FINAL

Feasibility Study for Operable Unit 4, Inert Disposal Area, Iowa Army Ammunition Plant, Middletown, Iowa

Contract No. W912QR21D0019
Delivery Order W912QR21F0421

Prepared for

U.S. Army Corps of Engineers
Louisville District

600 Dr. Martin Luther King Jr. Place
Louisville, Kentucky 40202-2232

September 2023

Executive Summary

This Operable Unit 4 (OU-4) Feasibility Study (FS) report develops and evaluates remedial alternatives for Installation Restoration Program (IRP) site IAAP-020G_Inert Disposal Area Groundwater (19105.1026), Iowa Army Ammunition Plant (IAAAP), in Middletown, Iowa. This work is being conducted under U.S. Army Corps of Engineers (USACE), Louisville District, Contract Number W912QR21D0019, Delivery Order W912QR21F0421. OU-4 was originally considered the installation-wide OU; however, as of 2009, this OU includes only the Inert Disposal Area (IDA) at the IAAAP. The FS was prepared in accordance with the U.S. Environmental Protection Agency's (USEPA's) *Guidance on Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA,1988).

IAAAP was added to the National Priorities List in August 1990 due to explosives-contaminated surface water leaving the installation boundaries. In September 1990, a Federal Facility Agreement (FFA) was signed by USEPA Region 7 and the U.S. Army; it became effective in December 1990. Through the FFA, the U.S. Army works with the USEPA, with support provided by the Iowa Department of Natural Resources. The IAAAP was placed under the U.S. Department of Defense IRP, which follows the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) process, as amended by the Superfund Amendments and Reauthorization Act.

IAAAP is an active Joint Munitions Command facility with a current mission to load, assemble, and pack ammunition items, including projectiles, mortar rounds, warheads, demolition charges, and munitions components such as fuses, primers, and boosters. IAAAP consists of 19,011 acres located in Middletown, Iowa, in Des Moines County. It is west of Burlington, which is the largest city in Des Moines County, with a population of 25,436. The installation is bordered by Highway 34 to the north, upland agricultural farms to the east and west, and the Skunk River Valley to the south. Approximately one third of IAAAP property is occupied by active or formerly active production or storage facilities. IAAAP consists of production lines, landfills, disposal areas, burn areas, a demolition area, and a fire training area. The remaining land is either woodlands or property leased for agricultural usage.

The IDA encompasses approximately 55 acres in the western portion of the IAAAP and includes Inert Landfill (ILF) Trenches 1–5, the Cap Extension Area (CEA), Trench 6, Trench 7 (Corrective Action Management Unit), and associated sedimentation ponds. Trench 6 is divided into two areas, Trench 6 North and Trench 6 Landfill (also known as the Soil Repository). IAAAP conducted waste management operations, including landfilling, at the IDA from 1941 until 2011. Wastes were also disposed of and managed in other areas of the IDA (for example, Former Blue Sludge Lagoon, Former Holding Pond/Sludge Drying Bed, Former Burning Ground, and Former Metal Storage Yard) located immediately southeast of the ILF. Closure activities at the ILF Trenches 1–5, CEA, Trench 6, Trench 7, and the Resource Conservation and Recovery Act (RCRA) Ash Disposal Cell (located within a portion of Trench 5) occurred from 1989 to 2011. In 2011 and 2012, the use of the CEA, Trench 6, and Trench 7 sedimentation ponds was discontinued, and the ponds were removed and revegetated. The anticipated future land use at OU-4 is industrial use.

There are two environmental sites associated with the IDA. This FS addresses groundwater media at the IDA, which falls under IRP site IAAP-020G_Inert Disposal Area Groundwater and has been assigned Headquarters Army Environmental System identification number 19105.1026. This FS does not evaluate remedial alternatives for soil and waste at the IDA, which fall under IRP site IAAP-020_Inert Disposal Area (19105.1025), which has already been addressed under previous decision documents, that is, *Action Memorandum for the Inert Landfill* (CDM, 1997) and *Interim Action Record of Decision for Trench 6, Trench 7, and the Cap Extension Area of the Inert Disposal Area (IDA) in Soils Operable Unit 4* (Tetra Tech,

2008), which is referred to as the OU-4 IROD. The remedial investigation (RI) for IAAP-020G_Inert Disposal Area Groundwater was finalized in 2022 (Leidos and Jacobs, 2022). As part of the RI, the human health risk assessment identified multiple groundwater radionuclides of concern and chemicals of concern (COCs), including volatile organic compounds, semivolatile organic compounds, explosives, metals, and dioxins/furans. As a result, the RI recommended an FS to address site-related COCs and radionuclides of concern in groundwater.

This FS report describes the development of remedial action objectives (RAOs) to protect human health and the environment, identifies applicable or relevant and appropriate requirements (ARARs) and to-be-considered criteria, and presents preliminary remediation goals (PRGs). Because COCs may pose a risk to future industrial workers and future hypothetical residents, PRGs for groundwater were established for both future industrial workers and residents. The RAOs developed for the IDA includes the following:

- Prevent exposure of future human receptors (residents and industrial workers) to impacted groundwater until COC concentrations meet remediation goals.
- Prevent and/or minimize further migration of the contaminated groundwater plume at OU-4.
- Restore groundwater quality to remediation goals, consistent with the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) expectation §300.430 (a)(iii)(F).

The remedial alternatives evaluated in this FS were developed by combining technology process options that were retained following an initial screening process. In accordance with the OU-4 RI recommendations, the remedial alternatives were also developed to comply with RCRA closure and post-closure groundwater monitoring requirements that are currently a part of the interim remedy for soil and waste media under the OU-4 IROD for IAAP-020_Inert Disposal Area (Tetra Tech, 2008). The most reasonable future land use for the IDA was also a consideration. In addition, although per- and polyfluoroalkyl substances (PFAS) are not currently identified as COCs, these substances are being evaluated at the IDA under a PFAS Site Inspection at IAAAP (Jacobs, 2021). Therefore, they were considered during the FS evaluation for IDA groundwater (19105.1026).

This FS report evaluates three alternatives in addition to the No Action Alternative required by the NCP. The following remedial alternatives were developed and assessed using the seven NCP evaluation criteria and compared in terms of ability to satisfy the criteria:

- Alternative 1—No action.
- Alternative 2—Monitored natural attenuation (MNA) with land use controls (LUCs).
- Alternative 3—Groundwater extraction and treatment with MNA and LUCs.
- Alternative 4—Permeable reactive barrier (PRB) with MNA and LUCs.

The No Action Alternative (Alternative 1) was included in accordance with the NCP; it is not protective of human health and the environment and does not meet ARARs. However, it has been retained throughout the FS process as a baseline for comparison to the other approaches.

The proposed remedy alternatives were compared. A summary of the alternatives analysis is presented in Table ES-1.

Table ES-1. Summary of Alternatives Analysis

Criterion	Alternative 1: No Action	Alternative 2: MNA with LUCs	Alternative 3: Groundwater Extraction and Treatment with MNA and LUCs	Alternative 4: PRB with MNA and LUCs
Overall protection of human health and the environment (threshold criterion)	Fail	Pass	Pass	Pass
Compliance with applicable or relevant and appropriate requirements (threshold criterion)	Fail	Pass	Pass	Pass
Long-term effectiveness and permanence	NA	3	3	3
Reduction of toxicity, mobility or volume through treatment	NA	2	3	3
Short-term effectiveness	NA	4	2	2
Implementability	NA	4	2	3
Cost[a]	$0	$1,306,000	$5,891,000	$6,584,000
Total Score	NA	13	10	11

[a] Cost is the total present-worth value; cost accuracy ranges from -30% to +50%.

Ranking:

4 = Satisfies criterion well

3 = Satisfies criterion

2 = Satisfies criterion somewhat

1= Does not meet criterion

NA = not applicable due to failing threshold criteria.

Alternatives 2, 3, and 4 all provide protection of human health and the environment and would be expected to comply with ARARs. The alternatives would rely on LUCs to help maintain protectiveness until COC concentrations meet remediation goals. Alternative 2 would rely solely on natural attenuation to meet RAOs, whereas Alternatives 3 and 4 would implement active treatment technologies to reduce contaminant mass and prevent migration of the contaminant plumes. Alternative 3 provides hydraulic containment of groundwater and ex situ treatment, and Alternative 4 provides in situ treatment through the use of a PRB. All three of these alternatives would have the same level of residual risks because no active treatment process would be used to reduce COC concentrations within landfill areas where concentrations exceed industrial or residential PRGs. However, all three alternatives would be adequate and reliable in preventing direct contact with exposure to untreated groundwater through LUCs until cleanup goals are achieved. Alternatives 2, 3, and 4 would gradually reduce risks and toxicity, mobility, or volume (TMV) of contaminants as a result of passive natural attenuation processes. However, only Alternatives 3 and 4 would meet the NCP preference for active treatment and result in a faster reduction of TMV via groundwater extraction and in situ PRB treatment. Alternative 4 would not generate any treatment residuals, while Alternative 3 would require disposal of granular activated carbon at the end of the treatment period. In addition, there is some uncertainty over whether this ex situ treatment technology would be consistent with future Army policy on the management of PFAS waste. Alternative 2 would provide the greatest short-term effectiveness, environmental impacts, and implementability because it would require the least amount of construction and maintenance of the three alternatives. However, all alternatives can be implemented reliably onsite. The active treatment components of Alternatives 3 and 4 would require that a greater number of subcontractors be involved and have higher likelihoods of schedule delays. The remediation timeframe is assumed to be greater than 30 years for all three alternatives because they all rely on natural attenuation processes within the higher-concentration landfill area. Last, Alternative 2 would be the lowest-cost alternative, while Alternative 4 would have the highest associated costs.

Upon finalization of the FS report, a Proposed Plan (PP) will be prepared in accordance with CERCLA guidance. The PP will include a recommendation for the preferred alternative using the information provided in the FS. The preferred alternative presented in the PP may be modified based on new information or public comments. A Record of Decision (ROD) will be drafted after receiving and addressing public comments on the PP. The final remedy selection will be made in the ROD.

Contents

Appendixes

Tables

Figures

Acronyms and Abbreviations

µg/L	microgram(s) per liter
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CAMU	Corrective Action Management Unit
CEA	Cap Extension Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
COC	chemical of concern
COPC	chemical of potential concern
CVOC	chlorinated volatile organic compound
DCA	dichloroethane
DCE	dichloroethene
DNT	dinitrotoluene
DO	dissolved oxygen
ELCR	excess lifetime cancer risk
FFA	Federal Facility Agreement
FS	Feasibility Study
FUSRAP	Formerly Utilized Sites Remedial Action Program
GAC	granular activated carbon
GRA	general response action
HAL	health advisory level
HHRA	human health risk assessment
HI	hazard index
HQAES	Headquarters Army Environmental System
IAAAP	Iowa Army Ammunition Plant
IDA	Inert Disposal Area
IDNR	Iowa Department of Natural Resources
ILF	Inert Landfill
IROD	Interim Record of Decision
IRP	Installation Restoration Program
LTM	long-term monitoring
LUC	land use control
LUCIP	land use control implementation plan

MCL	maximum contaminant level
mg/L	milligram(s) per liter
MNA	monitored natural attenuation
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
O&M	operation and maintenance
ORP	oxidation-reduction potential
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbon
PAL	project action limit
pCi/L	picocurie(s) per liter
PCP	pentachlorophenol
PDI	predesign investigation
PFAS	per- and polyfluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PP	Proposed Plan
PRB	permeable reactive barrier
PRG	preliminary remediation goal
RA	remedial action
RAB	Restoration Advisory Board
RDX	Royal Demolition Explosive
RG	remediation goal
RI	remedial investigation
ROC	radionuclide of concern
ROD	Record of Decision
ROPC	radionuclide of potential concern
SARA	Superfund Amendments and Reauthorization Act of 1986
SI	Site Inspection
SVOC	semivolatile organic compound
TBC	to be considered
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCE	trichloroethene
TEQ	toxic equivalent
TMV	toxicity, mobility, or volume

USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
yd^3	cubic yard(s)
ZVI	zero-valent iron

1. Introduction

This Feasibility Study (FS) develops and evaluates remedial alternatives to address groundwater contamination at the Inert Disposal Area (IDA) under Operable Unit 4 (OU-4), at the Iowa Army Ammunition Plant (IAAAP), in Middletown, Iowa. This FS does not address soil and waste contamination, which is already addressed under an interim remedial action (RA). IAAAP is an active Joint Munitions Command facility currently operated by civilian contractor American Ordnance, LLC. In accordance with the Federal Facility Agreement (FFA), "Site" refers to the IAAAP and any areas contaminated by the migration of hazardous substances from the IAAAP. The term "site" is used to refer to the environmental Solid Waste Management Units and areas of concern at the IAAAP (such as IAAP-020G); this is consistent with Section IX.B of the 2018 Resource Conservation and Recovery Act (RCRA) Permit for the IAAAP. The FS was prepared for the U.S. Army Corps of Engineers (USACE), Louisville District, under Contract Number W912QR21D0019, Delivery Order W912QR21F0421.

This FS was developed in accordance with Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986; the procedures established in U.S. Environmental Protection Agency's (USEPA's) *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988); and RCRA. The information in this FS will be used by USEPA Region 7, the Iowa Department of Natural Resources (IDNR), and the U.S. Army, which entered into an FFA for IAAAP, to select a remedial alternative for the site that complies with the requirements of the NCP. The recommended remedial alternative will be presented in a Proposed Plan (PP) for public review and comment. State acceptance and public comments will be considered in the final selection of a remedy, which will be addressed in the responsiveness summary of the Decision Document.

1.1 Purpose and Objectives

The purpose and objectives of this FS are as follows:

- Review the facility, site, and regulatory background, environmental setting, nature and extent of groundwater contamination, contaminant fate and transport, and the human health risk assessment (HHRA).
- Develop remedial action objectives (RAOs) to protect human health and the environment.
- Identify applicable or relevant and appropriate requirements (ARARs).
- Develop site preliminary remediation goals (PRGs) and screen applicable remedial technologies.
- Develop and evaluate remedial alternatives to mitigate unacceptable risk to human health from exposure to chemicals of concerns (COCs) and radionuclides of concern (ROCs).
- Analyze the alternatives against evaluation criteria and include enough information to allow decision-makers to weigh positive and negative aspects of each alternative.
- Apply sound engineering judgment and optimization principles to develop alternatives that are implementable, cost effective, and minimize the environmental footprint at the OU-4 groundwater site.

The remedial alternatives presented in this FS are conceptual; details for implementation of the selected remedial alternative will be developed in the remedial design phase of this project.

1.2 Installation Background

1.2.1 IAAAP Description

IAAAP is a U.S. Army military installation with a mission to load, assemble, and pack ammunition items including projectiles, mortar rounds, warheads, demolition charges, and munitions components such as fuses, primers, and boosters. IAAAP consists of 19,011 acres located in Middletown, Iowa, in Des Moines County. It is west of Burlington, which is the largest city in Des Moines County, with a population of 25,436. The installation is bordered by Highway 34 to the north, upland agricultural farms to the east and west, and the Skunk River Valley to the south (Figure 1-1). Approximately one third of IAAAP property is occupied by active or formerly active production and storage facilities. IAAAP consists of production lines, landfills, disposal areas, burn areas, a demolition area, and a fire training area. The remaining land is either woodlands or property leased for agricultural usage.

1.2.2 IAAAP Operational History

The principal mission of IAAAP has been to load, assemble, and pack a variety of conventional ammunition and fusing systems. IAAAP was constructed in November 1940, as the Iowa Ordnance Plant and started production in 1941. Production was stopped in 1945, when World War II ended. The plant resumed its ammunition manufacturing mission in 1949, prior to the Korean War. In 1950, in response to the Korean conflict, production increased dramatically. From 1947 through mid-1975, the former Atomic Energy Commission occupied facilities on the site for nuclear weapons and non-nuclear additional weapon-assembly operations, which then reverted to Army control in 1975 (H&S Environmental, 2016).

The primary source of contamination at IAAAP is attributable to past operating practices during which explosives-contaminated wastewater and sludge were discharged to uncontrolled onsite lagoons and impoundments. Additional sources of contamination included open burning of explosives materials and munitions and landfilling of waste material. Currently, process wastewaters are treated and recycled, with only a small portion of the treated wastewater, which contains residual explosives and other contaminants regulated under the plant's National Pollutant Discharge Elimination System permit, being discharged to the surface.

1.2.3 IAAAP Regulatory Setting

IAAAP was added to the National Priorities List in August 1990 due to explosives-contaminated surface water leaving the installation boundaries. In September 1990, a FFA was signed by USEPA Region 7 and the U.S. Army; it became effective in December 1990. The 1990 FFA identified 30 RCRA Solid Waste Management Units at the facility. The 2018 IAAAP Hazardous Waste Management Facility Permit (RCRA Permit) (USEPA, 2018) stated that the Solid Waste Management Units listed in the 1990 FFA are being integrated into the CERCLA sites; the integration plan is currently being developed. IAAAP was placed under the Department of Defense Installation Restoration Program (IRP), which follows the CERCLA process, as amended by the Superfund Amendments and Reauthorization Act (SARA).

In July 2002, several areas of IAAAP previously used by the former Atomic Energy Commission were designated by the USACE to be under the Formerly Utilized Sites Remedial Action Program (FUSRAP) and therefore were subsequently removed from the Department of Defense IRP (U.S. Army, 2007). Investigations continued at the FUSRAP areas, and an additional FFA was finalized in August 2006 (USEPA et al., 2006). Through these FFAs, the U.S. Army and USACE works with the USEPA, with support provided by the IDNR to implement the requirements of CERCLA and SARA.

The IAAAP is currently divided into 11 proposed OUs:

- OU-1 (Soils): soil on the IAAAP other than those contaminated by use or testing of military munitions or by radiological constituents.
- OU-3 (Offsite Groundwater): groundwater outside of the IAAAP boundary.
- OU-4 (IDA): the IDA and its associated landfills, trenches, and sedimentation ponds.
- OU-5 (Military Munitions Response Program): Military Munitions Response Program sites.
- OU-6 (Onsite Groundwater): groundwater within the IAAAP boundary.
- OU-7 (Installation-wide): Miscellaneous IAAAP sites not included in the other OUs.
- OU-8 (FUSRAP): sites contaminated by radiological and other contaminants by former Atomic Energy Commission activities and now being addressed by FUSRAP.
- OU-9 (Construction Debris Areas): construction debris disposal sites.
- OU-10 (Explosive Disposal Area): groundwater sites associated with Explosive Disposal Area.
- OU-11 (No Further Action): IRP sites that warrant no further action following the remedial investigation (RI).
- OU-12 (Compliance Cleanup): IRP sites that were formerly managed under the RCRA Compliance Cleanup program.

OU-2 was also established originally for soil removal actions but was subsequently merged into OU-1. OU-4 was originally considered the installation-wide OU; however, in October 2009, the previously unaddressed areas of soil contamination were placed in OU-7, and the IDA remained in OU-4 (Tetra Tech, 2011). OU-10, OU-11, and OU-12 are new OU divisions that have been proposed based on recommended remedial actions for the IAAAP sites to help streamline the CERCLA process.

This FS has been developed to address groundwater media for OU-4. This FS does not evaluate remedial alternatives for soil and waste at the IDA, which fall under IRP site IAAP-20_Inert Disposal Area (19105.1025) which has already been addressed under previous decision documents, that is, *Action Memorandum for the Inert Landfill* (CDM, 1997) and *Interim Action Record of Decision for Trench 6, Trench 7, and the Cap Extension Area of the Inert Disposal Area in Soils Operable Unit 4* (Tetra Tech, 2008). FS evaluations for IAAAP sites that fall under OU-6, OU-7, OU-9, OU-10, and OU-12 will be, or have been, provided in separate FS reports. A PP will be developed to document the preferred No Further Action remedy for OU-11. Remedies are already in place for OU-1, OU-3, OU-5, and OU-8.

2. Site Background

2.1 IAAAP Sites Included in This Report

The Headquarters Army Environmental System (HQAES) includes 75 IRP sites at the IAAAP. This OU-4 FS report addresses only one site:

Army Environmental Database Site Number	IAAAP Site Name	HQAES ID	Media Addressed in FS Report	COC and ROC Analytical Groups
IAAP-020G	IDA Groundwater	19105.1026	Groundwater	Volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), metals, dioxins and radionuclides

Soil and waste media under OU-4 are not included in this FS since they are addressed under a different IAAAP site ID (IAAP-020_Inert Disposal Area; 19105.1025), that has an action memorandum and interim record of decision (IROD) in place. However, site background and history for site IAAP-020_Inert Disposal Area are included in this FS report to support the conceptual site model for the IDA and remedial alternative development.

2.2 IAAP-020G_Inert Disposal Area Groundwater (19105.1026)

The IDA encompasses approximately 55 acres in the western portion of the IAAAP and includes Inert Landfill (ILF) Trenches 1–5 including the Ash Disposal Cell (northern part of Trench 5), the Cap Extension Area (CEA), Trench 6, Trench 7 (Corrective Action Management Unit, or CAMU), and the associated sedimentation ponds (Figure 2-1). Trench 6 is divided into two areas, Trench 6 North and Trench 6 Landfill (also known as the Soil Repository). IAAAP conducted waste management operations, including landfilling, at the IDA from 1941 until 2011. Wastes were also disposed and managed in other areas of the IDA (that is, Former Blue Sludge Lagoon, Former Holding Pond/Sludge Drying Bed, Former Burning Ground, and Former Metal Storage Yard) located immediately southeast of the ILF.

The IDA is surrounded by vegetation and trees. There is no residential or commercial land use in the immediate vicinity of the IDA (USACE, 2007) except for active railroad tracks north of the IDA. An office located at the IDA is used by maintenance workers.

2.2.1 Operational and Regulatory History

2.2.1.1 Operational History

A timeline of the operational history and current status of the IDA is provided in the RI report (Leidos and Jacobs, 2022). A summary of that history is provided below.

Starting in 1941, the ILF Trenches 1–5 and Trench 6 North received residential and industrial waste materials such as residential and cafeteria refuse, plastic, tin cans, scrap lumber, and unsalvageable paper and cardboard until the mid-1990s. The Trench 6 Landfill was originally intended to receive sanitary wastes but was never used for sanitary waste disposal. The trench-and-fill method of landfill operation was employed at IAAAP. To begin the operation of a new trench, the entire length of the trench was first excavated to an approximate depth of 25 feet below ground surface (bgs); excavated material was stockpiled alongside the trench and used as daily and final cover (USACE, 1988). From 1980 to 1983, a northern portion of Trench 5 (also known as the Ash Disposal Cell) received RCRA hazardous wastes, such as ash from the open burning of explosives and explosives-contaminated waste, the contaminated waste processor, and the explosive waste incinerator.

From 1998 to 2007, the Trench 6 Landfill (Soil Repository), Trench 7, and the CEA only received contaminated soils from OU-1 remediation activities under CERCLA. OU-1 RAs resulted in the excavation of approximately 211,000 cubic yards (yd^3) of soil contaminated predominantly with explosives, metals, and polycyclic aromatic hydrocarbons (PAHs), which was taken to the Trench 6 Landfill, Trench 7, and the CEA for disposal or taken to the ILF to be used as base grade for the ILF cap (USACE, 2007). Highly contaminated soils (cumulative risk greater than 10^{-5}) were considered a principal threat and stored in Trench 7, which was designated a CAMU, for treatment prior to final disposal. Moderately contaminated soils (cumulative risk between 10^{-5} and 10^{-6}) and low-level contaminated soils (cumulative risk less than 10^{-6}) were considered to present a low-level threat and therefore permanently disposed of at the IDA without any treatment. As detailed in the *Action Memorandum for the Inert Landfill* (CDM, 1997), *Interim Action Record of Decision for Trench 6, Trench 7, and the Cap Extension Area of the Inert Disposal Area (IDA) in Soils Operable Unit 4* (Tetra Tech, 2008), the ILF trenches were covered with approximately 73,000 yd^3 of low-level contaminated soils from OU-1 areas to provide an appropriate grade as a base for the RCRA synthetic cover. The CEA received approximately 49,000 yd^3 of low-level contaminated soils from OU-1 areas (Tetra Tech, 2008). The Trench 6 Landfill received approximately 74,000 yd^3 of moderately contaminated soils from OU-1 areas (Tetra Tech, 2008). Trench 7 received approximately 15,000 yd^3 of highly contaminated soils from OU-1 areas (Tetra Tech, 2008). These soil disposal actions supported the remedy for OU-1.

The Former Blue Sludge Lagoon was a surface impoundment that received chromium hydroxide sludge generated at other IAAAP production lines (Line 3 and Line 800) during metal-cleaning operations. In 1984, the contents of the lagoon and underlying soil were excavated and placed in the adjacent concrete-lined Former Holding Pond/Sludge Drying Bed. Salvageable metals- and explosives-contaminated wastes were flash-burned at the Former Burning Ground before the contaminated waste processor became operational at the facility in 1982. The Former Metal Storage Yard was used to store scrap lumber, metal, used railroad ties, paper, cardboard, etc., for eventual sale to the public.

2.2.1.2 Previous OU-4 Remedial Actions and Regulatory History

Several removal actions have been conducted at the IDA for long-term management. In 1984, the sludge from the Former Blue Sludge Lagoon (Figure 2-1) was excavated, removed, and placed in a nearby dewatering bed in preparation for casting the sludge into concrete blocks for disposal. The excavated area was backfilled and capped with clay soil, and vegetative cover was established. A Federal Facility Compliance Agreement between the USEPA and IAAAP in June 1987 established the sludge as nonhazardous (Terracon, 1989).

In 1989, the Ash Disposal Cell in the northern portion of Trench 5 (Figure 2-1) was capped and closed in accordance with RCRA Subtitle C requirements as described in the *Closure and Post-Closure Plans for Trench 5 of the Inert Landfill* (USACE, 1988). The RCRA cap included a 42-inch compacted clay layer overlain by a 6-inch topsoil vegetative layer. In March 1994, the USEPA issued a RCRA Consent Agreement/Consent Order which required an accelerated groundwater assessment in the Trench 5 area (USEPA, 1994). The hazardous constituents detected in groundwater during the groundwater assessment were not those constituents expected to result from the hazardous wastes disposed of in the Ash Disposal Cell. Namely, antimony, barium, cadmium, chromium, and lead were detected above action levels at the Ash Disposal Cell during the groundwater quality assessment. In its approval letter dated June 16, 1995, the USEPA stated that "[i]t appears that the contamination may not be from the wastes disposed of at the RCRA portion of Trench 5" and notified the Army of a reduction in the monitoring frequency at Trench 5 from a quarterly basis to semiannual basis (USEPA, 1995).

Beginning in 1997, the Army implemented a non–time critical removal action to begin consolidating contaminated soils, excavated from four areas at IAAAP, to within the IDA in accordance with the *Action Memorandum for the Inert Landfill* (CDM, 1997). As part of this removal, cleanup and closure activities were initiated at the IDA, including removal of the Former Blue Sludge Lagoon and Sludge Drying Bed/Holding Pond material and removal of contaminated soil at the Former Burning Grounds (Figure 2-1). Soil excavation was at areas that exceeded the applicable criteria (USEPA Region III Risk-Based Concentrations) in effect at that time. Prior to removal of soils from the IDA Metals Storage Yard and Burning Grounds, a pre-design investigation was conducted in 1998 and the results were presented in a Pre-Design Excavation Delineation Summary Report (USACE, 1998). Excavated materials from the Former Sludge Drying Bed/Holding Pond and Former Burning Grounds were disposed of in Trench 6 or used for base grade under the cap at the ILF (ECC, 2001). These areas are now covered by the RCRA caps associated with ILF Trenches 1–5, and the CEA (Figure 2-1).

A synthetic liner and a leak detection system were installed in the Trench 6 Landfill and used for the disposal of medium-level contaminated soils excavated as part of the OU-1 remedy. A former soil borrow area, Trench 7, located adjacent to Trench 6, was similarly lined and equipped with leak detection capabilities. This lined borrow area, designated by the USEPA as a CAMU, was used for the stockpiling and treatment of high-level contaminated soils as part of the OU-1 remedy. Both the Trench 6 Landfill and Trench 7 were constructed to meet RCRA Subtitle C landfill requirements.

In 1998, Trenches 1 through 5 were designated the ILF and capped with a synthetic cover system, including the Ash Disposal Cell portion of Trench 5 pursuant to the *Action Memorandum for the Inert Landfill* (CDM, 1997). The presumptive remedy for the landfill area was containment, which involved capping the existing landfill with an impermeable cover (CDM, 1997). Closure was performed by covering the trenches/wastes with a synthetic style cover system, which includes layers of compacted clay, a low-density polyethylene geomembrane, a geocomposite drainage layer, compacted select fill (low-level contaminated soil [cumulative excess cancer risks less than 10^{-6}] from OU-1 remedial actions), topsoil, and a vegetative cover. Trench 6 North was not capped in 1998 so that it could continue to be used as an access to the Trench 6 Landfill to the south and as a staging area for other construction activities.

In 2008, the *Interim Action Record of Decision for Trench 6, Trench 7, and the Cap Extension Area of the Inert Disposal Area in Soils Operable Unit 4* (OU-4 IROD) (Tetra Tech, 2008) presented the selected interim remedial action for closure of Trench 6, Trench 7, and the CEA. The selected remedy included removal of sediment from sedimentation ponds; removal, treatment, and transfer of contaminated soils in Trench 7 to Trench 6 Landfill; containment of CEA and Trench 6 Landfill; site restrictions; cover and groundwater monitoring to evaluate performance of the landfill cover systems; and cover maintenance.

In fall/winter 2009, all of the treated soil in Trench 7 was transferred to the Trench 6 Landfill. The liner from Trench 7 was also removed and placed in the Trench 6 Landfill. Closure of Trench 7 was completed in November 2011 after soil samples demonstrated that the subliner soil did not contain chemical constituents above the OU-1 RGs or a cumulative health risk greater than 10^{-6}. Closure of Trench 6 was started in June 2010 and completed in November 2011. Closure of the Trench 6 Landfill and Trench 6 North was performed by covering the trench with a RCRA Subtitle C-style cap, which includes a contouring layer, a geosynthetic clay liner, a low-density polyethylene geomembrane, a geocomposite drainage layer, compacted select fill, topsoil, and a vegetative cover. Prior to construction of the cap, the soil placed in the Trench 6 Landfill was stabilized with Class C Fly Ash to form a stable base for cap construction (Tetra Tech 2012).

In 2010 and 2011, closure of the CEA was performed pursuant to the OU-4 IROD (Tetra Tech, 2008). Closure included covering the trench with a RCRA Subtitle C-style cap, which includes a contouring layer, a geosynthetic clay liner, a low-density polyethylene geomembrane, a geocomposite drainage layer, compacted select fill, topsoil, and a vegetative cover (Tetra Tech, 2011). The selected remedy as part of the OU-4 IROD is a presumptive remedy for military landfills and is consistent with the agreements in the 1996 Resolution of Dispute between the EPA and Army and OU-1 Record of Decision (ROD) (Hazra,1998).

By 2012, the sedimentation ponds associated with Trench 6, Trench 7, and the CEA were removed from service. These ponds were originally designed to accumulate surface runoff from the area of the landfill cells in the ponds such that some sediment has a chance to settle out of the water prior to discharge. However, the design of the ponds was never intended to provide comprehensive sediment capture prior to discharge. Each of the sedimentation ponds contained a cement standpipe connected to a culvert that extends beneath a downgradient earthen berm. During closure activities conducted in 2011 and 2012, the holding capacity of the sedimentation ponds was permanently reduced by drilling drain holes in the standpipes to allow minimal water accumulation and to allow for establishment of a vegetative cover in the former ponds.

In 2014, the final Land Use Control Implementation Plan (LUCIP) for OU-4 defined land use controls (LUCs) for the IDA (Tetra Tech, 2014). Engineering controls for the IDA include fencing and warning signs. Institutional controls for the IDA include access and construction restrictions, lease and property transfer restrictions, and potable well/groundwater use restrictions. These LUCs will be maintained until the concentration of hazardous substances in the soil and groundwater are at such levels to allow for unrestricted use and unlimited exposure. In 2016, a boundary fence (42-inch chain link fence) was installed at the IDA. The fence encompasses Trench 6 North, Trench 6 Landfill, ILF, and CEA (Aerostar, 2016) to comply with the existing LUCIP (Tetra Tech, 2014).

Overall, the interim RA for soil and waste included sediment removal, soil transfer, construction of RCRA Subtitle C covers, long-term groundwater monitoring, LUCs, inspections, and leachate treatment at the water treatment plant. Annual groundwater monitoring is performed as specified in the RCRA Permit for IAAAP (USEPA, 2018). The IAAP-020G IDA was addressed in the groundwater RI finalized in February 2022 (Leidos and Jacobs, 2022). The RI identified groundwater COCs, including VOCs, SVOCs, explosives, radionuclides, metals, and dioxins/furans, which are further discussed as part of this FS.

To establish a RCRA/CERCLA integration at the IDA, the RA presented in the *OU-4 Interim Record of Decision (IROD) for Trench 6, Trench 7, and the Cap Extension Area* (Tetra Tech, 2008) and evaluated in 5-year reviews for IAAAP must be documented in a final ROD for OU-4. All RCRA requirements for Trench 5 will be incorporated in the final ROD. Trench 5 remains subject to conditions of the RCRA Permit until such time that the ROD is amended and approved by the USEPA, and a Permit Modification Request is prepared by the U.S. Army and approved by USEPA to remove Trench 5 from the RCRA Permit (USEPA, 2018). Until that time, the IDA will continue to have annual inspections, routine maintenance, and groundwater monitoring as part of the post-closure requirements for Trench 5, and as defined in the Hazardous Waste Management Permit (USEPA, 2018).

The RCRA requirements for Trench 5 are detailed in the 2018 RCRA Permit for IAAAP. As previously stated, Trench 5 was certified closed as a hazardous waste landfill by the Army in February 1990. The RCRA Permit establishes the post-closure period for Trench 5 at 30 years; however, the EPA can shorten the post-closure period in accordance with 40 CFR 264.117(a)(2)(i). The post-closure requirements for Trench 5 include the following:

- Maintain the integrity and effectiveness of the final covers of Trench 5.
- Install, implement, and maintain the integrity and effectiveness of all security requirements for Trench 5.
- Implement an inspection and maintenance program for groundwater monitoring wells listed in the RCRA Permit.

- Maintain and provide adequate access to all wells listed in the RCRA Permit for groundwater monitoring and groundwater elevation measurements.

Forty-eight rounds of post-closure groundwater monitoring for Trench 5 have been conducted since 1994. Three types of groundwater monitoring are described in the RCRA Permit for IAAAP, as follows:

- Groundwater detection—used to detect and characterize a release and to determine what further action is warranted.
- Groundwater compliance—used to determine if and when a release of hazardous waste or hazardous constituents into the groundwater exceeds specified concentration limits. The compliance period, during which the groundwater protection standard applies, is equal to at least 70 years (including the closure period). The compliance period will begin from closure of Trench 5 and initiation of post-closure groundwater monitoring at the unit.
- Groundwater corrective action—used to evaluate corrective measures that prevent hazardous wastes or hazardous constituents from exceeding their respective concentration limits at and beyond the point of compliance. The Army may request to terminate corrective action measures taken beyond the compliance period if the groundwater protection standard has not been exceeded for a period of 3 consecutive years.

The fourth 5-year review was completed in 2021 and concluded that the remedy is functioning as intended by the IROD. The engineered caps continue to isolate landfill refuse from contact with potential human and ecological receptors and prevent infiltration of surface water. Regular inspections and maintenance ensure the caps continue to effectively isolate waste from potential receptors and prevent migration of contaminants. Groundwater data indicate that the caps are preventing the release of toxic chemicals through leaching and therefore reducing potential exposure pathways for human and ecological receptors.

2.2.2 Environmental Investigations for Groundwater

Between 1981 and 2021, various environmental investigations were performed at the IDA, as presented in Table 2-1. Figure 2-1 shows the former and existing monitoring wells at the IDA. These investigations evaluated the nature and extent of contamination and provided visual characterization of the waste.

The most recent OU-4 RI was conducted in 2019 and focused on characterizing potential groundwater impacts downgradient of the waste limits. Groundwater samples for the recent RI were collected in April 2019 from 23 existing monitoring wells. A new groundwater monitoring well, MW20-01, was installed in the shallow overburden aquifer in December 2020 as part of the LTM program. Table 2-2 summarizes the IDA screened intervals for the 24 monitoring wells (18 overburden, 4 bedrock, and 2 interface) shown on Figure 2-1. Results of previous investigations were presented with the results of the RI fieldwork in the RI report (Leidos and Jacobs, 2022), which also includes human health and ecological risk assessment findings. Information regarding site investigations is available in the following documents and summarized in Table 2-1:

- *Contamination Report for the Iowa Army Ammunition Plant* (ERG, 1982).
- *Groundwater Quality Assessment. Inert Landfill and Line 6 Areas, Iowa Army Ammunition Plant, Middletown, Iowa* (Terracon, 1989).
- "Preliminary Site Characterization Report for the Inert Disposal Area (R14)." *Revised Preliminary Site Characterization Reports, Iowa Army Ammunition Plant, Middletown, Iowa* (JAYCOR, 1993).
- *Revised Draft Final Remedial Investigation Report, Iowa Army Ammunition Plant* (JAYCOR, 1996).

- *Accelerated Groundwater Quality Assessment for the Ash Disposal Cell in Trench 5 and Line 6, Iowa Army Ammunition Plant*. Volumes 1, 2, and 3 (Earth Tech, 1994).
- *Remedial Investigation Report for Operable Unit 4 Inert Disposal Area, Iowa Army Ammunition Plant, Middletown, Iowa* (Leidos and Jacobs, 2022).

2.2.3 Environmental Setting

A detailed discussion of the environmental setting for IAAAP is included in the OU-4 RI report (Leidos and Jacobs, 2022). This section summarizes site characteristics for the IDA as they relate to the site-related COCs and ROCs (presented in Subsection 2.2.6).

2.2.3.1 Topography

The topography of the IDA has been significantly altered by the construction of the landfill and subsequent capping. The IDA is generally highest in the northwest area of the ILF and slopes in all directions. Based on the topography in the vicinity of the IDA, the original land surface likely ranged from relatively flat to sloping toward the southwest.

2.2.3.2 Surface Water

The IDA is located within the Long Creek watershed (Figure 2-2). Permanent water bodies no longer exist at IDA because engineering controls (that is, drilling drain holes in each of the standpipes) were implemented in 2011 so that the sediment ponds do not retain water. The only surface water currently present at the IDA is where groundwater discharges to the ephemeral ditch entering the north end of the former CEA Sedimentation Pond.

2.2.3.3 Geology and Hydrology

A detailed discussion of the geologic and hydrogeologic framework at IAAAP is presented in the OU-4 RI report (Leidos and Jacobs, 2022). The subsurface at the IDA is characterized by fill material, waste, and glacial till. The fill, consisting generally of silty clay, is a combination of the impermeable cap and contouring layers that overlie ILF Trenches 1–5, Trench 6, and the CEA. The till underlies and surrounds the fill/waste and consists primarily of silty clay and clay with occasional discontinuous silty sand and sandy silt layers. The unconsolidated units are underlain by bedrock (interbedded shaly dolomitic limestone), which was encountered from 76 to 138 feet bgs (Tetra Tech, 2012). Cross sections depicting the general lithology are presented on Figures 2-3 and 2-4.

The aquifers of concern at the IDA are the overburden aquifer and the youngest bedrock (Mississippian) aquifer. Groundwater flow within the bedrock aquifer occurs primarily within secondary permeability zones, including fractures, joints, and bedding planes. Twenty-four groundwater monitoring wells are located at the IDA (Figure 2-1): 18 wells are screened in the overburden (glacial till or glacial outwash) from 16 to 62 feet bgs; 2 wells are screened across the overburden/bedrock interface from 112 to 116 feet bgs; and 4 wells are screened in bedrock underlying the till from 128.5 to 155.5 feet bgs (Table 2-2).

Shallow groundwater occurs from approximately 5 to 35 feet bgs in the overburden aquifer. Based on saturated thicknesses observed in overburden monitoring wells, the overburden unit groundwater is estimated to range from 10 to 30 feet thick. The low permeability of the overburden clay till matrix typically limits lateral and vertical flow of groundwater. However, lateral and vertical flow may be locally higher where fracture networks or sand or silt lenses exist. Groundwater in the bedrock aquifer occurs from approximately 36 to 59 feet bgs, reflecting semiconfined conditions in some areas.

Hydrogeologic conditions at the IDA indicate significantly low hydraulic conductivities (for example, horizontal conductivity of 2.1×10^{-11} feet per day and vertical conductivity of 1.1×10^{-15} feet per day) in the overburden glacial till. Hydraulic conductivities in the overburden groundwater unit range from a minimum of 0.051 foot/day in well T-03 to a maximum of 1.96 feet/day in well T-05, with higher conductivities in the bedrock groundwater unit (0.15 foot/day in well T-07 to 51.02 feet/day in well T-06). Groundwater lateral gradients measured between 1999 and 2016 at the IDA were low in the overburden aquifer with a similar gradient range from year to year (0.017 [2001] to 0.060 [2000] foot/feet), while lateral gradients in the bedrock groundwater unit are more variable (from 0.0028 [2004] to 0.037 [2001] foot/feet). An overall downward vertical gradient is indicated by groundwater elevations in the shallow overburden and bedrock monitoring wells at the IDA (Tetra Tech, 2012).

Shallow groundwater flow is consistently to the southwest, while bedrock groundwater flow is generally to the south (Figures 2-5 and 2-6, respectively). Estimated effective porosity for the overburden glacial till is assumed to range from 0.06 to 0.12 based on historical geotechnical data. Using a historical geometric mean hydraulic conductivity of 0.147 foot/day, groundwater velocities are estimated to range from 8 to 26 feet/year in the glacial till of the overburden aquifer. Based on the velocity and low vertical conductivity, there is a low potential for contaminants to migrate into the deeper bedrock aquifer. Estimated effective porosity for the bedrock aquifer is assumed to be in the range of 0.2 to 0.25 foot/day. Using a historical geometric mean hydraulic conductivity of 1.19 feet/day (based on data for wells T-06, T-07, and T-09), groundwater velocities in the bedrock are estimated to range from 8 to 80 feet/year.

2.2.3.4 Land and Resource Use

Current and future land use at the IDA is considered industrial. As stated in Section 2.2.1.2, LUCs are being implemented at the IDA by the Army in accordance with requirements of the OU-4 LUCIP (Tetra Tech, 2014). As a result, the IDA is closed to residential and recreational use and groundwater cannot be used for potable use. Although these LUCs were implemented as part of the interim RA for soil and waste, they apply to all IAAAP sites that fall under OU-4. Therefore, these LUCs apply to the groundwater site (IAAP-020G_Inert Disposal Area Groundwater; 19105.1026) as well as the soil/waste site (IAAP-020_Inert Disposal Area; 19105.1025).

2.2.4 Nature and Extent of Groundwater Contamination

The groundwater monitoring well network for the IDA is shown on Figure 2-1. Under the RI and RCRA long-term monitoring (LTM), groundwater samples at the IDA have been analyzed for explosives, metals, VOCs, SVOCs, radionuclides, and gross alpha/beta activity to evaluate the nature and extent of contamination. Groundwater wells ET-3, C-00-3, and IDA-MW1 were also sampled for dioxins/furans due to the potential degradation products associated with pentachlorophenol (PCP). Monitored natural attenuation (MNA) parameters were also analyzed for samples from wells ET-3 and C-001 in order to evaluate the effectiveness of natural attenuation in groundwater where PCP and chlorinated solvents have historically exhibited concentrations greater than maximum contaminant levels (MCLs). During the OU-4 RI, analytical data were screened against site characterization project action limits (PALs). Groundwater PALs were equivalent to the federal MCLs; however, if no MCL was available, then the site characterization PAL was defined as the greater of the lifetime Health Advisory Level or USEPA Regional Screening Level for tap water (hazard quotient = 1). The site characterization PALs were used to assess the distribution and nature and extent of chemicals whereas more conservative screening values were used for risk assessment (discussed in Section 2.2.6). Groundwater analytical data collected between 2016 and 2019 and the site characterization PALs are included in Appendix A.

2.2.4.1 Explosives

Ten explosives were detected in groundwater at the IDA in recent years (2016–2020; see Appendix A). Of those, only four explosive compounds (2,4-dinitrotoluene [DNT], 2,6-DNT, nitrobenzene, and Royal Demolition Explosive [RDX]) were detected at concentrations that exceeded their site characterization PALs. Exceedances were observed in only four samples (Appendix A). In 2019, only two explosives were detected above their site characterization PALs. As shown on Figure 2-7, the 2,4-DNT concentration at monitoring well ET-3 (1.1 microgram(s) per liter [µg/L]) exceeded its site characterization PAL of 0.24 µg/L and the RDX concentration at monitoring well CAMU-99-3S (2.2 µg/L) exceeded its site characterization PAL of 2 µg/L. In 2016, the 2,6-DNT concentration at monitoring well C-95-2 (0.2 µg/L) exceeded its PAL of 0.049 µg/L; however, it was not detected in the 2017, 2018, and 2019 samples. The nitrobenzene concentration at monitoring well ET-3 in 2016 (of 2.6 µg/L) exceeded its site characterization PAL of (0.14 µg/L) in 2016, but it was not detected in the 2017, 2018, and 2019 samples. Historically, concentrations of 2-amino-4,6-dinitrotoluene (DNT) also exceeded its site characterization PAL of 1.9 µg/L. However, there have been no exceedances since 2012.

2.2.4.2 Metals

Twenty-two metals were detected in groundwater at the IDA in recent years (2016–2020; see Appendix A). Of those, only three metals (arsenic, iron, and manganese) were detected at concentrations that exceeded their respective site characterization PALs.

- Historically, arsenic was exceeded its site characterization PAL (10 µg/L) in only four samples (Appendix A). During the 2019 monitoring event, arsenic was only detected above its site characterization PAL at shallow monitoring well ET-3 (14 J µg/L) and at bedrock monitoring well JAW-27 (16 µg/L). However, arsenic was not detected in any monitoring well above the background threshold value of 33.3 µg/L that was established for IAAAP (CH2M, 2020).
- Iron has only exceeded its site characterization PAL (14,000 µg/L) and background threshold value (9,736 µg/L) at monitoring well ET-3. Concentrations at this well have ranged from14,000 µg/L to 26,200 µg/L (Appendix A). In 2019, the iron concentration at ET-3 was detected at 23,000 µg/L (Figure 2-7).
- Manganese was frequently detected in groundwater at the IDA (Appendix A); however, its site characterization PAL (430 µg/L) and background threshold value (580 µg/L) were only exceeded in four samples from three locations (ET-3, T-6, and CAMU-99-1D). In 2019, manganese concentrations were in exceedance at shallow monitoring well ET-3 (650 µg/L), bedrock monitoring well T-6 (690 µg/L), and bedrock monitoring well CAMU-99-1D (630 µg/L), as shown on Figure 2-7.

2.2.4.3 Volatile Organic Compounds

Eighteen VOCs were detected in groundwater at the IDA in recent years (2016–2020; see Appendix A). Of those, only four compounds (1,1-dichloroethane [DCA], 1,1-dichloroethene [DCE], 1,2-DCA, and trichloroethene [TCE]) were detected at concentrations that exceeded their site characterization PALs since 2016 (Appendix A).

- The concentrations of all four VOCs exceeded their PALs at monitoring well C-00-1, which is a shallow overburden well located southwest and downgradient of the CEA (Figure 2-1). In 2019, the 1,1-DCA concentrations (3.1 J µg/L) exceeded its PAL of 2.8 µg/L, the 1,1-DCE concentrations (45 J µg/L) exceeded its PAL of 7 µg/L, 1,2-DCA concentrations (5.8 J µg/L) exceeded its PAL of 5 µg/L, and TCE concentrations (15 J µg/L) exceeded its PAL of 5 µg/L (Figure 2-7).

- 1,1-DCA and 1,1-DCE also exceeded site characterization PALs at monitoring well MW20-01. In 2020, the 1,1-DCA concentration (of 11 μg/L) exceeded its PAL of 2.8 μg/L, and the 1,1-DCE concentration (of 8.8 μg/L) exceeded its PAL of 7 μg/L (Figure 2-7). MW20-01, which is downgradient of C-00-1, was installed in 2020 and screened across the same interval as C-00-1 (Figure 2-1).

2.2.4.4 Semivolatile Organic Compounds (including Polyaromatic Hydrocarbons)

Ten SVOCs were detected in groundwater at the IDA in recent years (2016–2020; see Appendix A). Of those, only two SVOCs (2-methyl-4,6-dinitrophenol and PCP) were detected at concentrations that exceeded their site characterization PALs. The 2-methyl-4,6-dinitrophenol concentration at monitoring well ET-3 in 2019 (28 J μg/L J) exceeded its site characterization PAL of 7.4 μg/L (Figure 2-7). Historically, PCP concentrations have exceeded its site characterization PAL of 1 μg/L at two monitoring wells (ET-3 and C-00-1). During the 2019 monitoring event, only the PCP concentration at monitoring well ET-3 (110 μg/L) exceeded its PAL. PCP was not known to be used in the loading, assembling, or packing of ammunition at the IAAAP (Earth Tech, 1994). The borehole log from monitoring well ET-3 contains numerous references to landfilled material in Trench 5 (Earth Tech, 1994). Among the materials identified were numerous pieces of wood including railroad ties, possibly the source of the PCP detected at monitoring well ET-3. Since the most common use of PCP is as a wood preservative (Earth Tech, 1994), this could be the source of PCP at the Ash Disposal Cell, but it raises the issue of why PCP was not detected in the other three downgradient and one cross-gradient monitoring wells at the Ash Disposal Cell.

Historically, naphthalene and 2,4-dichlorophenol were detected in groundwater at concentrations above their site characterization PALs. Naphthalene was last detected above its PAL of 100 μg/L in 1996 at monitoring well ET-3. 2,4-Dichlorophenol was last detected above its PAL of 46 μg/L in 1997, also at monitoring well ET-3.

2.2.4.5 Dioxins/Furans

Groundwater samples were collected from shallow monitoring wells ET-3 and C-00-3 and bedrock monitoring well IDA-MW1 and analyzed for dioxins/furans in 2019. Total 2,3,7,8-tetrachlorinated dibenzo-p-dioxins (TCDDs) toxic equivalent (TEQ) was detected in all three wells. As shown on Figure 2-7, the detected concentrations during the RI at IDA-MW1 (2.3×10^{-5} μg/L), ET-3 (1.7×10^{-5} μg/L), and C-00-3 (1.8×10^{-5} μg/L) exceeded the site characterization PAL of 1.2×10^{-7} μg/L at all three monitoring wells.

2.2.4.6 Radionuclides

Ten radionuclides were detected in groundwater at the IDA in recent years (2016–2020; see Appendix A). Of those, site characterization PALs were established for only two of the seven radiological parameters that have been detected at the site: radium-226 and radium-228. While radium-226 and radium-228 were detected in groundwater, none of the concentrations exceeded the site characterization PAL of 5 picocuries per liter (pCi/L), which was established based on the MCL for both isotopes combined.

Other radiological parameters detected in groundwater at the IDA include lead-212, lead-214, and potassium-40 (Appendix A). Lead-212 and potassium-40 were nondetect during the RI and in subsequent sampling events through 2021. The last detection (12.72J pCi/L) of lead-212 occurred in 2017 at C-00-1. The last detection of potassium-40 (76.84J pCi/L) occurred in 2017 at C-95-1.

2.2.4.7 Per- and Polyfluoroalkyl Substances

Per- and polyfluoroalkyl substances (PFAS) have not been identified as COCs in groundwater at OU-4. However, a preliminary assessment for PFAS for IAAAP identified the IDA as an area of potential interest, given that soil from the fire training pit was disposed of at the Trench 6 Landfill (Arcadis, 2020a, 2020b). Firefighting-training activities were historically conducted at the fire training pit and may have included the use of foams. Based on the preliminary assessment conclusions, a site inspection (SI) for PFAS is currently ongoing at IAAAP. During the initial SI activities in December 2020, several PFAS constituents were detected in groundwater samples collected from the IDA. The results from the SI, along with a recommendation as to whether an RI for PFAS is warranted at IAAAP, will be presented in a future SI report.

2.2.4.8 Summary

A summary of contaminants exceeding site characterization PALs in recent years (2016–2020) is as follows:

- Four explosives (2,4-DNT, 2,6-DNT, nitrobenzene, and RDX) exceeded their site characterization PALs in recent years.
- Three metals (arsenic, iron, and manganese) exceeded their PALs during the RI.
- Four VOCs (1,1-DCA, 1,1-DCE, 1,2-DCA, and TCE) exceeded their PALs in the shallow overburden aquifer during the RI and the primary extent of contamination is around monitoring wells C-00-1, ET-3, and MW20-01 (Figure 2-7).
- Two SVOCs (2-methyl-4,6-dinitrophenol and PCP) exceeded their PALs in the shallow overburden aquifer during the RI.
- Total 2,3,7,8-TCDD exceeded its PAL during the RI in all three wells sampled.
- Radium-226 and radium-228 were detected but did not exceed their established PALs of 5 pCi/L during the RI.

2.2.5 Contaminant Fate and Transport

This section discusses the fate and transport of the contaminants identified at the site and discussed previously in the nature and extent. An overview of contaminant fate and transport for IAAAP is presented in the 2022 RI and includes discussions for contaminant mobility, persistence, and transport. Mechanisms controlling mobility and persistence include volatilization, sorption, solubility, degradation, and transformation. Transport mechanisms include unsaturated zone migration; surface water, sediment, and stormwater runoff migration; and saturated zone migration.

Residential and industrial wastes (ILF Trenches 1–5 and Trench 6 North), including some RCRA hazardous wastes in a portion of Trench 5 and contaminated soils (Trench 6 Landfill and the CEA) within the IDA, are contained with RCRA Subtitle C synthetic liner cover systems. The units have been closed, LUCs are in place, and post-closure monitoring is ongoing in accordance with CERCLA and RCRA requirements at the IDA. This cover system limits migration and infiltration of surface water into the subsurface. Stormwater from the cover systems does not pose a risk for stormwater runoff migration since it does not come in contact with a contaminant source.

The primary fate-and-transport mechanisms occurring at the IDA were identified based on review of the distribution (nature and extent) of the site-related chemicals relative to the environmental setting, their physical and chemical properties, and comparison to screening levels. Potential routes of migration relative to the IDA are the following:

- Potential leaching from surface soils/waste and subsurface soils/waste to groundwater.
- Discharge of groundwater/leachate at the IDA and/or downgradient of the waste.

The main source of potential contaminant migration from the site is groundwater that has come in contact with the waste. Shallow overburden groundwater occurs approximately 5 to 35 feet bgs, while waste in the trenches is buried down to 25 feet bgs. Groundwater flows through the waste and potentially transports contamination in the direction of groundwater flow to the south/southwest toward Brush Creek, Long Creek, Spring Creek, and the Skunk River. A leachate collection (and treatment) system is in place to address groundwater/leachate by minimizing discharge and migration of contaminants downgradient of the trenches.

Shallow overburden aquifer groundwater can also flow downwards toward the bedrock aquifer as indicated by downward vertical gradients. However, contaminant migration between the aquifers would be limited due to physical differences between the surficial (overburden) geology and the primary bedrock matrix and pressure (head). Groundwater in bedrock flows primarily through secondary porosity features, like fractures. Contaminants typically will not move as rapidly as groundwater because of retardation, or the adsorption of the contaminant to the solid media. Retardation can be a significant factor for the COCs within the shallow overburden aquifer, which is composed primarily of clays and silts. Retardation will not be important where sand lenses are present from the glacial meltwater.

Mechanisms that control or influence the fate and transport of specific contaminants are discussed in the following subsections.

2.2.5.1 Volatile Organic Compounds

VOCs such as TCE and vinyl chloride are characterized by relatively high solubilities and relatively low soil adsorption potential. They are also subject to degradation by biological and abiotic mechanisms. Under naturally occurring (or engineered) anaerobic conditions, biodegradation typically occurs by reductive dechlorination, a process in which chlorine atoms on a parent chlorinated VOC (CVOC) molecule are sequentially replaced with hydrogen. Some CVOCs can be aerobically biodegraded via aerobic co-metabolism to carbon dioxide. They are also subject to abiotic degradation, mediated mainly by iron-bearing minerals in the subsurface under reducing conditions.

Overall, conditions in the subsurface at IDA appear to be mostly aerobic (dissolved oxygen [DO] = 2.55 milligrams per liter [mg/L], oxidation-reduction potential [ORP] = 112.8 millivolts, and sulfate = 8.7 mg/L based on the average geochemical observations of groundwater monitoring wells sampled as part of the current permit monitoring program), which is not generally favorable for reductive dechlorination. This is also supported by the low concentrations of CVOC daughter products (typically less than 1 µg/L). However, at specific locations, like monitoring well ET-3, where the average DO concentration is 2.04 mg/L and the ORP is -111 millivolts, conditions may be suitable for biotic degradation processes, including methanogenesis, which is indicated by the presence of methane (11 mg/L at ET-3 in 2021). Though conditions at IDA may not be consistently favorable for biotic reductive dechlorination, there is evidence to suggest that physical attenuation processes like abiotic reductive dechlorination, volatilization, and sorption may be limiting contaminant migration. TCE concentrations in nearby downgradient wells G-7 and MW20-01 are below detection limits, which suggest the influence of physical attenuation processes.

2.2.5.2 Semivolatile Organic Compounds and Polycyclic Aromatic Hydrocarbons

SVOCs such as 2-methyl-4,6-dinitrophenol and PCP and low-molecular-weight PAHs such as naphthalene are less soluble and have a higher sorption potential than VOCs. They are also subject to degradation by aerobic and anaerobic biological processes. While evidence of degradation has not been monitored for these contaminants, decreasing concentrations of PCP and naphthalene have been observed over time.

