbia Well Concentration Greater than Effective Solubility
- Area where Confining Unit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)

	Hotspot of contamination above MCL
	Waste Management Area
	Zone C1
	Zone C2 (no waiver required)
	Zone C3 (no waiver required)
	Zone C4 (no waiver required)

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Areas of DNAPL in Columbia Aquifer Matrix
- Sediment Pore Water Concentrations Evident of DNAPL Contact*



Potomac Aquifer

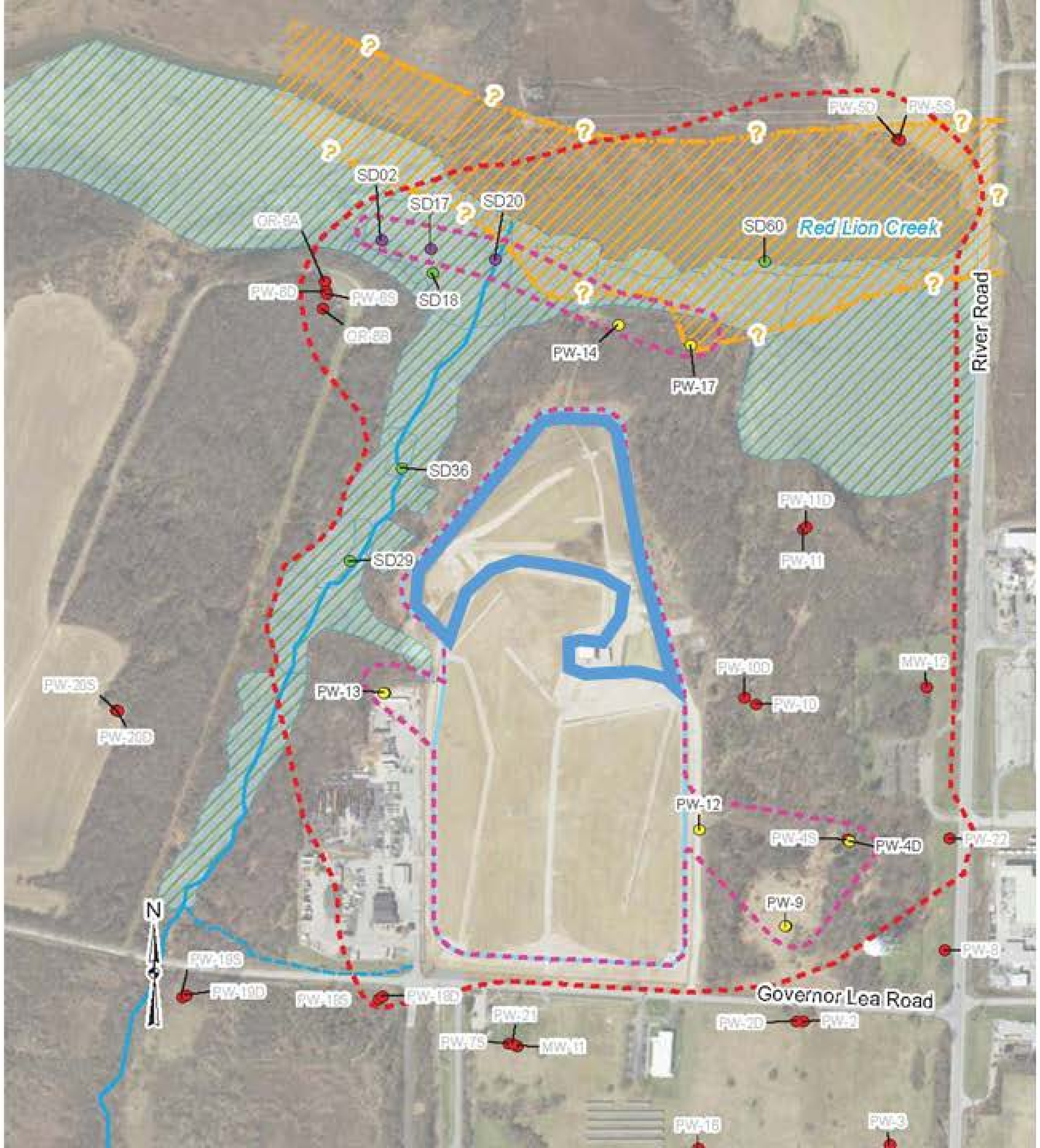
Chromium

- Potomac Well
- Aquifer Matrix Sample Locations
- Aquifer Matrix Sample Locations Concentration greater than C_{sat}
- Potomac Well Concentrations Greater than Effective Solubility

(pink fill)	Hotspot of contamination above MCL
(yellow outline)	Waste Management Area
(blue outline)	**Zone P1** (contamination inferred)
(orange outline)	Zone P2 (no waiver required)
(red outline)	Zone P3 (no waiver required)
(green outline)	Zone P4 (no waiver required)

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Inferred Area of DNAPL Presence
- Area where ConfiningUnit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)



Columbia Aquifer

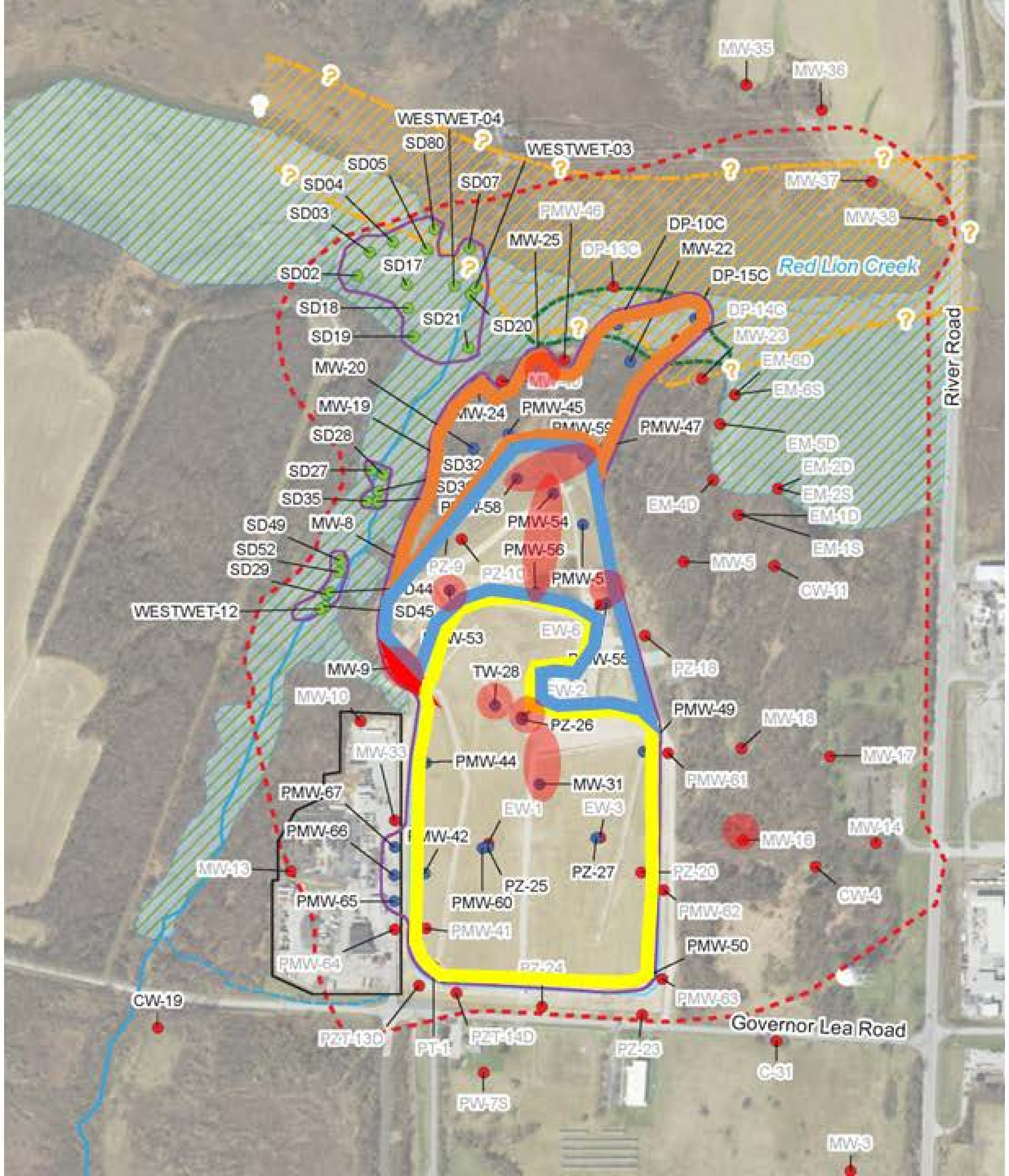
Thallium

- Columbia Well
- Sediment Sample Locations toAquifer Matrix Sample Locations Concentiton greater than C_{sat}
- Columbia Well Concentration Greater than Effective Solubility
- Area where Confining Unit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)

	Hotspot of contamination above MCL
	Waste Management Area
	Zone C1
	Zone C2
	Zone C3
	Zone C4 (no waiver required)

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Areas of DNAPL in Columbia Aquifer Matrix
- Sediment Pore Water Concentrations Evident of DNAPL Contact*



Potomac Aquifer

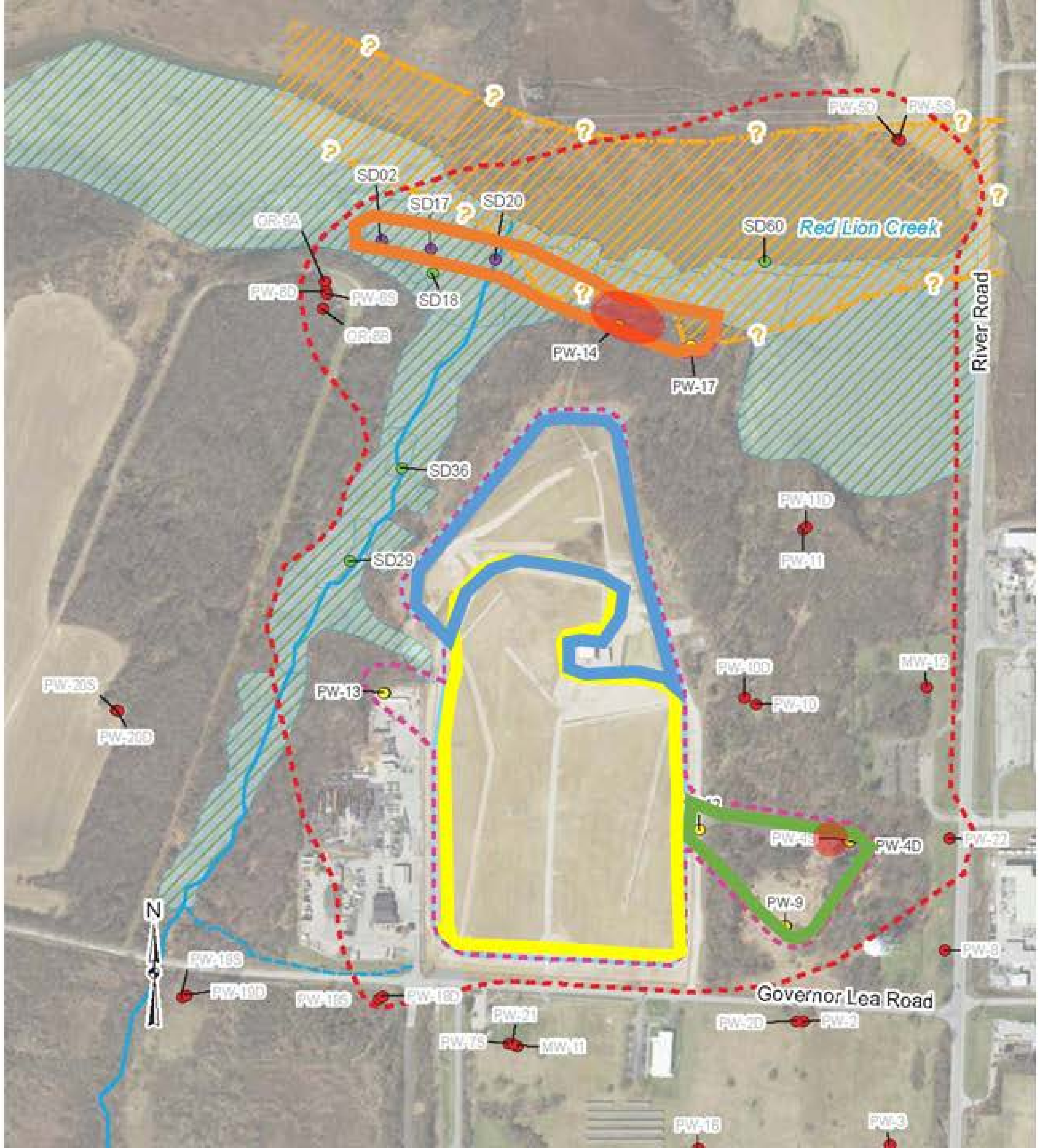
Thallium

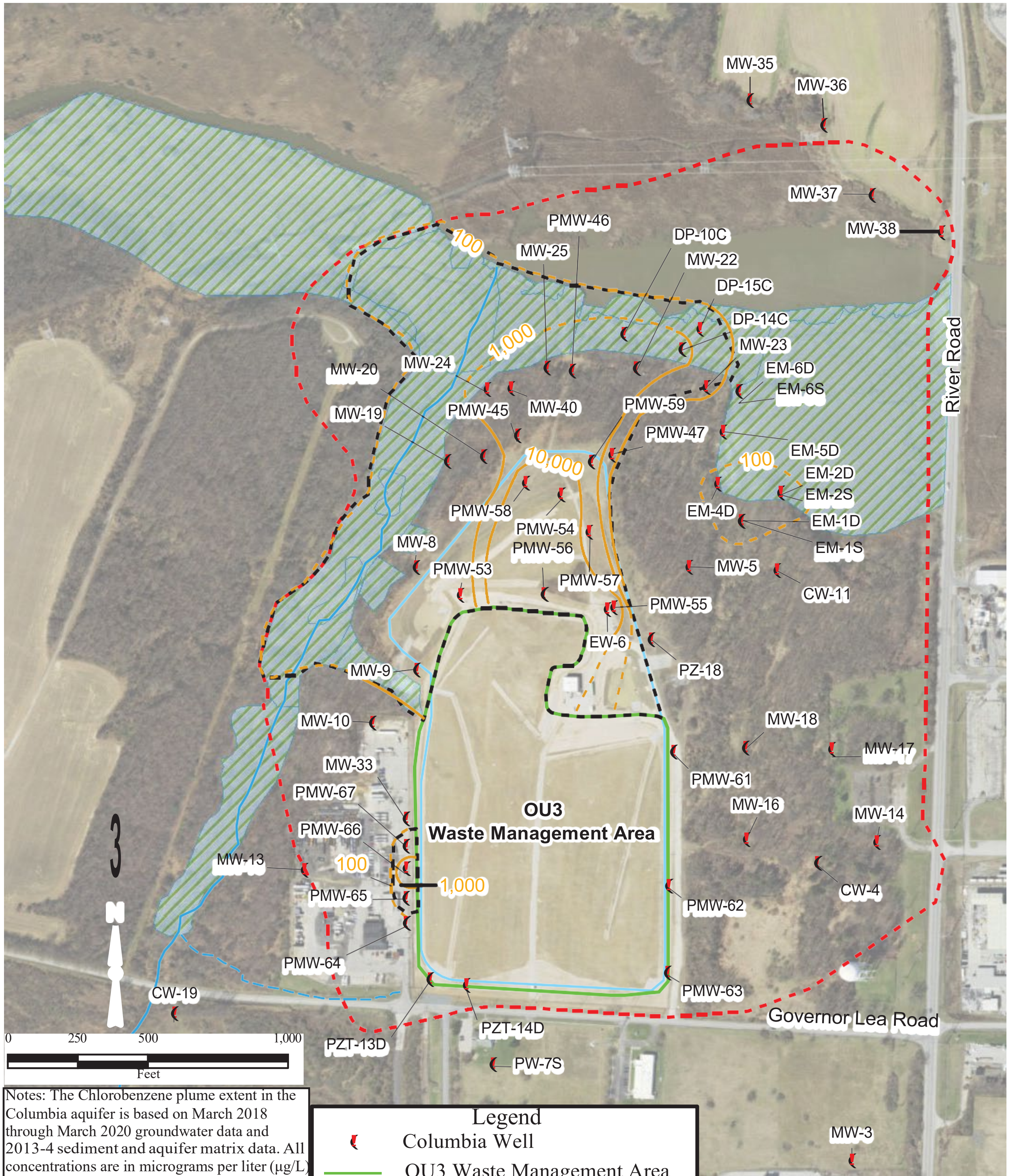
- Potomac Well
- Aquifer Matrix Sample Locations
- Aquifer Matrix Sample Locations Concentration greater than C_{sat}
- Potomac Well Concentrations Greater than Effective Solubility

(pink fill)	Hotspot of contamination above MCL
(yellow outline)	Waste Management Area
(blue outline)	**Zone P1** (contamination inferred)
(orange outline)	Zone P2
(red outline)	Zone P3 (no waiver required)
(green outline)	Zone P4

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Inferred Area of DNAPL Presence
- Area where ConfiningUnit may be Thin or Absent–Interpreted from Lorah et al. (2014) and Brayton et al. (2014)





Notes: The Chlorobenzene plume extent in the Columbia aquifer is based on March 2018 through March 2020 groundwater data and 2013-4 sediment and aquifer matrix data. All concentrations are in micrograms per liter (µg/L)

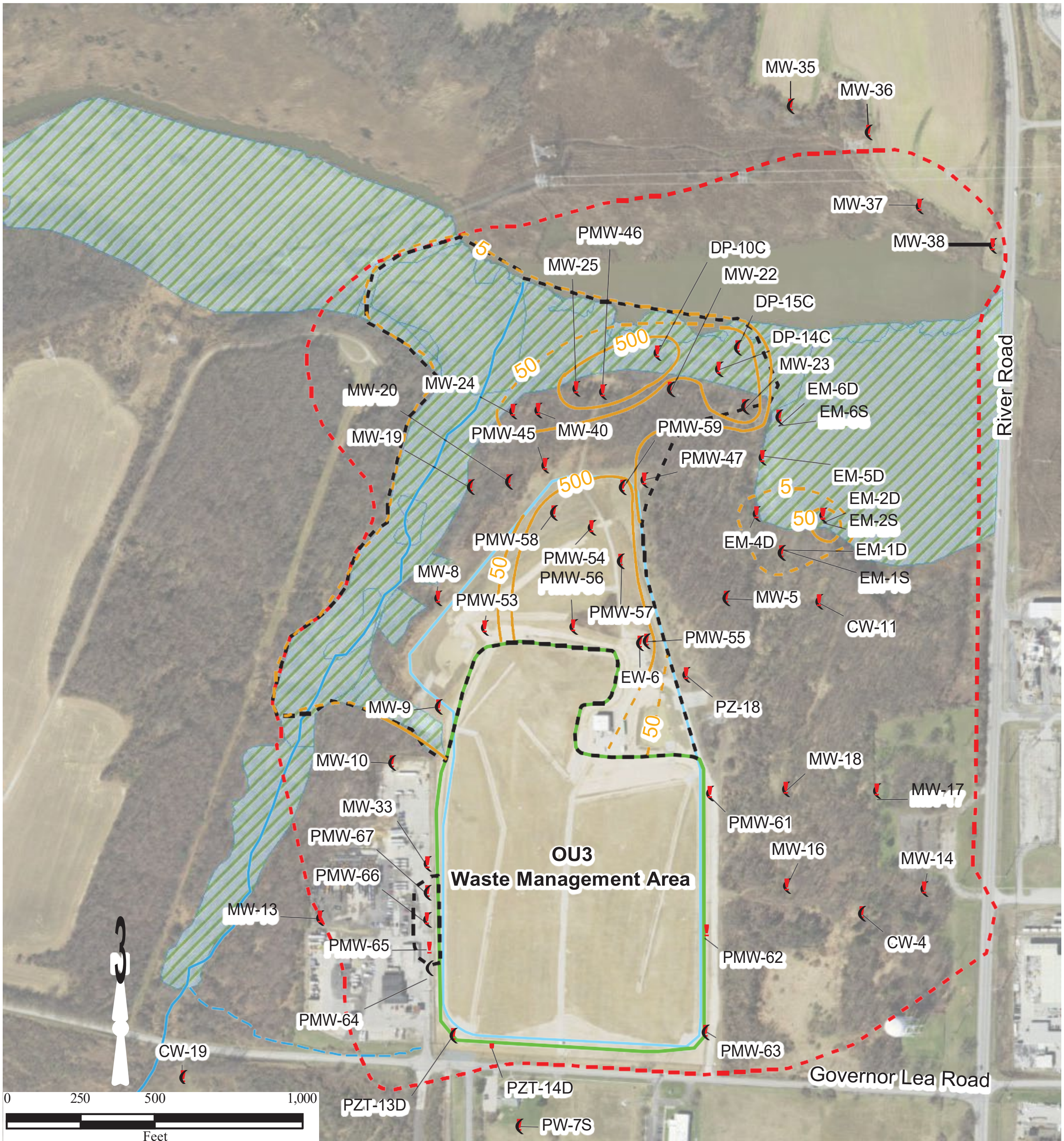
Legend

- Columbia Well
- OU3 Waste Management Area
- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Columbia Aquifer Chlorobenzene Concentration Contour (Dashed where inferred)
- Technical Impracticability (TI) Waiver Area Boundary

\\srv-gst-01\HGLGIS\Standard_Chlorine_MSIW\TI_WE\(1-2b)Chlorobenzene_Mar2020_Columbia.mxd
6/26/2020 CNL
Source: HGL
ESRI Online Aerial Imagery

HGL HydroGeoLogic, Inc

Figure 1.2b
Columbia Aquifer Chlorobenzene MCL Exceedance Areas
March 2020



Notes: The Benzene plume extent in the Columbia aquifer is based on March 2018 through March 2020 groundwater data and 2013-4 sediment and aquifer matrix data. All concentrations are in micrograms per liter (µg/L)

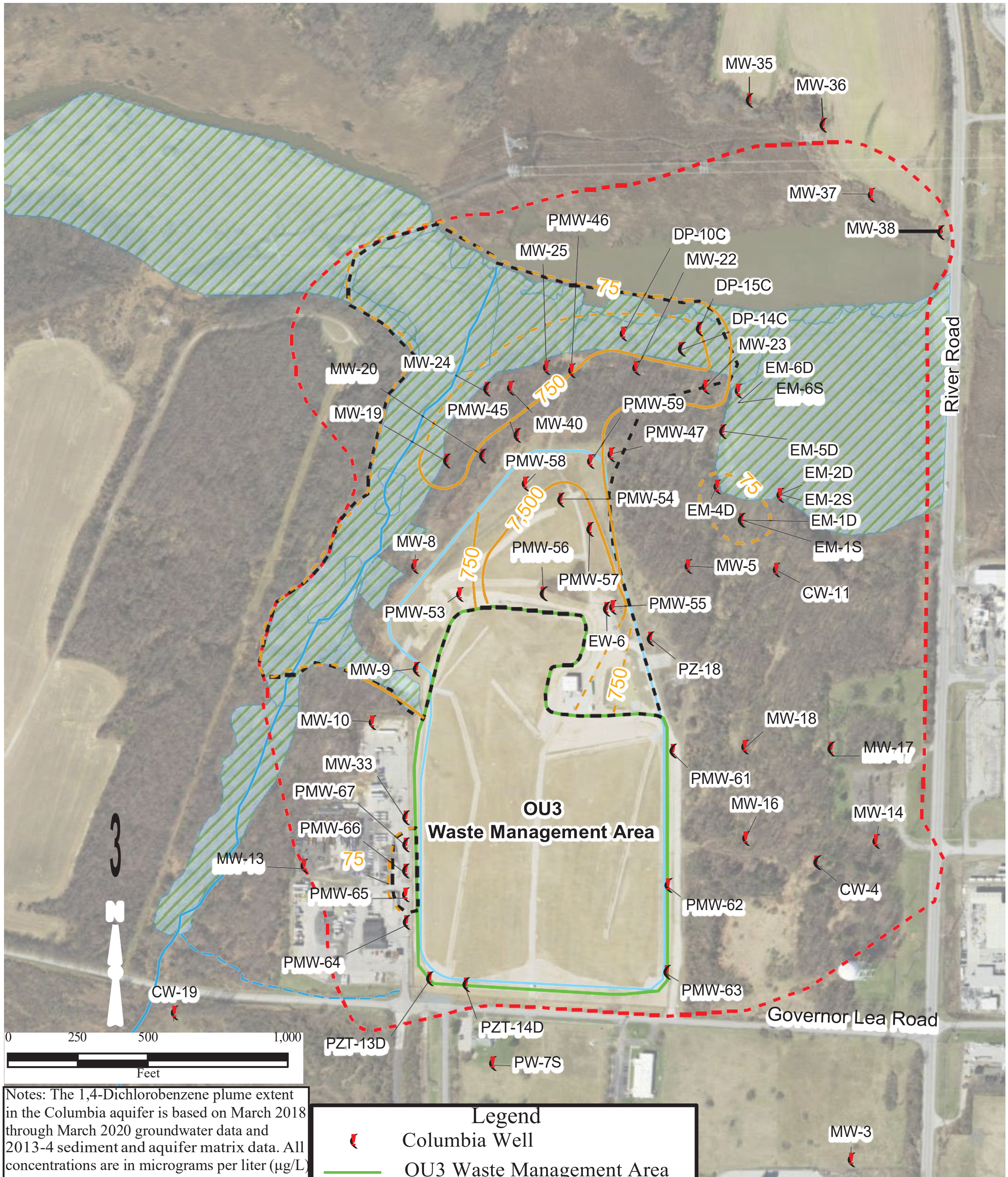
\\srv-gst-01\HGLGIS\Standard_Chlorine_MSIW\TI_WE\(1-2c)Benzene_Mar2020_Columbia.mxd
6/26/2020 TH
Source: HGL
ESRI Online Aerial Imagery

HGL HydroGeoLogic, Inc

Legend

- Columbia Well
- OU3 Waste Management Area
- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Columbia Aquifer Benzene Concentration Contour (Dashed where inferred)
- Technical Impracticability (TI) Waiver Area Boundary

Figure 1.2c
Columbia Aquifer Benzene MCL Exceedance Areas
March 2020



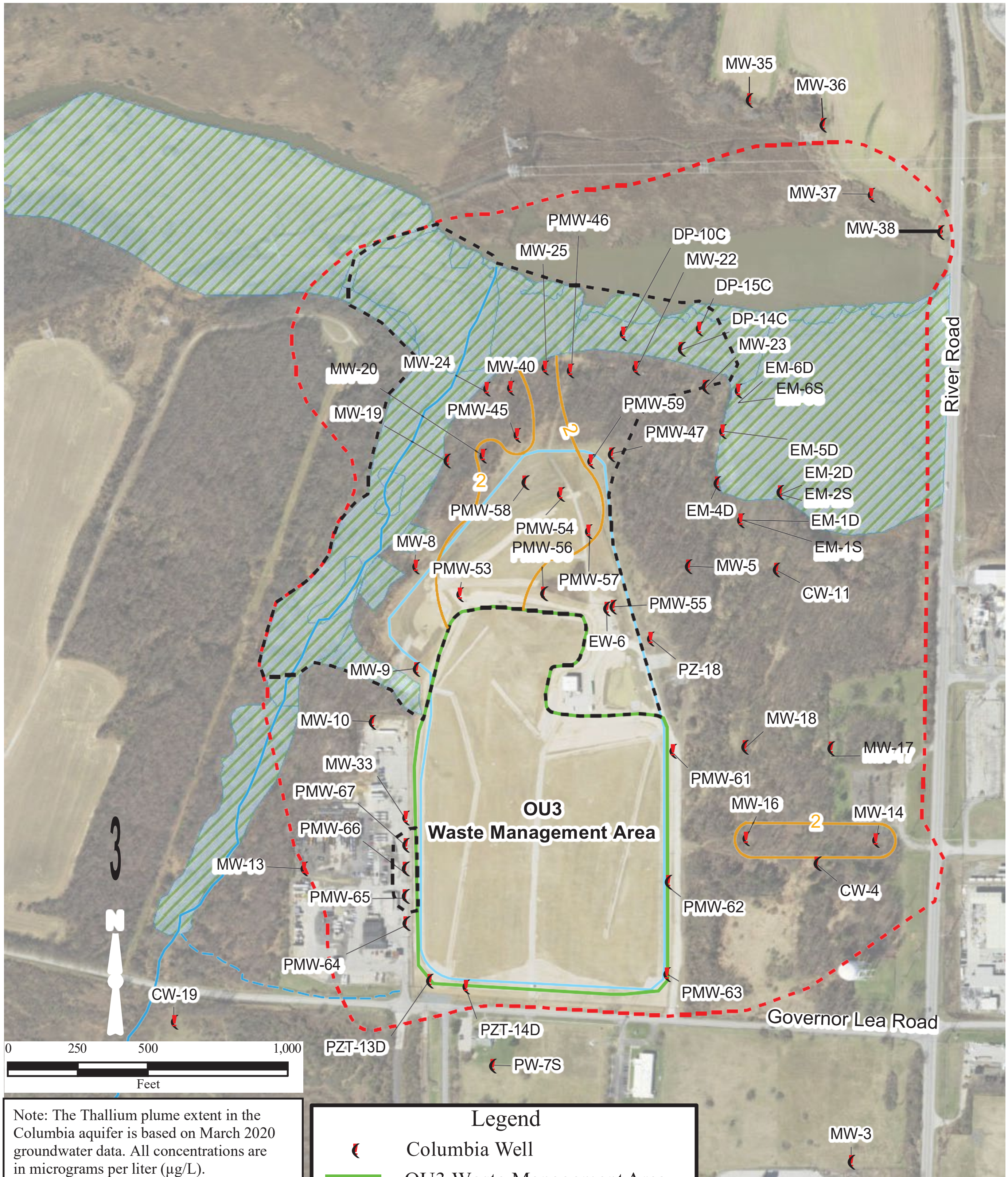
Notes: The 1,4-Dichlorobenzene plume extent in the Columbia aquifer is based on March 2018 through March 2020 groundwater data and 2013-4 sediment and aquifer matrix data. All concentrations are in micrograms per liter (µg/L)

Legend

- Columbia Well
- OU3 Waste Management Area
- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Columbia Aquifer 1,4-Dichlorobenzene Concentration Contour (Dashed where inferred)
- Technical Impracticability (TI) Waiver Area Boundary

\\srv-gst-01\HGLGIS\Standard_Chlorine_MSIW\TI_WE\(1-2d)1-4_DCB_Mar2020_Columbia.mxd
6/26/2020 TH
Source: HGL
ESRI Online Aerial Imagery

Figure 1.2d
Columbia Aquifer
1,4-Dichlorobenzene
MCL Exceedance Areas
March 2020



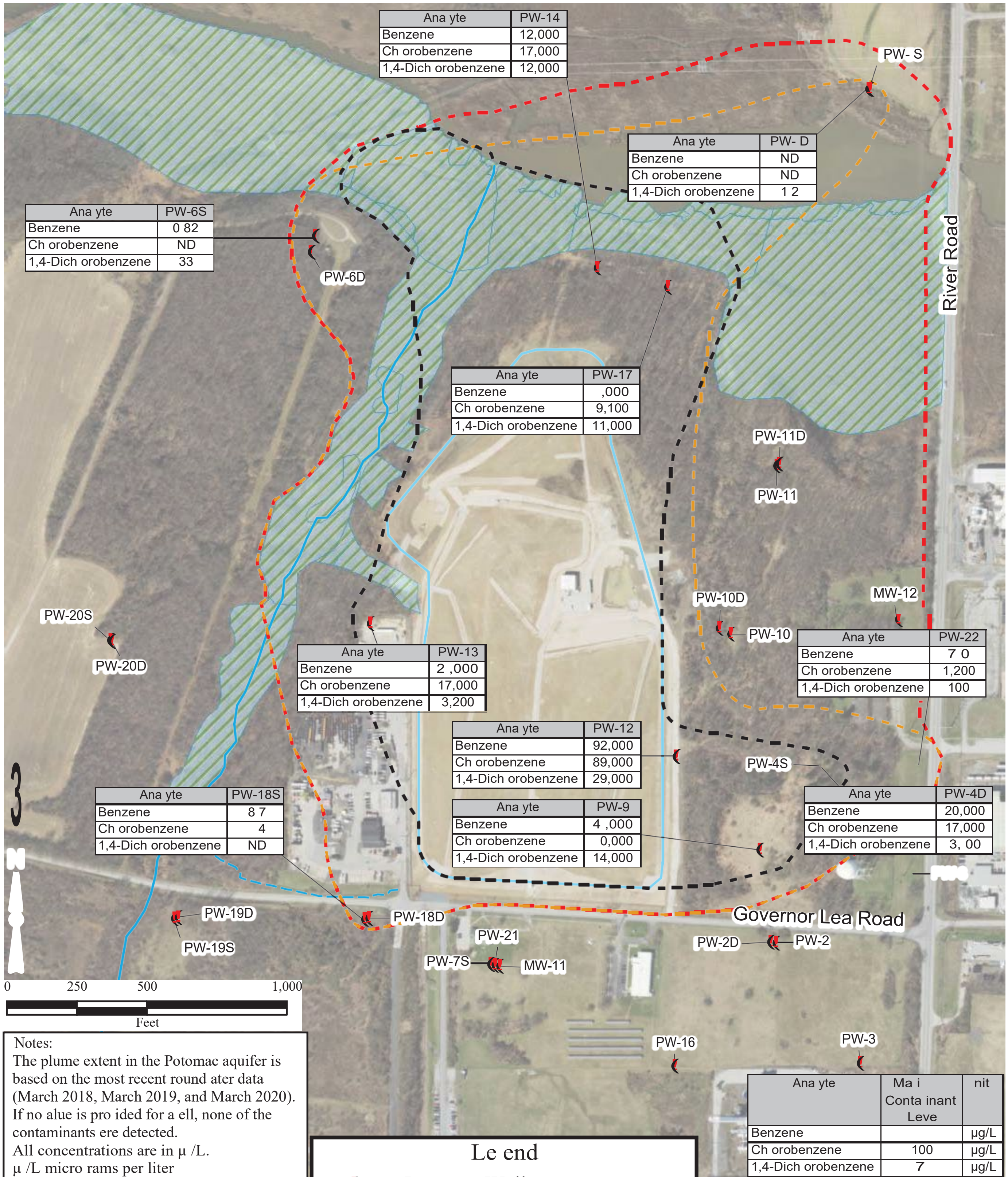
Note: The Thallium plume extent in the Columbia aquifer is based on March 2020 groundwater data. All concentrations are in micrograms per liter (µg/L).