The most evident concentration decrease occurred in 1998 when the synthetic cover system was placed over Trenches 1 through 5. A sharp decrease in PCP (and to an extent naphthalene) concentrations can be seen starting in 1998 with a decreasing concentration trend observed since then. This suggests that the cover system reduced surface water migration to the waste/subsurface soil where these SVOCs and PAHs are present and ultimately reduced the amount of these contaminants seen in ET-3 (Figure 2-8). These observations also suggest that these contaminants are less susceptible to migration with groundwater. Soil at the site is highly organic, which may preferentially sorb SVOCs within the subsurface, especially lower molecular weight PAHs such as naphthalene.

2.2.5.3 Dioxins and Furans

Dioxins and furans are resistant to microbial degradation and insoluble in water. Dioxins and furans also bind to soil irreversibly due to encapsulation of the compound in soil organic and mineral material. As noted previously, soils at the site contain high amounts of organic material. Therefore, any dioxins and furans in the waste are not expected to mobilize into the groundwater. However, they can mobilize as colloids by themselves or co-elude with organic contaminants. The total 2,3,7,8-TCDD TEQ concentration have been detected at low concentrations at the site and is expected to remain on the site due to its physical properties. Total 2,3,7,8-TCDD detections have been limited to the landfill trenches and have not been detected in any downgradient wells (G-5, C-95-2, IDA-TT-MW1, G-7, C-00-1, JAW-27, C-00-2, or MW20-01) suggesting attenuation of these contaminants.

2.2.5.4 Radionuclides

A significant characteristic influencing the persistence of radionuclides in the environment such as lead-212 and potassium-40 is radioactive decay. The decay rate of a radionuclide is expressed in terms of a radionuclide-specific half-life and can be on the order of days, weeks, or years. The half-life of a radioactive substance is the time in which half of the atoms are transformed to another substance or daughter product. Lead-212 is a byproduct of thorium-232 decay and would be present only when this decay series occurs. Analysis was also done for two parent radionuclides, radium-228 and actinium-228. Radium-228 has several detects above the reporting limit; actinium-228 had several detects, but none above the reporting limit; and lead-212 had several detects, but only one above the reporting limit, which occurred with a relatively high actinium-228 detect and a radium-228 detect above the reporting limit. The ratios between radium-228, actinium-228, and lead-212 indicate that the samples were not in secular equilibrium when counted. However, radium-228 was present in detectible concentrations whenever lead-212 was detected, and the single detect of lead-212 above the reporting limit also had radium-228 above the reporting limit. It is likely that the lead-212 activity in the samples is from radium-228 in the samples, and not from unsupported lead-212 concentrations in the sample.

Radionuclides such as lead-212 and potassium-40 behave similarly to their non-radionuclide metal counterparts, and potassium-40 may have sorbed to clay materials, organic material, and/or iron and manganese hydroxides (which are present in aerobic environments), which has limited its migration from the site. Lower pH (less than 4 to 5 standard units) and reducing conditions may have occurred at times, which made subsurface conditions favorable for the release of potassium-40 and observation of this radionuclide in downgradient wells.

2.2.6 Risk Assessment Summary

An HHRA was conducted to evaluate potential current and future health risks from exposure to chemicals in site groundwater. A Screening Level Ecological Risk Assessment was not conducted for the IDA because there are no complete exposure pathways for ecological receptors. The IDA is located in a restricted, fenced-in boundary and is closed to any residential or recreational use, in accordance with the Action

Memorandum for the Inert Landfill and the 2008 OU-4 IROD. LUCs are being implemented by the Army in accordance with requirements of a LUC Implementation Plan for the IDA.

The following potential human receptors and exposure pathway scenarios were identified in the HHRA for IDA groundwater for chemicals of potential concern (COPCs) and radionuclides of potential concern (ROPCs):

- Current site worker
  - Groundwater (vapor intrusion) COPCs—inhalation of volatiles in indoor air
- Future site worker
  - Groundwater (tap water) COPCs—ingestion and dermal contact
  - Groundwater (vapor intrusion) COPCs—inhalation of volatiles in indoor air
  - Groundwater (tap water) ROPCs—ingestion, external radiation (immersion)
- Future construction/utility worker
  - Shallow groundwater (trench, 0 to 10 feet bgs) COPCs—ingestion, dermal contact, and inhalation of volatiles
  - Shallow groundwater (trench, 0 to 10 feet bgs) ROPCs—ingestion and external radiation (immersion)
- Future hypothetical resident adult and child (ages 0 to 6 years)
  - Groundwater (tap water) COPCs— ingestion, dermal contact, and inhalation of volatiles in household air
  - Groundwater (vapor intrusion) COPCs—inhalation of volatiles in indoor air
  - Groundwater (tap water) ROPCs—ingestion, external radiation (immersion), and inhalation (radium-226 and decay progeny, including radon-222)

The risk characterization was completed using a four-step process. Step 1 presents the total combined risks and hazards from site-related COPCs and naturally occurring chemicals. Step 2 presents the risks and hazards from naturally occurring chemicals. Step 3 consists of calculation of receptor-specific excess lifetime cancer risks (ELCRs) and hazard indexes (HIs) for site-related COPCs and ROPCs. COCs and ROCs were identified In Step 4.

A final COC and/or ROC was determined to be an IDA-related contaminant in a groundwater exposure medium/pathway (that is, tap water, household air from volatilization of chemicals during tap water usage, or indoor air via vapor intrusion) associated with a cumulative ELCR or cumulative noncarcinogenic HI that exceeds the respective USEPA target limits of 10^{-4} or 1 (that is, "exposure medium of concern"). Individually, COCs/ROCs were identified as those IDA-related contaminants in an exposure medium of concern contributing a total pathway ELCR or target organ HI that exceeds a target limit of 10^{-6} or 1, respectively; exceed available MCLs; and/or that meet other criteria evaluated as weights of evidence during risk characterization. A nonvolatile contaminant present at a concentration resulting in an ELCR or HI exceeding target limits but that is at a concentration less than the MCL was eliminated from further consideration as a COC. However, since MCLs are protective of only the drinking water pathway, a volatile contaminant's potential to contribute risks or hazards via the volatilization pathway was considered.

The quantification of ELCRs and HIs for the above receptors and pathways, in conjunction with the evaluations conducted during the four-step risk characterization process, resulted in the identification of groundwater final COCs/ROCs, presented in Table 2-3, for industrial and residential land use scenarios. These COCs and ROCs are summarized in Table 2-4.

Table 2-4. Groundwater Final COCs and ROCs

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Industrial Land Use	Residential Land Use
2-Methyl-4,6-dinitrophenol	1,2-DCA
Naphthalene	2,4-Dichlorophenol
PCP	2,4-DNT
Total 2,3,7,8-TCDD (TEQ)	2,6-DNT
Trichloroethene	2-Amino-4,6-dinitrotoluene
Vinyl chloride	2-Methyl-4,6-dinitrophenol
Lead-212	Benzene
Potassium-40	Lead-212
	Manganese
	Naphthalene
	Nitrobenzene
	PCP
	Potassium-40
	Radium-226
	Total 2,3,7,8-TCDD (TEQ)
	Trichloroethene
	Vinyl chloride

3. Identification and Screening of Remediation Technologies

This section describes the initial steps to develop alternatives for the remediation of groundwater at OU-4, including the development of RAOs, presentation of ARARs, the identification of the PRGs, and the identification of general response actions (GRAs) and potential remedial technologies.

3.1 Remedial Action Objectives

RAOs are medium-specific goals for protecting human health and the environment. As indicated in the USEPA RI/FS guidance, the objectives identified in an FS should be as specific as possible but not so specific that the range of alternatives that can be developed is unduly limited (USEPA, 1988). Draft RAOs are identified in the FS stage to evaluate whether technologies and alternatives should be able to meet the two threshold criteria of the alternative evaluation. RAOs are finalized in the PP and ROD stages of the CERCLA process, which will follow this FS.

The anticipated future end use for the IDA is industrial based on its operational use and OU-4 LUCs. The OU-4 LUCIP includes residential and recreational use restrictions. It also prevents the use of groundwater for potable purposes. The appropriate land use and groundwater use restrictions will be incorporated into the groundwater alternatives.

Considering the future use of groundwater, the RAOs for groundwater are the following:

- Prevent exposure of future human receptors (residents and industrial workers) to impacted groundwater until COC concentrations meet remediation goals (RGs).
- Prevent and/or minimize further migration of the contaminated groundwater plume at OU-4.
- Restore groundwater quality to RGs, consistent with NCP expectation §300.430 (a)(iii)(F).

3.2 Applicable or Relevant and Appropriate Requirements

This section identifies and evaluates potential federal ARARs from regulations and guidance. ARARs are required under CERCLA regulations at 40 Code of Federal Regulations (CFR) 300.400(g) or under state-equivalent regulations. ARARs are the substantive requirements of regulations, not the administrative requirements, and compliance is required with the substantive parts of the regulation. ARARs are any standards, requirements, methods of control, or limitations specified in federal or state environmental laws and regulations. These requirements may specify a cleanup level, identify a method of controlling an action, or limit where or how a remedial alternative can be implemented.

CERCLA RAs must meet ARARs for the onsite RA unless a waiver is requested. ARARs include the substantive or technical components of federal and state environmental requirements that define the extent of site cleanup, identify sensitive land areas or land uses, develop remedial alternatives, and direct site remediation. CERCLA, as amended by SARA, requires that RAs comply with ARARs. Potential ARARs are discussed in this section because they can affect the development of RAOs. Remedial alternatives are then developed and evaluated to determine whether they meet ARARs. The identification of ARARs is considered an iterative process, and the final determination of ARARs (no longer "potential" ARARs) is part of the final RA alternative selection process.

Once a remedy is selected, final ARARs are identified in the Decision Document. ARARs do not include administrative or procedural requirements. Also, no federal, state, or local permit is required for onsite CERCLA actions under CERCLA §121(e). USEPA's interpretation of CERCLA §121(e) waives the requirement to obtain a permit and the associated administrative and procedural requirements of permits, but not the substantive provisions of permitting regulations that are ARARs.

ARARs are defined in the NCP (40 CFR 300.5) as either applicable requirements or relevant and appropriate requirements. “Applicable” requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address circumstances at a CERCLA site. The requirement is applicable if the jurisdictional prerequisites of the standard show a direct correspondence when objectively compared to the conditions at the site. An “applicable” federal requirement is an ARAR. An applicable state requirement is an ARAR only if it is more stringent than a federal ARAR, and proposed by the state in a timely manner.

If the requirement is not legally applicable, then the requirement is evaluated to determine whether it is relevant and appropriate. “Relevant and appropriate” requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable, address problems or situations similar to the circumstances of the proposed response action and are well suited to the conditions of the site (USEPA, 1988). A requirement must be determined to be both relevant and appropriate to be considered an ARAR.

The criteria for determining relevance and appropriateness are listed in 40 CFR 300.400(g)(2) and include the following:

- Purpose of both the requirement and the CERCLA action.
- Medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site.
- Substances regulated by the requirement and the substances found at the CERCLA site.
- Actions or activities regulated by the requirement and the response action contemplated at the CERCLA site.
- Variances, waivers, or exemptions of the requirement and their availability for the circumstances at the CERCLA site.
- Type of place regulated and the type of place affected by the release or CERCLA action.
- Type and size of structure or facility regulated and the type and size of structure or facility affected by the release or proposed in the CERCLA action.
- Consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resources at the CERCLA site.

To qualify as a state ARAR under CERCLA and the NCP, a state requirement must be all of the following:

- A state law or regulation.
- An environmental or facility siting law or regulation.
- Promulgated (of general applicability and legally enforceable).
- Substantive (not procedural or administrative).
- More stringent than federal requirements.
- Identified in a timely manner.
- Consistently applied.

“To be considered” criteria (TBCs) are non-promulgated advisories or guidance issued by federal or state government that are not legally binding and do not have the status of ARARs. However, in many circumstances, TBCs are considered along with ARARs and may be used in determining the necessary level of cleanup for protection of health or the environment.

There are three types of ARARs:

- *Chemical-specific* ARARs are health-based or risk-based concentrations in environmental media (for example, soil, sediment, groundwater, and surface water) for specific hazardous substances, pollutants, or contaminants that restrict chemical concentrations in or discharged to the environment.
- *Location-specific* ARARs set restrictions on activities within geographic areas (for example, wetlands, floodplains, and shorelines) and on potential impacts to fish, wildlife, habitat, and cultural resources depending on the location of the activity and the immediate environment.
- *Action-specific* ARARs set controls or restrictions on particular types of activities included in the selected remedial alternative. These ARARs may specify performance levels, actions, or technologies to be used to manage hazardous substances, pollutants, or contaminants.

A list of chemical-specific, location-specific, and action-specific ARARs and TBCs for the site are summarized in Tables 3-1, 3-2, and 3-3, respectively, and discussed in the following sections. Potential action levels are included as Table 3-4.

3.3 Identify Preliminary Remediation Goals

Per Section 2.2.6, eight COCs may pose a risk above USEPA-acceptable levels to future industrial workers from exposure to site groundwater (ingestion, dermal contact, inhalation of volatiles in indoor air, and external radiation) and 18 COCs may pose risk to future hypothetical residents (adult and child) from exposure to groundwater (ingestion, dermal contact, inhalation of volatiles and radionuclides in indoor air, and external radiation). Therefore, PRGs were established for future groundwater concentrations. The PRGs listed below are based on a target ELCR of 1×10^{-6} and target hazard quotient of 1. PRG calculations are presented in Appendix B. Figure 3-1 shows the extent of COC concentrations that exceed the industrial PRGs in groundwater and Figure 3-2 shows the extent of COC concentrations that exceed the residential PRGs in groundwater. The final remedial goals will be defined in the ROD once a remedy and target risk level are selected for the site.

Table 3-5. Proposed Residential and Industrial PRGs
OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

COC	Residential PRG (µg/L)[a]	Industrial PRG (µg/L)[b]
2-methyl-4,6-dinitrophenol	1.5	7.41
1,2-DCA	5	N/A
2,4-Dichlorophenol	20	N/A
2,4-DNT	5	N/A
2,6-DNT	5.1	N/A
2-Amino-4,6-dinitrotoluene	1.9	N/A
Benzene	5	N/A
Nitrobenzene	70	N/A
Naphthalene	100	100
PCP	1	1
Total 2,3,7,8-TCDD (TEQ)	3.0×10^{-5}	3.0×10^{-5}

Table 3-5. Proposed Residential and Industrial PRGs

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

COC	Residential PRG (µg/L)[a]	Industrial PRG (µg/L)[b]
TCE	5	5
Vinyl chloride	2	2
Manganese	30	N/A
Lead-212	2.02[c]	6.18[c]
Potassium-40	2.12[c]	6.48[c]
Radium-226	0.136[c]	N/A

N/A = not applicable; the chemical was only identified as a residential COC and is not an industrial COC.

[a] The basis for the residential PRG is provided in Table 3-4.

[b] The basis for the industrial PRG is provided in Table 3-4.

[c] Units for radium-226, lead-212, and potassium-40 are picocuries per liter.

Of the eight industrial land use COCs, only the following contaminants have exceeded their respective industrial PRGs in the last 5 years and were considered for treatment during alternative development:

- 2-methyl-4,6-dinitrophenol
- Naphthalene
- PCP
- TCE

Residential land use COCs are not being considered for treatment due to the current LUCs which will continue to be protective of future residential receptors. However, LUCs are included as part of the alternatives developed in Section 4.

3.4 Develop General Response Actions

After the RAO and PRGs are developed, GRAs are identified to address affected media at the site. As defined in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988), GRAs are medium-specific actions that satisfy RAOs. Actions for mitigating risk posed by affected media may be applied individually or in combination. Table 3-6 summarizes the GRAs, which were retained for achieving the RAO.

3.5 Identify and Screen Technologies and Process Options

Consistent with *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988), before developing remedial alternatives, potentially applicable remedial technologies were identified and screened within each remaining GRA, based on the following criteria:

- *Effectiveness* is the ability of the technology or process option to perform adequately to achieve the remedial objectives alone or as part of an overall system.
- *Implementability* refers to a technology that is effective and workable at a particular project site.

- *Relative cost* is comparative only and is judged similar to the effectiveness criterion. It is used to preclude further evaluation of process options that are very costly where there are other choices that perform similar functions with comparable effectiveness. It includes construction and long-term operation and maintenance costs.

Table 3-7 summarizes the screening process for achieving the RAOs for IAAP-020G_Inert Disposal Area Groundwater. Technologies and process options considered infeasible based on effectiveness, implementability, and costs are shown in shaded background. Screening was based on professional experience, published sources, and other relevant documentation. The technologies retained following screening include LUCs, monitoring, permeable reactive barrier (PRB), and groundwater extraction and treatment.

4. Alternative Development and Evaluation

Remedial alternatives were developed by combining the retained technologies following the screening process presented in Table 3-7. To avoid evaluating an unmanageable number of alternatives, only the most logistically and technically sensible combinations for the given site conditions were carried forward. As such, the following four remedial alternatives were developed:

- Alternative 1—No action.
- Alternative 2—MNA with LUCs.
- Alternative 3—Groundwater extraction and treatment with MNA and LUCs.
- Alternative 4—PRB with MNA and LUCs.

An alternative that allows for unlimited use and unrestricted exposure was not evaluated for groundwater at the IDA, given that contamination is still in place at the IDA under the soil site. As described in Section 2.2 of the FS report, soil media at the IDA is under an interim remedial action that includes containment (landfill). It is not beneficial to remediate groundwater at the IDA to unlimited use and unrestricted exposure at this time, given the selected soil remedy.

Conceptual designs have been developed for each alternative and are discussed in the subsections below. Specific details of the conceptual designs are provided for this FS to serve as representative examples to estimate order-of-magnitude costs (Appendix C). The actual alternative details would be developed during the remedial design phase and may vary from this FS. Though the current site data are adequate to evaluate technologies and alternatives for remediation of the OU-4 groundwater, additional data are required to design and implement the remedial alternatives. Components of alternative-specific predesign investigations (PDIs) are discussed in their respective sections below.

4.1 Target Treatment Areas Considered for Alternative Development

To support the development and evaluation of remedial alternatives, the following two target treatment areas within the shallow overburden aquifer were defined and discussed below: 1) MNA Target Treatment Area and 2) Active Target Capture/Treatment Area.

4.1.1 MNA Target Treatment Area

As shown on Figure 4-1, the boundary for the MNA target treatment areas have been approximated to be the areas surrounding monitoring wells ET-3 and C-00-1, where industrial COC PRGs have been exceeded at the site within the last 5 years and is approximately within a 30-foot radius of the wells. The radius was estimated based on the distance between C-00-1 and the nearest well (JAW-27). Since COC concentrations are low in C-00-1, it has been assumed that a similar sized area will be treated in ET-3 that also has low COC concentrations. Figure 3-1 presents the most recent (2019–2021) results that exceed industrial PRGs, and Figure 3-2 presents the most recent (2019–2021) results that exceed residential PRGs. As discussed further below, these wells will be monitored for natural attenuation parameters and included in the LTM plan.

4.1.2 Active Target Capture/Treatment Area

As shown on Figures 4-2 and 4-4, the active target/capture treatment area is downgradient of the disposal areas where a remedy may be required to capture and/or treat groundwater. The north and south boundaries of the area selected as shown on Figures 4-2 and 4-4 are based on accessibility of roads and site topography to allow for implementation of the alternatives while the east and west boundaries are based on the physical site boundaries. For Alternative 3, this is the area that extraction wells will be placed to capture groundwater before it leaves the site and is conveyed to the existing ex situ treatment system. For Alternative 4, this is the area where the PRB will be installed to intercept the COC plume before groundwater leaves the site.

4.2 Alternative 1–No Action

Alternative 1 consists of taking no action. The NCP requires that a No Action Alternative be retained throughout the FS process as a baseline for comparison to the other approaches. “No action” means that no RA would be undertaken and that no institutional controls, containment, removal, treatment, or other mitigating actions would be implemented to control exposure to COCs. Therefore, the potential human health and environmental risks associated with exposure to the COCs would not be mitigated. Five-year site reviews would be conducted as long as hazardous substances remain at the site at concentrations that do not allow unlimited use and unrestricted exposure, in accordance with the NCP. There are no capital or operations and maintenance (O&M) costs for the No Action Alternative.

4.3 Alternative 2–Monitored Natural Attenuation with Land Use Controls

MNA is defined by the USEPA in Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-17 (USEPA, 1997) as “the reliance on natural attenuation processes (within the context of a carefully-controlled and monitored cleanup approach) to achieve site-specific remedial objectives within a timeframe that is reasonable compared to other methods.” Natural attenuation processes include a variety of physical, chemical, and biological processes that act without human intervention to reduce the contaminant mass, toxicity, mobility, volume, or concentrations in soil and groundwater. Biodegradation is the most important destructive attenuation mechanism, although abiotic destruction of some compounds does occur. Nondestructive attenuation mechanisms include sorption, dispersion, dilution from recharge, and volatilization (USEPA, 1998).

MNA is appropriate as a remedial approach only when it can be demonstrated to be capable of achieving the RAOs within a timeframe that is reasonable compared to that offered by other methods. MNA is typically applied in conjunction with active remediation measures (for example, source control), or as a follow-up to active remediation measures that have already occurred. As previously discussed, the soil at the site has been capped to prevent direct contact and minimize the migration of waste materials.

The results of soil capping to minimize the migration of contaminants in the waste trenches on PCP concentrations in ET-3 can be seen on Figure 2-8, where its concentration has decreased since the cap was installed. PCP has a high K_{oc} value, thus would be more likely to sorb to soil, and is not likely to be very mobile. A linear regression using data for PCP from 1998 to 2021 indicates that concentrations are projected to be below its PRG by 2023. Consistent with the concentration trend, PCP concentrations were below detection limits in 2020 and 2021. Similar to PCP, a linear regression using detected data for naphthalene from 2014 to 2021 indicates that concentrations are projected to be below its PRG by 2035.

Elevated nitrate concentrations in groundwater can limit the effectiveness of attenuation via reductive dechlorination. However, other mechanisms of attenuation appear to be at work. The TCE concentration at C-00-1 has ranged from 12 to 26 µg/L over the last 20 years (Figure 2-8). Though no TCE daughter products have been observed in this well, TCE has not migrated to downgradient wells G-7 and MW20-01, suggesting that natural attenuation processes are limiting contaminant migration in this part of the site. A linear regression using detected data for TCE at this location from 2008 to 2021 indicates that concentrations are projected to be below its PRG by 2038.

No conclusions can be drawn on concentration trends for 2-methyl-4,6-dinitrophenol as it has only been detected one time since 1993 (in 2019 during the RI) at a concentration exceeding its current PRG.

As detailed below, Alternative 2 would include a PDI, performance monitoring, and implementation of LUCs.

4.3.1 Predesign Investigation

As part of a PDI, two additional wells would be installed in the downgradient, southern part of the site within the shallow overburden aquifer to expand the current monitoring well network. Because existing downgradient monitoring wells IDA-TT-MW1 and MW20-01 have detections of contaminants, additional wells are warranted to assess future plume dynamics and help evaluate the effectiveness of the remedial actions at meeting the RAOs. The new monitoring wells would be sampled for the site COCs and integrated into the LTM program.

4.3.2 Performance Monitoring

During the first year of implementation, groundwater samples (including sitewide gauging) would be collected semiannually to establish a baseline for the MNA remedial action. Although annual groundwater data have been collected under RCRA at the IDA, the RCRA sampling plan was not developed to assess MNA. Semiannual data during the first year would help establish the understanding of subsurface geochemical conditions that influence natural attenuation processes (e.g., sulfide/nitrate/nitrite/sulfite). Samples would be analyzed for site residential and industrial land use COCs, PFAS, and analytical parameters consistent with the 2018 RCRA Permit (USEPA, 2018), the Class I and II RCRA Permit Modifications, and any future permit modifications until the ROD is finalized. Eight of the 17 wells will also be sampled for MNA parameters (including total organic carbon, alkalinity, nitrate, nitrite, sulfate, iron, methane, ethane, and ethene) semiannually during the first year.

After the first year, the LTM plan will be revised so groundwater samples would be collected once a year from the 17 wells and MNA parameters from 8 of the 17 wells. Every 5 years as part of the 5-year reviews, samples will also be collected for residential land use COCs (that are currently not collected as part of the industrial COCs) from all 17 wells. For cost-estimating purposes (see Appendix C), it has been assumed that monitoring will occur for 30 years.

The requirements of the RCRA Permit for closure and post-closure monitoring will be fulfilled by this new monitoring program. During the remedy implementation and each 5-year review, the LTM plan would be reviewed periodically and optimized as needed to reflect any changes in site conditions and the fate and transport of the COCs at the site.

4.3.3 Land Use Controls

As described in section 2.2.1.2, LUCs are currently implemented at the IDA as a component of the interim RA for soil and waste (Tetra Tech, 2008). These LUCs can also prevent exposure of future human receptors to groundwater COCs and meet the RAOs for the IAAP-020G_Inert Disposal Area Groundwater site. LUCs for the IDA under the OU-4 LUCIP (Tetra Tech, 2014) include engineering (physical) and institutional (administrative, legal) controls to restrict access, prohibit unauthorized intrusive activities, and ban the use of groundwater as a drinking water supply within the landfill boundary. The performance objectives of the LUCs are as follows (Tetra Tech, 2014):

- Prohibit the development and use of property for residential housing, elementary and secondary schools, childcare facilities, and playgrounds.
- Prevent intrusive activity into or near the cap system.
- Maintain the integrity of cover/cap system.
- Restrict property access to only authorized individuals for approved commercial, industrial, and remedy operation and maintenance purposes.

- Maintain the integrity of any current or future remedial or monitoring system.

The OU-4 LUCIP details the implementation and monitoring of LUCs for the IDA. Regarding potable well restrictions, the LUCIP states that

> Groundwater will not be used for potable purposes on the installation. However, the Army and AO may employ specialty contractors for water well installation. With the industrial land use currently foreseen for the installation, any well installation will likely be limited to
>
> - Groundwater monitoring wells installed to extract small volumes of water to monitor the environmental conditions in and near remedial actions; or
> - Water supply wells installed to provide large volumes of water for specific industrial processes.

If needed, this LUCIP will be modified once the final ROD has been issued for OU-4 to incorporate the IAAP-020G Inert Disposal Area Groundwater site, AR-200-10, and IAAAP master planning requirements.

4.4 Alternative 3–Groundwater Extraction and Treatment with Monitored Natural Attenuation and Land Use Controls

The objective of Alternative 3 would be to extract and treat contaminated groundwater before it migrates offsite. Vertical extraction wells would be screened in the shallow overburden aquifer along the southern end of the site. Figure 4-2 shows the potential location of the extraction wells, treatment system, surface water discharge location, and conveyance system. Figure 4-3 is a process flow diagram of the components of the treatment system. While groundwater extraction and treatment will address potential contaminant migration, MNA would be implemented for the remainder of the site where COC concentrations exceed their industrial PRGs, and LUCs would restrict the site to industrial use.

As detailed below, Alternative 3 would include a PDI, installation of extraction wells and a conveyance system, an update of the existing groundwater treatment system, performance monitoring, and implementation of LUCs.

4.4.1 Predesign Investigation

The PDI for Alternative 3 would include the installation of two permanent and four temporary monitoring wells and two piezometers, a granular activated carbon (GAC) column test, and a groundwater pumping test to refine the design.

4.4.1.1 Plume Extent Investigation

The previously mentioned, two permanent and four temporary monitoring wells would be installed to define the horizontal and vertical extent of the plume to finalize the configuration of the hydraulic containment system. The two new permanent monitoring wells would be sampled for the site COCs and relevant groundwater chemical parameters.

4.4.1.2 GAC Column Test

A representative sample of site groundwater would be collected and sent to a treatability study laboratory to perform a rapid small-scale column test. It is assumed for cost-estimating purposes that two different GAC media will be selected for the test. The test will provide information regarding the performance of the different GAC media and the duration before change-out of the media is required.

4.4.1.3 Extraction System Pilot Test

Two hydraulic testing areas that represent the hydrogeologic conditions within the target capture area would be identified, and a pilot extraction well would be installed at each area. One would be selected within the southwest part of the target capture area, while the other area would be within the southern target capture area (Figure 4-2). The pilot extraction wells could be converted to permanent extraction wells at the completion of the hydraulic testing. Pilot extraction wells would be designed with screen length, slot size, and filter sand pack determined by grain size analysis of soils in the aquifer. These grain size samples will be collected during test drilling, prior to final well installation.

The hydraulic testing will consist of the following elements:

- **Slug test.** Estimate the hydraulic properties (hydraulic conductivities) at each well and provide an estimate of likely responses during the pump test.

- **Pilot pump test.** Determine whether the pumps and transducers used to monitor water levels work and verify that targeted pumping rates would not dewater the well or damage well testing equipment. The results of the pilot pump test would be used to identify the pumping rates for the subsequent step test. Data collected would also help refine design for additional extraction wells installed at the site.

- **Step pumping test.** Gauge aquifer responses and well performance at the targeted pumping rates. The pumping rates identified during the pilot test would be used to pump water at the identified rates for one day each within the test wells. The hydraulic data would be used to quantify well performance (well loss and well efficiency) as well as gauging for hydraulic properties.

- **Long-term pumping test.** Further quantify the hydraulic properties of the aquifer and identify long-term effects on pumping that may be important to the operation of the remedial groundwater extraction system. The length of the long-term pumping test will be determined as part of the remedial design work plan. Additional nearby wells, including G-5, MW20-01, IDA-TT-MW1, and G-7, may also be monitored to observe drawdown during this test. Two additional sets of wells (one piezometer at 10 to 15 feet and a temporary monitoring well approximately 50 to 75 feet) would be installed in a 90-degree configuration from one of the pilot extraction wells. The placement of these wells would allow for distance-drawdown observations and the collection of anisotropic data.

Data collected from the pumping tests would be used to determine the aquifer properties (hydraulic conductivity, storativity, well loss and efficiency, anisotropy, and radius of influence) using various tools including the AQTESOLVE program. The data would then be used to identify the final pumping rates, extraction well locations and spacing, and conveyance piping sizing. The pump test data would also be used to assess whether physical barriers could be placed along the western site boundary north of the westernmost extraction well and the southeastern boundary north of the easternmost extraction well to assist with directing groundwater toward the extraction wells. For cost-estimating purposes, it is assumed that the physical barriers would not be needed.

4.4.2 Extraction Wells

For the FS, a simple groundwater model using the Multi-Layer Unsteady state semianalytical model was developed to estimate the number of extraction wells, pumping rate, and screening interval. The assumptions for the groundwater modeling effort are included in Appendix D. While the modeling indicates that six extraction wells spaced evenly (200 feet apart) across approximately 1,000 feet would be sufficient to cover the treatment area, a more conservative estimate of 10 wells has been assumed due to uncertainties with the model and topography of the site. Conceptually, the 10 wells were placed across the same elevation where possible or along existing roads where access would not be an issue. For cost-estimating purposes, site preparation activities (for example, clearing and grubbing, and limited grading) have been included, and extraction well screen would be installed from 5 and 35 feet bgs and produce 2 gallons per minute of groundwater (for a total of 20 gallons per minute).

The 10 extraction wells would be pumped with pneumatically driven pumps perpendicular to the groundwater flow direction to create a capture zone. The extracted groundwater would be conveyed and treated in an aboveground treatment system. Pneumatic pumps were selected to simplify the system design, provide extraction rates that are typically below electric pump ranges, and to remove the need for localized panels with disconnects, switching, and motor savers that are typically associated with electrical pumps. Alternatives could be evaluated during the remedial design process.

4.4.3 Conveyance System

Figure 4-3 shows the conceptual layout for the conveyance system of groundwater and air conduit. All conveyance lines would be placed at least 18 inches below the ground surface. It has been estimated that 1-inch and 4-inch PFAS-free pipe will be used for groundwater conveyance, and 1-inch and 1.5-inch PFAS-free pipe and steel pipe will be used for air conveyance. Due to the challenges with the topography and distance covered by the extraction wells, it has been assumed that a pump station would be required to convey water from the six easternmost extraction wells to the treatment building. The pump station would consist of a pre-engineered structure, 10-horsepower multistage centrifugal pump, an aboveground 5,000-gallon equalization tank with secondary containment, and necessary controls to convey the water to the treatment building. An air compressor system (60 cubic-feet-per-minute rotary screw pump with 120-gallon receiver tank, integrated controller, air treatment, and flow control for the six most eastern extraction wells) would also be located at the pump station to provide air for the pneumatically driven extraction well pumps. An additional 40-cubic-feet-per-minute air compressor system would be used for the remainder of the extraction well pumps. It has been assumed that the electrical needs (240-volt, 3-phase power) for this pump station and air compressor system would be provided by a new power connection/drop to this location. Again, the layout and placement of the pump station, air compressor systems, and conveyance system would be determined after the completion of the PDI.

4.4.4 Groundwater Treatment Process

The unit processes for the treatment system would be selected based on the expected water quality and contaminants to be removed (including PFAS). Currently, a groundwater treatment system exists at the IDA to periodically assist with treatment of leachate from the landfill. This same groundwater treatment system would be used for the treatment of the extracted groundwater for this alternative and would be retrofitted with two Calgon Carbon Cyclosorb FP1 units pre-filled with 1,000 pounds of Filtrasorb 400-M (or equivalent) to replace the existing carbon treatment vessels. The process units are shown on Figure 4-2 and include an existing influent tank, a bag filtration system, GAC as the primary treatment process, and two batch (effluent) tanks. The treated water would then be discharged to the batch tank before it is discharged to the location shown on Figure 4-3.

O&M activities associated with this alternative include operation of the extraction wells and the water treatment operations. For the purposes of developing costs for this FS, it is assumed that the groundwater extraction and treatment system would operate for 30 years, and a carbon change-out would be required every 4 months (based on previous experience and professional judgment) during this timeframe. Carbon would not be disposed of but sent back to Calgon Carbon in the FP1 unit every 4 months for reactivation.

4.4.5 Performance Monitoring

In addition to MNA and the LTM plan described in Section 4.4.2, samples would also be collected for industrial COCs on a biweekly basis from the effluent side of both FP1 carbon vessels to meet discharge requirements and to determine when change-out of the lead FP1 carbon vessel would be required.

4.4.6 Land Use Controls

LUCs would be implemented as discussed for Alternative 2. Five-year reviews would also be conducted as part of this alternative to ensure the remedy continues to protect human health and the environment.

4.5 Alternative 4–Permeable Reactive Barrier with Monitored Natural Attenuation and Land Use Controls

Under Alternative 4, a PRB would be constructed to intercept contaminated groundwater under natural groundwater gradients. A PRB is an in situ permeable treatment zone designed to passively intercept and remediate a contaminant plume. Groundwater and target chemicals would flow through the PRB hydraulically without mechanical assistance; contaminants would be degraded, destroyed, and immobilized once in contact with the media, and treated water would exit the other side of the PRB.

The key benefit of a PRB is that it does not require pumping or aboveground treatment and typically does not interfere with land use of the affected property after construction. As such, a PRB requires minimal O&M other than site monitoring. The typical lifespan of a PRB ranges from 10 to 30 years or more based on field investigations and laboratory studies (ITRC, 2005); thus, PRBs can be a viable alternative to a conventional pump-and-treat system.

The three primary types of PRB configurations are (1) continuous reactive barrier system, (2) funnel-and-gate system, and (3) reactive vessels. The continuous reactive barrier system configuration is a uniform wall or barrier of reactive zone perpendicular to groundwater flow that is placed across the width of a contaminant plume. The funnel-and-gate configuration includes low-permeability walls (the funnel) that direct the groundwater plume toward a permeable treatment zone (the gate). A reactive vessel configuration is essentially a variation of the funnel-and-gate system, whereby the gate is replaced with a buried vessel that contains reactive materials for treatment of the contaminated groundwater. A reactive vessel system typically requires a steep hydraulic gradient that can be used to direct the groundwater up through the buried reactive media.

PRBs can be constructed via trenching or excavating and then backfilled with treatment media using a backhoe, clamshell, caisson, or one-pass trenching. The construction costs typically increase with depth. In some cases, direct injection techniques can also be used introduce reactive media directly into the ground without excavation. Those techniques include but are not limited to direct-push technology, hydraulic fracturing, jetting, and injection with a mandrel (or hollow steel shaft). Depending upon the selected construction approach, a PRB is hard to modify or relocate once constructed. Difficulty with making modifications to the PRB would be most typical for the more traditional excavated-trench systems. However, less traditional construction approaches, such as reactive vessel or injection well–based PRBs, can provide a more flexible system that can be more easily modified (CRC CARE, 2016).

For the IDA PRB, the selected media for addressing the industrial site COCs are zero-valent iron (ZVI) to address CVOCs and activated carbon to address the remaining COCs. For cost estimating purposes, PlumeStop Liquid Activated Carbon (PlumeStop) and Sulfidated-MicroZVI (S-MZVI) would be used for the IDA PRB and administered via injection wells.

Injectable carbon would be composed of fine-scale activated carbon particles (~2 microns) and food grade organic polymers to aid in distribution. Once injected, the injectable carbon disperses and coats aquifer materials. The carbon sorption capacity is regenerated in situ through the use of ZVI. The combination of injectable carbon and ZVI will immediately remove the contaminants from the dissolved phase onto the surface of the carbon, where ZVI will degrade contaminants susceptible to degradation (for example, TCE).

Although injectable carbon would treat the site-specific COCs independently, ZVI has been added to quicken the degradation of dissolved CVOCs to nontoxic end products. ZVI creates an anoxic and highly reducing environment, providing ideal conditions for sequential enhanced anaerobic biodegradation to destroy chlorinated contaminants. This abiotic process involves corrosion (oxidation) of the metal and dehalogenation of the dissolved chlorinated hydrocarbons. The process induces highly reducing conditions that cause substitution of chlorine (or other halogen) atoms by hydrogen in the structure of the targeted compound via the β-elimination pathway. The β-elimination pathway, in which two substitutes (halides) from a pair of adjacent molecules are released, dominates the reaction and results in the rapid production of ethene by producing unstable chloroacetylene intermediates that rapidly reduce to ethene (ITRC, 2005). This process skips the production of daughter products, such as vinyl chloride. This is the most prevalent process for ZVI PRB treatment.

Although agricultural land is near the IDA, nitrate levels are not anticipated to interfere with the effectiveness of injectable carbon and ZVI. The maximum levels of nitrate detected in wells C-00-1 and ET-3 in the past 5 years are 5,500 μg/L and 5,800 μg/L, respectively. Nitrate concentrations greater than 10,000 μg/L may reduce ZVI treatment effectiveness (ITRC, 2005).

To place the selected media, an injected continuous reactive barrier system was chosen as the most feasible option for the IDA for the following reasons:

- Installing temporary injection wells is easier than installing a trench with steep slopes and forested areas.
- Colloidal activated carbon disperses into the aquifer and would require less maintenance than a trench PRB design that would need to remove and replace spent carbon.
- Injection well placement allows for modification of PRB treatment location, unlike a trench, which would be difficult to relocate or modify.
- Injection-based PRBs have fewer depth limitations than trench-based PRBs.

As detailed below, Alternative 4 would include a PDI and treatability testing, selection of the PRB layout, media preparation and injection, performance monitoring, and implementation of LUCs.

4.5.1 Predesign Investigations and Treatability Testing

The PDI would include the installation of six new monitoring wells and pilot testing to finalize the PRB design.

4.5.1.1 Plume Extent Investigation

Six new monitoring wells would be installed to define the horizontal and vertical extent of the plume to finalize the configuration of the PRB (Figure 4-4). The new monitoring wells would be sampled for the site COCs and relevant groundwater chemical parameters. Samples would also be collected for geotechnical parameters (for example, grain size analysis and hydraulic conductivity) to support the design of the injection system.

4.5.1.2 Pilot Testing

Pilot testing would include using one or more of the injection wells or points and two proposed monitoring wells to meet the following objectives:

- Measure the achievable injection rate and required injection pressures.
- Evaluate the radius of influence and reagent distribution in the subsurface.
- Estimate field abiotic or biotic degradation rates.
- Evaluate the distribution and extent of contaminant mass reduction and the persistence of reactive conditions within the subsurface.
- Determine full-scale implementability implications, such as refining the number of injection wells needed, temporary injection well size, and well screen depths.

For the purposes of this FS, the costs associated with the injection testing pilot test are included in Regenesis's cost assumptions for the initial application of PlumeStop and S-MZVI (Appendix E).

4.5.2 Permeable Reactive Barrier Layout

Conceptually, the IDA PRB would be installed just downgradient of well MW20-01 across the migration path of the contaminated groundwater in the southwestern corner of the site (Figure 4-4). The PRB injection wells would be evenly distributed across 850 feet to target the COCs as shown on Figures 3-1 and 3-2. The location of the PRB was based on several factors:

- Position of the landfill—the PRB would be placed downgradient of the source.
- Topography—as possible, the PRB would be installed along existing roads or paths to avoid construction on the steep slopes in the area.
- Groundwater flow direction—site potentiometric maps were used to place the PRB alignment perpendicular to groundwater flow.
- Groundwater concentrations—the PRB does not span the entire plume because natural attenuation processes are expected to complement the performance of the PRB.

It is estimated the 850-foot-long barrier would require 10,300 pounds of ZVI to be mixed with 123,200 pounds of injectable carbon to be injected to reduce concentrations to less than the PRGs, assuming the site conditions stated in Appendix E. The final number of injection wells could change pending the results of the PDI and pilot testing. For cost-estimating purposes, site preparation activities (for example, clearing and grubbing, and limited grading) have been included for the installation of the temporary injection wells.

4.5.3 Reactive Media Preparation and Installation

The ZVI and injectable carbon would each be delivered to the job site in 2,000-pound reinforced-plastic totes. ZVI would be blended with injectable carbon and diluted with water in a volumetric ratio determined by Regenesis prior to being applied into low-pressure injection wells. Injection equipment would include pumps, mixing tanks, delivery manifold, injection heads with flow and pressure gauges, safety bypass valves, and hoses to convey the diluted injectable carbon and ZVI to the injection wells. It is assumed that a total of fifty 2-inch-diameter temporary injection wells would be screened in the shallow overburden aquifer and installed perpendicular to the groundwater flow direction using direct-push technology drilling techniques. Each injection location will have well nests consisting of two wells placed 5 feet apart in separate holes, for a total of 25 well locations. Within the well nests, one injection well would be installed to a depth of 30 feet bgs and screened between 5 and 20 feet bgs, and one injection well would be installed 40 feet bgs and screened between 20 and 35 feet bgs. Based on past construction experience, it is anticipated that mobilization, drilling, injections, waste management, and demobilization would take 45 days to complete. For cost-estimating purposes, the temporary injection wells will be removed after the first round of injections and reinstalled after 15 years, when another round of injections is needed.

The following would be monitored during the injection process:

- Injection flow rates and injection pressures.
- Water levels at the nearby existing and proposed monitoring wells in the target treatment area to identify whether groundwater mounding is occurring, and flow rate adjustments are required.
- In situ groundwater quality, including DO, ORP, specific conductivity, pH, and temperature, to evaluate the distribution of the injections.

For cost-estimating purposes, it has been assumed that the PRB would need to be active for at least 30 years. Because the primary reactive media, injectable carbon, would be expected to be effective for 15 years and treat all site contaminants, one additional round of injections is anticipated after 15 years from the initial injections when potential COC breakthrough concentrations are observed during performance monitoring activities. It is assumed that ZVI would be added during both injection events. Site restoration and performance monitoring would follow.

4.5.4 Performance Monitoring

In addition to MNA and the LTM plan described in Section 4.4.2, the effectiveness of this alternative would be monitored through collection of groundwater elevations and field parameters from five existing upgradient wells (G-5, IDA-TT-MW1, G-7, MW20-01, and C-00-1), two new side-gradient monitoring wells, and four new downgradient monitoring wells (Figure 4-4). Performance monitoring will include collecting the following analytical and field parameters:

- Industrial COCs (2-methyl-4,6-dinitrophenol, naphthalene, PCP, TCDD, TCE, vinyl chloride, lead-212, and potassium-40).
- pH.
- DO.
- ORP.
- Total iron, total manganese, dissolved iron, and dissolved manganese.
- Sulfate, sulfide, and nitrate.
- Total organic carbon.
- Alkalinity.
- Chloride.
- Methane, ethane, ethene, and carbon dioxide.

For FS cost-estimating purposes, it is assumed that 11 monitoring wells would be included in the performance monitoring plan for the PRB. Groundwater samples would be analyzed quarterly for the first year after PRB installation, semiannually during the second year, and annually thereafter for industrial COCs. Performance monitoring will overlap with OU-4 MNA monitoring in the five existing upgradient wells whenever possible. Additional sampling is included in the cost estimate for the six new monitoring wells.

The final groundwater monitoring plan, including the number of monitoring wells, sample parameters, and sample frequency, would be developed during the remedial design phase.

4.5.5 Land Use Controls

LUCs would be implemented as discussed for Alternative 2. Five-year reviews would also be conducted as part of this alternative to ensure the remedy continues to protect human health and the environment.

5. Detailed Analysis of Remedial Alternatives

The detailed analysis of alternatives presents the information needed to compare the remedial alternatives and consists of a detailed evaluation of each alternative against the evaluation criteria, followed by a comparative evaluation.

5.1 Evaluation Criteria

Provisions of the NCP require that each alternative be evaluated against nine criteria listed in 40 CFR 300.430(e)(9). These criteria were published in the *Federal Register* for March 8, 1990 (55 *FR* 8666), to provide grounds for comparing the relative performances of the alternatives and to identify their advantages and disadvantages. This approach is intended to provide sufficient information to adequately compare the alternatives and to select the most appropriate alternative for implementation at the Site as a RA. The seven criteria evaluated in this FS are the following:

- Overall protection of human health and the environment.
- Compliance with ARARs.
- Long-term effectiveness and permanence.
- Reduction of TMV through treatment.
- Short-term effectiveness.
- Implementability.
- Cost.

Two other criteria—state acceptance and community acceptance—will be evaluated following public comment on the selected remedy, as described in the PP.

The above criteria can be grouped into three types of evaluation criteria: threshold, balancing, and modifying. Threshold criteria must be met by a particular alternative for it to be eligible for selection as a RA. The two threshold criteria are overall protection of human health and the environment and compliance with ARARs. If ARARs cannot be met, a waiver may be obtained when one of the six exceptions listed in the NCP occurs (see 40 CFR 300.430 [f][1][ii][C][1 to 6]).

The five balancing criteria weigh the trade-offs among alternatives. The five balancing criteria are the following:

- Long-term effectiveness and permanence.
- Reduction of TMV through treatment.
- Short-term effectiveness.
- Implementability.
- Cost.

The modifying criteria are community and state acceptance. These are evaluated following public comment and are used to modify the selection of the recommended alternative. Community and state acceptance are not addressed in the FS but will be addressed in the PP for the site.

5.1.1 Threshold Criteria

Threshold criteria are standards an alternative must meet to be eligible for selection as an RA. There is little flexibility in meeting the threshold criteria—the alternative must meet these or it is unacceptable. If ARARs cannot be met, the NCP specifies criteria for a potential waiver.

5.1.1.1 Overall Protection of Human Health and the Environment

Protectiveness is the main requirement that RAs must meet under CERCLA. It is an assessment of whether each alternative achieves and maintains adequate protection of human health and the environment. A remedy is protective if it eliminates, reduces, or controls current and potential risks posed by the site through each exposure pathway.

5.1.1.2 Compliance with ARARs

Compliance with ARARs is a statutory requirement of remedy selection. This criterion is used to determine whether the selected alternative would meet the federal and state ARARs identified in Tables 3-1, 3-2, and 3-3. The compliance of each alternative with chemical-, location-, and action-specific ARARs is discussed in Section 2.2.

5.1.2 Balancing Criteria

Balancing criteria are used to weigh trade-offs among alternatives. They represent the standards upon which the detailed evaluation and comparative analysis of alternatives are based. A high rating on one balancing criterion generally can offset a low rating on another.

5.1.2.1 Long-term Effectiveness and Permanence

Long-term effectiveness and permanence reflect CERCLA's emphasis on remedies that will protect human health and the environment in the long term. Under this criterion, results of a remedial alternative are evaluated in terms of the risk remaining at the site after response objectives are met. The primary focus of the evaluation is the extent and effectiveness of the actions or controls that may be required to manage the risk posed by treatment residuals or untreated wastes.

Factors to be considered and addressed are magnitude of residual risk, adequacy of controls, and reliability of controls. Magnitude of residual risk is the assessment of the risk remaining from untreated waste or treatment residuals after remediation. Adequacy and reliability of controls is the evaluation of the controls that can be used to manage treatment residuals or untreated wastes that remain at a site.

5.1.2.2 Reduction of Toxicity, Mobility, or Volume through Treatment

This criterion addresses the statutory preference for remedies that employ treatment to reduce the TMV of the hazardous substances. That preference is satisfied when treatment is used to reduce the principal threats at a site significantly by destroying toxic chemicals or reducing the total mass or total volume of affected media. This criterion is specific to evaluating only how the treatment reduces the toxicity, mobility, and volume. It does not pertain to containment actions, such as capping.

5.1.2.3 Short-term Effectiveness

This criterion addresses short-term impacts of the remedial alternatives on human health and the environment during the construction and implementation activities. Short-term impacts include protection of community (risks include dust, increased traffic, odor, or air-quality impacts), protection of workers during RAs (risks from heavy equipment, machinery, and transportation), environmental impacts (such as greenhouse gas emissions, criteria pollutant emissions, destruction of habitats, and consumption of resources), and time until remedial response actions are achieved.

5.1.2.4 Implementability

The technical and administrative feasibility of executing an alternative and the availability of services and materials required during its implementation must be considered. Technical implementability includes the ability to construct and operate the technology, the reliability of the technology, and the ability to effectively monitor the technology. Administrative feasibility includes the degree to which any coordination with other government agencies (including local governments) can be achieved. This element considers whether implementing an alternative is technically and administratively feasible, whether trained workers, equipment, and materials are readily available, and how long it will take to implement an alternative.

5.1.2.5 Cost

For the detailed cost analysis of alternatives, the expenditures required to complete each measure are estimated in terms of both capital and annual O&M costs. Given these values, a present-worth calculation for each alternative was calculated for comparison based on a real discount rate of 0.5 percent up to a 30-year operation period. The discount rate is based on the 2022 Discount Rates for the federal Office of Management and Budget Circular No. A-94 (Office of Management and Budget, 2022). The cost estimates in this section provide an accuracy of -30 percent to +50 percent in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (USEPA, 2000).

5.1.3 Modifying Criteria

Modifying criteria are used to modify the selection of the recommended alternative.

5.1.3.1 State Acceptance

This criterion pertains to the technical and administrative issues and concerns the state may have regarding the alternatives. IDNR's comments on the FS report and also on the PP will factor into state acceptance of the recommended alternative.

5.1.3.2 Community Acceptance

This criterion pertains to the issues and concerns the public may have regarding the alternatives. This is not addressed in this report but will be addressed upon receipt of comments on the PP and documented in the remedy Decision Document.

5.2 Remedial Alternatives Evaluation

Table 5-1 provides a detailed evaluation of each remedial alternative against the first seven NCP criteria.

5.3 Comparative Analysis of Remedial Alternatives

A comparative analysis of the remedial alternatives allows evaluation of how well each alternative satisfies the seven evaluation criteria described above (excluding the modifying criteria, which would be evaluated as part of the public comment period). Table 5-2 presents the analysis of how well each alternative achieves the RAOs and the seven criteria, based on professional judgment. This approach is intended to compare the alternatives and to help select the most appropriate alternative for implementation as a RA.

5.3.1 Overall Protection of Human Health and the Environment

Alternative 1 (No Action) is not protective of human health and the environment because it allows for COC concentrations exceeding PRGs to remain in place and does not prevent or minimize plume migration. Alternative 2 is protective of human health and the environment even though no active treatment process is used because it prevents exposure and access to contaminated groundwater through LUCs. In addition to the LUCs, Alternative 3 is protective by hydraulically containing impacted groundwater and treating the groundwater through ex situ treatment. Alternative 4 is protective through plume containment via active in situ treatment and the use of LUCs.

5.3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 1 (No Action) does not comply with ARARs. Alternatives 2, 3, and 4 would only meet chemical-specific ARARs once natural attenuation processes have reduced COC concentrations within the areas of the IDA where concentrations currently exceed residential PRGs. However, groundwater treated through ex situ treatment (Alternative 3) and in situ treatment (Alternative 4) would meet chemical-specific ARARs after their respective treatment processes. Since the areas with the highest concentrations of COCs are not actively treated, it is anticipated that all alternatives would require the same timeframe to achieve ARARs.

5.3.3 Long-term Effectiveness and Permanence

The long-term effectiveness and permanence of the alternatives are evaluated in terms of the magnitude of residual risk, adequacy and reliability of controls, and potential environmental impacts of the RAs. The residual risk of Alternative 1 (No Action) would remain unchanged. Residual risks are associated with Alternatives 2, 3, and 4 because no treatment process would be used to reduce COC concentrations within areas of the IDA where concentrations exceed industrial and residential PRGs.

Alternatives 2, 3, and 4 include LUCs that would be adequate and reliable in preventing direct contact with exposure to untreated groundwater. While low hydraulic conductivity and recharge rates have been observed at the site (that could potentially limit the long-term effectiveness of a selected remedy), Alternatives 3 and 4 include a predesign investigation to determine the hydraulic properties of the targeted treatment area to allow for the proper design of extraction (Alternative 3) and permeable reactive barrier (Alternative 4) systems to allow for adequacy and reliability of the alternatives. Alternatives 2, 3, and 4 would also require LTM of COC concentrations and natural attenuation parameters to monitor the progress of natural attenuation processes. Alternatives 3 and 4 would also include monitoring to evaluate performance of the active treatment remedy.

5.3.4 Reduction in Toxicity, Mobility, and Volume through Treatment

Alternatives 2, 3, and 4 would reduce TMV of contaminants through MNA in the high-concentration areas, where concentrations exceed industrial and residential PRGs, within the same timeframe. However, Alternative 3 and 4 would also reduce the TMV of industrial COCs exceeding PRGs in areas of the site where active treatment is being proposed and would meet the NCP preference for treatment in the same treatment areas.

Alternative 2 is expected to be moderately effective at addressing all of the industrial COCs. Some COCs such as VOCs may be more quickly attenuated through various attenuation processes (see Section 2.2.5) than other COCs such as SVOCs, PAH, PCBs, dioxins/furans, and radionuclides. Evidence exists (see Section 2.2.5.2) that SVOCs (like 2-methyl-4,6-dinitrophenol and PCP) and PAHs (like naphthalene) are sorbed to the highly organic site soil which is preventing migration downgradient with site groundwater. Alternative 3 is expected to be highly effective at addressing all the industrial COCs and residential COCs. GAC is nonselective and will remove all contaminants that are processed through the treatment system. However, GAC is typically more effective at adsorbing VOCs than the other site COCs (like 2-methyl-4,6-dinitrophenol, PCP, and naphthalene) but all COCs are capable of being captured and removed by GAC. Alternative 4 would also be highly effective at treating the industrial and residential COCs. As with Alternative 3, injectable carbon should be most effective at adsorbing VOCs than other site COCs but all COCs are capable of being captured. ZVI also provides extra benefit of reducing some of the site COCs (predominantly VOCs) via treatment to less-toxic byproducts.

For the metric of reducing COC toxicity, mobility, and volume, Alternative 3 would capture groundwater in extraction wells and reduce COC concentrations with an ex situ groundwater treatment system. The ex situ treatment system is expected to be highly effective in removing all of the industrial and residential COCs. Alternative 4 would treat groundwater in situ via injection wells and would also be highly effective in removing all of the industrial and residential COCs. However, Alternative 4 may result in PFAS desorption after 10 to 15 years, when the injectable carbon particles are saturated, and Alternative 3 would require the regeneration or disposal of the GAC when treatment is completed at the site.

It is estimated that at least a 67 to 99 percent reduction in COC concentrations would occur for contaminants actively treated by Alternatives 3 and 4 based on the most recently detected concentration and the PRG for the individual COC. For example, TCE was detected at 15 μg/L (C-00-1) in 2021 and has a PRG of 5 μg/L. Therefore, once the PRG is achieved after treatment, the reduction in TCE concentration would be 67-percent.

5.3.5 Short-term Effectiveness

No additional risks are associated with Alternative 1 (No Action) because no RA would be taken, and no construction would be performed. Because short-term effectiveness takes into consideration the protection of the community and workers during RAs, environmental impacts, and the time until remedial response objectives are achieved, Alternative 2 (MNA and LUCs) scored the highest of the remaining alternatives because this remedy would take the least amount of construction and therefore have the fewest risks to workers and the environment during implementation. Short-term disruptions would be greater in Alternatives 3 and 4 from heavy equipment operations, such as increased traffic of construction trucks in and out of the IDA, increased noise levels, destruction of natural resources, and dust generation from the heavy equipment during clearing and grubbing, well installation, and groundwater conveyance construction. These disruptions would be minimized through a proper planning for traffic routing and scheduling, soil erosion and sediment controls implementation, and periodic dust suppression. The time to achieve RAOs would be similar for Alternatives 2, 3, and 4 because these alternatives rely on MNA to treat the higher-concentration areas.