Legend

- Columbia Well
- OU3 Waste Management Area
- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Columbia Aquifer Thallium Concentration Contour
- Technical Impracticability (TI) Waiver Area Boundary

\\srv-gst-01\HGLGIS\Standard_Chlorine_MSIW\TI_WE\(1-2e)Thallium_Mar2020_Columbia.mxd
6/26/2020 TH
Source: HGL
ESRI Online Aerial Imagery

Figure 1.2e
Columbia Aquifer Thallium MCL Exceedance Areas
March 2020

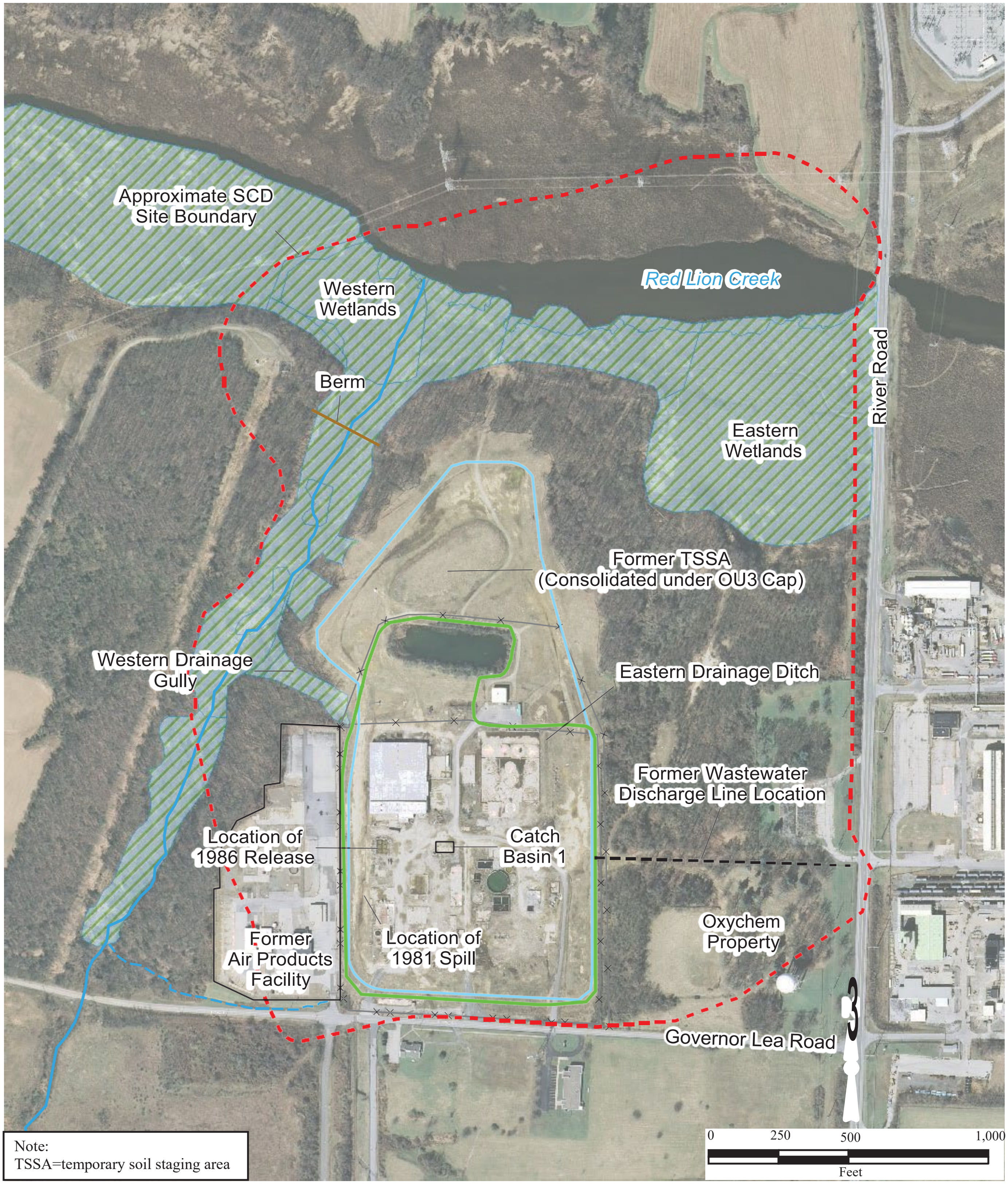


Notes:
The plume extent in the Potomac aquifer is based on the most recent round ater data (March 2018, March 2019, and March 2020). If no alue is pro ided for a ell, none of the contaminants ere detected.
All concentrations are in µ /L.
µ /L micro rams per liter

\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW \OU4_FS\(1-03b)Potomac_ContConc.mxd
6/25/2020 TB
Source: HGL
ESRI Online Aerial Imagery

Le end
- Potomac Well
- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Potomac Aquifer Plume Extent Dashed here inferred
- Technical Impracticability (TI) Wai er Area Boundary

Figure 1.3b Potomac Aquifer Sample TI Waiver Contaminant Concentrations



\\srv-gst-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-01)Site_Layout.mxd
6/26/2020 TH
Source: HGL
USGS aerial imagery dated 2010

Legend
- Former Facility Area Fence
- Former Wastewater Discharge Line
- OU3 Cap
- Approximate Site Boundary
- Soil-Bentonite Barrier
- Wetland

Figure 2.1
Historical Site Layout

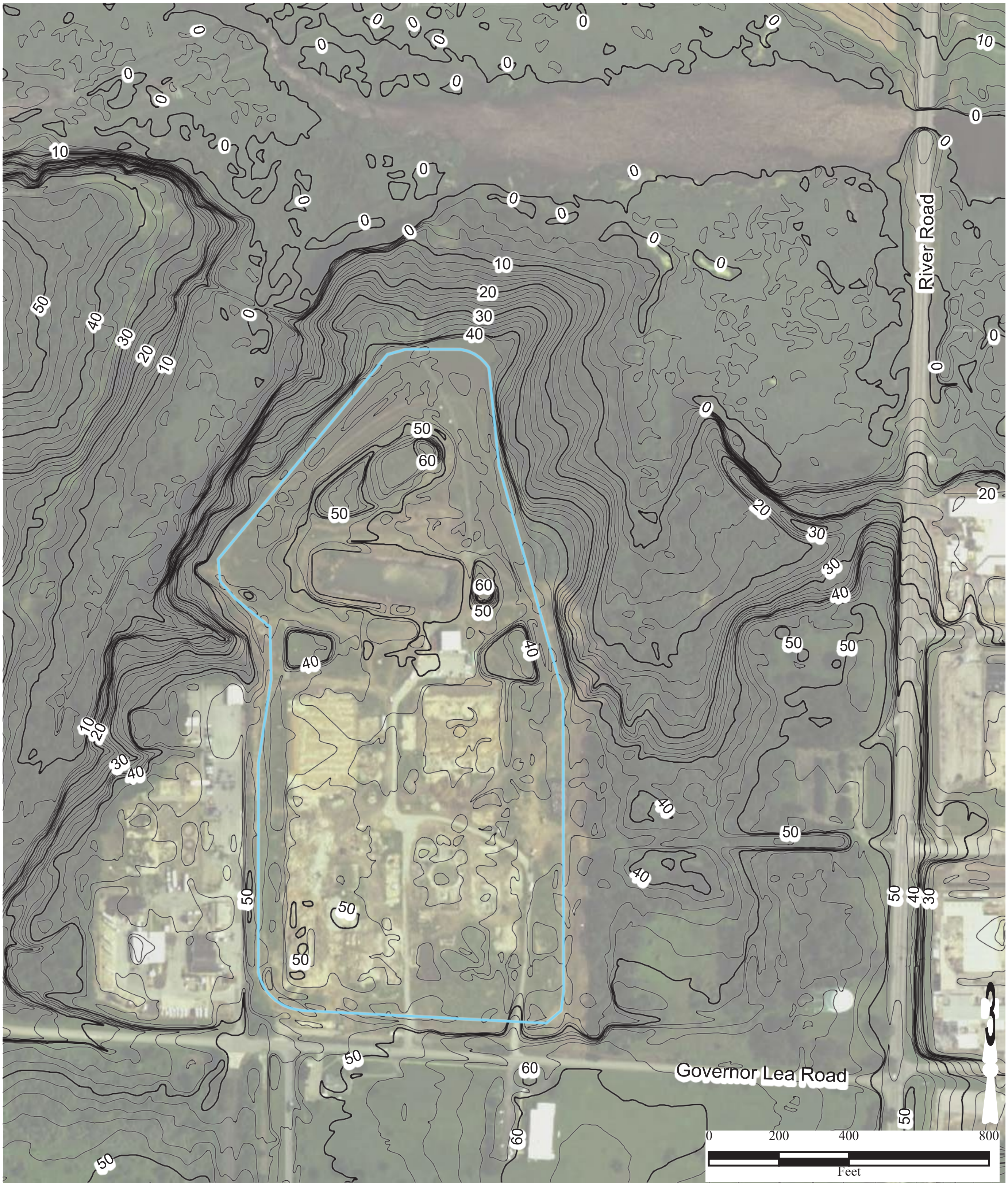
\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-02)ProductionWells.mxa
9/25/2017 TB
Source: HGL, USGS
ArcGIS Online Imagery

Legend

Production Well - Well Owner

- Artesian Water Company
- Delaware City
- Motiva
- Approximate Site Boundary
- Delaware Well Head Protection Areas

Figure 2.2
Well Head Protection Areas and Production Wells



\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-03)Topography.mxd
9/21/2017 TB
Source: HGL, USDA Soil Data

ESRI Online AerialImagery

Legend

Soil-Bentonite Barrier

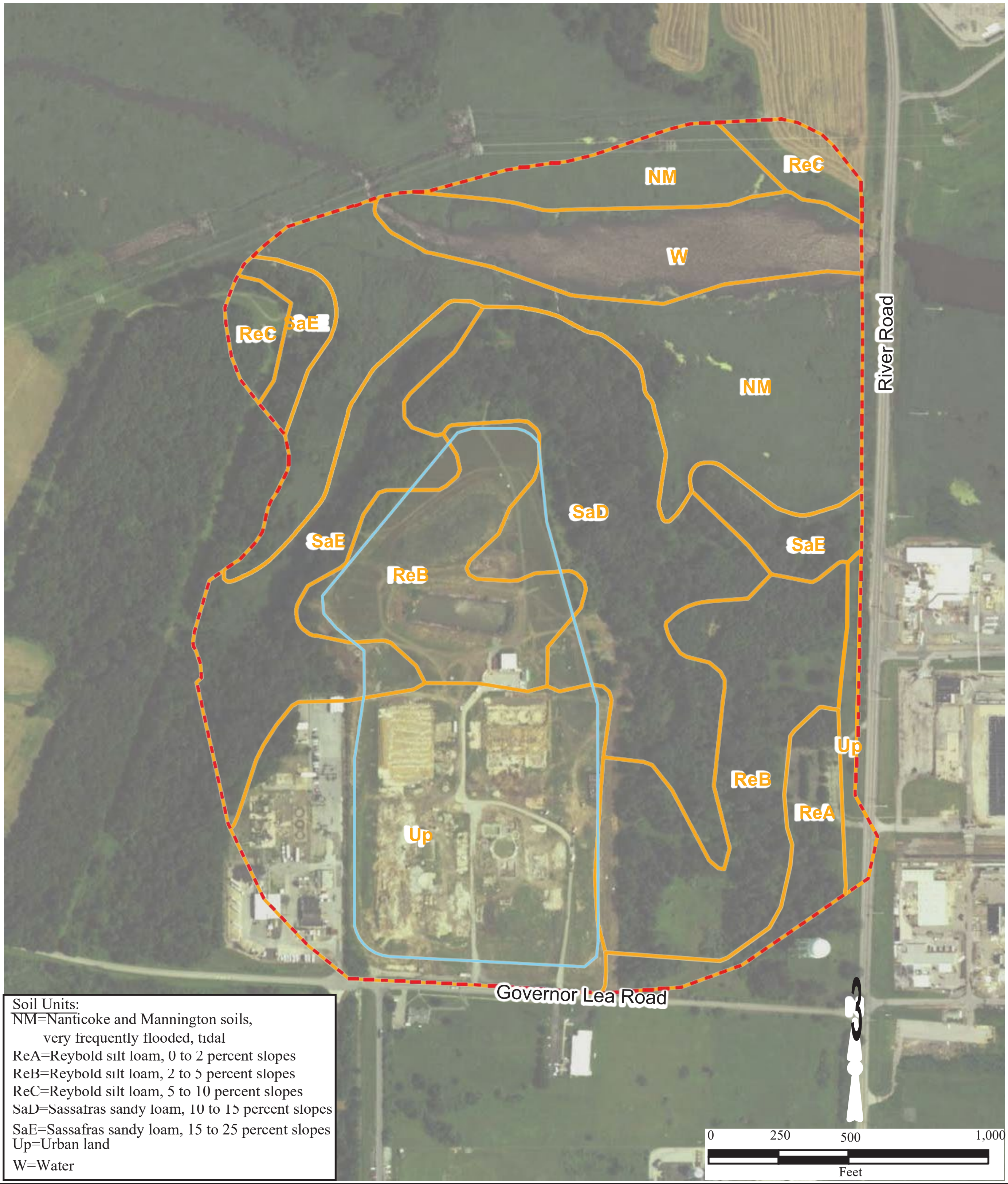
Topographic Contour (ft amsl)

(contour interval = 2 ft)

Notes:
ft=feet
amsl=above mean sea level

Figure 2.3

Topography of SCD Area



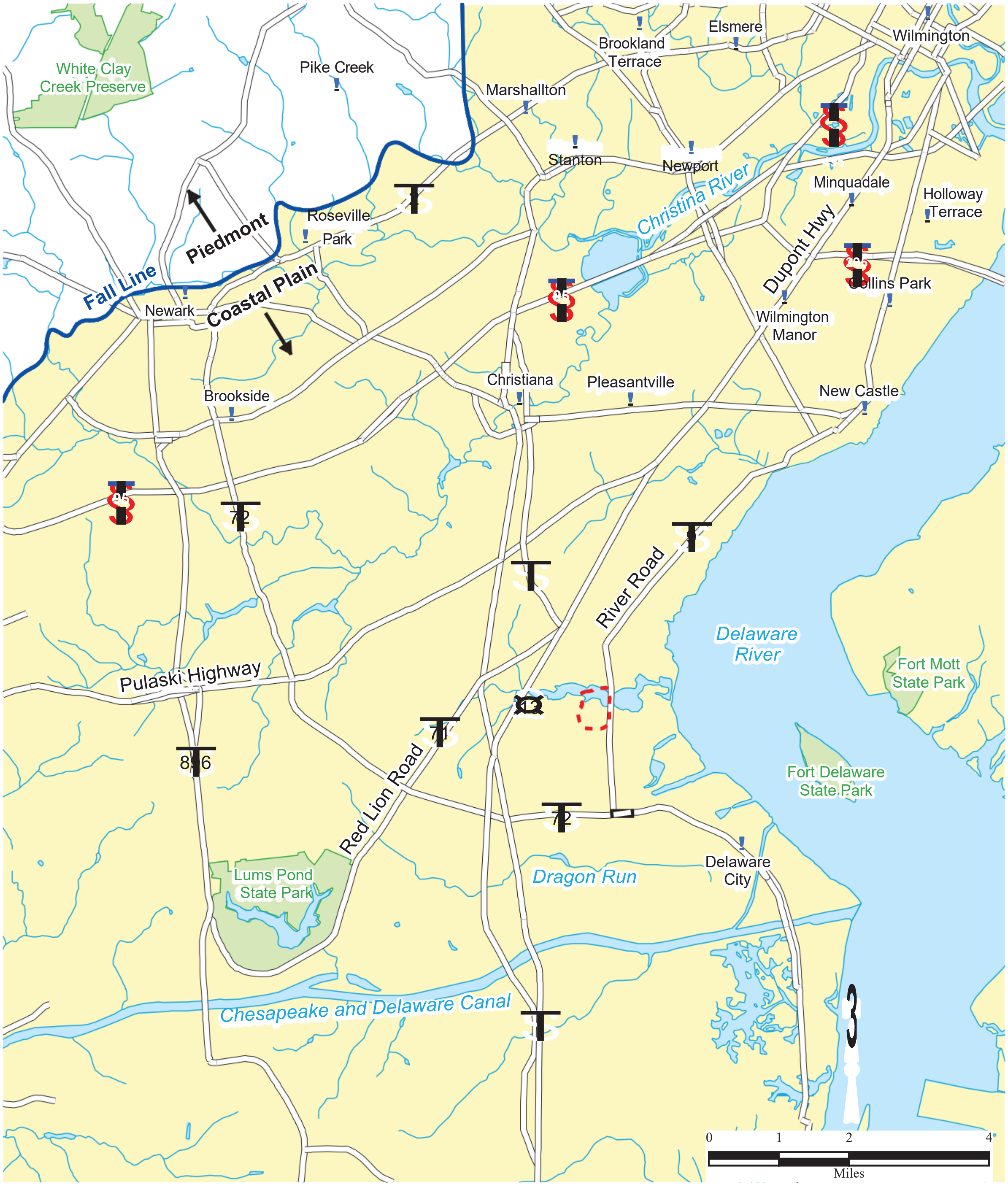
\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-04)Soils_Map.mxd
9/25/2017 TB
Source: HGL, USDA Soil Data
ESRI Online Aerial Imagery

Legend

Soil-Bentonite Barrier

Approximate Site Boundary

Figure 2.4
Soils Map

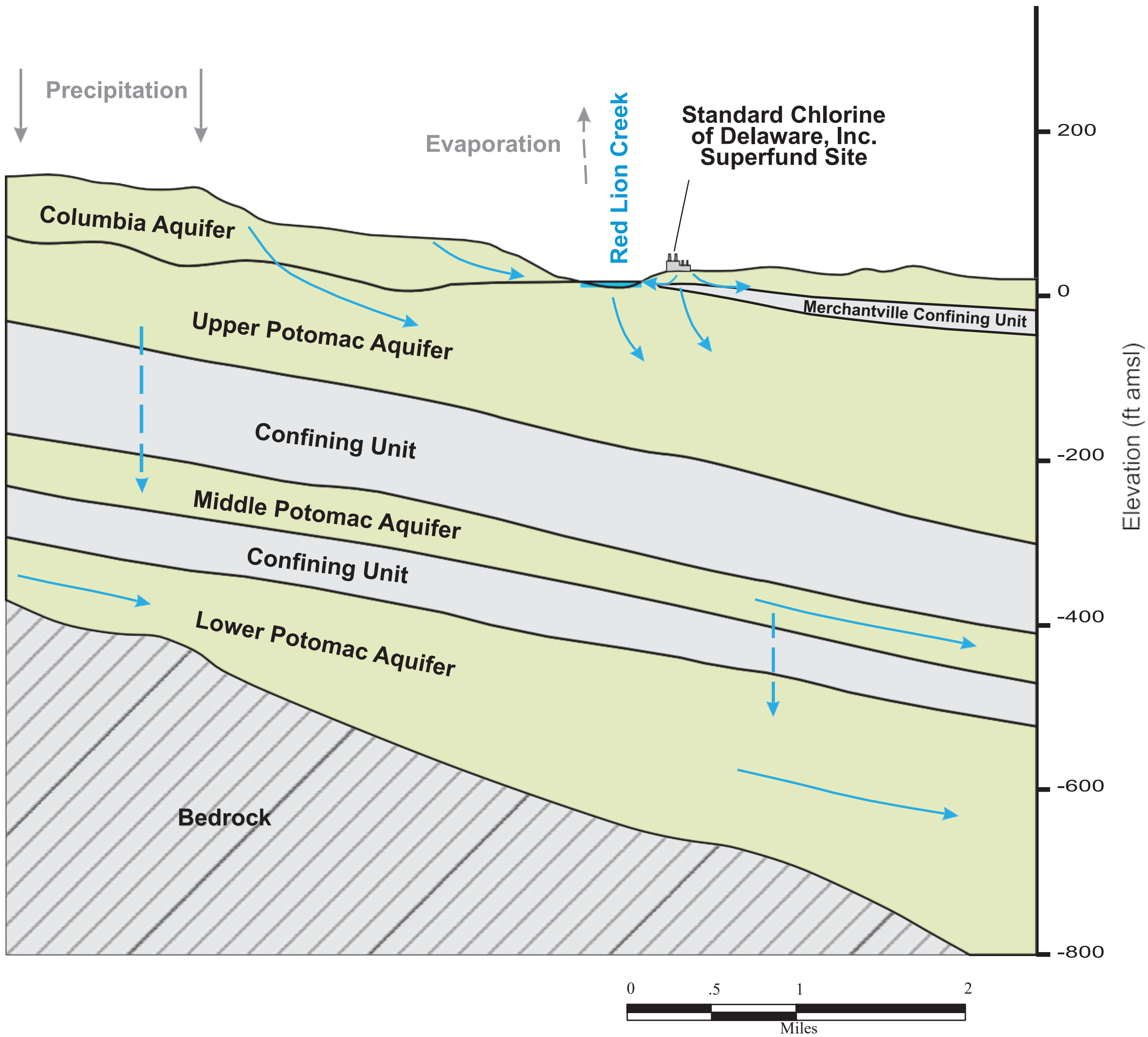


\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-05)Physio_Provs.mxd
9/25/2017 TB
Source: HGL
After Brayton et al. (2014)

Legend

- Approximate Site Boundary
- Piedmont
- Coastal Plain

Figure 2.5
Physiographic Provinces Near Standard Chlorine of Delaware

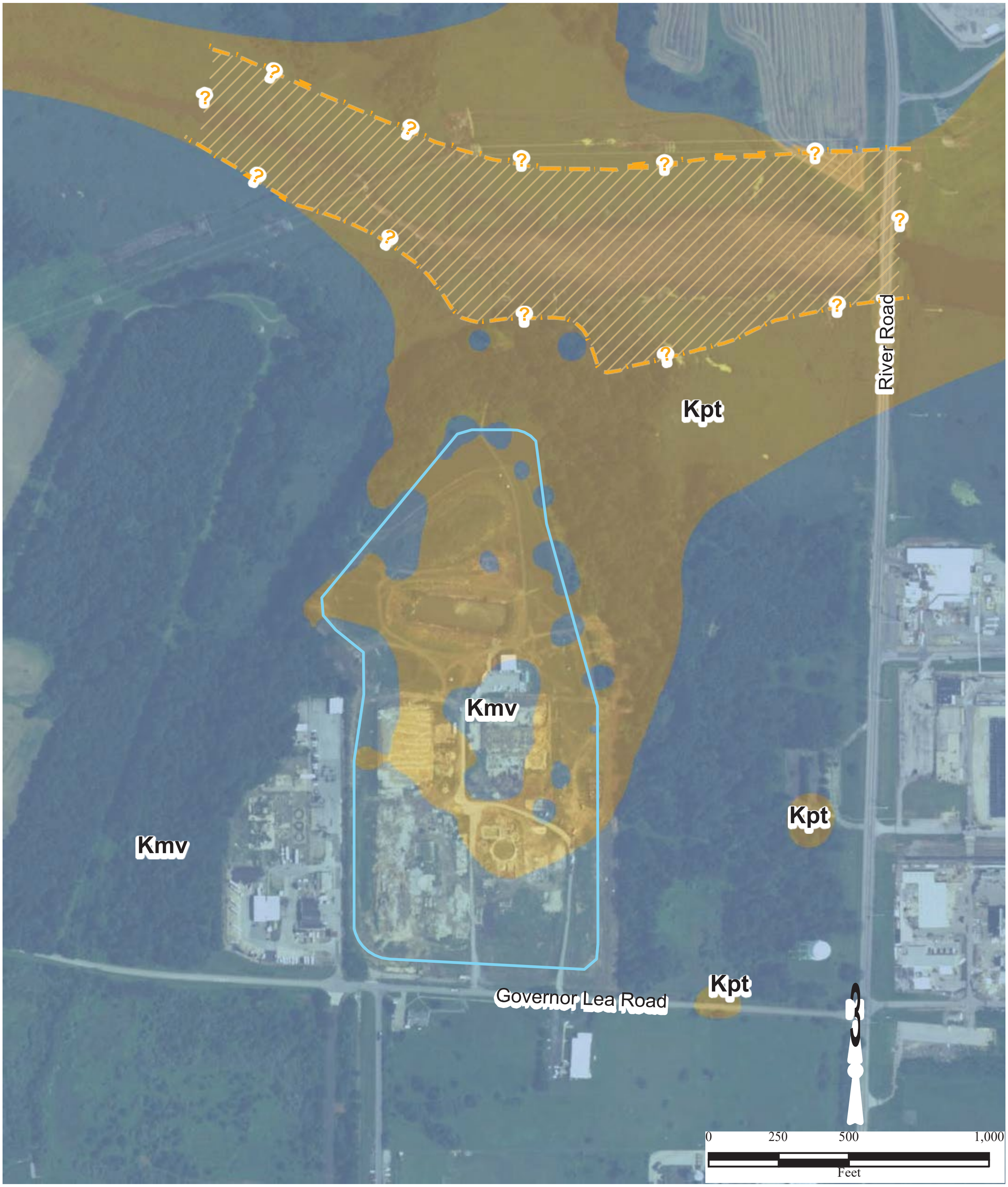


\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-07)Top_UCU.mxd
9/25/2017 TB
Source: HGL, USDA Soil Data
ESRI Online Aerial Imagery

Geologic Contact
Recharge
Generalized Groundwater Flow Direction

Notes:
Vertical Exaggeration=27X
ft amsl=feet above mean sea level

Figure 2.6
Schematic Cross Section of Standard Chlorine Site Geology



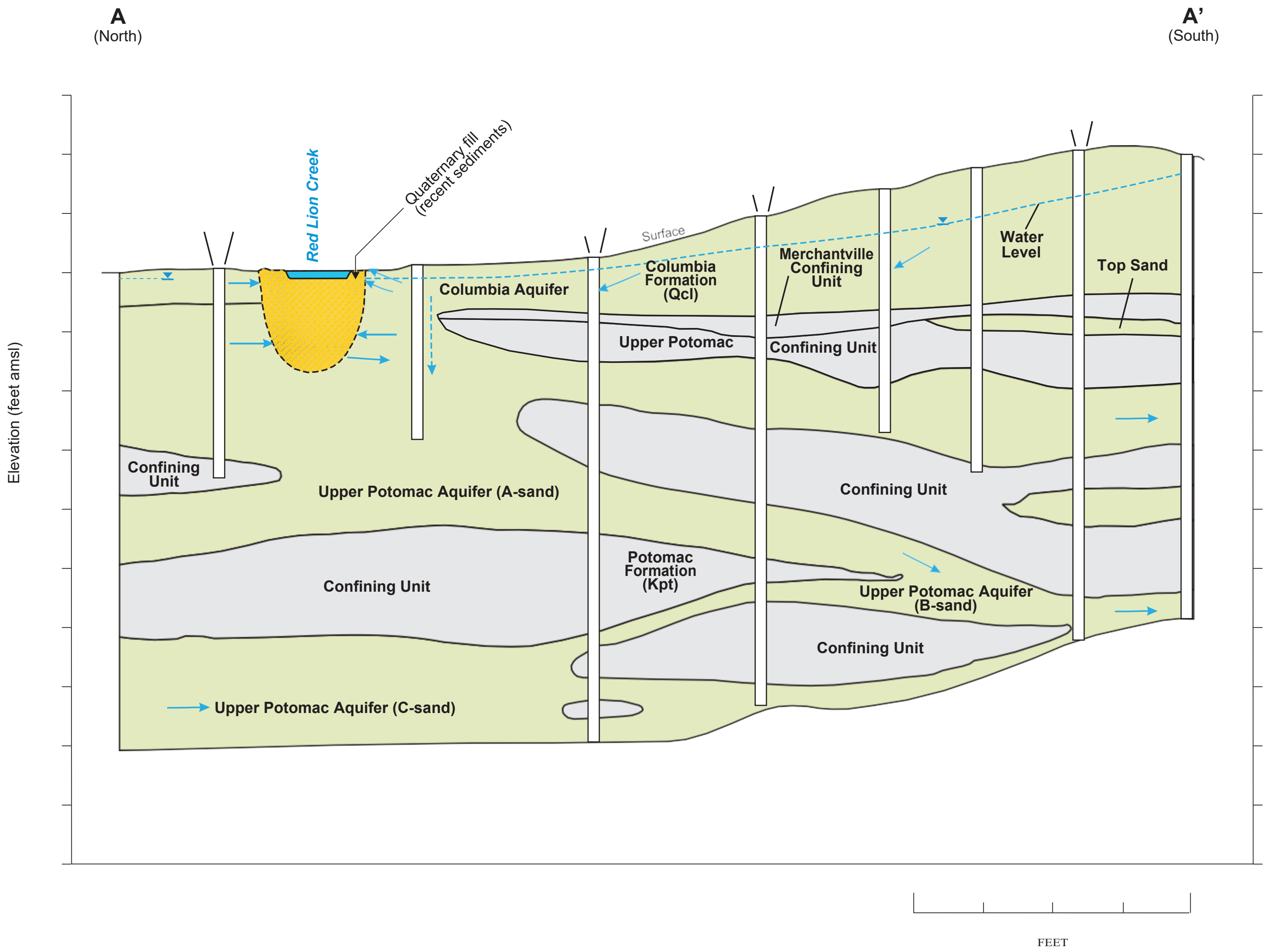
\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-07)Top_UCU.mxd
9/25/2017 TB
Source: HGL, USDA Soil Data
ESRI Online Aerial Imagery

Legend

- Soil-Bentonite Barrier
- Merchantville Clay (Kmv)
- Potomac Formation (Kpt) Predominantly Clay
- Area where Confining Unit may be thin or absent

Figure 2.7
Upper Confining Unit Subcrop Map

Figure 2.8
Cross Section A-A’



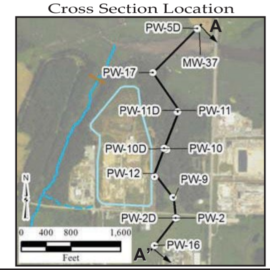
Groundwater Level

Generalized Groundwater Flow Direction (Note: Under pumping conditions at the Delaware City Refining Company)

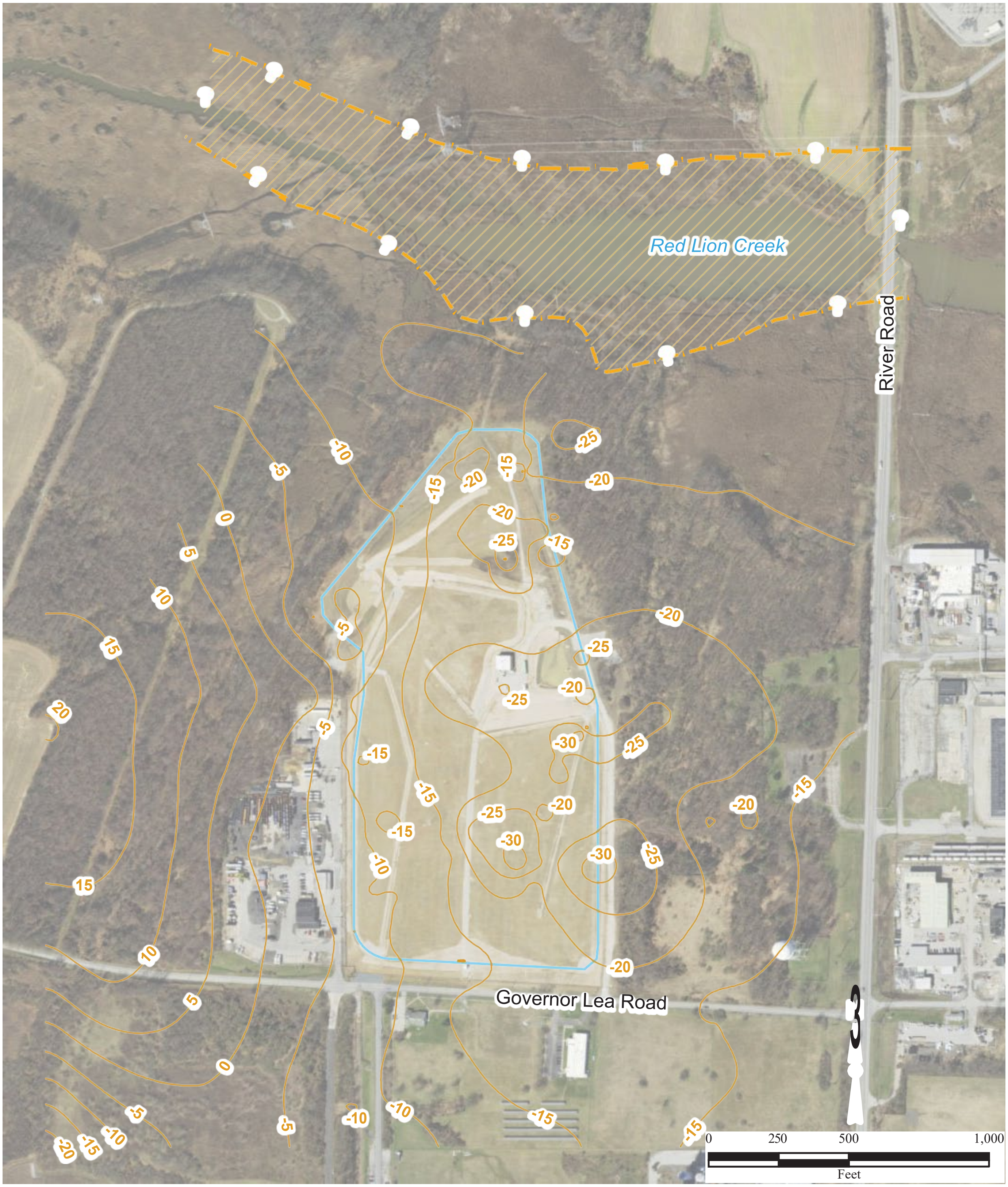
Generalized Leakage from Colombia Aquifer to Potomac Aquifer

V r ic x gg r i n=7.2x.
= n

Cross Section Location



gst-sr;-0J \JGLGIS Standard_Ch orine _MSIW \RI_OU4
(3-07)X-sec_A-A.cdr.
09/25/20J7 TB
Source: \JGL
ArcGIS On ine Imagerry



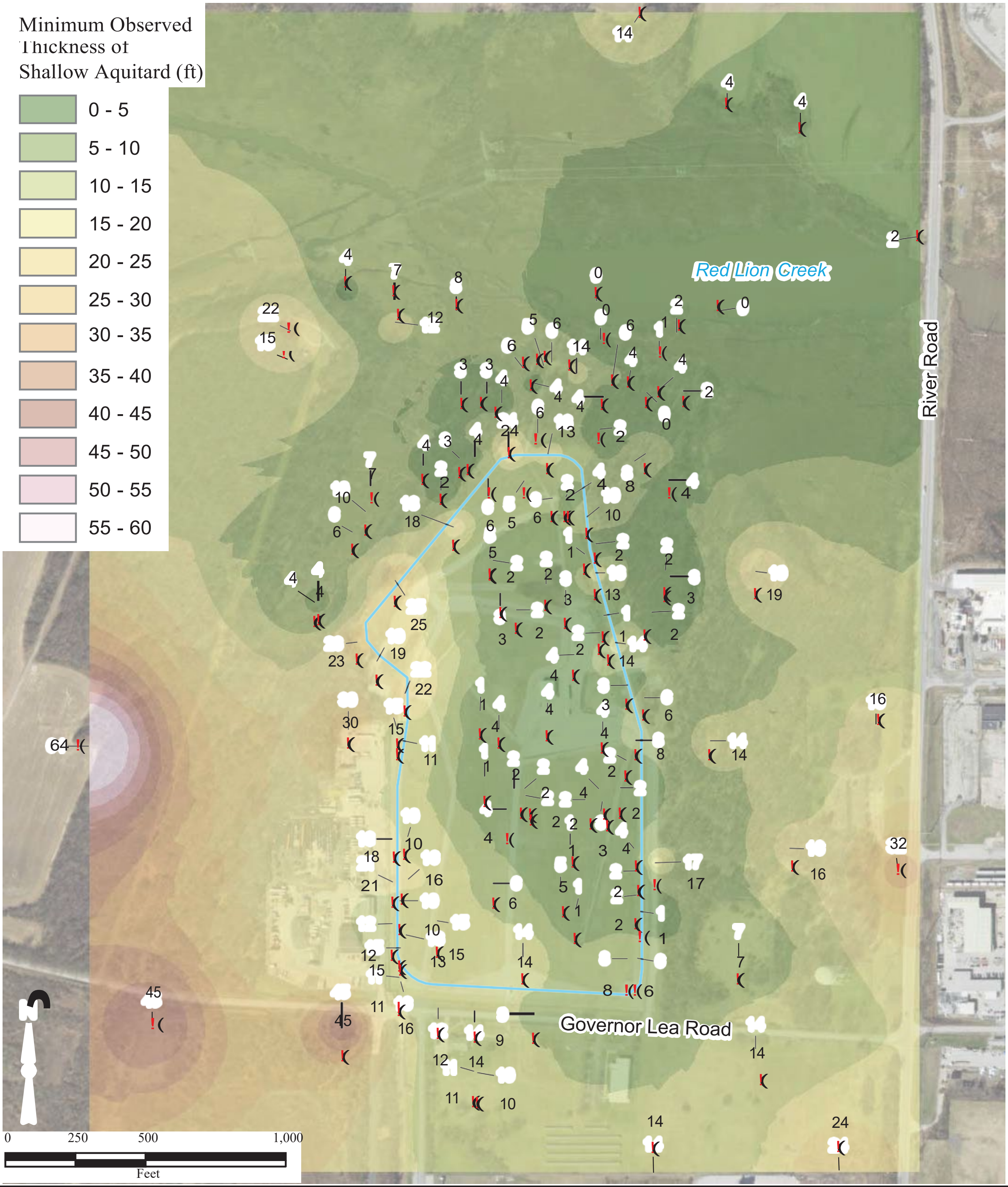
\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-09)Top_Shallow_Aquitard.mxd
4/19/2019 TH
Source: HGL,
ESRI Online Aerial Imagery

Legend

- 20 — Top of Shallow Aquitard (ft amsl)
- Soil-Bentonite Barrier
- Area where Confining Unit may be thin or absent

Notes:
ft amsl feet above mean sea level

Figure 2.9
Top of Shallow Aquitard



\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-09a)Min_ObsThck_SA.mxd
4/22/2019 TH
Source: HGL,
ESRI Online Aerial Imagery