5.3.6 Implementability

Alternative 1 (No Action) is readily implementable because no action would be implemented. The technologies in Alternatives 2, 3, and 4 are readily implementable because they are well accepted and conventional, and they have been used successfully at numerous other sites across the country. However, Alternative 2 (MNA with LUCs) would be easier to implement than Alternative 3 (Groundwater Extraction and Treatment with LUCs) and Alternative 4 (PRB with LUCs) because of the relative ease of installing two wells, routine groundwater monitoring, and implementation of LUCs, compared with construction for a groundwater conveyance system and extraction wells in Alternative 3 or construction of 50 injection wells in Alternative 4. Additionally, Alternatives 3 and 4 would require clearing and grubbing and construction of treatment components on fluctuating topography. Overall, Alternatives 3 and 4 would not be as easily implemented as Alternative 2. Also, Alternative 3 may be more difficult to implement because of the continued extraction of contaminated groundwater, the presence of PFAS in the extracted groundwater, and the Army's restrictions on how PFAS-contaminated groundwater can be managed. In addition, these management practices may evolve in the future, which adds a level of uncertainty to the conceptual design of this alternative.

5.3.7 Cost

As shown in Table 5-1, except for Alternative 1 (No Action), Alternative 2 (MNA with LUCs) is the lowest-cost alternative.

There is a high degree of uncertainty in the cost estimates. In the case of Alternatives 3 and 4, PDIs are necessary to provide more information on optimal spacing extraction wells (Alternative 3) and radius of influence of injections wells and frequency of reinjection (Alternative 4). Also, the time to achieve cleanup objectives for Alternatives 2, 3, and 4 is highly uncertain.

5.3.8 State Acceptance

This criterion evaluates concerns the state may have regarding each of the alternatives. This criterion is not discussed in this report but would be addressed in the PP and ROD.

5.3.9 Community Acceptance

The USACE, USEPA, and IDNR provide information regarding the cleanup of OU-4 to the public in accordance with the 2017 IAAAP community involvement plan (CH2M, 2017) and coordination with the IAAAP Restoration Advisory Board (RAB). The RAB enables community members and agency representatives to meet with the IAAAP Commander and review progress, participate in dialogue, address concerns, and provide recommendations. RAB meetings continue to be held each quarter and are open to the public. Assessment of community and stakeholder acceptance will be fully addressed in the ROD after receiving comments on the PP.

6. Summary

This FS was conducted to develop and evaluate remedial alternatives to address unacceptable risks or hazards from site-related COCs and ROCs at IRP site IAAP-020G_Inert Disposal Area Groundwater (19105.1026) under OU-4. This FS does not include the soil and waste IRP site (IAAP-020_Inert Disposal Area; 19105.1025), which is addressed under an OU-4 IROD. Site-related COCs and ROCs in groundwater at OU-4 include explosives, metals, VOCs, SVOCs, and radionuclides (Leidos and Jacobs, 2022). PFAS are not currently identified as COCs; however, these substances are being evaluated at the IDA under a PFAS SI at IAAAP. Therefore, they were considered during the FS evaluation for the environmental site IAAP-020G_Inert Disposal Area Groundwater (19105.1026).

As part of the remedial alternative development process, RAOs were established; location-, action-, and chemical-specific potential ARARs were identified; and industrial and residential PRGs were developed. The following RAOs were established, based on regulatory requirements, standards, and guidance:

- Prevent exposure of future human receptors (residents and industrial workers) to impacted groundwater until COC concentrations meet RGs.
- Prevent or minimize further migration of the contaminated groundwater plume at OU-4.
- Restore groundwater quality to RGs, consistent with NCP expectation (§300.430 (a)(iii)(F))..

Following an initial screening process of treatment technologies, four remedial alternatives were retained for detailed evaluation and comparative analysis against the seven NCP evaluation criteria:

- Alternative 1—No Action.
- Alternative 2—MNA and LUCs.
- Alternative 3—Groundwater Extraction and Treatment with MNA and LUCs.
- Alternative 4—PRB with MNA and LUCs.

The comparative analysis of the alternatives listed above evaluated how well each alternative satisfied the seven evaluation criteria (excluding the modifying criteria) to help select the most appropriate alternative for implementation as a RA. The results of the comparative analysis indicated that Alternative 1 (No Action) is not protective of human health and the environment and do not meet ARARs. However, it has been retained throughout the FS process as a baseline for comparison to the other approaches.

Alternatives 2, 3, and 4 all provide protection of human health and the environment and would be expected to comply with ARARs. The alternatives would rely on LUCs to help maintain protectiveness until COC concentrations meet RGs. Alternative 2 would rely solely on natural attenuation to meet RAOs, whereas Alternatives 3 and 4 would implement active treatment technologies to treat contaminant mass that passes through the defined active target capture/treatment area and prevent migration of the contaminant plumes. Alternative 3 provides hydraulic containment of groundwater and ex situ treatment, and Alternative 4 provides in situ treatment through the use of a PRB. All three of these alternatives would have the same level of residual risks, because no active treatment process would be used to reduce COC concentrations within landfill areas where concentrations exceed industrial or residential PRGs, and all three alternatives would be adequate and reliable in preventing direct contact with exposure to untreated groundwater through LUCs.

Alternatives 2, 3, and 4 would gradually reduce risks and TMV of contaminants as a result of passive natural attenuation processes. However, only Alternatives 3 and 4 would meet the NCP preference for active treatment and result in a faster reduction of TMV via groundwater extraction and in situ PRB treatment. Alternative 4 would not generate treatment residuals, and Alternative 3 would require disposal of GAC at the end of the treatment period. In addition, there is some uncertainty whether the ex situ treatment technology will be consistent with future Army policy on the management of PFAS waste. Alternative 2 would provide the greatest short-term effectiveness, environmental impacts, and implementability because of the three alternatives, it would require the least amount of construction and maintenance. However, all alternatives can be readily implemented onsite. The active treatment components of Alternatives 3 and 4 would require that a greater number of subcontractors be involved and have higher likelihoods of schedule delays. The remediation timeframe is assumed to be greater than 30 years for all three alternatives because they all rely on natural attenuation processes within the higher-concentration landfill area. Lastly, Alternative 2 would be the lowest-cost alternative while Alternative 4 would have the highest associated costs.

Upon finalization of the FS report, a PP will be prepared in accordance with CERCLA guidance documents. The PP will summarize the site background, site characteristics, and the remedial alternatives evaluated in this FS. It will also include a recommendation for the preferred remedial alternative. The preferred alternative presented in the PP may be modified based on new information or public comments. A ROD will be drafted after receiving and addressing public comments on the PP. The ROD will summarize the RI results, present the remedial alternatives evaluated in the FS, and describe the selected remedy. The final remedy selection will be made in the ROD.

7. References

Aerostar (Aerostar SES LLC). 2016. *Land Use Controls and Operations and Maintenance Report*. Environmental Remedial Action Services, Iowa Army Ammunition Plant. Draft Final. December.

Arcadis. 2020a. *Preliminary Assessment of Per- and Polyfluoroalkyl Substances Iowa Army Ammunition Plant, Iowa.* March.

Arcadis. 2020b. *Preliminary Assessment of Per- and Polyfluoroalkyl Substances Iowa Army Ammunition Plant, Iowa*. October.

CDM (CDM Federal Programs Corporation). 1997. *Action Memorandum for the Inert Landfill at the Iowa Army Ammunition Plant, Middletown, Iowa*. September.

CH2M. 2017. *Final Community Involvement Plan Iowa Army Ammunition Plant, Middletown, Iowa*. May

CH2M. 2020. *Evaluation of Background Concentrations of Metals in Groundwater, Iowa Army Ammunition Plant, Middletown, Iowa.* February.

CRC CARE (Cooperative Research Centre for Contamination Assessment and Remediation of the Environment). 2016. *A Framework for Selecting, Designing and Implementing a Permeable Reactive Barrier System*. Technical Report Series, No. 25, National Guideline Document. September.

Earth Tech. 1994. *Accelerated Groundwater Quality Assessment for the Ash Disposal Cell in Trench 5 and Line 6, Iowa Army Ammunition Plant.* Volumes 1, 2, and 3. October.

ECC 2001. Environmental Chemical Corporation. *Remedial Action Report, Iowa Army Ammunition Plant, Multiple Removal Actions, Middletown, Iowa*. Final. April.

ERG (Environmental Research Group). 1982. Environmental Research Group, Inc. Contamination Report for the Iowa Army Ammunition Plant, September.

Harza. 1998. Final *Record of Decision (Revision 1), Soils, Operable Unit #1, Iowa Army Ammunition Plant, 9427 Middletown, Iowa*. August.

H&S Environmental. 2016. *Final Preliminary Assessment Report*, Mathes Lake, Iowa Army Ammunition, Plant, Middletown, Des Moines, Iowa. January.

ITRC (Interstate Technology and Regulatory Council). 2005. *Permeable Reactive Barriers: Lessons Learned/New Directions*. PRB-4. February.

Jacobs 2021. *Site Inspection Report: Per- and Polyfluoroalkyl Substances (PFAS) Iowa Army Ammunition Plant, Middletown, Iowa*. December.

JAYCOR 1993. "Preliminary Site Characterization Report for the Inert Disposal Area (R14)." *Revised Preliminary Site Characterization Reports, Iowa Army Ammunition Plant, Middletown, Iowa*. March.

JAYCOR 1996. *Revised Draft Final Remedial Investigation Report, Iowa Army Ammunition Plant*. May.

Leidos and Jacobs. 2022. *Remedial Investigation Report for Operable Unit 4 Inert Disposal Area, Iowa Army Ammunition Plant, Middletown, Iowa*. February.

Office of Management and Budget. 2022. 2022 Discount Rates for the federal Office of Management and Budget Circular No. A-94. May.

Terracon (Terracon Consultants). 1989. *Groundwater Quality Assessment. Inert Landfill and Line 6 Areas, Iowa Army Ammunition Plant, Middletown, Iowa*. Final. December.

Tetra Tech. 2008. *Interim Action Record of Decision for Trench 6, Trench 7, and the Cap Extension Area of the Inert Disposal Area (IDA) in Soils Operable Unit 4 (OU-4), Iowa Army Ammunition Plant, Middletown, Iowa.* Draft Final, Rev. 1, September.

Tetra Tech. 2011. *Operable Unit 4 (OU-4) Remedial Action Completion Report, Capping of the Cap Extension Area (CEA) for Iowa Army Ammunition Plant, Middletown, Iowa*. Volume 1. Final. July.

Tetra Tech. 2012. *Operable Unit 4 (OU-4) Remedial Action Completion Report, Volume 2, Capping of Trench 6, The Removal of Trench 7 for Iowa Army Ammunition Plant, Middletown, Iowa*. Parts 1, 2, and 3. Final. August.

Tetra Tech. 2014. *Land Use Controls Implementation Plan for the Inert Disposal Area. Iowa Army Ammunition Plant, Middletown, Iowa*. April.

U.S. Army. 2007. *Installation Action Plan for the Iowa Army Ammunition Plant, Middletown, Iowa*.

USACE (U.S. Army Corps of Engineers). 1988. *Closure and Post-Closure Plans for Trench No. 5 of the Inert Landfill, Iowa Army Ammunition Plant, Iowa*. April.

USACE (U.S. Army Corps of Engineers). 1998. U.S. Army Corps of Engineers. *Summary Report, Pre-Design Excavation Delineation, Lines 5A/5B, Roundhouse RDX Site, IDA Storage Yard/Burning Grounds, Iowa Army Ammunition Plant, Middletown, Iowa.* December.

USACE (U.S. Army Corps of Engineers). 2007. *Proposed Plan for Trench 6, Trench 7, and the Cap Extension Area of the Inert Disposal Area (IDA), Iowa Army Ammunition Plant, Middletown, Des Moines, Iowa.* May.

USEPA (U.S. Environmental Protection Agency). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*. EPA/540/G-85/004. OSWER Directive 9355.3-01. Interim Final. Office of Emergency and Remedial Response, Washington, D.C. October.

USEPA (U.S. Environmental Protection Agency). 1994. U.S. Environmental Protection Agency. *U.S. Environmental Protection Agency, Region VII. Consent Agreement and Consent Order*. Department of the Army, Iowa Army Ammunition Plant, Middletown, Iowa. March 8.

USEPA (U.S. Environmental Protection Agency). 1995. U.S. Environmental Protection Agency. Letter dated June 16, 1995. From Kenneth V. Herstowski, Project Manager, Air, RCRA and Toxics Division, USEPA, to Mr. Leon Baxter, Commander, Plant Protection, Iowa Army Ammunition Plant. Subject: Groundwater Assessment Report – Trench 5 and Line 6.

USEPA (U.S. Environmental Protection Agency). 1997. *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*. OSWER Directive 9200.4-17. Office of Solid Waste and Emergency Response.

USEPA (U.S. Environmental Protection Agency). 1998. *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water*. EPA/600/R-98/128. September.

USEPA (U.S. Environmental Protection Agency). 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. July.

USEPA (U.S. Environmental Protection Agency). 2018. Hazardous Waste Management Facility Permit. RCRA Identification Number: 973 IA7213820445, September 28. (Modified via Class II Permit Modification on December 10, 2021.)

USEPA et al. 2006. Iowa Army Ammunition Plant Federal Facilities Agreement Under CERCLA Section 120, Administrative Docket Number: CERCLA-07-2005-0378, U.S. Environmental Protection Agency, Region VII.

Tables

Table 2-1. Previous Investigations

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

	1981 IAAAP Contamination Survey[a]	1988 Groundwater Quality Assessment[b]	1993–1995 RI[c]	1993–1994 Accelerated Groundwater Assessment[d]	1994–2017 RCRA/CERLCA Monitoring[e]
Media sampled	Groundwater	Groundwater	Soil Groundwater Sediment Surface water	Groundwater	Groundwater Surface water
Groundwater samples	4	9	14	7 wells near Ash Disposal Cell; 5 rounds of sampling	Extensive sampling of network of 23 monitoring wells; 43 rounds of sampling[e]
Surface water samples	—	—	7	—	Annual Sampling of CEA-POOL-UPSTR location since 2007

[a] ERG 1982.

[b] Terracon 1989.

[c] JAYCOR 1996.

[d] Earth Tech 1994.

[e] Monitoring wells at the IDA were installed at various periods between 1981 and 2007, and the analyte list sampled varied by well location and depth (shallow “drift” versus “bedrock” aquifers). The frequency of sampling was initiated on a quarterly basis in 1994 during the Accelerated Groundwater Quality Assessment (Earth Tech 1994), reduced to semiannual basis over time, and currently is conducted on an annual basis (Aerostar 2017).

Table 2-2. IDA Monitoring Wells and Screened Intervals

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Overburden Wells	Bedrock Wells	Interface Well
C-00-1 (12.35–22.35)	CAMU-99-1D (135.5–145.5)[a]	JAW-27 (101.0–116.0)
C-00-2 (18.85–28.85)	CAMU-99-2D (145.5–155.5)[a]	IDA-MW2 (102.0–112.0)[a]
C-00-3 (31.75–41.75)	IDA-MW1 (138.0–148.0)[a]	
C-95-1 (6.5–16.0)	T-06 (118.5–128.5) [a]	
C-95-2 (17.5–27.0)		
CAMU-99-1S (20–29.5)[a]		
CAMU-99-2S (20.0–30.0)[a]		
CAMU-99-3S (20.0–30.0)[a]		
ET-3 (15.0–30.0)		
G-4 (16.0–26.0)[a]		
G-5 (40.0–50.0)		
G-6R (17.0-27.0)		
G-7 (32.0–42.0)		
IDA-TT-MW1 (35.0–45.0)		
JAW-26 (12.5–22.5)		
JAW-65 (19.0–24.0)		
MW20-01 (13.8–23.8)		
T-01 (25.0–35.0)		

Notes:

[a] Well is currently not sampled as part of the long-term monitoring program.

Monitoring well screened intervals are measured in feet below ground surface.

Table 2-3. Final COCs and ROCs for Industrial and Residential Land Use Scenarios

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Industrial Land Use[a] Groundwater Final COCs & ROCs	Residential Land Use[b] Groundwater Final COCs and ROCs	
	Exposure Route–Specific	All Exposure Routes Consolidated
Tap Water	*Tap Water*	1,2-DCA 2,4-Dichlorophenol 2,4-DNT 2,6-DNT 2-Amino-4,6-dinitrotoluene 2-Methyl-4,6-dinitrophenol Benzene Lead-212 Manganese Naphthalene Nitrobenzene PCP Potassium-40 Radium-226 Total 2,3,7,8-TCDD (TEQ) Trichloroethene Vinyl chloride
2-Methyl-4,6-dinitrophenol Naphthalene PCP Total 2,3,7,8-TCDD (TEQ) Trichloroethene Vinyl chloride Lead-212 Potassium-40	1,2-DCA 2,4-Dichlorophenol 2,4-DNT 2,6-DNT 2-Amino-4,6-dinitrotoluene 2-Methyl-4,6-dinitrophenol Manganese Naphthalene PCP Total 2,3,7,8-TCDD (TEQ) Trichloroethene Vinyl Chloride Lead-212 Potassium-40	
	Household Air (Volatiles from Tap Water)	
	1,2-DCA Benzene Naphthalene Nitrobenzene Total 2,3,7,8-TCDD (TEQ) Trichloroethene Vinyl chloride Radium-226	
	Indoor Air Vapor Intrusion	
	Naphthalene Trichloroethene Vinyl chloride	

[a] The list of final groundwater COCs for Industrial Land Use is based on future site worker potable use exposure scenarios (i.e., via ingestion and dermal contact via the washing of face, arms and hands). The final list of groundwater ROCs for Industrial Land Use is based on future site worker potable use exposure scenarios (ingestion and external radiation - water immersion).

[b] For Residential Land Use, COCs were identified for groundwater based on tap water (ingestion and dermal contact), volatiles in household air from tap water usage (inhalation), and vapor intrusion (inhalation). ROCs were identified for groundwater based on tap water usage (ingestion, external radiation via water immersion and inhalation of household air). The consolidated list of groundwater COCs and ROCs is inclusive of all exposure pathways evaluated.

Table 3-1. Chemical-Specific ARARs

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Citation	Requirement/Purpose	Preliminary ARAR Determination and Alternative			Comment
		A	RA	TBC	
40 CFR 141 National Primary Drinking Water Regulations and National Revised Primary Drinking Water Regulations • 40 CFR 141.61, MCLs for Organic Chemicals • 40 CFR 141.62, MCLs for Inorganic Chemicals • 40 CFR 141.66, MCLs for Radionuclides	• Establishes Federal MCLs, which are health-based standards for specific contaminants in drinking water.	Alternatives 2, 3, 4	—	—	LUCs have been implemented so that groundwater will not be used as a drinking water supply until RGs are achieved. Table 3-4 includes the IDA COCs that have MCLs. https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations https://epa-prgs.ornl.gov/radionuclides/
40 CFR 264.93, Hazardous Constituents 40 CFR 264.94, Groundwater Concentration Limits	40 CFR 274.93 requires that hazardous constituents in groundwater from the disposal unit be determined. Groundwater protection standards for 14 toxic compounds in 40 CFR 264.94 Table 1 are equal to MCLs under Safe Drinking Water Act; additional constituents determined in 274.93 will also have concentration limits established based on a number of criteria that address potential risk from groundwater. None of the IDA COCs are found in 40 CFR 264.94 Table 1; the IDA OU-4 risk assessment addresses the potential risk from the COCs and can be used to develop concentration limits/cleanup levels that meet the 40 CFR 264.94 requirements.	—	Alternatives 2, 3, 4	—	Trench 5 is a RCRA unit in the middle of the Inert Disposal Area. Trench 5 is being managed under the RCRA Permit and is in post-closure care. Groundwater monitoring is required by the RCRA Permit.
USEPA Regional Screening Levels (RSLs)	USEPA RSLs for Chemical Contaminants at Superfund Sites (November 2022). RSLs provide conservative, risk-based, chemical-specific screening levels for human receptors (tap water based).	—	—	Alternatives 2, 3, 4	EPA's Regional Screening Levels (RSLs) are based on a cancer risk of $10^{-6.}$ and are available for tap water. Table 3-4 includes the IDA COCs that have residential and industrial RSLs (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables). Table 3-4 also includes radionuclides COCs that have EPA PRGs (https://epa-prgs.ornl.gov/radionuclides/). LUCs have been implemented so that groundwater will not be used as a drinking water supply until RGs are achieved.
567 IAC 133.4(3) EPA Health Advisory Levels	"HALs are EPA's lifetime health advisory level for a contaminant in drinking water. NRLs are also mentioned in this regulation. NRLs are negligible risk level for carcinogens established by the EPA, which is an estimate of one additional cancer case per million people exposed over a lifetime to the contaminant $1x10^{-6}$; the RSLs meet this risk level.	Alternatives 2, 3, 4			LUCs have been implemented so that groundwater will not be used as a drinking water supply until RGs are achieved. Table 3-4 includes the IDA COCs that have HALs.
567 IAC 137.5 Statewide Standards	Requires that Statewide standards for contaminants be issued for groundwater, soil, and air using specific risk calculations. Statewide standards for groundwater represent concentrations of contaminants at which normal exposure is considered unlikely to pose a threat to human health. Statewide standards are published for protected groundwater sources and for groundwater in a non-protected groundwater source. Groundwater at IDA is restricted from use as potable water by institutional controls that currently are in place and contains total dissolved solids above 2,500 mg/L. Therefore, the chemical-specific ARAR for IAAAP is the Sitewide Standard for a Non-Protected Groundwater Source.		Alternatives 2, 3, 4		Iowa Statewide Standards can be found at: Statewide Standards - Cumulative Risk Calculator (iowadnr.gov) Table 3-4 includes the IDA COCs that have a Sitewide Standard for a Non-Protected Groundwater. Note that 567 IAC 137.3(1)*b* states that sites subject to CERCLA (such as the IDA which is part of IAAAP, a CERCLA site) are not eligible for the land recycling program of 567 IAC 137; therefore, this regulation is relevant and appropriate.

Table 3-1. Chemical-Specific ARARs

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Citation	Requirement/Purpose	Preliminary ARAR Determination and Alternative			Comment
		A	RA	TBC	

μL = microliter

A = Applicable

ARAR = Applicable or Relevant and Appropriate Requirement

CFR = Code of Federal Regulations

IAAAP = Iowa Army Ammunition Plant

IAC = Iowa Administrative Code

IDA = Inert Disposal Area

LUC = Land Use Controls

MCL = maximum contaminant level

OU = Operable Unit

pCi/L = picocurie(s) per liter

PRG = Preliminary Remediation Goal

RA = Relevant and Appropriate

RCRA = Resource Conservation and Recovery Act

SDWA = Safe Drinking Water Act

TBC = to be considered

USEPA = United States Environmental Protection Agency

Table 3-2. Location-Specific ARARs

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Citation	Requirement/Purpose	Preliminary ARAR Determination and Alternative			Comment
		A	RA	TBC	
Interagency Cooperation for the Endangered Species Act, 50 CFR 402 50 CFR 402.01, Scope 16 USC 1538(a)(1)(B) Endangered Species, "Prohibited Acts"	Actions authorized, funded, or carried out by Federal agencies such as the Army, may not jeopardize the continued existence of threatened or endangered (T/E) species or result in adverse changes to species' critical habitats. Agencies are to avoid jeopardizing T/E species and their critical habitat.	Alternatives 2, 3, 4	—	—	T/E species, specifically the Indiana bat and bald eagle, may be present in the vicinity of OU-4; however, no impact is anticipated due to the construction. If remedial construction potentially affects such species, this regulation will apply. IAAAP has an ESMP for the Indiana bat.
Migratory Bird Treaty Act 16 USC 703(a) 50 CFR 10	This act makes it unlawful to pursue, hunt, take, capture, or kill any migratory bird, part, nest, egg, or product. All but a few bird species naturally occurring in the U.S. are protected under this act.	Alternatives 3, 4	—	—	Migratory birds may be present during remedy implementation. The remedy work plan will address actions to be taken to avoid adverse impacts on migratory birds during remedy construction.
IAAAP Integrated Natural Resources Management Plan	This plan is designed to integrate natural resources conservation programs with military operations and to be consistent with stewardship and legal requirements through cooperation among DOD, USFWS, NOAA Fisheries Service, and State fish and wildlife agencies. The plan is designed to meet the requirements of the ARARs mentioned above.			Alternatives 2, 3, 4	The remedy will address the requirements of the IAAAP plan.

A = Applicable

ARAR = Applicable or Relevant and Appropriate Requirement

CFR = Code of Federal Regulations

CWA = Clean Water Act

ESA = Endangered Species Act

ESMP = Endangered Species Management Plan

IAAAP = Iowa Army Ammunition Plant

IAC = Iowa Administrative Code

OU = Operable Unit

RA = Relevant and Appropriate

TBC = to be considered

T/E = threatened or endangered species

USC = United States Code

USFWS = US Fish and Wildlife Service

Table 3-3 Action-Specific ARARs

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Citation	Requirement/Purpose	Preliminary ARAR Determination and Alternative			Comment
		A	RA	TBC	
40 CFR 403, General Pretreatment Regulations for Existing and New Sources of Pollution	Applies to discharges of pollutants to treatment systems such as POTWs and FOTWs. Requires that such pollutants not interfere with operation of the treatment system or pass through the treatment system at concentrations that cause a violation of the treatment system's NPDES permit.	—	Alternatives 3, 4	—	Relevant and Appropriate if there are plans to discharge untreated or treated water to an existing treatment system.
40 CFR 262.17, Standards Applicable to Large Quantity Generators of Hazardous Waste	Establishes standards for generators on the management of hazardous waste onsite. IAAAP is a large-quantity generator, so certain of the waste management requirements would be applicable, specifically: • 40 CFR 262.17(a)(1). Containers must be kept closed except when adding or removing waste, containers must be compatible with the waste and must be in good condition, containers must be inspected weekly for deterioration and remedial action performed as necessary, and incompatible wastes must be separated. • 40 CFR 262.17(a)(5). Containers must be appropriately labeled with the words "hazardous waste," the risk, and the accumulation start date so that it is clear what the container holds. • 40 CFR 262.17(a)(8)(iii). The hazardous waste accumulation area must be closed in a manner that removes or decontaminates hazardous waste residue or minimizes the need for further maintenance.	Alternatives 3, 4	—	—	IAAAP will manage any hazardous wastes generated in accordance with these requirements
Area of Contamination Policy	The Area of Contamination (AOC) Policy allows contaminated soils and waste to be managed and moved around within an AOC, if the soil or waste is not removed and put in a container.	—	—	Alternative 4	Contaminated soils may be moved around the AOC during installation of the permeable barrier. Iowa has adopted the AOC Policy https://www.iowadnr.gov/Portals/idnr/uploads/waste/contaminatedsoilfactsheet.pdf
40 CFR 144 Subpart G, Underground Injection Control Program Class V wells	Establishes regulations for minimum requirements for UIC programs, including defining different class of Wells for injection. A well that is used to inject chemical agents, substrates, or chemically amended groundwater into the aquifer would be considered a Class V injection well. Class V injection wells have specific requirements, including providing EPA 7 with specific information about the well and properly closing the well when it is no longer needed.	Alternatives 3, 4	—	—	Applicable if remedial action involves injection of chemical agents, substrates, or chemically amended groundwater into the aquifer, such as with installation of a permeable barrier.
40 CFR 264.117 and .118, Post-Closure Plan; amendment of plan	Describes the requirements for post-closure care and maintaining a written post-closure plan which addresses planned monitoring and maintenance activities and includes contact information for a person knowledgeable about the unit. A Professional Engineer must certify post-closure, once post-closure care is completed.	—	Alternatives 2, 3, 4	—	The requirement for post-closure care and a RCRA post-closure plan is applicable to Trench 5 and relevant and appropriate for other areas of the IDA. The RCRA Permit requires that the Trench 5 cover system, run-on/runoff erosion protection, fence, security measures, signs, benchmarks, and monitoring wells be inspected and maintained.
40 CFR 403.5, National Pretreatment Standards: Prohibited Discharges	Sets standards for the treatment of water prior to discharge to a FOTW or POTW. Local requirements of the FOTW or POTW must also be met.	—	Alternatives 3, 4	—	Relevant and appropriate if remedial action discharges treated water that ultimately goes to a FOTW or POTW or other treatment system.
40 CFR 258.51, Ground-water monitoring systems Criteria for Municipal Solid Waste Landfills	All municipal solid waste landfills shall have a groundwater monitoring system that complies with 40 CFR 258.51, including well design and abandonment requirements.	Alternatives 2, 3, 4	—	—	Monitoring wells may be installed or abandoned under Alternatives 2, 3, or 4.

Table 3-3 Action-Specific ARARs

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Citation	Requirement/Purpose	Preliminary ARAR Determination and Alternative			Comment
		A	RA	TBC	
40 CFR 258.57, Selection of Remedy Criteria for Municipal Solid Waste Landfills	A remedy must be selected based on the results of the corrective measures assessment conducted under 40 CFR 258.56 and must be protective of human health and environment; attain the groundwater protection standards, control the source(s) of release so as to reduce or eliminate further releases of Appendix II constituents; and comply with standards for management of wastes.	—	—	Alternatives 3, 4	This feasibility study meets requirements of Selection of Remedy
40 CFR 258.61, Post-Closure Care Requirements Criteria for Municipal Solid Waste Landfills	Describes the requirements for post-closure care and maintaining a written post-closure plan which addresses planned monitoring and maintenance activities and their frequencies, planned use of the landfill, and includes contact information for a person knowledgeable about the unit. A Professional Engineer must certify post-closure, once post-closure care is completed.	Alternatives 2, 3, 4	—	—	The requirements for post-closure care and a solid waste landfill post-closure plan is relevant and appropriate to Trench 5 and applicable for other areas of the IDA.
567 IAC 49, Non-Public Well Construction Standards	Describes construction standards for monitoring wells constructed as part of the remedy.	Alternatives 2, 3, 4			
567 IAC 39, Requirements for Properly Plugging Abandoned Wells	Provides well abandonment requirements for monitoring wells abandoned as part of the remedy.	Alternatives 2, 3, 4			

A = applicable

AOC = Area of Contamination

ARAR = Applicable or Relevant and Appropriate Requirement

BMP = best management practice

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

CFR = Code of Federal Regulations

FOTW = federally owned treatment works

HAL = Health Advisory Level

IAAAP = Iowa Army Ammunition Plant

IAC = Iowa Administrative Code

IDA = Inert Debris Area

MSWLF = municipal solid waste landfill

NPDES = National Pollutant Discharge Elimination System

POTW = publicly owned treatment works

RA = relevant and appropriate

RCRA = Resource Conservation and Recovery Act

TBC = to be considered

TSD = treatment, storage, and disposal

USC = United States Code

USEPA = United States Environmental Protection Agency

Table 3-4. Potential Action Levels and Proposed PRGs

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Analyte	Federal MCL[a] (mg/L)	EPA HAL[b] (mg/L)	Iowa Statewide Standards for a Non-Protected Groundwater Source[c,d] (mg/L)	Residential RSL[e] (10^{-6} Risk) (mg/L)	Proposed Residential PRG[f, h, i] (mg/L)	Industrial PRG[g] (10^{-6} Risk) (mg/L)
1,2-DCA	0.005	—	0.038	0.00017	0.005	NA
2,4-Dichlorophenol	—	0.02	0.10	0.046	0.02	NA
2,4-DNT	—	—	0.005	0.00024	0.005	NA
2,6-DNT	—	—	0.0051	0.000049	0.0051	NA
2-Amino-4,6-dinitrotoluene	—	—	—	0.0019	0.0019	NA
2-Methyl-4,6-dinitrophenol	—	—	—	0.0015	0.0015	0.00741
Benzene	0.005	0.003	0.064	0.00046	0.005	NA
Lead-212	—	—	—	2.02 pCi/L	2.02 pCi/L	6.18 pCi/L
Manganese	—	0.03	4.9	0.430	0.03	NA
Naphthalene	—	0.1	0.7	0.00012	0.1	0.1
Nitrobenzene	—	—	0.07	0.00014	0.07	NA
Pentachlorophenol	0.001	0.04	0.0088	0.000041	0.001	0.001
Potassium-40	—	—	—	2.12 pCi/L	2.12 pCi/L	6.48 pCi/L
Radium-226	5 pCi/L	—	—	0.136 pCi/L	0.136 pCi/L	NA
Total 2,3,7,8-TCDD (TEQ)	3.0×10^{-8}	—	1.5×10^{-7}	1.2×10^{-10}	3.0×10^{-8}	3.0×10^{-8}
Trichloroethene	0.005	—	0.076	0.00049	0.005	0.005
Vinyl chloride	0.002	—	0.01	0.000019	0.002	0.002

[a] https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

[b] https://www.epa.gov/sdwa/drinking-water-health-advisories-has

[c] https://programs.iowadnr.gov/riskcalc/Home/statewidestandards

Table 3-4. Potential Action Levels and Proposed PRGs

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Analyte	Federal MCL[a] (mg/L)	EPA HAL[b] (mg/L)	Iowa Statewide Standards for a Non-Protected Groundwater Source[c,d] (mg/L)	Residential RSL[e] (10^{-6} Risk) (mg/L)	Proposed Residential PRG[f, h, i] (mg/L)	Industrial PRG[g] (10^{-6} Risk) (mg/L)

[d] Groundwater at IDA contains more than 2,500 mg/L total dissolved solids, which means it is a non-protected groundwater source, as discussed in IAC 567-137.5. Therefore, the chemical-specific ARAR for IAAAP is the Sitewide Standard for a Non-Protected Groundwater Source.

[e] The RSLs are based on a 10^{-6} risk and can be found either in the EPA May 2023 chemical-specific RSLs tables (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables)or the EPA PRGs for radionuclides calculator (https://epa-prgs.ornl.gov/radionuclides/). The default calculator settings were used for calculating the radionuclide PRGs. The source and decay output option selected for calculation of PRGs was an assumed secular equilibrium throughout chain (no decay).

[f] As discussed in Iowa's Statewide Groundwater Standards (https://www.iowadnr.gov/Portals/idnr/uploads/consites/statewidegwstandards.pdf), the hierarchy for the Potential Action Level for the State of Iowa is the MCL, HAL, Iowa risk-based statewide standard (for Non-Protected Groundwater Source), and then the respective RSL.

[g] Industrial PRGs were the MCL if available. Otherwise, it was calculated for COCs identified in groundwater using the ratio between the target risk and the calculated risk, as follows:

$$\text{PRG (chemical } i) = \frac{\text{EPC (chemical } i) \times \text{Target Risk (chemical } i)}{\text{Calculated Risk (chemical } i)}$$

Where:

PRG (chemical *i*) = preliminary remediation goal for chemical *i*

EPC (chemical *i*) = exposure point concentration for chemical *i*

Target Risk = selected so that cumulative cancer risk does not exceed 10^{-6} and cumulative target organ hazard index does not exceed 1.

Calculated Risk (chemical *i*) = calculated risk (cancer risk for carcinogenic endpoints, noncancer hazard for noncarcinogenic endpoints) for chemical *i*
Values for the EPC and calculated risk were obtained from the HHRA (Leidos and Jacobs, 2022).

In addition, if no MCL was available for the industrial COC and a residential PRG was also available, the higher of the residential PRG or industrial RSL was selected.

NA = not applicable; the chemical was only identified as a residential COC and is not an industrial COC.

[h] The MCL was not selected as the PRG for Radium-226 because the drinking water MCL is not protective of the radon inhalation pathway resulting from the radiological decay of Radium-226 (as cited in the 2021 HHRA); therefore, the PRG from EPA's radionuclides PRG calculator was selected. The PRG is based on ingestion and immersion as there is no inhalation PRG.

[i] The PRG for Lead-212 and Potassium-40 are based on ingestion and immersion only because potable water was evaluated as a means for determining if the conditions of the areas met the conditions for NFA or unlimited use and unrestricted exposure; future residential development is not anticipated at any IAAAP areas.

Table 3-6. General Response Actions Retained for the Site

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

GRA	Approach to Achieving the RAO
No action	This baseline alternative will be evaluated because it is required by CERCLA, but no action will not achieve the RAO because no measures are in place to confirm that indoor air concentrations do not increase over time.
Monitoring	Establishes a program with appropriately identified locations to monitor groundwater concentrations and/or chemical plumes and degradation. Monitoring does not reduce groundwater concentrations. However, monitoring can satisfy the RAO by confirming that groundwater concentrations are below the target levels. It may also be used in conjunction with other GRAs to satisfy the RAO.
Containment	Minimizes or prevents the migration of contaminants. Groundwater containment typically consist of vertical barriers or hydraulic containment systems.
In situ treatment	Involves treating contaminants in the original source area without removing the groundwater. Examples of in situ treatment technologies for groundwater include chemical oxidation, chemical reduction, permeable reactive barriers, air sparging, steam flushing, enhanced bioremediation, natural attenuation, and phytoremediation. In situ treatment would satisfy the RAO if used in conjunction with other GRAs to limit exposure during the time it takes for the in situ treatment to meet remedial goals.
Ex situ treatment	Involves treating contaminants by removing groundwater from the original source area. Examples of ex situ treatment technologies for groundwater include granular activated carbon, filtration, ion exchange, and various other processes to physically remove or chemically treat contaminants.
Removal	Removes contaminants from the saturated zone by physical extraction of groundwater and/or removal of impacted saturated soil. Removes soil contaminants by excavation. Removes groundwater contaminants by groundwater extraction.
Land use controls	Uses physical (such as, engineering), legal, and/or administrative mechanisms to limit access or exposure to the contaminated media. LUCs include CERCLA institutional controls (legal and administrative). LUCs are typically used in conjunction with other GRAs to meet the RAO. Administrative LUCs include activities such as restricting groundwater use through land-use, deed, or access restrictions. A system of approvals may be set up to require a permit for various activities (such as excavation or installation of wells). Engineering controls physically limit access or land use on a property or exposure to contaminated media through engineered structures.

Table 3-7. Technology and Process Option Screening
OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

General Response Actions	Remedial Technology Types	Process Options	Description	Effectiveness	Implementability	Relative Cost	Retain for Further Evaluation?
No Action	None	None	No further actions to address contaminated groundwater and baseline for CERCLA process.	Will not result in the attainment of the remedial action objectives (RAOs) in the foreseeable future.	Can be easily implemented.	No cost	Yes
Institutional Controls	Access and Use Restrictions	Land Use Controls	Land use controls (LUCs) issued for property within potentially contaminated areas to restrict property use and well installation.	Effective in reducing ingestion of contaminated groundwater or exposure due to volatilization of contaminants. No reduction in toxicity, mobility, or volume of contaminants.	Can be easily implemented; some administrative requirements will apply.	Low	Yes
Monitoring	Monitoring	Monitoring	Periodical monitoring and data evaluation to assess effectiveness of natural and/or active treatment processes. Monitoring is necessary to demonstrate that contaminant concentrations and/or mass continue to decrease and verify that potentially toxic transformation products are not created at levels that are a threat to human health or the environment.	Can be used to monitor the effectiveness or completion of a remedy especially in areas with low concentrations.	Can be easily implemented.	Low	Yes
Containment	Groundwater Containment	Physical Barriers	Slurry wall, sheet piling, vibrating barrier wall, etc. Physical and/or chemical wall that prevents contaminated groundwater from flowing either horizontally or vertically.	Effective at preventing contaminated groundwater from flowing either horizontally or vertically.	Moderately difficult to implement as a stand alone remedy; unknown effect to groundwater flow characteristics with placement of barriers. Groundwater modeling will help address uncertainty.	High	Yes but not as a stand-alone remedy
		Permeable Reactive Barrier	Contaminated groundwater flows through a permeable *in situ* treatment system. Treatment can be chemical (e.g., zero-valent iron [ZVI] barrier) or biological (e.g., mulch bio-barrier). Physical barriers/walls can be added to help direct groundwater flow to the treatment zones.	In-situ treatment system would be effective in treating contaminants.	Moderately difficult to implement; would require installation of injection wells or trenches to 40 feet bgs. Topography of the site presents challenges to excavating and installing wells.	Moderate	Yes
		Pump and Treat	Groundwater is extracted and treated in an ex situ treatment system. System can be designed to alter the natural hydraulic gradient to prevent contaminated groundwater flow either horizontally or vertically.	May be effective at containing migration of groundwater further downgradient. Extracted groundwater can be effectively treated by various ex situ treatment systems.	Moderately difficult to implement due to installation of extraction wells on uneven topography; existing treatment system can be used for the treatment of extracted water; infrastructure required to convey water to onsite treatment system and operations and maintenance would be required.	High	Yes

Table 3-7. Technology and Process Option Screening
OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

General Response Actions	Remedial Technology Types	Process Options	Description	Effectiveness	Implementability	Relative Cost	Retain for Further Evaluation?
Treatment	Removal	Excavation	Groundwater dewatering and excavation of impacted soils.	May be effective in removing contamination as long as contaminant area is well defined.	Highly difficult to implement; would require excavation of contamination greater than 35 feet bgs. Excavation of soil would damage remedy in place for soil at the site.	High	No; remedy requires disturbing existing remedy in place
		Dual-phase Extraction	A groundwater collection system is used to lower the water table to expose contaminated soil. Soil vapor extraction (SVE) is then used to removed absorbed or trapped contaminants. Used for NAPL source zones.	May not be effective because no nonaqueous phase liquid (NAPL) source area exists at the site. Not effective for all SVOCs.	Moderately difficult to implement; would require installation of wells and support equipment to operate system.	High	No; NAPL not present
	In Situ Biological Treatment	Aerobic Cometabolic Bioremediation	Injection of substrate containing inducers and electron acceptors (oxygen) to enhance aerobic biodegradation. Inducers serve as carbon sources that activate aerobic enzyme systems known to degrade chlorinated volatile organic compounds (CVOCs) (fortuitous cometabolism).	Delivery of reagents may be ineffective/challenging due to site geology.	Can be implemented; vendors that specialize in this technology are readily available. Injection and distribution may be challenging with site geology but could be overcome with hydraulic/jet fracturing.	Moderate	No; limited effectiveness of reagent delivery
		Anaerobic Bioremediation (Enhanced Bioremediation)	Subsurface delivery of electron donors, nutrients, pH buffering agent, etc., and bioaugmentation culture if needed, within the target zone to stimulate anaerobic biodegradation of chlorinated compounds.	Delivery of reagents may be ineffective/challenging due to site geology.	Can be implemented; vendors that specialize in this technology are readily available. Injection and distribution may be challenging with site geology but could be overcome with hydraulic/jet fracturing.	Moderate	No; limited effectiveness of reagent delivery
		Phytoremediation	Use of plants and their associated rhizospheric microorganisms to remove, degrade, or contain chemical contaminants in groundwater.	May be effective at removing contamination through the use of plants and trees.	Requires disturbing existing landfill cap to plant vegetation and trees. May be difficult to reach contaminant mass located 35 feet bgs.	Low	No; remedy requires disturbing existing remedy in place
		Air Sparging	Air is injected into saturated matrices to remove contaminants mainly through volatilization, aerobic biodegradation may play a minor role.	May not be effective due to site geology, which would limit air distribution. Limited effectiveness for SVOCs.	Would require installation of significant infrastructure, including SVE system to collect vapors.	High	No; limited effectiveness of air distribution
		In Situ Thermal Technology	There are different types of thermal technology that all involve the use of a heat source to volatilize contaminants in the subsurface: - Electrical resistive Heating (ERH) involves installation of electrodes in hexagonal or three point arrays and application of high-voltage electrical power to cause boiling of volatile compounds in groundwater. - Also referred to as In Situ Thermal Desorption (ISTD), TCH involves heating the soil in situ by conduction/convection, using heaters installed at relatively close spacing. - Steam injection involves the introduction of hot air and steam to boil off contaminants With all technologies, contaminants mobilized from the subsurface (liquid and vapor) are collected and typically	Effective at reducing contaminant mass and volume from groundwater. However, considered impractical for dilute concentrations. May not be effective for all COCs.	Would require installation of significant infrastructure, including vapor collection and ex situ treatment system.	High	No; technology used to treat high concentration source areas

Table 3-7. Technology and Process Option Screening

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

General Response Actions	Remedial Technology Types	Process Options	Description	Effectiveness	Implementability	Relative Cost	Retain for Further Evaluation?
	In Situ Physical, Chemical Treatment	Solidification and Stabilization	Solidification and stabilization is designed to immobilize contaminants within the media, rather than removing them through treatment. Solidification uses a reagent to bind the contaminated media while stabilization uses a reagent to reduce the leachability of COCs by chemically immobilizing them or reducing their solubility.	Effective at reducing mobility and leachability of contaminant mass.	Would require disruption of existing soil cap and the use of large augers to mix reagents or drill rigs to inject reagents into the subsurface.	High	No; remedy requires disturbing existing remedy in place
		In Situ Sorption	Injection of powder or granular activated carbon into the subsurface to remove contaminants from the mobile phase.	Effective at reducing volume and toxicity of organic contaminants including some SVOCs and explosives through treatment by adsorption. However delivery of the reagent may be ineffective/challenging due to site geology.	Can be implemented; vendors that specialize in this technology are readily available. Injection and distribution of sorptive reagents may be challenging due to site geology but could be overcome with hydraulic/jet fracturing.	Moderate	Yes but not as a stand-alone remedy
		In Situ Chemical Oxidation	Injection of oxidizing agents (such as Fenton's reagent, permanganate, ozone) to promote abiotic in situ destruction of chlorinated organic compounds or petroleum hydrocarbons.	Effective at reducing volume of organic contaminants including some SVOCs and explosives through treatment by chemical oxidant. However delivery of reagents may be ineffective/challenging due to site geology and can produce more toxic byproducts of PFAS (if PFAS is present).	Can be implemented; vendors that specialize in this technology are readily available. Injection and distribution of oxidants may be challenging due to site geology but could be overcome with hydraulic/jet fracturing.	Moderate	No; limited effectiveness of reagent delivery
		In Situ Chemical Reduction	Injection of reducing agents (such as ZVI) to promote abiotic in situ destruction of chlorinated organic compounds.	Effective at reducing volume and toxicity of organic contaminants including some SVOCs and explosives through treatment by chemical reduction. However delivery of reagent may be ineffective/challenging due to site geology.	Can be implemented; vendors that specialize in this technology are readily available. Injection and distribution of reductants may be challenging due to site geology but could be overcome with hydraulic/jet fracturing.	Moderate	Yes but not as a stand-alone remedy

Table 5-1. Detailed Evaluation of Remedial Alternatives
OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Alternative Description: Criterion	Alternative 1—No Action	Alternative 2—Monitored Natural Attenuation with Land Use Controls	Alternative 3—Groundwater Extraction and Treatment with Monitored Natural Attenuation and Land Use Controls	Alternative 4—Permeable Reactive Barrier with Monitored Natural Attenuation and Land Use Controls
1. Overall protection of human health and the environment	Alternative would not provide protection of human health and the environment. RAOs would not be met because does not prevent or minimize plume migration from the site and does not include measures to address groundwater COCs that exceed PRGs. Existing OU-4 LUCs would likely prevent exposure of future human receptors (residents and industrial workers) to groundwater COCs; however, alternative does not include mechanism to update current LUCIP to ensure groundwater site (IAAP-020G) is included.	Alternative would provide protection of human health and the environment. COC concentrations onsite are relatively low and natural attenuation would reduce COC concentrations over time. Groundwater monitoring would be conducted until RAOs are achieved. LUCs would prevent exposure of current and future residents and workers to groundwater while concentrations are greater than PRGs.	Alternative would provide protection of human health and the environment. COC concentrations onsite are relatively low and natural attenuation would reduce COC concentrations over time. Groundwater monitoring would be conducted until RAOs are achieved. Containment would prevent the migration of groundwater greater than PRGs from leaving the site. Extracted groundwater would be treated to concentrations below PRGs. LUCs would prevent exposure of current and future residents to groundwater and workers while concentrations are greater than PRGs.	Alternative would provide protection of human health and the environment. COC concentrations onsite are relatively low and natural attenuation would reduce COC concentrations over time. Groundwater monitoring would be conducted until RAOs are achieved. The PRB would reduce groundwater COCs to concentrations below PRGs prior to leaving the site. LUCs would prevent exposure of current and future residents and workers to groundwater while concentrations are greater than PRGs.
2. Compliance with ARARs	ARARs would not be met because no remedial action is taken to address unacceptable risk. Monitoring is not conducted, so it would remain unknown whether groundwater COCs continue to exceed PRGs. Would not trigger location-specific or action-specific ARARs.	ARARs would be met once natural attenuation reduces COC concentrations below the PRGs. Field activities will be performed in a manner to minimize disruption of endangered or threatened species and migratory birds to achieve location-specific ARARs.	ARARs would be met once natural attenuation and groundwater extraction and treatment reduces COC concentrations below the PRGs. Field activities will be performed in a manner to minimize disruption of endangered or threatened species and migratory birds to achieve location-specific ARARs.	ARARs would be met once natural attenuation and PRB treatment reduces COC concentrations below the PRGs. Field activities will be performed in a manner to minimize disruption of endangered or threatened species and migratory birds to achieve location-specific ARARs.
3. Long-term effectiveness and permanence				
(a) Magnitude of residual risks	No treatment of monitoring would be conducted and therefore, residual risks would be unknown.	Risks would be gradually reduced through natural attenuation processes. Residual risk would remain until COC concentrations are reduced to below their PRGs.	Risks would be gradually reduced through natural attenuation processes. Residual risks would remain until COC concentrations have been reduced to below PRGs. Groundwater extraction would immediately remove residual risks from the downgradient area of the IDA. Requires active treatment for extracted groundwater; treatment residuals will need to be properly managed to reduce risks.	Risks would be gradually reduced through natural attenuation processes. Residual risks would remain until COC concentrations have been reduced to below PRGs. PRB treatment would quickly remove residual risks from the downgradient area of the IDA. Treatment chemicals for injections are expected to have a lifespan of approximately 15 years and would remain dispersed in the groundwater at the site at the completion of treatment. Reinjection is needed if breakthrough of contaminants, such as PFAS, are observed downgradient from the PRB treatment zone after initial injection loses effectiveness.
(b) Adequacy and reliability of controls	Although LUCs are in place for OU-4, there is no mechanism under this alternative to document the adequacy and reliability of the controls for the groundwater site.	LUCs are adequate and reliable in preventing exposure to COCs above their PRGs. Expected to require long term monitoring of contaminants and natural attenuation parameters until RAOs are achieved. A five-year review would be required to assess performance of this alternative and evaluate whether RAOS are being met.	LUCs are adequate and reliable in preventing exposure to COCs above their PRGs. Predesign investigation will be utilized to determine hydraulic properties (hydraulic conductivity, well recharge rates, etc.) of the areas where extraction will occur to allow for adequacy and reliability of the extraction well system to control and capture groundwater before it leaves the site. Expected to require long term monitoring of contaminants and natural attenuation parameters until RAOs are achieved. A five-year review would be required to assess performance of this alternative and evaluate whether RAOs are being met.	LUCs are adequate and reliable in preventing exposure to COCs above their PRGs. Predesign investigation will be utilized to determine hydraulic properties (hydraulic conductivity, well recharge rates, etc.) of the areas where injection wells will be placed to allow for adequacy and reliability of COC treatment through the permeable reactive barrier. Reinjection may be required to ensure future treatment of groundwater. Expected to require long term monitoring of contaminants and natural attenuation parameters until RAOs are achieved. A five-year review would be required to assess performance of this alternative and evaluate whether RAOs are being met.

Table 5-1. Detailed Evaluation of Remedial Alternatives

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Alternative Description: Criterion	Alternative 1—No Action	Alternative 2—Monitored Natural Attenuation with Land Use Controls	Alternative 3—Groundwater Extraction and Treatment with Monitored Natural Attenuation and Land Use Controls	Alternative 4—Permeable Reactive Barrier with Monitored Natural Attenuation and Land Use Controls
4. Reduction of TMV through treatment				
(a) Treatment process used	No treatment processes used.	No active treatment processes used. Reduction in TMV would gradually occur as a result of passive natural attenuation processes	Alternative would include active groundwater extraction and ex-situ technology. Ex-situ treatment of extracted groundwater using a groundwater treatment system that may include (but is not limited to) filtration and GAC. Additional reduction in TMV would gradually occur as a result of passive natural attenuation processes.	Alternative would include active PRB technology. Injection of treatment reagents utilizes in situ sorption and in situ chemical reduction (ISCR) to remove groundwater contaminants from the dissolved phase onto the surface of liquid activated carbon and degrade COCs susceptible to ISCR degradation (e.g. TCE). Additional reduction in TMV would gradually occur as a result of passive natural attenuation processes.
(b) Degree and quantity of TMV reduction	None.	There would be no reduction from active treatment. Monitoring would be conducted to assess TMV of site-related COCs in groundwater from passive natural attenuation.	Expect to achieve 67 to 99% reduction in COC concentrations through groundwater treatment system. No reduction in COC mass within the site through active treatment, but COC mass would be actively extracted from the site. Only groundwater captured in extraction wells would be actively treated.	Expect to achieve 67 to 99% reduction in COC concentrations for groundwater contaminants that pass through the PRB. Reduction in COC mass would occur as contaminated groundwater flows through PRB treatment zone in the downgradient area of the IDA. Treatment distribution during injections could be inconsistent or slow in the clay layers at the site.
(c) Irreversibility of TMV reduction	Not applicable.	Passive natural attenuation degradation processes would be considered irreversible.	Ex-situ treatment via the groundwater treatment system is irreversible. Passive natural attenuation degradation processes would also be considered irreversible.	In-situ treatment via PRB injection wells is irreversible. Passive natural attenuation degradation processes would also be considered irreversible.
(d) Type and quantity of treatment residuals	Not applicable.	Not applicable.	Treatment residuals generated at the end of operations of the groundwater treatment system would need to be properly managed for disposal. No treatment chemical residuals are expected at the completion of treatment.	Treatment reagents are expected to treat contaminants and are not considered treatment residuals.
(e) Statutory preference for treatment as a principal element	Preference not met because no treatment included.	Preference not met because no active treatment included.	Preference met because COCs are actively treated and contained to the site.	Preference met because COCs are actively treated to below PRGs prior to leaving the site.
5. Short-term effectiveness				
(a) Protection of workers during remedial action	No remedial construction, so no risks to workers.	Low to moderate risk to workers during installation of new monitoring wells. Low risk to workers during the monitoring phase. Risks can be properly managed with a thorough health and safety plan and appropriately trained staff.	Low to moderate risk to workers during installation of new monitoring and extraction wells. Moderate to high risk to workers during construction and operation activities of the groundwater treatment system. Treatment uses mechanical machinery and produces waste residuals. Low risk to workers during the monitoring phase. Risks can be properly managed with a thorough health and safety plan and appropriately trained staff.	Low to moderate risk to workers during installation of new monitoring and injection wells. Moderate risk to workers during injection due to exposure to concentrated treatment reagents, handling of injection chemicals, and working with pressurized injection lines. Low risk to workers during the monitoring phase. Risks can be properly managed with a thorough health and safety plan and appropriately trained staff.
(b) Protection of community during remedial action	No remedial construction, so no short-term risks to community.	Limited risk to community during transportation of heavy equipment for well installation and monitoring activities.	Minimal risks to the community during transportation of heavy equipment and construction materials to the site.	Minimal risks to the community during transportation of heavy equipment and PRB treatment materials to the site. Minimal impacts to the community during injection delivery as delivery rates are low and completed infrequently.

Table 5-1. Detailed Evaluation of Remedial Alternatives
OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Alternative Description: Criterion	Alternative 1—No Action	Alternative 2—Monitored Natural Attenuation with Land Use Controls	Alternative 3—Groundwater Extraction and Treatment with Monitored Natural Attenuation and Land Use Controls	Alternative 4—Permeable Reactive Barrier with Monitored Natural Attenuation and Land Use Controls
(c) Environmental impacts of remedial action	No remedial construction, so no environmental impacts from remedial action.	Low environmental impacts from drilling and monitoring activities at the site would be expected compared to other alternatives.	This alternative would have the highest energy and water footprint of all the alternatives, mainly due to material (treatment reagents) and electrical usage. Disposal of spent treatment chemicals and materials would be required with this alternative. Increased greenhouse gas emissions due to the operation of drilling and construction equipment. Relatively low environmental impacts from residual handling during monitoring and transportation of personnel for monitoring activities.	Clearing and grubbing over 1,000 linear feet on steep slopes is needed for multiple surface penetrations for PRB injections, resulting in increasing sediment and erosion during precipitation events until restoration. Environmental impacts would also include increased greenhouse gas emissions due to the operation of drill rigs during injections and well installation and production of treatment reagents. Relatively low environmental impacts from residual handling during monitoring and transportation of personnel for monitoring activities.
(d) Time until RAOs are achieved	Not met.	Evaluation of long-term monitoring results would be required to evaluate when RAOs are achieved. Timeframe is estimated to be greater than 30 years for this FS. However, some industrial COCs that currently exceed PRGs are expected to achieve RAOs by 2038 through MNA.	Evaluation of long-term monitoring results would be required to evaluate when RAOs are achieved. Timeframe is estimated to be greater than 30 years for this FS. However, some industrial COCs that currently exceed PRGs are expected to achieve RAOs by 2038 through MNA.	Evaluation of long-term monitoring results would be required to evaluate when RAOs are achieved. Timeframe is estimated to be greater than 30 years for this FS. However, some industrial COCs that currently exceed PRGs are expected to achieve RAOs by 2038 through MNA.
6. Implementability				
(a) Technical feasibility	No impediments.	Easy to construct new monitoring wells and monitor groundwater. These are highly reliable technologies and unlikely to have schedule delays.	Able to construct new monitoring and extraction wells and construct groundwater treatment and extraction system using standard construction methods and equipment. The difficulty of implementing this alternative would increase with the number of ex-situ treatment processes required. For example, the addition of another unit process such as ion exchange would require additional monitoring and change out of media. Schedule delays are possible due to construction activities including the installation of extraction wells and trenching and installation of conveyance lines. While there is reasonable confidence the remedy can be constructed, the ability to effectively contain groundwater is uncertain with the conceptual design presented as a part of this FS. However, it would not be difficult to modify the conceptual extraction system based on the PDI to successfully implement this alternative. Once constructed, operation is considered moderately complex. However, the use of instrumentation and controls help operators maintain optimal conditions. Monitoring groundwater is easy to implement as part of a monitoring program.	Installation of injection wells requires common well installation and construction methods and equipment. PRB implementation only requires the installation of injection wells and delivery of treatment reagents. The remedial design will need to consider how to best optimize substrate delivery and installing injection wells on steep slopes. Treatment reagents can be added rapidly into the injection well and start treating COCs immediately after construction is complete. Accurate prediction of lifespan of a PRB is often difficult until the PRB has been installed and monitoring is underway. However, reinjection of PRB reagents should be easy. Schedule delays are possible due to construction and injection activities. Monitoring groundwater is easy to implement as part of a monitoring program.