HGL HydroGeoLogic, Inc

Legend

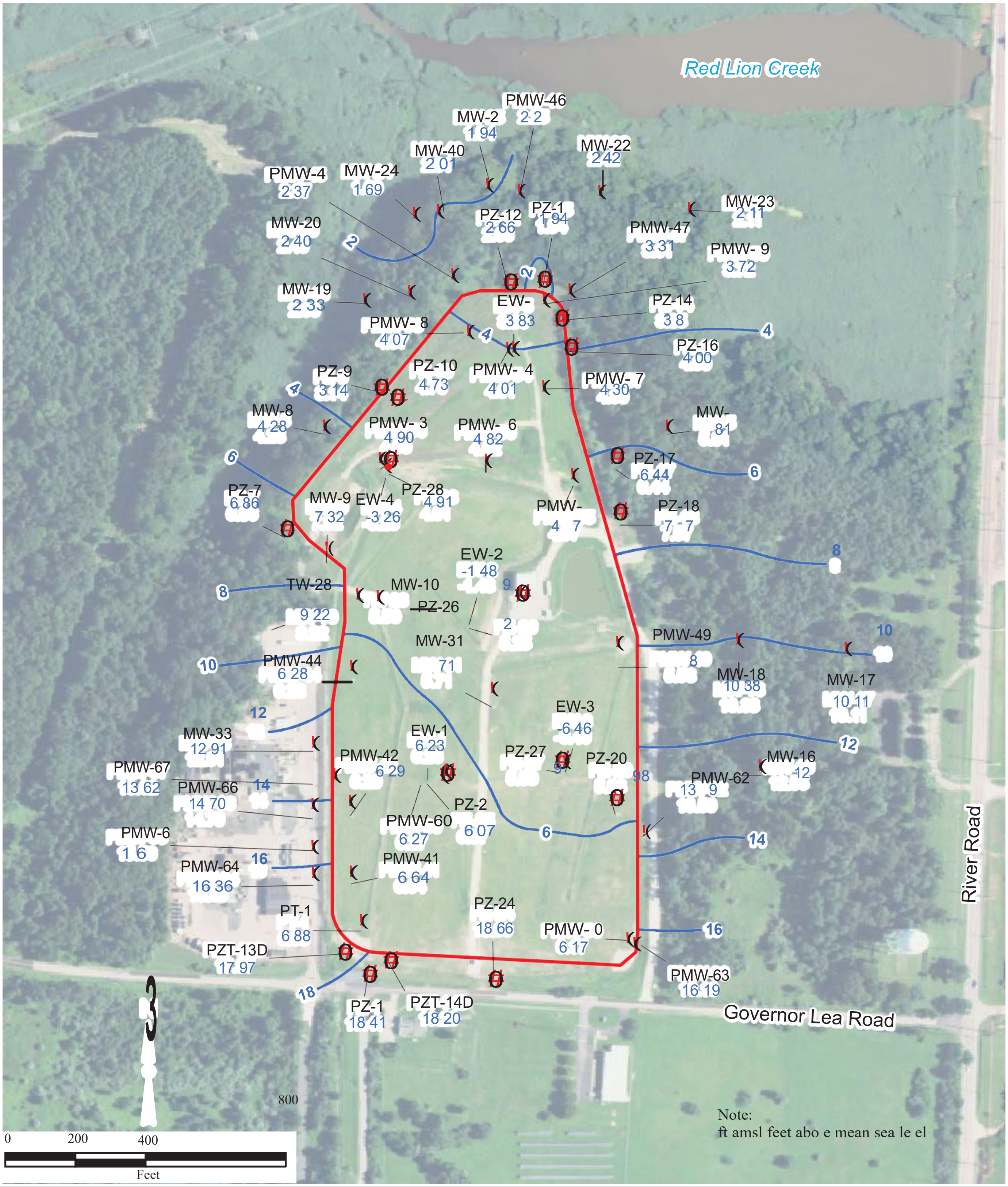
Boring/Well

14 Observed Thickness in feet

Soil-Bentonite Barrier

Notes:
ft=feet

Figure 2.9a
Minimum Observed Thickness of Shallow Aquitard

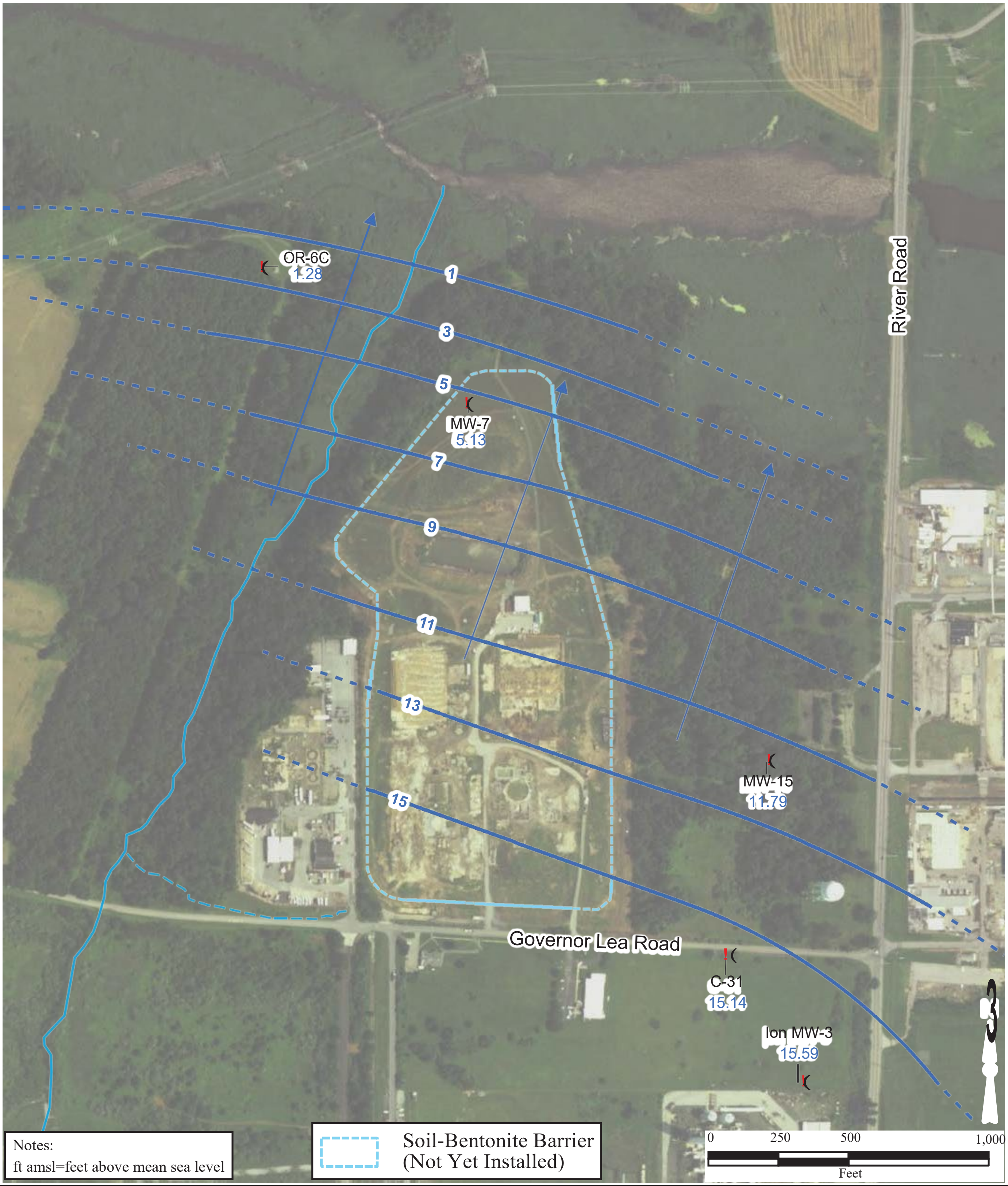


\\srv-gst-01\hglgis\Standard_Chlorine_MSIW\TI_OU4\(2-10)2019-11_GWE.mxd
6/25/2020 TB
Source: HGL, USGS
ArcGIS Online Imagery

Le end

- Monitorin Well
- Piezometer
- MW-10 / 9 22 — Well Identification / Ground ater Ele ation (ft amsl)
- Soil Bentonite Contaminant Barrier
- 2 — Ground ater Contour (ft amsl)

Figure 2.10
Groundwater Elevations
Columbia Aquifer
November 2019



\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-11)GWElev_ColumbiaAq_05-2006.mxa
9/25/2017 TB
Source: HGL,
ESRI Online Aerial Imagery,
After Brayton et al. (2014)

Legend

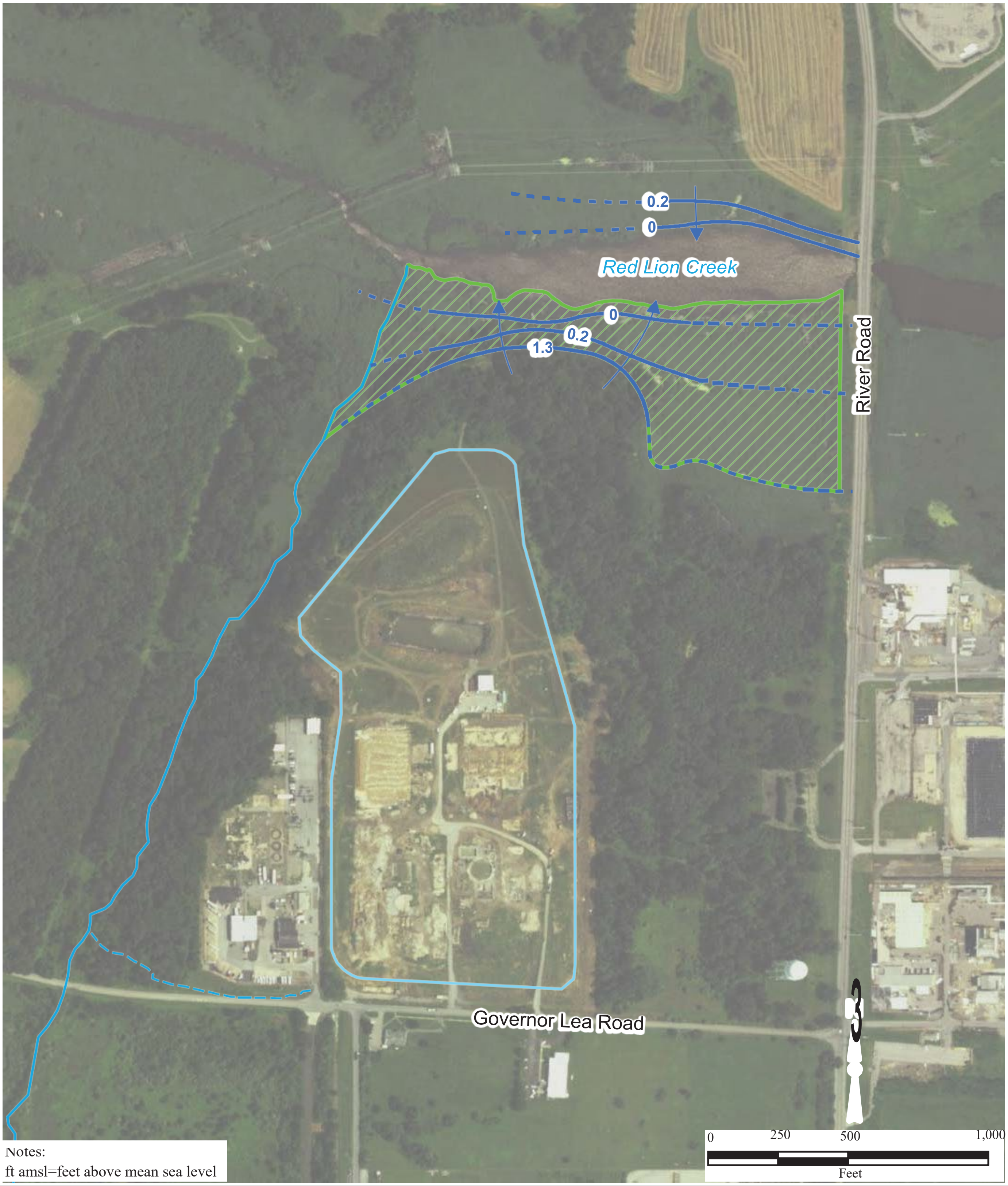
Monitoring Well

MW-7
5.13
Well Identification
Groundwater Elevation (ft amsl)

3.0
Groundwater Elevation
(dashed where inferred, ft amsl)

Generalized Groundwater Flow

Figure 2.11
Groundwater Elevations in Columbia Aquifer Prior to Slurry Wall Installation
May 13, 2006



\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\
(2-12)AppxColumbiaAqDis.mxd
9/25/2017 TB
Source: HGL, After Loran et al. (2014)
August 8, 2012 Data,
ESRI Online Aerial Imagery

Legend

0.2 Equipotential Line (ft amsl) (dashed where inferred)

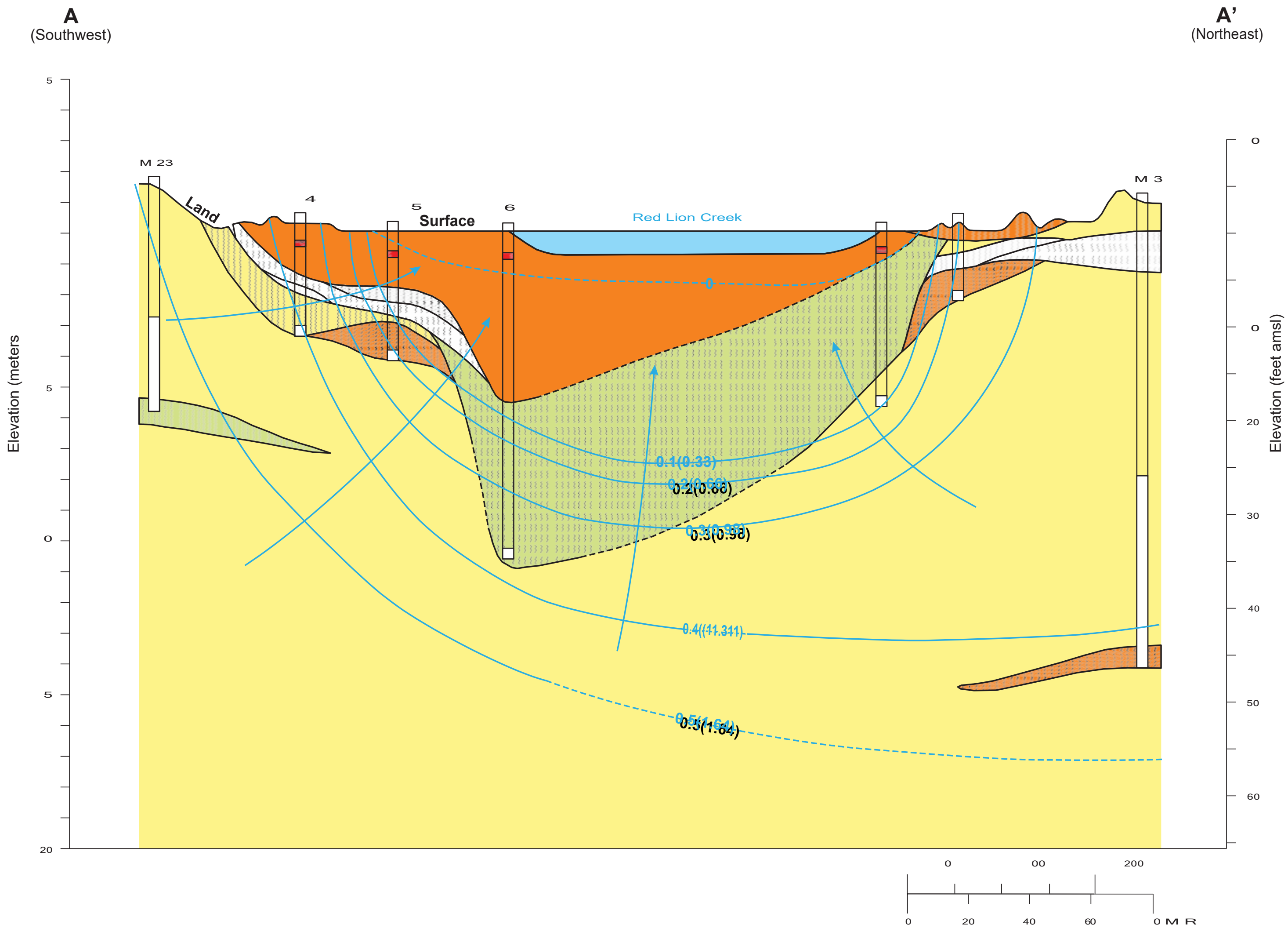
Generalized Groundwater Flow

Soil-Bentonite Barrier

Approximate Area of Columbia Aquifer Discharge to Wetlands

Figure 2.12
Approximate Area of Columbia Aquifer Discharge to Wetlands

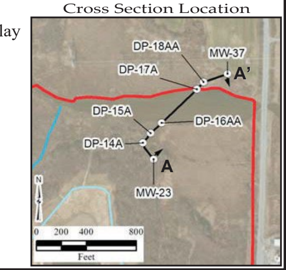
Figure 2.13
Vertical Hydraulic Gradients in Northern Wetlands



Legend

- Well/Soil boring (M 3)
- Well boring/Screened interval
- Generalized Groundwater Flow Direction
- Geologic contact (Dashed where inferred)
- Line of Equal Head in meters (Dashed where inferred)
- 0.3/(0.98) Piezometric Head meters/(feet) (August 8, 2012)
- Clay
- Clay/Sand
- Clay/Silt
- Gravel
- Organics
- Organics/Clay
- Sand (Columbia Formation)
- Sand/Clay
- Silt
- Silt/Clay

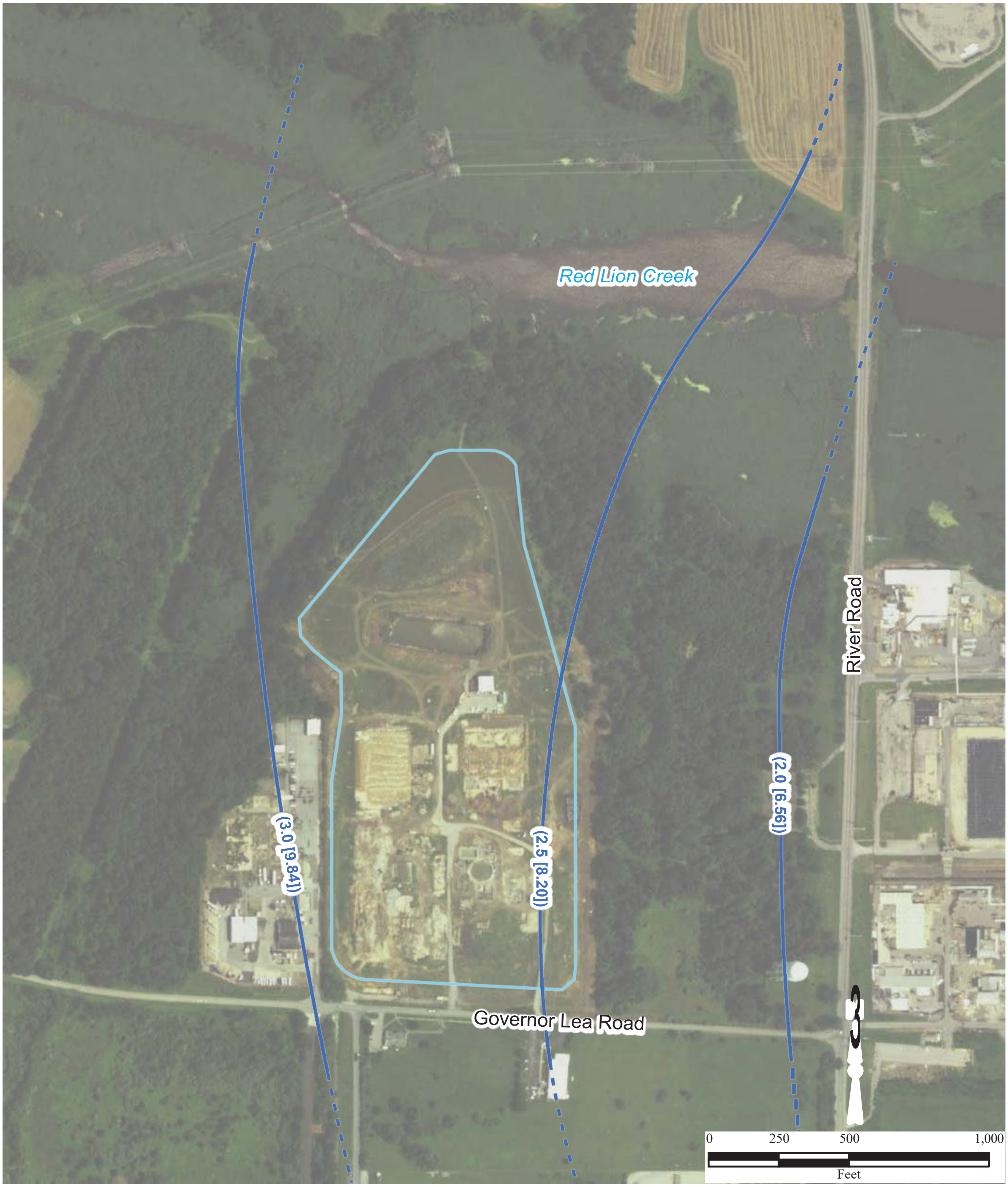
Cross Section Location



\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-20a)2018-03_PotoAq_B-CSand.mxd
4/17/2019 TH
Source: HGL, USGS
ArcGIS Online Imagery

Notes:
Piezometric Head values originally e pressed as meters in Lorah et al (2014)
Vertical elevation
amsl above mean sea level

From Lorah et al (2014)



\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-14)Pot_Sept14-2011.mxd
9/25/2017 TB
Source: HGL,
ESRI Online Aerial Imagery,
After Brayton et al. (2014)

Legend

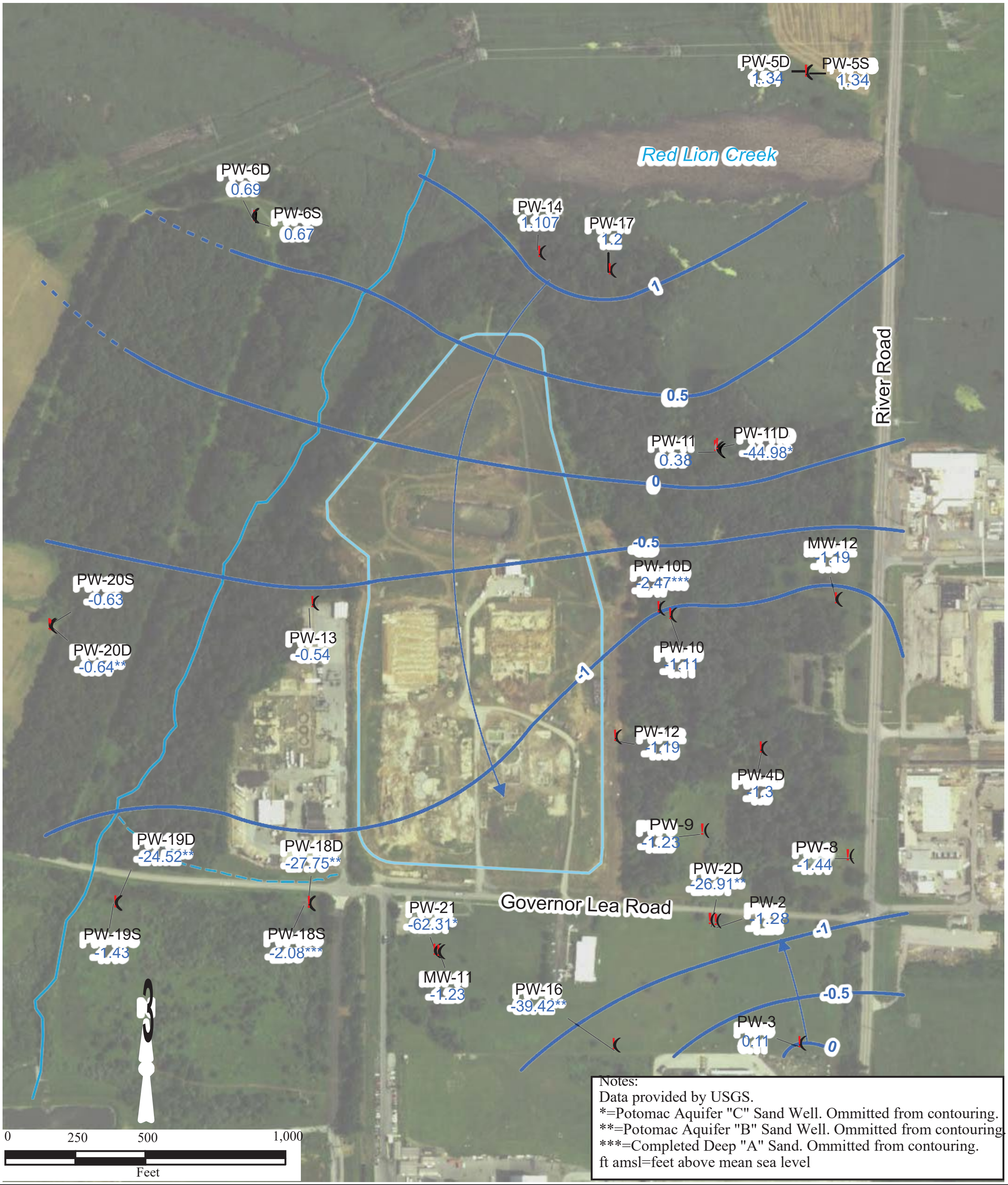
3.0 Potentiometric Contour Map (dashed where inferred) (meter amsl[feet])

Soil-Bentonite Barrier

Note:
ft amsl=feet above mean sea level

Figure 2.14

Upper Potomac Aquifer Potentiometric Contour Map September 14, 2011



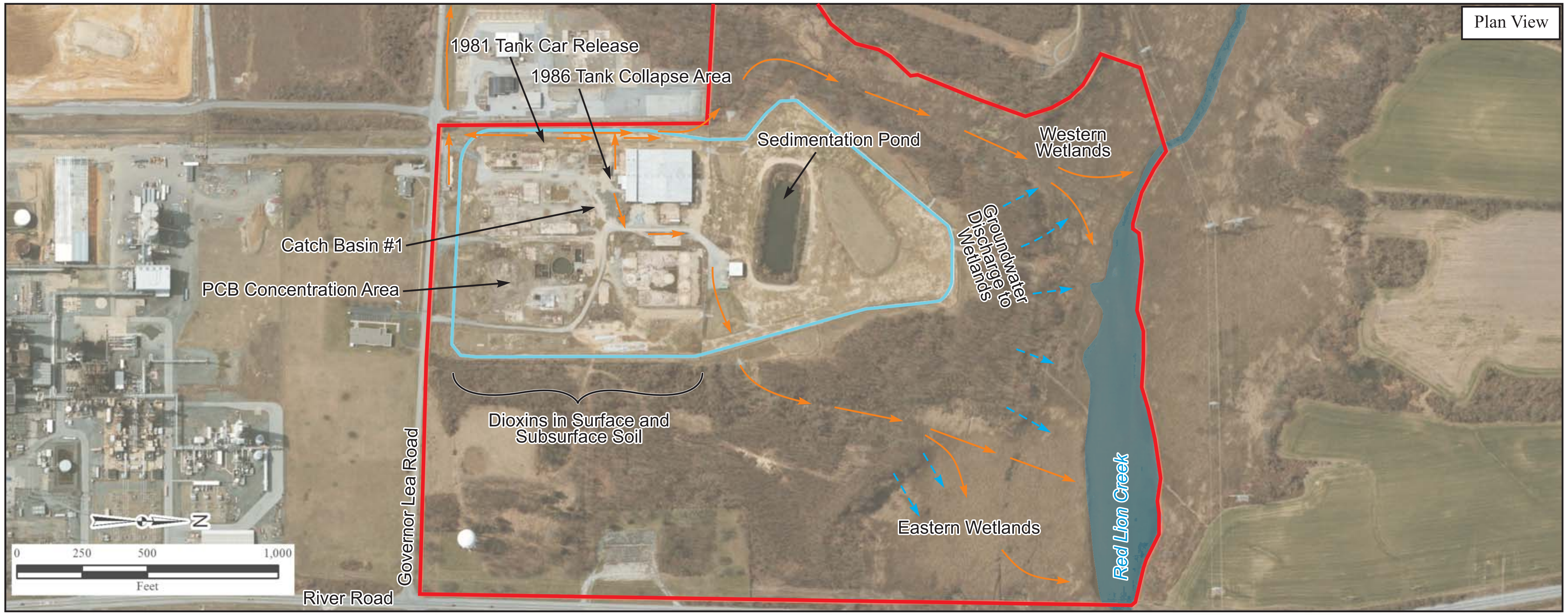
\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-15)UpperPotomacAqPot_05-2015.mxa
9/28/2017 TB
Source: HGL,
ESRI Online Aerial Imagery,
After Brayton et al. (2014)

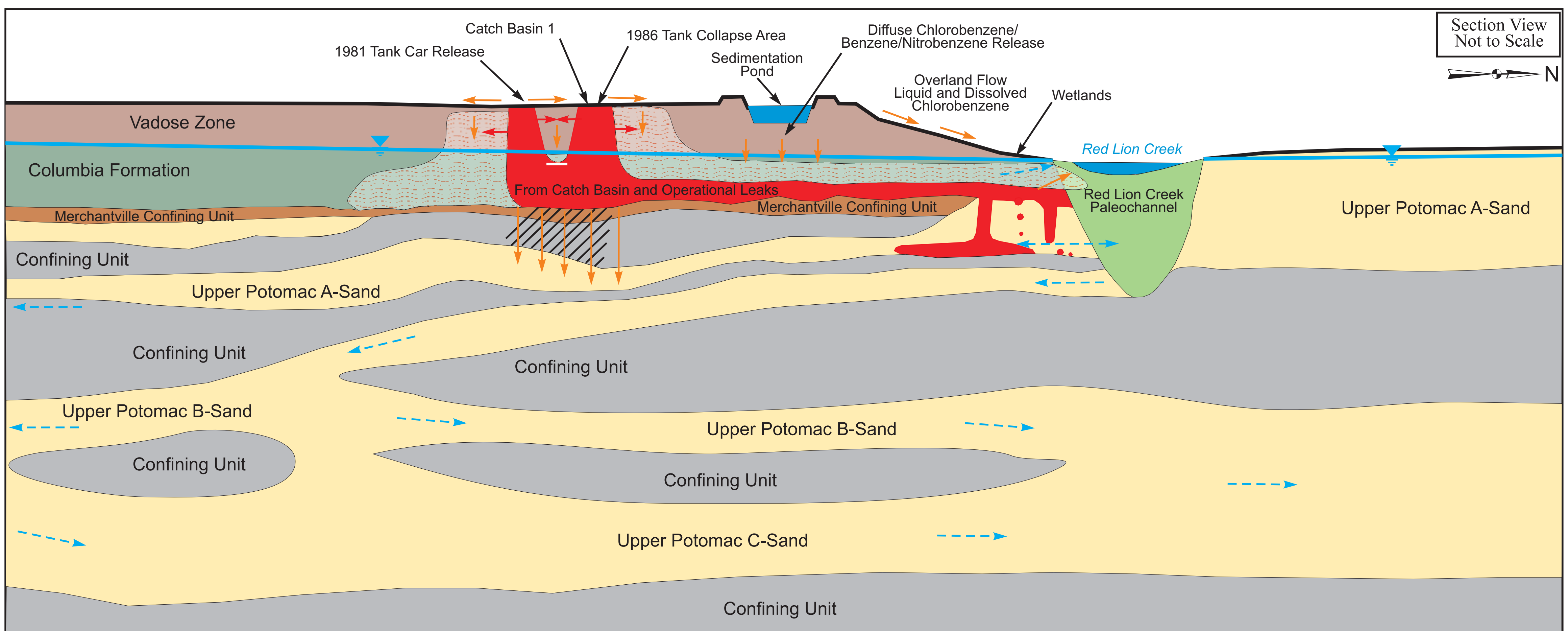
Legend

- Monitoring Well
- 1.0 — Potentiometric Contour Map (dashed where inferred, ft amsl)
- Generalized Groundwater Flow
- Soil-Bentonite Barrier

Figure 2.15
Upper Potomac Aquifer Potentiometric Contour Map
May 2015

Figure 2.16
Graphical Conceptual Site Model



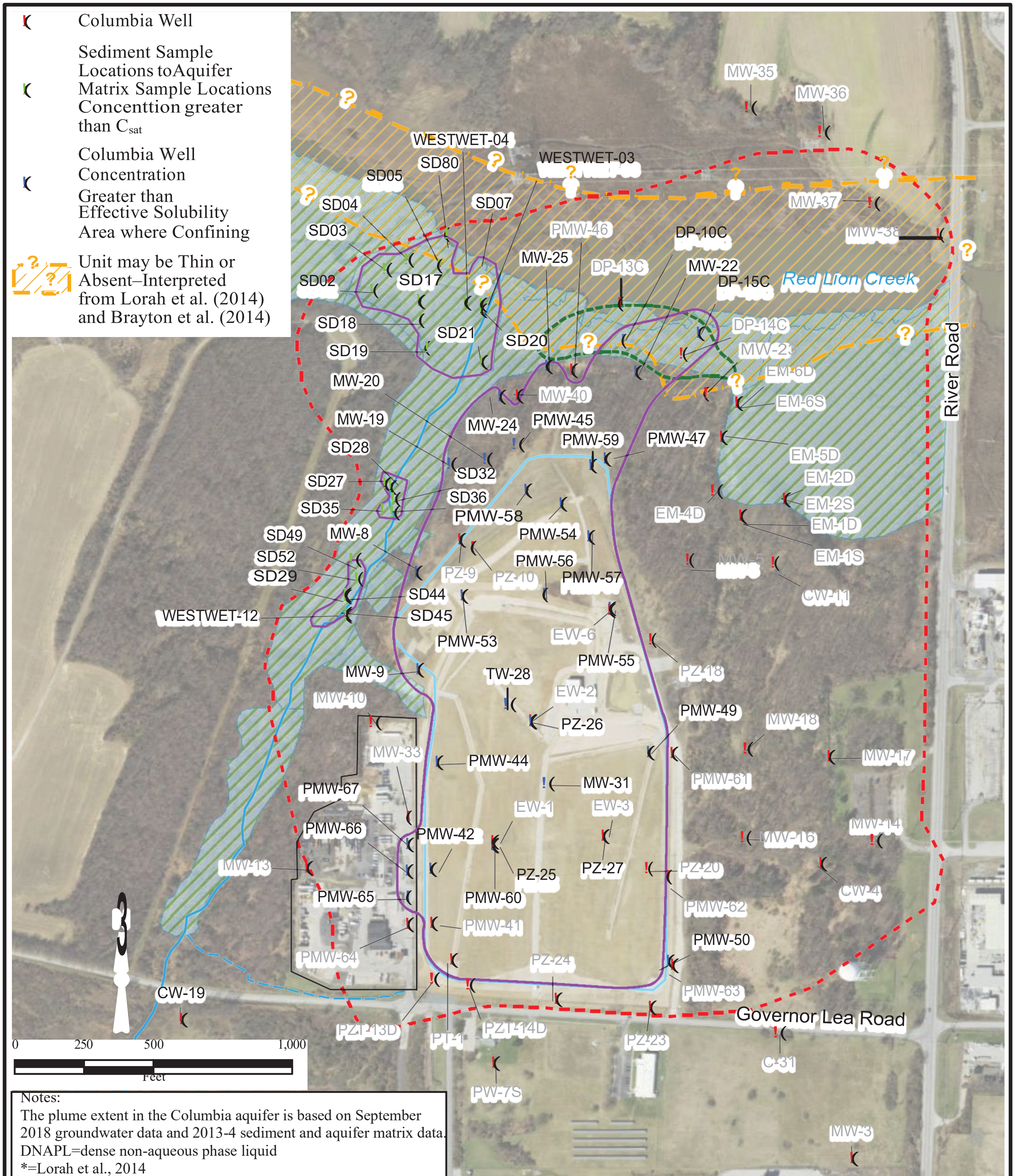


Legend

- Site Boundary
- Containment Barrier
- Groundwater Table (Generalized)
- Groundwater Flow (Generalized)
- Contaminant Pathway (Generalized)
- Lateral Separate-Phase Migration Due to Pumping
- Separate-Phase Contamination
- Dissolved and Vapor-Phase Contamination
- Vadose Zone
- Columbia Formation
- Merchantville Confining Unit
- Merchantville Formation Thin or Absent
- Sand
- Confining Unit
- Confining Unit Thin or Absent
- Paleochannel

Notes:
All locational information on this figure is conceptual or approximate. See text for discussion.
Aerial Photograph Date: March 19, 2011.
Hydrostratigraphy is a generalized version of information in Brayton et al. (2004).