Table 5-1. Detailed Evaluation of Remedial Alternatives

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Alternative Description: Criterion	Alternative 1—No Action	Alternative 2—Monitored Natural Attenuation with Land Use Controls	Alternative 3—Groundwater Extraction and Treatment with Monitored Natural Attenuation and Land Use Controls	Alternative 4—Permeable Reactive Barrier with Monitored Natural Attenuation and Land Use Controls
(b) Administrative feasibility	No impediments.	Requires coordination with local, state, and federal entities to revise current land use controls (if needed) and monitoring.	Requires coordination with local, state, and federal entities to revise current land use controls (if needed) and monitoring. There are uncertainties with the management and disposal of extracted PFAS-contaminated water and will require coordination with the Army	Requires coordination with local, state, and federal entities to revise current land use controls (if needed) and monitoring. Implementation for this alternative will also require coordination with local, state, and federal entities for defining injection well restrictions and monitoring.
(c) Availability of services and materials	None needed	Services and materials are available.	Services and materials are available.	Services and materials are available.
7. Total Cost (over a 30-year period)				
Direct Capital Cost	$0	$114,000	$1,694,000	$2,683,000
Initial O&M Cost	$0	$903,000	$3,840,000	$1,358,000
Total Periodic Cost	$0	$289,000	$357,000	$2,543,000
Total Present Value	$0	$1,306,000	$5,891,000	$6,584,000

μg/L = micrograms per liter
LTM = long-term monitoring
PRB = Permeable Reactive Barrier
RAO = remedial action objective
ARAR = applicable, relevant, and appropriate requirement
O&M = operation and maintenance
PRG = preliminary remediation goal
TMV = toxicity, mobility, or volume

Table 5-2. Comparative Analysis of Alternatives

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Criterion	Alternative 1: No Action	Alternative 2: MNA with LUCs	Alternative 3: Groundwater Extraction and Treatment with LUCs	Alternative 4: PRB with LUCs
Overall protection of human health and the environment (threshold criterion)	Fail	Pass	Pass	Pass
Compliance with applicable or relevant and appropriate requirements (threshold criterion)	Fail	Pass	Pass	Pass
Long-term effectiveness and permanence	NA	3	3	3
Reduction of toxicity, mobility or volume through treatment	NA	2	3	3
Short-term effectiveness	NA	4	2	2
Implementability	NA	4	2	3
Cost[a]	$0	$1,306,000	$5,891,000	$6,584,000
Total Score	NA	13	10	11

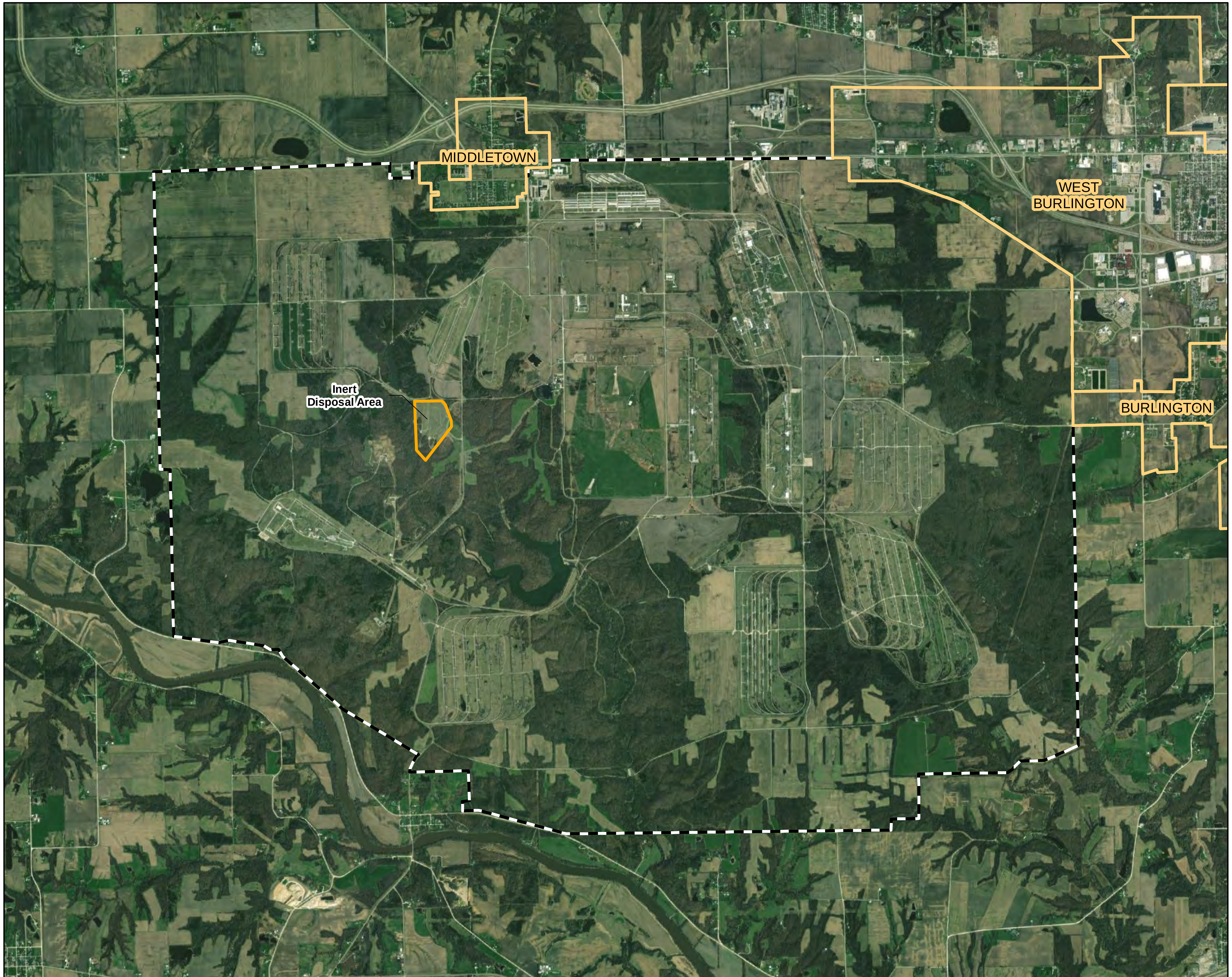
[a] Cost is the total present-worth value; cost accuracy ranges from -30% to +50%.

Ranking:

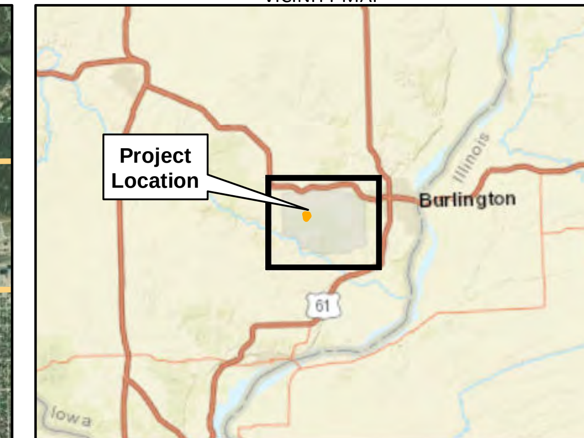
- 4 = Satisfies criterion well
- 3 = Satisfies criterion
- 2 = Satisfies criterion somewhat
- 1= Does not meet criterion

NA = not applicable due to failing threshold criteria.

Figures



VICINITY MAP



LEGEND

- IDA Boundary
- Plant Boundary
- City Boundary
- County Boundary

Note:
2020 Esri World Imagery Basemap

0 0.75 1.5
Miles

Figure 1-1
IAAAP Location Map
Inert Disposal Area
Iowa Army Ammunition Plant
Middletown, Iowa

Jacobs

\\DC1VS01\GISPROJ\U\USACE\IAAAP_679172\MAPFILES\SITEWIDE\FIGURE_1-1_FACILITY LOCATION_OU4.MXD GTWIGG 5/13/2022 12:28:46 PM

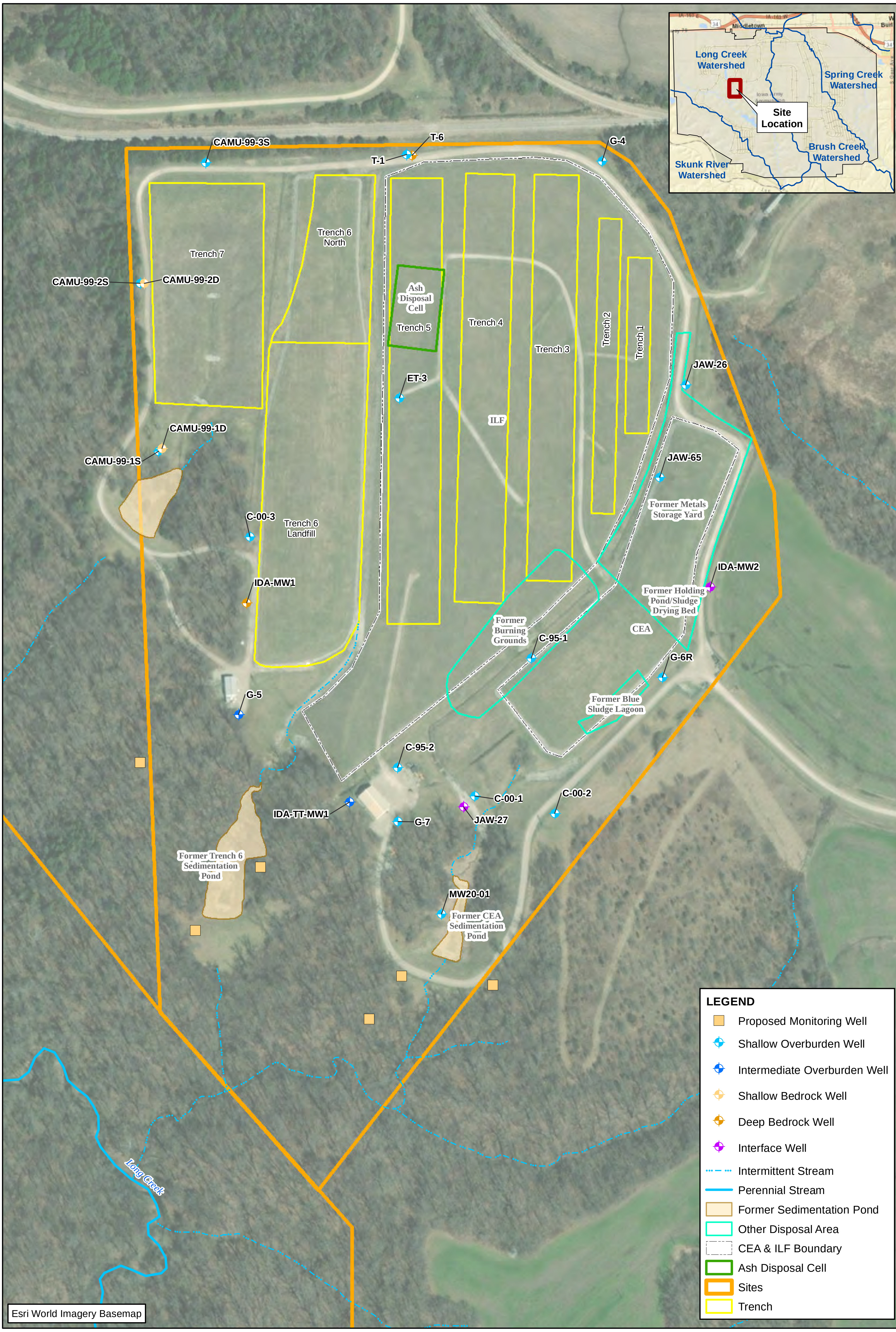


Figure 2-1
IAAAP Inert Disposal Area Layout
Inert Disposal Area
Iowa Army Ammunition Plant OU-4
Middletown, Iowa

\\DC1VS01\GISPROJ\U\USACE\IAAAP_679172\MAPFILES\TECHMEMO\FIGURE2-1_IDA_LAYOUT.MXD AESPEJO 6/20/2022 5:17:58 PM

Jacobs

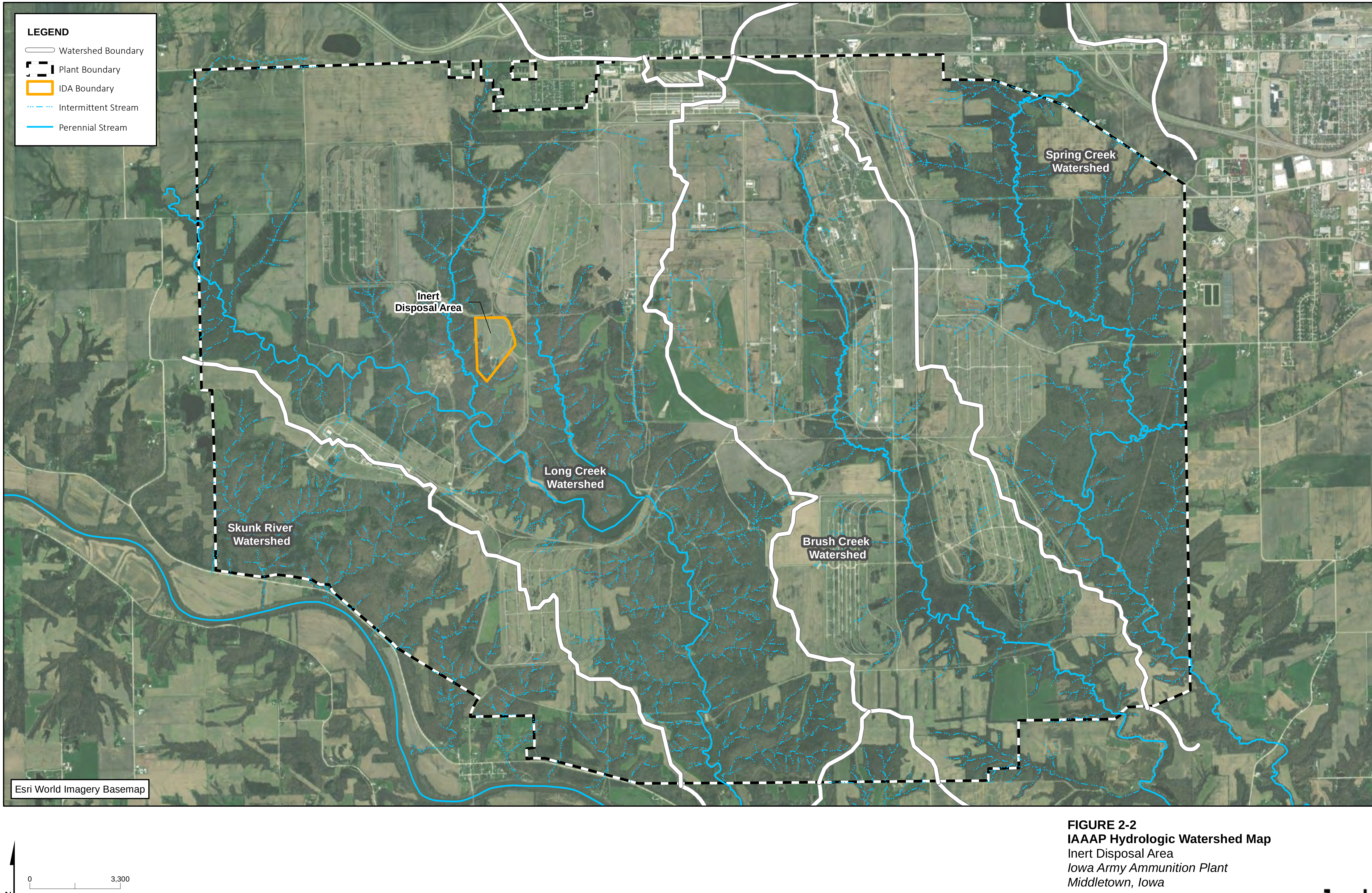


FIGURE 2-2
IAAAP Hydrologic Watershed Map
Inert Disposal Area
Iowa Army Ammunition Plant
Middletown, Iowa

Jacobs

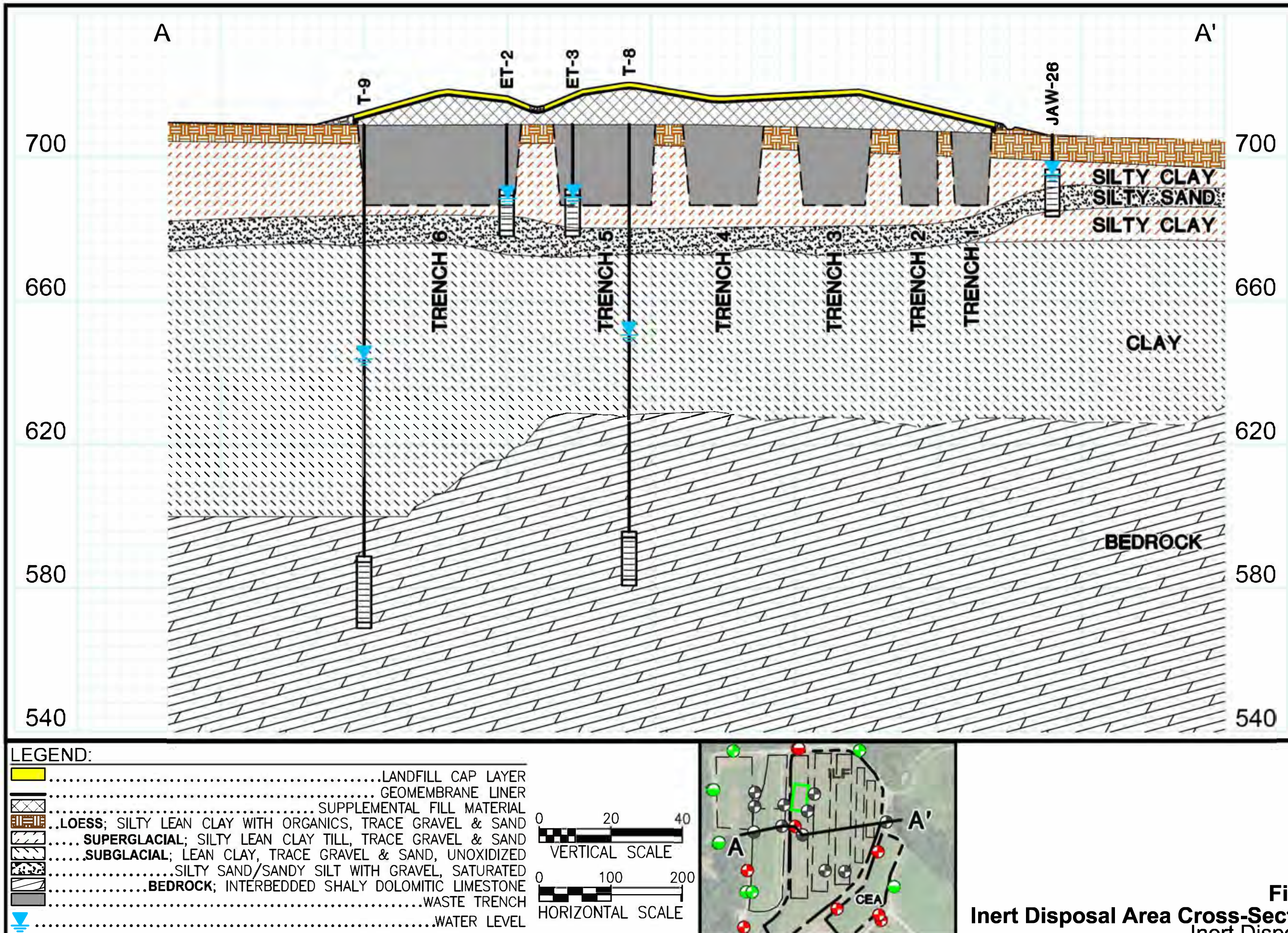


Figure 2-3
Inert Disposal Area Cross-Section A-A'
Inert Disposal Area
Iowa Army Ammunition Plant OU-4
Middletown, Iowa

Drawing Source: Leidos; IAAP-20 Inert Disposal Area Iowa Army Ammunition Plant; Middletown, Iowa; Rev. No./Date: 1-7/11/17

PW | DEN001 | DOCUMENTS - DEN1 WBG IMPERIAL SF | DESIGNS - SMALL PROJECTS | D3563000 - IRP | DLV | F01_D3563000.dgn

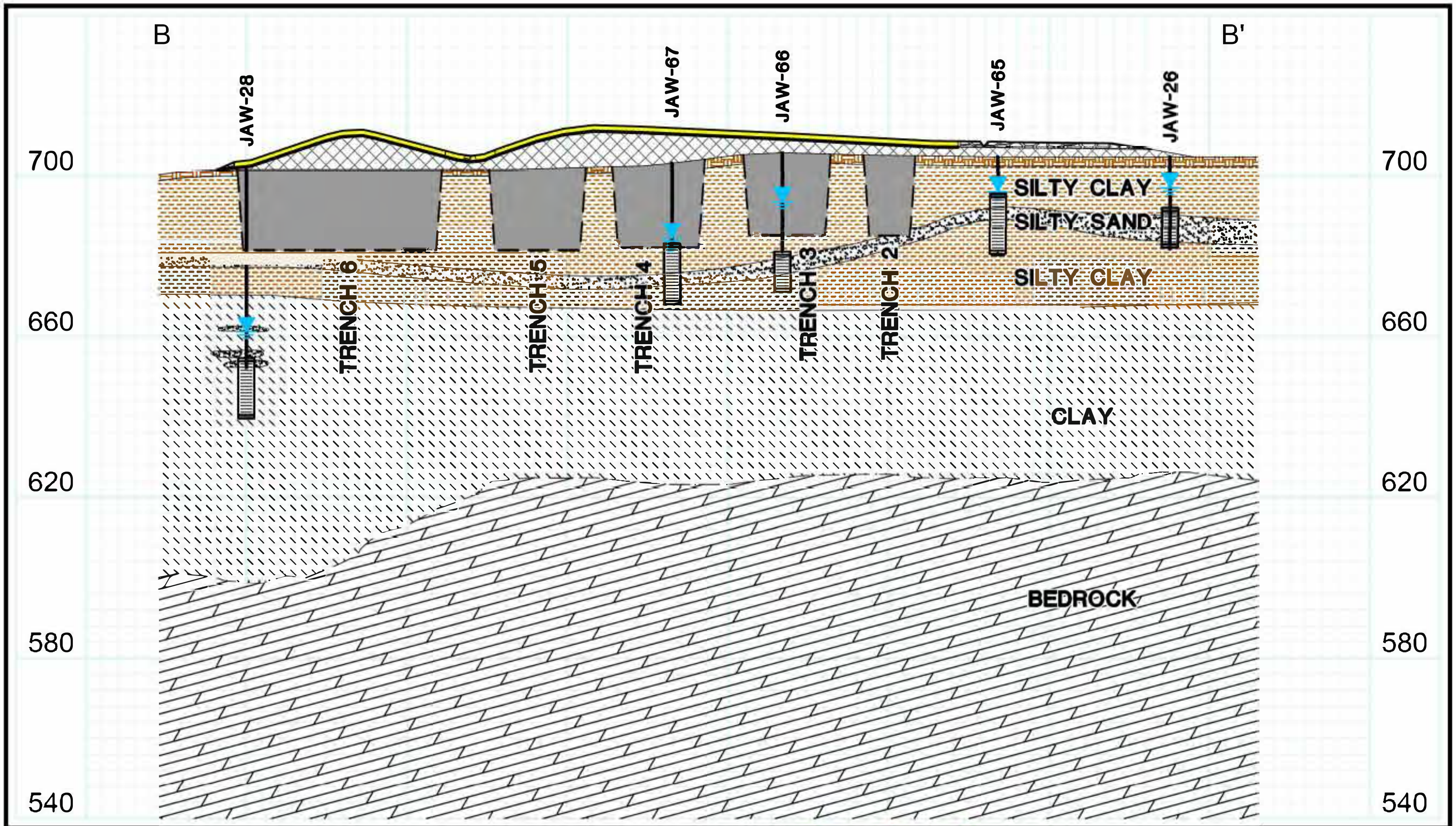


Figure 2-4
Inert Disposal Area Cross-Section B-B'
Inert Disposal Area
Iowa Army Ammunition Plant OU-4
Middletown, Iowa

Drawing Source: Leidos; IAAP-20 Inert Disposal Area Iowa Army Ammunition Plant; Middletown, Iowa; Rev. No./Date: 1-7/11/17

Jacobs

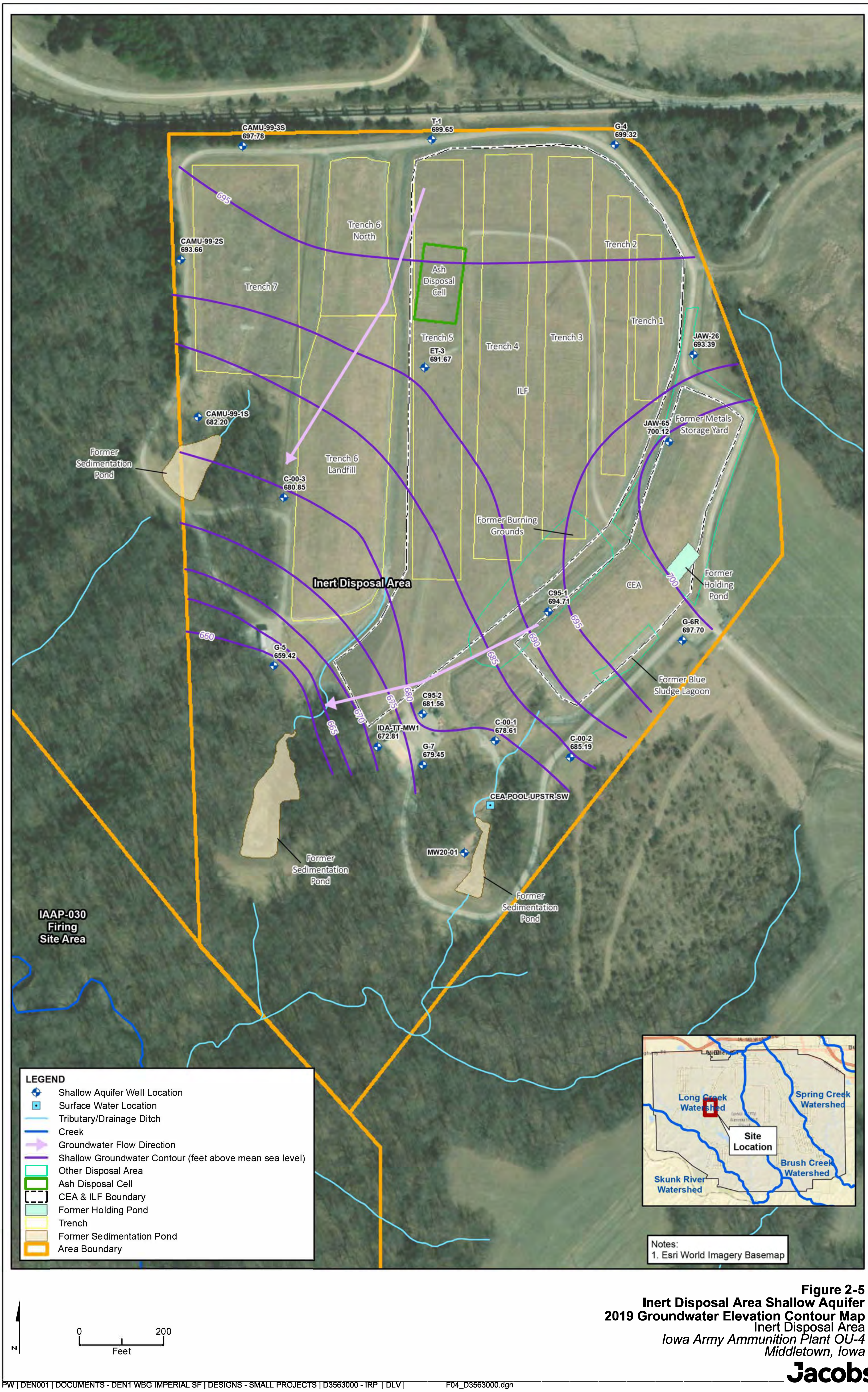


Figure 2-5
Inert Disposal Area Shallow Aquifer
2019 Groundwater Elevation Contour Map
Inert Disposal Area
Iowa Army Ammunition Plant OU-4
Middletown, Iowa

Jacobs

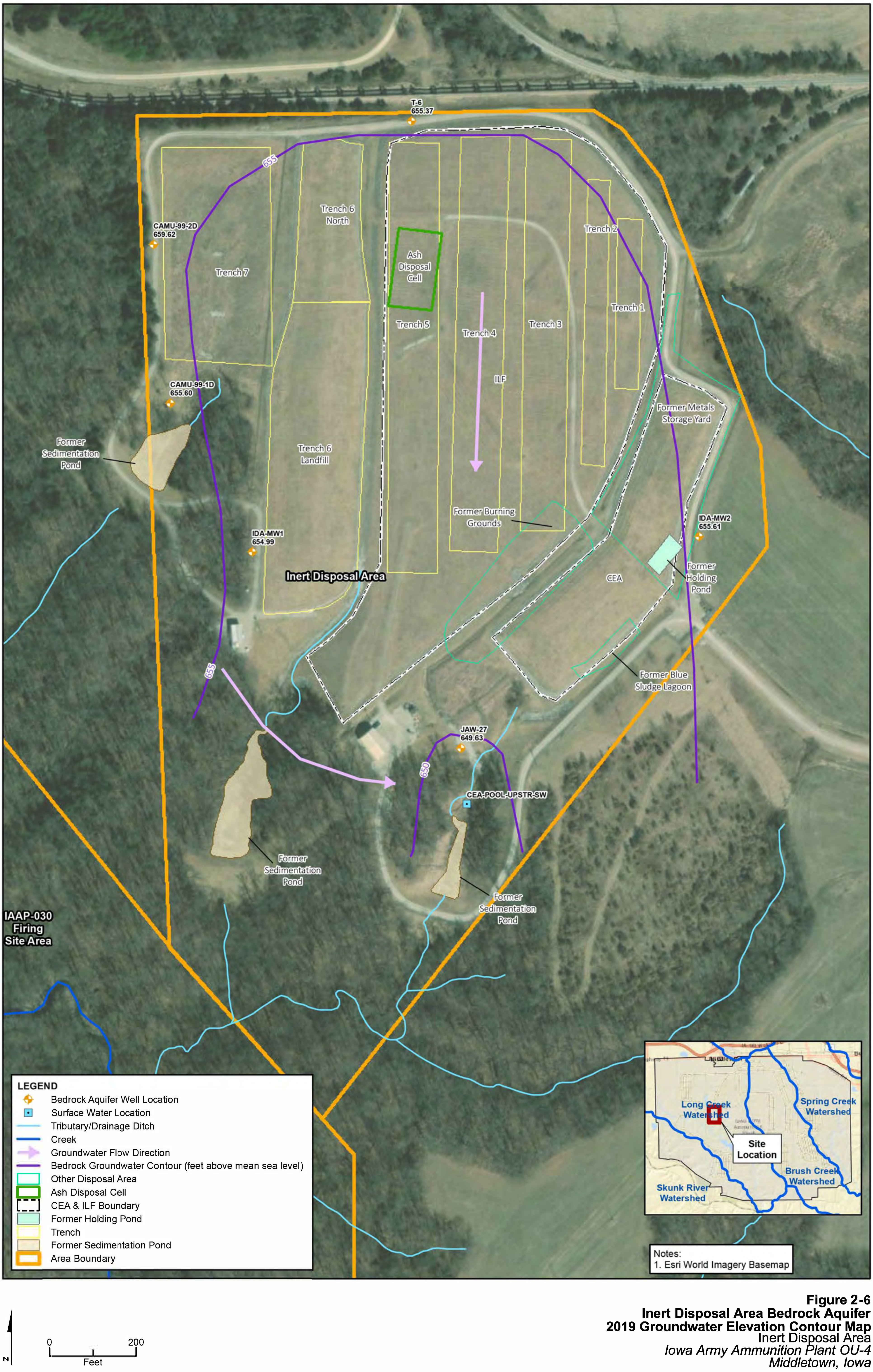
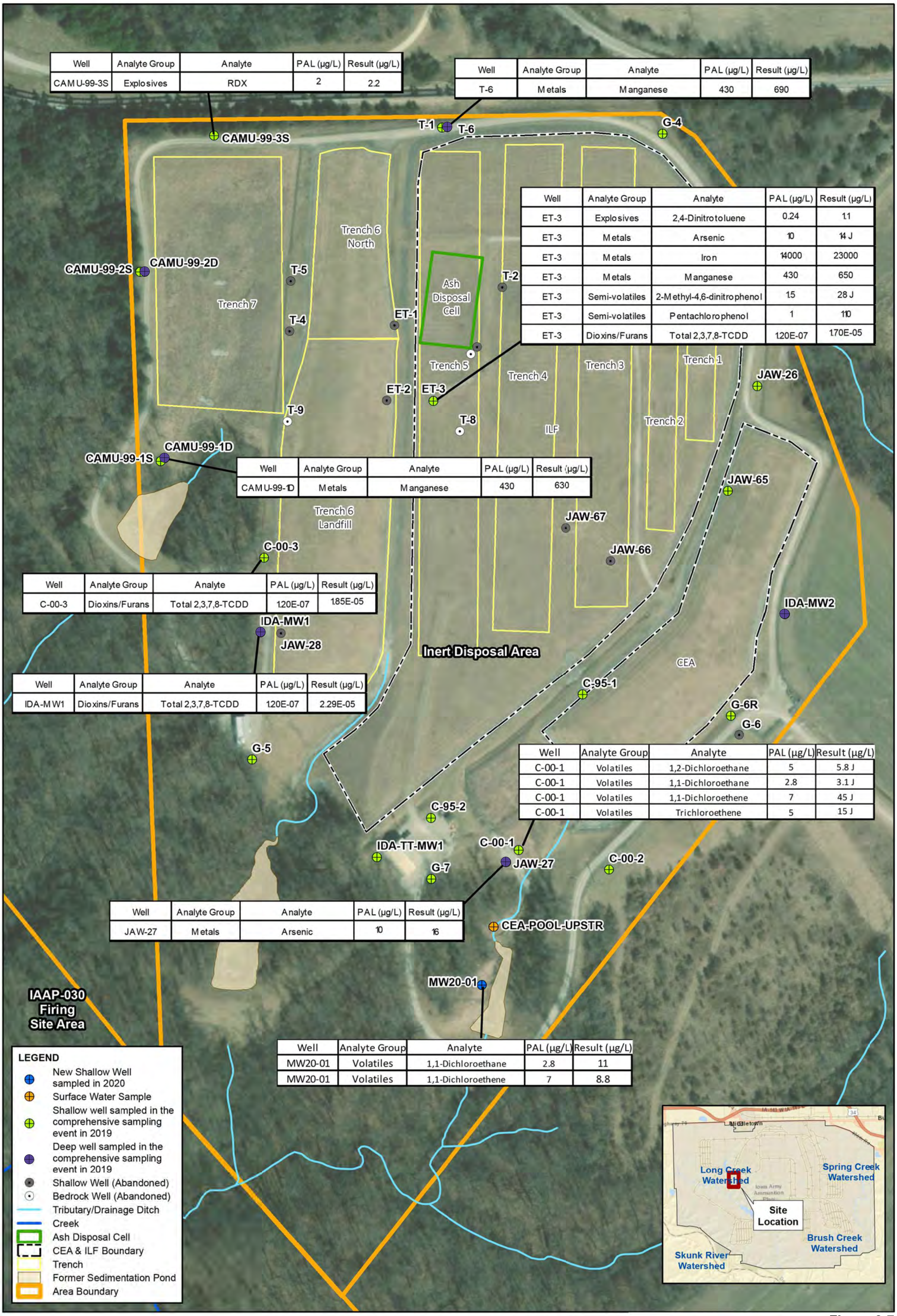


Figure 2-6
Inert Disposal Area Bedrock Aquifer
2019 Groundwater Elevation Contour Map
Inert Disposal Area
Iowa Army Ammunition Plant OU-4
Middletown, Iowa

Jacobs



Well	Analyte Group	Analyte	PAL (µg/L)	Result (µg/L)
CAMU-99-3S	Explosives	RDX	2	2.2

Well	Analyte Group	Analyte	PAL (µg/L)	Result (µg/L)
T-6	Metals	Manganese	430	690

Well	Analyte Group	Analyte	PAL (µg/L)	Result (µg/L)
ET-3	Explosives	2,4-Dinitrotoluene	0.24	1.1
ET-3	Metals	Arsenic	10	14 J
ET-3	Metals	Iron	14000	23000
ET-3	Metals	Manganese	430	650
ET-3	Semi-volatiles	2-Methyl-4,6-dinitrophenol	1.5	28 J
ET-3	Semi-volatiles	Pentachlorophenol	1	110
ET-3	Dioxins/Furans	Total 2,3,7,8-TCDD	1.20E-07	1.70E-05

Well	Analyte Group	Analyte	PAL (µg/L)	Result (µg/L)
CAMU-99-1D	Metals	Manganese	430	630

Well	Analyte Group	Analyte	PAL (µg/L)	Result (µg/L)
C-00-3	Dioxins/Furans	Total 2,3,7,8-TCDD	1.20E-07	1.85E-05

Well	Analyte Group	Analyte	PAL (µg/L)	Result (µg/L)
IDA-MW1	Dioxins/Furans	Total 2,3,7,8-TCDD	1.20E-07	2.29E-05

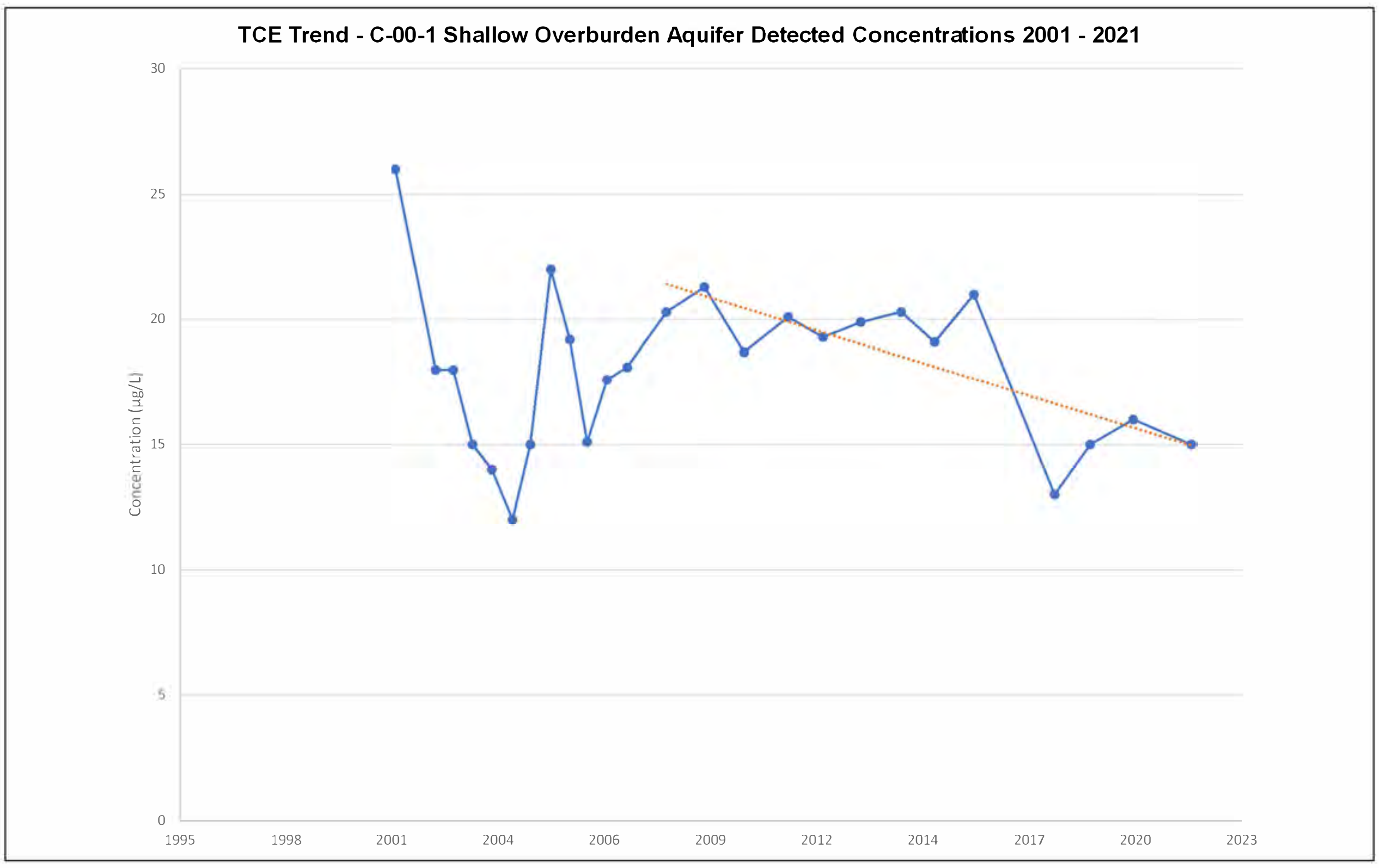
Well	Analyte Group	Analyte	PAL (µg/L)	Result (µg/L)
C-00-1	Volatiles	1,2-Dichloroethane	5	5.8 J
C-00-1	Volatiles	1,1-Dichloroethane	2.8	3.1 J
C-00-1	Volatiles	1,1-Dichloroethene	7	45 J
C-00-1	Volatiles	Trichloroethene	5	15 J

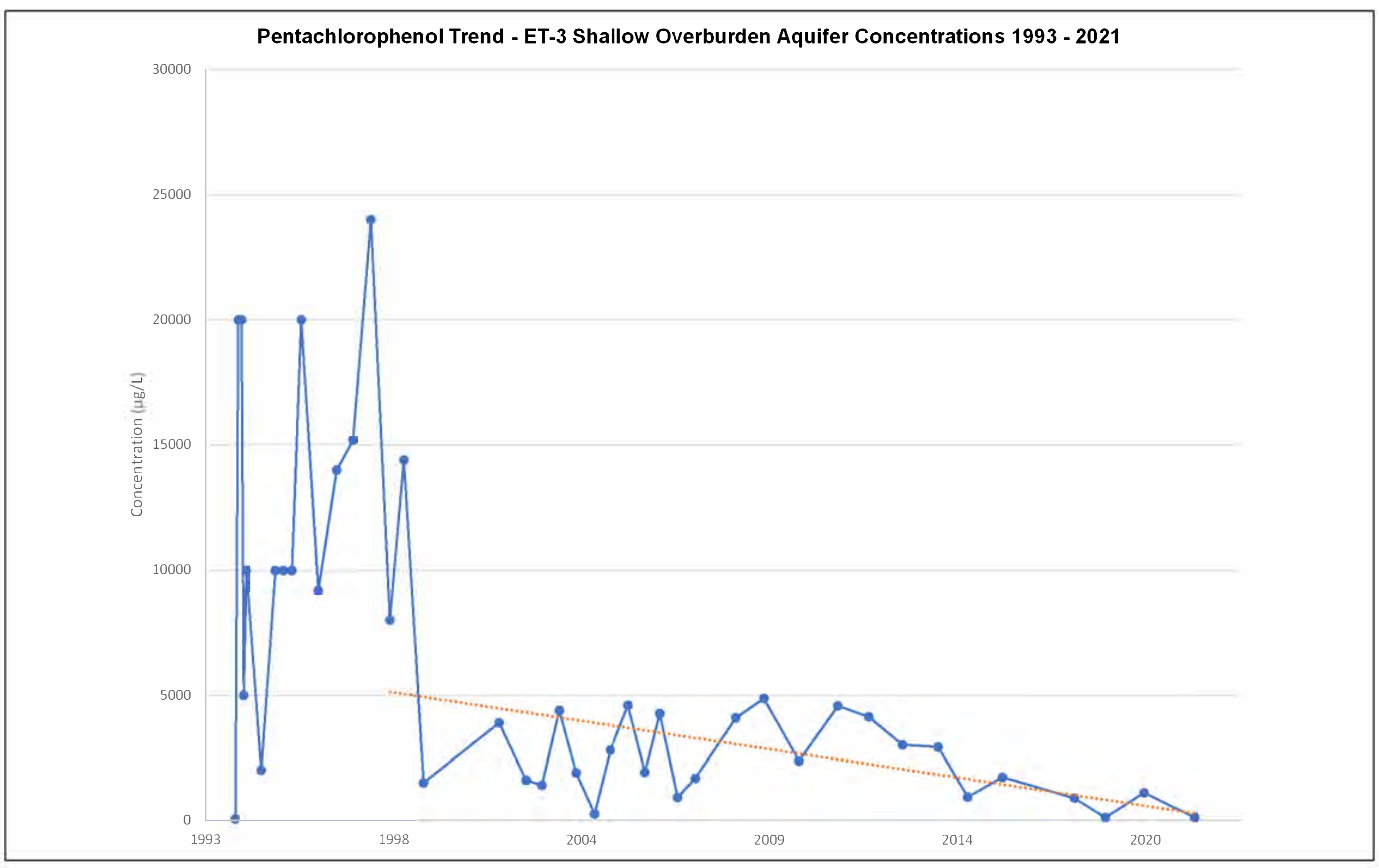
Well	Analyte Group	Analyte	PAL (µg/L)	Result (µg/L)
JAW-27	Metals	Arsenic	10	16

Well	Analyte Group	Analyte	PAL (µg/L)	Result (µg/L)
MW20-01	Volatiles	1,1-Dichloroethane	2.8	11
MW20-01	Volatiles	1,1-Dichloroethene	7	8.8

Figure 2-7
Inert Disposal Area Groundwater Project Action Limit Exceedances in 2019 and 2020
Inert Disposal Area
Iowa Army Ammunition Plant OU-4
Middletown, Iowa

Jacobs





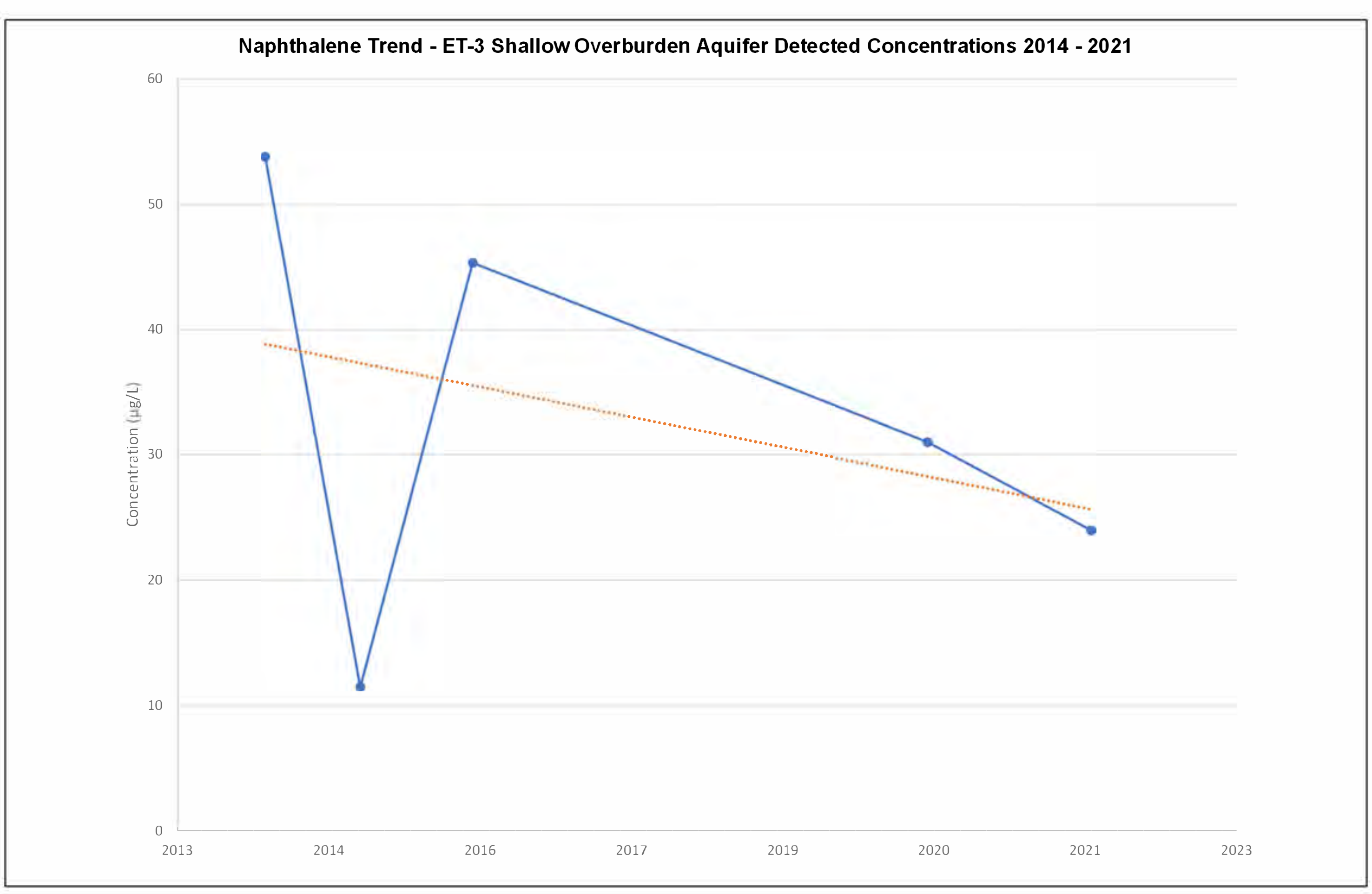
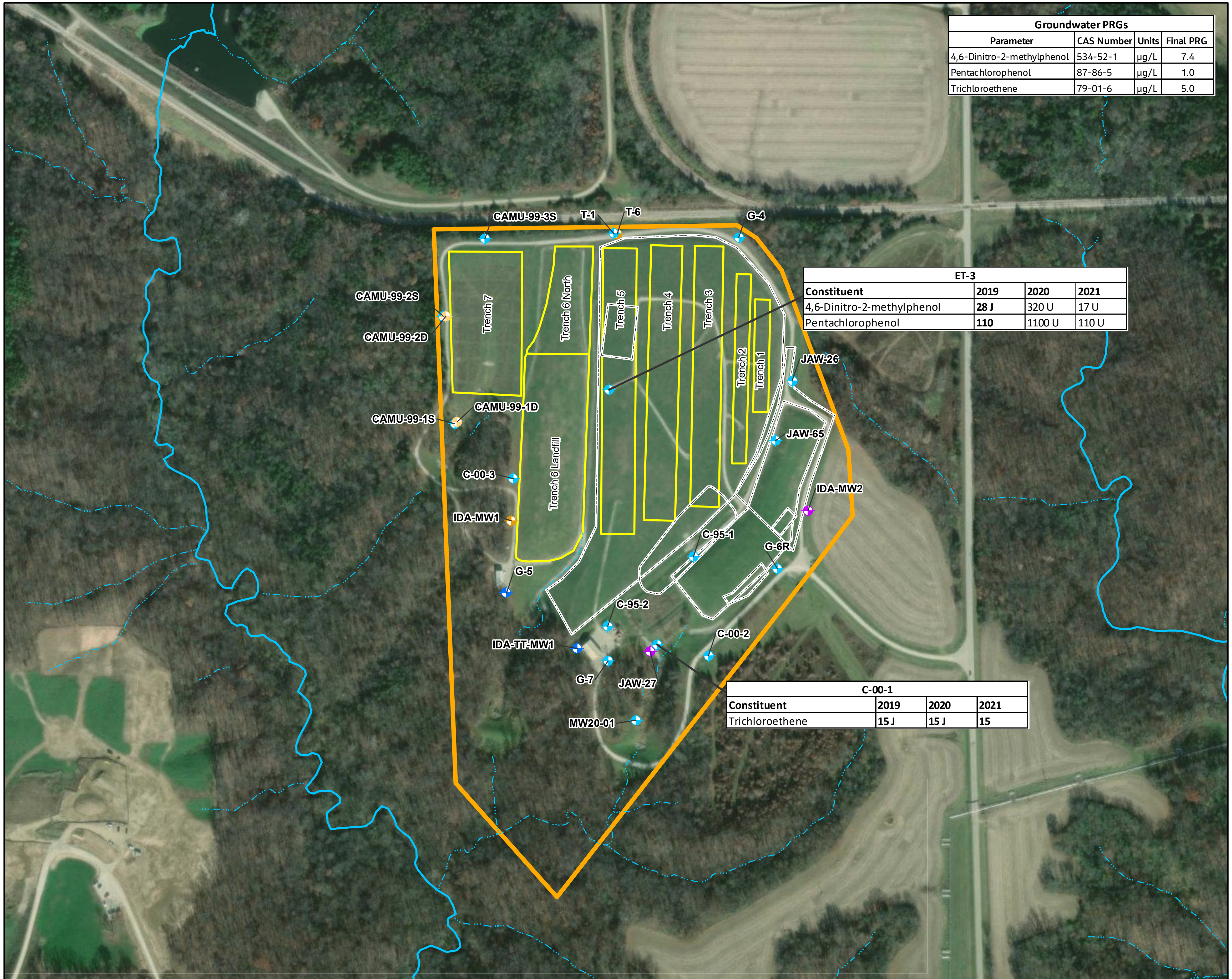


Figure 2-8
Trend Graphs for Select Constituents at Monitoring Wells C-00-1 and ET-3
Inert Disposal Area
Iowa Army Ammunition Plant OU-4
Middletown, Iowa

Jacobs

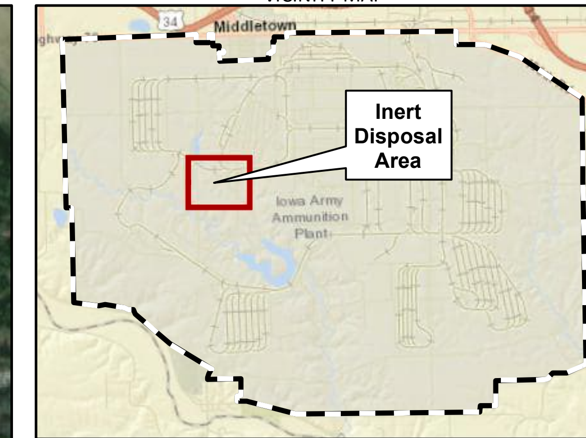


Groundwater PRGs			
Parameter	CAS Number	Units	Final PRG
4,6-Dinitro-2-methylphenol	534-52-1	µg/L	7.4
Pentachlorophenol	87-86-5	µg/L	1.0
Trichloroethene	79-01-6	µg/L	5.0

ET-3			
Constituent	2019	2020	2021
4,6-Dinitro-2-methylphenol	**28 J**	320 U	17 U
Pentachlorophenol	**110**	1100 U	110 U

C-00-1			
Constituent	2019	2020	2021
Trichloroethene	**15 J**	**15 J**	**15**

VICINITY MAP



LEGEND

- Shallow Overburden Well
- Intermediate Overburden Well
- Shallow Bedrock Well
- Deep Bedrock Well
- Interface Well
- Intermittent Stream
- Perennial Stream
- Inert Disposal Area IRP Site Boundary (HQAES # IAAP-020/020G)
- Plant Boundary
- CEA & ILF Boundary

Notes:
1. 2022 Esri World Imagery Basemap
2. Results are reported in micrograms per liter (µg/L).
3. U = The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
4. J = The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
5. Groundwater results collected in 2019, 2020, and 2021.
6. Bold results exceed the project industrial preliminary remedial goals (PRGs). If a MCL was available, PRG is the higher value of the background value and MCL. If no MCL was available, PRG is the adjusted risk-based goal.

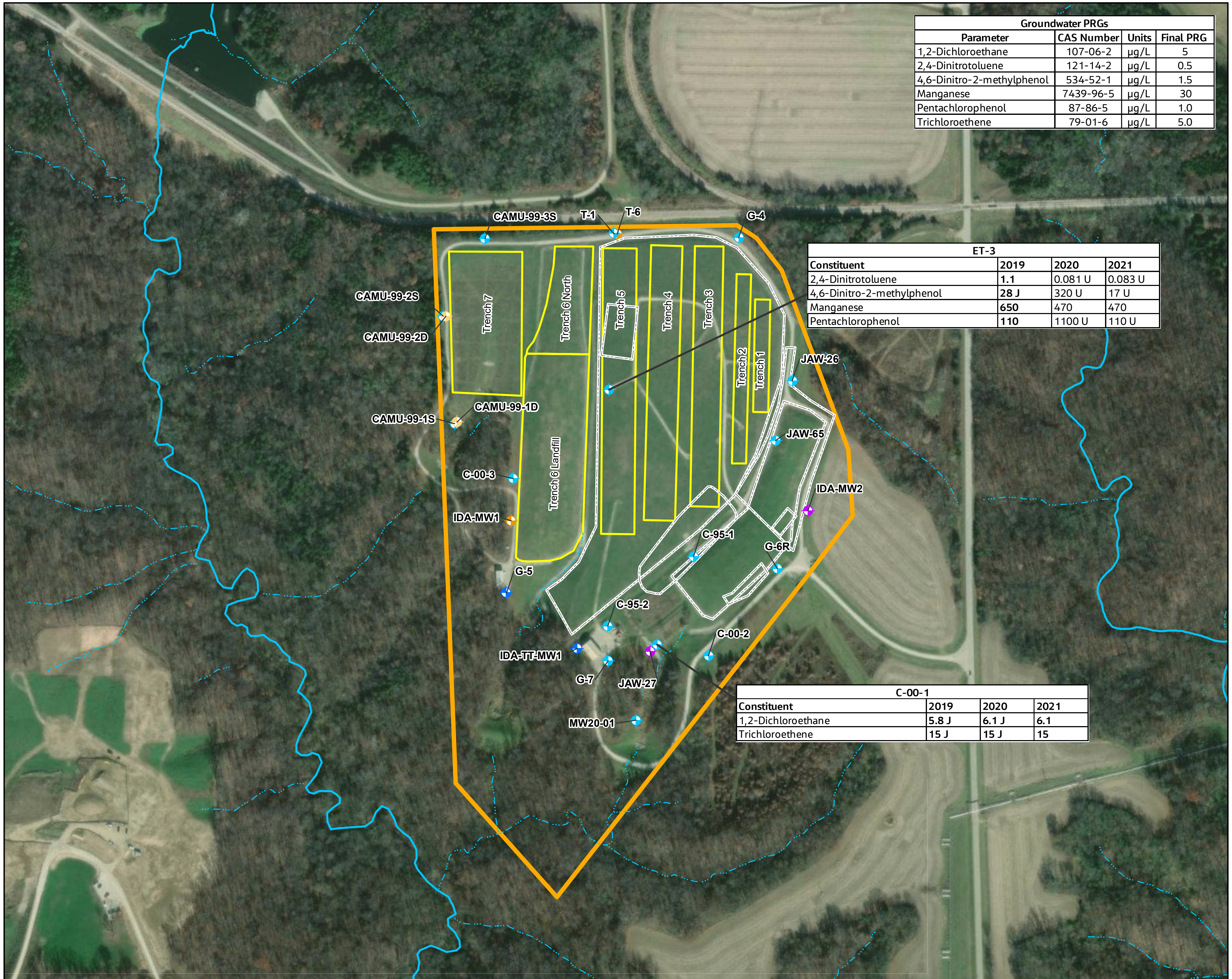
N

0 350 700
Feet

FIGURE 3-1
Industrial Groundwater PRG Exceedances from 2019 to 2021
Inert Disposal Area
Iowa Army Ammunition Plant
Middletown, Iowa

Jacobs

SCO \\DC1VS01\GISPROJ\U\USACE\IAAAP_679172\MAPFILES\TECHMEMO\FIGURE3-1_IDA_RESULTS.MXD GTWIGG 7/3/2023 10:06:14 AM

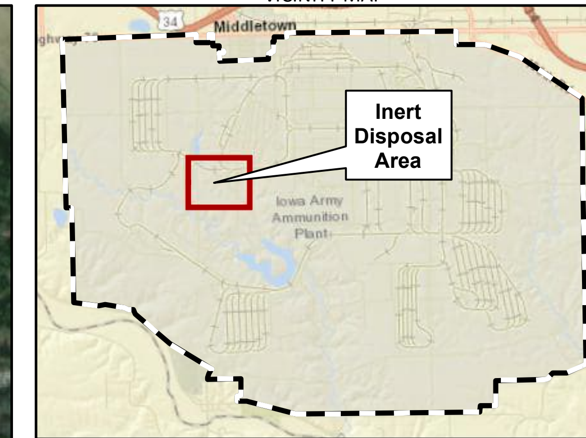


Groundwater PRGs			
Parameter	CAS Number	Units	Final PRG
1,2-Dichloroethane	107-06-2	µg/L	5
2,4-Dinitrotoluene	121-14-2	µg/L	0.5
4,6-Dinitro-2-methylphenol	534-52-1	µg/L	1.5
Manganese	7439-96-5	µg/L	30
Pentachlorophenol	87-86-5	µg/L	1.0
Trichloroethene	79-01-6	µg/L	5.0

ET-3			
Constituent	2019	2020	2021
2,4-Dinitrotoluene	**1.1**	0.081 U	0.083 U
4,6-Dinitro-2-methylphenol	**28 J**	320 U	17 U
Manganese	**650**	470	470
Pentachlorophenol	**110**	1100 U	110 U

C-00-1			
Constituent	2019	2020	2021
1,2-Dichloroethane	**5.8 J**	**6.1 J**	**6.1**
Trichloroethene	**15 J**	**15 J**	**15**

VICINITY MAP



LEGEND

- Shallow Overburden Well
- Intermediate Overburden Well
- Shallow Bedrock Well
- Deep Bedrock Well
- Interface Well
- Intermittent Stream
- Perennial Stream
- Inert Disposal Area IRP Site Boundary (HQAES # IAAP-020/020G)
- Plant Boundary
- CEA & ILF Boundary

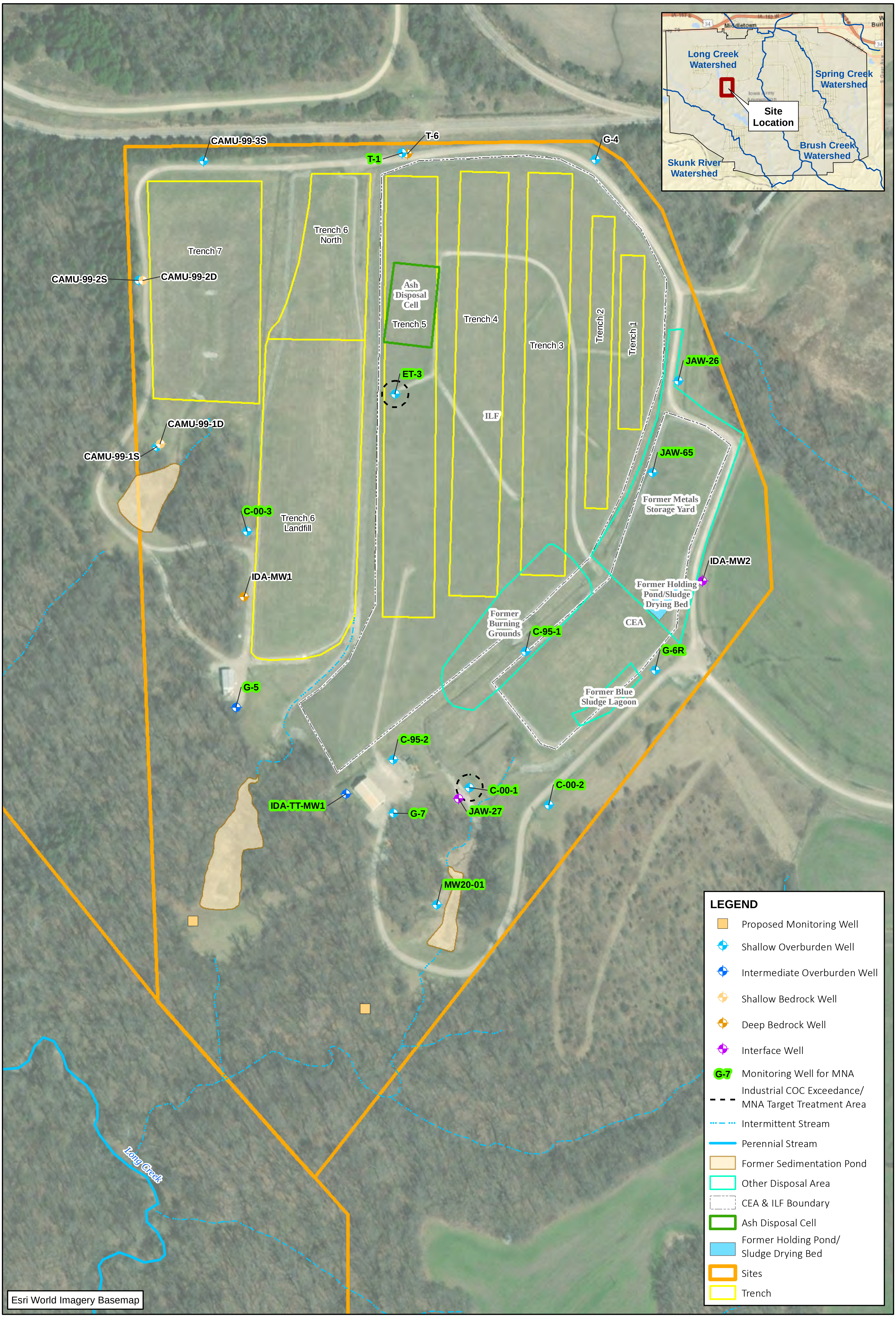
Notes:
1. 2022 Esri World Imagery Basemap
2. Results are reported in micrograms per liter (µg/L).
3. U = The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
4. J = The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
5. Groundwater results collected in 2019, 2020, and 2021.
6. Bold results exceed the project residential preliminary remedial goals (PRGs).

N

0 350 700
Feet

FIGURE 3-2
Residential Groundwater PRG Exceedances from 2019 to 2021
Inert Disposal Area
Iowa Army Ammunition Plant
Middletown, Iowa

Jacobs



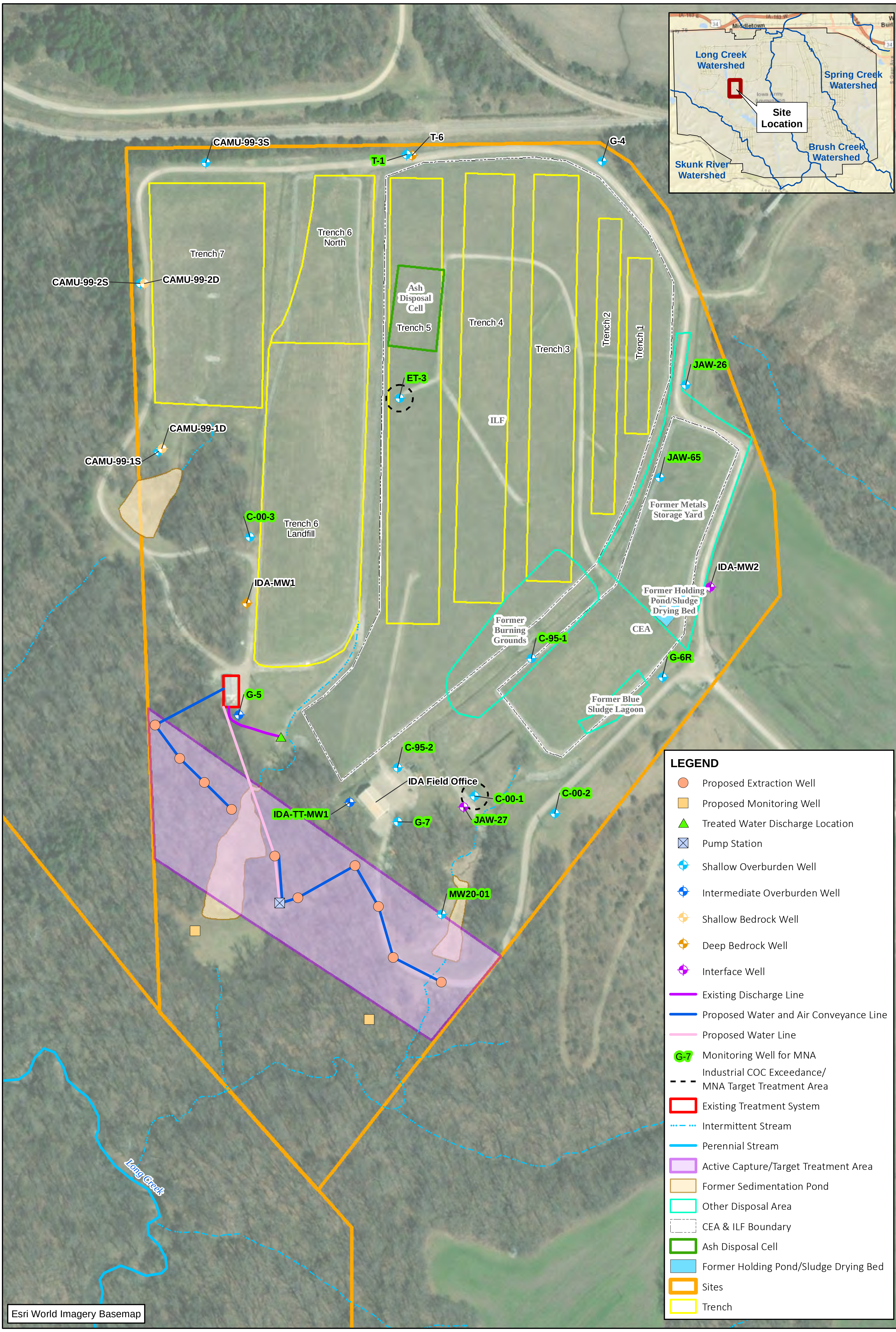
N

0 200
Feet

Figure 4-1
Alternative 2 Monitored Natural Attenuation Monitoring Well Locations
Inert Disposal Area
Iowa Army Ammunition Plant OU-4
Middletown, Iowa

\\DC1VS01\GISPROJ\U\USACE\IAAAP_679172\MAPFILES\TECHMEMO\IDA_ALT2_GWE.MXD GTWIGG 9/8/2022 11:41:38 AM

Jacobs



Notes:
1. All water/air conveyance lines and electrical conduit would be buried at least 18-inches below the ground surface.

N

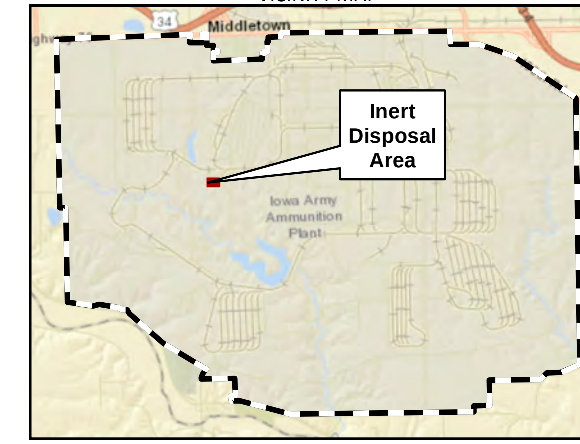
0 200
Feet

Figure 4-2
Alternative 3 Groundwater Extraction and Treatment Layout
Inert Disposal Area
Iowa Army Ammunition Plant OU-4
Middletown, Iowa

Jacobs

\\DC1VS01\GISPROJ\U\USACE\IAAAP_679172\MAPFILES\TECHMEMO\IDA_ALT3_GWE.MXD GTWIGG 9/8/2022 11:38:57 AM

VICINITY MAP



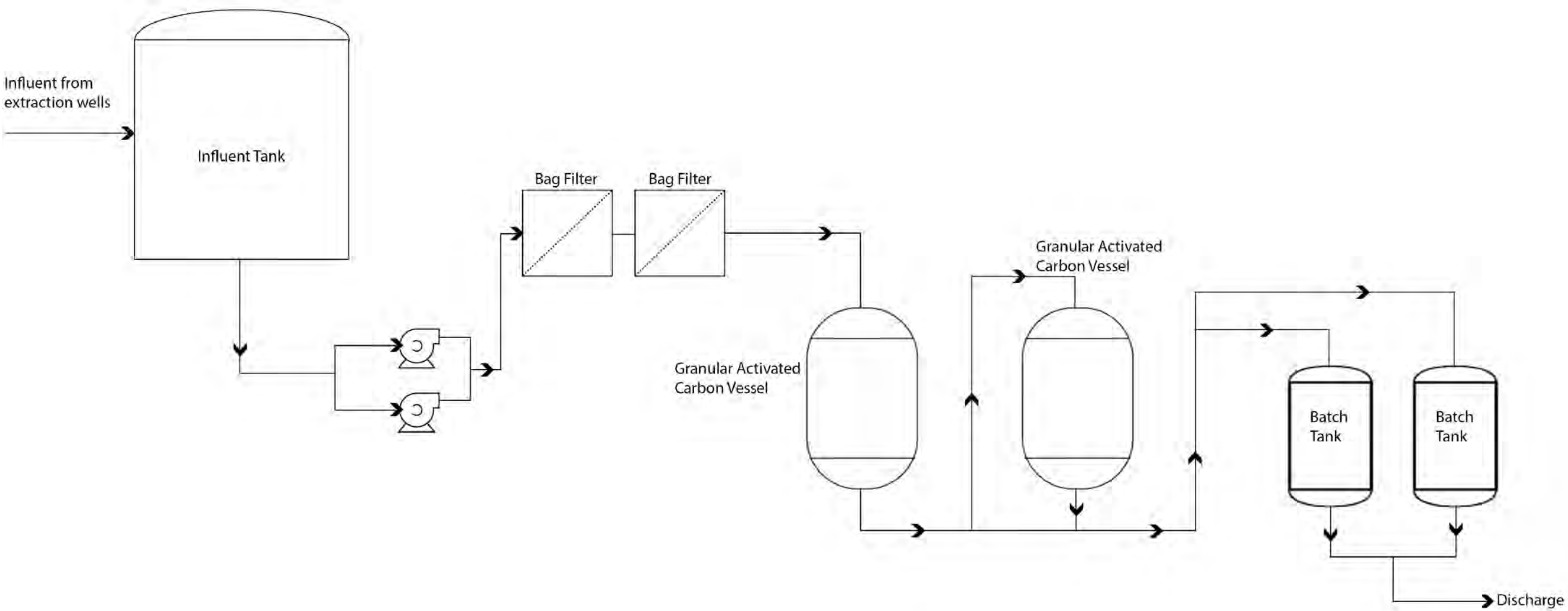
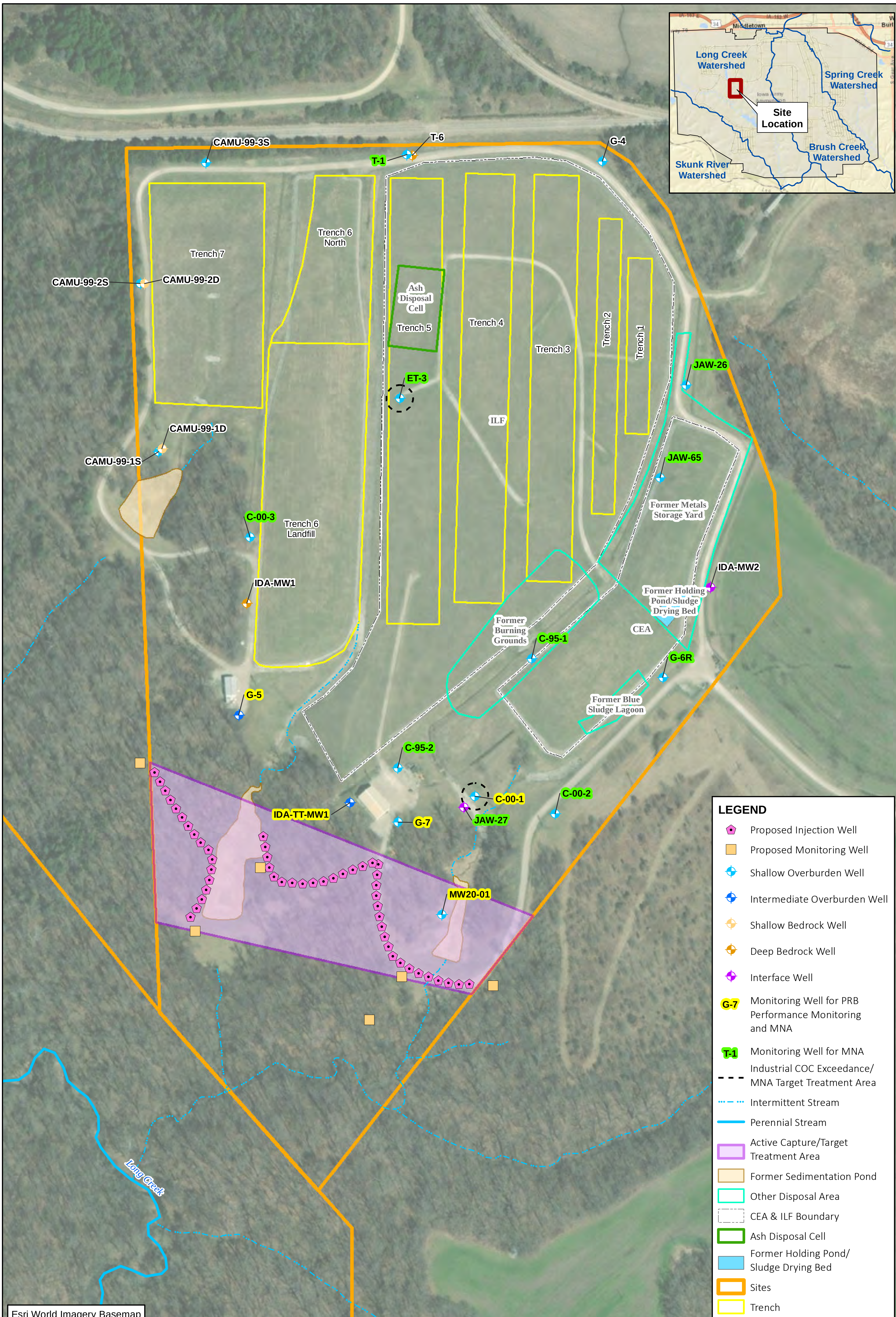


FIGURE 4-3
Alternative 3 Groundwater Treatment System Process Flow Diagram
Inert Disposal Area
Iowa Army Ammunition Plant
Middletown, Iowa

SCO \\DC1VS01\GISPROJ\U\USACE\IAAAP_679172\MAPFILES\TECHMEMO\FIGURE4-3_IDA_TS_FLOWDIAGRAM.MXD GTWIGG 5/16/2022 1:33:46 PM

Jacobs



N
0 200
Feet

Figure 4-4
Alternative 4 Permeable Reactive Barrier Layout
Inert Disposal Area
Iowa Army Ammunition Plant OU-4
Middletown, Iowa

Jacobs

\\DC1VS01\GISPROJ\U\USACE\IAAAP_679172\MAPFILES\TECHMEMO\IDA_ALT4_GWE.MXD GTWIGG 9/8/2022 11:36:48 AM

Appendix A
OU-4 RI Groundwater Data

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual
Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	C-00-1								C-00-2								C-00-3							
			Sample ID:	S16-T5-C-00-1		S17-T5-C-00-1		S18-T5-C-00-1		S19-T5-C-00-1		S16-T5-C-00-2		S17-T5-C-00-2		S18-T5-C-00-2		S19-T5-C-00-2		S16-T5-C-00-3		S17-T5-C-00-3		S18-T5-C-00-3		S19-T5-C-00-3	
			Date Collected:	4/12/2016		5/02/2017		5/11/2018		4/11/2019		4/12/2016		5/05/2017		5/16/2018		3/31/2019		4/12/2016		5/04/2017		5/13/2018		4/1/2019	
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ
99-35-4	1,3,5-Trinitrobenzene	Explosives	µg/L	0.19	U	0.093	U	0.051	UJ	0.11	U	0.19	U	0.094	U	0.053	U	0.1	U	0.19	U	0.093	U	0.053	J	0.11	U
99-65-0	1,3-Dinitrobenzene	Explosives	µg/L	0.19	U	0.075	U	0.1	UJ	0.11	U	0.19	U	0.076	U	0.11	U	0.1	U	0.19	U	0.075	U	0.1	U	0.11	U
118-96-7	2,4,6-Trinitrotoluene	Explosives	µg/L	0.19	U	0.075	U	0.1	UJ	0.11	U	0.19	U	0.076	U	0.11	U	0.1	U	0.19	U	0.075	U	0.1	U	0.11	U
121-14-2	2,4-Dinitrotoluene	Explosives	µg/L	0.19	U	0.075	U	0.1	UJ	0.11	U	0.19	U	0.076	U	0.11	U	0.1	U	0.19	U	0.075	U	0.1	U	0.11	U
606-20-2	2,6-Dinitrotoluene	Explosives	µg/L	0.19	U	0.075	U	0.1	UJ	0.11	U	0.19	U	0.076	U	0.11	U	0.1	U	0.19	U	0.075	U	0.1	U	0.11	U
35572-78-2	2-Amino-4,6-Dinitrotoluene	Explosives	µg/L	0.19	U	0.075	U	0.1	UJ	0.11	U	0.19	U	0.076	U	0.11	U	0.1	U	0.19	U	0.075	U	0.1	U	0.11	U
19406-51-0	4-Amino-2,6-Dinitrotoluene	Explosives	µg/L	0.19	U	0.075	U	0.1	UJ	0.11	U	0.19	U	0.076	U	0.11	U	0.1	U	0.19	U	0.075	U	0.1	U	0.11	U
2691-41-0	HMX	Explosives	µg/L	0.19	J	0.075	U	0.2	J	0.18		0.19	U	0.076	U	0.053	U	0.052	UJ	0.19	U	0.075	U	0.051	U	0.11	UJ
99-08-1	2-Nitrotoluene	Explosives	µg/L	0.19	U	0.075	U	0.1	UJ	0.21	U	0.19	U	0.076	U	0.11	U	0.21	U	0.19	U	0.075	U	0.1	U	0.21	U
98-95-3	Nitrobenzene	Explosives	µg/L	0.19	U	0.075	U	0.1	UJ	0.11	U	0.19	U	0.092	U	0.11	U	0.1	U	0.19	U	0.092	U	0.1	U	0.11	U
88-72-2	3-Nitrotoluene	Explosives	µg/L	0.19	U	0.075	U	0.1	UJ	0.21	U	0.19	U	0.076	U	0.11	U	0.21	U	0.19	U	0.075	U	0.1	U	0.21	U
99-99-0	4-Nitrotoluene	Explosives	µg/L	0.19	U	0.075	U	0.1	UJ	0.21	U	0.19	U	0.076	U	0.11	U	0.21	U	0.19	U	0.075	U	0.1	U	0.21	U
121-82-4	RDX	Explosives	µg/L	0.27		0.075	U	0.21	J	0.27		0.19	U	0.076	U	0.053	U	0.1	UJ	0.19	U	0.075	U	0.051	U	0.11	UJ
479-45-8	Tetryl	Explosives	µg/L	0.38	U	0.075	U	0.1	UJ	0.11	U	0.19	U	0.076	U	0.11	U	0.1	U	0.19	U	0.075	U	0.1	U	0.11	U
7429-90-5	Aluminum	Metals	µg/L	---		---		---		40	U	---		---		---		40	U	---		---		---		210	J
7440-43-9	Cadmium	Metals	µg/L	5	U	0.2	U	5	U	0.4	U	5	U	0.2	U	5	U	0.4	U	5	U	0.2	U	5	U	0.4	U
7440-70-2	Calcium	Metals	µg/L	---		---		---		140000		---		---		---		91000		---		---		---		97000	
7440-48-4	Cobalt	Metals	µg/L	---		---		---		3.2		---		---		---		1.8	U	---		---		---		1.8	U
7439-89-6	Iron	Metals	µg/L	300	U	52.2	J	100	U	22	J	---		---		40	J	40	U	---		---		170	=	320	
7439-95-4	Magnesium	Metals	µg/L	---		---		---		48000		---		---		---		33000		---		---		---		31000	
7439-96-5	Manganese	Metals	µg/L	53.9		134		19	J	30		15	U	5.1	J	300	U	3	U	16.3		34.9		12	J	17	
7439-98-7	Molybdenum	Metals	µg/L	---		---		---		4	U	---		---		---		4	U	---		---		---		2.8	J
7440-02-0	Nickel	Metals	µg/L	0.7	J	1.5	J	100	U	4	U	40	U	0.4	U	100	U	4	U	40	U	0.8	J	100	U	4	U
7440-09-7	Potassium	Metals	µg/L	---		---		---		570		---		---		---		450		---		---		---		950	
7440-22-4	Silver	Metals	µg/L	10	U	0.7	U	50	U	1.8	U	10	U	0.7	U	50	U	1.8	U	10	U	0.7	U	50	U	1.8	U
7440-23-5	Sodium	Metals	µg/L	---		---		---		31000		---		---		---		13000		---		---		---		13000	
7440-62-2	Vanadium	Metals	µg/L	0.8	J	0.9	J	50	U	8	U	50	U	0.7	J	50	U	8	U	0.9	J	2	J	50	U	8	U
7440-66-6	Zinc	Metals	µg/L	---		---		---		15	U	---		---		---		15	U	---		---		---		8.1	J
541-73-1	1,3-Dichlorobenzene	Semi-volatiles	µg/L	4.7	U	0.5	U	610	U	3.2	U	4.7	U	0.51	U	640	U	3.1	U	4.8	U	0.49	UJ	620	U	3	U
95-95-4	2,4,5-Trichlorophenol	Semi-volatiles	µg/L	4.7	U	0.74	U	400000	U	6.4	U	4.7	U	0.76	U	420000	U	6.2	U	4.8	U	0.73	UJ	410000	U	5.9	U
88-06-2	2,4,6-Trichlorophenol	Semi-volatiles	µg/L	4.7	U	0.75	U	2000	U	6.4	U	4.7	U	0.77	U	2100	U	6.2	U	4.8	U	0.74	UJ	2100	U	5.9	U
120-83-2	2,4-Dichlorophenol	Semi-volatiles	µg/L	4.7	U	0.84	U	20	U	6.4	U	4.7	U	0.85	U	21	UJ	6.2	U	4.8	U	0.82	UJ	21	U	5.9	U
105-67-9	2,4-Dimethylphenol	Semi-volatiles	µg/L	4.7	U	0.74	U	200000	U	6.4	U	4.7	U	0.75	U	210000	UJ	6.2	U	4.8	U	0.72	UJ	210000	U	5.9	U
51-28-5	2,4-Dinitrophenol	Semi-volatiles	µg/L	24	U	5	U	16	U	54	U	24	U	5.1	UJ	17	U	52	U	24	U	4.9	U	17	U	50	U
121-14-2	2,4-Dinitrotoluene	Semi-volatiles	µg/L	4.7	U	0.81	U	---		6.4	U	4.7	U	0.83	U	---		6.2	U	4.8	U	0.8	U	---		5.9	U
606-20-2	2,6-Dinitrotoluene	Semi-volatiles	µg/L	4.7	U	0.71	U	---		6.4	U	4.7	U	0.73	U	---		6.2	U	4.8	U	0.7	UJ	---		5.9	U
91-58-7	2-Chloronaphthalene	Semi-volatiles	µg/L	4.7	U	0.5	U	1.6	U	3.2	U	4.7	U	0.51	U	1.7	U	3.1	U	4.8	U	0.49	UJ	1.7	U	3	U
95-57-8	2-Chlorophenol	Semi-volatiles	µg/L	4.7	U	0.63	U	40	U	6.4	U	4.7	U	0.64	UJ	42	UJ	6.2	U	4.8	U	0.62	UJ	41	U	5.9	U
534-52-1	2-Methyl-4,6-dinitrophenol	Semi-volatiles	µg/L	9.4	U	2	U	16	U	6.4	U	9.4	U	2	U	17	U	6.2	U	9.5	U	2	U	17	U	5.9	U
91-57-6	2-Methylnaphthalene	Semi-volatiles	µg/L	---		0.6	U	1.6	U	3.2	U	---		0.61	U	1.7	UJ	3.1	U	---		0.59	UJ	1.7	U	3	U
95-48-7	2-Methylphenol	Semi-volatiles	µg/L	4.7	U	0.56	U	1.6	U	3.2	U	4.7	U	0.57	UJ	1.7	UJ	3.1	U	4.8	U	0.55	UJ	1.7	U	3	U
88-74-4	2-Nitroaniline	Semi-volatiles	µg/L	4.7	U	1.8	U	4	U	6.4	U	4.7	U	1.8	U	4.2	U	6.2	U	4.8	U	1.8	UJ	4.1	U	5.9	U
88-75-5	2-Nitrophenol	Semi-volatiles	µg/L	4.7	U	0.85	U	8.1	U	6.4	U	4.7	U	0.87	U	8.5	UJ	6.2	U	4.8	U	0.84	UJ	8.3	U	5.9	U
91-94-1	3,3'-Dichlorobenzidine	Semi-volatiles	µg/L	4.7	U	0.64	U	4	U	3.2	U	4.7	U	0.66	U	4.2	U	3.1	U	4.8	U	0.63	U	4.1	U	3	U
65794-96-9	3+4-Methylphenol	Semi-volatiles	µg/L	4.7	U	0.98	U	200000	U	3.2	UJ	4.7	U	1	U	210000	U	3.1	U	4.8	U	0.96	UJ	210000	U	3	U
99-09-2	3-Nitroaniline	Semi-volatiles	µg/L	4.7	U	0.88	U	61	U	3.2	U	4.7	U	0.9	U	64	U	3.1	U	4.8	U	0.86	UJ	62	U	3	U
101-55-3	4-Bromophenyl phenyl ether	Semi-volatiles	µg/L	4.7	U	0.85	U	4	U	3.2	U	4.7	U	0.86	U	4.2	U	3.1	U	4.8	U	0.83	U	4.1	U	3	U
59-50-7	4-Chloro-3-methylphenol	Semi-volatiles	µg/L	4.7	U	0.59	U	8.1	U	6.4	U	4.7	U	0.61	U	8.5	U	6.2	U	4.8	U	0.58	UJ	8.3	U	5.9	U
106-47-8	4-Chloroaniline	Semi-volatiles	µg/L	4.7	U	0.63	U	8.1	U	6.4	U	4.7	U	0.64	U	8.5	U	6.2	U	4.8	U	0.62	UJ	8.3	U	5.9	U
7005-72-3	4-Chlorophenyl phenyl ether	Semi-volatiles	µg/L	4.7	U	0.54	U	4	U	3.2	U	4.7	U	0.55	U	4.2	U	3.1	U	4.8	U	0.53	UJ	4.1	U	3	U
100-01-6	4-Nitroaniline	Semi-volatiles	µg/L	4.7	U	1.2	U	8.1	U	3.2	U	4.7	U	1.2	U	8.5	U	3.1	U	4.8	U	1.1	U	8.3	U	3	U
100-02-7	4-Nitrophenol	Semi-volatiles	µg/L	24	U	5	U	61	U	21	U	24	U	5.1	U	64	U	21	U	24	U	4.9	U	62	U	20	U
83-32-9	Acenaphthene	Semi-volatiles	µg/L	---		0.63	U	0.81	U	---		---		0.64	U	0.85	UJ	---		---		0.61	UJ	0.83	U	---	
208-96-8	Acenaphthylene	Semi-volatiles	µg/L	---		0.64	U	0.81	U	---		---		0.65	U	0.85	UJ	---		---		0.63	UJ	0.83	U	---	
120-12-7	Anthracene	Semi-volatiles	µg/L	---		0.8	U	0.81	U	---		---		0.81	U	0.85	UJ	---		---		0.78	U	0.83	U	---	
56-55-3	Benz(a)anthracene	Semi-volatiles	µg/L	---		0.76	U	0.16	U	---		---		0.78	U	0.17	UJ	---		---		0.75	U	0.17	U	---	
100-51-6	Benzyl alcohol	Semi-volatiles	µg/L	4.7	U	0.61	U	16	U	6.4	U	4.7	U	0.63	UJ	17	U	6.2	U	4.8	U	0.6	UJ	17	U	5.9	U
205-99-2	Benzo(b)fluoranthene	Semi-volatiles	µg/L	---		0.78	U	0.16	U	---		---		0.79	U	0.17	UJ	---		---		0.76	U	0.17	U	---	
191-24-2	Benzo(ghi)perylene	Semi-volatiles	µg/L	---		0.82	U	0.81	U	---		---		0.84	U	0.85	UJ	---		---		0.81	U	0.83	U	---	
207-08-9	Benzo(k)fluoranthene	Semi-volatiles	µg/L	---		0.86	U	0.16	U	---		---		0.88	U	0.17	UJ	---		---		0.84	U	0.17	U	---	
65-85-0	Benzoic acid	Semi-volatiles	µg/L	47	U	10	U	16	U	54	U	47	U	10	U	17	UJ	52	U	48	U	9.8	U	17	U	50	U
111-91-1	Bis(2-chloroethoxy) methane	Semi-volatiles	µg/L	4.7	U	0.81	U	1.6	U	3.2	U	4.7	U	0.83	UJ	1.7	U	3.1	U	4.8	U	0.79	UJ	1.7	U	3	U
111-44-4	Bis(2-chloroethyl) ether	Semi-volatiles	µg/L	4.7	U	0.73	U	1.6	U	3.2	U	4.7	U	0.75	UJ	1.7	U	3.1	U	4.8	U	0.72	UJ	1.7	U	3	U
108-60-1	Bis(2-chloroisopropyl) ether	Semi-volatiles	µg/L	4.7	U	0.76	U	300	U	3.2	UJ	4.7	U	0.77	UJ	320	U	3.1	U	4.8	U	0.74	UJ	310	U	3	U
85-68-7	Butyl benzyl phthalate	Semi-volatiles	µg/L	4.7	U	1	U	1.6	U	3.2	U	4.7	U	1	U	1.7	U	3.1	U	4.8	U	0.98	U	1.7	U	3	U
86-74-8	Carbazole	Semi-volatiles	µg/L	4.7	U	0.6	U	4	U	3.2	U	4.7	U	0.61	U	4.2	UJ	3.1	U	4.8	U	0.59	U	4.1	U	3	U

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	C-95-1								C-95-2								CAMU-99-1S		CAMU-99-1D		CAMU-99-2S	
			Sample ID:	S16-T5-C95-1		S17-T5-C-95-1		S18-T5-C-95-1		S19-T5-C95-1		S16-T5-C95-2		S17-T5-C-95-2		S18-T5-C95-2		S19-T5-C95-2		IAAP020-CAMU-99-1S-GW		IAAP020-CAMU-99-1D-GW		IAAP020-CAMU-99-2S-GW	
			Date Collected:	4/13/2016		5/03/2017		5/16/2018		4/10/2019		4/13/2016		5/04/2017		5/12/2018		3/28/2019		4/2/2019		4/2/2019		4/2/2019	
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
99-35-4	1,3,5-Trinitrobenzene	Explosives	µg/L	0.19	U	0.094	U	0.05	U	0.11	U	0.2	U	0.093	U	0.053	U	0.1	U	0.033	J	0.11	UJ	0.1	UJ
99-65-0	1,3-Dinitrobenzene	Explosives	µg/L	0.19	U	0.076	U	0.099	U	0.11	U	0.2	U	0.075	U	0.11	U	0.1	U	0.11	U	0.11	U	0.1	U
118-96-7	2,4,6-Trinitrotoluene	Explosives	µg/L	0.19	U	0.076	U	0.099	U	0.11	U	0.2	U	0.075	U	0.11	U	0.1	U	0.11	U	0.11	U	0.1	U
121-14-2	2,4-Dinitrotoluene	Explosives	µg/L	0.19	U	0.076	U	0.099	U	0.11	U	0.2	U	0.075	U	0.11	U	0.1	U	0.11	U	0.11	U	0.1	U
606-20-2	2,6-Dinitrotoluene	Explosives	µg/L	0.19	U	0.076	U	0.099	U	0.11	U	0.2		0.075	U	0.11	U	0.1	U	0.11	U	0.11	U	0.1	U
35572-78-2	2-Amino-4,6-Dinitrotoluene	Explosives	µg/L	0.19	U	0.076	U	0.12	J	0.11	U	0.2	U	0.075	U	0.11	U	0.1	U	0.11	U	0.11	U	0.1	U
19406-51-0	4-Amino-2,6-Dinitrotoluene	Explosives	µg/L	0.19	U	0.076	U	0.11	=	0.11	U	0.2	U	0.075	U	0.11	U	0.1	U	0.11	U	0.11	U	0.1	U
2691-41-0	HMX	Explosives	µg/L	0.85	J	0.076	U	0.43	J	0.42	J	0.2	U	0.075	U	0.053	U	0.1	U	0.11	U	0.11	U	0.1	U
99-08-1	2-Nitrotoluene	Explosives	µg/L	0.19	U	0.076	U	0.099	U	0.21	U	0.2	U	0.075	U	0.11	U	0.21	U	0.21	U	0.22	U	0.21	U
98-95-3	Nitrobenzene	Explosives	µg/L	0.19	U	0.092	U	0.099	U	0.11	U	0.2	U	0.092	U	0.11	U	0.1	U	0.11	U	0.11	U	0.1	U
88-72-2	3-Nitrotoluene	Explosives	µg/L	0.19	U	0.076	U	0.099	U	0.21	U	0.2	U	0.075	U	0.11	U	0.21	U	0.21	U	0.22	U	0.21	U
99-99-0	4-Nitrotoluene	Explosives	µg/L	0.19	U	0.076	U	0.099	U	0.21	U	0.2	U	0.075	U	0.11	U	0.21	U	0.21	U	0.22	U	0.21	U
121-82-4	RDX	Explosives	µg/L	0.19	U	0.076	U	0.05	U	0.11	UJ	0.23		0.29		0.28	J	0.2		0.11	U	0.11	U	0.086	J
479-45-8	Tetryl	Explosives	µg/L	0.19	U	0.076	U	0.099	U	0.11	U	0.2	U	0.075	U	0.11	U	0.1	U	0.11	U	0.11	U	0.1	U
7429-90-5	Aluminum	Metals	µg/L	---		---		---		1000		---		---		---		290		63		210		91	
7440-43-9	Cadmium	Metals	µg/L	5	U	0.2	U	5	U	0.4	U	5	U	0.2	U	5	U	0.4	U	0.4	U	0.4	U	0.4	U
7440-70-2	Calcium	Metals	µg/L	---		---		---		120000		---		---		---		100000		82000		160000		40000	
7440-48-4	Cobalt	Metals	µg/L	---		---		---		1.8	U	---		---		---		1.8	U	1.2	J	1.8	U	1.8	U
7439-89-6	Iron	Metals	µg/L	---		---		130	=	990		---		---		36	J	440		290		240		68	
7439-95-4	Magnesium	Metals	µg/L	---		---		---		24000		---		---		---		32000		27000		56000		14000	
7439-96-5	Manganese	Metals	µg/L	6.9	J	21.9		13	J	23		2.3		4.8	J	300	U	6.6		88		630		19	
7439-98-7	Molybdenum	Metals	µg/L	---		---		---		3.4	J	---		---		---		4	U	---		---		---	
7440-02-0	Nickel	Metals	µg/L	2.5	J	1.1	J	100	U	2.3	J	40	U	0.4	U	100	U	4	U	2.9	J	4	U	4	U
7440-09-7	Potassium	Metals	µg/L	---		---		---		1400		---		---		---		400		2900		1200		1300	
7440-22-4	Silver	Metals	µg/L	10	U	0.7	U	50	U	1.8	U	10	U	0.7	U	50	U	1.8	U	1.8	U	1.8	U	1.8	U
7440-23-5	Sodium	Metals	µg/L	---		---		---		15000		---		---		---		27000		72000		27000		16000	
7440-62-2	Vanadium	Metals	µg/L	50	U	0.6	U	50	U	8	U	50	U	0.9	J	50	U	8	U	8	U	8	U	8	U
7440-66-6	Zinc	Metals	µg/L	---		---		---		15	U	---		---				15	U	15	U	15	U	15	U
541-73-1	1,3-Dichlorobenzene	Semi-volatiles	µg/L	5	U	0.51	UJ	610	U	3.3	UJ	5	U	0.49	UJ	630	U	3.1	U	3.2	U	3	U	3.2	U
95-95-4	2,4,5-Trichlorophenol	Semi-volatiles	µg/L	5	U	0.76	UJ	410000	U	6.6	U	5	U	0.73	UJ	420000	U	6.3	U	6.3	U	6	U	6.3	U
88-06-2	2,4,6-Trichlorophenol	Semi-volatiles	µg/L	5	U	0.77	UJ	2000	U	6.6	U	5	U	0.74	UJ	2100	U	6.3	U	6.3	U	6	U	6.3	U
120-83-2	2,4-Dichlorophenol	Semi-volatiles	µg/L	5	U	0.85	UJ	20	UJ	6.6	U	5	U	0.82	UJ	21	U	6.3	U	6.3	U	6	U	6.3	U
105-67-9	2,4-Dimethylphenol	Semi-volatiles	µg/L	5	U	0.75	UJ	200000	UJ	6.6	U	5	U	0.72	UJ	210000	U	6.3	U	6.3	U	6	U	6.3	U
51-28-5	2,4-Dinitrophenol	Semi-volatiles	µg/L	25	U	5.1	U	16	U	55	U	25	U	4.9	U	17	U	52	U	53	U	50	U	53	U
121-14-2	2,4-Dinitrotoluene	Semi-volatiles	µg/L	5	U	0.83	U	---		6.6	U	5	U	0.075	U	---		6.3	U	6.3	U	6	U	6.3	U
606-20-2	2,6-Dinitrotoluene	Semi-volatiles	µg/L	5	U	0.73	UJ	---		6.6	U	5	U	0.075	U	---		6.3	U	6.3	U	6	U	6.3	U
91-58-7	2-Chloronaphthalene	Semi-volatiles	µg/L	5	U	0.51	UJ	1.6	U	3.3	U	5	U	0.49	UJ	1.7	U	3.1	U	3.2	U	3	U	3.2	U
95-57-8	2-Chlorophenol	Semi-volatiles	µg/L	5	U	0.64	UJ	41	UJ	6.6	UJ	5	U	0.62	UJ	42	U	6.3	U	6.3	U	6	U	6.3	U
534-52-1	2-Methyl-4,6-dinitrophenol	Semi-volatiles	µg/L	10	U	2	U	16	U	6.6	U	9.9	U	2	U	17	U	6.3	U	6.3	U	6	U	6.3	U
91-57-6	2-Methylnaphthalene	Semi-volatiles	µg/L	---		0.61	UJ	1.6	U	3.3	U	---		0.59	UJ	1.7	U	3.1	U	3.2	U	3	U	3.2	U
95-48-7	2-Methylphenol	Semi-volatiles	µg/L	5	U	0.57	UJ	1.6	UJ	3.3	U	5	U	0.55	UJ	1.7	U	3.1	U	3.2	U	3	U	3.2	U
88-74-4	2-Nitroaniline	Semi-volatiles	µg/L	5	U	1.8	UJ	4.1	U	6.6	U	5	U	1.8	UJ	4.2	U	6.3	U	6.3	U	6	U	6.3	U
88-75-5	2-Nitrophenol	Semi-volatiles	µg/L	5	U	0.87	UJ	8.2	UJ	6.6	U	5	U	0.84	UJ	8.4	U	6.3	U	6.3	U	6	U	6.3	U
91-94-1	3,3'-Dichlorobenzidine	Semi-volatiles	µg/L	5	U	0.66	U	4.1	U	3.3	U	5	U	0.63	U	4.2	U	3.1	U	3.2	U	3	U	3.2	U
65794-96-9	3+4-Methylphenol	Semi-volatiles	µg/L	5	U	1	UJ	200000	U	3.3	U	5	U	0.96	UJ	210000	U	3.1	U	3.2	UJ	3	U	3.2	U
99-09-2	3-Nitroaniline	Semi-volatiles	µg/L	5	U	0.9	UJ	61	U	3.3	U	5	U	0.86	UJ	63	U	3.1	U	3.2	U	3	U	3.2	U
101-55-3	4-Bromophenyl phenyl ether	Semi-volatiles	µg/L	5	U	0.86	U	4.1	U	3.3	U	5	U	0.83	U	4.2	U	3.1	U	3.2	U	3	U	3.2	U
59-50-7	4-Chloro-3-methylphenol	Semi-volatiles	µg/L	5	U	0.61	UJ	8.2	U	6.6	U	5	U	0.58	UJ	8.4	U	6.3	U	6.3	U	6	U	6.3	U
106-47-8	4-Chloroaniline	Semi-volatiles	µg/L	5	U	0.64	UJ	8.2	U	6.6	U	5	U	0.62	UJ	8.4	U	6.3	U	6.3	U	6	U	6.3	U
7005-72-3	4-Chlorophenyl phenyl ether	Semi-volatiles	µg/L	5	U	0.55	UJ	4.1	U	3.3	U	5	U	0.53	UJ	4.2	U	3.1	U	3.2	U	3	U	3.2	U
100-01-6	4-Nitroaniline	Semi-volatiles	µg/L	5	U	1.2	U	8.2	U	3.3	U	5	U	1.1	U	8.4	U	3.1	U	3.2	U	3	U	3.2	U
100-02-7	4-Nitrophenol	Semi-volatiles	µg/L	25	U	5.1	U	61	U	22	U	25	U	4.9	U	63	U	21	U	21	U	20	U	21	U
83-32-9	Acenaphthene	Semi-volatiles	µg/L	---		0.64	UJ	0.82	UJ	---		---		0.61	UJ	0.84	U	---		---		---		---	
208-96-8	Acenaphthylene	Semi-volatiles	µg/L	---		0.65	UJ	0.82	UJ	---		---		0.63	UJ	0.84	U	---		---		---		---	
120-12-7	Anthracene	Semi-volatiles	µg/L	---		0.81	U	0.82	UJ	---		---		0.78	U	0.84	U	---		---		---		---	
56-55-3	Benz(a)anthracene	Semi-volatiles	µg/L	---		0.78	U	0.16	UJ	---		---		0.75	U	0.17	U	---		---		---		---	
100-51-6	Benzyl alcohol	Semi-volatiles	µg/L	5	U	0.63	UJ	16	U	6.6	U	5	U	0.6	UJ	17	U	6.3	U	6.3	U	6	U	6.3	U
205-99-2	Benzo(b)fluoranthene	Semi-volatiles	µg/L	---		0.79	U	0.16	UJ	---		---		0.76	U	0.17	U	---		---		---		---	
191-24-2	Benzo(ghi)perylene	Semi-volatiles	µg/L	---		0.84	U	0.82	UJ	---		---		0.81	U	0.84	U	---		---		---		---	
207-08-9	Benzo(k)fluoranthene	Semi-volatiles	µg/L	---		0.88	U	0.16	UJ	---		---		0.84	U	0.17	U	---		---		---		---	
65-85-0	Benzoic acid	Semi-volatiles	µg/L	50	U	10	U	16	UJ	55	U	50	U	9.8	U	17	U	52	U	53	U	50	U	53	U
111-91-1	Bis(2-chloroethoxy) methane	Semi-volatiles	µg/L	5	U	0.83	UJ	1.6	U	3.3	U	5	U	0.79	UJ	1.7	U	3.1	U	3.2	U	3	U	3.2	U
111-44-4	Bis(2-chloroethyl) ether	Semi-volatiles	µg/L	5	U	0.75	UJ	1.6	U	3.3	UJ	5	U	0.72	UJ	1.7	U	3.1	U	3.2	U	3	U	3.2	U
108-60-1	Bis(2-chloroisopropyl) ether	Semi-volatiles	µg/L	5	U	0.77	UJ	310	U	3.3	U	5	U	0.74	UJ	320	U	3.1	U	3.2	UJ	3	U	3.2	U
85-68-7	Butyl benzyl phthalate	Semi-volatiles	µg/L	5	U	1	U	1.6	U	3.3	U	5	U	0.98	U	1.7	U	3.1	U	3.2	U	3	U	3.2	U
86-74-8	Carbazole	Semi-volatiles	µg/L	5	U	0.61	U	4.1	UJ	3.3	U	5	U	0.59	U	4.2	U	3.1	U	3.2	U	3	U	3.2	U

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	CAMU-99-2D		CAMU-99-3S		ET-3								G-5							
			Sample ID:	IAAP020-CAMU-99-2D-GW		IAAP020-CAMU-99-3S-GW		S16-T5-ET-3		S17-T5-ET-3		S18-T5-ET-3		S19-T5-ET-3		S16-T5-G-5		S17-T5-G-5		S18-T5-G-5		S19-T5-G-5	
			Date Collected:	4/2/2019		4/3/2019		4/14/2016		5/02/2017		5/15/2018		4/11/2019		4/13/2016		5/05/2017		5/13/2018		4/1/2019	
			Units	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ
99-35-4	1,3,5-Trinitrobenzene	Explosives	µg/L	0.11	UJ	0.11	U	2	U	0.93	U	0.43	J	0.7	J	0.19	U	0.093	U	0.051	U	0.11	U
99-65-0	1,3-Dinitrobenzene	Explosives	µg/L	0.11	U	0.11	U	2	U	0.75	U	0.1	UJ	0.2	UJ	0.19	U	0.075	U	0.1	U	0.11	U
118-96-7	2,4,6-Trinitrotoluene	Explosives	µg/L	0.11	U	0.11	U	2	U	0.75	U	0.8	J	0.17	J	0.19	U	0.075	U	0.1	U	0.11	U
121-14-2	2,4-Dinitrotoluene	Explosives	µg/L	0.11	U	0.11	U	2	U	0.75	U	0.1	UJ	1.1		0.19	U	0.075	U	0.1	U	0.11	U
606-20-2	2,6-Dinitrotoluene	Explosives	µg/L	0.11	U	0.11	U	2	U	0.75	U	0.1	UJ	0.2	UJ	0.19	U	0.075	U	0.1	U	0.11	U
35572-78-2	2-Amino-4,6-Dinitrotoluene	Explosives	µg/L	0.11	U	0.11	U	2	U	0.75	U	0.1	UJ	0.3	J	0.19	U	0.075	U	0.1	U	0.11	U
19406-51-0	4-Amino-2,6-Dinitrotoluene	Explosives	µg/L	0.11	U	0.11	U	2	U	0.75	U	0.1	UJ	0.2	UJ	0.19	U	0.075	U	0.1	U	0.11	U
2691-41-0	HMX	Explosives	µg/L	0.11	U	0.16		2	U	0.75	U	0.36	J	6	J	0.24	J	0.075	U	0.27	J	0.36	J
99-08-1	2-Nitrotoluene	Explosives	µg/L	0.21	U	0.22	U	2	U	0.75	U	0.1	UJ	0.4	UJ	0.19	U	0.075	U	0.1	U	0.22	U
98-95-3	Nitrobenzene	Explosives	µg/L	0.11	U	0.11	U	2.6		0.92	U	0.1	UJ	0.2	UJ	0.19	U	0.092	U	0.1	U	0.11	U
88-72-2	3-Nitrotoluene	Explosives	µg/L	0.21	U	0.22	U	2	U	0.75	U	0.1	UJ	0.4	UJ	0.19	U	0.075	U	0.1	U	0.22	U
99-99-0	4-Nitrotoluene	Explosives	µg/L	0.21	U	0.22	U	2	U	0.75	U	0.1	UJ	0.4	UJ	0.19	U	0.075	U	0.1	U	0.22	U
121-82-4	RDX	Explosives	µg/L	0.11	U	2.2		2	U	0.75	U	0.052	UJ	0.88	J	0.19	U	0.075	U	0.066	J	0.089	UJ
479-45-8	Tetryl	Explosives	µg/L	0.11	U	0.11	U	2	U	0.75	U	0.1	UJ	0.43	UJ	0.19	U	0.075	U	0.1	U	0.11	U
7429-90-5	Aluminum	Metals	µg/L	330		120		---		---		---		40	U	---		---		---		27	J
7440-43-9	Cadmium	Metals	µg/L	0.4	U	0.4	U	5	U	0.2	U	5	U	1	U	5	U	0.2	U	5	U	0.4	U
7440-70-2	Calcium	Metals	µg/L	100000		120000		---		---		---		190000		---		---		---		150000	
7440-48-4	Cobalt	Metals	µg/L	0.95	J	1.8	U	---		---		---		2.5	J	---		---		---		1.8	U
7439-89-6	Iron	Metals	µg/L	1700		100		---		26200		16000	=	23000		---		---		170	=	350	
7439-95-4	Magnesium	Metals	µg/L	40000		48000		---		---		---		340000		---		---		---		54000	
7439-96-5	Manganese	Metals	µg/L	180		2.8	J	442		512		440	=	650		227		191		34	J	69	
7439-98-7	Molybdenum	Metals	µg/L	---		---		---		---		---		10	U	---		---		---		4	U
7440-02-0	Nickel	Metals	µg/L	5.2		4	U	31.9	J	15.2	J	25	J	20		4	J	2.3	J	100	U	2.7	J
7440-09-7	Potassium	Metals	µg/L	3100		500		---		---		---		12000		---		---		---		660	
7440-22-4	Silver	Metals	µg/L	1.8	U	1.8	U	10	U	0.7	U	50	U	4.5	U	10	U	0.7	U	50	U	1.8	U
7440-23-5	Sodium	Metals	µg/L	48000		22000		---		---		---		170000		---		---		---		23000	
7440-62-2	Vanadium	Metals	µg/L	8	U	8	U	1.4	J	2.1	J	50	U	20	U	2.6	J	0.6	U	50	U	8	U
7440-66-6	Zinc	Metals	µg/L	9.2	J	15	U	---		---		---		38	U	---		---		---		15	U
541-73-1	1,3-Dichlorobenzene	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	0.5	U	6400	UJ	3	U	4.8	U	0.5	UJ	620	U	3.1	U
95-95-4	2,4,5-Trichlorophenol	Semi-volatiles	µg/L	6.2	U	6.4	U	41	U	0.88	J	4300000	UJ	6	U	4.8	U	0.74	UJ	410000	U	6.1	U
88-06-2	2,4,6-Trichlorophenol	Semi-volatiles	µg/L	6.2	U	6.4	U	41	U	1.3	J	21000	UJ	6	U	4.8	U	0.75	UJ	2100	U	6.1	U
120-83-2	2,4-Dichlorophenol	Semi-volatiles	µg/L	6.2	U	6.4	U	41	U	16.1		210	UJ	6	U	4.8	U	0.84	UJ	21	U	6.1	U
105-67-9	2,4-Dimethylphenol	Semi-volatiles	µg/L	6.2	U	6.4	U	41	U	0.74	U	2100000	UJ	6	U	4.8	U	0.74	UJ	210000	U	6.1	U
51-28-5	2,4-Dinitrophenol	Semi-volatiles	µg/L	52	U	54	U	R		5	U	170	UJ	50	U	24	U	5	U	17	U	51	U
121-14-2	2,4-Dinitrotoluene	Semi-volatiles	µg/L	6.2	U	6.4	U	41	U	0.81	U	---		6	U	4.8	U	0.81	U	---		6.1	U
606-20-2	2,6-Dinitrotoluene	Semi-volatiles	µg/L	6.2	U	6.4	U	41	U	0.71	U	---		6	U	4.8	U	0.71	UJ	---		6.1	U
91-58-7	2-Chloronaphthalene	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	0.5	U	17	U	3	U	4.8	U	0.5	UJ	1.7	U	3.1	U
95-57-8	2-Chlorophenol	Semi-volatiles	µg/L	6.2	U	6.4	U	41	U	1.1	J	430	UJ	6	U	4.8	U	0.63	UJ	41	U	6.1	U
534-52-1	2-Methyl-4,6-dinitrophenol	Semi-volatiles	µg/L	6.2	U	6.4	U	82	U	2	U	170	UJ	28	J	9.5	U	2	U	17	U	6.1	U
91-57-6	2-Methylnaphthalene	Semi-volatiles	µg/L	3.1	U	3.2	U	---		0.6	U	17	U	3	U	---		0.6	UJ	1.7	U	3.1	U
95-48-7	2-Methylphenol	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	0.56	U	17	UJ	3	U	4.8	U	0.56	UJ	1.7	U	3.1	U
88-74-4	2-Nitroaniline	Semi-volatiles	µg/L	6.2	U	6.4	U	41	U	1.8	U	43	U	6	U	4.8	U	1.8	UJ	4.1	U	6.1	U
88-75-5	2-Nitrophenol	Semi-volatiles	µg/L	6.2	U	6.4	U	41	U	0.85	U	86	UJ	6	U	4.8	U	0.85	UJ	8.3	U	6.1	U
91-94-1	3,3'-Dichlorobenzidine	Semi-volatiles	µg/L	3.1	U	3.2	U	R		0.64	U	43	U	3	U	4.8	U	0.64	U	4.1	U	3.1	U
65794-96-9	3+4-Methylphenol	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	4.2	J	15	J	2.1	J	4.8	U	0.98	UJ	210000	U	3.1	U
99-09-2	3-Nitroaniline	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	0.88	U	640	U	3	U	4.8	U	0.88	UJ	62	U	3.1	U
101-55-3	4-Bromophenyl phenyl ether	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	0.85	U	43	U	3	U	4.8	U	0.85	U	4.1	U	3.1	U
59-50-7	4-Chloro-3-methylphenol	Semi-volatiles	µg/L	6.2	U	6.4	U	41	U	0.59	U	86	UJ	6	U	4.8	U	0.59	UJ	8.3	U	6.1	U
106-47-8	4-Chloroaniline	Semi-volatiles	µg/L	6.2	U	6.4	U	41	U	0.63	U	86	UJ	6	U	4.8	U	0.63	UJ	8.3	U	6.1	U
7005-72-3	4-Chlorophenyl phenyl ether	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	0.54	U	43	U	3	U	4.8	U	0.54	UJ	4.1	U	3.1	U
100-01-6	4-Nitroaniline	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	1.2	U	86	U	3	U	4.8	U	1.2	U	8.3	U	3.1	U
100-02-7	4-Nitrophenol	Semi-volatiles	µg/L	21	U	21	U	200	U	5	U	640	UJ	20	U	24	U	5	U	62	U	20	U
83-32-9	Acenaphthene	Semi-volatiles	µg/L	---		---		---		0.63	U	8.6	UJ	---		---		0.63	UJ	0.83	UJ	---	
208-96-8	Acenaphthylene	Semi-volatiles	µg/L	---		---		---		0.64	U	8.6	UJ	---		---		0.64	UJ	0.83	UJ	---	
120-12-7	Anthracene	Semi-volatiles	µg/L	---		---		---		0.8	U	8.6	UJ	---		---		0.8	U	0.83	UJ	---	
56-55-3	Benz(a)anthracene	Semi-volatiles	µg/L	---		---		---		0.76	U	1.7	UJ	---		---		0.76	U	0.17	UJ	---	
100-51-6	Benzyl alcohol	Semi-volatiles	µg/L	6.2	U	6.4	U	41	U	0.61	U	170	UJ	6	U	4.8	U	0.61	UJ	17	U	6.1	U
205-99-2	Benzo(b)fluoranthene	Semi-volatiles	µg/L	---		---		---		0.78	U	1.7	UJ	---		---		0.78	U	0.17	UJ	---	
191-24-2	Benzo(ghi)perylene	Semi-volatiles	µg/L	---		---		---		0.82	U	8.6	UJ	---		---		0.82	U	0.83	UJ	---	
207-08-9	Benzo(k)fluoranthene	Semi-volatiles	µg/L	---		---		---		0.86	U	1.7	UJ	---		---		0.86	U	0.17	UJ	---	
65-85-0	Benzoic acid	Semi-volatiles	µg/L	52	U	54	U	R		10	U	170	UJ	50	U	48	U	10	U	17	U	51	U
111-91-1	Bis(2-chloroethoxy) methane	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	0.81	U	17	UJ	3	U	4.8	U	0.81	UJ	1.7	U	3.1	U
111-44-4	Bis(2-chloroethyl) ether	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	0.73	U	17	U	3	U	4.8	U	0.73	UJ	1.7	U	3.1	U
108-60-1	Bis(2-chloroisopropyl) ether	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	0.76	U	3200	U	3	U	4.8	U	0.76	UJ	310	U	3.1	U
85-68-7	Butyl benzyl phthalate	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	1	U	17	U	3	U	4.8	U	1	U	1.7	U	3.1	U
86-74-8	Carbazole	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	0.6	U	43	UJ	3	U	4.8	U	0.6	U	4.1	U	3.1	U