PCB=polychlorinated biphenyl



\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\FI_OU4\(2-17)Columbia_DNAPL.mxd

6/26/2020 TH

Source: HGL

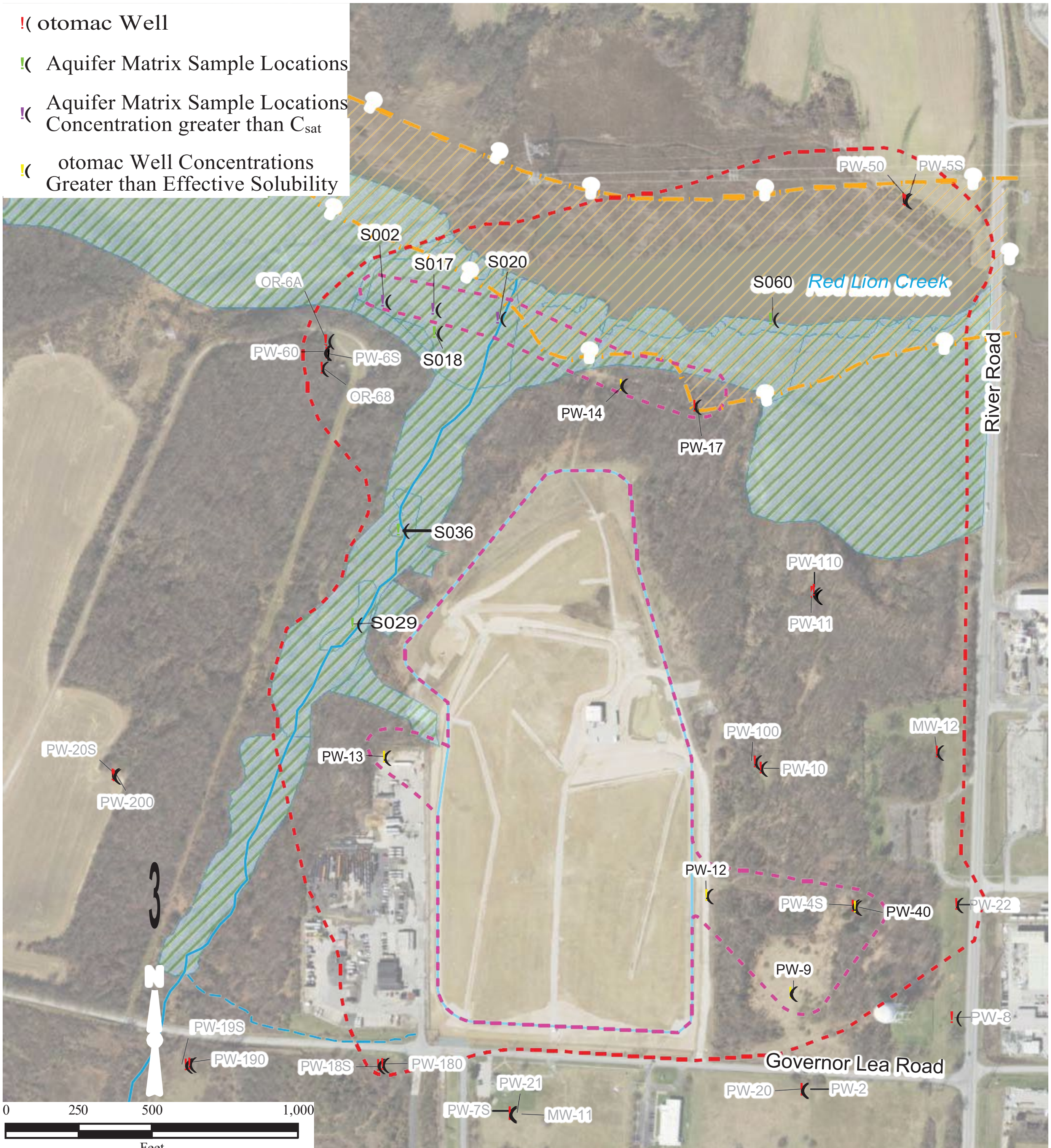
ESRI Online Aerial Imagery

Legend

- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Areas of DNAPL in Columbia Aquifer Matrix
- Sediment Pore Water Concentrations Evident of DNAPL Contact*

HGL HydroGeoLogic, Inc

Figure 2.17
Columbia Aquifer DNAPL

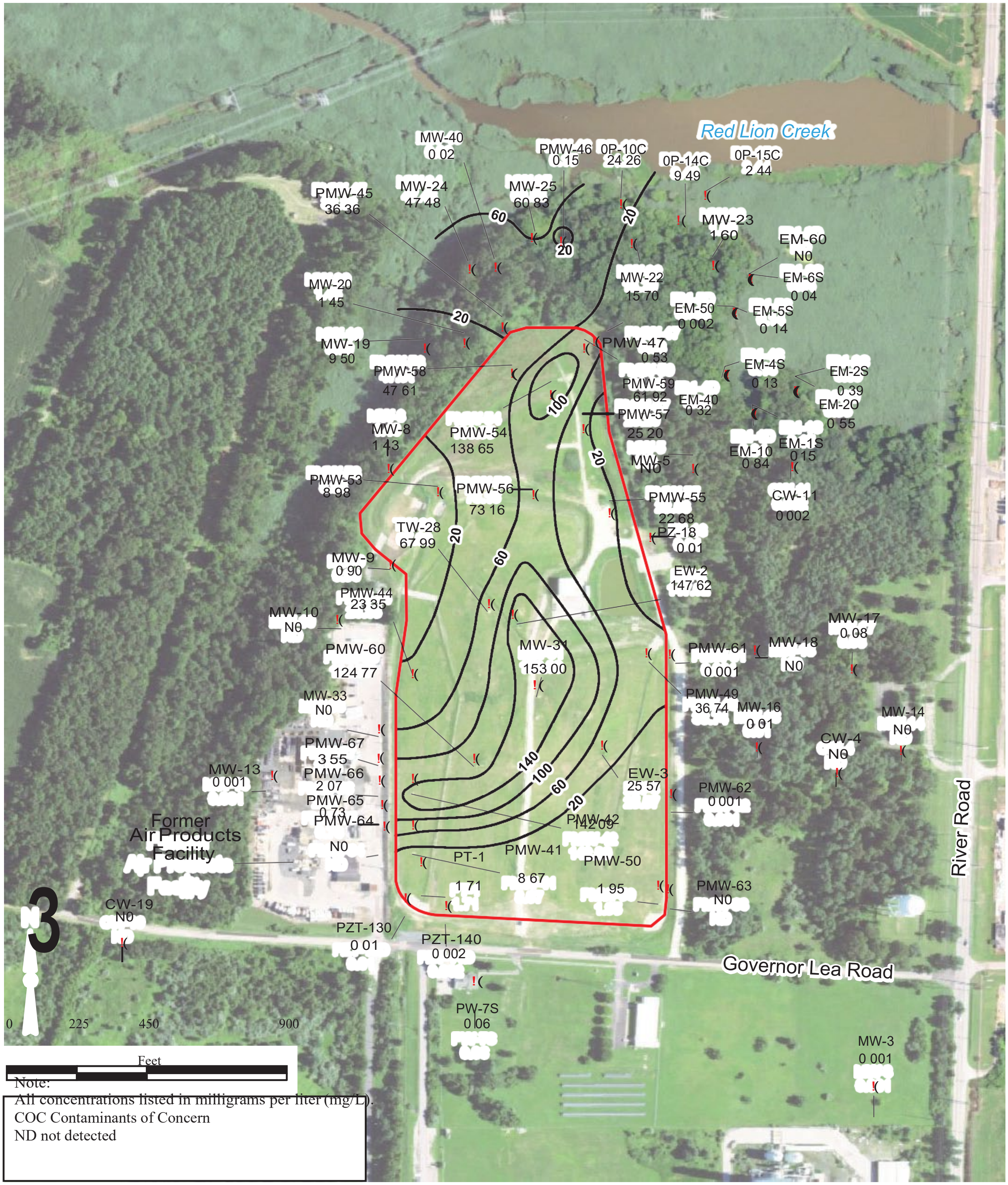


Notes:
The plume extent in the otomac aquifer is based on the most recent groundwater data March 2018, March 2019, March 2020.
DNA L dense non-aqueous phase liquid

\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW \OU4_FS\(2-18)Potomac_DNAPL.mxd
6/25/2020 TH
Source: HGL
ESRI Online Aerial Imagery

Legend
- Wetland
- Soil-Bentonite Barrier
- Approximate Site Boundary
- Inferred Area of DNA L resence
- Area where ConfiningUnit may be Thin or Absent-Interpreted from Lorah et al. (2014) and Brayton et al. (2014)

Figure 2.18
Potomac Aquifer
DNAPL

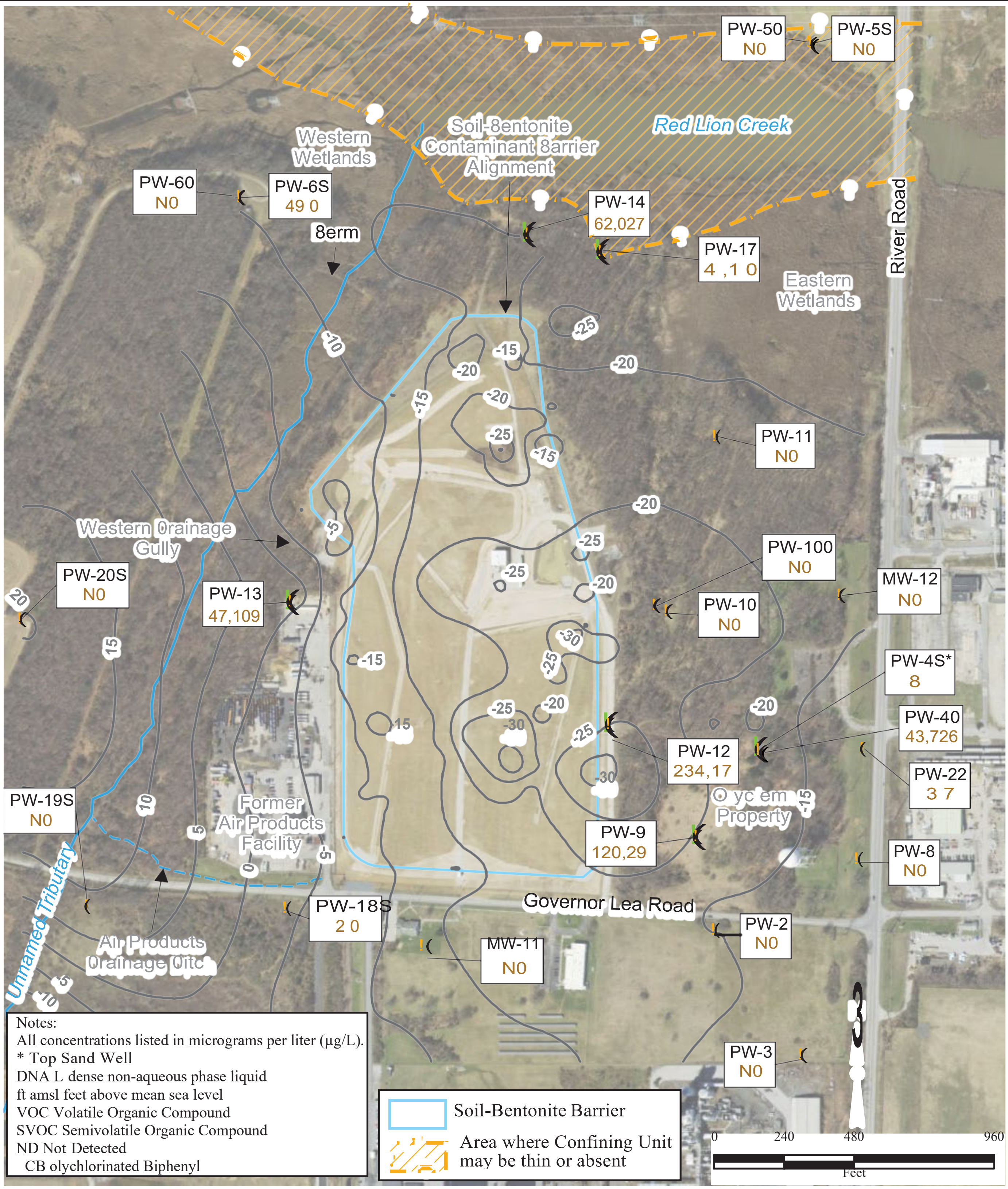


Note:
All concentrations listed in milligrams per liter (mg/L).
COC Contaminants of Concern
ND not detected

\\gst-srv-01\hglgis\Standard_Chlorine_MSIW\ISR_2018-01-2018-06\(2-20)2018-03_Total_COCs_Columbia.mxd
4/17/2019 TH
Source: HGL, USGS
USDA Imagery

Legend
Columbia Well
MW-9 Well Identification
0 90 Total COC Concentration (mg/L)
Soil Bentonite Contaminant Barrier
20 COC Concentration Contour (mg/L)

Figure 2.19 Total COCs Columbia Aquifer March 2018



\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-19)2018-03_PotoAq_ASand.mxd
4/17/2019 TH
Source: HGL, USGS
ArcGIS Online Imagery

HGL HydroGeoLogic, Inc

Legend

Monitoring Well Completed in A-Sand
Evidence of DNA L based on Exceedance of Effective Solubilty
PW-14 Well Identification
74 Total VOCs and SVOC Concentration (µg/L) in A-Sand
20 Top of Confining Unit Elevation (ft amsl)

Figure 2.20
Total V Cs and SV Cs in Groundwater in Potomac Aquifer A-Sand March 2018

Notes:
All concentrations listed in micrograms per liter (µg/L).
VOC Volatile Organic Compound
SVOC Semivolatile Organic Compound
ND Not Detected
CB olychlorinated Biphenyl

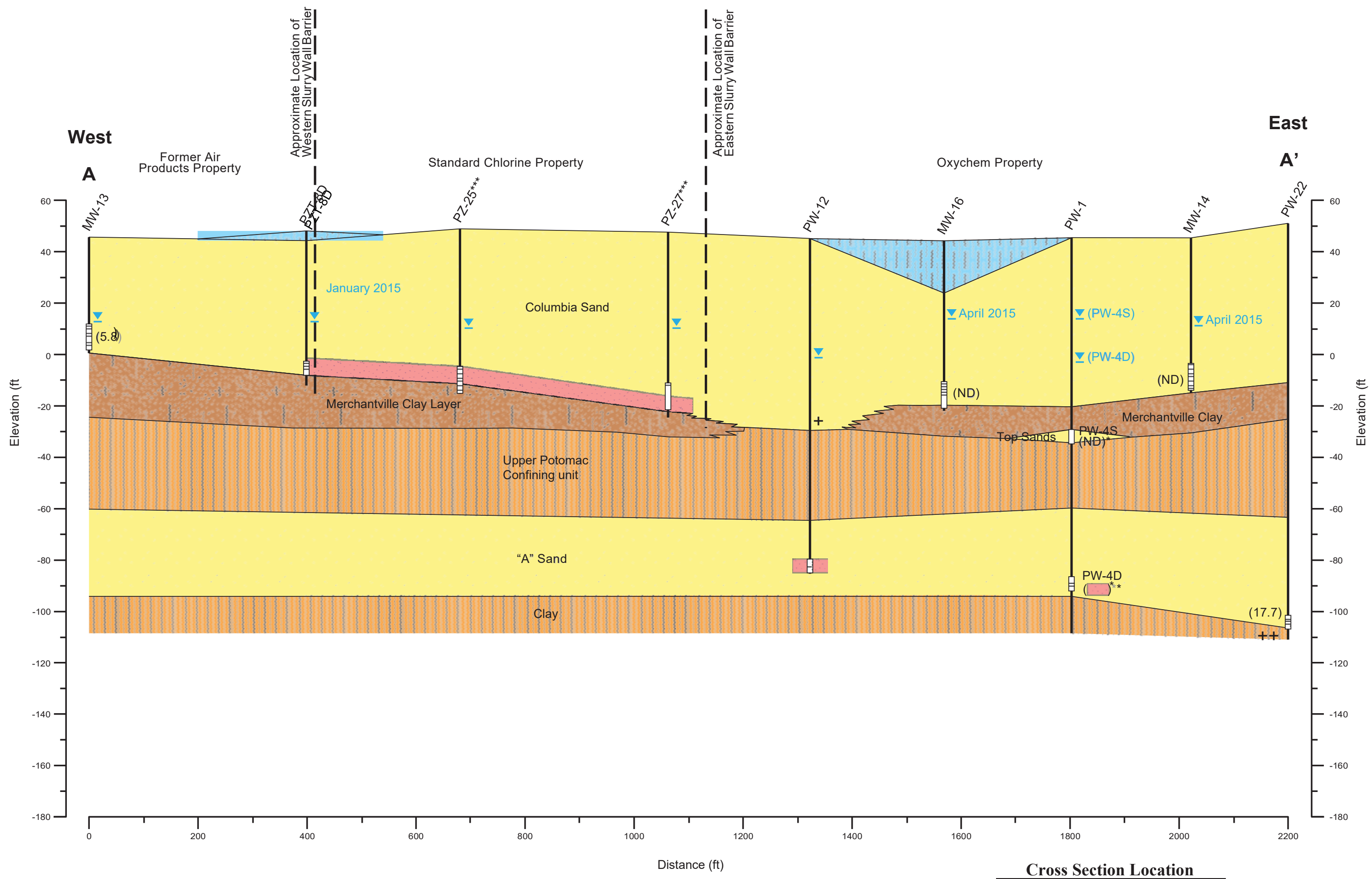
\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-20a)2018-03_PotoAq_B-CSand.mxd
4/17/2019 TH
Source: HGL, USGS
ArcGIS Online Imagery

Legend
Monitoring Well Completed in B-Sand
Monitoring Well Completed in C-Sand
PW-21 Well Identification
Total VOC and SVOC Concentration (µg/L)
22 in B-Sand
N0 in C-Sand
Soil-Bentonite Barrier

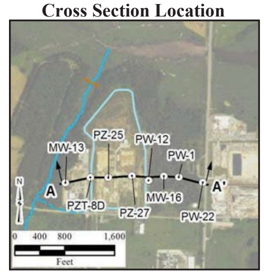
HydroGeoLogic, Inc

Figure 2.20a
Total V C and SV Cs in Groundwater in Potomac Aquifer B-Sand and C-Sand
March 2018

Figure 2.21
Cross Section A-A'



Cross Section Location



Legend

- PW-1 — Well Identification
- Well Casing
- Well Screen
- (5.8) — Sum of 1,2,4,5-TeCB, 1,2,3-TCB, 1,2,4-TCB, 1,2-DCB, 1,4-DCB, CB, Benzene in µg/L (September, 2014)
- May 2015 Groundwater Elevation or as noted
- Evidence of DNAPL

Lithology Description:

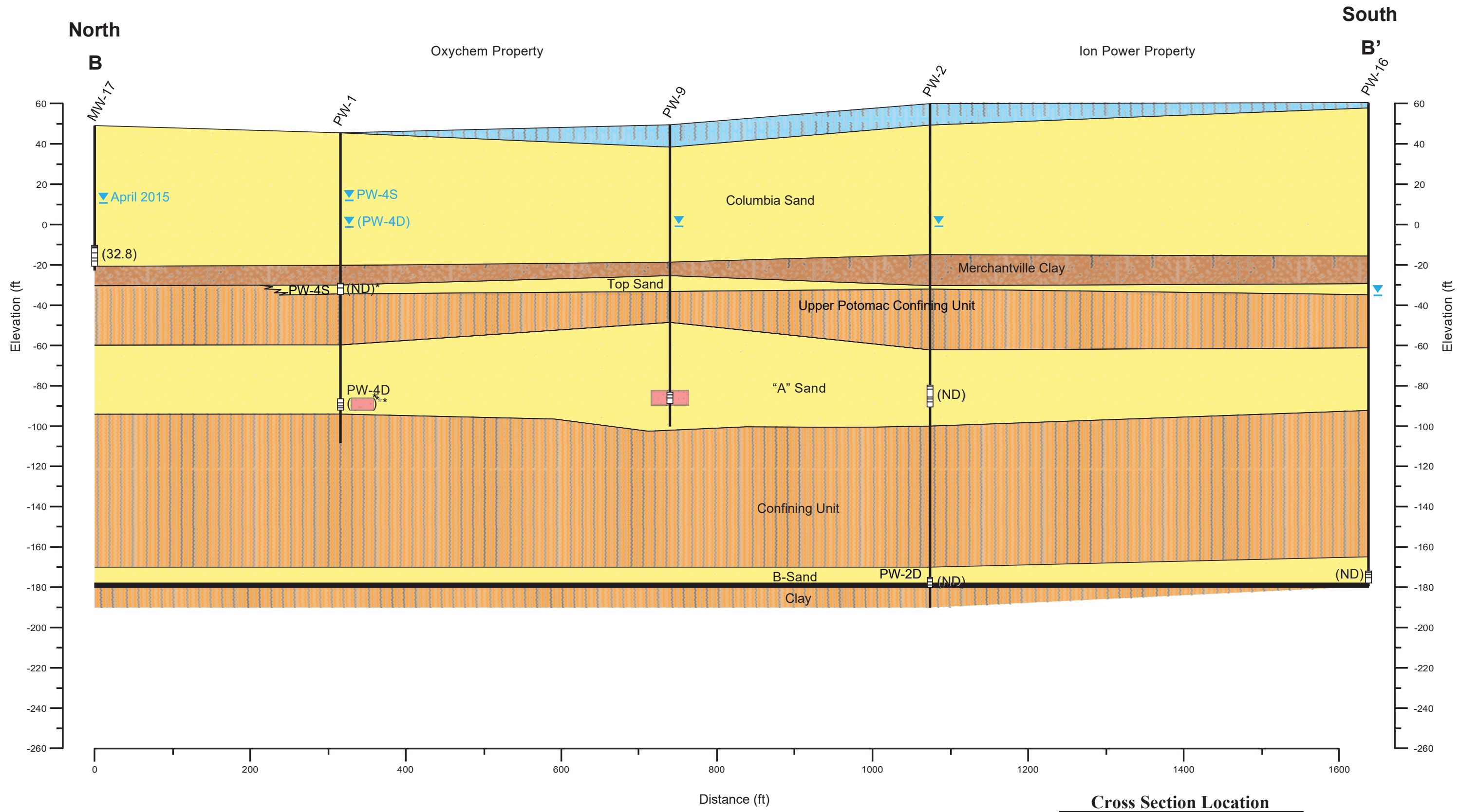
- Clay
- Merchantville Clay
- Sand
- Silt

Notes:
Vertical Exaggeration=4.57x
ft amsl=feet above mean sea level
+=Log indicates color change to grey sand. No true Merchantville clay observed.
++=No water level available
*=Data from proximal well PW-4S (see text for discussion)
**=Data from proximal well PW-4D (see text for discussion)
***=Logs for proximal extraction wells used for lithology (EW-1 PZ-25, EW-3 PZ-27)
µg/L=micrograms per liter
TeCB=tetrachlorobenzene
TCB=trichlorobenzene
DCB=dichlorobenzene
CB=chlorobenzene
DNAPLE=dense non-aqueous phase liquid

\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4
Cross-SectionAA.cdr
09/25/2017 TB
Source: HGL

HGL HydroGeoLogic, Inc

Figure 2.22
Cross Section B-B'



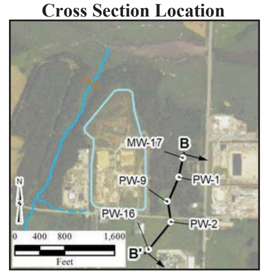
Legend

- PW-1 — Well Identification
- Well Casing
- Well Screen
- (32.8) — Sum of 1,2,4,5-TeCB, 1,2,3-TCB, 1,2,4-TCB, 1,2-DCB, 1,4-DCB, CB Benzene in μg/L (September, 2014)
- May 2015 Groundwater Elevation or as noted
- Evidence of DNAPL

Lithology Description:

- Clay
- Merchantville Clay
- Sand
- Silt

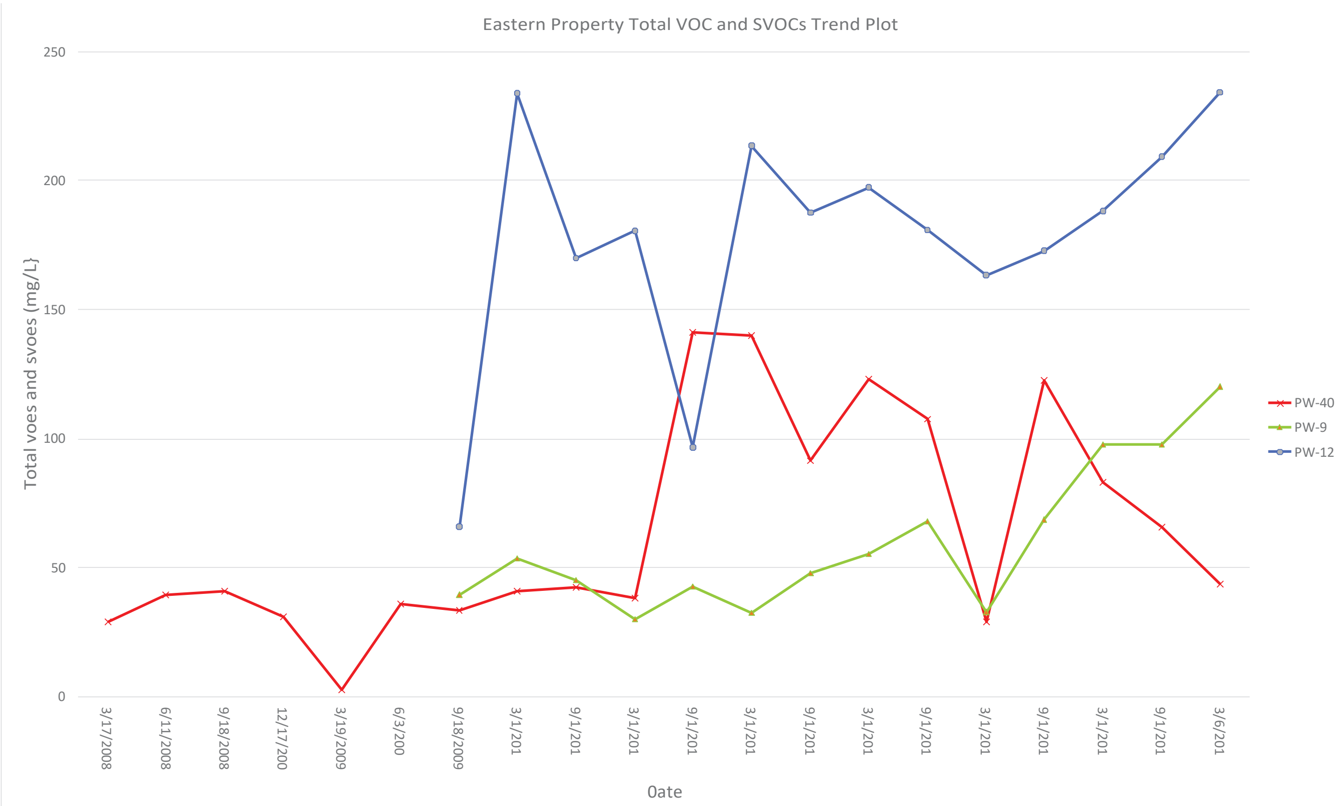
Cross Section Location



Notes:
Vertical Exaggeration=2.56x
ft amsl=feet above mean sea level
*=Data from proximal well PW-4S (see text for discussion)
**=Data from proximal well PW-4D (see text for discussion)
μg/L=micrograms per liter
TeCB=tetrachlorobenzene
TCB=trichlorobenzene
DCB=dichlorobenzene
CB=chlorobenzene
DNAPLE=dense non-aqueous phase liquid

\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4
Cross-SectionBB.cdr
09/25/2017 TB
Source: HGL

Figure 2.23
Eastern Property Total VOCs and SVOCs Trend Plot

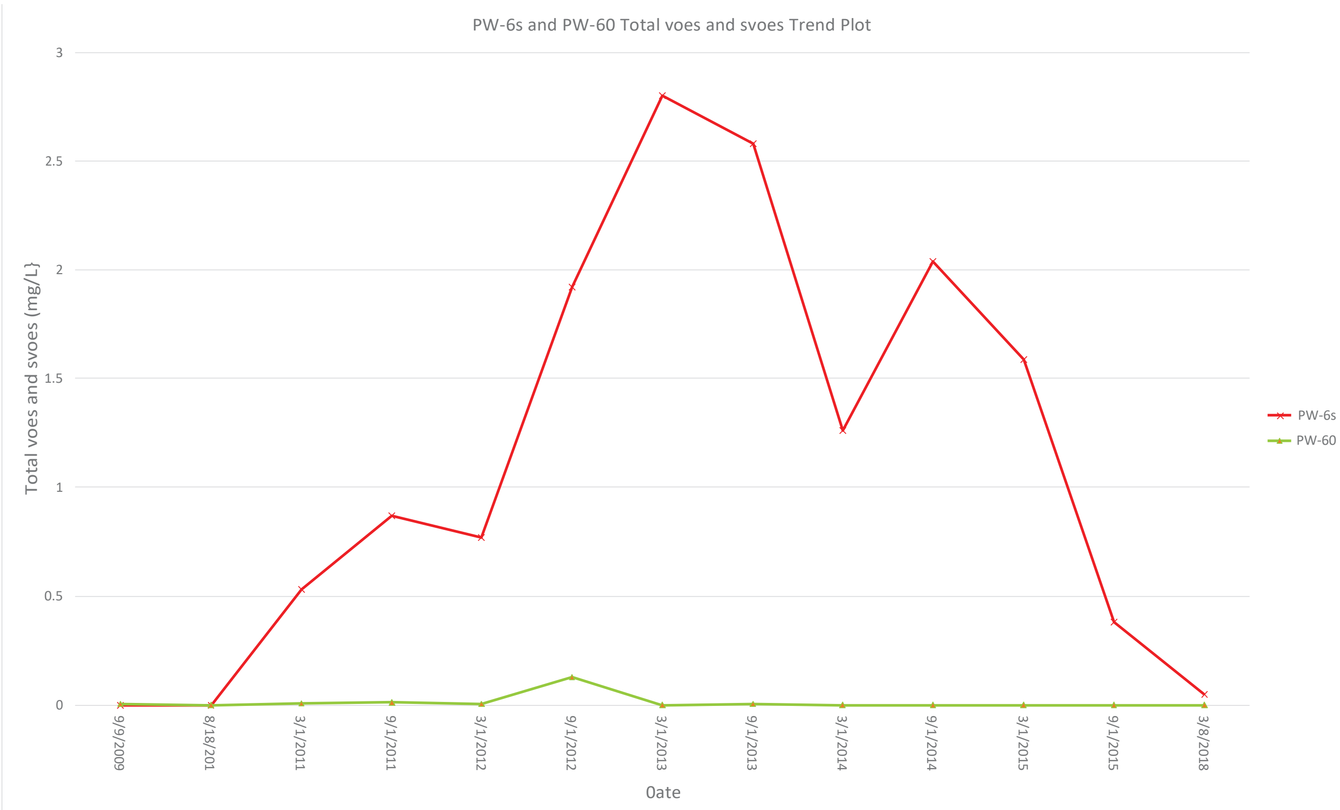


Notes:
SVOC Semivolatile Organic Compound
VOC Volatile Organic Compound
mg/L milligrams per liter

\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4
\(2-23)Potomac_east_Side_Total_VOC_SVOC.mxd
4/18/2019 TB
Source: HGL

HGL HydroGeoLogic, Inc

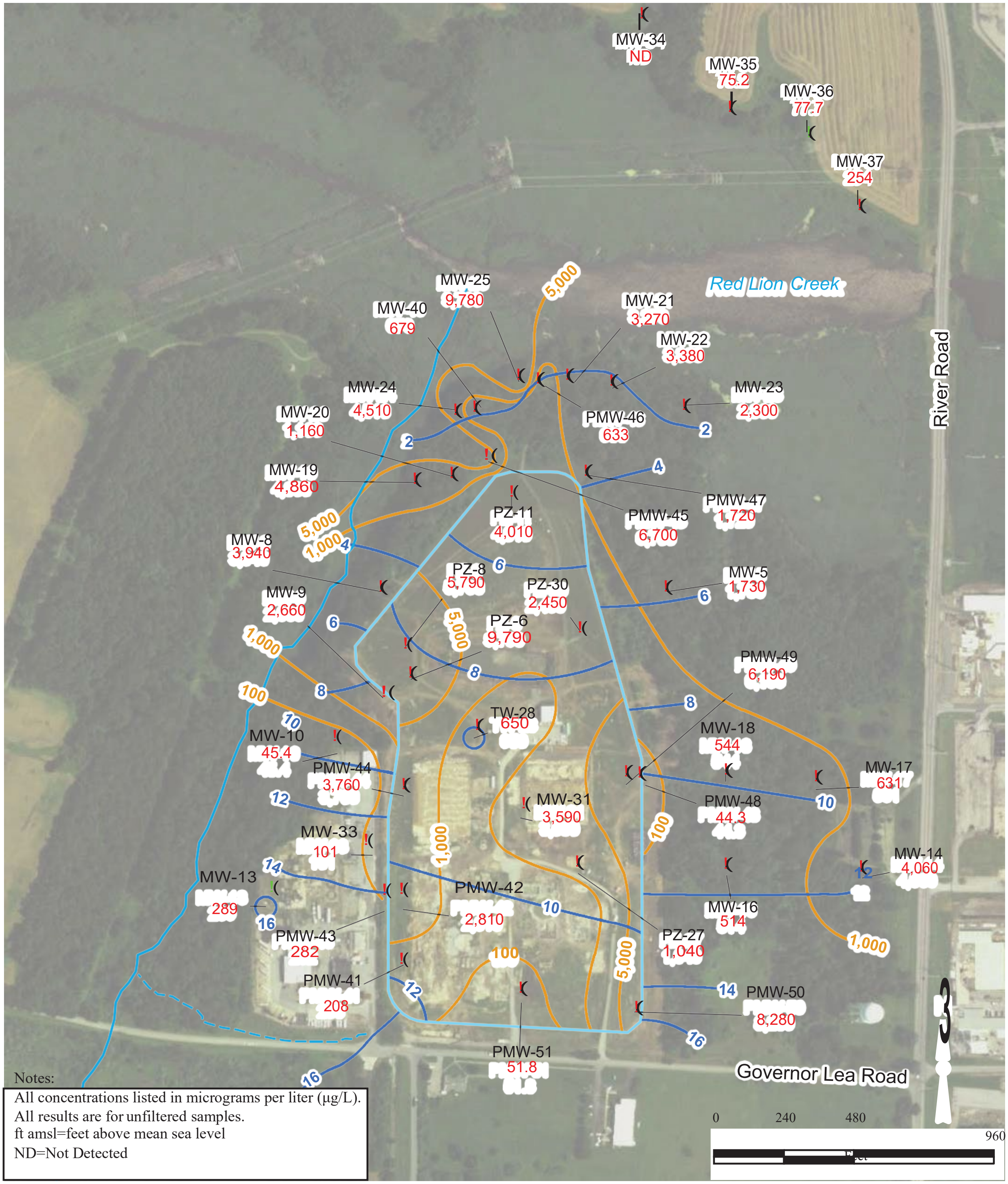
Figure 2.24
PW-6S and PW-6D Total VOCs and SVOCs Trend Plot



Notes:
SVOC Semivolatile Organic Compound
VOC Volatile Organic Compound
mg/L milligrams per liter

\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4
\(2-24)PW_6S_PW_6D_Total_VOC_SVOC.mxd
4/18/2019 TH
Source: HGL

HGL HydroGeoLogic, Inc

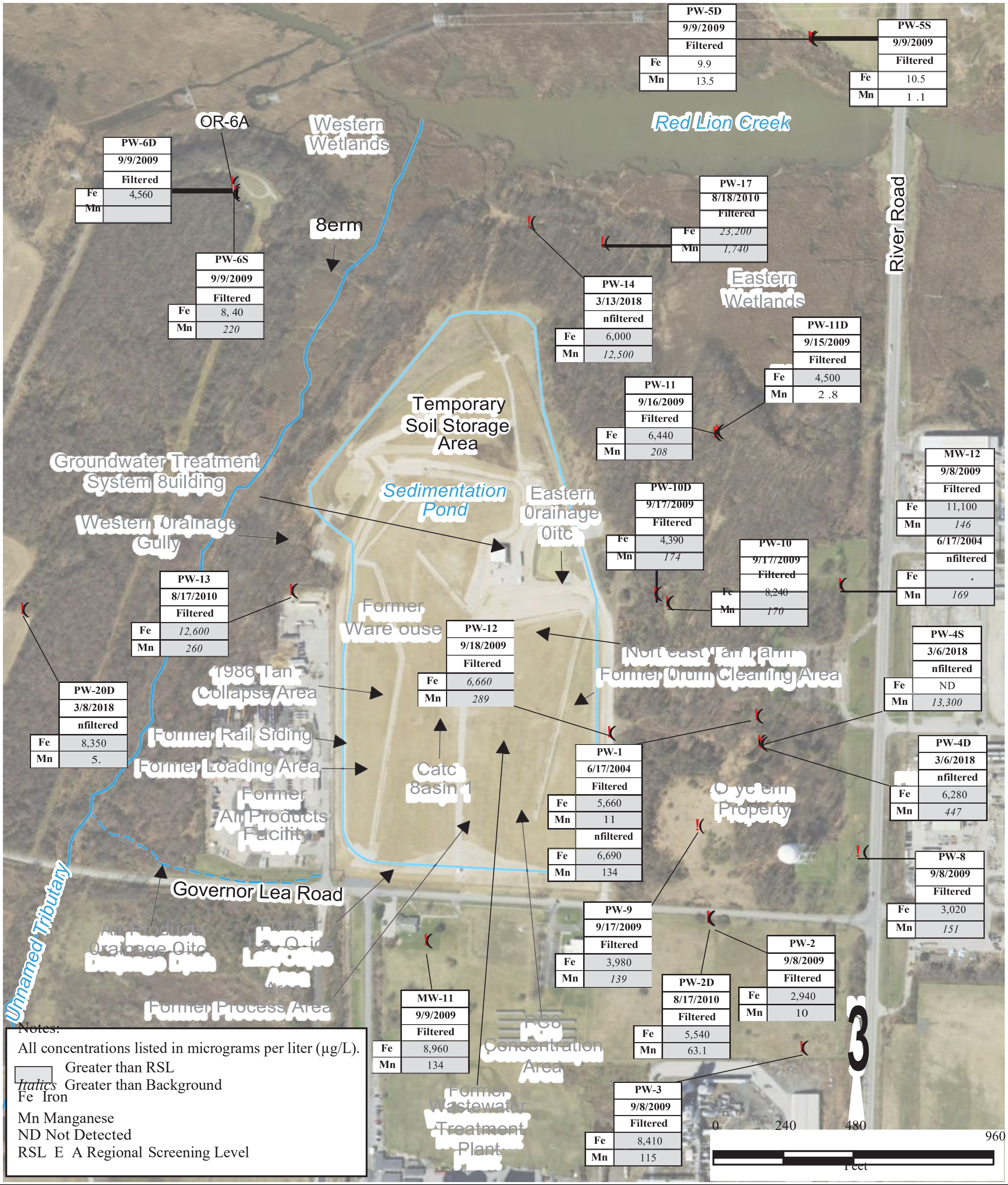


Notes:
All concentrations listed in micrograms per liter (µg/L).
All results are for unfiltered samples.
ft amsl=feet above mean sea level
ND=Not Detected

\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-25)Aq_Mn_Conc.mxd
10/2/2017 TB
Source: HGL, USGS
ArcGIS Online Imagery

Legend
- Monitoring Well
- Background Well
- MW-13 Well Identification
- 289 Manganese Concentration (µg/L)
- 100 Manganese Concentration Contour (µg/L)
- 2 Groundwater Contour (ft amsl)
- Soil-Bentonite Barrier

Figure 2.25
Columbia Aquifer Groundwater Manganese Concentrations 2010



Notes:

All concentrations listed in micrograms per liter (µg/L).