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	G-6R								G-7								IDA-MW1	
			Sample ID:	S16-T5-G-6R		S17-T5-G-6R		S18-T5-G-6R		S19-T5-G-6R		S16-T5-G-7		S17-T5-G-7		S18-T5-G-7		S19-T5-G-7		IAAP020-IDA-MW1-GW	
			Date Collected:	4/15/2016		5/05/2017		5/17/2018		3/31/2019		4/14/2016		5/04/2017		5/13/2018		3/28/2019		4/3/2019	
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ
99-35-4	1,3,5-Trinitrobenzene	Explosives	µg/L	---		---		---		0.1	U	---		---		---		0.1	U	0.1	U
99-65-0	1,3-Dinitrobenzene	Explosives	µg/L	---		---		---		0.1	U	---		---		---		0.1	U	0.1	U
118-96-7	2,4,6-Trinitrotoluene	Explosives	µg/L	---		---		---		0.1	U	---		---		---		0.1	U	0.1	U
121-14-2	2,4-Dinitrotoluene	Explosives	µg/L	---		---		---		0.1	U	---		---		---		0.1	U	0.1	U
606-20-2	2,6-Dinitrotoluene	Explosives	µg/L	---		---		---		0.1	U	---		---		---		0.1	U	0.1	U
35572-78-2	2-Amino-4,6-Dinitrotoluene	Explosives	µg/L	---		---		---		0.1	U	---		---		---		0.1	U	0.1	U
19406-51-0	4-Amino-2,6-Dinitrotoluene	Explosives	µg/L	---		---		---		0.1	U	---		---		---		0.1	U	0.1	U
2691-41-0	HMX	Explosives	µg/L	---		---		---		0.1	UJ	---		---		---		0.1	U	0.1	U
99-08-1	2-Nitrotoluene	Explosives	µg/L	---		---		---		0.21	U	---		---		---		0.2	U	0.21	U
98-95-3	Nitrobenzene	Explosives	µg/L	---		---		---		0.1	U	---		---		---		0.1	U	0.1	U
88-72-2	3-Nitrotoluene	Explosives	µg/L	---		---		---		0.21	U	---		---		---		0.2	U	0.21	U
99-99-0	4-Nitrotoluene	Explosives	µg/L	---		---		---		0.21	U	---		---		---		0.2	U	0.21	U
121-82-4	RDX	Explosives	µg/L	---		---		---		0.1	UJ	---		---		---		0.1	U	0.1	U
479-45-8	Tetryl	Explosives	µg/L	---		---		---		0.1	U	---		---		---		0.1	U	0.1	U
7429-90-5	Aluminum	Metals	µg/L	---		---		---		40	U	---		---		---		200		1300	
7440-43-9	Cadmium	Metals	µg/L	5	U	0.2	U	5	U	0.4	U	---		---		---		0.4	U	0.24	J
7440-70-2	Calcium	Metals	µg/L	---		---		---		92000		---		---		---		120000		80000	
7440-48-4	Cobalt	Metals	µg/L	---		---		---		1.8	U	---		---		---		1.8	U	2.7	
7439-89-6	Iron	Metals	µg/L	---		---		100	U	40	U	---		---		---		270		3900	
7439-95-4	Magnesium	Metals	µg/L	---		---		---		29000		---		---		---		40000		29000	
7439-96-5	Manganese	Metals	µg/L	37.9		9	J	300	U	3	U	---		---		---		5.9		120	
7439-98-7	Molybdenum	Metals	µg/L	---		---		---		4	U	---		---		---		2	J	---	
7440-02-0	Nickel	Metals	µg/L	3	J	0.4	U	100	U	4	U	---		---		---		4	U	7.5	J
7440-09-7	Potassium	Metals	µg/L	---		---		---		830		---		---		---		660		2800	
7440-22-4	Silver	Metals	µg/L	10	U	0.7	U	50	U	1.8	U	---		---		---		1.8	U	1.8	U
7440-23-5	Sodium	Metals	µg/L	---		---		---		46000		---		---		---		25000		70000	
7440-62-2	Vanadium	Metals	µg/L	0.7	J	0.7	J	50	U	8	U	---		---		---		8	U	5	J
7440-66-6	Zinc	Metals	µg/L	---		---		---		15	U	---		---		---		15	U	14	J
541-73-1	1,3-Dichlorobenzene	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
95-95-4	2,4,5-Trichlorophenol	Semi-volatiles	µg/L	---		---		---		6.3	U	---		---		---		6	U	6.2	U
88-06-2	2,4,6-Trichlorophenol	Semi-volatiles	µg/L	---		---		---		6.3	U	---		---		---		6	U	6.2	U
120-83-2	2,4-Dichlorophenol	Semi-volatiles	µg/L	---		---		---		6.3	U	---		---		---		6	U	6.2	U
105-67-9	2,4-Dimethylphenol	Semi-volatiles	µg/L	---		---		---		6.3	U	---		---		---		6	U	6.2	U
51-28-5	2,4-Dinitrophenol	Semi-volatiles	µg/L	---		---		---		53	U	---		---		---		50	U	52	U
121-14-2	2,4-Dinitrotoluene	Semi-volatiles	µg/L	---		---		---		6.3	U	---		---		---		6	U	6.2	U
606-20-2	2,6-Dinitrotoluene	Semi-volatiles	µg/L	---		---		---		6.3	U	---		---		---		6	U	6.2	U
91-58-7	2-Chloronaphthalene	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
95-57-8	2-Chlorophenol	Semi-volatiles	µg/L	---		---		---		6.3	U	---		---		---		6	U	6.2	U
534-52-1	2-Methyl-4,6-dinitrophenol	Semi-volatiles	µg/L	---		---		---		6.3	U	---		---		---		6	U	6.2	U
91-57-6	2-Methylnaphthalene	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
95-48-7	2-Methylphenol	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
88-74-4	2-Nitroaniline	Semi-volatiles	µg/L	---		---		---		6.3	U	---		---		---		6	U	6.2	U
88-75-5	2-Nitrophenol	Semi-volatiles	µg/L	---		---		---		6.3	U	---		---		---		6	U	6.2	U
91-94-1	3,3'-Dichlorobenzidine	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
65794-96-9	3+4-Methylphenol	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
99-09-2	3-Nitroaniline	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
101-55-3	4-Bromophenyl phenyl ether	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
59-50-7	4-Chloro-3-methylphenol	Semi-volatiles	µg/L	---		---		---		6.3	U	---		---		---		6	U	6.2	U
106-47-8	4-Chloroaniline	Semi-volatiles	µg/L	---		---		---		6.3	U	---		---		---		6	U	6.2	U
7005-72-3	4-Chlorophenyl phenyl ether	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
100-01-6	4-Nitroaniline	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
100-02-7	4-Nitrophenol	Semi-volatiles	µg/L	---		---		---		21	U	---		---		---		20	U	21	U
83-32-9	Acenaphthene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---	
208-96-8	Acenaphthylene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---	
120-12-7	Anthracene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---	
56-55-3	Benz(a)anthracene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---	
100-51-6	Benzyl alcohol	Semi-volatiles	µg/L	---		---		---		6.3	U	---		---		---		6	U	6.2	U
205-99-2	Benzo(b)fluoranthene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---	
191-24-2	Benzo(ghi)perylene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---	
207-08-9	Benzo(k)fluoranthene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---	
65-85-0	Benzoic acid	Semi-volatiles	µg/L	---		---		---		53	U	---		---		---		50	U	52	U
111-91-1	Bis(2-chloroethoxy) methane	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
111-44-4	Bis(2-chloroethyl) ether	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
108-60-1	Bis(2-chloroisopropyl) ether	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
85-68-7	Butyl benzyl phthalate	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
86-74-8	Carbazole	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	IDA-TT-MW1								IDA-MW2		JAW-26							
			Sample ID:	S16-T5-IDA-TT-MW1		S17-T5-IDA-TT-MW1		S18-T5-IDA-TT-MW1		S19-T5-IDA-TT-MW1		IAAP020-IDA-MW2-GW		S16-T5-JAW-26		S17-T5-JAW-26		S18-T5-JAW-26		S19-T5-JAW-26	
			Date Collected:	4/14/2016		5/03/2017		5/12/2018		4/1/2019		4/10/2019		4/14/2016		5/03/2017		5/13/2018		3/28/2019	
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Results	Qual	Result	VQ	Result	VQ
99-35-4	1,3,5-Trinitrobenzene	Explosives	µg/L	0.2	U	0.095	U	0.052	U	0.1	U	0.11	U	0.2	U	0.095	U	0.051	U	0.1	U
99-65-0	1,3-Dinitrobenzene	Explosives	µg/L	0.2	U	0.077	U	0.1	U	0.1	U	0.11	U	0.2	U	0.077	U	0.1	U	0.1	U
118-96-7	2,4,6-Trinitrotoluene	Explosives	µg/L	0.2	U	0.077	U	0.1	U	0.1	U	0.11	U	0.2	U	0.077	U	0.1	U	0.1	U
121-14-2	2,4-Dinitrotoluene	Explosives	µg/L	0.2	U	0.077	U	0.1	U	0.1	U	0.11	U	0.2	U	0.077	U	0.1	U	0.1	U
606-20-2	2,6-Dinitrotoluene	Explosives	µg/L	0.2	U	0.077	U	0.1	U	0.1	U	0.11	U	0.2	U	0.077	U	0.1	U	0.1	U
35572-78-2	2-Amino-4,6-Dinitrotoluene	Explosives	µg/L	0.2	U	0.077	U	0.1	U	0.1	U	0.11	U	0.2	U	0.077	U	0.1	U	0.1	U
19406-51-0	4-Amino-2,6-Dinitrotoluene	Explosives	µg/L	0.2	U	0.077	U	0.1	U	0.1	U	0.11	U	0.2	U	0.077	U	0.1	U	0.1	U
2691-41-0	HMX	Explosives	µg/L	0.2	U	0.077	U	0.052	U	0.1	UJ	0.11	UJ	0.2	U	0.077	U	0.051	U	0.1	U
99-08-1	2-Nitrotoluene	Explosives	µg/L	0.2	U	0.077	U	0.1	U	0.21	U	0.21	U	0.2	U	0.077	U	0.1	U	0.2	U
98-95-3	Nitrobenzene	Explosives	µg/L	0.2	U	0.093	U	0.1	U	0.1	U	0.11	U	0.2	U	0.093	U	0.1	U	0.1	U
88-72-2	3-Nitrotoluene	Explosives	µg/L	0.2	U	0.077	U	0.1	U	0.21	U	0.21	U	0.2	U	0.077	U	0.1	U	0.2	U
99-99-0	4-Nitrotoluene	Explosives	µg/L	0.2	U	0.077	U	0.1	U	0.21	U	0.21	U	0.2	U	0.077	U	0.1	U	0.2	U
121-82-4	RDX	Explosives	µg/L	0.2	U	0.077	U	0.052	U	0.1	UJ	0.11	UJ	0.2	U	0.077	U	0.051	U	0.1	UJ
479-45-8	Tetryl	Explosives	µg/L	0.2	U	0.077	U	0.1	U	0.1	U	0.11	U	0.2	U	0.077	U	0.1	U	0.1	U
7429-90-5	Aluminum	Metals	µg/L	---		---		---		20	J	4900		---		---		---		41	J
7440-43-9	Cadmium	Metals	µg/L	5	U	0.2	U	5	U	0.4	U	0.57		5	U	0.2	U	5	U	0.4	U
7440-70-2	Calcium	Metals	µg/L	---		---		---		100000		99000		---		---		---		110000	
7440-48-4	Cobalt	Metals	µg/L	---		---		---		1.8	U	3.1		---		---		---		1.8	U
7439-89-6	Iron	Metals	µg/L	---		---		180	=	160		5400		---		---		67	J	62	
7439-95-4	Magnesium	Metals	µg/L	---		---		---		37000		45000		---		---		---		59000	
7439-96-5	Manganese	Metals	µg/L	97.2		40.7		55	J	47		160		15		5.4	J	37	J	5.2	
7439-98-7	Molybdenum	Metals	µg/L	---		---		---		3.7	J	4.6	J	---		---		---		4	U
7440-02-0	Nickel	Metals	µg/L	1.9	J	0.7	J	100	U	4	U	14		2.4	J	1.1	J	100	U	2.1	J
7440-09-7	Potassium	Metals	µg/L	---		---		---		1000		5400		---		---		---		500	
7440-22-4	Silver	Metals	µg/L	10	U	0.7	U	50	U	1.8	U	1.8	U	10	U	0.7	U	50	U	1.8	U
7440-23-5	Sodium	Metals	µg/L	---		---		---		16000		38000		---		---		---		39000	
7440-62-2	Vanadium	Metals	µg/L	50	U	0.6	U	50	U	8	U	12		1.3	J	0.6	J	50	U	8	U
7440-66-6	Zinc	Metals	µg/L	---		---		---		7.7	J	19	J	---		---		---		15	U
541-73-1	1,3-Dichlorobenzene	Semi-volatiles	µg/L	4.7	U	0.51	UJ	680	U	3.2	U	3.4	UJ	---		---		---		3.1	U
95-95-4	2,4,5-Trichlorophenol	Semi-volatiles	µg/L	4.7	U	0.76	UJ	450000	U	6.3	U	6.7	U	---		---		---		6.3	U
88-06-2	2,4,6-Trichlorophenol	Semi-volatiles	µg/L	4.7	U	0.77	UJ	2300	U	6.3	U	6.7	U	---		---		---		6.3	U
120-83-2	2,4-Dichlorophenol	Semi-volatiles	µg/L	4.7	U	0.85	UJ	23	U	6.3	U	6.7	U	---		---		---		6.3	U
105-67-9	2,4-Dimethylphenol	Semi-volatiles	µg/L	4.7	U	0.75	UJ	230000	U	6.3	U	6.7	U	---		---		---		6.3	U
51-28-5	2,4-Dinitrophenol	Semi-volatiles	µg/L	23	U	5.1	U	18	U	53	U	56	U	---		---		---		52	U
121-14-2	2,4-Dinitrotoluene	Semi-volatiles	µg/L	4.7	U	0.83	U	---		6.3	U	6.7	U	---		---		---		6.3	U
606-20-2	2,6-Dinitrotoluene	Semi-volatiles	µg/L	4.7	U	0.73	UJ	---		6.3	U	6.7	U	---		---		---		6.3	U
91-58-7	2-Chloronaphthalene	Semi-volatiles	µg/L	4.7	U	0.51	UJ	1.8	U	3.2	U	3.4	U	---		---		---		3.1	U
95-57-8	2-Chlorophenol	Semi-volatiles	µg/L	4.7	U	0.64	UJ	45	U	6.3	U	6.7	UJ	---		---		---		6.3	U
534-52-1	2-Methyl-4,6-dinitrophenol	Semi-volatiles	µg/L	9.3	U	2	U	18	U	6.3	U	6.7	U	---		---		---		6.3	U
91-57-6	2-Methylnaphthalene	Semi-volatiles	µg/L	---		0.61	UJ	1.8	U	3.2	U	3.4	U	---		---		---		3.1	U
95-48-7	2-Methylphenol	Semi-volatiles	µg/L	4.7	U	0.57	UJ	1.8	U	3.2	U	3.4	U	---		---		---		3.1	U
88-74-4	2-Nitroaniline	Semi-volatiles	µg/L	4.7	U	1.8	UJ	4.5	U	6.3	U	6.7	U	---		---		---		6.3	U
88-75-5	2-Nitrophenol	Semi-volatiles	µg/L	4.7	U	0.87	UJ	9	U	6.3	U	6.7	U	---		---		---		6.3	U
91-94-1	3,3'-Dichlorobenzidine	Semi-volatiles	µg/L	4.7	U	0.66	U	4.5	U	3.2	U	3.4	U	---		---		---		3.1	U
65794-96-9	3+4-Methylphenol	Semi-volatiles	µg/L	4.7	U	1	UJ	230000	U	3.2	UJ	3.4	U	---		---		---		3.1	U
99-09-2	3-Nitroaniline	Semi-volatiles	µg/L	4.7	U	0.9	UJ	68	U	3.2	U	3.4	U	---		---		---		3.1	U
101-55-3	4-Bromophenyl phenyl ether	Semi-volatiles	µg/L	4.7	U	0.86	U	4.5	U	3.2	U	3.4	U	---		---		---		3.1	U
59-50-7	4-Chloro-3-methylphenol	Semi-volatiles	µg/L	4.7	U	0.61	UJ	9	U	6.3	U	6.7	U	---		---		---		6.3	U
106-47-8	4-Chloroaniline	Semi-volatiles	µg/L	4.7	U	0.64	UJ	9	U	6.3	U	6.7	U	---		---		---		6.3	U
7005-72-3	4-Chlorophenyl phenyl ether	Semi-volatiles	µg/L	4.7	U	0.55	UJ	4.5	U	3.2	U	3.4	U	---		---		---		3.1	U
100-01-6	4-Nitroaniline	Semi-volatiles	µg/L	4.7	U	1.2	U	9	U	3.2	U	3.4	U	---		---		---		3.1	U
100-02-7	4-Nitrophenol	Semi-volatiles	µg/L	23	U	5.1	U	68	U	21	U	22	U	---		---		---		21	U
83-32-9	Acenaphthene	Semi-volatiles	µg/L	---		0.64	UJ	0.9	U	---		---		---		---		---		---	
208-96-8	Acenaphthylene	Semi-volatiles	µg/L	---		0.65	UJ	0.9	U	---		---		---		---		---		---	
120-12-7	Anthracene	Semi-volatiles	µg/L	---		0.81	U	0.9	U	---		---		---		---		---		---	
56-55-3	Benz(a)anthracene	Semi-volatiles	µg/L	---		0.78	U	0.18	U	---		---		---		---		---		---	
100-51-6	Benzyl alcohol	Semi-volatiles	µg/L	4.7	U	0.63	UJ	18	U	6.3	U	6.7	U	---		---		---		6.3	U
205-99-2	Benzo(b)fluoranthene	Semi-volatiles	µg/L	---		0.79	U	0.18	U	---		---		---		---		---		---	
191-24-2	Benzo(ghi)perylene	Semi-volatiles	µg/L	---		0.84	U	0.9	U	---		---		---		---		---		---	
207-08-9	Benzo(k)fluoranthene	Semi-volatiles	µg/L	---		0.88	U	0.18	U	---		---		---		---		---		---	
65-85-0	Benzoic acid	Semi-volatiles	µg/L	47	U	10	U	18	U	53	U	56	U	---		---		---		52	U
111-91-1	Bis(2-chloroethoxy) methane	Semi-volatiles	µg/L	4.7	U	0.83	UJ	1.8	U	3.2	U	3.4	U	---		---		---		3.1	U
111-44-4	Bis(2-chloroethyl) ether	Semi-volatiles	µg/L	4.7	U	0.75	UJ	1.8	U	3.2	U	3.4	UJ	---		---		---		3.1	U
108-60-1	Bis(2-chloroisopropyl) ether	Semi-volatiles	µg/L	4.7	U	0.77	UJ	340	U	3.2	UJ	3.4	U	---		---		---		3.1	U
85-68-7	Butyl benzyl phthalate	Semi-volatiles	µg/L	4.7	U	1	U	1.8	U	3.2	U	3.4	U	---		---		---		3.1	U
86-74-8	Carbazole	Semi-volatiles	µg/L	4.7	U	0.61	U	4.5	U	3.2	U	3.4	U	---		---		---		3.1	U

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	JAW-27								JAW-65								T-1							
			Sample ID:	S16-T5-JAW-27		S17-T5-JAW-27		S18-T5-JAW-27		S19-T5-JAW-27		S16-T5-JAW-65		S17-T5-JAW-65		S18-T5-JAW-65		S19-T5-JAW-65		S16-T5-T-1		S17-T5-T-1		S18-T5-T-1		S19-T5-T-1	
			Date Collected:	4/14/2016		5/02/2017		5/16/2018		4/12/2019		4/14/2016		5/03/2017		5/16/2018		3/28/2019		4/11/2016		5/04/2017		5/10/2018		3/31/2019	
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ
99-35-4	1,3,5-Trinitrobenzene	Explosives	µg/L	---		---		---		0.11	U	0.2	U	0.093	U	0.05	UJ	0.1	U	---		---		---		0.1	U
99-65-0	1,3-Dinitrobenzene	Explosives	µg/L	---		---		---		0.11	U	0.2	U	0.075	U	0.1	UJ	0.1	U	---		---		---		0.1	U
118-96-7	2,4,6-Trinitrotoluene	Explosives	µg/L	---		---		---		0.11	U	0.2	U	0.075	U	0.1	UJ	0.1	U	---		---		---		0.1	U
121-14-2	2,4-Dinitrotoluene	Explosives	µg/L	---		---		---		0.11	U	0.2	U	0.075	U	0.1	UJ	0.1	U	---		---		---		0.1	U
606-20-2	2,6-Dinitrotoluene	Explosives	µg/L	---		---		---		0.11	U	0.2	U	0.075	U	0.1	UJ	0.1	U	---		---		---		0.1	U
35572-78-2	2-Amino-4,6-Dinitrotoluene	Explosives	µg/L	---		---		---		0.11	U	0.2	U	0.075	U	0.1	UJ	0.1	U	---		---		---		0.1	U
19406-51-0	4-Amino-2,6-Dinitrotoluene	Explosives	µg/L	---		---		---		0.11	U	0.2	U	0.075	U	0.1	UJ	0.1	U	---		---		---		0.1	U
2691-41-0	HMX	Explosives	µg/L	---		---		---		0.11	U	1.8	J	0.84		1	J	0.64		---		---		---		0.1	UJ
99-08-1	2-Nitrotoluene	Explosives	µg/L	---		---		---		0.21	U	0.2	U	0.075	U	0.13	J	0.21	U	---		---		---		0.2	U
98-95-3	Nitrobenzene	Explosives	µg/L	---		---		---		0.11	U	0.2	U	0.092	U	0.1	UJ	0.1	U	---		---		---		0.1	U
88-72-2	3-Nitrotoluene	Explosives	µg/L	---		---		---		0.21	U	0.2	U	0.075	U	0.1	UJ	0.21	U	---		---		---		0.2	U
99-99-0	4-Nitrotoluene	Explosives	µg/L	---		---		---		0.21	U	0.2	U	0.075	U	0.1	UJ	0.21	U	---		---		---		0.2	U
121-82-4	RDX	Explosives	µg/L	---		---		---		0.11	U	0.65		0.075	U	0.22	J	0.1	U	---		---		---		0.1	UJ
479-45-8	Tetryl	Explosives	µg/L	---		---		---		0.11	U	0.2	U	0.075	U	0.1	UJ	0.1	U	---		---		---		0.1	U
7429-90-5	Aluminum	Metals	µg/L	---		---		---		180		---		---		---		380		---		---		---		40	U
7440-43-9	Cadmium	Metals	µg/L	---		---		---		0.4	U	5	U	0.2	U	5	U	0.4	U	5	U	0.2	U	5	U	0.4	U
7440-70-2	Calcium	Metals	µg/L	---		---		---		55000		---		---		---		62000		---		---		---		140000	
7440-48-4	Cobalt	Metals	µg/L	---		---		---		1.8	U	---		---		---		1.2	J	---		---		---		1.8	U
7439-89-6	Iron	Metals	µg/L	---		---		---		1600		---		---		72	J	620		---		---		100	U	40	U
7439-95-4	Magnesium	Metals	µg/L	---		---		---		13000		---		---		---		25000		---		---		---		58000	
7439-96-5	Manganese	Metals	µg/L	---		---		---		93		39.5		33.4		24	J	130		50.5		14.1	J	300	U	8.9	
7439-98-7	Molybdenum	Metals	µg/L	---		---		---		---		---		---		---		4	U	---		---		---		4	U
7440-02-0	Nickel	Metals	µg/L	---		---		---		4.3	J	5.3	J	2.6	J	100	U	3.9	J	2.1	J	2.9	J	100	U	4	U
7440-09-7	Potassium	Metals	µg/L	---		---		---		3600		---		---		---		1400		---		---		---		650	
7440-22-4	Silver	Metals	µg/L	---		---		---		1.8	U	10	U	0.7	U	50	U	1.8	U	10	U	0.7	U	50	U	1.8	U
7440-23-5	Sodium	Metals	µg/L	---		---		---		44000		---		---		---		26000		---		---		---		28000	
7440-62-2	Vanadium	Metals	µg/L	---		---		---		8	U	0.6	J	0.6	U	50	U	8	U	0.7	J	0.8	J	50	U	8	U
7440-66-6	Zinc	Metals	µg/L	---		---		---		15	U	---		---		---		10	J	---		---		---		15	U
541-73-1	1,3-Dichlorobenzene	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
95-95-4	2,4,5-Trichlorophenol	Semi-volatiles	µg/L	---		---		---		6.4	U	---		---		---		6.5	U	---		---		---		6.5	U
88-06-2	2,4,6-Trichlorophenol	Semi-volatiles	µg/L	---		---		---		6.4	U	---		---		---		6.5	U	---		---		---		6.5	U
120-83-2	2,4-Dichlorophenol	Semi-volatiles	µg/L	---		---		---		6.4	U	---		---		---		6.5	U	---		---		---		6.5	U
105-67-9	2,4-Dimethylphenol	Semi-volatiles	µg/L	---		---		---		6.4	U	---		---		---		6.5	U	---		---		---		6.5	U
51-28-5	2,4-Dinitrophenol	Semi-volatiles	µg/L	---		---		---		53	U	---		---		---		54	U	---		---		---		54	U
121-14-2	2,4-Dinitrotoluene	Semi-volatiles	µg/L	---		---		---		6.4	U	---		---		---		6.5	U	---		---		---		6.5	U
606-20-2	2,6-Dinitrotoluene	Semi-volatiles	µg/L	---		---		---		6.4	U	---		---		---		6.5	U	---		---		---		6.5	U
91-58-7	2-Chloronaphthalene	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
95-57-8	2-Chlorophenol	Semi-volatiles	µg/L	---		---		---		6.4	U	---		---		---		6.5	U	---		---		---		6.5	U
534-52-1	2-Methyl-4,6-dinitrophenol	Semi-volatiles	µg/L	---		---		---		6.4	U	---		---		---		6.5	U	---		---		---		6.5	U
91-57-6	2-Methylnaphthalene	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
95-48-7	2-Methylphenol	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
88-74-4	2-Nitroaniline	Semi-volatiles	µg/L	---		---		---		6.4	U	---		---		---		6.5	U	---		---		---		6.5	U
88-75-5	2-Nitrophenol	Semi-volatiles	µg/L	---		---		---		6.4	U	---		---		---		6.5	U	---		---		---		6.5	U
91-94-1	3,3'-Dichlorobenzidine	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
65794-96-9	3+4-Methylphenol	Semi-volatiles	µg/L	---		---		---		3.2	UJ	---		---		---		3.2	U	---		---		---		3.2	U
99-09-2	3-Nitroaniline	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
101-55-3	4-Bromophenyl phenyl ether	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
59-50-7	4-Chloro-3-methylphenol	Semi-volatiles	µg/L	---		---		---		6.4	U	---		---		---		6.5	U	---		---		---		6.5	U
106-47-8	4-Chloroaniline	Semi-volatiles	µg/L	---		---		---		6.4	U	---		---		---		6.5	U	---		---		---		6.5	U
7005-72-3	4-Chlorophenyl phenyl ether	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
100-01-6	4-Nitroaniline	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
100-02-7	4-Nitrophenol	Semi-volatiles	µg/L	---		---		---		21	U	---		---		---		22	U	---		---		---		22	U
83-32-9	Acenaphthene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
208-96-8	Acenaphthylene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
120-12-7	Anthracene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
56-55-3	Benz(a)anthracene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
100-51-6	Benzyl alcohol	Semi-volatiles	µg/L	---		---		---		6.4	U	---		---		---		6.5	U	---		---		---		6.5	U
205-99-2	Benzo(b)fluoranthene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
191-24-2	Benzo(ghi)perylene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
207-08-9	Benzo(k)fluoranthene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
65-85-0	Benzoic acid	Semi-volatiles	µg/L	---		---		---		53	U	---		---		---		54	U	---		---		---		54	U
111-91-1	Bis(2-chloroethoxy) methane	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
111-44-4	Bis(2-chloroethyl) ether	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
108-60-1	Bis(2-chloroisopropyl) ether	Semi-volatiles	µg/L	---		---		---		3.2	UJ	---		---		---		3.2	U	---		---		---		3.2	U
85-68-7	Butyl benzyl phthalate	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
86-74-8	Carbazole	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	T-6								MW20-01		Statistical Summary								Groundwater PAL Evaluation	
			Sample ID:	S16-T5-T-6		S17-T5-T-6		S18-T5-T-6		S19-T5-T-6		IAAP020-MW20-01-GW		Minimum Detected Concentration (Qualifier) (1)(2)		Maximum Detected Concentration (Qualifier) (1)(2)		Units	Location of Maximum Concentration		Detection Frequency (2)	Groundwater PAL (3)	Groundwater Maximum Detected Conc. > PAL Value (Y/N)
			Date Collected:	4/11/2016		5/04/2017		5/10/2018		3/31/2019		12/9/2020							Sample ID (2)	Date Collected (2)			
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ										
99-35-4	1,3,5-Trinitrobenzene	Explosives	µg/L	---		---		---		0.099	U	0.19	U	0.033	J	0.7	J	µg/L	S19-T5-ET-3	4/11/2019	4 / 53	590	No
99-65-0	1,3-Dinitrobenzene	Explosives	µg/L	---		---		---		0.099	U	0.097	U	ND		ND		µg/L	NA	NA	0 / 53	2	No
118-96-7	2,4,6-Trinitrotoluene	Explosives	µg/L	---		---		---		0.099	U	0.097	U	0.17	J	0.8	J	µg/L	S18-T5-ET-3	5/15/2018	2 / 53	2.5	No
121-14-2	2,4-Dinitrotoluene	Explosives	µg/L	---		---		---		0.099	U	0.078	U	1.1		1.1		µg/L	S19-T5-ET-3	4/11/2019	1 / 53	0.24	Yes
606-20-2	2,6-Dinitrotoluene	Explosives	µg/L	---		---		---		0.099	U	0.078	U	0.2		0.2		µg/L	S16-T5-C95-2	4/13/2016	1 / 53	0.049	Yes
35572-78-2	2-Amino-4,6-Dinitrotoluene	Explosives	µg/L	---		---		---		0.099	U	0.097	U	0.12	J	0.3	J	µg/L	S19-T5-ET-3	4/11/2019	2 / 53	39	No
19406-51-0	4-Amino-2,6-Dinitrotoluene	Explosives	µg/L	---		---		---		0.099	U	0.12	U	0.11	=	0.11	=	µg/L	S19-T5-C-00-1	4/11/2019	1 / 53	1.9	No
2691-41-0	HMX	Explosives	µg/L	---		---		---		0.099	UJ	0.19	U	0.16		6	J	µg/L	S19-T5-ET-3	4/11/2019	16 / 53	1000	No
99-08-1	2-Nitrotoluene	Explosives	µg/L	---		---		---		0.2	U	0.39	U	0.13	J	0.13	J	µg/L	S18-T5-JAW-65	5/16/2018	1 / 53	1.7	No
98-95-3	Nitrobenzene	Explosives	µg/L	---		---		---		0.099	U	0.19	U	2.6		2.6		µg/L	S16-T5-ET-3	4/14/2016	1 / 53	0.14	Yes
88-72-2	3-Nitrotoluene	Explosives	µg/L	---		---		---		0.2	U	0.19	U	ND		ND		µg/L	NA	NA	0 / 53	1.7	No
99-99-0	4-Nitrotoluene	Explosives	µg/L	---		---		---		0.2	U	0.39	U	ND		ND		µg/L	NA	NA	0 / 53	4.3	No
121-82-4	RDX	Explosives	µg/L	---		---		---		0.099	UJ	0.19	U	0.066	J	2.2		µg/L	IAAP020-CAMU-99-3S-GW	4/3/2019	13 / 53	2	Yes
479-45-8	Tetryl	Explosives	µg/L	---		---		---		0.099	U	0.097	U	ND		ND		µg/L	NA	NA	0 / 53	39	No
7429-90-5	Aluminum	Metals	µg/L	---		---		---		40	U	28	UJ	20	J	4900		µg/L	IAAP020-IDA-MW2-GW	4/10/2019	17 / 23	20000	No
7440-43-9	Cadmium	Metals	µg/L	---		---		---		0.4	U	0.4	U	0.24	J	0.57		µg/L	IAAP020-IDA-MW2-GW	4/10/2019	2 / 59	5	No
7440-70-2	Calcium	Metals	µg/L	---		---		---		74000		150000	J	40000		190000		µg/L	S19-T5-ET-3	4/11/2019	23 / 23	--	No
7440-48-4	Cobalt	Metals	µg/L	---		---		---		1.7	J	0.92	J	0.92	J	3.2		µg/L	S19-T5-C-00-1	4/11/2019	9 / 23	6	No
7439-89-6	Iron	Metals	µg/L	---		---		---		400		50	J	22	J	26200		µg/L	S17-T5-ET-3	5/2/2017	31 / 38	14000	Yes
7439-95-4	Magnesium	Metals	µg/L	---		---		---		38000		50000	J	13000		340000		µg/L	S19-T5-ET-3	4/11/2019	23 / 23	--	No
7439-96-5	Manganese	Metals	µg/L	---		---		---		690		340		2.3		690		µg/L	S19-T5-T-6	3/31/2019	52 / 59	430	Yes
7439-98-7	Molybdenum	Metals	µg/L	---		---		---		4.2	J	---	U	2	J	4.6	J	µg/L	IAAP020-IDA-MW2-GW	4/10/2019	5 / 15	100	No
7440-02-0	Nickel	Metals	µg/L	---		---		---		3.9	J	4	U	0.7	J	31.9	J	µg/L	S16-T5-ET-3	4/14/2016	30 / 59	390	No
7440-09-7	Potassium	Metals	µg/L	---		---		---		6000		1000		400		12000		µg/L	S19-T5-ET-3	4/11/2019	23 / 23	--	No
7440-22-4	Silver	Metals	µg/L	---		---		---		1.8	U	1.8	U	ND		ND		µg/L	NA	NA	0 / 59	94	No
7440-23-5	Sodium	Metals	µg/L	---		---		---		42000		36000		13000		170000		µg/L	S19-T5-ET-3	4/11/2019	23 / 23	--	No
7440-62-2	Vanadium	Metals	µg/L	---		---		---		8	U	8	U	0.6	J	12		µg/L	IAAP020-IDA-MW2-GW	4/10/2019	18 / 59	86	No
7440-66-6	Zinc	Metals	µg/L	---		---		---		15	U	15	U	7.7	J	19	J	µg/L	IAAP020-IDA-MW2-GW	4/10/2019	6 / 23	6000	No
541-73-1	1,3-Dichlorobenzene	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND		ND		µg/L	NA	NA	0 / 47	75	No
95-95-4	2,4,5-Trichlorophenol	Semi-volatiles	µg/L	---		---		---		6.3	U	6	U	0.88	J	0.88	J	µg/L	S17-T5-ET-3	5/2/2017	1 / 47	1200	No
88-06-2	2,4,6-Trichlorophenol	Semi-volatiles	µg/L	---		---		---		6.3	U	6	U	1.3	J	1.3	J	µg/L	S17-T5-ET-3	5/2/2017	1 / 47	4.1	No
120-83-2	2,4-Dichlorophenol	Semi-volatiles	µg/L	---		---		---		6.3	U	6	U	16.1		16.1		µg/L	S17-T5-ET-3	5/2/2017	1 / 47	46	No
105-67-9	2,4-Dimethylphenol	Semi-volatiles	µg/L	---		---		---		6.3	U	6	U	ND		ND		µg/L	NA	NA	0 / 47	360	No
51-28-5	2,4-Dinitrophenol	Semi-volatiles	µg/L	---		---		---		53	U	50	U	ND		ND		µg/L	NA	NA	0 / 46	39	No
121-14-2	2,4-Dinitrotoluene	Semi-volatiles	µg/L	---		---		---		6.3	U	6	U	ND		ND		µg/L	NA	NA	0 / 39	0.24	No
606-20-2	2,6-Dinitrotoluene	Semi-volatiles	µg/L	---		---		---		6.3	U	6	U	ND		ND		µg/L	NA	NA	0 / 39	0.049	No
91-58-7	2-Chloronaphthalene	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND		ND		µg/L	NA	NA	0 / 47	750	No
95-57-8	2-Chlorophenol	Semi-volatiles	µg/L	---		---		---		6.3	U	6	U	1.1	J	1.1	J	µg/L	S17-T5-ET-3	5/2/2017	1 / 47	91	No
534-52-1	2-Methyl-4,6-dinitrophenol	Semi-volatiles	µg/L	---		---		---		6.3	U	6	U	28	J	28	J	µg/L	S19-T5-ET-3	4/11/2019	1 / 47	1.5	Yes
91-57-6	2-Methylnaphthalene	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND		ND		µg/L	NA	NA	0 / 39	36	No
95-48-7	2-Methylphenol	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND		ND		µg/L	NA	NA	0 / 47	930	No
88-74-4	2-Nitroaniline	Semi-volatiles	µg/L	---		---		---		6.3	U	6	U	ND		ND		µg/L	NA	NA	0 / 47	190	No
88-75-5	2-Nitrophenol	Semi-volatiles	µg/L	---		---		---		6.3	U	6	U	ND		ND		µg/L	NA	NA	0 / 47	--	No
91-94-1	3,3'-Dichlorobenzidine	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND		ND		µg/L	NA	NA	0 / 46	0.13	No
65794-96-9	3+4-Methylphenol	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	2.1	J	15	J	µg/L	S18-T5-ET-3	5/15/2018	3 / 47	930	No
99-09-2	3-Nitroaniline	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND		ND		µg/L	NA	NA	0 / 47	3.8	No
101-55-3	4-Bromophenyl phenyl ether	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND		ND		µg/L	NA	NA	0 / 47	--	No
59-50-7	4-Chloro-3-methylphenol	Semi-volatiles	µg/L	---		---		---		6.3	U	6	U	ND		ND		µg/L	NA	NA	0 / 47	1400	No
106-47-8	4-Chloroaniline	Semi-volatiles	µg/L	---		---		---		6.3	U	6	U	ND		ND		µg/L	NA	NA	0 / 47	0.37	No
7005-72-3	4-Chlorophenyl phenyl ether	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND		ND		µg/L	NA	NA	0 / 47	--	No
100-01-6	4-Nitroaniline	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND		ND		µg/L	NA	NA	0 / 47	3.8	No
100-02-7	4-Nitrophenol	Semi-volatiles	µg/L	---		---		---		21	U	20	U	ND		ND		µg/L	NA	NA	0 / 47	60	No
83-32-9	Acenaphthene	Semi-volatiles	µg/L	---		---		---		---		0.006	U	ND		ND		µg/L	NA	NA	0 / 17	530	No
208-96-8	Acenaphthylene	Semi-volatiles	µg/L	---		---		---		---		0.006	U	ND		ND		µg/L	NA	NA	0 / 17	530	No
120-12-7	Anthracene	Semi-volatiles	µg/L	---		---		---		---		0.006	U	ND		ND		µg/L	NA	NA	0 / 17	1800	No
56-55-3	Benz(a)anthracene	Semi-volatiles	µg/L	---		---		---		---		0.006	U	ND		ND		µg/L	NA	NA	0 / 17	0.03	No
100-51-6	Benzyl alcohol	Semi-volatiles	µg/L	---		---		---		6.3	U	6	U	ND		ND		µg/L	NA	NA	0 / 47	2000	No
205-99-2	Benzo(b)fluoranthene	Semi-volatiles	µg/L	---		---		---		---		0.006	U	ND		ND		µg/L	NA	NA	0 / 17	0.25	No
191-24-2	Benzo(ghi)perylene	Semi-volatiles	µg/L	---		---		---		---		0.006	U	ND		ND		µg/L	NA	NA	0 / 17	120	No
207-08-9	Benzo(k)fluoranthene	Semi-volatiles	µg/L	---		---		---		---		0.006	U	ND		ND		µg/L	NA	NA	0 / 17	2.5	No
65-85-0	Benzoic acid	Semi-volatiles	µg/L	---		---		---		53	U	50	U	ND		ND		µg/L	NA	NA	0 / 46	75000	No
111-91-1	Bis(2-chloroethoxy) methane	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND		ND		µg/L	NA	NA	0 / 47	59	No
111-44-4	Bis(2-chloroethyl) ether	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND		ND		µg/L	NA	NA	0 / 47	0.014	No
108-60-1	Bis(2-chloroisopropyl) ether	Semi-volatiles	µg/L	---		---		---		3.2	U	3	UJ	ND		ND		µg/L	NA	NA	0 / 47	710	No
85-68-7	Butyl benzyl phthalate	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND		ND		µg/L	NA	NA	0 / 47	16	No
86-74-8	Carbazole	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND		ND		µg/L	NA	NA	0 / 47	--	No

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	C-00-1								C-00-2								C-00-3							
			Sample ID:	S16-T5-C-00-1		S17-T5-C-00-1		S18-T5-C-00-1		S19-T5-C-00-1		S16-T5-C-00-2		S17-T5-C-00-2		S18-T5-C-00-2		S19-T5-C-00-2		S16-T5-C-00-3		S17-T5-C-00-3		S18-T5-C-00-3		S19-T5-C-00-3	
			Date Collected:	4/12/2016		5/02/2017		5/11/2018		4/11/2019		4/12/2016		5/05/2017		5/16/2018		3/31/2019		4/12/2016		5/04/2017		5/13/2018		4/1/2019	
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ
218-01-9	Chrysene	Semi-volatiles	µg/L	---		0.85	U	0.16	U	---		---		0.87	U	0.17	UJ	---		---		0.83	U	0.17	U	---	
53-70-3	Dibenz(a,h)anthracene	Semi-volatiles	µg/L	---		0.8	U	0.24	U	---		---		0.82	U	0.25	U	---		---		0.79	U	0.25	U	---	
132-64-9	Dibenzofuran	Semi-volatiles	µg/L	4.7	U	0.6	U	1.6	U	3.2	U	4.7	U	0.61	U	1.7	U	3.1	U	4.8	U	0.59	UJ	1.7	U	3	U
84-66-2	Diethyl phthalate	Semi-volatiles	µg/L	4.7	U	1	U	4	U	3.2	U	4.7	U	1	U	4.2	U	3.1	U	4.8	U	0.98	U	4.1	U	3	U
131-11-3	Dimethyl phthalate	Semi-volatiles	µg/L	4.7	U	1	U	4	U	3.2	U	4.7	U	1	U	4.2	U	3.1	U	4.8	U	0.98	UJ	4.1	U	3	U
84-74-2	Di-n-butyl phthalate	Semi-volatiles	µg/L	4.7	U	1	U	4	U	3.2	U	4.7	U	1	U	4.2	U	3.1	U	4.8	U	0.98	U	4.1	U	3	U
117-84-0	Di-n-octyl phthalate	Semi-volatiles	µg/L	4.7	U	1	U	8.1	U	3.2	U	4.7	U	1	U	8.5	U	3.1	U	4.8	U	0.98	U	8.3	U	3	U
206-44-0	Fluoranthene	Semi-volatiles	µg/L	---		0.55	U	0.81	U	---		---		0.56	U	0.85	UJ	---		---		0.54	U	0.83	U	---	
86-73-7	Fluorene	Semi-volatiles	µg/L	---		0.7	U	0.81	U	---		---		0.72	U	0.85	UJ	---		---		0.69	UJ	0.83	U	---	
87-68-3	Hexachlorobutadiene	Semi-volatiles	µg/L	4.7	U	0.5	U	510	U	3.2	U	4.7	U	0.51	UJ	530	U	3.1	U	4.8	U	0.49	UJ	520	U	3	U
67-72-1	Hexachloroethane	Semi-volatiles	µg/L	4.7	U	1.6	U	1	U	3.2	U	4.7	U	1.7	UJ	1.1	U	3.1	U	4.8	U	1.6	UJ	1	U	3	U
193-39-5	Indeno(1,2,3-cd)pyrene	Semi-volatiles	µg/L	---		0.71	U	0.16	U	---		---		0.73	U	0.17	UJ	---		---		0.7	U	0.17	U	---	
78-59-1	Isophorone	Semi-volatiles	µg/L	4.7	U	0.78	U	100	U	3.2	U	4.7	U	0.79	U	110	U	3.1	U	4.8	U	0.76	UJ	100	U	3	U
91-20-3	Naphthalene	Semi-volatiles	µg/L	---		1.8	J	100	U	---		---		0.51	UJ	110	UJ	---		---		0.49	UJ	100	U	---	
98-95-3	Nitrobenzene	Semi-volatiles	µg/L	4.7	U	0.93	U	---		6.4	U	4.7	U	0.95	U	---		6.2	U	4.8	U	0.91	UJ	---		5.9	U
62-75-9	N-Nitrosodimethylamine	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.1	U	---		---		---		3	U
621-64-7	N-Nitrosodi-n-propylamine	Semi-volatiles	µg/L	4.7	U	0.67	U	0.4	U	3.2	U	4.7	U	0.68	U	0.42	U	3.1	U	4.8	U	0.66	UJ	0.41	U	3	U
86-30-6	N-Nitrosodiphenylamine	Semi-volatiles	µg/L	4.7	U	0.81	U	1.6	U	3.2	U	4.7	U	0.82	U	1.7	UJ	3.1	U	4.8	U	0.79	UJ	1.7	U	3	U
85-01-8	Phenanthrene	Semi-volatiles	µg/L	---		0.86	U	0.81	U	3.3	U	---		0.88	U	0.85	UJ	---		---		0.85	U	0.83	U	---	
108-95-2	Phenol	Semi-volatiles	µg/L	4.7	U	0.5	U	2000	U	3.2	U	4.7	U	0.51	UJ	2100	U	3.1	U	4.8	U	0.49	UJ	2100	U	3	U
129-00-0	Pyrene	Semi-volatiles	µg/L	---		0.68	U	0.81	U	---		---		0.7	U	0.85	UJ	---		---		0.67	U	0.83	U	---	
98-06-6	(1,1-Dimethylethyl)benzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
135-98-8	(1-Methylpropyl)benzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
630-20-6	1,1,1,2-Tetrachloroethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
79-34-5	1,1,2,2-Tetrachloroethane	Volatiles	µg/L	1	U	0.3	U	1	U	1	U	1	U	0.3	U	1	U	1	U	1	U	0.3	U	1	U	1	U
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	Volatiles	µg/L	1	U	0.48	U	1	U	1	U	1	U	0.48	U	1	U	1	U	1	U	0.48	U	1	U	1	U
75-34-3	1,1-Dichloroethane	Volatiles	µg/L	4.6		2.7		2.4	J	3.1	J	1	U	0.34	U	7	U	1	U	1	U	0.34	U	7	U	1	U
563-58-6	1,1-Dichloropropene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
87-61-6	1,2,3-Trichlorobenzene	Volatiles	µg/L	---		---		---		5	U	---		---		---		5	U	---		---		---		5	U
96-18-4	1,2,3-Trichloropropane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
95-63-6	1,2,4-Trimethylbenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
95-47-6	1,2-Dimethylbenzene	Volatiles	µg/L	---		---		---		0.5	U	---		---		---		0.5	U	---		---		---		0.5	U
108-67-8	1,3,5-Trimethylbenzene	Volatiles	µg/L	---		---		---		0.5	U	---		---		---		0.5	U	---		---		---		0.5	U
541-73-1	1,3-Dichlorobenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
142-28-9	1,3-Dichloropropane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
106-43-4	1-Chloro-4-methylbenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
544-10-5	1-Chlorohexane	Volatiles	µg/L	---		---		---		2	U	---		---		---		2	U	---		---		---		2	U
99-87-6	1-Methyl-4-(1-methylethyl)benzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
594-20-7	2,2-Dichloropropane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
78-93-3	2-Butanone	Volatiles	µg/L	5	U	2	U	4000	U	10	U	5	U	2	U	4000	U	10	U	5	U	2	U	4000	U	10	U
591-78-6	2-Hexanone	Volatiles	µg/L	10	U	2	U	5	U	5	U	10	U	2	U	5	U	5	U	10	U	2	U	5	U	5	U
1634-04-4	2-Methoxy-2-methylpropane	Volatiles	µg/L	---		---		---		0.5	U	---		---		---		0.5	U	---		---		---		0.5	U
108-10-1	4-Methyl-2-pentanone	Volatiles	µg/L	5	U	1	U	5	U	5	U	5	U	1	U	5	U	5	U	5	U	1	U	5	U	5	U
67-64-1	Acetone	Volatiles	µg/L	25	U	10	U	5	U	10	U	25	U	10	U	5.5	=	10	U	25	U	10	U	5	U	10	U
108-86-1	Bromobenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
74-97-5	Bromochloromethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
74-83-9	Bromomethane	Volatiles	µg/L	2	U	0.59	U	10	U	5	U	2	U	0.59	U	10	U	5	U	2	U	0.59	U	10	U	5	U
104-51-8	Butylbenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
75-15-0	Carbon disulfide	Volatiles	µg/L	2	U	0.53	U	2	U	2	U	2	U	0.53	U	2	U	2	U	2	U	0.53	U	2	U	2	U
75-00-3	Chloroethane	Volatiles	µg/L	2	U	0.67	U	1	U	5	U	2	U	0.67	U	1	U	5	U	2	U	0.67	U	1	UJ	5	U
74-87-3	Chloromethane	Volatiles	µg/L	2	U	0.5	U	1	U	1	U	2	U	0.5	U	1	U	1	U	2	U	0.5	U	1	U	1	UJ
10061-01-5	cis-1,3-Dichloropropene	Volatiles	µg/L	1	U	0.29	U	1	U	1	UJ	1	U	0.29	U	1	U	1	U	1	U	0.29	U	1	U	1	U
98-82-8	Cumene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
74-95-3	Dibromomethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
75-71-8	Dichlorodifluoromethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
87-68-3	Hexachlorobutadiene	Volatiles	µg/L	---		---		---		5	UJ	---		---		---		5	U	---		---		---		5	U
136777-61-2	M + P Xylene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
91-20-3	Naphthalene	Volatiles	µg/L	---		---		---		5	U	---		---		---		5	U	---		---		---		5	U
95-49-8	o-Chlorotoluene	Volatiles	µg/L	---		---		---		0.5	U	---		---		---		0.5	U	---		---		---		0.5	U
103-65-1	Propylbenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
10061-02-6	trans-1,3-Dichloropropene	Volatiles	µg/L	1	U	0.21	U	1	U	1	U	1	U	0.21	U	1	U	1	U	1	U	0.21	U	1	U	1	U
75-69-4	Trichlorofluoromethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		---		---		1	U
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		0.00000074	J

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	C-95-1								C-95-2								CAMU-99-1S		CAMU-99-1D		CAMU-99-2S	
			Sample ID:	S16-T5-C95-1		S17-T5-C-95-1		S18-T5-C-95-1		S19-T5-C95-1		S16-T5-C95-2		S17-T5-C-95-2		S18-T5-C95-2		S19-T5-C95-2		IAAP020-CAMU-99-1S-GW		IAAP020-CAMU-99-1D-GW		IAAP020-CAMU-99-2S-GW	
			Date Collected:	4/13/2016		5/03/2017		5/16/2018		4/10/2019		4/13/2016		5/04/2017		5/12/2018		3/28/2019		4/2/2019		4/2/2019		4/2/2019	
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
218-01-9	Chrysene	Semi-volatiles	µg/L	---		0.87	U	0.16	UJ	---		---		0.83	U	0.17	U	---		---		---		---	
53-70-3	Dibenz(a,h)anthracene	Semi-volatiles	µg/L	---		0.82	U	0.25	U	---		---		0.79	U	0.25	U	---		---		---		---	
132-64-9	Dibenzofuran	Semi-volatiles	µg/L	5	U	0.61	UJ	1.6	U	3.3	U	5	U	0.59	UJ	1.7	U	3.1	U	3.2	U	3	U	3.2	U
84-66-2	Diethyl phthalate	Semi-volatiles	µg/L	5	U	1	U	4.1	U	3.3	U	5	U	0.98	U	4.2	U	3.1	U	3.2	U	3	U	3.2	U
131-11-3	Dimethyl phthalate	Semi-volatiles	µg/L	5	U	1	UJ	4.1	U	3.3	U	5	U	0.98	UJ	4.2	U	3.1	U	3.2	U	3	U	3.2	U
84-74-2	Di-n-butyl phthalate	Semi-volatiles	µg/L	5	U	1	U	4.1	U	3.3	U	5	U	0.98	U	4.2	U	3.1	U	3.2	U	3	U	3.2	U
117-84-0	Di-n-octyl phthalate	Semi-volatiles	µg/L	5	U	1	U	8.2	U	3.3	U	5	U	0.98	U	8.4	U	3.1	U	3.2	U	3	U	3.2	U
206-44-0	Fluoranthene	Semi-volatiles	µg/L	---		0.56	U	0.82	UJ	---		---		0.54	U	0.84	U	---		---		---		---	
86-73-7	Fluorene	Semi-volatiles	µg/L	---		0.72	UJ	0.82	UJ	---		---		0.69	UJ	0.84	U	---		---		---		---	
87-68-3	Hexachlorobutadiene	Semi-volatiles	µg/L	5	U	0.51	UJ	510	U	3.3	U	5	U	0.49	UJ	530	U	3.1	U	3.2	U	3	U	3.2	U
67-72-1	Hexachloroethane	Semi-volatiles	µg/L	5	U	1.7	UJ	1	U	3.3	UJ	5	U	1.6	UJ	1.1	U	3.1	U	3.2	U	3	U	3.2	U
193-39-5	Indeno(1,2,3-cd)pyrene	Semi-volatiles	µg/L	---		0.73	U	0.16	UJ	---		---		0.7	U	0.17	U	---		---		---		---	
78-59-1	Isophorone	Semi-volatiles	µg/L	5	U	0.79	UJ	100	U	3.3	U	5	U	0.76	UJ	110	U	3.1	U	3.2	U	3	U	3.2	U
91-20-3	Naphthalene	Semi-volatiles	µg/L	---		0.51	UJ	100	UJ	---		---		0.49	UJ	110	U	---		---		---		---	
98-95-3	Nitrobenzene	Semi-volatiles	µg/L	5	U	0.95	UJ	---		6.6	U	5	U	0.092	U	---		6.3	U	6.3	U	6	U	6.3	U
62-75-9	N-Nitrosodimethylamine	Semi-volatiles	µg/L	---		---		---		3.3	UJ	---		---		---		3.1	U	3.2	U	3	U	3.2	U
621-64-7	N-Nitrosodi-n-propylamine	Semi-volatiles	µg/L	5	U	0.68	UJ	0.41	U	3.3	U	5	U	0.66	UJ	0.42	U	3.1	U	3.2	U	3	U	3.2	U
86-30-6	N-Nitrosodiphenylamine	Semi-volatiles	µg/L	5	U	0.82	UJ	1.6	UJ	3.3	U	5	U	0.79	UJ	1.7	U	3.1	U	3.2	U	3	U	3.2	U
85-01-8	Phenanthrene	Semi-volatiles	µg/L	---		0.88	U	0.82	UJ	---		---		0.85	U	0.84	U	---		---		---		---	
108-95-2	Phenol	Semi-volatiles	µg/L	5	U	0.51	UJ	2000	U	3.3	U	5	U	0.49	UJ	2100	U	3.1	U	3.2	U	3	U	3.2	U
129-00-0	Pyrene	Semi-volatiles	µg/L	---		0.7	U	0.82	UJ	---		---		0.67	U	0.84	U	---		---		---		---	
98-06-6	(1,1-Dimethylethyl)benzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U	1	U	1	U
135-98-8	(1-Methylpropyl)benzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		1	U	1	U
630-20-6	1,1,1,2-Tetrachloroethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U	1	U	1	U
79-34-5	1,1,2,2-Tetrachloroethane	Volatiles	µg/L	1	U	0.3	U	1	U	1	U	1	U	0.3	U	1	U	1	U	1	U	1	U	1	U
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	Volatiles	µg/L	1	U	0.48	U	1	U	1	U	1	U	0.48	U	1	U	1	U	1	U	1	U	1	U
75-34-3	1,1-Dichloroethane	Volatiles	µg/L	1	U	0.34	U	7	U	1	U	1	U	0.34	U	7	U	1	U	1	U	1	U	1	U
563-58-6	1,1-Dichloropropene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		1	U	1	U
87-61-6	1,2,3-Trichlorobenzene	Volatiles	µg/L	---		---		---		5	U	---		---		---		5	U	5	U	5	U	5	U
96-18-4	1,2,3-Trichloropropane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U	1	U	1	U
95-63-6	1,2,4-Trimethylbenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U	1	U	1	U
95-47-6	1,2-Dimethylbenzene	Volatiles	µg/L	---		---		---		0.5	U	---		---		---		0.5	U	0.5	U	0.5	U	0.5	U
108-67-8	1,3,5-Trimethylbenzene	Volatiles	µg/L	---		---		---		0.5	U	---		---		---		0.5	U	---		0.5	U	0.5	U
541-73-1	1,3-Dichlorobenzene	Volatiles	µg/L	---		---		---		1	U	---		0.49	UJ	---		1	U	---		1	U	1	U
142-28-9	1,3-Dichloropropane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		1	U	1	U
106-43-4	1-Chloro-4-methylbenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		1	U	1	U
544-10-5	1-Chlorohexane	Volatiles	µg/L	---		---		---		2	U	---		---		---		2	U	---		2	U	2	U
99-87-6	1-Methyl-4-(1-methylethyl)benzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U	1	U	1	U
594-20-7	2,2-Dichloropropane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U	1	U	1	U
78-93-3	2-Butanone	Volatiles	µg/L	5	U	2	U	4000	U	10	U	5	U	2	U	4000	U	10	U	10	U	10	U	10	U
591-78-6	2-Hexanone	Volatiles	µg/L	10	U	2	U	5	U	5	U	10	U	2	U	5	U	5	U	---		5	U	5	U
1634-04-4	2-Methoxy-2-methylpropane	Volatiles	µg/L	---		---		---		0.5	U	---		---		---		0.5	U	---		0.5	U	0.5	U
108-10-1	4-Methyl-2-pentanone	Volatiles	µg/L	5	U	1	U	5	U	5	U	5	U	1	U	5	U	5	U	---		5	U	5	U
67-64-1	Acetone	Volatiles	µg/L	25	U	10	U	5	U	10	U	25	U	10	U	5	U	10	U	10	U	10	U	10	U
108-86-1	Bromobenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		1	U	1	U
74-97-5	Bromochloromethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U	1	U	1	U
74-83-9	Bromomethane	Volatiles	µg/L	2	U	0.59	U	10	U	5	U	2	U	0.59	U	10	U	5	U	5	U	5	U	5	U
104-51-8	Butylbenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		1	U	1	U
75-15-0	Carbon disulfide	Volatiles	µg/L	2	U	0.53	U	2	U	2	U	2	U	0.53	U	2	U	2	U	2	U	2	U	2	U
75-00-3	Chloroethane	Volatiles	µg/L	2	U	0.67	U	1	U	5	U	2	U	0.67	U	1	UJ	5	U	5	U	5	U	5	U
74-87-3	Chloromethane	Volatiles	µg/L	2	U	0.5	U	1	U	1	U	2	U	0.5	U	1	U	1	U	1	U	1	U	1	U
10061-01-5	cis-1,3-Dichloropropene	Volatiles	µg/L	1	U	0.29	U	1	U	1	U	1	U	0.29	U	1	U	1	U	---		1	U	1	U
98-82-8	Cumene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U	1	U	1	U
74-95-3	Dibromomethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U	1	U	1	U
75-71-8	Dichlorodifluoromethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U	1	U	1	U
87-68-3	Hexachlorobutadiene	Volatiles	µg/L	---		---		---		5	UJ	---		0.49	UJ	---		5	U	5	U	5	U	5	U
136777-61-2	M + P Xylene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		1	U	1	U
91-20-3	Naphthalene	Volatiles	µg/L	---		---		---		5	U	---		0.49	UJ	---		5	U	5	U	5	U	5	U
95-49-8	o-Chlorotoluene	Volatiles	µg/L	---		---		---		0.5	U	---		---		---		0.5	U	0.5	U	0.5	U	0.5	U
103-65-1	Propylbenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	---		1	U	1	U
10061-02-6	trans-1,3-Dichloropropene	Volatiles	µg/L	1	U	0.21	U	1	U	1	U	1	U	0.21	U	1	U	1	U	---		1	U	1	U
75-69-4	Trichlorofluoromethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U	1	U	1	U
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---	

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	CAMU-99-2D		CAMU-99-3S		ET-3								G-5							
			Sample ID:	IAAP020-CAMU-99-2D-GW		IAAP020-CAMU-99-3S-GW		S16-T5-ET-3		S17-T5-ET-3		S18-T5-ET-3		S19-T5-ET-3		S16-T5-G-5		S17-T5-G-5		S18-T5-G-5		S19-T5-G-5	
			Date Collected:	4/2/2019		4/3/2019		4/14/2016		5/02/2017		5/15/2018		4/11/2019		4/13/2016		5/05/2017		5/13/2018		4/1/2019	
			Units	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ
218-01-9	Chrysene	Semi-volatiles	µg/L	---		---		---		0.85	U	1.7	UJ	---		---		0.85	U	0.17	UJ	---	
53-70-3	Dibenz(a,h)anthracene	Semi-volatiles	µg/L	---		---		---		0.8	U	2.6	UJ	---		---		0.8	U	0.25	U	---	
132-64-9	Dibenzofuran	Semi-volatiles	µg/L	3.1	U	---		41	U	0.6	U	17	U	3	U	4.8	U	0.6	UJ	1.7	U	3.1	U
84-66-2	Diethyl phthalate	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	1	U	43	U	3	U	4.8	U	1	U	4.1	U	3.1	U
131-11-3	Dimethyl phthalate	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	1	U	43	U	3	U	4.8	U	1	UJ	4.1	U	3.1	U
84-74-2	Di-n-butyl phthalate	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	1	U	43	U	3	U	4.8	U	1	U	4.1	U	3.1	U
117-84-0	Di-n-octyl phthalate	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	1	U	86	U	3	U	4.8	U	1	U	8.3	U	3.1	U
206-44-0	Fluoranthene	Semi-volatiles	µg/L	---		---		---		0.55	U	8.6	UJ	---		---		0.55	U	0.83	UJ	---	
86-73-7	Fluorene	Semi-volatiles	µg/L	---		---		---		0.7	U	8.6	UJ	---		---		0.7	UJ	0.83	UJ	---	
87-68-3	Hexachlorobutadiene	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	0.5	U	5400	UJ	3	U	4.8	U	0.5	UJ	520	U	3.1	U
67-72-1	Hexachloroethane	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	1.6	U	11	UJ	3	U	4.8	U	1.6	UJ	1	U	3.1	U
193-39-5	Indeno(1,2,3-cd)pyrene	Semi-volatiles	µg/L	---		---		---		0.71	U	1.7	UJ	---		---		0.71	U	0.17	UJ	---	
78-59-1	Isophorone	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	0.78	U	1100	UJ	3	U	4.8	U	0.78	UJ	100	U	3.1	U
91-20-3	Naphthalene	Semi-volatiles	µg/L	---		---		---		89.1		1100	UJ	---		---		0.5	UJ	100	UJ	---	
98-95-3	Nitrobenzene	Semi-volatiles	µg/L	6.2	U	6.4	U	41	U	0.93	U	---		6	U	4.8	U	0.93	UJ	---		6.1	U
62-75-9	N-Nitrosodimethylamine	Semi-volatiles	µg/L	3.1	U	3.2	U	---		---		---		3	U	---		---		---		3.1	U
621-64-7	N-Nitrosodi-n-propylamine	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	0.67	U	4.3	UJ	3	U	4.8	U	0.67	UJ	0.41	U	3.1	U
86-30-6	N-Nitrosodiphenylamine	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	0.81	U	17	UJ	3	U	4.8	U	0.81	UJ	1.7	U	3.1	U
85-01-8	Phenanthrene	Semi-volatiles	µg/L	---		---		---		0.86	U	8.6	UJ	3	U	---		0.86	U	0.83	UJ	---	
108-95-2	Phenol	Semi-volatiles	µg/L	3.1	U	3.2	U	41	U	8.6		91	J	7.9	J	4.8	U	0.5	UJ	2100	U	3.1	U
129-00-0	Pyrene	Semi-volatiles	µg/L	---		---		---		0.68	U	8.6	UJ	---		---		0.68	U	0.83	UJ	---	
98-06-6	(1,1-Dimethylethyl)benzene	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
135-98-8	(1-Methylpropyl)benzene	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
630-20-6	1,1,1,2-Tetrachloroethane	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
79-34-5	1,1,2,2-Tetrachloroethane	Volatiles	µg/L	1	U	1	U	1	U	0.3	UJ	1	U	1	UJ	1	U	0.3	U	1	U	1	U
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	Volatiles	µg/L	1	U	1	U	1	U	0.48	UJ	1	U	1	UJ	1	U	0.48	U	1	U	1	U
75-34-3	1,1-Dichloroethane	Volatiles	µg/L	1	U	1	U	1	U	0.34	UJ	7	U	1	UJ	1	U	0.34	U	7	U	1	U
563-58-6	1,1-Dichloropropene	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
87-61-6	1,2,3-Trichlorobenzene	Volatiles	µg/L	5	U	5	U	---		---		---		5	UJ	---		---		---		5	U
96-18-4	1,2,3-Trichloropropane	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
95-63-6	1,2,4-Trimethylbenzene	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
95-47-6	1,2-Dimethylbenzene	Volatiles	µg/L	0.5	U	0.5	U	---		---		---		0.5	UJ	---		---		---		0.5	U
108-67-8	1,3,5-Trimethylbenzene	Volatiles	µg/L	0.5	U	0.5	U	---		---		---		0.5	UJ	---		---		---		0.5	U
541-73-1	1,3-Dichlorobenzene	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
142-28-9	1,3-Dichloropropane	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
106-43-4	1-Chloro-4-methylbenzene	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
544-10-5	1-Chlorohexane	Volatiles	µg/L	2	U	2	U	---		---		---		2	UJ	---		---		---		2	U
99-87-6	1-Methyl-4-(1-methylethyl)benzene	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
594-20-7	2,2-Dichloropropane	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
78-93-3	2-Butanone	Volatiles	µg/L	10	U	10	U	5	U	2	UJ	4000	U	10	UJ	5	U	2	U	4000	U	10	U
591-78-6	2-Hexanone	Volatiles	µg/L	5	U	5	U	10	U	2	UJ	5	U	5	UJ	10	U	2	U	5	U	5	U
1634-04-4	2-Methoxy-2-methylpropane	Volatiles	µg/L	0.5	U	0.5	U	---		---		---		0.33	J	---		---		---		0.5	U
108-10-1	4-Methyl-2-pentanone	Volatiles	µg/L	5	U	5	U	5	U	1	UJ	5	U	5	UJ	5	U	1	U	5	U	5	U
67-64-1	Acetone	Volatiles	µg/L	10	U	10	U	22.6	J	20.7	J	11	=	10	UJ	25	U	10	U	5	U	10	U
108-86-1	Bromobenzene	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
74-97-5	Bromochloromethane	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
74-83-9	Bromomethane	Volatiles	µg/L	5	U	5	U	2	U	0.59	UJ	10	U	5	UJ	2	U	0.59	U	10	U	5	U
104-51-8	Butylbenzene	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
75-15-0	Carbon disulfide	Volatiles	µg/L	2	U	2	U	0.46	J	0.53	UJ	2	U	2	UJ	2	U	0.53	U	2	U	2	U
75-00-3	Chloroethane	Volatiles	µg/L	5	U	5	U	2	U	0.67	UJ	1	U	5	UJ	2	U	0.67	U	1	UJ	5	U
74-87-3	Chloromethane	Volatiles	µg/L	1	U	1	U	2	U	0.5	UJ	1	U	1	UJ	2	U	0.5	U	1	U	1	U
10061-01-5	cis-1,3-Dichloropropene	Volatiles	µg/L	1	U	1	U	1	U	0.29	UJ	1	U	1	UJ	1	U	0.29	U	1	U	1	U
98-82-8	Cumene	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
74-95-3	Dibromomethane	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
75-71-8	Dichlorodifluoromethane	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
87-68-3	Hexachlorobutadiene	Volatiles	µg/L	5	U	5	U	---		---		---		5	UJ	---		---		---		5	U
136777-61-2	M + P Xylene	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
91-20-3	Naphthalene	Volatiles	µg/L	5	U	5	U	---		---		---		5	UJ	---		---		---		5	U
95-49-8	o-Chlorotoluene	Volatiles	µg/L	0.5	U	0.5	U	---		---		---		0.5	UJ	---		---		---		0.5	U
103-65-1	Propylbenzene	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
10061-02-6	trans-1,3-Dichloropropene	Volatiles	µg/L	1	U	1	U	1	U	0.21	UJ	1	U	1	UJ	1	U	0.21	U	1	U	1	U
75-69-4	Trichlorofluoromethane	Volatiles	µg/L	1	U	1	U	---		---		---		1	UJ	---		---		---		1	U
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		0.0000063	U	---		---		---		---	

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	G-6R								G-7								IDA-MW1	
			Sample ID:	S16-T5-G-6R		S17-T5-G-6R		S18-T5-G-6R		S19-T5-G-6R		S16-T5-G-7		S17-T5-G-7		S18-T5-G-7		S19-T5-G-7		IAAP020-IDA-MW1-GW	
			Date Collected:	4/15/2016		5/05/2017		5/17/2018		3/31/2019		4/14/2016		5/04/2017		5/13/2018		3/28/2019		4/3/2019	
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ
218-01-9	Chrysene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---	
53-70-3	Dibenz(a,h)anthracene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---	
132-64-9	Dibenzofuran	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
84-66-2	Diethyl phthalate	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
131-11-3	Dimethyl phthalate	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
84-74-2	Di-n-butyl phthalate	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
117-84-0	Di-n-octyl phthalate	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
206-44-0	Fluoranthene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---	
86-73-7	Fluorene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---	
87-68-3	Hexachlorobutadiene	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
67-72-1	Hexachloroethane	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
193-39-5	Indeno(1,2,3-cd)pyrene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---	
78-59-1	Isophorone	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
91-20-3	Naphthalene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---	
98-95-3	Nitrobenzene	Semi-volatiles	µg/L	---		---		---		6.3	U	---		---		---		6	U	6.2	U
62-75-9	N-Nitrosodimethylamine	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
621-64-7	N-Nitrosodi-n-propylamine	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
86-30-6	N-Nitrosodiphenylamine	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
85-01-8	Phenanthrene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---	
108-95-2	Phenol	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3	U	3.1	U
129-00-0	Pyrene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---	
98-06-6	(1,1-Dimethylethyl)benzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
135-98-8	(1-Methylpropyl)benzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
630-20-6	1,1,1,2-Tetrachloroethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
79-34-5	1,1,2,2-Tetrachloroethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
75-34-3	1,1-Dichloroethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
563-58-6	1,1-Dichloropropene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
87-61-6	1,2,3-Trichlorobenzene	Volatiles	µg/L	---		---		---		5	U	---		---		---		5	U	5	U
96-18-4	1,2,3-Trichloropropane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
95-63-6	1,2,4-Trimethylbenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
95-47-6	1,2-Dimethylbenzene	Volatiles	µg/L	---		---		---		0.5	U	---		---		---		0.5	U	0.5	U
108-67-8	1,3,5-Trimethylbenzene	Volatiles	µg/L	---		---		---		0.5	U	---		---		---		0.5	U	0.5	U
541-73-1	1,3-Dichlorobenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
142-28-9	1,3-Dichloropropane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
106-43-4	1-Chloro-4-methylbenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
544-10-5	1-Chlorohexane	Volatiles	µg/L	---		---		---		2	U	---		---		---		2	U	2	U
99-87-6	1-Methyl-4-(1-methylethyl)benzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
594-20-7	2,2-Dichloropropane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
78-93-3	2-Butanone	Volatiles	µg/L	---		---		---		10	U	---		---		---		10	U	10	U
591-78-6	2-Hexanone	Volatiles	µg/L	---		---		---		5	U	---		---		---		5	U	5	U
1634-04-4	2-Methoxy-2-methylpropane	Volatiles	µg/L	---		---		---		0.5	U	---		---		---		0.5	U	0.5	U
108-10-1	4-Methyl-2-pentanone	Volatiles	µg/L	---		---		---		5	U	---		---		---		5	U	5	U
67-64-1	Acetone	Volatiles	µg/L	---		---		---		10	U	---		---		---		10	U	10	U
108-86-1	Bromobenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
74-97-5	Bromochloromethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
74-83-9	Bromomethane	Volatiles	µg/L	---		---		---		5	U	---		---		---		5	U	5	U
104-51-8	Butylbenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
75-15-0	Carbon disulfide	Volatiles	µg/L	---		---		---		2	U	---		---		---		2	U	2	U
75-00-3	Chloroethane	Volatiles	µg/L	---		---		---		5	U	---		---		---		5	U	5	U
74-87-3	Chloromethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
10061-01-5	cis-1,3-Dichloropropene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
98-82-8	Cumene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
74-95-3	Dibromomethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
75-71-8	Dichlorodifluoromethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
87-68-3	Hexachlorobutadiene	Volatiles	µg/L	---		---		---		5	U	---		---		---		5	U	5	U
136777-61-2	M + P Xylene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
91-20-3	Naphthalene	Volatiles	µg/L	---		---		---		5	U	---		---		---		5	U	5	U
95-49-8	o-Chlorotoluene	Volatiles	µg/L	---		---		---		0.5	U	---		---		---		0.5	U	0.5	U
103-65-1	Propylbenzene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
10061-02-6	trans-1,3-Dichloropropene	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
75-69-4	Trichlorofluoromethane	Volatiles	µg/L	---		---		---		1	U	---		---		---		1	U	1	U
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		0.00000041	U

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	IDA-TT-MW1								IDA-MW2		JAW-26							
			Sample ID:	S16-T5-IDA-TT-MW1		S17-T5-IDA-TT-MW1		S18-T5-IDA-TT-MW1		S19-T5-IDA-TT-MW1		IAAP020-IDA-MW2-GW		S16-T5-JAW-26		S17-T5-JAW-26		S18-T5-JAW-26		S19-T5-JAW-26	
			Date Collected:	4/14/2016		5/03/2017		5/12/2018		4/1/2019		4/10/2019		4/14/2016		5/03/2017		5/13/2018		3/28/2019	
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Results	Qual	Result	VQ	Result	VQ
218-01-9	Chrysene	Semi-volatiles	µg/L	---		0.87	U	0.18	U	---		---		---		---		---		---	
53-70-3	Dibenz(a,h)anthracene	Semi-volatiles	µg/L	---		0.82	U	0.27	U	---		---		---		---		---		---	
132-64-9	Dibenzofuran	Semi-volatiles	µg/L	4.7	U	0.61	UJ	1.8	U	3.2	U	3.4	U	---		---		---		3.1	U
84-66-2	Diethyl phthalate	Semi-volatiles	µg/L	4.7	U	1	U	4.5	U	3.2	U	3.4	U	---		---		---		3.1	U
131-11-3	Dimethyl phthalate	Semi-volatiles	µg/L	4.7	U	1	UJ	4.5	U	3.2	U	3.4	U	---		---		---		3.1	U
84-74-2	Di-n-butyl phthalate	Semi-volatiles	µg/L	4.7	U	1	U	4.5	U	3.2	U	3.4	U	---		---		---		3.1	U
117-84-0	Di-n-octyl phthalate	Semi-volatiles	µg/L	4.7	U	1	U	9	U	3.2	U	3.4	U	---		---		---		3.1	U
206-44-0	Fluoranthene	Semi-volatiles	µg/L	---		0.56	U	0.9	U	---		---		---		---		---		---	
86-73-7	Fluorene	Semi-volatiles	µg/L	---		0.72	UJ	0.9	U	---		---		---		---		---		---	
87-68-3	Hexachlorobutadiene	Semi-volatiles	µg/L	4.7	U	0.51	UJ	560	U	3.2	U	3.4	U	---		---		---		3.1	U
67-72-1	Hexachloroethane	Semi-volatiles	µg/L	4.7	U	1.7	UJ	1.1	U	3.2	U	3.4	UJ	---		---		---		3.1	U
193-39-5	Indeno(1,2,3-cd)pyrene	Semi-volatiles	µg/L	---		0.73	U	0.18	U	---		---		---		---		---		---	
78-59-1	Isophorone	Semi-volatiles	µg/L	4.7	U	0.79	UJ	110	U	3.2	U	3.4	U	---		---		---		3.1	U
91-20-3	Naphthalene	Semi-volatiles	µg/L	---		0.51	UJ	110	U	---		---		---		---		---		---	
98-95-3	Nitrobenzene	Semi-volatiles	µg/L	4.7	U	0.95	UJ	---		6.3	U	6.7	U	---		---		---		6.3	U
62-75-9	N-Nitrosodimethylamine	Semi-volatiles	µg/L	---		---		---		3.2	U	3.4	UJ	---		---		---		3.1	U
621-64-7	N-Nitrosodi-n-propylamine	Semi-volatiles	µg/L	4.7	U	0.68	UJ	0.45	U	3.2	U	3.4	U	---		---		---		3.1	U
86-30-6	N-Nitrosodiphenylamine	Semi-volatiles	µg/L	4.7	U	0.82	UJ	1.8	U	3.2	U	3.4	U	---		---		---		3.1	U
85-01-8	Phenanthrene	Semi-volatiles	µg/L	---		0.88	U	0.9	U	---		---		---		---		---		---	
108-95-2	Phenol	Semi-volatiles	µg/L	4.7	U	0.51	UJ	2300	U	3.2	U	3.4	U	---		---		---		3.1	U
129-00-0	Pyrene	Semi-volatiles	µg/L	---		0.7	U	0.9	U	---		---		---		---		---		---	
98-06-6	(1,1-Dimethylethyl)benzene	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
135-98-8	(1-Methylpropyl)benzene	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
630-20-6	1,1,1,2-Tetrachloroethane	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
79-34-5	1,1,2,2-Tetrachloroethane	Volatiles	µg/L	1	U	0.3	U	1	U	1	U	1	U	---		---		---		1	U
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	Volatiles	µg/L	1	U	0.48	U	1	U	1	U	1	U	---		---		---		1	U
75-34-3	1,1-Dichloroethane	Volatiles	µg/L	1	U	0.34	U	7	U	1	U	1	U	---		---		---		1	U
563-58-6	1,1-Dichloropropene	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
87-61-6	1,2,3-Trichlorobenzene	Volatiles	µg/L	---		---		---		5	U	5	U	---		---		---		5	U
96-18-4	1,2,3-Trichloropropane	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
95-63-6	1,2,4-Trimethylbenzene	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
95-47-6	1,2-Dimethylbenzene	Volatiles	µg/L	---		---		---		0.5	U	0.5	U	---		---		---		0.5	U
108-67-8	1,3,5-Trimethylbenzene	Volatiles	µg/L	---		---		---		0.5	U	0.5	U	---		---		---		0.5	U
541-73-1	1,3-Dichlorobenzene	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
142-28-9	1,3-Dichloropropane	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
106-43-4	1-Chloro-4-methylbenzene	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
544-10-5	1-Chlorohexane	Volatiles	µg/L	---		---		---		2	U	2	U	---		---		---		2	U
99-87-6	1-Methyl-4-(1-methylethyl)benzene	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
594-20-7	2,2-Dichloropropane	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
78-93-3	2-Butanone	Volatiles	µg/L	5	U	2	U	4000	U	10	U	10	U	---		---		---		10	U
591-78-6	2-Hexanone	Volatiles	µg/L	10	U	2	U	5	U	5	U	5	U	---		---		---		5	U
1634-04-4	2-Methoxy-2-methylpropane	Volatiles	µg/L	---		---		---		0.5	U	0.5	U	---		---		---		0.5	U
108-10-1	4-Methyl-2-pentanone	Volatiles	µg/L	5	U	1	U	5	U	5	U	5	U	---		---		---		5	U
67-64-1	Acetone	Volatiles	µg/L	25	U	10	U	5	U	10	U	10	U	---		---		---		10	U
108-86-1	Bromobenzene	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
74-97-5	Bromochloromethane	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
74-83-9	Bromomethane	Volatiles	µg/L	2	U	0.59	U	10	U	5	U	5	U	---		---		---		5	U
104-51-8	Butylbenzene	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
75-15-0	Carbon disulfide	Volatiles	µg/L	2	U	0.53	U	2	U	2	U	2	U	---		---		---		2	U
75-00-3	Chloroethane	Volatiles	µg/L	2	U	0.67	U	1	UJ	5	U	5	U	---		---		---		5	U
74-87-3	Chloromethane	Volatiles	µg/L	2	U	0.5	U	1	U	1	UJ	1	U	---		---		---		1	U
10061-01-5	cis-1,3-Dichloropropene	Volatiles	µg/L	1	U	0.29	U	1	U	1	U	1	U	---		---		---		1	U
98-82-8	Cumene	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
74-95-3	Dibromomethane	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
75-71-8	Dichlorodifluoromethane	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
87-68-3	Hexachlorobutadiene	Volatiles	µg/L	---		---		---		5	U	5	UJ	---		---		---		5	U
136777-61-2	M + P Xylene	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
91-20-3	Naphthalene	Volatiles	µg/L	---		---		---		5	U	5	U	---		---		---		5	U
95-49-8	o-Chlorotoluene	Volatiles	µg/L	---		---		---		0.5	U	0.5	U	---		---		---		0.5	U
103-65-1	Propylbenzene	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
10061-02-6	trans-1,3-Dichloropropene	Volatiles	µg/L	1	U	0.21	U	1	U	1	U	1	U	---		---		---		1	U
75-69-4	Trichlorofluoromethane	Volatiles	µg/L	---		---		---		1	U	1	U	---		---		---		1	U
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---	

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	JAW-27								JAW-65								T-1							
			Sample ID:	S16-T5-JAW-27		S17-T5-JAW-27		S18-T5-JAW-27		S19-T5-JAW-27		S16-T5-JAW-65		S17-T5-JAW-65		S18-T5-JAW-65		S19-T5-JAW-65		S16-T5-T-1		S17-T5-T-1		S18-T5-T-1		S19-T5-T-1	
			Date Collected:	4/14/2016		5/02/2017		5/16/2018		4/12/2019		4/14/2016		5/03/2017		5/16/2018		3/28/2019		4/11/2016		5/04/2017		5/10/2018		3/31/2019	
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ
218-01-9	Chrysene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
53-70-3	Dibenz(a,h)anthracene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
132-64-9	Dibenzofuran	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
84-66-2	Diethyl phthalate	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
131-11-3	Dimethyl phthalate	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
84-74-2	Di-n-butyl phthalate	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
117-84-0	Di-n-octyl phthalate	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
206-44-0	Fluoranthene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
86-73-7	Fluorene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
87-68-3	Hexachlorobutadiene	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
67-72-1	Hexachloroethane	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
193-39-5	Indeno(1,2,3-cd)pyrene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
78-59-1	Isophorone	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
91-20-3	Naphthalene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
98-95-3	Nitrobenzene	Semi-volatiles	µg/L	---		---		---		6.4	U	---		---		---		6.5	U	---		---		---		6.5	U
62-75-9	N-Nitrosodimethylamine	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
621-64-7	N-Nitrosodi-n-propylamine	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
86-30-6	N-Nitrosodiphenylamine	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
85-01-8	Phenanthrene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
108-95-2	Phenol	Semi-volatiles	µg/L	---		---		---		3.2	U	---		---		---		3.2	U	---		---		---		3.2	U
129-00-0	Pyrene	Semi-volatiles	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
98-06-6	(1,1-Dimethylethyl)benzene	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
135-98-8	(1-Methylpropyl)benzene	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
630-20-6	1,1,1,2-Tetrachloroethane	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
79-34-5	1,1,2,2-Tetrachloroethane	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
75-34-3	1,1-Dichloroethane	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
563-58-6	1,1-Dichloropropene	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
87-61-6	1,2,3-Trichlorobenzene	Volatiles	µg/L	---		---		---		5	UJ	---		---		---		5	U	---		---		---		5	U
96-18-4	1,2,3-Trichloropropane	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
95-63-6	1,2,4-Trimethylbenzene	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
95-47-6	1,2-Dimethylbenzene	Volatiles	µg/L	---		---		---		0.5	UJ	---		---		---		0.5	U	---		---		---		0.5	U
108-67-8	1,3,5-Trimethylbenzene	Volatiles	µg/L	---		---		---		0.5	UJ	---		---		---		0.5	U	---		---		---		0.5	U
541-73-1	1,3-Dichlorobenzene	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
142-28-9	1,3-Dichloropropane	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
106-43-4	1-Chloro-4-methylbenzene	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
544-10-5	1-Chlorohexane	Volatiles	µg/L	---		---		---		2	UJ	---		---		---		2	U	---		---		---		2	U
99-87-6	1-Methyl-4-(1-methylethyl)benzene	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
594-20-7	2,2-Dichloropropane	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
78-93-3	2-Butanone	Volatiles	µg/L	---		---		---		10	UJ	---		---		---		10	U	---		---		---		10	U
591-78-6	2-Hexanone	Volatiles	µg/L	---		---		---		5	UJ	---		---		---		5	U	---		---		---		5	U
1634-04-4	2-Methoxy-2-methylpropane	Volatiles	µg/L	---		---		---		0.5	UJ	---		---		---		0.5	U	---		---		---		0.5	U
108-10-1	4-Methyl-2-pentanone	Volatiles	µg/L	---		---		---		5	UJ	---		---		---		5	U	---		---		---		5	U
67-64-1	Acetone	Volatiles	µg/L	---		---		---		10	UJ	---		---		---		10	U	---		---		---		10	U
108-86-1	Bromobenzene	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
74-97-5	Bromochloromethane	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
74-83-9	Bromomethane	Volatiles	µg/L	---		---		---		5	UJ	---		---		---		5	U	---		---		---		5	U
104-51-8	Butylbenzene	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
75-15-0	Carbon disulfide	Volatiles	µg/L	---		---		---		2	UJ	---		---		---		2	U	---		---		---		2	U
75-00-3	Chloroethane	Volatiles	µg/L	---		---		---		5	UJ	---		---		---		5	U	---		---		---		5	U
74-87-3	Chloromethane	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
10061-01-5	cis-1,3-Dichloropropene	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
98-82-8	Cumene	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
74-95-3	Dibromomethane	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
75-71-8	Dichlorodifluoromethane	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
87-68-3	Hexachlorobutadiene	Volatiles	µg/L	---		---		---		5	UJ	---		---		---		5	U	---		---		---		5	U
136777-61-2	M + P Xylene	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
91-20-3	Naphthalene	Volatiles	µg/L	---		---		---		5	UJ	---		---		---		5	U	---		---		---		5	U
95-49-8	o-Chlorotoluene	Volatiles	µg/L	---		---		---		0.5	UJ	---		---		---		0.5	U	---		---		---		0.5	U
103-65-1	Propylbenzene	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
10061-02-6	trans-1,3-Dichloropropene	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
75-69-4	Trichlorofluoromethane	Volatiles	µg/L	---		---		---		1	UJ	---		---		---		1	U	---		---		---		1	U
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	T-6								MW20-01		Statistical Summary						Groundwater PAL Evaluation	
			Sample ID:	S16-T5-T-6		S17-T5-T-6		S18-T5-T-6		S19-T5-T-6		IAAP020-MW20-01-GW		Minimum Detected Concentration (Qualifier)	Maximum Detected Concentration (Qualifier)	Units	Location of Maximum Concentration		Detection Frequency	Groundwater PAL	Groundwater Maximum Detected Conc. > PAL Value
			Date Collected:	4/11/2016		5/04/2017		5/10/2018		3/31/2019		12/9/2020					Sample ID	Date Collected			
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	(1)(2)	(1)(2)		(2)	(2)	(2)	(3)	(Y/N)
218-01-9	Chrysene	Semi-volatiles	µg/L	---		---		---		---		0.006	U	ND	ND	µg/L	NA	NA	0 / 17	25	No
53-70-3	Dibenz(a,h)anthracene	Semi-volatiles	µg/L	---		---		---		---		0.006	U	ND	ND	µg/L	NA	NA	0 / 17	0.025	No
132-64-9	Dibenzofuran	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND	ND	µg/L	NA	NA	0 / 46	7.9	No
84-66-2	Diethyl phthalate	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND	ND	µg/L	NA	NA	0 / 47	15000	No
131-11-3	Dimethyl phthalate	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND	ND	µg/L	NA	NA	0 / 47	--	No
84-74-2	Di-n-butyl phthalate	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND	ND	µg/L	NA	NA	0 / 47	900	No
117-84-0	Di-n-octyl phthalate	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND	ND	µg/L	NA	NA	0 / 47	200	No
206-44-0	Fluoranthene	Semi-volatiles	µg/L	---		---		---		---		0.0089	U	ND	ND	µg/L	NA	NA	0 / 17	800	No
86-73-7	Fluorene	Semi-volatiles	µg/L	---		---		---		---		0.006	U	ND	ND	µg/L	NA	NA	0 / 17	290	No
87-68-3	Hexachlorobutadiene	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND	ND	µg/L	NA	NA	0 / 47	0.14	No
67-72-1	Hexachloroethane	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND	ND	µg/L	NA	NA	0 / 47	1	No
193-39-5	Indeno(1,2,3-cd)pyrene	Semi-volatiles	µg/L	---		---		---		---		0.006	U	ND	ND	µg/L	NA	NA	0 / 17	0.25	No
78-59-1	Isophorone	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND	ND	µg/L	NA	NA	0 / 47	100	No
91-20-3	Naphthalene	Semi-volatiles	µg/L	---		---		---		---		0.0085	J	1.8 J	89.1	µg/L	S17-T5-ET-3	5/2/2017	3 / 17	100	No
98-95-3	Nitrobenzene	Semi-volatiles	µg/L	---		---		---		6.3	U	6	U	ND	ND	µg/L	NA	NA	0 / 39	0.14	No
62-75-9	N-Nitrosodimethylamine	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND	ND	µg/L	NA	NA	0 / 23	0.00011	No
621-64-7	N-Nitrosodi-n-propylamine	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND	ND	µg/L	NA	NA	0 / 47	0.011	No
86-30-6	N-Nitrosodiphenylamine	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	ND	ND	µg/L	NA	NA	0 / 47	12	No
85-01-8	Phenanthrene	Semi-volatiles	µg/L	---		---		---		---		0.006	U	ND	ND	µg/L	NA	NA	0 / 19	1800	No
108-95-2	Phenol	Semi-volatiles	µg/L	---		---		---		3.2	U	3	U	7.9 J	91	µg/L	S18-T5-ET-3	5/15/2018	3 / 47	5800	No
129-00-0	Pyrene	Semi-volatiles	µg/L	---		---		---		---		0.0089	U	ND	ND	µg/L	NA	NA	0 / 17	120	No
98-06-6	(1,1-Dimethylethyl)benzene	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 23	690	No
135-98-8	(1-Methylpropyl)benzene	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 22	2000	No
630-20-6	1,1,1,2-Tetrachloroethane	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 23	70	No
79-34-5	1,1,2,2-Tetrachloroethane	Volatiles	µg/L	---		---		---		1	U	2	U	ND	ND	µg/L	NA	NA	0 / 47	0.076	No
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 47	10000	No
75-34-3	1,1-Dichloroethane	Volatiles	µg/L	---		---		---		1	U	11		0 J	4.6	µg/L	S16-T5-C-00-1	4/12/2016	5 / 47	2.8	Yes
563-58-6	1,1-Dichloropropene	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 22	0.47	No
87-61-6	1,2,3-Trichlorobenzene	Volatiles	µg/L	---		---		---		5	U	5	U	ND	ND	µg/L	NA	NA	0 / 23	7	No
96-18-4	1,2,3-Trichloropropane	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 23	0.00075	No
95-63-6	1,2,4-Trimethylbenzene	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 23	56	No
95-47-6	1,2-Dimethylbenzene	Volatiles	µg/L	---		---		---		0.5	U	0.5	U	ND	ND	µg/L	NA	NA	0 / 23	190	No
108-67-8	1,3,5-Trimethylbenzene	Volatiles	µg/L	---		---		---		0.5	U	1	U	ND	ND	µg/L	NA	NA	0 / 22	60	No
541-73-1	1,3-Dichlorobenzene	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 23	75	No
142-28-9	1,3-Dichloropropane	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 22	370	No
106-43-4	1-Chloro-4-methylbenzene	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 22	250	No
544-10-5	1-Chlorohexane	Volatiles	µg/L	---		---		---		2	U	2	U	ND	ND	µg/L	NA	NA	0 / 22	--	No
99-87-6	1-Methyl-4-(1-methylethyl)benzene	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 23	--	No
594-20-7	2,2-Dichloropropane	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 23	0.14	No
78-93-3	2-Butanone	Volatiles	µg/L	---		---		---		10	U	10	U	ND	ND	µg/L	NA	NA	0 / 47	5600	No
591-78-6	2-Hexanone	Volatiles	µg/L	---		---		---		5	U	5	U	ND	ND	µg/L	NA	NA	0 / 46	38	No
1634-04-4	2-Methoxy-2-methylpropane	Volatiles	µg/L	---		---		---		0.5	U	1	U	0.33 J	0.33 J	µg/L	S19-T5-ET-3	4/11/2019	1 / 22	14	No
108-10-1	4-Methyl-2-pentanone	Volatiles	µg/L	---		---		---		5	U	5	U	ND	ND	µg/L	NA	NA	0 / 46	6300	No
67-64-1	Acetone	Volatiles	µg/L	---		---		---		10	U	25	U	5.5 J	22.6 J	µg/L	S16-T5-ET-3	4/14/2016	4 / 47	18000	No
108-86-1	Bromobenzene	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 22	62	No
74-97-5	Bromochloromethane	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 23	90	No
74-83-9	Bromomethane	Volatiles	µg/L	---		---		---		5	U	5	U	ND	ND	µg/L	NA	NA	0 / 47	10	No
104-51-8	Butylbenzene	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 22	1000	No
75-15-0	Carbon disulfide	Volatiles	µg/L	---		---		---		2	U	1	U	0.46 J	0.46 J	µg/L	S16-T5-ET-3	4/14/2016	1 / 47	810	No
75-00-3	Chloroethane	Volatiles	µg/L	---		---		---		5	U	5	U	ND	ND	µg/L	NA	NA	0 / 47	21000	No
74-87-3	Chloromethane	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 47	190	No
10061-01-5	cis-1,3-Dichloropropene	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 46	0.47	No
98-82-8	Cumene	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 23	450	No
74-95-3	Dibromomethane	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 23	8.3	No
75-71-8	Dichlorodifluoromethane	Volatiles	µg/L	---		---		---		1	U	2	U	ND	ND	µg/L	NA	NA	0 / 23	1000	No
87-68-3	Hexachlorobutadiene	Volatiles	µg/L	---		---		---		5	U	5	U	ND	ND	µg/L	NA	NA	0 / 24	0.14	No
136777-61-2	M + P Xylene	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 22	190	No
91-20-3	Naphthalene	Volatiles	µg/L	---		---		---		5	U	5	U	ND	ND	µg/L	NA	NA	0 / 24	100	No
95-49-8	o-Chlorotoluene	Volatiles	µg/L	---		---		---		0.5	U	1	U	ND	ND	µg/L	NA	NA	0 / 23	0.14	No
103-65-1	Propylbenzene	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 22	660	No
10061-02-6	trans-1,3-Dichloropropene	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 46	0.47	No
75-69-4	Trichlorofluoromethane	Volatiles	µg/L	---		---		---		1	U	1	U	ND	ND	µg/L	NA	NA	0 / 23	5200	No
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		0.00000074 J	0.00000074 J	µg/L	S19-T5-C-00-3	4/1/2019	1 / 3		No

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	C-00-1								C-00-2								C-00-3							
			Sample ID:	S16-T5-C-00-1		S17-T5-C-00-1		S18-T5-C-00-1		S19-T5-C-00-1		S16-T5-C-00-2		S17-T5-C-00-2		S18-T5-C-00-2		S19-T5-C-00-2		S16-T5-C-00-3		S17-T5-C-00-3		S18-T5-C-00-3		S19-T5-C-00-3	
			Date Collected:	4/12/2016		5/02/2017		5/11/2018		4/11/2019		4/12/2016		5/05/2017		5/16/2018		3/31/2019		4/12/2016		5/04/2017		5/13/2018		4/1/2019	
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		0.0000015	J
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		0.000014	U
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		0.0000072	U
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		0.0000019	J
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		0.000014	U
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		0.00000063	J
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		0.0000012	J
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		0.00000089	J
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		0.0000072	U
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		0.0000072	U
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		0.0000072	U
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		0.000014	U
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		0.0000056	U
3268-87-9	Octachloro-dibenzo[b,e][1,4]dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		0.000048	J
39001-02-0	Octachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		0.0000016	J
14331-83-0	Actinium-228	Radiological	pCi/L	23.38	U	31.08	U	3.34	U	---		20.05	U	22.75	U	19	U	---		21	U	25.32	U	16.4	U	---	
10045-97-3	Cesium-137	Radiological	pCi/L	7.26	U	9.3	U	3.17	U	-12.3	U	4.95	U	6	U	3.79	U	5.25	U	5.37	U	5.39	U	-2.08	U	-10.5	U
15092-94-1	Lead-212	Radiological	pCi/L	9.95	U	12.72	J	12.5	U	---		7.91	U	8.79	U	-2.75	U	---		8.31	U	8.19	U	4.68	U	---	
15067-28-4	Lead-214	Radiological	pCi/L	11.73	U	40.22	J	29.5	=	---		9.62	U	61.93	J	-0.0616	U	---		9.62	U	49.89		18.8	U	---	
13966-00-2	Potassium-40	Radiological	pCi/L	81.07	U	98.01	U	-46.6	U	---		63.62	U	74.24	U	-83.6	U	---		70.18	U	77.96	U	50.1	U	---	
13982-63-3	Radium-226	Radiological	pCi/L	0.38	U	0.33	U	0.172	J	0.103	J	0.28	U	0.26	U	0.141	J	0.0687	U	0.18	U	0.29	J	0.233	J	0.186	J
15262-20-1	Radium-228	Radiological	pCi/L	0.89	U	1.17	J	0.256	U	0.784	J	0.92	U	0.89	U	0.825	J	0.641	J	0.82	U	1.11	U	0.562	J	0.522	J
14808-79-8	Sulfate	Anions	mg/L	109		129		130	=	140		---		---		---		---		---		---		---		---	
74-84-0	Ethane	Miscellaneous	mg/L	1	U	0.32	U	0.005	U	1.1	U	---		---		---		---		---		---		---		---	
74-85-1	Ethene	Miscellaneous	mg/L	1	U	0.43	U	0.005	U	1	U	---		---		---		---		---		---		---		---	
74-82-8	Methane	Miscellaneous	mg/L	0.3	J	0.43	U	0.005	UJ	0.42	J	---		---		---		---		---		---		---		---	

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	C-95-1								C-95-2								CAMU-99-1S		CAMU-99-1D		CAMU-99-2S	
			Sample ID:	S16-T5-C95-1		S17-T5-C-95-1		S18-T5-C-95-1		S19-T5-C95-1		S16-T5-C95-2		S17-T5-C-95-2		S18-T5-C95-2		S19-T5-C95-2		IAAP020-CAMU-99-1S-GW		IAAP020-CAMU-99-1D-GW		IAAP020-CAMU-99-2S-GW	
			Date Collected:	4/13/2016		5/03/2017		5/16/2018		4/10/2019		4/13/2016		5/04/2017		5/12/2018		3/28/2019		4/2/2019		4/2/2019		4/2/2019	
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---	
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---	
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---	
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---	
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---	
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---	
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---	
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---	
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---	
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---	
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---	
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---	
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---	
3268-87-9	Octachloro-dibenzo[b,e][1,4]dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---	
39001-02-0	Octachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---	
14331-83-0	Actinium-228	Radiological	pCi/L	18.6	U	22.27	U	-16.1	U	---		18.38	U	23.82	U	6.38	U	---		---		---		---	
10045-97-3	Cesium-137	Radiological	pCi/L	5.57	U	5.78	U	-0.396	U	3.17	U	5.76	U	6.91	U	2.77	U	-3.79	U	---		---		---	
15092-94-1	Lead-212	Radiological	pCi/L	7.98	U	8.69	U	-2.33	U	---		7.59	U	9.99	U	2.87	U	---		---		---		---	
15067-28-4	Lead-214	Radiological	pCi/L	10.05	U	33.96		13.7	U	---		15.41	U	73.67	J	-7.63	U	---		---		---		---	
13966-00-2	Potassium-40	Radiological	pCi/L	64.29	U	76.84	J	-111	U	---		63.62	U	79.1	U	-0.126	U	---		---		---		---	
13982-63-3	Radium-226	Radiological	pCi/L	0.28	U	0.28	U	0.121	J	0.0241	U	0.2	U	1.04	U	0.17	J	0.0934	J	---		---		---	
15262-20-1	Radium-228	Radiological	pCi/L	0.88	U	0.9	U	0.71	J	-0.161	U	0.87	U	1.92	U	0.375	J	0.318	U	---		---		---	
14808-79-8	Sulfate	Anions	mg/L	---		---		---		---		---		---		---		---		---		---		---	
74-84-0	Ethane	Miscellaneous	mg/L	---		---		---		---		---		---		---		---		---		---		---	
74-85-1	Ethene	Miscellaneous	mg/L	---		---		---		---		---		---		---		---		---		---		---	
74-82-8	Methane	Miscellaneous	mg/L	---		---		---		---		---		---		---		---		---		---		---	

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	CAMU-99-2D		CAMU-99-3S		ET-3								G-5							
			Sample ID:	IAAP020-CAMU-99-2D-GW		IAAP020-CAMU-99-3S-GW		S16-T5-ET-3		S17-T5-ET-3		S18-T5-ET-3		S19-T5-ET-3		S16-T5-G-5		S17-T5-G-5		S18-T5-G-5		S19-T5-G-5	
			Date Collected:	4/2/2019		4/3/2019		4/14/2016		5/02/2017		5/15/2018		4/11/2019		4/13/2016		5/05/2017		5/13/2018		4/1/2019	
			Units	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		0.0000022	J	---		---		---		---	
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		0.000012	U	---		---		---		---	
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		0.0000063	U	---		---		---		---	
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		0.0000013	U	---		---		---		---	
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		0.000012	U	---		---		---		---	
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		0.00000028	J	---		---		---		---	
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		0.00000039	UJ	---		---		---		---	
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		0.000012	U	---		---		---		---	
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		0.0000063	U	---		---		---		---	
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		0.0000063	U	---		---		---		---	
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		0.0000063	U	---		---		---		---	
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		0.000012	U	---		---		---		---	
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		0.0000049	U	---		---		---		---	
3268-87-9	Octachloro-dibenzo[b,e][1,4]dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		0.000018	J	---		---		---		---	
39001-02-0	Octachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		0.00000099	J	---		---		---		---	
14331-83-0	Actinium-228	Radiological	pCi/L	---		---		---		---		---		---		---		---		---		---	
10045-97-3	Cesium-137	Radiological	pCi/L	---		---		---		---		---		---		---		---		---		---	
15092-94-1	Lead-212	Radiological	pCi/L	---		---		---		---		---		---		---		---		---		---	
15067-28-4	Lead-214	Radiological	pCi/L	---		---		---		---		---		---		---		---		---		---	
13966-00-2	Potassium-40	Radiological	pCi/L	---		---		---		---		---		---		---		---		---		---	
13982-63-3	Radium-226	Radiological	pCi/L	---		---		---		---		---		---		---		---		---		---	
15262-20-1	Radium-228	Radiological	pCi/L	---		---		---		---		---		---		---		---		---		---	
14808-79-8	Sulfate	Anions	mg/L	---		---		64		13.1	J	14	=	8.7		---		---		---		---	
74-84-0	Ethane	Miscellaneous	mg/L	---		---		0.41	J	0.88	J	0.005	U	1.9		---		---		---		---	
74-85-1	Ethene	Miscellaneous	mg/L	---		---		1	U	0.68	J	0.0031	J	1	U	---		---		---		---	
74-82-8	Methane	Miscellaneous	mg/L	---		---		4060		7090	J	6	=	13000		---		---		---		---	

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	G-6R								G-7								IDA-MW1	
			Sample ID:	S16-T5-G-6R		S17-T5-G-6R		S18-T5-G-6R		S19-T5-G-6R		S16-T5-G-7		S17-T5-G-7		S18-T5-G-7		S19-T5-G-7		IAAP020-IDA-MW1-GW	
			Date Collected:	4/15/2016		5/05/2017		5/17/2018		3/31/2019		4/14/2016		5/04/2017		5/13/2018		3/28/2019		4/3/2019	
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		0.00000098	U
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		0.000013	UJ
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		0.0000069	U
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		0.000026	UJ
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		0.000013	U
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		0.000013	U
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		0.0000069	UJ
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		0.000013	UJ
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		0.0000069	U
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		0.0000069	U
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		0.0000069	UJ
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		0.000013	UJ
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		0.0000053	U
3268-87-9	Octachloro-dibenzo[b,e][1,4]dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		0.0000045	U
39001-02-0	Octachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		0.00000053	U
14331-83-0	Actinium-228	Radiological	pCi/L	---		---		---		---		---		---		---		---		---	
10045-97-3	Cesium-137	Radiological	pCi/L	---		---		---		---		---		---		---		---		---	
15092-94-1	Lead-212	Radiological	pCi/L	---		---		---		---		---		---		---		---		---	
15067-28-4	Lead-214	Radiological	pCi/L	---		---		---		---		---		---		---		---		---	
13966-00-2	Potassium-40	Radiological	pCi/L	---		---		---		---		---		---		---		---		---	
13982-63-3	Radium-226	Radiological	pCi/L	---		---		---		---		---		---		---		---		---	
15262-20-1	Radium-228	Radiological	pCi/L	---		---		---		---		---		---		---		---		---	
14808-79-8	Sulfate	Anions	mg/L	---		---		---		---		---		---		---		---		---	
74-84-0	Ethane	Miscellaneous	mg/L	---		---		---		---		---		---		---		---		---	
74-85-1	Ethene	Miscellaneous	mg/L	---		---		---		---		---		---		---		---		---	
74-82-8	Methane	Miscellaneous	mg/L	---		---		---		---		---		---		---		---		---	

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	IDA-TT-MW1								IDA-MW2		JAW-26							
			Sample ID:	S16-T5-IDA-TT-MW1		S17-T5-IDA-TT-MW1		S18-T5-IDA-TT-MW1		S19-T5-IDA-TT-MW1		IAAP020-IDA-MW2-GW		S16-T5-JAW-26		S17-T5-JAW-26		S18-T5-JAW-26		S19-T5-JAW-26	
			Date Collected:	4/14/2016		5/03/2017		5/12/2018		4/1/2019		4/10/2019		4/14/2016		5/03/2017		5/13/2018		3/28/2019	
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Result	VQ	Results	Qual	Result	VQ	Result	VQ
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---	
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---	
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---	
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---	
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---	
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---	
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---	
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---	
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---	
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---	
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---	
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---	
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---	
3268-87-9	Octachloro-dibenzo[b,e][1,4]dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---	
39001-02-0	Octachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---	
14331-83-0	Actinium-228	Radiological	pCi/L	20.6	U	24.39	U	11.5	U	---		---		---		---		---		---	
10045-97-3	Cesium-137	Radiological	pCi/L	5.42	U	5.68	U	2.73	U	5.58	U	---		---		---		---		---	
15092-94-1	Lead-212	Radiological	pCi/L	10.87	U	8.88	U	-12.6	U	---		---		---		---		---		---	
15067-28-4	Lead-214	Radiological	pCi/L	9.02	U	41.22		16	U	---		---		---		---		---		---	
13966-00-2	Potassium-40	Radiological	pCi/L	75.03	U	78.01	U	-148	U	---		---		---		---		---		---	
13982-63-3	Radium-226	Radiological	pCi/L	0.43	U	0.67	J	0.382	J	0.31	J	---		---		---		---		---	
15262-20-1	Radium-228	Radiological	pCi/L	1.85		1.07	U	0.663	J	0.878	J	---		---		---		---		---	
14808-79-8	Sulfate	Anions	mg/L	---		---		---		---		---		---		---		---		---	
74-84-0	Ethane	Miscellaneous	mg/L	---		---		---		---		---		---		---		---		---	
74-85-1	Ethene	Miscellaneous	mg/L	---		---		---		---		---		---		---		---		---	
74-82-8	Methane	Miscellaneous	mg/L	---		---		---		---		---		---		---		---		---	

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	JAW-27								JAW-65								T-1							
			Sample ID:	S16-T5-JAW-27		S17-T5-JAW-27		S18-T5-JAW-27		S19-T5-JAW-27		S16-T5-JAW-65		S17-T5-JAW-65		S18-T5-JAW-65		S19-T5-JAW-65		S16-T5-T-1		S17-T5-T-1		S18-T5-T-1		S19-T5-T-1	
			Date Collected:	4/14/2016		5/02/2017		5/16/2018		4/12/2019		4/14/2016		5/03/2017		5/16/2018		3/28/2019		4/11/2016		5/04/2017		5/10/2018		3/31/2019	
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ	Results	VQ	Result	VQ	Result	VQ
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
3268-87-9	Octachloro-dibenzo[b,e][1,4]dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
39001-02-0	Octachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		---		---		---		---		---		---		---	
14331-83-0	Actinium-228	Radiological	pCi/L	---		---		---		---		---		---		---		---		---		---		---		---	
10045-97-3	Cesium-137	Radiological	pCi/L	---		---		---		---		---		---		---		---		---		---		---		---	
15092-94-1	Lead-212	Radiological	pCi/L	---		---		---		---		---		---		---		---		---		---		---		---	
15067-28-4	Lead-214	Radiological	pCi/L	---		---		---		---		---		---		---		---		---		---		---		---	
13966-00-2	Potassium-40	Radiological	pCi/L	---		---		---		---		---		---		---		---		---		---		---		---	
13982-63-3	Radium-226	Radiological	pCi/L	---		---		---		---		---		---		---		---		---		---		---		---	
15262-20-1	Radium-228	Radiological	pCi/L	---		---		---		---		---		---		---		---		---		---		---		---	
14808-79-8	Sulfate	Anions	mg/L	---		---		---		---		---		---		---		---		---		---		---		---	
74-84-0	Ethane	Miscellaneous	mg/L	---		---		---		---		---		---		---		---		---		---		---		---	
74-85-1	Ethene	Miscellaneous	mg/L	---		---		---		---		---		---		---		---		---		---		---		---	
74-82-8	Methane	Miscellaneous	mg/L	---		---		---		---		---		---		---		---		---		---		---		---	

Appendix A. Nature and Extent Assessment Groundwater Data Collected During the 2016–2019 Annual Monitoring Events and 2019/2020 Remedial Investigation

Chemical Abstracts Service Number	Analyte	Analytical Group	Station ID:	T-6								MW20-01		Statistical Summary								Groundwater PAL Evaluation	
			Sample ID:	S16-T5-T-6		S17-T5-T-6		S18-T5-T-6		S19-T5-T-6		IAAP020-MW20-01-GW		Minimum Detected Concentration (Qualifier) (1)(2)		Maximum Detected Concentration (Qualifier) (1)(2)		Units	Location of Maximum Concentration		Detection Frequency (2)	Groundwater PAL (3)	Groundwater Maximum Detected Conc. > PAL Value (Y/N)
			Date Collected:	4/11/2016		5/04/2017		5/10/2018		3/31/2019		12/9/2020							Sample ID (2)	Date Collected (2)			
			Units	Result	VQ	Results	VQ	Result	VQ	Result	VQ	Result	VQ										
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		0.0000015	J	0.0000022	J	µg/L	S19-T5-ET-3	4/11/2019	2 / 3		No
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		ND		ND		µg/L	NA	NA	0 / 3		No
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		ND		ND		µg/L	NA	NA	0 / 3		No
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		0.0000019	J	0.0000019	J	µg/L	S19-T5-C-00-3	4/1/2019	1 / 3		No
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		ND		ND		µg/L	NA	NA	0 / 3		No
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		0.00000028	J	0.00000063	J	µg/L	S19-T5-C-00-3	4/1/2019	2 / 3		No
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		0.0000012	J	0.0000012	J	µg/L	S19-T5-C-00-3	4/1/2019	1 / 3		No
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		0.00000089	J	0.00000089	J	µg/L	S19-T5-C-00-3	4/1/2019	1 / 3		No
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		ND		ND		µg/L	NA	NA	0 / 3		No
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		ND		ND		µg/L	NA	NA	0 / 3		No
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		ND		ND		µg/L	NA	NA	0 / 3		No
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		ND		ND		µg/L	NA	NA	0 / 3		No
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		ND		ND		µg/L	NA	NA	0 / 3		No
3268-87-9	Octachloro-dibenzo[b,e][1,4]dioxin	Dioxins/Furans	µg/L	---		---		---		---		---		0.000018	J	0.000048	J	µg/L	S19-T5-C-00-3	4/1/2019	2 / 3		No
39001-02-0	Octachlorodibenzofuran	Dioxins/Furans	µg/L	---		---		---		---		---		0.00000099	J	0.0000016	J	µg/L	S19-T5-C-00-3	4/1/2019	2 / 3		No
14331-83-0	Actinium-228	Radiological	pCi/L	---		---		---		---		---		ND		ND		pCi/L	NA	NA	0 / 18		No
10045-97-3	Cesium-137	Radiological	pCi/L	---		---		---		---		---		ND		ND		pCi/L	NA	NA	0 / 24		No
15092-94-1	Lead-212	Radiological	pCi/L	---		---		---		---		---		12.72	J	12.72	J	pCi/L	S17-T5-C-00-1	5/2/2017	1 / 18		No
15067-28-4	Lead-214	Radiological	pCi/L	---		---		---		---		---		29.5	=	73.67	J	pCi/L	S17-T5-C-95-2	5/4/2017	7 / 18		No
13966-00-2	Potassium-40	Radiological	pCi/L	---		---		---		---		---		76.84	J	76.84	J	pCi/L	S17-T5-C-95-1	5/3/2017	1 / 18		No
13982-63-3	Radium-226	Radiological	pCi/L	---		---		---		---		---		0.0934	J	0.67	J	pCi/L	S17-T5-IDA-TT-MW1	5/3/2017	12 / 24	5	No
15262-20-1	Radium-228	Radiological	pCi/L	---		---		---		---		---		0.375	J	1.85		pCi/L	S16-T5-IDA-TT-MW1	4/14/2016	11 / 24	5	No
14808-79-8	Sulfate	Anions	mg/L	---		---		---		---		---		8.7		140		mg/L	S19-T5-C-00-1	4/11/2019	8 / 8	--	No
74-84-0	Ethane	Miscellaneous	mg/L	---		---		---		---		---		0.41	J	1.9		mg/L	S19-T5-ET-3	4/11/2019	3 / 8		No
74-85-1	Ethene	Miscellaneous	mg/L	---		---		---		---		---		0.0031	J	0.68	J	mg/L	S17-T5-ET-3	5/2/2017	2 / 8		No
74-82-8	Methane	Miscellaneous	mg/L	---		---		---		---		---		0.3	J	13000		mg/L	S19-T5-ET-3	4/11/2019	6 / 8		No

Notes:

Green Shaded Cells - All sample and field duplicate data were used for defining ranges of detected and non-detected results, locations of maximum detections, frequencies of detection, and the concentrations used for screening to determine COPCs. Rejected ("R"-flagged) results were not incorporated.