Greater than RSL

Italics Greater than Background

Fe Iron

Mn Manganese

ND Not Detected

RSL E A Regional Screening Level

\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-26)RecentData_Iron-Mang.mxd
4/18/2019 TH
Source: HGL, USGS
ArcGIS Online Imagery

Legend

!(Monitoring Well Soil-Bentonite Barrier

HGL HydroGeoLogic, Inc

Figure 2.26
Iron and Manganese in Potomac Aquifer Groundwater 2004-2018

Notes:
All concentrations listed in nanograms per liter (ng/L).
Listed values are maximum observed during 2008 sampling.
PCB=Polychlorinated Biphenyl

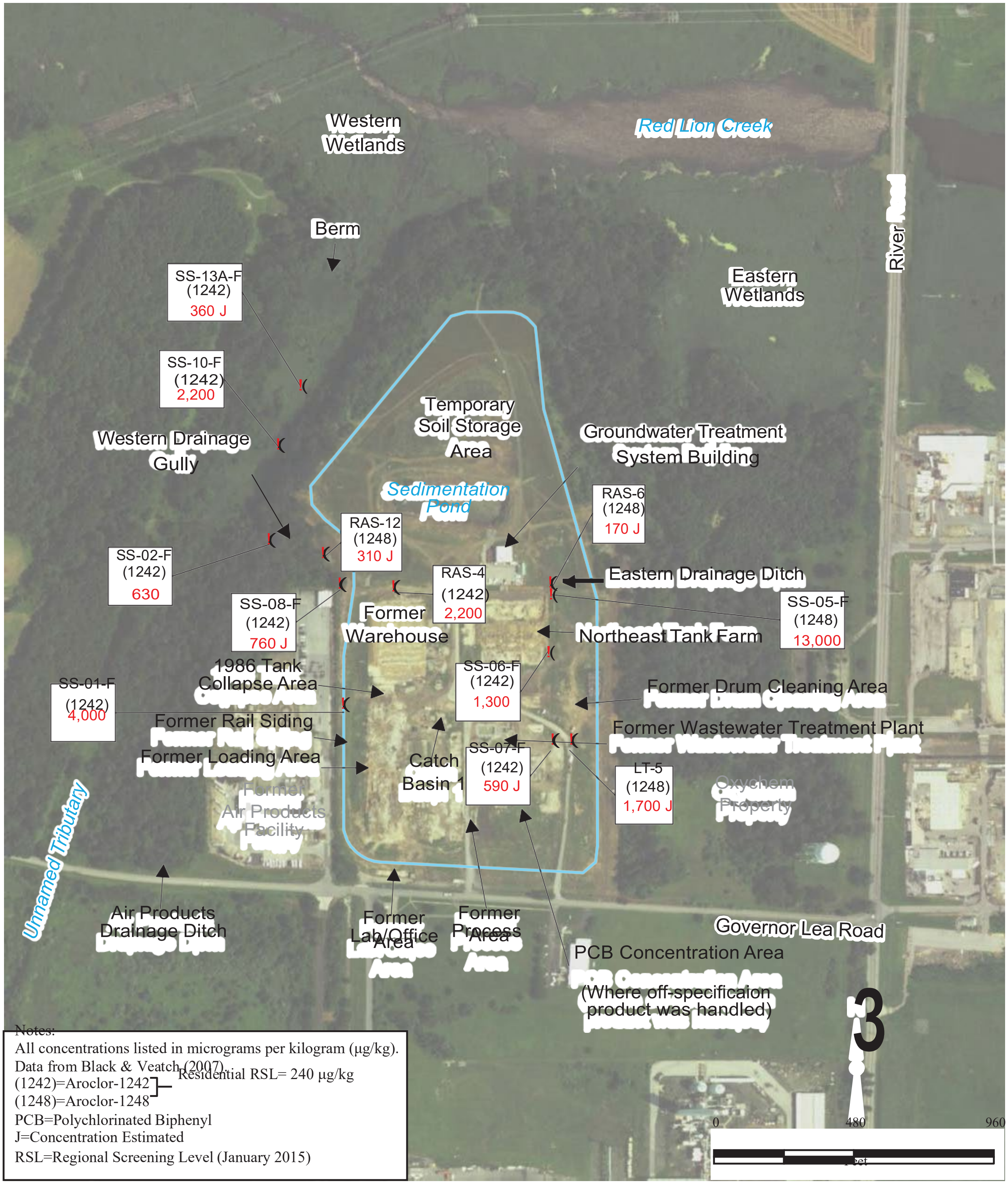
\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-27)TotPCB_ColAq.mxd
3/6/2018 TB
Source: HGL, USGS
ArcGIS Online Imagery

HGL HydroGeoLogic, Inc

Legend

- Monitoring Well
- PMW-46 Well Identification
- 22 Total PCB Congeners (ng/L)
- Soil-Bentonite Barrier

Figure 2.27
2008 Total PCB Congeners in Columbia Aquifer Groundwater



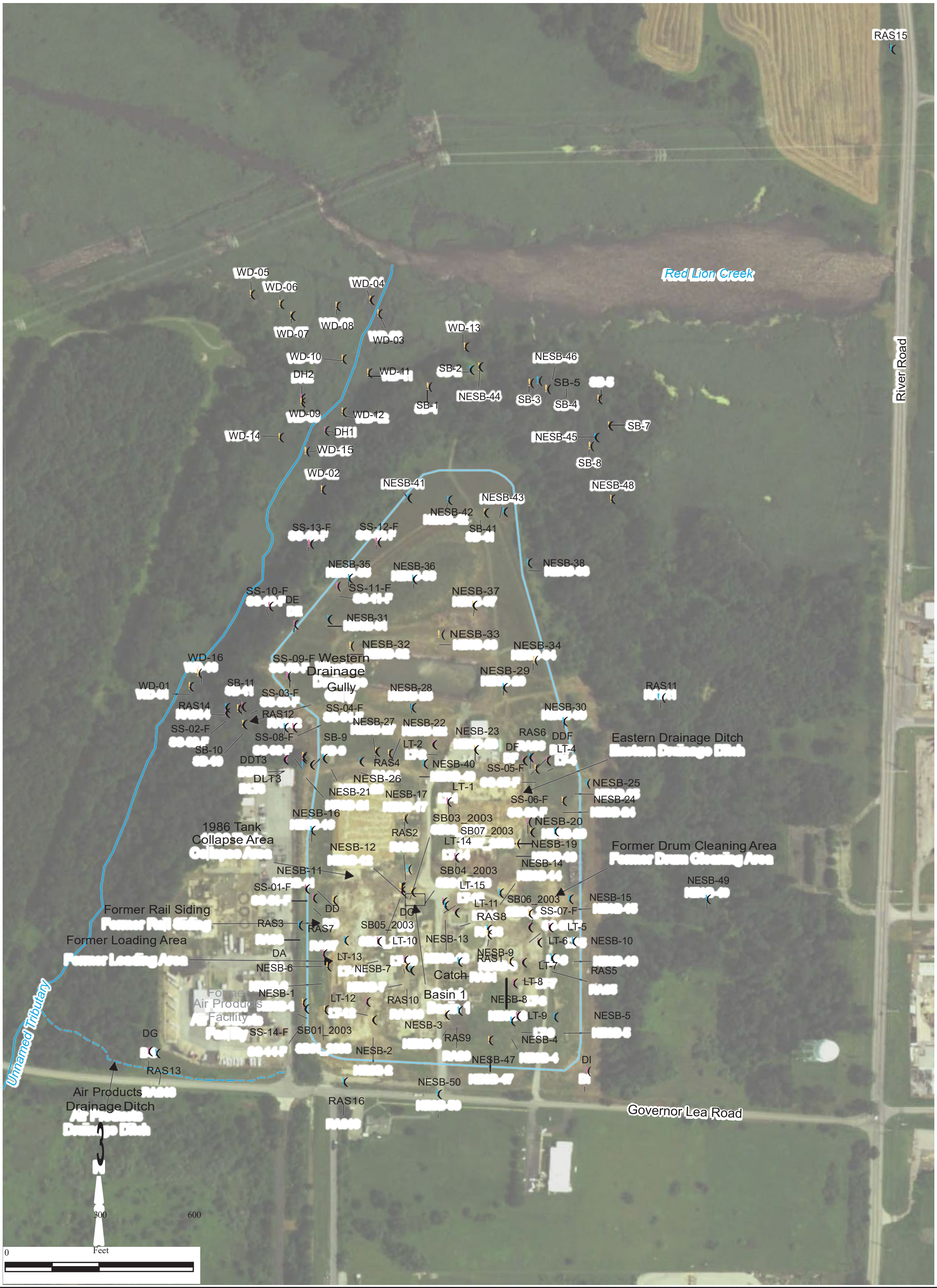
Notes:
All concentrations listed in micrograms per kilogram (µg/kg).
Data from Black & Veatch (2007).
(1242)=Aroclor-1242] Residential RSL= 240 µg/kg
(1248)=Aroclor-1248
PCB=Polychlorinated Biphenyl
J=Concentration Estimated
RSL=Regional Screening Level (January 2015)

\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-28)PCB_SurfaceSoil.mxd
9/25/2017 TB
Source: HGL
ESRI Online Aerial Imagery

Legend

!(	Surface Soil Samples
RAS-4	Well Identification
2,200	PCB Concentration (µg/kg) (2002 and 2003 Data)
	Soil-Bentonite Barrier

Figure 2.28
Relatively Elevated PCBs in Surface Soil

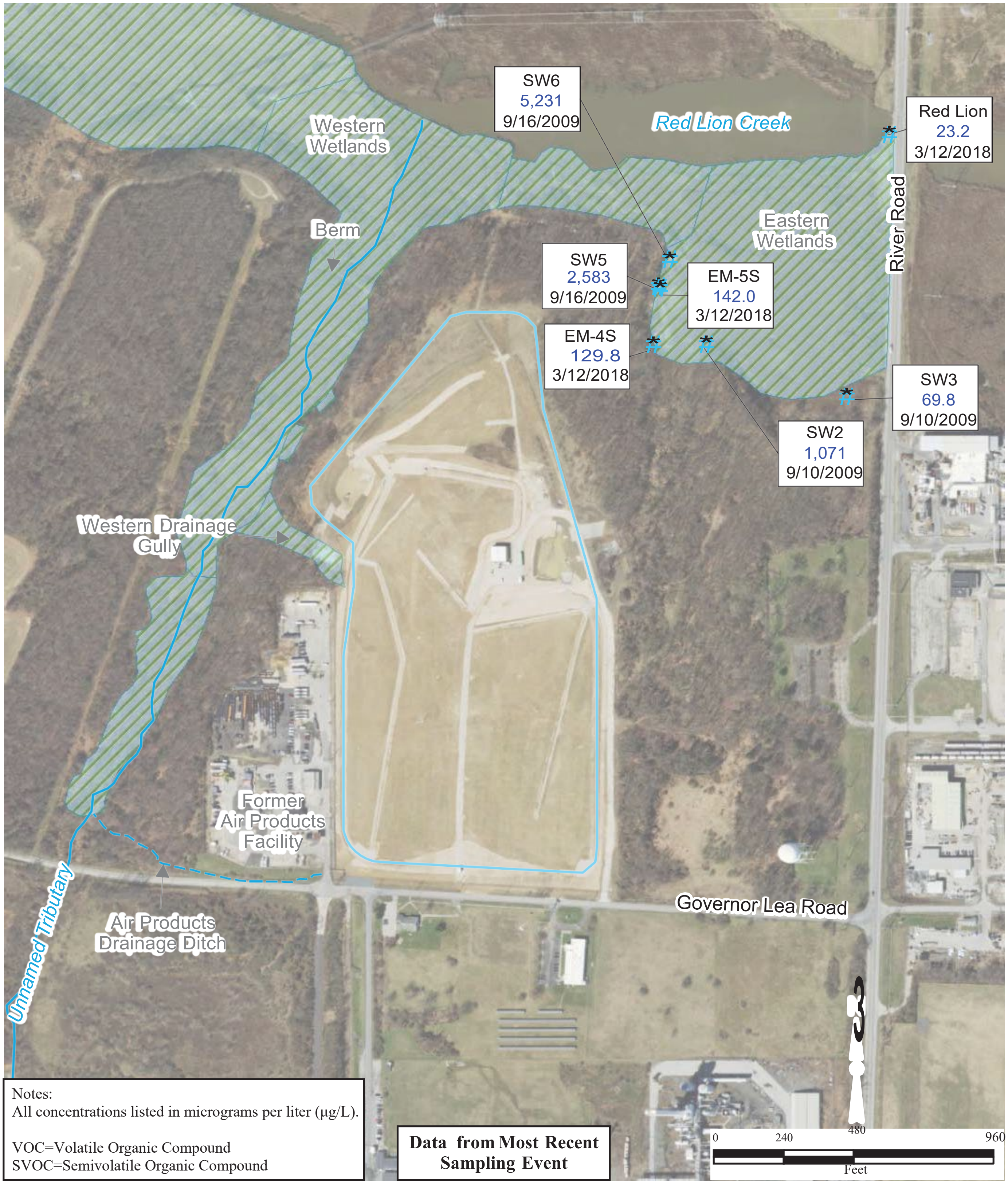


\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(2-29)Surf_SubSurf_SS_Loc.mxd
9/25/2017 TB
Source: HGL
ESRI Online Aerial Imagery

Legend

- Surface Soil Samples
- Subsurface Soil Samples
- Surface and Subsurface Soil Samples
- SB-10 Sample Identification
- Soil-Bentonite Barrier

Figure 2.29
Surface and Subsurface Soil Sample Location Map



Notes:
All concentrations listed in micrograms per liter (µg/L).

VOC=Volatile Organic Compound
SVOC=Semivolatile Organic Compound

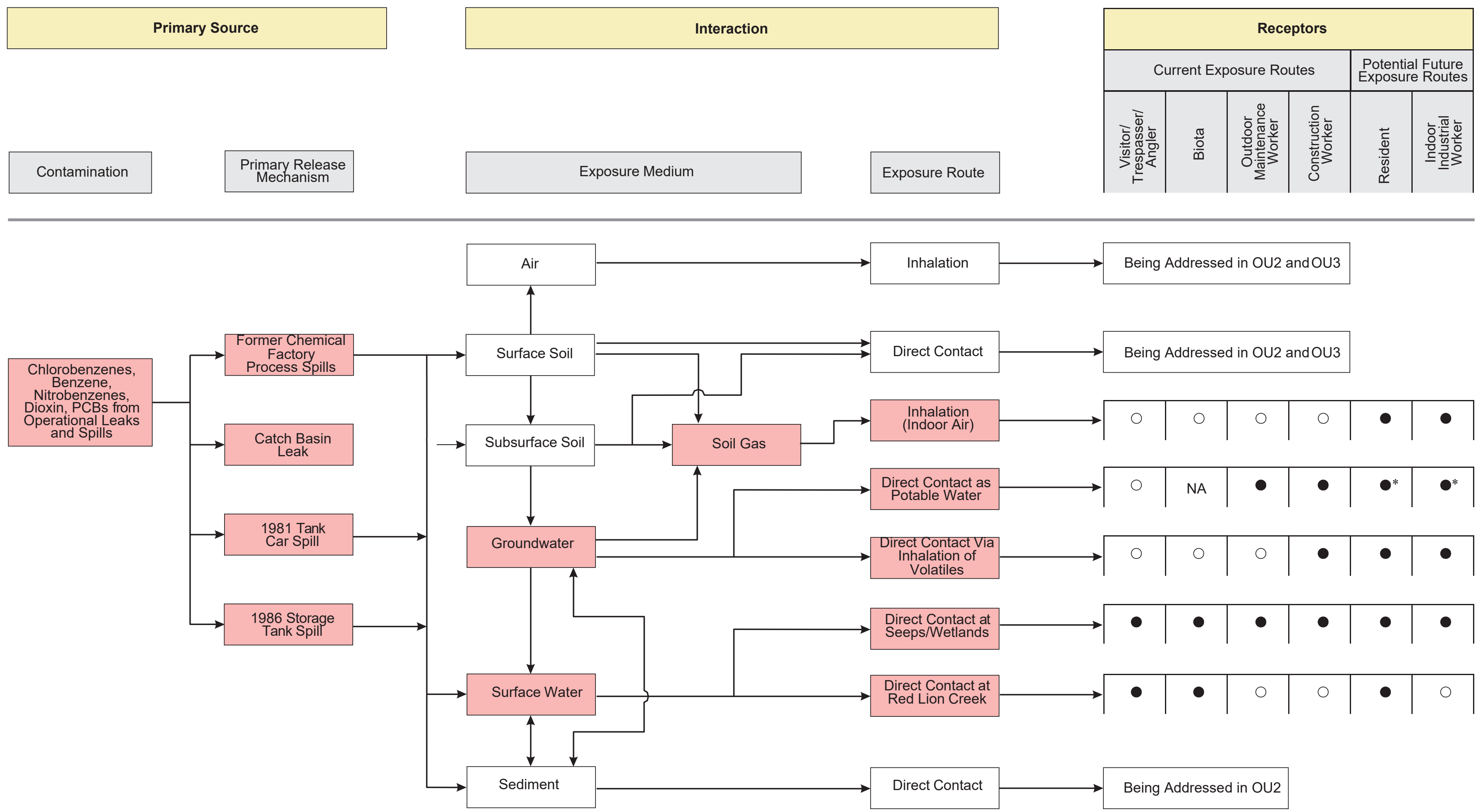
Data from Most Recent Sampling Event

\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW
\OU4_FS\(1-08)Tot(S)VOCinSW.mxa
4/12/2019 TB
Source: HGL, USGS
ArcGIS Online Imagery

Legend

#	Surface Water Sample
SW3	Sample Identification
69.8	Total VOC and SVOC Concentration (g/L)
9/10/2009	Sample Date
	Soil-Bentonite Barrier

Figure 2.30
Total VOCs and SVOCs in Surface Water



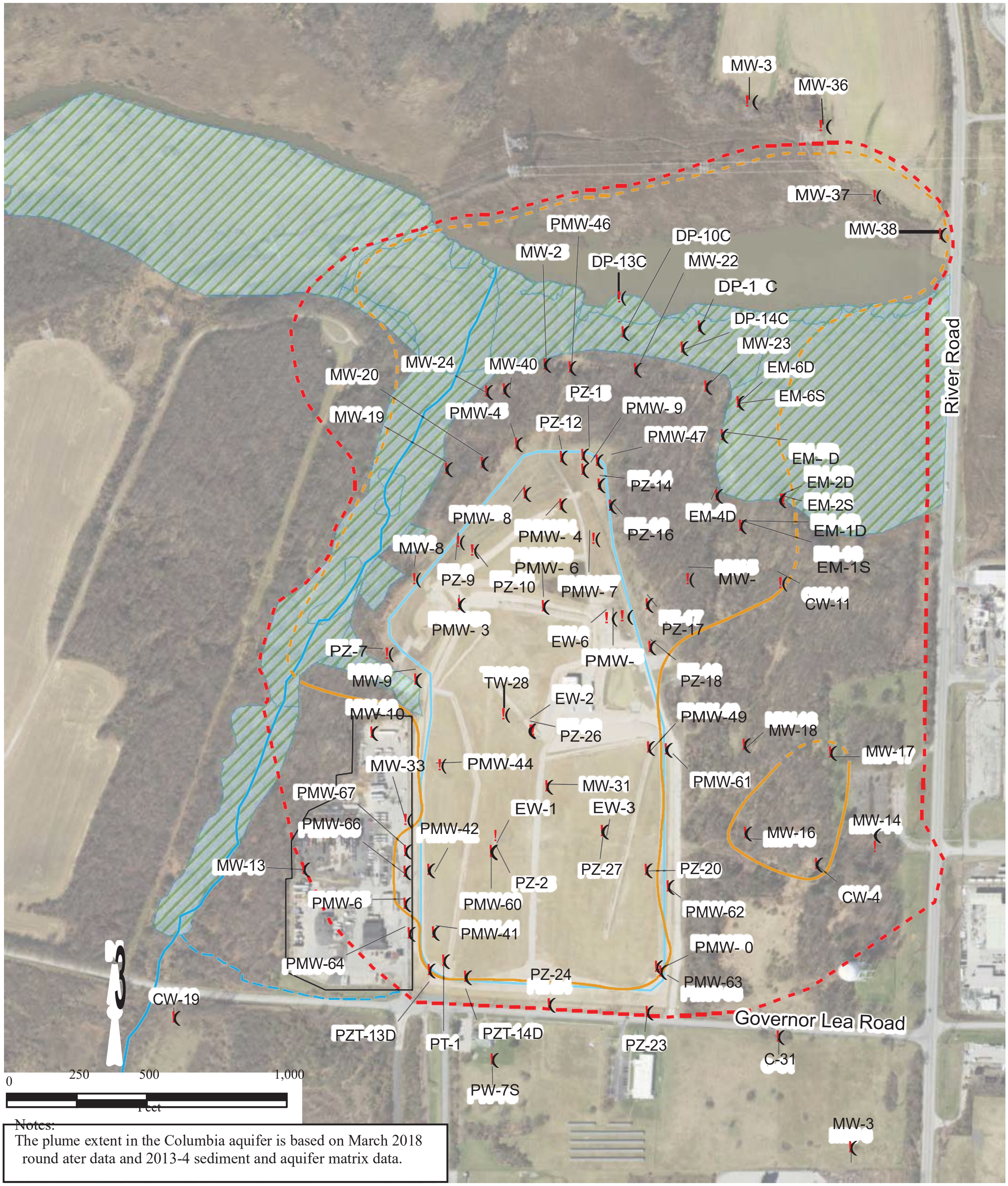
Notes: *=Groundwater is not currently used for potable purposes, but has the potential to be used in the future.
PCB=Polychlorinated Biphenyl

\\gst-srv-01\hglgis\Standard_Chlorine_MSIW\TI_OU4\
CSM_Chart.cdr
09/25/2017 TB
Source: HGL

Legend

→	Pathway	●	Complete Pathway
(pink box)	Medium/Exposure Route Part of OU4	○	Incomplete Pathway
		NA	Not Applicable

Figure 2.31
Exposure Conceptual Site Model Flowchart



Notes:
The plume extent in the Columbia aquifer is based on March 2018 round ater data and 2013-4 sediment and aquifer matrix data.

\\srv-gst-01\hglgis\Standard_Chlorine_MSIW\TI_WE (3-01)Well_Locs_Columbia.mxd
6/23/2020 TB
Source: HGL
ESRI Online Aerial Imagery

Legend Columbia Well

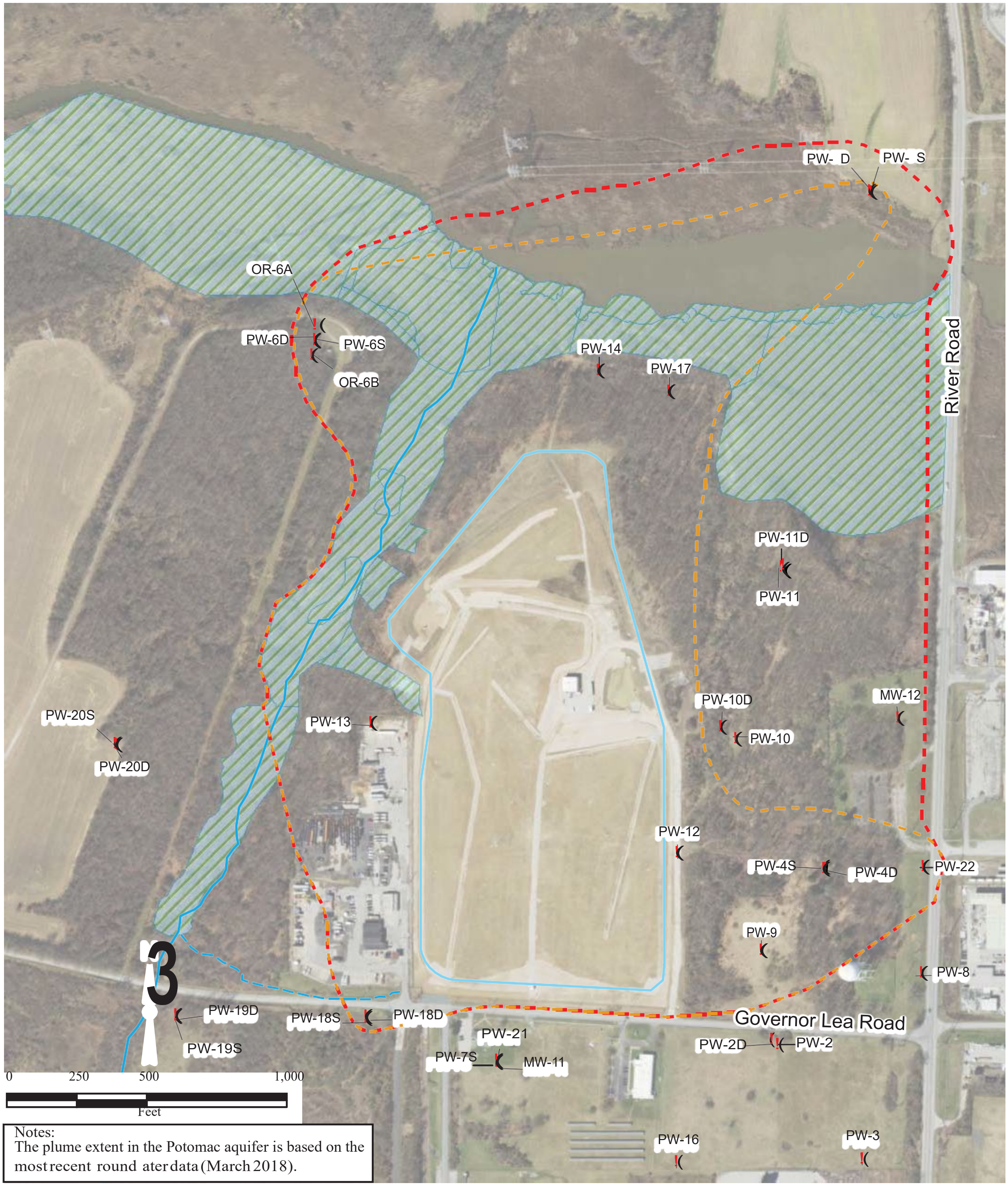
Wetland

Soil-Bentonite Barrier

Approximate Site Boundary

Columbia Aquifer Plume Extent
Dashed here inferred

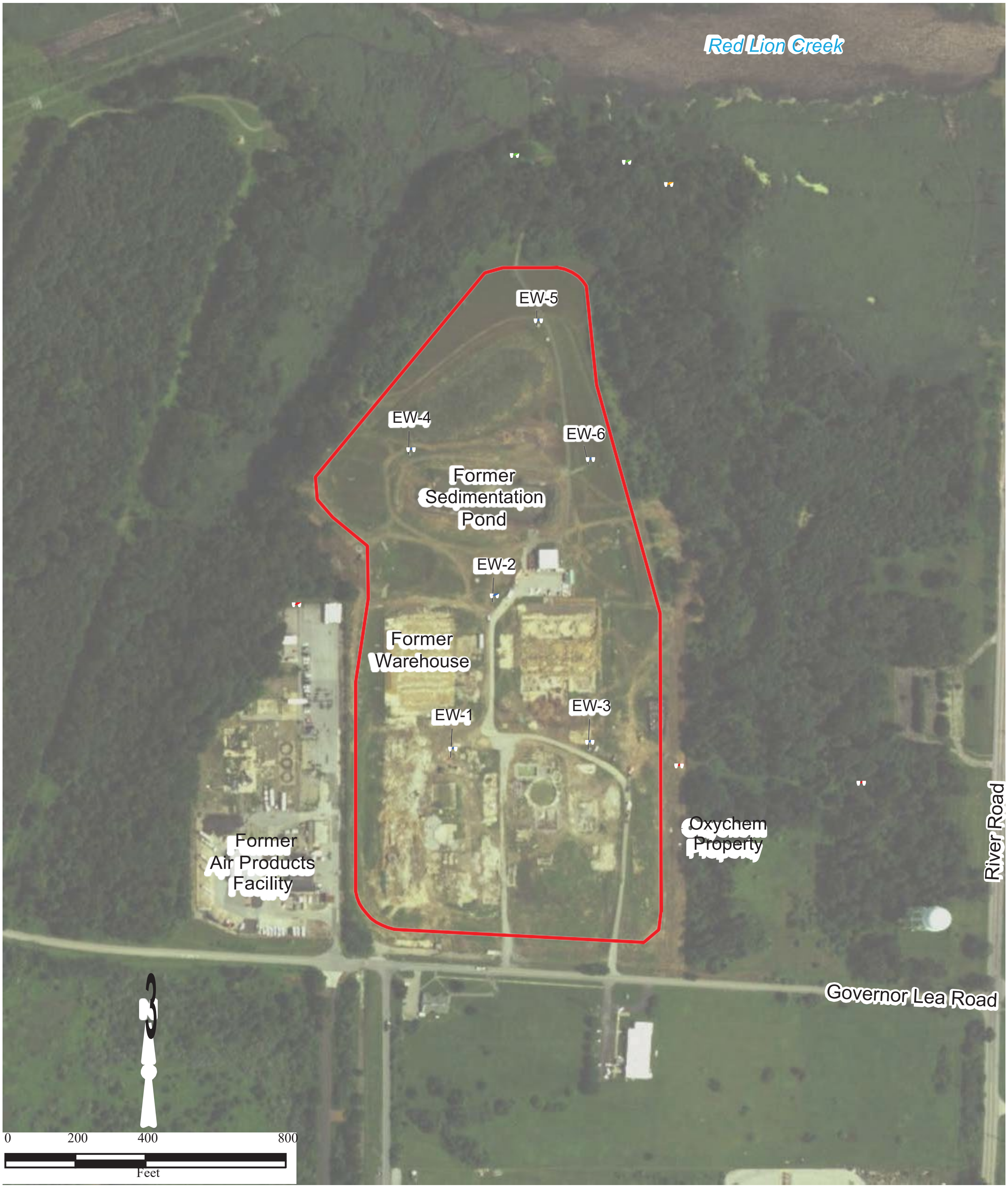
Figure 2.32
Columbia Aquifer Well Location and COC Plume Map



\\srv-gst-01\hglgis\Standard_Chlorine_MSIW\TI_OU4\(3-02)Well_Locs_Potomac.mxd
6/25/2020 TB
Source: HGL
ESRI Online Aerial Imagery

Legend Potomac Well
Wetland
Soil-Bentonite Barrier
Approximate Site Boundary
Potomac Aquifer Plume Extent
Dashed here inferred

Figure 2.33
Potomac Aquifer Well Location Map



\\gst-srv-01\HGLGIS\Standard_Chlorine_MSIW\TI_OU4\(3-01)Exist-Prop_EW.mxd
9/25/2017 TB
Source: HGL, USGS
ArcGIS Online Imagery

Legend

- Existing Extraction Well
- Proposed Potomac Extraction Well
- Proposed Columbia Extraction Well
- Possible Additional Potomac Extraction Well
- EW-1 Well Identification
- Soil-Bentonite Slurry Wall

Figure 3.3
Existing and Proposed Extraction Well Locations

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APPENDIX A

REMEDIAL TECHNOLOGY COST ESTIMATES

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Appendix A-1 – Alternative ARS1

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Assumptions

Capital costs of additional treatment components are based on vendor quotes.
Assumed that ion exchange unit will be installed.
Expansion of treatment building footprint is required to accommodate new and additional treatment components.

Description	Qty	UOM	Unit Cost		Total	Basis
Air stripper (one additional tray)	1	LS	$ 2,000.00		$ 2,000	Vendor Quote
Multi-media sand/anthracite filters	2	each	$ 4,000.00		$ 8,000	Vendor Quote
Bag filters unit	1	LS	$ 6,000.00		$ 6,000	Vendor Quote
Expand/reprogram control system	1	LS	$ 120,000.00		$ 120,000	Vendor Quote
Filter press	1	LS	$ 30,000.00		$ 30,000	Vendor Quote
Liquid-phase GAC	1	LS	$ 7,000.00		$ 7,000	Vendor Quote
Vapor-phase GAC	1	LS	$ 20,000.00		$ 20,000	Vendor Quote
Replacement of effluent pump	1	LS	$ 2,000.00		$ 2,000	Vendor Quote
Ion exchange unit	1	LS	$ 200,000.00		$ 200,000	Vendor Quote
Building expansion	1	LS	$ 120,000.00		$ 120,000	Engineering Estimate
Expansion of existing GETS Subtotal					$ 515,000	
Bid and Scope Contingency				10%	$ 51,500	EPA Guidance (single groundwater treatment)
Expansion of existing GETS with Contingency					$ 566,500	
Project Management				6%	$ 33,990	EPA Guidance
Construction Management				8%	$ 45,320	
Remedial Design				12%	$ 67,980	EPA Guidance
Expansion of existing GETS Total					**$ 713,790**	

Assumptions

Assume that second GETS will include the same treatment components with the existing GETS.
Acquisition of the needed land is included. It is assumed that the new building and the associated trenching/piping would require 2 acres.
Utility costs are assumed to be similar to the costs incurred in the existing GETS.
Assume that the footprint of new building would be 25 x 50 ft.
If RACER did not provide cost estimates, vendor quotes or engineering estimates were used.

	Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost Basis	
Filter Press	18020324	12" Structural Slab on Grade	64	SF	$ 7.29	$ 6.03	$ 0.19	$ -	$ 863.97	
	33130102	4' Diameter Electric Automatic Pressure Filter Unit	1	EA	$ 9,512.00	$ 10,674.86	$ 5,074.64	$ -	$ 25,261.50	
	33260202	2" Stainless Steel Piping, Schedule 40, Threaded, Includes Coupling 10' OC, Excludes Hangers	40	LF	$ 27.75	$ 24.02	$ -	$ -	$ 2,070.89	
								Subtotal	**$ 28,196.35**	
Air Stripper	18020321	6" Structural Slab on Grade	70	SF	$ 3.67	$ 4.33	$ 0.08	$ -	$ 565.88	
	19010204	Polyvinyl chloride pressure pipe, 2", class 200, SDR 21, includes trenching to 3' deep	100	LF	$ 1.21	$ 9.43	$ 5.32	$ -	$ 1,595.94	
	33130834	Low Profile Stripper, 46 to 90 gpm, 5 Trays	1	EA	$ 33,966.00	$ 3,764.62	$ -	$ -	$ 37,730.62	
	33130855	Low Profile Stripper Control Package	1	EA	$ 7,006.88	$ -	$ -	$ -	$ 7,006.88	
	33290121	50 GPM, 1.5 HP, Transfer Pump with Motor, Valves, Piping	1	EA	$ 2,990.90	$ 2,084.99	$ -	$ -	$ 5,075.89	
	33310106	500 CFM Blower System, 9" Pressure, 2 HP	1	EA	$ 1,381.95	$ 446.35	$ -	$ -	$ 1,828.30	
								Subtotal	**$ 53,803.51**	
Liquid GAC	18020324	12" Structural Slab on Grade	50	SF	$ 7.29	$ 6.03	$ 0.19	$ -	$ 674.97	
	33021501	Air & process gas purification, carbon adsorption, vapor phase, modular carbon adsorbers	1	EA	$ 59.54	$ -	$ -	$ -	$ 59.54	
	33021502	Thermostat & Humidity Control Devices	1	EA	$ 190.21	$ 104.69	$ -	$ -	$ 294.90	
	33131950	25' x 6" Flexible Stainless Steel High-pressure Hose	1	EA	$ 1,249.48	$ 167.43	$ -	$ -	$ 1,416.91	
	33131971	1 KW Hazardous Air Heater	1	EA	$ 811.33	$ 216.79	$ -	$ -	$ 1,028.12	
	33131980	Dual Bed,500 CFM Series/1000 CFM Parallel, 1000 Lb Fill each	2	EA	$ 46,176.00	$ 1,510.43	$ 79.40	$ -	$ 95,531.65	
	33310109	1,000 CFM Blower System, 5" Pressure, 1 1/2 HP	1	EA	$ 1,195.47	$ 394.45	$ -	$ -	$ 1,589.92	
	33310209	Pressure Gauge	2	EA	$ 109.89	$ 87.20	$ -	$ -	$ 394.19	
								Subtotal	**$ 100,990.20**	
Vapor GAC	18020322	8" Structural Slab on Grade	35	SF	$ 5.54	$ 5.23	$ 0.17	$ -	$ 382.62	
	33132029	Modular liquid-phase activated carbon, Dual Bed, 2 - 4' Diameter, 65 GPM Series, 130 GPM Parallel, 2,000 Lb Each	2	EA	$ 44,968.78	$ 19,503.44	$ 2,029.63	$ -	$ 133,003.68	
	33290121	50 GPM, 1.5 HP, Transfer Pump with Motor, Valves, Piping	1	EA	$ 2,990.90	$ 2,084.99	$ -	$ -	$ 5,075.89	
								Subtotal	**$ 138,462.19**	
Trenching /Piping	17030257	Cat 215, 1.0 CY, Soil, Shallow, Trenching, Excludes Sheeting, Excludes Dewatering	149	BCY	$ -	$ 0.87	$ 0.36	$ -	$ 182.25	
	17030415	On-Site Backfill for Large Excavations, Includes Compaction	201.15	ECY	$ -	$ 1.02	$ 0.88	$ 0.04	$ 390.72	
	17030418	Backfill with Crushed Stone	37.04	CY	$ 27.75	$ 1.53	$ 0.79	$ -	$ 1,113.98	
	17030501	Compaction, subgrade, 18" wide, 8" lifts, walk behind, vibrating plate	37.04	ECY	$ -	$ 2.91	$ 0.17	$ -	$ 114.17	
	33260211	4" Stainless Steel, Schedule 40, Connection Piping	2150	LF	$ 75.00	$ 31.32	$ -	$ -	$ 228,588.00	
								Subtotal	**$ 230,389.12**	
Purchase of Land	33220102	Project Manager	60	HR	$ -	$ 175.00	$ -	$ -	$ 10,500.00	
	33220106	Staff Engineer	30	HR	$ -	$ 120.00	$ -	$ -	$ 3,600.00	
	33220109	Staff Scientist	30	HR	$ -	$ 110.00	$ -	$ -	$ 3,300.00	
	33220110	QA/QC Officer	20	HR	$ -	$ 115.00	$ -	$ -	$ 2,300.00	
	33220114	Word Processing/Clerical	40	HR	$ -	$ 60.00	$ -	$ -	$ 2,400.00	
	33220115	Draftsman/CADD	20	HR	$ -	$ 90.00	$ -	$ -	$ 1,800.00	
	33220504	Attorney, Partner, Contracts	20	HR	$ -	$ 275.00	$ -	$ -	$ 5,500.00	
	33220507	Attorney, Associate, Real Estate	20	HR	$ -	$ 190.00	$ -	$ -	$ 3,800.00	
	33220508	Attorney, Associate, Contracts	40	HR	$ -	$ 190.00	$ -	$ -	$ 7,600.00	
	33220509	Paralegal, Real Estate	20	HR	$ -	$ 75.00	$ -	$ -	$ 1,500.00	
	33220510	Paralegal, Contracts	40	HR	$ -	$ 75.00	$ -	$ -	$ 3,000.00	
	33240101	Other Direct Costs	1	LS	$ 5,982.87	$ -	$ -	$ -	$ 5,982.87	
		Purchase of Land	2	acres	$ 100,000.00	$ -	$ -	$ -	$ 200,000.00	Average price of the area for agriculture/industrial lands
								Subtotal	**$ 251,282.87**	

Assumptions

Assume that second GETS will include the same treatment components with the existing GETS.
Acquisition of the needed land is included. It is assumed that the new building and the associated trenching/piping would require 2 acres.
Utility costs are assumed to be similar to the costs incurred in the existing GETS.
Assume that the footprint of new building would be 25 x 50 ft.
If RACER did not provide cost estimates, vendor quotes or engineering estimates were used.

	Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
	33430101	Equipment Building 10' Ceiling, Built-Up Roof, Concrete Block Exterior	1250	SF	$ -	$ -	$ -	$ 208.45	$ 260,558.75	
	33430401	PLC, 160 I/O points, 6K logic memory,	1	EA	$ 266,174.09	$ 153,957.17	$ -	$ -	$ 420,131.25	
		Ion exchange unit	1	LS	$ 200,000.00	$ -	$ -	$ -	$ 200,000.00	Vendor Quote
		Bag filters unit	3	EA	$ 4,000.00	$ -	$ -	$ -	$ 12,000.00	Vendor Quote
Building Construction		Thinning/clearing/grubbing	5	acres	$ 2,145.00	$ -	$ -	$ -	$ 10,725.00	Engineering Judgment
		Site Preparation	1.00	LS	$ -	$ -	$ -	$ 9,300	$ 9,300.00	Vendor Quote
		Site Restoration	1.00	LS	$ -	$ -	$ -	$ 5,600	$ 5,600.00	Vendor Quote
		E&S Controls	1.00	LS	$ -	$ -	$ -	$ 27,200	$ 27,200.00	Vendor Quote
		Short-Term ICs	1	LS	$ 50,000.00	$ -	$ -	$ -	$ 50,000.00	Engineering Judgment
		Utilities Installation/Extension	1	LS	$ 150,000.00	$ -	$ -	$ -	$ 150,000.00	Engineering Judgment
								Subtotal	**$ 1,145,515.01**	

Additional GETS Subtotal		$ 1,948,639	
Bid and Scope Contingency	25%	$ 487,160	EPA Guidance
Additional GETS with Contingency		$ 2,435,799	
Project Management	6%	$ 146,148	EPA Guidance
Remedial Design	12%	$ 292,296	EPA Guidance
Construction Management	8%	$ 194,864	EPA Guidance
Additional GETS Total		**$ 3,069,107**	

Assumptions
Three Potomac wells at depth of approximately 150 ft bgs.
Two Columbia wells at depth of approximately 30 ft bgs.
Stainless steel and double casing in all wells.

	Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
Potomac Extraction Wells	33010101	Mobilize/DeMobilize Drilling Rig & Crew	1	LS	$ -	$ 16,665.59	$ 6,659.79	$ -	$ 23,325.37	
	33020303	Organic Vapor Analyzer Rental, per Day	7	DAY	$ -	$ -	$ -	$ 37.66	$ 263.63	
	33109660	5,000 Gallon Single-wall Steel Aboveground Tank, Includes Cradles, Coating, Fittings, Excludes Foundation, Pumps, Pipi	1	EA	$ 6,743.25	$ 986.95	$ -	$ -	$ 7,730.20	
	33170808	Decontaminate Rig, Augers, Screen (Rental Equipment)	6	DAY	$ 28.03	$ 666.76	$ -	$ -	$ 4,168.74	
	33220112	Field Technician	66	HR	$ -	$ 42.49	$ -	$ -	$ 2,804.23	
	33230123	6" Stainless Steel, Well Casing	615	LF	$ 114.40	$ 58.87	$ 57.28	$ -	$ 141,788.25	
	33230157	2" Pitless Adapter	3	EA	$ 849.15	$ 83.72	$ -	$ -	$ 2,798.60	
	33230223	6" Stainless Steel, Well Screen	60	LF	$ 83.40	$ 6.15	$ 6.03	$ -	$ 5,734.80	
	33230313	6" Stainless Steel, Well Plug	3	EA	$ 279.00	$ 15.38	$ 15.06	$ -	$ 928.32	
	33230536	4" Submersible Pump, 15-20 GPM, 241'< Head <=300', 1 1/2 hp, w/ controls	3	EA	$ 1,257.26	$ 145.34	$ -	$ -	$ 4,207.81	
	33231257	Sonic Drilling, 9" OD,Borehole, 100 ft < Depth <= 500 ft	450	LF	$ -	$ 59.14	$ 34.72	$ -	$ 42,237.00	
	33231124	Mud Drilling, 15" Dia Borehole, Depth <= 100 ft	225	LF	$ -	$ 29.19	$ 48.32	$ -	$ 17,439.75	
	33231172	Split Spoon Sample, 2" x 24", During Drilling	45	LF	$ -	$ -	$ -	$ 334.11	$ 15,034.95	
	33231182	DOT steel drums, 55 gal., open, 17C	132	EA	$ 78.83	$ -	$ -	$ -	$ 10,405.85	
	33231186	Well Development Equipment Rental (weekly)	3	WK	$ -	$ -	$ -	$ 588.30	$ 1,764.90	
	33231403	6" Screen, Filter Pack	60	LF	$ 17.73	$ 10.66	$ 8.56	$ -	$ 2,217.14	
	33232103	6" Well, Bentonite Seal	3	EA	$ 45.68	$ 63.79	$ 51.23	$ -	$ 482.13	
	33232206	Restricted Area, Well Protection (with 4 Posts & Explosionproof Receptacle)	3	EA	$ 1,171.42	$ 973.54	$ 1.30	$ -	$ 6,438.79	
	33260211	4" Stainless Steel, Schedule 40, Connection Piping	300	LF	$ 75.00	$ 31.32	$ -	$ -	$ 31,896.00	
								Subtotal	**$ 321,666.46**	
Columbia Extraction Wells	33010101	Mobilize/DeMobilize Drilling Rig & Crew	1	LS	$ -	$ 1,665.59	$ 659.79	$ -	$ 2,325.37	
	33020303	Organic Vapor Analyzer Rental, per Day	5	DAY	$ -	$ -	$ -	$ 37.66	$ 188.30	
	33109660	5,000 Gallon Single-wall Steel Aboveground Tank, Includes Cradles, Coating, Fittings, Excludes Foundation, Pumps, Pipi	1	EA	$ 6,743.25	$ 986.95	$ -	$ -	$ 7,730.20	
	33170808	Decontaminate Rig, Augers, Screen (Rental Equipment)	4	DAY	$ 28.03	$ 666.76	$ -	$ -	$ 2,779.16	
	33220112	Field Technician	15	HR	$ -	$ 42.49	$ -	$ -	$ 637.33	
	33230123	6" Stainless Steel, Well Casing	30	LF	$ 114.40	$ 58.87	$ 57.28	$ -	$ 6,916.50	
	33230157	2" Pitless Adapter	2	EA	$ 849.15	$ 83.72	$ -	$ -	$ 1,865.73	
	33230223	6" Stainless Steel, Well Screen	30	LF	$ 83.40	$ 6.15	$ 6.03	$ -	$ 2,867.40	
	33230313	6" Stainless Steel, Well Plug	2	EA	$ 279.00	$ 15.38	$ 15.06	$ -	$ 618.88	
	33230536	4" Submersible Pump, 15-20 GPM, 241'< Head <=300', 1 1/2 hp, w/ controls	2	EA	$ 1,257.26	$ 145.34	$ -	$ -	$ 2,805.21	
	33231124	Mud Drilling, 15" Dia Borehole, Depth <= 100 ft	60	LF	$ -	$ 29.19	$ 48.32	$ -	$ 4,650.60	
	33231172	Split Spoon Sample, 2" x 24", During Drilling	6	LF	$ -	$ -	$ -	$ 334.11	$ 2,004.66	
	33231182	DOT steel drums, 55 gal., open, 17C	19	EA	$ 78.83	$ -	$ -	$ -	$ 1,497.81	
	33231186	Well Development Equipment Rental (weekly)	2	WK	$ -	$ -	$ -	$ 588.30	$ 1,176.60	
	33231403	6" Screen, Filter Pack	40	LF	$ 17.73	$ 10.66	$ 8.56	$ -	$ 1,478.09	
	33232103	6" Well, Bentonite Seal	2	EA	$ 45.68	$ 63.79	$ 51.23	$ -	$ 321.42	
	33232206	Restricted Area, Well Protection (with 4 Posts & Explosionproof Receptacle)	2	EA	$ 1,171.42	$ 973.54	$ 1.30	$ -	$ 4,292.52	
	33260210	2" Stainless Steel, Schedule 40, Connection Piping	350	LF	$ 25.00	$ 17.75	$ -	$ -	$ 14,962.50	
								Subtotal	**$ 59,118.29**	

Assumptions

Three Potomac wells at depth of approximately 150 ft bgs.
Two Columbia wells at depth of approximately 30 ft bgs.
Stainless steel and double casing in all wells.

	Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
	33170904	Load LLW Roll-Off Containers on Truck or directly in disposal pit/landfill	1	EA	$ -	$ 160.16	$ -	$ -	$ 160.16	
	33170924	Transport LLW Roll-Off Containers (1 per truck)	250	MI	$ -	$ -	$ -	$ 3.85	$ 962.93	
	33190101	Liquid Loading Into 5,000 Gallon Bulk Tank Truck	1	EA	$ -	$ 604.82	$ 337.75	$ -	$ 942.57	
	33190102	Bulk Solid Waste Loading Into Disposal Vehicle or Bulk Disposal Container	35	BCY	$ 1.00	$ 1.39	$ 0.40	$ -	$ 97.61	
	33190108	Tanker Pumping Equipment to Load Liquid	1	HR	$ -	$ -	$ -	$ 29.93	$ 29.93	
IDW management	33190205	Transport Bulk Solid Hazardous Waste, Maximum 20 CY (per Mile)	500	MI	$ -	$ -	$ -	$ 2.89	$ 1,443.00	
	33190207	Transport Bulk Liquid/Sludge Hazardous Waste, Maximum 5,000 Gallon (per Mile)	250	MI	$ -	$ -	$ -	$ 2.89	$ 721.50	
	33190317	Waste Stream Evaluation Fee, Not Including 50% Rebate on 1st Shipment	3	EA	$ -	$ -	$ -	$ 69.38	$ 208.13	
	33190807	32 Ft. Dump Truck, 6 Mil Liner, disposable	2	EA	$ 25.73	$ -	$ -	$ -	$ 51.46	
	33190815	Bulk Solid Waste Disposal Container, 20 CY Roll-Off	1	MO	$ 3,774.00	$ -	$ -	$ -	$ 3,774.00	
	33197270	Landfill Nonhazardous Solid Bulk Waste by CY	35	CY	$ -	$ -	$ -	$ 25.12	$ 879.18	
	33197273	Commercial RCRA landfills, liquid	37	GAL	$ -	$ -	$ -	$ 0.61	$ 22.59	
								Subtotal	**$ 9,293**	

Additional extraction wells Subtotal		$ 390,078	
Bid and Scope Contingency	10%	$ 39,008	EPA Guidance
Additional extraction wells with Contingency		$ 429,086	
Project Management	6%	$ 25,745	EPA Guidance
Construction Management	6%	$ 25,745	EPA Guidance
Additional extraction wells Total		**$ 480,576**	

Assumptions

Description	Qty	UOM	Unit Cost		Total	Notes
Mobilization/Demobilization						
Work Plans/Permits	1	LS	$ 50,000		$ 50,000	Engineering Judgment
Mobilization/Demobilization	1	LS	$ 50,000		$ 50,000	Engineering Judgment
Site Preparation						
Thinning/clearing/grubbing	3	acres	$ 5,145		$ 15,435	2018 RSMeans, 31 13 13.10 0020, burdened, location factors accounted for
Short-Term ICs	1	LS	$ 25,000		$ 25,000	Engineering Judgment, includdes signs and access agreements
Temporary Road / Swamp Mats	1	LS	$ 95,931.25		$ 95,931	Vendor Quote
Sheet pile (45 ft deep cells)	37035	square ft	$ 26.52		$ 982,297	2018 RSMeans, 31 41 16.10 1200, location factors accounted for
Sheet pile (75 ft deep cells)	31500	square ft	$ 34.58		$ 1,089,270	2018 RSMeans, 31 41 16.10 1200, location factors accounted for
Site Preparation Subtotal					$ 2,307,934	
Bid and Scope Contingency				20%	$ 461,587	EPA Guidance
Site Preparation with Contingency					$ 2,769,520	
Project Management				5%	$ 138,476	EPA Guidance
Site Preparation Total					**$ 2,907,996**	

Assumptions

Waste Management is 1% of the total capital cost prior any contigencies
Completion report will be required to document all remedial component

Description	Qty	UOM	Unit Cost	Total	Basis
Waste Handling	1	LS	$ 28,537	$ 28,537	Engineering Judgment
Long-Term ICs	1	LS	$ 50,000	$ 50,000	Engineering Judgment
Completion Report	1	LS	$ 50,000	$ 50,000	Engineering Judgment
Site Restoration Subtotal				$ 128,537	
Bid and Scope Contingency			20%	$ 25,707	EPA Guidance
Site Restoration with Contingency				$ 154,245	
Project Management			5%	$ 7,712	EPA Guidance
Site Restoration Total				**$ 161,957**	

Assumptions

Assume that expansion of the existing GETS and construction of the second GETS, taking into account for startup and optimization, would take one year.
For this first year, the project manager would be on site two days per week.
The construction engineer, SSHO, and QA officer would be on site for the entire year.

	Description	Qty	UOM	Unit Cost	Total	Basis
Oversight personnel	Project Manager	1040	hour	$ 175.00	$ 182,000	Engineering Judgment
	Construction Engineer	3120	hour	$ 146.00	$ 455,520	Engineering Judgment
	SSHO and QA officer	6240	hour	$ 115.00	$ 717,600	Engineering Judgment
	Per Diem	1095	day	$ 178.00	$ 194,910	GSA rates
	Labor Total				**$ 1,550,030**	

Assumptions

Existing GETS O&M costs for the upgraded system, including carbon replacements, filter media, ion exchange resin, spent media disposal, and labor for treatment plant operators, treatment plant sampling, and reporting,
Second GETS O&M also includes costs for system startup, commissioning, and optimization.

	Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
	33020402	Decontamination Materials per Sample	48	EA	$ 14.36	$ -	$ -	$ -	$ 689.18	
	33021670	Metals Screen, 25 Metals Listed In Method EPA 200.7, Water Analysis	48	EA	$ -	$ -	$ -	$ 62.00	$ 2,976.00	
	33021721	Testing, semi-volatile organics (625, 8270)	48	EA	$ -	$ -	$ -	$ 105.00	$ 5,040.00	
	33021720	Testing, purgeable organics (624, 8260)	48	EA	$ -	$ -	$ -	$ 47.00	$ 2,256.00	
	33021834	Volatile Organic Compounds (TO-14)	48	EA	$ -	$ -	$ -	$ 392.98	$ 18,863.25	
	33022042	Overnight delivery service, 21 to 50 lb packages	24	EA	$ -	$ -	$ -	$ 280.00	$ 6,720.00	
		Bulk liquid-phase activated carbon, > 10,000 Lb	4400	LB	$ 2.42	$ -	$ -	$ -	$ 10,648.00	SCD System Data
		Bulk vapor-phase activated carbon, > 10,000 Lb	54000	LB	$ 0.96	$ -	$ -	$ -	$ 51,840.00	SCD System Data
		Transportation and Disposal of Treatment System Sludge and Bag Filters, Hazardous Waste	108	DRUM	$ -	$ -	$ -	$ 595.00	$ 64,260.00	SCD System Data
		Project Manager	120	HR	$ -	$ 175.00	$ -	$ -	$ 21,000.00	Vendor Quote
Second GETS		Staff Engineer	120	HR	$ -	$ 120.00	$ -	$ -	$ 14,400.00	Vendor Quote
		Staff Scientist	96	HR	$ -	$ 110.00	$ -	$ -	$ 10,560.00	Vendor Quote
		QA/QC Officer	40	HR	$ -	$ 115.00	$ -	$ -	$ 4,600.00	Vendor Quote
		Word Processing/Clerical	80	HR	$ -	$ 60.00	$ -	$ -	$ 4,800.00	Vendor Quote
		Draftsman/CADD	40	HR	$ -	$ 90.00	$ -	$ -	$ 3,600.00	Vendor Quote
		Treatment System Operator	520	HR	$ -	$ 75.00	$ -	$ -	$ 39,000.00	Vendor Quote
	33240101	Other Direct Costs	1	LS	$ 2,551.80	$ -	$ -	$ -	$ 2,551.80	
	33240104	Startup Costs	1	LS	$ 58,283.00	$ 35,253.04	$12,424.50	$ -	$ 105,960.54	
		Water/Sewer Utility Charge	12	MONTH	$ 160.00	$ -	$ -	$ -	$ 1,920.00	SCD System Data
	33420101	Electrical Charge	176000	KWH	$ 0.12	$ -	$ -	$ -	$ 21,489.60	
		Wireless and Phone Charge	12	MONTH	$ -	$ -	$ -	$ 98.00	$ 1,176.00	SCD System Data
								Subtotal	**$ 394,350.37**	
	33020402	Decontamination Materials per Sample	48	EA	$ 14.36	$ -	$ -	$ -	$ 689.18	
	33021670	Metals Screen, 25 Metals Listed In Method EPA 200.7, Water Analysis	48	EA	$ -	$ -	$ -	$ 62.00	$ 2,976.00	
	33021721	Testing, semi-volatile organics (625, 8270)	48	EA	$ -	$ -	$ -	$ 105.00	$ 5,040.00	
	33021720	Testing, purgeable organics (624, 8260)	48	EA	$ -	$ -	$ -	$ 47.00	$ 2,256.00	
	33021834	Volatile Organic Compounds (TO-14)	48	EA	$ -	$ -	$ -	$ 392.98	$ 18,863.25	
	33022042	Overnight delivery service, 21 to 50 lb packages	24	EA	$ -	$ -	$ -	$ 280.00	$ 6,720.00	
		Bulk liquid-phase activated carbon, > 10,000 Lb	17600	LB	$ 2.42	$ -	$ -	$ -	$ 42,592.00	SCD System Data
		Bulk vapor-phase activated carbon, > 10,000 Lb	126000	LB	$ 0.96	$ -	$ -	$ -	$ 120,960.00	SCD System Data
		Transportation and Disposal of Treatment System Sludge and Bag Filters, Hazardous Waste	162	DRUM	$ -	$ -	$ -	$ 595.00	$ 96,390.00	SCD System Data
Existing GETS		Project Manager	120	HR	$ -	$ 175.00	$ -	$ -	$ 21,000.00	Vendor Quote
		Staff Engineer	120	HR	$ -	$ 120.00	$ -	$ -	$ 14,400.00	Vendor Quote
		Staff Scientist	96	HR	$ -	$ 110.00	$ -	$ -	$ 10,560.00	Vendor Quote
		QA/QC Officer	40	HR	$ -	$ 115.00	$ -	$ -	$ 4,600.00	Vendor Quote
		Word Processing/Clerical	80	HR	$ -	$ 60.00	$ -	$ -	$ 4,800.00	Vendor Quote
		Draftsman/CADD	40	HR	$ -	$ 90.00	$ -	$ -	$ 3,600.00	Vendor Quote
		Treatment System Operator	520	HR	$ -	$ 75.00	$ -	$ -	$ 39,000.00	Vendor Quote
	33240101	Other Direct Costs	1	LS	$ -	$ 2,478.00	$ -	$ -	$ 2,478.00	
		Water/Sewer Utility Charge	12	MONTH	$ 160.00	$ -	$ -	$ -	$ 1,920.00	SCD System Data
	33420101	Electrical Charge	264000	KWH	$ 0.12	$ -	$ -	$ -	$ 32,234.40	
		Wireless and Phone Charge	12	MONTH	$ -	$ -	$ -	$ 98.00	$ 1,176.00	SCD System Data

Assumptions

Existing GETS O&M costs for the upgraded system, including carbon replacements, filter media, ion exchange resin, spent media disposal, and labor for treatment plant operators, treatment plant sampling, and reporting,
Second GETS O&M also includes costs for system startup, commissioning, and optimization.

Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
							Subtotal $	**432,254.83**	
O&M First year Subtotal							$	826,605	
Bid and Scope Contingency							10% $	82,661	EPA Guidance
O&M First year with Contingency							$	909,266	
Project Management							5% $	45,463	EPA Guidance
O&M First year Total							**$**	**954,729**	

<u>Assumptions</u>

Existing GETS O&M costs for the upgraded system, including carbon replacements, filter media, ion exchange resin, spent media disposal, and labor for treatment plant operators, treatment plant sampling, and reporting,
Second GETS O&M includes the same costs with the existing GETS.

	Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
	33020402	Decontamination Materials per Sample	48	EA	$ 14.36	$ -	$ -	$ -	$ 689.18	
	33021670	Metals Screen, 25 Metals Listed In Method EPA 200.7, Water Analysis	48	EA	$ -	$ -	$ -	$ 62.00	$ 2,976.00	
	33021721	Testing, semi-volatile organics (625, 8270)	48	EA	$ -	$ -	$ -	$ 105.00	$ 5,040.00	
	33021720	Testing, purgeable organics (624, 8260)	48	EA	$ -	$ -	$ -	$ 47.00	$ 2,256.00	
	33021834	Volatile Organic Compounds (TO-14)	48	EA	$ -	$ -	$ -	$ 392.98	$ 18,863.25	
	33022042	Overnight delivery service, 21 to 50 lb packages	24	EA	$ -	$ -	$ -	$ 280.00	$ 6,720.00	
		Bulk liquid-phase activated carbon, > 10,000 Lb	4400	LB	$ 2.42	$ -	$ -	$ -	$ 10,648.00	SCD System Data
		Bulk vapor-phase activated carbon, > 10,000 Lb	54000	LB	$ 0.96	$ -	$ -	$ -	$ 51,840.00	SCD System Data
		Transportation and Disposal of Treatment System Sludge and Bag Filters, Hazardous Waste	108	DRUM	$ -	$ -	$ -	$ 595.00	$ 64,260.00	SCD System Data
Second GETS		Project Manager	120	HR	$ -	$ 175.00	$ -	$ -	$ 21,000.00	Vendor Quote
		Staff Engineer	60	HR	$ -	$ 120.00	$ -	$ -	$ 7,200.00	Vendor Quote
		Staff Scientist	60	HR	$ -	$ 110.00	$ -	$ -	$ 6,600.00	Vendor Quote
		QA/QC Officer	40	HR	$ -	$ 115.00	$ -	$ -	$ 4,600.00	Vendor Quote
		Word Processing/Clerical	80	HR	$ -	$ 60.00	$ -	$ -	$ 4,800.00	Vendor Quote
		Draftsman/CADD	40	HR	$ -	$ 90.00	$ -	$ -	$ 3,600.00	Vendor Quote
		Treatment System Operator	520	HR	$ -	$ 75.00	$ -	$ -	$ 39,000.00	Vendor Quote
	33240101	Other Direct Costs	1	LS	$ 2,551.80	$ -	$ -	$ -	$ 2,551.80	
		Water/Sewer Utility Charge	12	MONTH	$ 160.00	$ -	$ -	$ -	$ 1,920.00	SCD System Data
	33420101	Electrical Charge	176000	KWH	$ 0.12	$ -	$ -	$ -	$ 21,489.60	
		Wireless and Phone Charge	12	MONTH	$ -	$ -	$ -	$ 98.00	$ 1,176.00	SCD System Data
								Subtotal	**$ 277,229.83**	
	33020402	Decontamination Materials per Sample	48	EA	$ 14.36	$ -	$ -	$ -	$ 689.18	
	33021670	Metals Screen, 25 Metals Listed In Method EPA 200.7, Water Analysis	48	EA	$ -	$ -	$ -	$ 62.00	$ 2,976.00	
	33021721	Testing, semi-volatile organics (625, 8270)	48	EA	$ -	$ -	$ -	$ 105.00	$ 5,040.00	
	33021720	Testing, purgeable organics (624, 8260)	48	EA	$ -	$ -	$ -	$ 47.00	$ 2,256.00	
	33021834	Volatile Organic Compounds (TO-15)	48	EA	$ -	$ -	$ -	$ 392.98	$ 18,863.25	
	33022042	Overnight delivery service, 21 to 50 lb packages	24	EA	$ -	$ -	$ -	$ 280.00	$ 6,720.00	
		Bulk liquid-phase activated carbon, > 10,000 Lb	17600	LB	$ 2.42	$ -	$ -	$ -	$ 42,592.00	SCD System Data
		Bulk vapor-phase activated carbon, > 10,000 Lb	126000	LB	$ 0.96	$ -	$ -	$ -	$ 120,960.00	SCD System Data
		Transportation and Disposal of Treatment System Sludge and Bag Filters, Hazardous Waste	162	DRUM	$ -	$ -	$ -	$ 595.00	$ 96,390.00	SCD System Data
Existing GETS		Project Manager	120	HR	$ -	$ 175.00	$ -	$ -	$ 21,000.00	Vendor Quote
		Staff Engineer	60	HR	$ -	$ 120.00	$ -	$ -	$ 7,200.00	Vendor Quote
		Staff Scientist	60	HR	$ -	$ 110.00	$ -	$ -	$ 6,600.00	Vendor Quote
		QA/QC Officer	40	HR	$ -	$ 115.00	$ -	$ -	$ 4,600.00	Vendor Quote
		Word Processing/Clerical	80	HR	$ -	$ 60.00	$ -	$ -	$ 4,800.00	Vendor Quote
		Draftsman/CADD	40	HR	$ -	$ 90.00	$ -	$ -	$ 3,600.00	Vendor Quote
		Treatment System Operator	520	HR	$ -	$ 75.00	$ -	$ -	$ 39,000.00	Vendor Quote
	33240101	Other Direct Costs	1	LS	$ -	$ 2,478.00	$ -	$ -	$ 2,478.00	
		Water/Sewer Utility Charge	12	MONTH	$ 160.00	$ -	$ -	$ -	$ 1,920.00	SCD System Data
	33420101	Electrical Charge	264000	KWH	$ 0.12	$ -	$ -	$ -	$ 32,234.40	
		Wireless and Phone Charge	12	MONTH	$ -	$ -	$ -	$ 98.00	$ 1,176.00	SCD System Data

Assumptions

Existing GETS O&M costs for the upgraded system, including carbon replacements, filter media, ion exchange resin, spent media disposal, and labor for treatment plant operators, treatment plant sampling, and reporting,
Second GETS O&M includes the same costs with the existing GETS.

Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
							Subtotal	$ 421,094.83	

Assumptions

Existing GETS O&M costs for the upgraded system, including carbon replacements, filter media, ion exchange resin, spent media disposal, and labor for treatment plant operators, treatment plant sampling, and reporting,
Second GETS O&M includes the same costs with the existing GETS.

Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
O&M Subtotal							$	698,325	
Bid and Scope Contingency							10% $	69,832	EPA Guidance
O&M with Contingency							$	768,157	
Project Management							5% $	38,408	EPA Guidance
O&M Total							**$**	**806,565**	

Assumptions

The long-term groundwater monitoring program would include approximately 60 Columbia aquifer wells and 30 Potomac aquifer wells, including the 11 extraction wells. Semi-annual sampling is assumed for the first 5 years

Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
33020401	Disposable Materials per Sample	283	EA	$ 10.93	$ -	$ -	$ -	$ 3,091.90	
33020402	Decontamination Materials per Sample	283	EA	$ 14.36	$ -	$ -	$ -	$ 4,063.27	
33020561	Lysimeter accessories, nylon tubing, 1/4" OD	9115	LF	$ 0.20	$ -	$ -	$ -	$ 1,821.18	
33021509	Monitor well sampling equipment, rental, water quality testing parameter device rental	5	WK	$ -	$ -	$ -	$ 333.00	$ 1,665.00	
33021618	Testing, purgeable organics (624, 8260)	283	EA	$ -	$ -	$ -	$ 47.00	$ 13,301.00	
33021619	Testing, semi-volatile organics (625, 8270)	283	EA	$ -	$ -	$ -	$ 105.00	$ 29,715.00	
33021620	Testing, TAL metals (6010)	283	EA	$ -	$ -	$ -	$ 62.00	$ 17,546.00	
33022043	Overnight delivery service, 51 to 70 lb packages	49	EA	$ -	$ -	$ -	$ 280.00	$ 13,720.00	
33022124	Testing, RCRA evaluations, EP toxicity analysis, metals (6010,7470)	1	EA	$ -	$ -	$ -	$ 62.00	$ 62.00	
33010108	Sedan, Automobile, Rental	10	DAY	$ -	$ -	$ -	$ 59.16	$ 591.60	
33010202	Per Diem (per person)	10	DAY	$ -	$ -	$ -	$ 166.00	$ 1,660.00	
33230614	Peristaltic Pump, Weekly Rental	5	WK	$ -	$ -	$ -	$ 99.90	$ 499.50	
33220102	Project Manager	40	HR	$ -	$ 175.00	$ -	$ -	$ 7,000.00	
33220106	Staff Engineer	60	HR	$ -	$ 120.00	$ -	$ -	$ 7,200.00	
33220109	Staff Scientist	120	HR	$ -	$ 110.00	$ -	$ -	$ 13,200.00	
33220110	QA/QC Officer	40	HR	$ -	$ 115.00	$ -	$ -	$ 4,600.00	
33220114	Word Processing/Clerical	40	HR	$ -	$ 60.00	$ -	$ -	$ 2,400.00	
33220115	Draftsman/CADD	40	HR	$ -	$ 90.00	$ -	$ -	$ 3,600.00	

LTM 1 5 Subtotal		$ 125,736	
Bid and Scope Contingency	10%	$ 12,574	EPA Guidance
LTM 1 5 with Contingency		$ 138,310	
Project Management	5%	$ 6,916	EPA Guidance
LTM 1 5 Total		**$ 145,226**	

Assumptions

The long-term groundwater monitoring program would include approximately 60 Columbia aquifer wells and 30 Potomac aquifer wells, including the 11 extraction wells. Annual sampling is assumed after the first 5 years

Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
33020401	Disposable Materials per Sample	143	EA	$ 10.93	$ -	$ -	$ -	$ 1,562.34	
33020402	Decontamination Materials per Sample	143	EA	$ 14.36	$ -	$ -	$ -	$ 2,053.17	
33020561	Lysimeter accessories, nylon tubing, 1/4" OD	4570	LF	$ 0.20	$ -	$ -	$ -	$ 913.09	
33021509	Monitor well sampling equipment, rental, water quality testing parameter device rental	3	WK	$ -	$ -	$ -	$ 333.00	$ 999.00	
33021618	Testing, purgeable organics (624, 8260)	143	EA	$ -	$ -	$ -	$ 47.00	$ 6,721.00	
33021619	Testing, semi-volatile organics (625, 8270)	143	EA	$ -	$ -	$ -	$ 105.00	$ 15,015.00	
33021620	Testing, TAL metals (6010)	143	EA	$ -	$ -	$ -	$ 62.00	$ 8,866.00	
33022043	Overnight delivery service, 51 to 70 lb packages	25	EA	$ -	$ -	$ -	$ 280.00	$ 7,000.00	
33022124	Testing, RCRA evaluations, EP toxicity analysis, metals (6010,7470)	1	EA	$ -	$ -	$ -	$ 62.00	$ 62.00	
33010108	Sedan, Automobile, Rental	5	DAY	$ -	$ -	$ -	$ 59.16	$ 295.80	
33010202	Per Diem (per person)	5	DAY	$ -	$ -	$ -	$ 166.00	$ 830.00	
33230614	Peristaltic Pump, Weekly Rental	3	WK	$ -	$ -	$ -	$ 99.90	$ 299.70	
33220102	Project Manager	40	HR	$ -	$ 175.00	$ -	$ -	$ 7,000.00	
33220106	Staff Engineer	60	HR	$ -	$ 120.00	$ -	$ -	$ 7,200.00	
33220109	Staff Scientist	120	HR	$ -	$ 110.00	$ -	$ -	$ 13,200.00	
33220110	QA/QC Officer	40	HR	$ -	$ 115.00	$ -	$ -	$ 4,600.00	
33220114	Word Processing/Clerical	40	HR	$ -	$ 60.00	$ -	$ -	$ 2,400.00	
33220115	Draftsman/CADD	40	HR	$ -	$ 90.00	$ -	$ -	$ 3,600.00	

LTM 6 30 Subtotal		$ 82,617	
Bid and Scope Contingency	10%	$ 8,262	EPA Guidance
LTM 6 30 with Contingency		$ 90,879	
Project Management	5%	$ 4,544	EPA Guidance
LTM 6 30 Total		**$ 95,423**	

Assumptions

Tasks included are: document review, site inspection, travel, and reporting.
FYRs would be required until the cleanup goals for the Site are achieved

Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
33220102 Project Manager		20	HR	$ -	$ 175.00	$ -	$ -	$ 3,500.00	
33220106 Staff Engineer		40	HR	$ -	$ 120.00	$ -	$ -	$ 4,800.00	
33220109 Staff Scientist		80	HR	$ -	$ 110.00	$ -	$ -	$ 8,800.00	
33220110 QA/QC Officer		20	HR	$ -	$ 115.00	$ -	$ -	$ 2,300.00	
33220114 Word Processing/Clerical		20	HR	$ -	$ 60.00	$ -	$ -	$ 1,200.00	
33220115 Draftsman/CADD		20	HR	$ -	$ 90.00	$ -	$ -	$ 1,800.00	
FYR Subtotal								$ 22,400	
Bid and Scope Contingency							10%	$ 2,240	EPA Guidance
FYR with Contingency								$ 24,640	
Project Management							5%	$ 1,232	EPA Guidance
FYR Total								**$ 25,872**	

Appendix A-2 – Alternative ARS2

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Assumptions

Capital costs of additional treatment components are based on vendor quotes.
Assumed that ion exchange unit will be installed.
Expansion of treatment building footprint is required to accommodate new and additional treatment components.

Description	Qty	UOM	Unit Cost		Total	Basis
Air stripper (one additional tray)	1	LS	$ 2,000.00		$ 2,000	Vendor Quote
Multi-media sand/anthracite filters	2	each	$ 4,000.00		$ 8,000	Vendor Quote
Bag filters unit	1	LS	$ 6,000.00		$ 6,000	Vendor Quote
Expand/reprogram control system	1	LS	$ 50,000.00		$ 50,000	Vendor Quote
Filter press	1	LS	$ 30,000.00		$ 30,000	Vendor Quote
Liquid-phase GAC	1	LS	$ 7,000.00		$ 7,000	Vendor Quote
Vapor-phase GAC	1	LS	$ 20,000.00		$ 20,000	Vendor Quote
Replacement of effluent pump	1	LS	$ 2,000.00		$ 2,000	Vendor Quote
Ion exchange unit	1	LS	$ 200,000.00		$ 200,000	Vendor Quote
Building expansion	1	LS	$ 100,000.00		$ 100,000	Engineering Estimate
Expansion of existing GETS Subtotal					$ 425,000	
Bid and Scope Contingency				10%	$ 42,500	EPA Guidance (single groundwater treatment
Expansion of existing GETS with Contingency					$ 467,500	
Project Management				6%	$ 28,050	EPA Guidance
Construction Management				8%	$ 37,400	
Remedial Design				12%	$ 56,100	EPA Guidance
Expansion of existing GETS Total					**$ 589,050**	

Assumptions

Assume that second GETS will include the same treatment components with the existing GETS.
Acquisition of the needed land is included. It is assumed that the new building and the associated trenching/piping would require 2 acres.
Utility costs are assumed to be similar to the costs incurred in the existing GETS.
Assume that the footprint of new building would be 25 x 50 ft.
If RACER did not provide cost estimates, vendor quotes or engineering estimates were used.

	Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
Filter Press	18020324	12" Structural Slab on Grade	64	SF	$ 7.29	$ 6.03	$ 0.19	$ -	$ 863.97	
	33130102	4' Diameter Electric Automatic Pressure Filter Unit	1	EA	$ 9,512.00	$ 10,674.86	$ 5,074.64	$ -	$ 25,261.50	
	33260202	2" Stainless Steel Piping, Schedule 40, Threaded, Includes Coupling 10' OC, Excludes Hangers	40	LF	$ 27.75	$ 24.02	$ -	$ -	$ 2,070.89	
								Subtotal	**$ 28,196.35**	
Air Stripper	18020321	6" Structural Slab on Grade	70	SF	$ 3.67	$ 4.33	$ 0.08	$ -	$ 565.88	
	19010204	Polyvinyl chloride pressure pipe, 2", class 200, SDR 21, includes trenching to 3' deep	100	LF	$ 1.21	$ 9.43	$ 5.32	$ -	$ 1,595.94	
	33130834	Low Profile Stripper, 46 to 90 gpm, 5 Trays	1	EA	$ 33,966.00	$ 3,764.62	$ -	$ -	$ 37,730.62	
	33130855	Low Profile Stripper Control Package	1	EA	$ 7,006.88	$ -	$ -	$ -	$ 7,006.88	
	33290121	50 GPM, 1.5 HP, Transfer Pump with Motor, Valves, Piping	1	EA	$ 2,990.90	$ 2,084.99	$ -	$ -	$ 5,075.89	
	33310106	500 CFM Blower System, 9" Pressure, 2 HP	1	EA	$ 1,381.95	$ 446.35	$ -	$ -	$ 1,828.30	
								Subtotal	**$ 53,803.51**	
Liquid GAC	18020324	12" Structural Slab on Grade	50	SF	$ 7.29	$ 6.03	$ 0.19	$ -	$ 674.97	
	33021501	Air & process gas purification, carbon adsorption, vapor phase, modular carbon adsorbers	1	EA	$ 59.54	$ -	$ -	$ -	$ 59.54	
	33021502	Thermostat & Humidity Control Devices	1	EA	$ 190.21	$ 104.69	$ -	$ -	$ 294.90	
	33131950	25' x 6" Flexible Stainless Steel High-pressure Hose	1	EA	$ 1,249.48	$ 167.43	$ -	$ -	$ 1,416.91	
	33131971	1 KW Hazardous Air Heater	1	EA	$ 811.33	$ 216.79	$ -	$ -	$ 1,028.12	
	33131980	Dual Bed,500 CFM Series/1000 CFM Parallel, 1000 Lb Fill each	2	EA	$ 46,176.00	$ 1,510.43	$ 79.40	$ -	$ 95,531.65	
	33310109	1,000 CFM Blower System, 5" Pressure, 1 1/2 HP	1	EA	$ 1,195.47	$ 394.45	$ -	$ -	$ 1,589.92	
	33310209	Pressure Gauge	2	EA	$ 109.89	$ 87.20	$ -	$ -	$ 394.19	
								Subtotal	**$ 100,990.20**	
Vapor GAC	18020322	8" Structural Slab on Grade	35	SF	$ 5.54	$ 5.23	$ 0.17	$ -	$ 382.62	
	33132029	Modular liquid-phase activated carbon, Dual Bed, 2 - 4' Diameter, 65 GPM Series, 130 GPM Parallel, 2,000 Lb Each	2	EA	$ 44,968.78	$ 19,503.44	$ 2,029.63	$ -	$ 133,003.68	
	33290121	50 GPM, 1.5 HP, Transfer Pump with Motor, Valves, Piping	1	EA	$ 2,990.90	$ 2,084.99	$ -	$ -	$ 5,075.89	
								Subtotal	**$ 138,462.19**	
Trenching /Piping	17030257	Cat 215, 1.0 CY, Soil, Shallow, Trenching, Excludes Sheeting, Excludes Dewatering	149	BCY	$ -	$ 0.87	$ 0.36	$ -	$ 182.25	
	17030415	On-Site Backfill for Large Excavations, Includes Compaction	201.15	ECY	$ -	$ 1.02	$ 0.88	$ 0.04	$ 390.72	
	17030418	Backfill with Crushed Stone	37.04	CY	$ 27.75	$ 1.53	$ 0.79	$ -	$ 1,113.98	
	17030501	Compaction, subgrade, 18" wide, 8" lifts, walk behind, vibrating plate	37.04	ECY	$ -	$ 2.91	$ 0.17	$ -	$ 114.17	
	33260211	4" Stainless Steel, Schedule 40, Connection Piping	850	LF	$ 75.00	$ 31.32	$ -	$ -	$ 90,372.00	
								Subtotal	**$ 92,173.12**	
Purchase of Land	33220102	Project Manager	60	HR	$ -	$ 175.00	$ -	$ -	$ 10,500.00	
	33220106	Staff Engineer	30	HR	$ -	$ 120.00	$ -	$ -	$ 3,600.00	
	33220109	Staff Scientist	30	HR	$ -	$ 110.00	$ -	$ -	$ 3,300.00	
	33220110	QA/QC Officer	20	HR	$ -	$ 115.00	$ -	$ -	$ 2,300.00	
	33220114	Word Processing/Clerical	40	HR	$ -	$ 60.00	$ -	$ -	$ 2,400.00	
	33220115	Draftsman/CADD	20	HR	$ -	$ 90.00	$ -	$ -	$ 1,800.00	
	33220504	Attorney, Partner, Contracts	20	HR	$ -	$ 275.00	$ -	$ -	$ 5,500.00	
	33220507	Attorney, Associate, Real Estate	20	HR	$ -	$ 190.00	$ -	$ -	$ 3,800.00	
	33220508	Attorney, Associate, Contracts	40	HR	$ -	$ 190.00	$ -	$ -	$ 7,600.00	
	33220509	Paralegal, Real Estate	20	HR	$ -	$ 75.00	$ -	$ -	$ 1,500.00	
	33220510	Paralegal, Contracts	40	HR	$ -	$ 75.00	$ -	$ -	$ 3,000.00	
	33240101	Other Direct Costs	1	LS	$ 5,982.87	$ -	$ -	$ -	$ 5,982.87	
		Purchase of Land	2	acres	$ 100,000.00	$ -	$ -	$ -	$ 200,000.00	Average price of the area for agriculture/industrial lands
								Subtotal	**$ 251,282.87**	
	33430101	Equipment Building 10' Ceiling, Built-Up Roof, Concrete Block Exterior	1250	SF	$ -	$ -	$ -	$ 208.45	$ 260,558.75	
	33430401	PLC, 160 I/O points, 6K logic memory,	1	EA	$ 266,174.09	$ 153,957.17	$ -	$ -	$ 420,131.25	
		Ion exchange unit	1	LS	$ 200,000.00	$ -	$ -	$ -	$ 200,000.00	Vendor Quote

Assumptions

Assume that second GETS will include the same treatment components with the existing GETS.
Acquisition of the needed land is included. It is assumed that the new building and the associated trenching/piping would require 2 acres.
Utility costs are assumed to be similar to the costs incurred in the existing GETS.
Assume that the footprint of new building would be 25 x 50 ft.
If RACER did not provide cost estimates, vendor quotes or engineering estimates were used.

Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
	Bag filters unit	3	EA	$ 4,000.00	$ -	$ -	$ -	$ 12,000.00	Vendor Quote
Building	Thinning/clearing/grubbing	5	acres	$ 2,145.00	$ -	$ -	$ -	$ 10,725.00	Engineering Judgment
Construction	Site Preparation	1.00	LS	$ -	$ -	$ -	$ 9,300	$ 9,300.00	Vendor Quote
	Site Restoration	1.00	LS	$ -	$ -	$ -	$ 5,600	$ 5,600.00	Vendor Quote
	E&S Controls	1.00	LS	$ -	$ -	$ -	$ 27,200	$ 27,200.00	Vendor Quote
	Short-Term ICs	1	LS	$ 50,000.00	$ -	$ -	$ -	$ 50,000.00	Engineering Judgment
	Utilities Installation/Extension	1	LS	$ 150,000.00	$ -	$ -	$ -	$ 150,000.00	Engineering Judgment
							Subtotal	**$ 1,145,515.01**	

Additional GETS Subtotal		$ 1,810,423	
Bid and Scope Contingency	25%	$ 452,606	EPA Guidance
Additional GETS with Contingency		$ 2,263,029	
Project Management	6%	$ 135,782	EPA Guidance
Remedial Design	12%	$ 271,563	EPA Guidance
Construction Management	8%	$ 181,042	EPA Guidance
Additional GETS Total		**$ 2,851,417**	

Assumptions

Three Potomac wells at depth of approximately 150 ft bgs.
Stainless steel and double casing in all wells.

	Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
	33010101	Mobilize/DeMobilize Drilling Rig & Crew	1	LS	$ -	$ 16,665.59	$ 6,659.79	$ -	$ 23,325.37	
	33020303	Organic Vapor Analyzer Rental, per Day	7	DAY	$ -	$ -	$ -	$ 37.66	$ 263.63	
	33109660	5,000 Gallon Single-wall Steel Aboveground Tank, Includes Cradles, Coating, Fittings, Excludes Foundation, Pumps, Pipi	1	EA	$ 6,743.25	$ 986.95	$ -	$ -	$ 7,730.20	
	33170808	Decontaminate Rig, Augers, Screen (Rental Equipment)	6	DAY	$ 28.03	$ 666.76	$ -	$ -	$ 4,168.74	
	33220112	Field Technician	66	HR	$ -	$ 42.49	$ -	$ -	$ 2,804.23	
	33230123	6" Stainless Steel, Well Casing	615	LF	$ 114.40	$ 58.87	$ 57.28	$ -	$ 141,788.25	
	33230157	2" Pitless Adapter	3	EA	$ 849.15	$ 83.72	$ -	$ -	$ 2,798.60	
	33230223	6" Stainless Steel, Well Screen	60	LF	$ 83.40	$ 6.15	$ 6.03	$ -	$ 5,734.80	
	33230313	6" Stainless Steel, Well Plug	3	EA	$ 279.00	$ 15.38	$ 15.06	$ -	$ 928.32	
Potomac Extraction Wells	33230536	4" Submersible Pump, 15-20 GPM, 241'< Head <=300', 1 1/2 hp, w/ controls	3	EA	$ 1,257.26	$ 145.34	$ -	$ -	$ 4,207.81	
	33231257	Sonic Drilling, 9" OD,Borehole, 100 ft < Depth <= 500 ft	450	LF	$ -	$ 59.14	$ 34.72	$ -	$ 42,237.00	
	33231124	Mud Drilling, 15" Dia Borehole, Depth <= 100 ft	225	LF	$ -	$ 29.19	$ 48.32	$ -	$ 17,439.75	
	33231172	Split Spoon Sample, 2" x 24", During Drilling	45	LF	$ -	$ -	$ -	$ 334.11	$ 15,034.95	
	33231182	DOT steel drums, 55 gal., open, 17C	132	EA	$ 78.83	$ -	$ -	$ -	$ 10,405.85	
	33231186	Well Development Equipment Rental (weekly)	3	WK	$ -	$ -	$ -	$ 588.30	$ 1,764.90	
	33231403	6" Screen, Filter Pack	60	LF	$ 17.73	$ 10.66	$ 8.56	$ -	$ 2,217.14	
	33232103	6" Well, Bentonite Seal	3	EA	$ 45.68	$ 63.79	$ 51.23	$ -	$ 482.13	
	33232206	Restricted Area, Well Protection (with 4 Posts & Explosionproof Receptacle)	3	EA	$ 1,171.42	$ 973.54	$ 1.30	$ -	$ 6,438.79	
	33260210	2" Stainless Steel, Schedule 40, Connection Piping	300	LF	$ 75.00	$ 31.32	$ -	$ -	$ 31,896.00	
								Subtotal	**$ 321,666.46**	
	33170904	Load LLW Roll-Off Containers on Truck or directly in disposal pit/landfill	1	EA	$ -	$ 160.16	$ -	$ -	$ 160.16	
	33170924	Transport LLW Roll-Off Containers (1 per truck)	250	MI	$ -	$ -	$ -	$ 3.85	$ 962.93	
	33190101	Liquid Loading Into 5,000 Gallon Bulk Tank Truck	1	EA	$ -	$ 604.82	$ 337.75	$ -	$ 942.57	
	33190102	Bulk Solid Waste Loading Into Disposal Vehicle or Bulk Disposal Container	35	BCY	$ 1.00	$ 1.39	$ 0.40	$ -	$ 97.61	
	33190108	Tanker Pumping Equipment to Load Liquid	1	HR	$ -	$ -	$ -	$ 29.93	$ 29.93	
IDW management	33190205	Transport Bulk Solid Hazardous Waste, Maximum 20 CY (per Mile)	500	MI	$ -	$ -	$ -	$ 2.89	$ 1,443.00	
	33190207	Transport Bulk Liquid/Sludge Hazardous Waste, Maximum 5,000 Gallon (per Mile)	250	MI	$ -	$ -	$ -	$ 2.89	$ 721.50	
	33190317	Waste Stream Evaluation Fee, Not Including 50% Rebate on 1st Shipment	3	EA	$ -	$ -	$ -	$ 69.38	$ 208.13	
	33190807	32 Ft. Dump Truck, 6 Mil Liner, disposable	2	EA	$ 25.73	$ -	$ -	$ -	$ 51.46	
	33190815	Bulk Solid Waste Disposal Container, 20 CY Roll-Off	1	MO	$ 3,774.00	$ -	$ -	$ -	$ 3,774.00	
	33197270	Landfill Nonhazardous Solid Bulk Waste by CY	35	CY	$ -	$ -	$ -	$ 25.12	$ 879.18	
	33197273	Commercial RCRA landfills, liquid	37	GAL	$ -	$ -	$ -	$ 0.61	$ 22.59	
								Subtotal	**$ 9,293**	

Additional extraction wells Subtotal		$ 330,959	
Bid and Scope Contingency	10%	$ 33,096	EPA Guidance
Additional extraction wells with Contingency		$ 364,055	
Project Management	6%	$ 21,843	EPA Guidance
Construction Management	6%	$ 21,843	EPA Guidance
Additional extraction wells Total		**$ 407,742**	

Assumptions

Biowall installation north of the containment area instead of extraction wells will address the organic contamination.
The dimensions of the biowall would be 800 ft long by 25 ft deep by 2 ft wide.
Biowall material costs are based on estimates provide by M.Lorah from pilot tests conducted at the site.
No costs associated with pilot studies or replacement of the media are included.

Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
	Mobilization/Demobilization of Trencher	1.00	LS	$ -	$ -	$ -	$ 120,000	$ 120,000.00	Vendor Quote
18050203	Rock Cover, Riprap, Medium (10 to 200 Lb Pieces)	88.89	CY	$ 60.64	$ 18.81	$ 13.33	$ -	$ 8,247.37	
18050301	Loam or topsoil, imported topsoil, 6" deep, furnish and place	134.50	LCY	$ 27.97	$ 6.53	$ 1.88	$ -	$ 4,893.65	
18050402	Seeding, Vegetative Cover	0.17	ACR	$ 3,466.68	$ 559.03	$ 213.51	$ -	$ 720.67	
18050413	Watering with 3,000-Gallon Tank Truck, per Pass	0.83	ACR	$ 204.37	$ 51.31	$ 48.88	$ -	$ 252.79	
	Biowall installation	1.00	LS	$ -	$ -	$ -	$ 500,000	$ 500,000.00	Vendor Quote
33080532	Geotextile Fabric, Non-Woven 80 Mil	266.67	SY	$ 0.99	$ 1.03	$ 0.03	$ -	$ 544.84	
33061027	Key-in Treatment Wall	165.93	CY	$ 16.10	$ 59.54	$ 16.68	$ -	$ 15,319.12	
	Thinning/clearing/grubbing	1.00	ACR	$ -	$ -	$ -	$ 5,145	$ 5,145.00	2018 RSMeans, 31 13 13.10 0020, burdened, location factors accounted for
	Biowall material	20,000.00	SF	$ 145.51	$ -	$ -	$ -	$ 2,910,240.00	

Biowall Subtotal		$	3,565,363	
Bid and Scope Contingency	20%	$	713,073	EPA Guidance
Biowall with Contingency		$	4,278,436	
Project Management	5%	$	213,922	EPA Guidance
Remedial Design	8%	$	342,275	EPA Guidance
Construction Management	6%	$	256,706	EPA Guidance
Biowall Total		**$**	**5,091,339**	

Assumptions

PRB would be installed downgradient of the biowall to treat metals contamination.
The dimensions of the PRB would be 800 ft long by 25 ft deep by 2 ft wide.
Mobilization of equipment to install PRB is included in the mobilization of equipment to install the biowall.
Site preparation (tree clearing, clear and grub, e&s controls) and site restoration includes all activities required to include both the PRB and the biowall.
Zero valent iron or similar sulfate compounds will be used to fill the PRB
Replacement of amendment and disposal of the spent media is assumed to take place every 10 years. The associated cost is $ 450,000 based on an engineering estimate.
Assumed monitoring wells downgradient of the PRB will be stainless steel (50 ft spacing, 16 wells). Wells will be sampled quarterly for the first year and then will be sampled along the other wells of the site.

Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
18050301	Loam or topsoil, imported topsoil, 6" deep, furnish and place	134.50	LCY	$ 27.97	$ 6.53	$ 1.88	$ -	$ 4,893.65	
18050402	Seeding, Vegetative Cover	0.17	ACR	$ 3,466.68	$ 559.03	$ 213.51	$ -	$ 720.67	
18050413	Watering with 3,000-Gallon Tank Truck, per Pass	0.83	ACR	$ 204.37	$ 51.31	$ 48.88	$ -	$ 252.79	
	PRB Installation	1.00	LS	$ -	$ -	$ -	$ 500,000	$ 500,000.00	Vendor Quote
	Tree Clearing	1.00	LS	$ -	$ -	$ -	$ 5,970	$ 5,970.00	Vendor Quote
	Site Preparation	1.00	LS	$ -	$ -	$ -	$ 9,300	$ 9,300.00	Vendor Quote
	Site Restoration	1.00	LS	$ -	$ -	$ -	$ 5,600	$ 5,600.00	Vendor Quote
	Clear and Grub	1.00	LS	$ -	$ -	$ -	$ 13,200	$ 13,200.00	Vendor Quote
	E&S Controls	1.00	LS	$ -	$ -	$ -	$ 27,200	$ 27,200.00	Vendor Quote
33061039	Proprietary Metal Oxidizing Powder	1,647.41	CY	$ 573.18	$ 46.64	$ 13.78	$ -	$ 1,043,814.31	
33230121	2" Stainless Steel, Well Casing	380.00	LF	$ 81.70	$ 6.10	$ 6.02	$ -	$ 35,651.60	
33230221	2" Stainless Steel, Well Screen	160.00	LF	$ 90.40	$ 6.15	$ 6.03	$ -	$ 16,412.80	
33230312	2" Stainless Steel, Well Plug	16.00	EA	$ 133.00	$ 13.67	$ 13.39	$ -	$ 2,560.96	
	Mobilization for well installation	1.00	LS				$ 20,000.00	$ 20,000.00	Past Project Experience
	Monitoring well installation (equipment rental, field crew)	6.00	DAY				$ 5,650.00	$ 33,900.00	Past Project Experience
	Monitoring well sampling - first year (metals + organics)	64.00	LS	$ 57.00	$ 62.00			$ 7,616.00	
	Biowall Subtotal							$ 1,727,093	
	Bid and Scope Contingency						20%	$ 345,419	EPA Guidance
	Biowall with Contingency							$ 2,072,511	
	Project Management						5%	$ 103,626	EPA Guidance
	Remedial Design						12%	$ 248,701	EPA Guidance
	Construction Management						6%	$ 124,351	EPA Guidance
	Biowall Total							**$ 2,549,189**	

Description	Qty	UOM	Unit Cost		Total	Notes
Mobilization/Demobilization						
Work Plans/Permits	1	LS	$ 50,000		$ 50,000	Engineering Judgment
Mobilization/Demobilization	1	LS	$ 50,000		$ 50,000	Engineering Judgment
Site Preparation						
Thinning/clearing/grubbing	3	acres	$ 5,145		$ 15,435	2018 RSMeans, 31 13 13.10 0020, burdened, location factors accounted for
Short-Term ICs	1	LS	$ 25,000		$ 25,000	Engineering Judgment, includdes signs, fences, S&E control
Temporary Road / Swamp Mats	1	LS	$ 95,931.25		$ 95,931	Vendor Quote
Sheet pile (45 ft deep cells)	37035	square ft	$ 26.52		$ 982,297	2018 RSMeans, 31 41 16.10 1200, location factors accounted for
Sheet pile (75 ft deep cells)	31500	square ft	$ 34.58		$ 1,089,270	2018 RSMeans, 31 41 16.10 1200, location factors accounted for
Site Preparation Subtotal					$ 2,307,934	
Bid and Scope Contingency				20%	$ 461,587	EPA Guidance
Site Preparation with Contingency					$ 2,769,520	
Project Management				5%	$ 138,476	EPA Guidance
Site Preparation Total					**$ 2,907,996**	

Assumptions

Waste Management is 1% of the total capital cost prior any contigencies
Completion report will be required to document all remedial components

	Description	Qty	UOM	Unit Cost		Total	Basis
General Post-treatment activities	Waste Handling	1	LS	$ 75,279		$ 75,279	Engineering Judgment
	Long-Term ICs	1	LS	$ 50,000		$ 50,000	Engineering Judgment
	Completion Report	1	LS	$ 50,000		$ 50,000	Engineering Judgment
	Site Restoration Subtotal					$ 175,279	
	Bid and Scope Contingency				20%	$ 35,056	EPA Guidance
	Site Restoration with Contingency					$ 210,335	
	Project Management				5%	$ 10,517	EPA Guidance
	Site Restoration Total					**$ 220,851**	

Assumptions

Assume that expansion of the existing GETS and construction of the second GETS, taking into account for startup and optimization, would take one year.
For this first year, the project manager would be on site two days per week.
The construction engineer, SSHO, and QA officer would be on site for the entire year.

	Description	Qty	UOM	Unit Cost	Total	Notes
Oversight personnel	Project Manager	1040	hour	$ 175.00	$ 182,000	Engineering Judgment
	Construction Engineer	3120	hour	$ 146.00	$ 455,520	Engineering Judgment
	SSH officer	3120	hour	$ 115.00	$ 358,800	Engineering Judgment
	QA officer	3120	hour	$ 115.00	$ 358,800	Engineering Judgment
	Per Diem	1095	day	$ 178.00	$ 194,910	GSA rates
	Labor Total				**$ 1,550,030**	

Assumptions

Existing GETS O&M costs for the upgraded system, including carbon replacements, filter media, ion exchange resin, spent media disposal, and labor for treatment plant operators, treatment plant sampling, and reporting,
Second GETS O&M also includes costs for system startup, commissioning, and optimization.

	Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
	33020402	Decontamination Materials per Sample	48	EA	$ 14.36	$ -	$ -	$ -	$ 689.18	
	33021670	Metals Screen, 25 Metals Listed In Method EPA 200.7, Water Analysis	48	EA	$ -	$ -	$ -	$ 62.00	$ 2,976.00	
	33021721	Testing, semi-volatile organics (625, 8270)	48	EA	$ -	$ -	$ -	$ 105.00	$ 5,040.00	
	33021720	Testing, purgeable organics (624, 8260)	48	EA	$ -	$ -	$ -	$ 47.00	$ 2,256.00	
	33021834	Volatile Organic Compounds (TO-14)	48	EA	$ -	$ -	$ -	$ 392.98	$ 18,863.25	
	33022042	Overnight delivery service, 21 to 50 lb packages	24	EA	$ -	$ -	$ -	$ 280.00	$ 6,720.00	
	33132053	Bulk liquid-phase activated carbon, >10,000 Lb	4400	LB	$ 2.42	$ -	$ -	$ -	$ 10,648.00	SCD System Data
	33132059	Bulk vapor-phase activated carbon, >10,000 Lb	54000	LB	$ 0.96	$ -	$ -	$ -	$ 51,840.00	SCD System Data
	33190207	Transportation and Disposal of Treatment System Sludge and Bag Filters, Hazardous Waste	54	DRUM	$ -	$ -	$ -	$ 595.00	$ 32,130.00	SCD System Data
		Project Manager	120	HR	$ -	$ 175.00	$ -	$ -	$ 21,000.00	Vendor Quote
Second GETS		Staff Engineer	120	HR	$ -	$ 120.00	$ -	$ -	$ 14,400.00	Vendor Quote
		Staff Scientist	96	HR	$ -	$ 110.00	$ -	$ -	$ 10,560.00	Vendor Quote
		QA/QC Officer	40	HR	$ -	$ 115.00	$ -	$ -	$ 4,600.00	Vendor Quote
		Word Processing/Clerical	80	HR	$ -	$ 60.00	$ -	$ -	$ 4,800.00	Vendor Quote
		Draftsman/CADD	40	HR	$ -	$ 90.00	$ -	$ -	$ 3,600.00	Vendor Quote
		Treatment System Operator	520	HR	$ -	$ 75.00	$ -	$ -	$ 39,000.00	Vendor Quote
	33240101	Other Direct Costs	1	LS	$ 2,551.80	$ -	$ -	$ -	$ 2,551.80	
	33240104	Startup Costs	1	LS	$ 58,283.00	$ 35,253.04	$12,424.50	$ -	$ 105,960.54	
		Water/Sewer Utility Charge	12	MONTH	$ 160.00	$ -	$ -	$ -	$ 1,920.00	SCD System Data
		Wireless and Phone Charge	12	MONTH	$ -	$ -	$ -	$ 98.00	$ 1,176.00	SCD System Data
	33420101	Electrical Charge	176000	KWH	$ 0.12	$ -	$ -	$ -	$ 21,489.60	
								Subtotal	**$ 362,220.37**	
	33020402	Decontamination Materials per Sample	48	EA	$ 14.36	$ -	$ -	$ -	$ 689.18	
	33021670	Metals Screen, 25 Metals Listed In Method EPA 200.7, Water Analysis	48	EA	$ -	$ -	$ -	$ 62.00	$ 2,976.00	
	33021721	Testing, semi-volatile organics (625, 8270)	48	EA	$ -	$ -	$ -	$ 105.00	$ 5,040.00	
	33021720	Testing, purgeable organics (624, 8260)	48	EA	$ -	$ -	$ -	$ 47.00	$ 2,256.00	
	33021834	Volatile Organic Compounds (TO-15)	48	EA	$ -	$ -	$ -	$ 392.98	$ 18,863.25	
	33022042	Overnight delivery service, 21 to 50 lb packages	24	EA	$ -	$ -	$ -	$ 280.00	$ 6,720.00	
		Bulk liquid-phase activated carbon, > 10,000 Lb	13200	LB	$ 2.42	$ -	$ -	$ -	$ 31,944.00	SCD System Data
		Bulk vapor-phase activated carbon, > 10,000 Lb	90000	LB	$ 0.96	$ -	$ -	$ -	$ 86,400.00	SCD System Data
		Transportation and Disposal of Treatment System Sludge and Bag Filters, Hazardous Waste	108	DRUM	$ -	$ -	$ -	$ 595.00	$ 64,260.00	SCD System Data
Existing GETS		Project Manager	120	HR	$ -	$ 175.00	$ -	$ -	$ 21,000.00	Vendor Quote
		Staff Engineer	120	HR	$ -	$ 120.00	$ -	$ -	$ 14,400.00	Vendor Quote
		Staff Scientist	96	HR	$ -	$ 110.00	$ -	$ -	$ 10,560.00	Vendor Quote
		QA/QC Officer	40	HR	$ -	$ 115.00	$ -	$ -	$ 4,600.00	Vendor Quote
		Word Processing/Clerical	80	HR	$ -	$ 60.00	$ -	$ -	$ 4,800.00	Vendor Quote
		Draftsman/CADD	40	HR	$ -	$ 90.00	$ -	$ -	$ 3,600.00	Vendor Quote
		Treatment System Operator	520	HR	$ -	$ 75.00	$ -	$ -	$ 39,000.00	Vendor Quote
	33240101	Other Direct Costs	1	LS	$ -	$ 2,478.00	$ -	$ -	$ 2,478.00	
		Wireless and Phone Charge	12	MONTH	$ -	$ -	$ -	$ 98.00	$ 1,176.00	SCD System Data
		Water/Sewer Utility Charge	12	MONTH	$ 160.00	$ -	$ -	$ -	$ 1,920.00	SCD System Data
	33420101	Electrical Charge	264000	KWH	$ 0.12	$ -	$ -	$ -	$ 32,234.40	

Assumptions

Existing GETS O&M costs for the upgraded system, including carbon replacements, filter media, ion exchange resin, spent media disposal, and labor for treatment plant operators, treatment plant sampling, and reporting,
Second GETS O&M also includes costs for system startup, commissioning, and optimization.

Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
							Subtotal $	**354,916.83**	
O&M First year Subtotal							$	717,137	
Bid and Scope Contingency							10% $	71,714	EPA Guidance
O&M First year with Contingency							$	788,851	
Project Management							5% $	39,443	EPA Guidance
O&M First year Total							**$**	**828,293**	

Assumptions

Existing GETS O&M costs for the upgraded system, including carbon replacements, filter media, ion exchange resin, spent media disposal, and labor for treatment plant operators, treatment plant sampling, and reporting,
Second GETS O&M includes the same costs with the existing GETS.

	Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
	33020402	Decontamination Materials per Sample	48	EA	$ 14.36	$ -	$ -	$ -	$ 689.18	
	33021670	Metals Screen, 25 Metals Listed In Method EPA 200.7, Water Analysis	48	EA	$ -	$ -	$ -	$ 62.00	$ 2,976.00	
	33021721	Testing, semi-volatile organics (625, 8270)	48	EA	$ -	$ -	$ -	$ 105.00	$ 5,040.00	
	33021720	Testing, purgeable organics (624, 8260)	48	EA	$ -	$ -	$ -	$ 47.00	$ 2,256.00	
	33021834	Volatile Organic Compounds (TO-15)	48	EA	$ -	$ -	$ -	$ 392.98	$ 18,863.25	
	33022042	Overnight delivery service, 21 to 50 lb packages	24	EA	$ -	$ -	$ -	$ 280.00	$ 6,720.00	
		Bulk liquid-phase activated carbon, > 10,000 Lb	4400	LB	$ 2.42	$ -	$ -	$ -	$ 10,648.00	SCD System Data
		Bulk vapor-phase activated carbon, > 10,000 Lb	54000	LB	$ 0.96	$ -	$ -	$ -	$ 51,840.00	SCD System Data
		Transportation and Disposal of Treatment System Sludge and Bag Filters, Hazardous Waste	54	DRUM	$ -	$ -	$ -	$ 595.00	$ 32,130.00	SCD System Data
Second GETS		Project Manager	120	HR	$ -	$ 175.00	$ -	$ -	$ 21,000.00	Vendor Quote
		Staff Engineer	60	HR	$ -	$ 120.00	$ -	$ -	$ 7,200.00	Vendor Quote
		Staff Scientist	60	HR	$ -	$ 110.00	$ -	$ -	$ 6,600.00	Vendor Quote
		QA/QC Officer	40	HR	$ -	$ 115.00	$ -	$ -	$ 4,600.00	Vendor Quote
		Word Processing/Clerical	80	HR	$ -	$ 60.00	$ -	$ -	$ 4,800.00	Vendor Quote
		Draftsman/CADD	40	HR	$ -	$ 90.00	$ -	$ -	$ 3,600.00	Vendor Quote
		Treatment System Operator	520	HR	$ -	$ 75.00	$ -	$ -	$ 39,000.00	Vendor Quote
	33240101	Other Direct Costs	1	LS	$ 2,551.80	$ -	$ -	$ -	$ 2,551.80	
		Water/Sewer Utility Charge	12	MONTH		$ -	$ -	$ 98.00	$ 1,176.00	SCD System Data
		Wireless and Phone Charge	12	MONTH	$ 160.00	$ -	$ -	$ -	$ 1,920.00	SCD System Data
	33420101	Electrical Charge	176000	KWH	$ 0.12	$ -	$ -	$ -	$ 21,489.60	
								Subtotal	**$ 245,099.83**	
	33020402	Decontamination Materials per Sample	48	EA	$ 14.36	$ -	$ -	$ -	$ 689.18	
	33021670	Metals Screen, 25 Metals Listed In Method EPA 200.7, Water Analysis	48	EA	$ -	$ -	$ -	$ 62.00	$ 2,976.00	
	33021721	Testing, semi-volatile organics (625, 8270)	48	EA	$ -	$ -	$ -	$ 105.00	$ 5,040.00	
	33021720	Testing, purgeable organics (624, 8260)	48	EA	$ -	$ -	$ -	$ 47.00	$ 2,256.00	
	33021834	Volatile Organic Compounds (TO-15)	48	EA	$ -	$ -	$ -	$ 392.98	$ 18,863.25	
	33022042	Overnight delivery service, 21 to 50 lb packages	24	EA	$ -	$ -	$ -	$ 280.00	$ 6,720.00	
		Bulk liquid-phase activated carbon, > 10,000 Lb	13200	LB	$ 2.42	$ -	$ -	$ -	$ 31,944.00	SCD System Data
		Bulk vapor-phase activated carbon, > 10,000 Lb	90000	LB	$ 0.96	$ -	$ -	$ -	$ 86,400.00	SCD System Data
		Transportation and Disposal of Treatment System Sludge and Bag Filters, Hazardous Waste	108	DRUM	$ -	$ -	$ -	$ 595.00	$ 64,260.00	SCD System Data
Existing GETS		Project Manager	120	HR	$ -	$ 175.00	$ -	$ -	$ 21,000.00	Vendor Quote
		Staff Engineer	60	HR	$ -	$ 120.00	$ -	$ -	$ 7,200.00	Vendor Quote
		Staff Scientist	60	HR	$ -	$ 110.00	$ -	$ -	$ 6,600.00	Vendor Quote
		QA/QC Officer	40	HR	$ -	$ 115.00	$ -	$ -	$ 4,600.00	Vendor Quote
		Word Processing/Clerical	80	HR	$ -	$ 60.00	$ -	$ -	$ 4,800.00	Vendor Quote
		Draftsman/CADD	40	HR	$ -	$ 90.00	$ -	$ -	$ 3,600.00	Vendor Quote
		Treatment System Operator	520	HR	$ -	$ 75.00	$ -	$ -	$ 39,000.00	Vendor Quote
	33240101	Other Direct Costs	1	LS	$ -	$ 2,478.00	$ -	$ -	$ 2,478.00	
		Water/Sewer Utility Charge	12	MONTH	$ 160.00	$ -	$ -	$ -	$ 1,920.00	SCD System Data
		Wireless and Phone Charge	12	MONTH		$ -	$ -	$ 98.00	$ 1,176.00	SCD System Data
	33420101	Electrical Charge	264000	KWH	$ 0.12	$ -	$ -	$ -	$ 32,234.40	
								Subtotal	**$ 343,756.83**	

Assumptions

Existing GETS O&M costs for the upgraded system, including carbon replacements, filter media, ion exchange resin, spent media disposal, and labor for treatment plant operators, treatment plant sampling, and reporting,
Second GETS O&M includes the same costs with the existing GETS.

Assembly	Description	Qty	UOM	Material	Labor	Equipment Sub Bid		Total Cost	Basis
O&M Subtotal								$ 588,857	
Bid and Scope Contingency							10%	$ 58,886	EPA Guidance
O&M with Contingency								$ 647,742	
Project Management							5%	$ 32,387	EPA Guidance
O&M Total								**$ 680,129**	

Assumptions

The long-term groundwater monitoring program would include approximately 60 Columbia aquifer wells and 30 Potomac aquifer wells, including the 11 extraction wells. Semi-annual sampling is assumed for the first 5 years

Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
33020401	Disposable Materials per Sample	283	EA	$ 10.93	$ -	$ -	$ -	$ 3,091.90	
33020402	Decontamination Materials per Sample	283	EA	$ 14.36	$ -	$ -	$ -	$ 4,063.27	
33020561	Lysimeter accessories, nylon tubing, 1/4" OD	9115	LF	$ 0.20	$ -	$ -	$ -	$ 1,821.18	
33021509	Monitor well sampling equipment, rental, water quality testing parameter device rental	5	WK	$ -	$ -	$ -	$ 333.00	$ 1,665.00	
33021618	Testing, purgeable organics (624, 8260)	283	EA	$ -	$ -	$ -	$ 47.00	$ 13,301.00	
33021619	Testing, semi-volatile organics (625, 8270)	283	EA	$ -	$ -	$ -	$ 105.00	$ 29,715.00	
33021620	Testing, TAL metals (6010)	283	EA	$ -	$ -	$ -	$ 62.00	$ 17,546.00	
33022043	Overnight delivery service, 51 to 70 lb packages	49	EA	$ -	$ -	$ -	$ 280.00	$ 13,720.00	
33022124	Testing, RCRA evaluations, EP toxicity analysis, metals (6010,7470)	1	EA	$ -	$ -	$ -	$ 62.00	$ 62.00	
33010108	Sedan, Automobile, Rental	10	DAY	$ -	$ -	$ -	$ 59.16	$ 591.60	
33010202	Per Diem (per person)	10	DAY	$ -	$ -	$ -	$ 166.00	$ 1,660.00	
33230614	Peristaltic Pump, Weekly Rental	5	WK	$ -	$ -	$ -	$ 99.90	$ 499.50	
33240101	Other Direct Costs	1	LS	$ 5,045.05	$ -	$ -	$ -	$ 5,045.05	
33220102	Project Manager	40	HR	$ -	$ 175.00	$ -	$ -	$ 7,000.00	
33220106	Staff Engineer	60	HR	$ -	$ 120.00	$ -	$ -	$ 7,200.00	
33220109	Staff Scientist	120	HR	$ -	$ 110.00	$ -	$ -	$ 13,200.00	
33220110	QA/QC Officer	40	HR	$ -	$ 115.00	$ -	$ -	$ 4,600.00	
33220114	Word Processing/Clerical	40	HR	$ -	$ 60.00	$ -	$ -	$ 2,400.00	
33220115	Draftsman/CADD	40	HR	$ -	$ 90.00	$ -	$ -	$ 3,600.00	
LTM 1 5 Subtotal								$ 130,781	
Bid and Scope Contingency							10%	$ 13,078	EPA Guidance
LTM 1 5 with Contingency								$ 143,860	
Project Management							5%	$ 7,193	EPA Guidance
LTM 1 5 Total								**$ 151,053**	

Assumptions

The long-term groundwater monitoring program would include approximately 60 Columbia aquifer wells and 30 Potomac aquifer wells, including the 11 extraction wells. Annual sampling is assumed after the first 5 years

Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
33020401	Disposable Materials per Sample	141	EA	$ 10.93	$ -	$ -	$ -	$ 1,540.49	
33020402	Decontamination Materials per Sample	141	EA	$ 14.36	$ -	$ -	$ -	$ 2,024.46	
33020561	Lysimeter accessories, nylon tubing, 1/4" OD	4570	LF	$ 0.20	$ -	$ -	$ -	$ 913.09	
33021509	Monitor well sampling equipment, rental, water quality testing parameter device rental	3	WK	$ -	$ -	$ -	$ 333.00	$ 999.00	
33021618	Testing, purgeable organics (624, 8260)	141	EA	$ -	$ -	$ -	$ 47.00	$ 6,627.00	
33021619	Testing, semi-volatile organics (625, 8270)	141	EA	$ -	$ -	$ -	$ 105.00	$ 14,805.00	
33021620	Testing, TAL metals (6010)	141	EA	$ -	$ -	$ -	$ 62.00	$ 8,742.00	
33022043	Overnight delivery service, 51 to 70 lb packages	25	EA	$ -	$ -	$ -	$ 280.00	$ 7,000.00	
33022124	Testing, RCRA evaluations, EP toxicity analysis, metals (6010,7470)	1	EA	$ -	$ -	$ -	$ 62.00	$ 62.00	
33010108	Sedan, Automobile, Rental	5	DAY	$ -	$ -	$ -	$ 59.16	$ 295.80	
33010202	Per Diem (per person)	5	DAY	$ -	$ -	$ -	$ 166.00	$ 830.00	
33230614	Peristaltic Pump, Weekly Rental	3	WK	$ -	$ -	$ -	$ 99.90	$ 299.70	
33240101	Other Direct Costs	1	LS	$ 5,045.05	$ -	$ -	$ -	$ 5,045.05	
33220102	Project Manager	40	HR	$ -	$ 175.00	$ -	$ -	$ 7,000.00	
33220106	Staff Engineer	60	HR	$ -	$ 120.00	$ -	$ -	$ 7,200.00	
33220109	Staff Scientist	120	HR	$ -	$ 110.00	$ -	$ -	$ 13,200.00	
33220110	QA/QC Officer	40	HR	$ -	$ 115.00	$ -	$ -	$ 4,600.00	
33220114	Word Processing/Clerical	40	HR	$ -	$ 60.00	$ -	$ -	$ 2,400.00	
33220115	Draftsman/CADD	40	HR	$ -	$ 90.00	$ -	$ -	$ 3,600.00	

LTM 6 30 Subtotal		$ 87,184	
Bid and Scope Contingency	10%	$ 8,718	EPA Guidance
LTM 6 30 with Contingency		$ 95,902	
Project Management	5%	$ 4,795	EPA Guidance
LTM 6 30 Total		**$ 100,697**	

Assumptions

Tasks included are: document review, site inspection, travel, and reporting.
FYRs would be required until the cleanup goals for the Site are achieved

Assembly	Description	Qty	UOM	Material	Labor	Equipment	Sub Bid	Total Cost	Basis
33220102	Project Manager	20	HR	$ -	$ 175.00	$ -	$ -	$ 3,500.00	
33220106	Staff Engineer	40	HR	$ -	$ 120.00	$ -	$ -	$ 4,800.00	
33220109	Staff Scientist	80	HR	$ -	$ 110.00	$ -	$ -	$ 8,800.00	
33220110	QA/QC Officer	20	HR	$ -	$ 115.00	$ -	$ -	$ 2,300.00	
33220114	Word Processing/Clerical	20	HR	$ -	$ 60.00	$ -	$ -	$ 1,200.00	
33220115	Draftsman/CADD	20	HR	$ -	$ 90.00	$ -	$ -	$ 1,800.00	

FYR Subtotal		$ 22,400	
Bid and Scope Contingency	10%	$ 2,240	EPA Guidance
FYR with Contingency		$ 24,640	
Project Management	5%	$ 1,232	EPA Guidance
FYR Total		**$ 25,872**	

APPENDIX C

HUMAN HEALTH RISK

ASSESMENT FILES

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Identification of Carcinogenic Contaminants of Concern, Columbia Aquifer
Operable Unit 4, Standard Chlorine of Delaware Site, Delaware

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Age-adjusted

Chemical	Calculated Cancer Risk Across All Exposure Routes (from RAGS Part D Table 9)	Is Calculated Risk Greater Than Initial Target Risk?	Retained as COC?	Final Target Risk for Each COC
Arsenic	3.1E-04	YES	YES	5.3E-06
Chromium	2.9E-03	YES	YES	5.3E-06
2,4,6-TRICHLOROPHENOL	3.0E-06	NO	NO	Not a COC
4-CHLOROANILINE	7.0E-04	YES	YES	5.3E-06
ATRAZINE	3.3E-06	NO	NO	Not a COC
BIS(2-ETHYLHEXYL) PHTHALATE	1.2E-03	YES	YES	5.3E-06
NAPHTHALENE	1.9E-05	YES	YES	5.3E-06
NITROBENZENE	1.1E-04	YES	YES	5.3E-06
PENTACHLOROPHENOL	1.1E-02	YES	YES	5.3E-06
1,2,4-TRICHLOROBENZENE	3.8E-01	YES	YES	5.3E-06
1,4-DICHLOROBENZENE	3.2E-01	YES	YES	5.3E-06
BENZENE	4.7E-02	YES	YES	5.3E-06
CARBON TETRACHLORIDE	5.1E-04	YES	YES	5.3E-06
CHLOROFORM	9.0E-04	YES	YES	5.3E-06
METHYL TERT-BUTYL ETHER	2.9E-06	NO	NO	Not a COC
METHYLENE CHLORIDE	8.8E-05	YES	YES	5.3E-06
TRICHLOROETHYLENE	1.6E-03	YES	YES	5.3E-06
Dioxinlike PCBs (TEQ)	1.3E-02	YES	YES	5.3E-06
2,3,7,8-TCDD TEQ	8.2E-05	YES	YES	5.3E-06
High Risk PCBs	1.9E-04	YES	YES	5.3E-06

Initial count, all carcinogenic COPCs with risk greater than 1E-06	20
Initial target cancer risk for all COPCs	5.0E-06
Final count, chemicals retained as carcinogenic COCs	17
Final combined cancer risk, COPCs eliminated as COCs	9.2E-06
Final target cumulative cancer risk (1E-04 less combined risk of COPCs not retained as COCs divided by number of COCs)	5.3E-06

lth Preliminary Remedial Goal Calculations - Groundwater, Columbia Aquifer, Child Resident (non-cance

All calculations are based on child resident exposure

Exposure Assumptions

Groundwater ingestion rate	0.78	L/day
Exposure time	24	hr/day
Exposure Frequency	350	days/year or events/year (dermal)
Exposure Duration	6	years
Skin Surface Area	6365	cm^2
Body weight, child	15	kg
Averaging time	2190	days

Chemical	RfDoral (mg/kg-day)	RfDdermal (mg/kg-day)	Target HQ	Groundwater Concentration (mg/L)
Aluminum	1.0E+00	1.0E+00	0.33	6.7E+00
Arsenic	3.0E-04	3.0E-04	0.50	3.0E-03
Barium	2.0E-01	1.4E-02	0.13	4.7E-01
Beryllium	2.0E-03	1.4E-05	0.50	1.2E-02
Cadmium	5.0E-04	2.5E-05	0.13	1.2E-03
Chromium	3.0E-03	7.5E-05	1.00	4.4E-02
Cobalt	3.0E-04	3.0E-04	0.50	3.0E-03
Iron	7.0E-01	7.0E-01	0.50	7.0E+00
Manganese	2.4E-02	9.6E-04	0.33	1.4E-01
Mercury	3.0E-04	2.1E-05	0.33	1.9E-03
Nickel	2.0E-02	8.0E-04	0.33	1.3E-01
Selenium	5.0E-03	5.0E-03	1.00	1.0E-01
Silver	5.0E-03	2.0E-04	0.50	4.7E-02
Thallium	1.0E-05	1.0E-05	0.50	1.0E-04
Vanadium	5.0E-03	1.3E-04	0.50	4.3E-02
1,2,4,5-TETRACHLOROBENZENE	3.0E-04	3.0E-04	0.13	2.1E-04
2,3,4,6-TETRACHLOROPHENOL	3.0E-02	3.0E-02	0.10	2.2E-02
2,4,6-TRICHLOROPHENOL	1.0E-03	1.0E-03	0.25	3.0E-03
2,4-DICHLOROPHENOL	3.0E-03	3.0E-03	0.33	1.5E-02
2-CHLOROPHENOL	5.0E-03	5.0E-03	0.25	2.3E-02
2-METHYLNAPHTHALENE	4.0E-03	4.0E-03	1.00	3.6E-02
4-CHLOROANILINE	4.0E-03	4.0E-03	1.00	7.6E-02
ATRAZINE	3.5E-02	3.5E-02	1.00	6.3E-01
BIS(2-ETHYLHEXYL) PHTHALATE	2.0E-02	2.0E-02	0.10	6.5E-04
NAPHTHALENE	2.0E-02	2.0E-02	1.00	2.6E-01
NITROBENZENE	2.0E-03	2.0E-03	0.50	1.9E-02
PENTACHLOROBENZENE	8.0E-04	8.0E-04	0.10	2.9E-04
PENTACHLOROPHENOL	5.0E-03	5.0E-03	0.10	2.3E-03
1,2,3-TRICHLOROBENZENE	8.0E-04	8.0E-04	0.10	7.5E-04
1,2,4-TRICHLOROBENZENE	1.0E-02	1.0E-02	1.00	9.3E-02
1,2-DICHLOROBENZENE	9.0E-02	9.0E-02	0.33	3.8E-01
1,4-DICHLOROBENZENE	7.0E-02	7.0E-02	0.10	8.8E-02
ACETONE	9.0E-01	9.0E-01	0.13	2.2E+00
BENZENE	4.0E-03	4.0E-03	0.50	3.5E-02
CARBON TETRACHLORIDE	4.0E-03	4.0E-03	0.10	6.5E-03
CHLOROBENZENE	2.0E-02	2.0E-02	0.10	3.1E-02
CHLOROFORM	1.0E-02	1.0E-02	0.10	1.9E-02
METHYLENE CHLORIDE	6.0E-03	6.0E-03	0.10	1.2E-02
TOLUENE	8.0E-02	8.0E-02	0.13	1.5E-01
TRICHLOROETHYLENE	5.0E-04	5.0E-04	0.33	2.9E-03
Dioxinlike PCBs (TEQ)	7.0E-10	7.0E-10	0.25	7.5E-11
2,3,7,8-TCDD TEQ	7.0E-10	7.0E-10	0.25	1.9E-10

Human Health Preliminary Remedial Goal Calculations - Groundwater, Columbia Aquifer, Adult Resident

All calculations are based on adult resident exposure

Exposure Assumptions

Groundwater ingestion rate	2.5	L/day
Exposure time	0.183	hr/day
Exposure Frequency	350	days/year or events/year (dermal)
Exposure Duration	20	years
Skin Surface Area	19652	cm^2
Body weight, adult	80	kg
Cancer averaging time	7300	days
Inhalation averaging time	175200	hours

Chemical	RfDoral (mg/kg-day)	RfDdermal (mg/kg-day)	RfC (mg/m^3)	Target HQ	Groundwater Concentration (mg/L)
Aluminum	1.0E+00	1.0E+00	Not volatile	0.33	1.1E+01
Arsenic	3.0E-04	3.0E-04	Not volatile	0.50	5.0E-03
Barium	2.0E-01	1.4E-02	Not volatile	0.13	7.7E-01
Beryllium	2.0E-03	1.4E-05	Not volatile	0.50	1.9E-02
Cadmium	5.0E-04	2.5E-05	Not volatile	0.13	1.9E-03
Chromium	3.0E-03	7.5E-05	Not volatile	1.00	6.9E-02
Cobalt	3.0E-04	3.0E-04	Not volatile	0.50	5.0E-03
Iron	7.0E-01	7.0E-01	Not volatile	0.50	1.2E+01
Manganese	2.4E-02	9.6E-04	Not volatile	0.33	2.3E-01
Mercury	3.0E-04	2.1E-05	Not volatile	0.33	3.1E-03
Nickel	2.0E-02	8.0E-04	Not volatile	0.33	2.2E-01
Selenium	5.0E-03	5.0E-03	Not volatile	1.00	1.7E-01
Silver	5.0E-03	2.0E-04	Not volatile	0.50	7.7E-02
Thallium	1.0E-05	1.0E-05	Not volatile	0.50	1.7E-04
Vanadium	5.0E-03	1.3E-04	Not volatile	0.50	6.9E-02
1,2,4,5-TETRACHLOROBENZENE	3.0E-04	3.0E-04	NV	0.13	3.3E-04
2,3,4,6-TETRACHLOROPHENOL	3.0E-02	3.0E-02	Not volatile	0.10	3.5E-02
2,4,6-TRICHLOROPHENOL	1.0E-03	1.0E-03	Not volatile	0.25	4.8E-03
2,4-DICHLOROPHENOL	3.0E-03	3.0E-03	Not volatile	0.33	2.4E-02
2-CHLOROPHENOL	5.0E-03	5.0E-03	NV	0.25	3.8E-02
2-METHYLNAPHTHALENE	4.0E-03	4.0E-03	NV	1.00	5.7E-02
4-CHLOROANILINE	4.0E-03	4.0E-03	Not volatile	1.00	1.3E-01
ATRAZINE	3.5E-02	3.5E-02	Not volatile	1.00	1.0E+00
BIS(2-ETHYLHEXYL) PHTHALATE	2.0E-02	2.0E-02	Not volatile	0.10	9.9E-04
NAPHTHALENE	2.0E-02	2.0E-02	0.003	1.00	7.9E-02
NITROBENZENE	2.0E-03	2.0E-03	0.009	0.50	3.0E-02
PENTACHLOROBENZENE	8.0E-04	8.0E-04	NV	0.10	4.4E-04
PENTACHLOROPHENOL	5.0E-03	5.0E-03	Not volatile	0.10	3.5E-03
1,2,3-TRICHLOROBENZENE	8.0E-04	8.0E-04	NV	0.10	1.2E-03
1,2,4-TRICHLOROBENZENE	1.0E-02	1.0E-02	0.002	1.00	4.3E-02
1,2-DICHLOROBENZENE	9.0E-02	9.0E-02	0.2	0.33	4.6E-01
1,4-DICHLOROBENZENE	7.0E-02	7.0E-02	0.8	0.10	1.3E-01
ACETONE	9.0E-01	9.0E-01	31	0.13	3.7E+00
BENZENE	4.0E-03	4.0E-03	0.03	0.50	4.8E-02
CARBON TETRACHLORIDE	4.0E-03	4.0E-03	0.1	0.10	1.0E-02
CHLOROBENZENE	2.0E-02	2.0E-02	0.05	0.10	3.4E-02
CHLOROFORM	1.0E-02	1.0E-02	0.098	0.10	2.7E-02
CHLOROMETHANE	NV	NV	0.09	0.33	4.4E-01
METHYL TERT-BUTYL ETHER	NV	NV	3	1	7.8E+01
METHYLENE CHLORIDE	6.0E-03	6.0E-03	0.6	0.10	1.9E-02
TOLUENE	8.0E-02	8.0E-02	5	0.13	2.4E-01
TRICHLOROETHYLENE	5.0E-04	5.0E-04	0.002	0.33	3.6E-03
Dioxinlike PCBs (TEQ)	7.0E-10	7.0E-10	Not volatile	0.25	1.1E-10
2,3,7,8-TCDD TEQ	7.0E-10	7.0E-10	Not volatile	0.25	2.9E-10

Human Health Preliminary Remedial Goal Calculations - Groundwater, Columbia Aquifer

All calculations are based on age-adjusted resident exposure

Exposure Assumptions

Groundwater ingestion rate, adult	2.5	L/day
Groundwater ingestion rate, child	0.78	L/day
Exposure time - inhalation (adult only)	0.183	hr/day
Exposure Frequency	350	days/year or events/year (dermal)
Exposure Duration, adult	20	years
Exposure Duration, child	6	years
Skin Surface Area, adult	19652	cm^2
Skin Surface Area, child	6365	cm^2
Body weight, adult	80	kg
Body weight, child	15	kg
Cancer averaging time	25550	days
Inhalation averaging time	613200	hours

Chemical	CSForal $(mg/kg\text{-}day)^{-1}$	CSFdermal $(mg/kg\text{-}day)^{-1}$	IUR $(mg/m^3)^{-1}$	Target risk	Groundwater Concentration (mg/L)
Arsenic	1.5E+00	1.5E+00	Not volatile	5.3E-06	2.7E-04
4-CHLOROANILINE	2.0E-01	2.0E-01	Not volatile	5.3E-06	1.9E-03
BIS(2-ETHYLHEXYL) PHTHALATE	1.4E-02	1.4E-02	Not volatile	5.3E-06	4.5E-04
NAPHTHALENE	NV	NV	3.4E-02	5.3E-06	1.8E-02
NITROBENZENE	NV	NV	4.0E-02	5.3E-06	1.1E-01
PENTACHLOROPHENOL	4.0E-01	4.0E-01	Not volatile	5.3E-06	2.2E-04
1,2,4-TRICHLOROBENZENE	2.9E-02	2.9E-02	NV	5.3E-06	6.4E-03
1,4-DICHLOROBENZENE	5.4E-03	5.4E-03	1.1E-02	5.3E-06	2.3E-02
BENZENE	5.5E-02	5.5E-02	7.8E-03	5.3E-06	5.7E-03
CARBON TETRACHLORIDE	7.0E-02	7.0E-02	6.0E-03	5.3E-06	4.4E-03
CHLOROFORM	3.1E-02	3.1E-02	2.3E-02	5.3E-06	7.4E-03
METHYLENE CHLORIDE	2.0E-03	2.0E-03	1.0E-05	5.3E-06	2.0E-01
Dioxinlike PCBs (TEQ)	1.3E+05	1.3E+05	Not volatile	5.3E-06	6.4E-11
2,3,7,8-TCDD TEQ	1.3E+05	1.3E+05	Not volatile	5.3E-06	1.6E-10
High Risk PCBs	2	2	5.7E-01	5.3E-06	1.8E-05

Chemical	0-2 years ADAF x CSF $(mg/kg\text{-}day)^{-1}$	2-16 years ADAF x CSF $(mg/kg\text{-}day)^{-1}$	16-26 years CSF $(mg/kg\text{-}day)^{-1}$	Target risk	Water Conc (mg/L)
Chromium	5.00E+00	1.50E+00	5.00E-01	5.3E-06	1.9E-04

Chemical	0-2 years ADAF x CSF $(mg/kg\text{-}day)^{-1}$	2-16 years ADAF x CSF $(mg/kg\text{-}day)^{-1}$	16-26 years CSF $(mg/kg\text{-}day)^{-1}$	6 - 16 years IUR $(mg/m^3)^{-1}$	16 -26 years IUR $(mg/m^3)^{-1}$	Target risk	Water Conc (mg/L)
Trichloroethene	1.30E-01	6.49E-02	4.63E-02	6.10E-03	4.1E-03	5.3E-06	5.40E-03

Human Health Preliminary Remedial Goal Calculations - Groundwater, Potomac Aquifer, Child Resident

All calculations are based on child resident exposure

Exposure Assumptions

Groundwater ingestion rate	0.78	L/day
Exposure time	24	hr/day
Exposure Frequency	350	days/year or events/year (dermal)
Exposure Duration	6	years
Skin Surface Area	6365	cm^2
Body weight, child	15	kg
Cancer averaging time	2190	days
Inhalation averaging time	52560	hours

Chemical	RfDoral (mg/kg-day)	RfDdermal (mg/kg-day)	Target HQ	Groundwater Concentration (mg/L)
Iron	7.0E-01	7.0E-01	1.00	1.4E+01
Manganese	2.4E-02	9.6E-04	0.33	1.4E-01
1,2,4,5-TETRACHLOROBENZENE	3.0E-04	3.0E-04	0.25	4.3E-04
2,3,4,6-TETRACHLOROPHENOL	3.0E-02	3.0E-02	0.10	2.2E-02
2,4,6-TRICHLOROPHENOL	1.0E-03	1.0E-03	0.25	3.0E-03
2,4-DICHLOROPHENOL	3.0E-03	3.0E-03	0.25	1.1E-02
2-CHLOROPHENOL	5.0E-03	5.0E-03	0.33	3.0E-02
2-METHYLNAPHTHALENE	4.0E-03	4.0E-03	1.00	3.6E-02
4-CHLOROANILINE	4.0E-03	4.0E-03	1.00	7.6E-02
ATRAZINE	3.5E-02	3.5E-02	1.00	6.3E-01
BIS(2-ETHYLHEXYL) PHTHALATE	2.0E-02	2.0E-02	0.17	1.1E-03
NAPHTHALENE	2.0E-02	2.0E-02	1.00	2.6E-01
NITROBENZENE	2.0E-03	2.0E-03	0.50	1.9E-02
PENTACHLOROBENZENE	8.0E-04	8.0E-04	0.10	2.9E-04
PENTACHLOROPHENOL	5.0E-03	5.0E-03	0.10	8.6E-04
1,2,3-TRICHLOROBENZENE	8.0E-04	8.0E-04	0.17	1.2E-03
1,2,4-TRICHLOROBENZENE	1.0E-02	1.0E-02	1.00	9.3E-02
1,2-DICHLOROBENZENE	9.0E-02	9.0E-02	0.50	5.7E-01
1,4-DICHLOROBENZENE	7.0E-02	7.0E-02	0.17	1.5E-01
ACETONE	9.0E-01	9.0E-01	0.14	2.6E+00
BENZENE	4.0E-03	4.0E-03	0.50	3.5E-02
CARBON TETRACHLORIDE	4.0E-03	4.0E-03	0.10	6.5E-03
CHLOROBENZENE	2.0E-02	2.0E-02	0.17	5.1E-02
CHLOROFORM	1.0E-02	1.0E-02	0.17	3.1E-02
METHYLENE CHLORIDE	6.0E-03	6.0E-03	0.17	1.9E-02
TOLUENE	8.0E-02	8.0E-02	0.25	3.1E-01
TRICHLOROETHYLENE	5.0E-04	5.0E-04	0.33	2.9E-03
Dioxinlike PCBs (TEQ)	7.0E-10	7.0E-10	0.33	1.0E-10
2,3,7,8-TCDD TEQ	7.0E-10	7.0E-10	0.33	2.5E-10
1,4-Dioxane	0.03	0.03	0.25	1.5E-01
1,2-Dichloroethane	0.006	0.006	0.25	2.9E-02
Bromodichloromethane	0.02	0.02	0.25	9.4E-02
Tetrachloroethene	0.006	0.006	0.33	2.6E-02

Human Health Preliminary Remedial Goal Calculations - Groundwater, Potomac Aquifer, Adult Resident

All calculations are based on adult resident exposure

Exposure Assumptions

Groundwater ingestion rate	2.5	L/day
Exposure time	0.183	hr/day
Exposure Frequency	350	days/year or events/year (dermal)
Exposure Duration	20	years
Skin Surface Area	19652	cm^2
Body weight, adult	80	kg
Cancer averaging time	7300	days
Inhalation averaging time	175200	hours

Chemical	RfDoral (mg/kg-day)	RfDdermal (mg/kg-day)	RfC (mg/m^3)	Target HQ	Groundwater Concentration (mg/L)
Iron	7.0E-01	7.0E-01	Not volatile	1.00	2.3E+01
Manganese	2.4E-02	9.6E-04	Not volatile	0.33	2.3E-01
1,2,4,5-TETRACHLOROBENZENE	3.0E-04	3.0E-04	NV	0.25	6.6E-04
2,3,4,6-TETRACHLOROPHENOL	3.0E-02	3.0E-02	Not volatile	0.10	3.5E-02
2,4,6-TRICHLOROPHENOL	1.0E-03	1.0E-03	Not volatile	0.25	4.8E-03
2,4-DICHLOROPHENOL	3.0E-03	3.0E-03	Not volatile	0.50	3.7E-02
2-CHLOROPHENOL	5.0E-03	5.0E-03	NV	0.33	5.0E-02
2-METHYLNAPHTHALENE	4.0E-03	4.0E-03	NV	1.00	5.7E-02
4-CHLOROANILINE	4.0E-03	4.0E-03	Not volatile	1.00	1.3E-01
ATRAZINE	3.5E-02	3.5E-02	Not volatile	1.00	1.0E+00
BIS(2-ETHYLHEXYL) PHTHALATE	2.0E-02	2.0E-02	Not volatile	0.17	1.6E-03
NAPHTHALENE	2.0E-02	2.0E-02	0.003	1.00	7.9E-02
NITROBENZENE	2.0E-03	2.0E-03	0.009	0.50	3.0E-02
PENTACHLOROBENZENE	8.0E-04	8.0E-04	NV	0.10	4.4E-04
PENTACHLOROPHENOL	5.0E-03	5.0E-03	Not volatile	0.10	1.3E-03
1,2,3-TRICHLOROBENZENE	8.0E-04	8.0E-04	NV	0.17	2.0E-03
1,2,4-TRICHLOROBENZENE	1.0E-02	1.0E-02	0.002	1.00	4.3E-02
1,2-DICHLOROBENZENE	9.0E-02	9.0E-02	0.2	0.50	6.8E-01
1,4-DICHLOROBENZENE	7.0E-02	7.0E-02	0.8	0.17	2.2E-01
ACETONE	9.0E-01	9.0E-01	31	0.14	4.2E+00
BENZENE	4.0E-03	4.0E-03	0.03	0.50	4.8E-02
CARBON TETRACHLORIDE	4.0E-03	4.0E-03	0.1	0.10	1.0E-02
CHLOROBENZENE	2.0E-02	2.0E-02	0.05	0.17	5.7E-02
CHLOROFORM	1.0E-02	1.0E-02	0.098	0.17	4.5E-02
CHLOROMETHANE	NV	NV	0.09	0.33	4.4E-01
METHYL TERT-BUTYL ETHER	NV	NV	3	1	7.8E+01
METHYLENE CHLORIDE	6.0E-03	6.0E-03	0.6	0.17	3.2E-02
TOLUENE	8.0E-02	8.0E-02	5	0.25	4.9E-01
TRICHLOROETHYLENE	5.0E-04	5.0E-04	0.002	0.33	3.6E-03
Dioxinlike PCBs (TEQ)	7.0E-10	7.0E-10	Not volatile	0.33	1.5E-10
2,3,7,8-TCDD TEQ	7.0E-10	7.0E-10	Not volatile	0.33	3.8E-10
1,4-Dioxane	0.03	0.03	0.03	1.00	9.6E-01
1,2-Dichloroethane	0.006	0.006	0.007	0.25	2.2E-02
Bromodichloromethane	0.02	0.02	NV	0.10	6.2E-02
Tetrachloroethene	0.006	0.006	0.04	0.33	3.8E-02

Human Health Preliminary Remedial Goal Calculations - Groundwater, Potomac Aquifer, Age-adjusted resident (cancer endpoints)

All calculations are based on age-adjusted resident exposure

Exposure Assumptions

Groundwater ingestion rate, adult	2.5	L/day
Groundwater ingestion rate, child	0.78	L/day
Exposure time - inhalation (adult only)	0.183	hr/day
Exposure Frequency	350	days/year or events/year (dermal)
Exposure Duration, adult	20	years
Exposure Duration, child	6	years
Skin Surface Area, adult	19652	cm^2
Skin Surface Area, child	6365	cm^2
Body weight, adult	80	kg
Body weight, child	15	kg
Cancer averaging time	25550	days
Inhalation averaging time	613200	hours

Chemical	CSForal $(mg/kg\text{-}day)^{-1}$	CSFdermal $(mg/kg\text{-}day)^{-1}$	IUR $(mg/m^3)^{-1}$	Target risk	Groundwater Concentration (mg/L)
4-CHLOROANILINE	2.0E-01	2.0E-01	Not volatile	5.4E-06	2.0E-03
BIS(2-ETHYLHEXYL) PHTHALATE	1.4E-02	1.4E-02	Not volatile	5.4E-06	4.6E-04
NAPHTHALENE	NV	NV	3.4E-02	5.4E-06	1.8E-02
NITROBENZENE	NV	NV	4.0E-02	5.4E-06	1.1E-01
1,2,4-TRICHLOROBENZENE	2.9E-02	2.9E-02	NV	5.4E-06	6.5E-03
1,4-DICHLOROBENZENE	5.4E-03	5.4E-03	1.1E-02	5.4E-06	2.3E-02
BENZENE	5.5E-02	5.5E-02	7.8E-03	5.4E-06	5.8E-03
CHLOROFORM	3.1E-02	3.1E-02	2.3E-02	5.4E-06	7.5E-03
METHYLENE CHLORIDE	2.0E-03	2.0E-03	1.0E-05	5.4E-06	2.0E-01
Dioxinlike PCBs (TEQ)	1.3E+05	1.3E+05	Not volatile	5.4E-06	6.5E-11
2,3,7,8-TCDD TEQ	1.3E+05	1.3E+05	Not volatile	5.4E-06	1.6E-10
High Risk PCBs	2	2	5.7E-01	5.4E-06	1.8E-05
1,4-Dioxane	1.0E-01	0.1	5.0E-03	5.4E-06	4.2E-03
1,2-Dichloroethane	9.1E-02	9.1E-02	2.6E-02	5.4E-06	3.5E-03
Bromodichloromethane	6.2E-02	6.2E-02	3.7E-02	5.4E-06	4.4E-03

Chemical	0-2 years ADAF x CSF $(mg/kg\text{-}day)^{-1}$	2-16 years ADAF x CSF $(mg/kg\text{-}day)^{-1}$	16-26 years CSF $(mg/kg\text{-}day)^{-1}$	Target risk	Groundwater Concentration (mg/L)
Chromium	5.00E+00	1.50E+00	5.00E-01	5.4E-06	1.9E-04
Indeno(1,2,3-c,d)pyrene	1.00E+00	3.00E-01	1.00E-01	5.4E-06	5.2E-05

Chemical	0-2 years ADAF x CSF $(mg/kg\text{-}day)^{-1}$	2-16 years ADAF x CSF $(mg/kg\text{-}day)^{-1}$	16-26 years CSF $(mg/kg\text{-}day)^{-1}$	6 - 16 years IUR $(mg/m^3)^{-1}$	16 -26 years IUR $(mg/m^3)^{-1}$	Target risk	Groundwater Concentration (mg/L)
Trichloroethene	1.30E-01	6.49E-02	4.63E-02	6.10E-03	4.1E-03	5.4E-06	5.5E-03

Identification of Carcinogenic Contaminants of Concern, Potomac Aquifer
Operable Unit 4, Standard Chlorine of Delaware Site, Delaware

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Age-adjusted

Chemical	Calculated Cancer Risk Across All Exposure Routes (from RAGS Part D Table 9)	Is Calculated Risk Greater Than Initial Target Risk?	Retained as COC?	Final Target Risk for Each COC
Chromium	1.4E-04	YES	YES	5.4E-06
4-CHLOROANILINE	2.2E-03	YES	YES	5.4E-06
BIS(2-ETHYLHEXYL) PHTHALATE	8.0E-05	YES	YES	5.4E-06
NAPHTHALENE	5.3E-06	YES	YES	5.4E-06
NITROBENZENE	1.6E-04	YES	YES	5.4E-06
1,2,4-TRICHLOROBENZENE	3.1E-03	YES	YES	5.4E-06
1,4-DICHLOROBENZENE	7.2E-03	YES	YES	5.4E-06
BENZENE	6.0E-02	YES	YES	5.4E-06
CHLOROFORM	3.5E-04	YES	YES	5.4E-06
METHYLENE CHLORIDE	6.4E-06	YES	YES	5.4E-06
TRICHLOROETHYLENE	1.6E-05	YES	YES	5.4E-06
Dioxinlike PCBs (TEQ)	2.2E-04	YES	YES	5.4E-06
2,3,7,8-TCDD TEQ	2.7E-05	YES	YES	5.4E-06
1,4-Dioxane	4.0E-05	YES	YES	5.4E-06
Indeno(1,2,3-c,d)pyrene	2.7E-03	YES	YES	5.4E-06
1,2-Dichloroethane	1.7E-04	YES	YES	5.4E-06
Bromodichloromethane	7.3E-06	YES	YES	5.4E-06
Tetrachloroethene	3.0E-06	NO	NO	Not a COC
High Risk PCBs	1.0E-05	YES	YES	5.4E-06

Initial count, all carcinogenic COPCs with risk greater than 1E-06	19
Initial target cancer risk for all COPCs	5.3E-06
Final count, chemicals retained as carcinogenic COCs	18
Final combined cancer risk, COPCs eliminated as COCs	3.0E-06
Final target cumulative cancer risk (1E-04 less combined risk of COPCs not retained as COCs divided by number of COCs)	5.4E-06