"---" - Indicates that no data are available for sample/analyte (i.e., not analyzed).

(1) The following are definitions for the applied validation qualifiers:

J - The analyte was detected below the reporting limit in the sample.

R - Based on data validation, the sample result is not usable (i.e., "R" = rejected).

U - The analyte is not detected. The reported concentrations is the detection limit.

UJ - The analyte is not detected. The reported detection limit is an estimated value.

= - The analyte is detected at The reported concentration.

(2) All sample and field duplicate data were used for defining ranges of detected results, locations of maximum detections, and frequencies of detection. Rejected ("R"-flagged) results were not incorporated.

(3) Final groundwater PAL is MCL, if available. If MCL is not available, the higher value between Tap Water RSL and Health Advisory Standard (lifetime). (USEPA. 2012. Maximum Contaminant Levels and Health Advisory Level. April.) https://www.epa.gov/dwstandardsregulations/drinking-water-

NE - Not Established

NA - Not Applicable or Not Available

Appendix B
PRGs

Table 1. Preliminary Remediation Goals for Groundwater (Risk Basis of 1E-06 and HQ of 1)

OU4 Inert Disposal Area, Iowa Army Ammunition Plant, Middletown, Iowa

COC	Background Value µg/L	MCL µg/L	Residential Scenario: PRG - Potable Groundwater µg/L	Residential Scenario: Indoor Air µg/L	Residential Scenario: PRG (1) µg/L	Residential Scenario: Final PRG Basis	Industrial Scenario: PRG - Potable Groundwater µg/L	Industrial Scenario: PRG (1) µg/L	Industrial Scenario: Final PRG Basis
1,2-DCA	NA	5	0.2	NC	5	MCL	NC	NC	NC
2,4-Dichlorophenol	NA	NA	46	NC	46	RG	NC	NC	NC
2,4-DNT	NA	NA	0.2	NC	0.2	RG	NC	NC	NC
2,6-DNT	NA	NA	0.05	NC	0.05	RG	NC	NC	NC
2-Amino-4,6-dinitrotoluene	NA	NA	1.93	NC	1.93	RG	NC	NC	NC
2-Methyl-4,6-dinitrophenol	NA	NA	1.51	NC	1.51	RG	7.4	7.4	RG
Manganese	580	NA	434	NC	580	Background	NC	NC	NC
Naphthalene	NA	NA	0.1	10	0.1	RG	2	2.0	RG
PCP	NA	1	0.04	NC	1	MCL	0.42	1.0	MCL
Total 2,3,7,8-TCDD (TEQ)	NA	3.0E-05	1.4E-08	NC	3.0E-05	MCL	3.3E-07	3.0E-05	MCL
Trichloroethene	NA	5	0.04	1.9	5	MCL	6	5.0	MCL
Vinyl Chloride	NA	2	0.02	0.2	2	MCL	0.36	2.0	MCL
Benzene	NA	5	0.7	NC	5	MCL	NC	NC	NC
Nitrobenzene	NA	NA	0.1	NC	0.1	RG	NC	NC	NC

Notes:

(1) If a MCL was available, final RG is the higher value of the background value and MCL. If no MCL was available, final RG is the higher of the background value and adjusted RG. Adjusted RGs for resident were selected as the lowest value calculated for adult, child, and adult/child aggregate receptors.

COC = chemical of concern
DCA = dichloroethane
DNT = dinitrotoluene
EPC = exposure point concentration
HI = hazard index
HQ = hazard quotient
MCL = Maximum Contaminat Level
NA = not applicable or not available
NC = not calculated, chemical was not a COC for that receptor/pathway
PCP = pentachlorophenol
2,3,7,8-TCDD TEQ = 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity equivalence

Table 1 Supplement. Calculation of Preliminary Remediation Goals for Groundwater

OU4 Inert Disposal Area, Iowa Army Ammunition Plant, Middletown, Iowa

COC	EPC	Cancer Calculated Risk	Noncancer Calculated Hazard	Carcinogenic PRG Based on Cancer Risk Level			Noncarcinogenic PRG Based on HQ/HI Level	Final HI Level and Target Organ	Carcinogenic PRG - Final Risk Level	Noncarcinogenic PRG - Final HI Level
	µg/L			µg/L			µg/L		µg/L	
				1E-06	1E-05	1E-04	1		1E-06	1
Industrial Worker - Groundwater										
2-Methyl-4,6-dinitrophenol	28	NA	4	NA	NA	NA	7.4	HI = 0.5 (Body Weight, Ocular)	NA	7.4
Naphthalene	89.1	4E-05	0.1	2.0E+00	2.0E+01	2.0E+02	1722	HI = 0.5 (Body Weight, Nervous, Respiratory)	2.0	1721.8
PCP	1940	5E-03	7	4.2E-01	4.2E+00	4.2E+01	298	HI = 0.3 (Hepatic)	0.42	298.2
Total 2,3,7,8-TCDD (TEQ)	2.3E-05	7E-05	2	3.3E-07	3.3E-06	3.3E-05	1.1E-05	HI = 0.3 (Hepatic, Reproductive, Developmental, Endocrine, Respiratory, Hematologic)	3.3E-07	1.1E-05
Trichloroethene	21	4E-06	0.5	5.6E+00	5.6E+01	5.6E+02	46	HI = 0.5 (Developmental, Immune)	5.6	45.7
Vinyl Chloride	1.5	4E-06	0.005	3.6E-01	3.6E+00	3.6E+01	278	HI = 0.3 (Hepatic)	0.36	277.5
Adult Resident - Potable Groundwater										
1,2-DCA	1.639	NA	0.1	NA	NA	NA	16	HI = 0.2 (Urinary, Nervous)	NA	16.2
2,4-Dichlorophenol	16.1	NA	0.2	NA	NA	NA	74	HI = 0.3 (Immune)	NA	74.2
2,4-DNT	1.1	NA	0.02	NA	NA	NA	63	HI = 0.2 (Nervous, Hepatic, Hematologic)	NA	63.0
2,6-DNT	0.2	NA	0.02	NA	NA	NA	9.3	HI = 0.3 (Hematologic)	NA	9.3
2-Amino-4,6-dinitrotoluene	0.3	NA	0.09	NA	NA	NA	3.2	HI = 0.2 (Hepatic)	NA	3.2
2-Methyl-4,6-dinitrophenol	28	NA	11	NA	NA	NA	2.5	HI = 0.5 (Body Weight, Ocular)	NA	2.5
Manganese	217.5	NA	0.3	NA	NA	NA	703	HI = 0.2 (Nervous)	NA	702.8
Naphthalene	89.1	NA	15	NA	NA	NA	6.1	HI = 0.2 (Body Weight, Nervous, Respiratory)	NA	6.1
PCP	1940	NA	60	NA	NA	NA	32	HI = 0.2 (Hepatic)	NA	32.1
Total 2,3,7,8-TCDD (TEQ)	2.3E-05	NA	39	NA	NA	NA	5.9E-07	HI = 0.2 (Hepatic, Reproductive, Developmental, Endocrine, Respiratory, Hematologic)	NA	0.0000006
Trichloroethene	21	NA	7	NA	NA	NA	3.2	HI = 0.3 (Developmental, Immune)	NA	3.2
Vinyl Chloride	1.5	NA	0.02	NA	NA	NA	64	HI = 0.2 (Hepatic)	NA	64.1
Benzene	1.6	NA	0.03	NA	NA	NA	62	HI = 0.3 (Immune)	NA	62.1
Nitrobenzene	2.6	NA	0.1	NA	NA	NA	19	HI = 0.2 (Hematologic, Nervous, Respiratory)	NA	18.6
Child Resident - Potable Groundwater										
1,2-DCA	1.639	NA	0.1	NA	NA	NA	15.51	HI = 0.2 (Urinary, Nervous)	NA	15.5
2,4-Dichlorophenol	16.1	NA	0.4	NA	NA	NA	45.69	HI = 0.3 (Immune)	NA	45.7
2,4-DNT	1.1	NA	0.03	NA	NA	NA	38.07	HI = 0.2 (Nervous, Hepatic, Hematologic)	NA	38.1
2,6-DNT	0.2	NA	0.04	NA	NA	NA	5.65	HI = 0.3 (Hematologic)	NA	5.7
2-Amino-4,6-dinitrotoluene	0.3	NA	0.2	NA	NA	NA	1.93	HI = 0.2 (Hepatic)	NA	1.9
2-Methyl-4,6-dinitrophenol	28	NA	19	NA	NA	NA	1.51	HI = 0.5 (Body Weight, Ocular)	NA	1.5
Manganese	217.5	NA	1	NA	NA	NA	433.56	HI = 0.2 (Nervous)	NA	433.6
Naphthalene	89.1	NA	15	NA	NA	NA	6.06	HI = 0.2 (Body Weight, Nervous, Respiratory)	NA	6.1
PCP	1940	NA	93	NA	NA	NA	20.89	HI = 0.2 (Hepatic)	NA	20.9
Total 2,3,7,8-TCDD (TEQ)	2.3E-05	NA	58	NA	NA	NA	3.9E-07	HI = 0.2 (Hepatic, Reproductive, Developmental, Endocrine, Respiratory, Hematologic)	NA	0.0000004
Trichloroethene	21	NA	7	NA	NA	NA	2.81	HI = 0.3 (Developmental, Immune)	NA	2.8
Vinyl Chloride	1.5	NA	0.03	NA	NA	NA	44.19	HI = 0.2 (Hepatic)	NA	44.2
Benzene	1.6	NA	0.03	NA	NA	NA	62.07	HI = 0.3 (Immune)	NA	62.1
Nitrobenzene	2.6	NA	0.1	NA	NA	NA	18.62	HI = 0.2 (Hematologic, Nervous, Respiratory)	NA	18.6
Adult/Child Aggregate - Potable Groundwater										
1,2-DCA	1.639	8E-06	NA	0.20	2.0	20	NA	NA	0.20	NA
2,4-Dichlorophenol	16.1	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4-DNT	1.1	5E-06	NA	0.24	2.4	24	NA	NA	0.24	NA
2,6-DNT	0.2	4E-06	NA	0.049	0.49	4.9	NA	NA	0.049	NA
2-Amino-4,6-dinitrotoluene	0.3	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Methyl-4,6-dinitrophenol	28	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	217.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	89.1	8E-04	NA	0.12	1.2	12	NA	NA	0.12	NA
PCP	1940	5E-02	NA	0.039	0.39	3.9	NA	NA	0.039	NA
Total 2,3,7,8-TCDD (TEQ)	2.3E-05	2E-03	NA	1.4E-08	1.4E-07	1.4E-06	NA	NA	0.00000001	NA

Table 1 Supplement. Calculation of Preliminary Remediation Goals for Groundwater

OU4 Inert Disposal Area, Iowa Army Ammunition Plant, Middletown, Iowa

COC	EPC	Cancer Calculated Risk	Noncancer Calculated Hazard	Carcinogenic PRG Based on Cancer Risk Level			Noncarcinogenic PRG Based on HQ/HI Level	Final HI Level and Target Organ	Carcinogenic PRG - Final Risk Level	Noncarcinogenic PRG - Final HI Level
	µg/L			µg/L			µg/L		µg/L	
				1E-06	1E-05	1E-04	1		1E-06	1
Trichloroethene	21	6E-04	NA	0.035	0.35	3.5	NA	NA	0.035	NA
Vinyl Chloride	1.5	8E-05	NA	0.019	0.19	1.9	NA	NA	0.019	NA
Benzene	1.6	2E-06	NA	0.71	7.1	71	NA	NA	0.71	NA
Nitrobenzene	2.6	2E-05	NA	0.14	1.4	14	NA	NA	0.14	NA
Adult Resident - Indoor Air (Groundwater Vapor Intrusion)										
Naphthalene	89.1	NA	0.2	NA	NA	NA	365	HI = 1 (Nervous, Respiratory)	NA	365
Trichloroethene	21	NA	3	NA	NA	NA	8	HI = 1 (Developmental, Immune)	NA	8.3
Vinyl Chloride	1.5	NA	0.01	NA	NA	NA	59	HI = 1 (Hepatic)	NA	59
Child Resident - Indoor Air (Groundwater Vapor Intrusion)										
Naphthalene	89.1	NA	0.2	NA	NA	NA	365	HI = 1 (Nervous, Respiratory)	NA	365
Trichloroethene	21	NA	3	NA	NA	NA	8	HI = 1 (Developmental, Immune)	NA	8.3
Vinyl Chloride	1.5	NA	0.01	NA	NA	NA	59	HI = 1 (Hepatic)	NA	59
Adult/Child Aggregate - Indoor Air (Groundwater Vapor Intrusion)										
Naphthalene	89.1	9E-06	NA	9.6E+00	9.6E+01	9.6E+02	NA	NA	10	NA
Trichloroethene	21	1E-05	NA	1.9E+00	1.9E+01	1.9E+02	NA	NA	2	NA
Vinyl Chloride	1.5	8E-06	NA	1.9E-01	1.9E+00	1.9E+01	NA	NA	0.19	NA

Notes:

(1) Adjusted Carcinogenic RG is calculated based on the number of carcinogenic COCs in an exposure medium so that the cumulative cancer risk does not exceed 1E-06 for a receptor group:

$$\text{Adjusted Carcinogenic RG } (\mu g/L) = \frac{\text{Carcinogenic RG (based on cancer risk level of 1E-06) } (\mu g/L)}{\text{Number of Carcinogenic COCs in Exposure Medium}}$$

(2) Adjusted Noncarcinogenic RG is calculated based on the number of noncarcinogenic COCs acting on the same target organ in an exposure medium so that the cumulative target organ HI does not exceed 1 for a receptor group:

$$\text{Adjusted Noncarcinogenic RG } (\mu g/L) = \frac{\text{Noncarcinogenic RG (based on HQ or HI Level of 1) } (\mu g/L)}{\text{Number of Noncarcinogenic COCs Acting on Same Target Organ in Exposure Medium}}$$

COC = chemical of concern
DCA = dichloroethane
DNT = dinitrotoluene
EPC = exposure point concentration
HI = hazard index
HQ = hazard quotient
NA = not applicable or not
PCP = pentachlorophenol
2,3,7,8-TCDD TEQ = 2,3,7,8-tetrachlorodibenzo-p-dioxin toxicity
µg/L = microgram per liter

Variable	Resident Tap Water Default Value	Industrial Form-input Value
Air exchanges per hour for A_{eq} 1/hr	0.18	0
$CF_{res-produce}$ (contaminated plant fraction) unitless	1	0
ED_{res-a} (produce exposure duration - resident adult) yr	20	25
ED_{res-c} (produce exposure duration - resident child) yr	6	0
EF_{res-a} (produce exposure frequency - resident adult) day/yr	350	250
EF_{res-c} (produce exposure frequency - resident child) day/yr	350	0
TR (produce target cancer risk) unitless	0.000001	0.000001
Soil type	Default	Default
$DFA_{res-adj}$ (age-adjusted immersion factor - resident) hr	6104	1250
ED_{res} (exposure duration - resident) yr	26	25
ED_{res-a} (exposure duration - resident adult) yr	20	25
ED_{res-c} (exposure duration - resident child) yr	6	0
EF_{res-a} (exposure frequency - resident adult) day/yr	350	250
EF_{res-c} (exposure frequency - resident child) day/yr	350	0
ET_{res-a} (exposure time - resident adult) hr/day	24	0.2
ET_{res-c} (exposure time - resident child) hr/day	24	0
EV_{res-a} (bathing events per day - resident adult) event/day	1	1
EV_{res-c} (bathing events per day - resident child) event/day	1	1
F (irrigation period) unitless	0.25	0.25
$IFA_{res-adj}$ (age-adjusted inhalation factor - resident) m^3	161000	1041.667
I_f (interception fraction) unitless	0.42	0.42
$IFW_{res-adj}$ (adjusted intake factor - resident) L-yr/kg-day	19138	6250
IRA_{res-a} (inhalation rate - resident adult) m^3/day	20	20
IRA_{res-c} (inhalation rate - resident child) m^3/day	10	10
I_r (irrigation rate) L/m^2-day	3.62	3.62
IRW_{res-a} (water intake rate - resident adult) L/day	2.5	1
IRW_{res-c} (water intake rate - resident child) L/day	0.78	0
K (volatilization factor of Andelman) L/m^3	0.5	0
$Lambda_{HL}$ (soil leaching rate) 1/day	0.000027	0.000027
P (area density for root zone) kg/m^2	240	240
T (translocation factor) unitless	1	1
$ET_{event-res-a}$ (duration of bathing event - adult) hr/event	0.71	0.2
t_b (long term deposition and buildup) day	10950	10950
$ET_{event-res-c}$ (duration of bathing event - child) hr/event	0.54	0
TR (target cancer risk) unitless	0.000001	0.000001
t_v (above ground exposure time) day	60	60
t_w (weathering half-life) day	14	14
Y_v (plant yield - wet) kg/m^2	2	2

Output generated 14APR2022:21:25:48

Site-specific
Industrial PRGs for Tap Water - Secular Equilibrium

Isotope	Ingestion PRG TR=1.0E-06 (pCi/L)	Inhalation PRG TR=1.0E-06 (pCi/L)	Immersion PRG TR=1.0E-06 (pCi/L)	Produce Consumption PRG TR=1.0E-06 (pCi/L)	Total PRG TR=1.0E-06 (pCi/L)
Secular Equilibrium PRG for K-40	*6.48E+00*	-	*4.48E+06*	-	*6.48E+00*
Secular Equilibrium PRG for Pb-212	*6.18E+00*	-	*4.79E+05*	-	*6.18E+00*

Output generated 14APR2022:21:25:48

Site-specific

Industrial Individual Contribution PRGs for Tap Water - Secular Equilibrium

Isotope	Parent	0 exchanges per hour A_{eq} (unitless)	ICRP Lung Absorption Type	Water Ingestion Slope Factor (risk/pCi)	Inhalation Slope Factor (risk/pCi)	Food Ingestion Slope Factor (risk/pCi)	Immersion Slope Factor (risk/yr per pCi/L)	Halflife (d)	$Lambda_i$(1/day)	$Lambda_B$(1/day)	$Lambda_E$(1/day)	Irr_{dep}(L/kg)	Ingestion PRG TR=1.0E-06 (pCi/L)	Inhalation PRG TR=1.0E-06 (pCi/L)	Immersion PRG TR=1.0E-06 (pCi/L)	Produce Consumption PRG TR=1.0E-06 (pCi/L)	Total PRG TR=1.0E-06 (pCi/L)	Total PRG TR=1.0E-06 (mg/L)
Secular Equilibrium PRG for K-40	***K-40***	**-**		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	***6.48E+00***	**-**	***4.48E+06***	**-**	***6.48E+00***	**-**
K-40	K-40	-	S	2.47E-11	2.22E-10	3.42E-11	1.56E-12	4.57E+11	0.00E+00	2.70E-05	4.95E-02	-	6.48E+00	-	4.48E+06	-	**6.48E+00**	9.08E-04
Secular Equilibrium PRG for Pb-212	***Pb-212***	**-**		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	***6.18E+00***	**-**	***4.79E+05***	**-**	***6.18E+00***	**-**
Pb-212	Pb-212	1.00E+00	S	2.52E-11	6.29E-10	3.57E-11	1.23E-12	4.43E-01	0.00E+00	2.70E-05	4.95E-02	-	6.36E+00	-	5.72E+06	-	**6.36E+00**	4.59E-15
Bi-212	Pb-212	1.00E+00	S	7.18E-13	1.13E-10	1.01E-12	9.91E-13	4.20E-02	0.00E+00	2.70E-05	4.95E-02	-	2.23E+02	-	7.07E+06	-	**2.23E+02**	1.52E-14
Po-212	Pb-212	6.41E-01	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.46E-12	0.00E+00	2.70E-05	4.95E-02	-	-	-	-	-	**-**	-
Tl-208	Pb-212	3.59E-01	-	0.00E+00	0.00E+00	0.00E+00	3.46E-11	2.12E-03	0.00E+00	2.70E-05	4.95E-02	-	-	-	5.64E+05	-	**5.64E+05**	1.91E-12

Output generated 14APR2022:21:25:48

Resident Input Parameters

Variable	Value
Air exchanges per hour for A_{eq} 1/hr	0.18
Climate zone	Temperate
Soil type	Default
$IRAP_{res-a}$ (apple ingestion rate - resident adult) g/day	73.9
$IRAP_{res-c}$ (apple ingestion rate - resident child) g/day	72
$IFAP_{res-adj}$ (age-adjusted apple ingestion fraction) g	668500
$IRCI_{res-a}$ (citrus ingestion rate - resident adult) g/day	306.5
$IRCI_{res-c}$ (citrus ingestion rate - resident child) g/day	206
$IFCI_{res-adj}$ (age-adjusted citrus ingestion fraction) g	2578100
$IRBE_{res-a}$ (berry ingestion rate - resident adult) g/day	35.2
$IRBE_{res-c}$ (berry ingestion rate - resident child) g/day	24.2
$IFBE_{res-adj}$ (age-adjusted berry ingestion fraction) g	297220
$IRPC_{res-a}$ (peach ingestion rate - resident adult) g/day	115.7
$IRPC_{res-c}$ (peach ingestion rate - resident child) g/day	110.2
$IFPC_{res-adj}$ (age-adjusted peach ingestion fraction) g	1041320
$IRPR_{res-a}$ (pear ingestion rate - resident adult) g/day	52.1
$IRPR_{res-c}$ (pear ingestion rate - resident child) g/day	69.4
$IFPR_{res-adj}$ (age-adjusted pear ingestion fraction) g	510440
$IRST_{res-a}$ (strawberry ingestion rate - resident adult) g/day	40.6
$IRST_{res-c}$ (strawberry ingestion rate - resident child) g/day	27.5
$IFST_{res-adj}$ (age-adjusted strawberry ingestion fraction) g	341950
$IRAS_{res-a}$ (asparagus ingestion rate - resident adult) g/day	40.1
$IRAS_{res-c}$ (asparagus ingestion rate - resident child) g/day	11.9
$IFAS_{res-adj}$ (age-adjusted asparagus ingestion fraction) g	305690
$IRBT_{res-a}$ (beet ingestion rate - resident adult) g/day	34.4
$IRBT_{res-c}$ (beet ingestion rate - resident child) g/day	6
$IFBT_{res-adj}$ (age-adjusted beet ingestion fraction) g	253400
$IRBR_{res-a}$ (broccoli ingestion rate - resident adult) g/day	30.5
$IRBR_{res-c}$ (broccoli ingestion rate - resident child) g/day	13.2
$IFBR_{res-adj}$ (age-adjusted broccoli ingestion fraction) g	241220
$IRCB_{res-a}$ (cabbage ingestion rate - resident adult) g/day	85.1
$IRCB_{res-c}$ (cabbage ingestion rate - resident child) g/day	11.8
$IFCB_{res-adj}$ (age-adjusted cabbage ingestion fraction) g	620480
$IRCR_{res-a}$ (carrot ingestion rate - resident adult) g/day	27.1
$IRCR_{res-c}$ (carrot ingestion rate - resident child) g/day	14.5
$IFCR_{res-adj}$ (age-adjusted carrot ingestion fraction) g	220150
$IRCO_{res-a}$ (corn ingestion rate - resident adult) g/day	60.2
$IRCO_{res-c}$ (corn ingestion rate - resident child) g/day	23.2
$IFCO_{res-adj}$ (age-adjusted corn ingestion fraction) g	470120
$IRCU_{res-a}$ (cucumber ingestion rate - resident adult) g/day	82.3
$IRCU_{res-c}$ (cucumber ingestion rate - resident child) g/day	24.5
$IFCU_{res-adj}$ (age-adjusted cucumber ingestion fraction) g	627550
$IRLE_{res-a}$ (lettuce ingestion rate - resident adult) g/day	36.7
$IRLE_{res-c}$ (lettuce ingestion rate - resident child) g/day	3.4
$IFLE_{res-adj}$ (age-adjusted lettuce ingestion fraction) g	264040
$IRLI_{res-a}$ (lima bean ingestion rate - resident adult) g/day	33.9
$IRLI_{res-c}$ (lima bean ingestion rate - resident child) g/day	22
$IFLI_{res-adj}$ (age-adjusted lima bean ingestion fraction) g	283500
$IROK_{res-a}$ (okra ingestion rate - resident adult) g/day	30.4
$IROK_{res-c}$ (okra ingestion rate - resident child) g/day	9.4
$IFOK_{res-adj}$ (age-adjusted okra ingestion fraction) g	232540
$IRON_{res-a}$ (onion ingestion rate - resident adult) g/day	21.5
$IRON_{res-c}$ (onion ingestion rate - resident child) g/day	5.9
$IFON_{res-adj}$ (age-adjusted onion ingestion fraction) g	162890
$IRPE_{res-a}$ (pea ingestion rate - resident adult) g/day	35

Resident Input Parameters

Variable	Value
$IRPE_{res\text{-}c}$ (pea ingestion rate - resident child) g/day	22.6
$IFPE_{res\text{-}adj}$ (age-adjusted pea ingestion fraction) g	292460
$IRPP_{res\text{-}a}$ (pepper ingestion rate - resident adult) g/day	19.1
$IRPP_{res\text{-}c}$ (pepper ingestion rate - resident child) g/day	5.9
$IFPP_{res\text{-}adj}$ (age-adjusted pepper ingestion fraction) g	146090
$IRPU_{res\text{-}a}$ (pumpkin ingestion rate - resident adult) g/day	63.5
$IRPU_{res\text{-}c}$ (pumpkin ingestion rate - resident child) g/day	21.2
$IFPU_{res\text{-}adj}$ (age-adjusted pumpkin ingestion fraction) g	489020
$IRSN_{res\text{-}a}$ (snap bean ingestion rate - resident adult) g/day	53.8
$IRSN_{res\text{-}c}$ (snap bean ingestion rate - resident child) g/day	28.3
$IFSN_{res\text{-}adj}$ (age-adjusted snap bean ingestion fraction) g	436030
$IRTO_{res\text{-}a}$ (tomato ingestion rate - resident adult) g/day	80.1
$IRTO_{res\text{-}c}$ (tomato ingestion rate - resident child) g/day	36
$IFTO_{res\text{-}adj}$ (age-adjusted tomato ingestion fraction) g	636300
$IRPT_{res\text{-}a}$ (potato ingestion rate - resident adult) g/day	127.8
$IRPT_{res\text{-}c}$ (potato ingestion rate - resident child) g/day	47.3
$IFPT_{res\text{-}adj}$ (age-adjusted potato ingestion fraction) g	993930
$CF_{res\text{-}produce}$ (contaminated plant fraction) unitless	1
$CF_{res\text{-}apple}$ (contaminated apple fraction) unitless	1
$CF_{res\text{-}citrus}$ (contaminated citrus fraction) unitless	1
$CF_{res\text{-}berry}$ (contaminated berry fraction) unitless	1
$CF_{res\text{-}peach}$ (contaminated peach fraction) unitless	1
$CF_{res\text{-}pear}$ (contaminated pear fraction) unitless	1
$CF_{res\text{-}strawberry}$ (contaminated strawberry fraction) unitless	1
$CF_{res\text{-}asparagus}$ (contaminated asparagus fraction) unitless	1
$CF_{res\text{-}beet}$ (contaminated beet fraction) unitless	1
$CF_{res\text{-}broccoli}$ (contaminated broccoli fraction) unitless	1
$CF_{res\text{-}cabbage}$ (contaminated cabbage fraction) unitless	1
$CF_{res\text{-}carrot}$ (contaminated carrot fraction) unitless	1
$CF_{res\text{-}corn}$ (contaminated corn fraction) unitless	1
$CF_{res\text{-}cucumber}$ (contaminated cucumber fraction) unitless	1
$CF_{res\text{-}lettuce}$ (contaminated lettuce fraction) unitless	1
$CF_{res\text{-}lima\ bean}$ (contaminated lima bean fraction) unitless	1
$CF_{res\text{-}okra}$ (contaminated okra fraction) unitless	1
$CF_{res\text{-}onion}$ (contaminated onion fraction) unitless	1
$CF_{res\text{-}pea}$ (contaminated pea fraction) unitless	1
$CF_{res\text{-}pepper}$ (contaminated pepper fraction) unitless	1
$CF_{res\text{-}pumpkin}$ (contaminated pumpkin fraction) unitless	1
$CF_{res\text{-}snap\ bean}$ (contaminated snap bean fraction) unitless	1
$CF_{res\text{-}tomato}$ (contaminated tomato fraction) unitless	1
$CF_{res\text{-}potato}$ (contaminated potato fraction) unitless	1
MLF_{apple} (apple mass loading factor) unitless	0.00016
MLF_{citrus} (citrus mass loading factor) unitless	0.000157
MLF_{berry} (berry mass loading factor) unitless	0.000166
MLF_{peach} (peach mass loading factor) unitless	0.00015
MLF_{pear} (pear mass loading factor) unitless	0.00016
$MLF_{strawberry}$ (strawberry mass loading factor) unitless	0.00008
$MLF_{asparagus}$ (asparagus mass loading factor) unitless	0.000079
MLF_{beet} (beet mass loading factor) unitless	0.000138
$MLF_{broccoli}$ (broccoli mass loading factor) unitless	0.00101
$MLF_{cabbage}$ (cabbage mass loading factor) unitless	0.000105
MLF_{carrot} (carrot mass loading factor) unitless	0.000097
MLF_{corn} (corn mass loading factor) unitless	0.000145
$MLF_{cucumber}$ (cucumber mass loading factor) unitless	0.00004
$MLF_{lettuce}$ (lettuce mass loading factor) unitless	0.0135

Resident Input Parameters

Variable	Value
$MLF_{lima\ bean}$ (lima bean mass loading factor) unitless	0.00383
MLF_{okra} (okra mass loading factor) unitless	0.00008
MLF_{onion} (onion mass loading factor) unitless	0.000097
MLF_{pea} (pea mass loading factor) unitless	0.000178
MLF_{pepper} (pepper mass loading factor) unitless	0.00222
$MLF_{pumpkin}$ (pumpkin mass loading factor) unitless	0.000058
$MLF_{snap\ bean}$ (snap bean mass loading factor) unitless	0.005
MLF_{tomato} (tomato mass loading factor) unitless	0.00177
MLF_{potato} (potato mass loading factor) unitless	0.00021
TR (produce target cancer risk) unitless	0.000001
EF_{res} (produce exposure frequency - resident) day/yr	350
ED_{res} (produce exposure duration - resident) yr	26
ED_{res-c} (produce exposure duration - resident child) yr	6
ED_{res-a} (produce exposure duration - resident adult) yr	20
EF_{res-c} (produce exposure frequency - resident child) day/yr	350
EF_{res-a} (produce exposure frequency - resident adult) day/yr	350
t_{res} (produce time - resident) yr	26
TR (target cancer risk) unitless	0.000001
EF_{res} (exposure frequency - resident) day/yr	350
EV_{res-c} (bathing events per day - resident child) event/day	1
EV_{res-a} (bathing events per day - resident adult) event/day	1
EF_{res-c} (exposure frequency - resident child) day/yr	350
EF_{res-a} (exposure frequency - resident adult) day/yr	350
ED_{res} (exposure duration - resident) yr	26
ET_{res-c} (exposure time - resident child) hr/day	24
ET_{res-a} (exposure time - resident adult) hr/day	24
ED_{res-a} (exposure duration - resident adult) yr	20
ED_{res-c} (exposure duration - resident child) yr	6
IRW_{res-a} (water intake rate - resident adult) L/day	2.5
IRW_{res-c} (water intake rate - resident child) L/day	0.78
K (volatilization factor of Andelman) L/m^3	0.5
IRA_{res-a} (inhalation rate - resident adult) m^3/day	20
IRA_{res-c} (inhalation rate - resident child) m^3/day	10
$IFW_{res-adj}$ (adjusted intake factor - resident) L-yr/kg-day	19138
$IFA_{res-adj}$ (age-adjusted inhalation factor - resident) m^3	161000
$DFA_{res-adj}$ (age-adjusted immersion factor - resident) hr	6104
$ET_{event-res-c}$ (duration of bathing event - child) hr/event	0.54
$ET_{event-res-a}$ (duration of bathing event - adult) hr/event	0.71
$MLF_{produce}$ (produce plant mass loading factor) unitless	0.26
F (irrigation period) unitless	0.25
I_f (interception fraction) unitless	0.42
I_r (irrigation rate) L/m^2-day	3.62
$Lambda_{HL}$ (soil leaching rate) 1/day	0.000027
P (area density for root zone) kg/m^2	240
T (translocation factor) unitless	1
t_b (long term deposition and buildup) day	10950
t_v (above ground exposure time) day	60
t_w (weathering half-life) day	14
Y_v (plant yield - wet) kg/m^2	2

Output generated 14APR2022:20:57:51

Default

Resident PRGs for Tap Water - Secular Equilibrium

Isotope	Ingestion PRG TR=1.0E-06 (pCi/L)	Inhalation PRG TR=1.0E-06 (pCi/L)	Immersion PRG TR=1.0E-06 (pCi/L)	Produce Consumption PRG TR=1.0E-06 (pCi/L)	Total PRG TR=1.0E-06 (pCi/L)	Total PRG TR=1.0E-06 (pCi/L) w/o Produce Consumption
Secular Equilibrium PRG for K-40	*2.12E+00*	-	*9.17E+05*	*1.35E-01*	*1.27E-01*	*2.12E+00*
Secular Equilibrium PRG for Pb-212	*2.02E+00*	-	*9.80E+04*	*5.17E-01*	*4.12E-01*	*2.02E+00*

Output generated 14APR2022:20:57:51

Ra-226	*1.36E-01*	-	*2.29E+07*	*6.71E-01*	*1.13E-01*	*1.36E-01*

Output generated 19SEP2023:14:46:32

Default

Resident Individual Contribution PRGs for Tap Water - Secular Equilibrium

Isotope	Parent	0.18 exchanges per hour A_{eq} (unitless)	ICRP Lung Absorption Type	Water Ingestion Slope Factor (risk/pCi)	Inhalation Slope Factor (risk/pCi)	Food Ingestion Slope Factor (risk/pCi)	Immersion Slope Factor (risk/yr per pCi/L)	Halflife (d)	Wet Soil-to-plant transfer factor Woody tree (pCi/g-fresh plant per pCi/g-dry soil)	Wet Soil-to-plant transfer factor Leaf (pCi/g-fresh plant per pCi/g-dry soil)	Wet Soil-to-plant transfer factor Root (pCi/g-fresh plant per pCi/g-dry soil)	Wet Soil-to-plant transfer factor Shrub (pCi/g-fresh plant per pCi/g-dry soil)	Wet Soil-to-plant transfer factor Non-leafy fruit (pCi/g-fresh plant per pCi/g-dry soil)	Wet Soil-to-plant transfer factor Maize grain (pCi/g-fresh plant per pCi/g-dry soil)	Wet Soil-to-plant transfer factor Legume seed (pCi/g-fresh plant per pCi/g-dry soil)	Wet Soil-to-plant transfer factor Tuber (pCi/g-fresh plant per pCi/g-dry soil)
Secular Equilibrium PRG for K-40	***K-40***	-		-	-	-	-	-	-	-	-	-	-	-	-	-
K-40	K-40	-	S	2.47E-11	2.22E-10	3.42E-11	1.56E-12	4.57E+11	3.00E-01	1.30E+00	3.00E-01	3.00E-01	3.00E-01	3.00E-01	3.00E-01	3.00E-01
Secular Equilibrium PRG for Pb-212	***Pb-212***	-		-	-	-	-	-	-	-	-	-	-	-	-	-
Pb-212	Pb-212	2.66E-01	S	2.52E-11	6.29E-10	3.57E-11	1.23E-12	4.43E-01	1.00E-02	8.00E-02	1.50E-02	1.00E-02	1.50E-02	1.20E-03	5.30E-03	1.50E-03
Bi-212	Pb-212	2.11E-01	S	7.18E-13	1.13E-10	1.01E-12	9.91E-13	4.20E-02	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
Po-212	Pb-212	1.35E-01	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.46E-12	2.00E-04	7.40E-03	5.80E-03	2.00E-04	2.00E-04	2.40E-04	2.70E-04	2.70E-03
Tl-208	Pb-212	7.46E-02	-	0.00E+00	0.00E+00	0.00E+00	3.46E-11	2.12E-03	8.00E-05	8.00E-04	8.00E-05	8.00E-05	8.00E-04	8.00E-04	8.00E-04	8.00E-05

Isotope	Parent	Soil-to-plant transfer factor Herbaceous (pCi/g-fresh plant	$Lambda_i$(1/day)	$Lambda_B$(1/day)	$Lambda_E$(1/day)	Irr_{dep}(L/kg)	Ingestion PRG TR=1.0E-06 (pCi/L)	Inhalation PRG TR=1.0E-06 (pCi/L)	Immersion PRG TR=1.0E-06 (pCi/L)	Produce Consumption PRG TR=1.0E-06 (pCi/L)	Total PRG TR=1.0E-06 (pCi/L)	Total PRG TR=1.0E-06 (mg/L)
Equilibrium PRG	***K-40***	-	-	-	-	-	***2.12E+00***	-	***9.17E+05***	***1.35E-01***	***1.27E-01***	-
K-40	K-40	3.00E-01	0.00E+00	2.70E-05	4.95E-02	3.64E+00	2.12E+00	-	9.17E+05	1.35E-01	**1.27E-01**	1.78E-05
Equilibrium PRG	***Pb-212***	-	-	-	-	-	***2.02E+00***	-	***9.80E+04***	***5.17E-01***	***4.12E-01***	-
Pb-212	Pb-212	1.00E-02	0.00E+00	2.70E-05	4.95E-02	3.64E+00	2.08E+00	-	1.17E+06	5.42E-01	**4.30E-01**	3.10E-16
Bi-212	Pb-212	1.00E-01	0.00E+00	2.70E-05	4.95E-02	3.64E+00	7.28E+01	-	1.45E+06	1.13E+01	**9.77E+00**	6.68E-16
Po-212	Pb-212	2.00E-04	0.00E+00	2.70E-05	4.95E-02	3.64E+00	-	-	-	-	**-**	-
Tl-208	Pb-212	8.00E-05	0.00E+00	2.70E-05	4.95E-02	3.64E+00	-	-	1.16E+05	-	**1.16E+05**	3.91E-13

Output generated 14APR2022:20:57:51

Appendix C
Cost Estimate

Table C-1. Costs for Alternative 2: MNA and Land Use Controls

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

CAPITAL COSTS						
Capital Item	Quantity	Units	Unit Cost	Subtotal	Total	Basis
Monitoring Well Installation					$ 11,085	
Mobilization/Demobilization	1	LS	$ 1,460	$ 1,460		
Decontamination of Equipment	1	LS	$ 870	$ 870		Standby of Crew for 1.5 hours
HSA Drilling 2" Well	80	LF	$ 47	$ 3,760		2 wells down to 40 feet, 2" diameter well. Drilling Only
Well Development	2	Ea	$ 915	$ 1,830		Includes 10' PVC well screen, 1/2hp pump. 915 per well to develop
IDW Management	1	LS	$ 1,000	$ 1,000		
Crew Daily Rate (per diem)	3	Day	$ 495	$ 1,485		3 man crew with pickup, 155 per day per man, 30/day for pickup
55 gallon drums for IDW	17	Ea	$ 40	$ 680		9 drums estimated for soil, 6 for water; 2 extra just in case
Utility Locate					$ 2,125	
Mobilization/Demobilization	1	LS	$ 375	$ 375		Vendor quote
Utility Surveying	1	Day	$ 1,600	$ 1,600		Vendor quote
Per Diem	1	Ea	$ 150	$ 150		Vendor quote
IDW for MW Installation					$ 2,623	
Transportation of non-hazardous drilling waste	9	EA	$ 75	$ 675		Used waste estimator to determine # of drums
Disposal of non-hazardous drilling waste	9	EA	$ 28	$ 252		
Transportation of non-hazardous liquid waste	6	EA	$ 145	$ 870		Used waste estimator to determine # of drums
Disposal of non-hazardous liquid waste	6	EA	$ 27	$ 159		
TCLP VOCs (soil)	1	EA	$ 87	$ 87		1 sample per 20 drums
TCLP SVOCs (soil)	1	EA	$ 120	$ 120		1 sample per 20 drums
TCLP RCRA 8 Metals (soil)	1	EA	$ 39	$ 39		1 sample per 20 drums
Corrosivity (pH) (soil)	1	EA	$ 12	$ 12		1 sample per 20 drums
Total PCBs (soil)	1	EA	$ 43	$ 43		1 sample per 20 drums
Ignitability (soil)	1	EA	$ 14	$ 14		1 sample per 20 drums
TCLP Pesticides (soil)	1	EA	$ 74	$ 74		1 sample per 20 drums
VOCs (25-ml purge)	1	EA	$ 53	$ 53		1 sample per 20 drums
SVOCs	1	EA	$ 97	$ 97		1 sample per 20 drums
Pesticides	1	EA	$ 77	$ 77		1 sample per 20 drums
RCRA 8 Metals	1	EA	$ 39	$ 39		1 sample per 20 drums
Corrosivity (includes pH)	1	EA	$ 12	$ 12		1 sample per 20 drums
Monitoring Well Survey					$ 1,050	
Mobilization	2	Ea	$ -	$ -		Vendor quote
Well Survey	2	Ea	$ 150	$ 300		Vendor quote
Report	1	LS	$ 750	$ 750		Vendor quote
MNA Monitoring and Analytical Costs					$ 32,268	
VOC (8260C)	21	EA	$ 62	$ 1,302		Eurofins TA quote - 17 + 2FD + 1MS/SD
Metals (6010C)	21	EA	$ 76	$ 1,596		Eurofins TA quote - 17 + 2FD + 1MS/SD
Metals (6020)	21	EA	$ 76	$ 1,596		Eurofins TA quote - 17 + 2FD + 1MS/SD
Mercury, Total (SW7470A)	21	EA	$ 21	$ 441		Eurofins TA quote - 17 + 2FD + 1MS/SD
SVOC (8270D)	21	EA	$ 133	$ 2,793		Eurofins TA quote - 17 + 2FD + 1MS/SD
SVOC (8270-SIM)	21	EA	$ 96	$ 2,016		Eurofins TA quote - 17 + 2FD + 1MS/SD
Explosives (8330B)	21	EA	$ 180	$ 3,780		TA Savannah quote - 17 + 2FD + 1MS/SD
Methane, Ethane, Ethene (RSK-175)	11	EA	$ 48	$ 528		Eurofins TA quote - 8 + 1FD + 1MS/SD
Alkalinity	11	EA	$ 9	$ 99		Eurofins TA quote - 8 + 1FD + 1MS/SD
Total Organic Carbon	11	EA	$ 22	$ 242		Eurofins TA quote - 8 + 1FD + 1MS/SD
Chloride	11	EA	$ 11	$ 121		Eurofins TA quote - 8 + 1FD + 1MS/SD
Nitrate/Nitrite/Sulfate (9056)	11	EA	$ 39	$ 429		Eurofins TA quote - 8 + 1FD + 1MS/SD
PFAS (537 v1.1 and 4 additional in the Army 2018's PFAS guidance)	21	EA	$ 350	$ 7,350		Eurofins TA quote - 17 + 2FD + 1MS/SD
Baseline Residential COC - Radionuclides	21	EA	$100	$ 2,100		Eurofins TA quote - 17 + 2FD + 1MS/SD
Baseline Residential COC - Dioxins/Furans (8290)	21	EA	$375	$ 7,875		Eurofins TA quote - 17 + 2FD + 1MS/SD
Land Use Controls Planning					$ 16,000	
Project Manager	5	DAY	$1,200	$ 6,000		
Project Engineer	10	DAY	$1,000	$ 10,000		
CAPITAL COST SUBTOTAL					$ 65,151	
Contingency (15%)					$ 9,773	
CAPITAL COST TOTAL					$ 74,924	
Payment/Performance Bonds and Insurance (2%)					$ 1,303	Applied to the Subcontract subtotal.

Table C-1. Costs for Alternative 2: MNA and Land Use Controls

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Contractor Professional/Technical Services					$ 38,211	
Engineering/Design (20%)	1	LS	$ 14,985	$ 14,985		Exhibit 5-8 from EPA's Feasibility Costing Guide
Construction Management (15%)	1	LS	$ 11,239	$ 11,239		Exhibit 5-8 from EPA's Feasibility Costing Guide
Prime Contractor Markup (6%)	1	LS	$ 4,495	$ 4,495		EPA's Feasibility Costing Guide
Project Management (10%)	1	LS	$ 7,492	$ 7,492		Exhibit 5-8 from EPA's Feasibility Costing Guide
TOTAL ESTIMATED CAPITAL COST (FY 2022 Dollars)					$ 114,438	

Annual Sampling Costs

Sampling Item		Units	Unit Cost	Subtotal	Total	Basis
MNA Monitoring Analytical Cost (Table C-1)					$ 22,293	
VOC (8260C)	21	EA	$ 62	$ 1,302		Eurofins TA quote - 17 + 2FD + 1MS/SD
Metals (6010C)	21	EA	$ 76	$ 1,596		Eurofins TA quote - 17 + 2FD + 1MS/SD
Metals (6020)	21	EA	$ 76	$ 1,596		Eurofins TA quote - 17 + 2FD + 1MS/SD
Mercury, Total (SW7470A)	21	EA	$ 21	$ 441		Eurofins TA quote - 17 + 2FD + 1MS/SD
SVOC (8270D)	21	EA	$ 133	$ 2,793		Eurofins TA quote - 17 + 2FD + 1MS/SD
SVOC (8270-SIM)	21	EA	$ 96	$ 2,016		Eurofins TA quote - 17 + 2FD + 1MS/SD
Explosives (8330B)	21	EA	$ 180	$ 3,780		TA Savannah quote - 17 + 2FD + 1MS/SD
Methane, Ethane, Ethene (RSK-175)	11	EA	$ 48	$ 528		Eurofins TA quote - 8 + 1FD + 1MS/SD
Alkalinity	11	EA	$ 9	$ 99		Eurofins TA quote - 8 + 1FD + 1MS/SD
Total Organic Carbon	11	EA	$ 22	$ 242		Eurofins TA quote - 8 + 1FD + 1MS/SD
Chloride	11	EA	$ 11	$ 121		Eurofins TA quote - 8 + 1FD + 1MS/SD
Nitrate/Nitrite/Sulfate (9056)	11	EA	$ 39	$ 429		Eurofins TA quote - 8 + 1FD + 1MS/SD
PFAS (537 v1.1 and 4 additional in the Army 2018's PFAS guidance)	21	EA	$ 350	$ 7,350		Eurofins TA quote - 17 + 2FD + 1MS/SD
ANNUAL SUBTOTAL					$ 22,293	
Contingency (15%)					$ 3,344	
ANNUAL TOTAL					$ 25,637	
Payment/Performance Bonds and Insurance (2%)					$ 446	
Contractor Professional/Technical Services					$ 6,409	
Technical Support (15%)	1	LS	$ 3,846	$ 3,846		EPA's Feasibility Costing Guide
Project Management (10%)	1	LS	$ 2,564	$ 2,564		Exhibit 5-8 from EPA's Feasibility Costing Guide
TOTAL ESTIMATED ANNUAL SAMPLING COST (FY 2022 Dollars)					$ 32,492	

Table C-1. Costs for Alternative 2: MNA and Land Use Controls
OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

PERIODIC COSTS (YEARS 5, 10, 15, 20, 25, 30) Periodic Cost Item	Quantity	Units	Unit Cost	Subtotal	Total	Basis
5-Year Review					$ 26,000	
Project Manager	5	DAY	$1,200	$ 6,000		
Project Engineer	20	DAY	$1,000	$ 20,000		
5-Year Review Sampling					$ 9,975	
Radionuclides	21	EA	$100	$ 2,100		Not analyzed as part of normal performance/LTM plan
Dioxins/Furans	21	EA	$375	$ 7,875		Not analyzed as part of normal performance/LTM plan
PERIODIC COST SUBTOTAL					$ 35,975	
Contingency (15%)					$ 5,396	
PERIODIC COST TOTAL					$ 41,371	
Payment/Performance Bonds and Insurance (2%)					$ 720	
Contractor Professional/Technical Services					$ 10,343	
Technical Support (15%)	1	LS	$ 6,206	$ 6,206		EPA's Feasibility Costing Guide
Project Management (10%)	1	LS	$ 4,137	$ 4,137		Exhibit 5-8 from EPA's Feasibility Costing Guide
TOTAL ESTIMATED PERIODIC COST (FY 2022 Dollars) - YEARS 5, 10, 15, 20, 25, 30					$ 52,434	

PRESENT VALUE ANALYSIS (30-YEAR) Discount Rate = 0.5%

Year	Cost Type	Non-Discounted Costs Annual	Periodic	Total Cost Per	Discount	Discounted Costs Discounted	Discounted	Annual Present
0	Capital Cost	$0	$0	$114,438	1.000	$0	$0	$114,438
1	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.995	$32,330	$0	$32,330
2	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.990	$32,170	$0	$32,170
3	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.985	$32,010	$0	$32,010
4	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.980	$31,850	$0	$31,850
5	Annual Cost - Annual Sampling and Periodic Costs	$32,492	$52,434	$84,926	0.975	$31,692	$51,142	$82,834
6	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.971	$31,534	$0	$31,534
7	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.966	$31,377	$0	$31,377
8	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.961	$31,221	$0	$31,221
9	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.956	$31,066	$0	$31,066
10	Annual Cost - Annual Sampling and Periodic Costs	$32,492	$52,434	$84,926	0.951	$30,911	$49,883	$80,794
11	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.947	$30,757	$0	$30,757
12	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.942	$30,604	$0	$30,604
13	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.937	$30,452	$0	$30,452
14	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.933	$30,301	$0	$30,301
15	Annual Cost - Annual Sampling and Periodic Costs	$32,492	$52,434	$84,926	0.928	$30,150	$48,654	$78,804
16	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.923	$30,000	$0	$30,000
17	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.919	$29,851	$0	$29,851
18	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.914	$29,702	$0	$29,702
19	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.910	$29,554	$0	$29,554
20	Annual Cost - Annual Sampling and Periodic Costs	$32,492	$52,434	$84,926	0.905	$29,407	$47,456	$76,863
21	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.901	$29,261	$0	$29,261
22	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.896	$29,115	$0	$29,115
23	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.892	$28,971	$0	$28,971
24	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.887	$28,826	$0	$28,826
25	Annual Cost - Annual Sampling and Periodic Costs	$32,492	$52,434	$84,926	0.883	$28,683	$46,287	$74,970
26	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.878	$28,540	$0	$28,540
27	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.874	$28,398	$0	$28,398
28	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.870	$28,257	$0	$28,257
29	Annual Cost - Annual Sampling	$32,492	$0	$32,492	0.865	$28,117	$0	$28,117
30	Annual Cost - Annual Sampling and Periodic Costs	$32,492	$52,434	$84,926	0.861	$27,977	$45,147	$73,123
	TOTAL ALTERNATIVE COSTS	$974,761	$314,601	$1,403,801		$903,086	$288,568	$1,306,092
	PV OF ALTERNATIVE (FY 2022 Dollars)							$1,306,092

Note:
Contractor Professional/Technical Services Percentages are from EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study"

Table C-2. Costs for Alternative 3: Groundwater Extraction and Treatment with MNA and LUCs
OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

CAPITAL COSTS

Capital Item	Quantity	Units	Unit Cost	Subtotal	Total	Basis
Monitoring Well Installation					$ 11,085	
Mobilization/Demobilization	1	LS	$ 1,460	$ 1,460		
Decontamination of Equipment	1	LS	$ 870	$ 870		Standby of Crew for 1.5 hours
HSA Drilling 2" Well	80	LF	$ 47	$ 3,760		2 wells down to 40 feet, 2" diameter well. Drilling Only
Well Development	2	Ea	$ 915	$ 1,830		Includes 10' PVC well screen, 1/2hp pump. 915 per well to develop
IDW Management	1	LS	$ 1,000	$ 1,000		
Crew Daily Rate (per diem)	3	Day	$ 495	$ 1,485		3 man crew with pickup, 155 per day per man, 30/day for pickup
55 gallon drums for IDW	17	Ea	$ 40	$ 680		9 drums estimated for soil, 6 for water; 2 extra just in case
Utility Locate					$ 2,125	
Mobilization/Demobilization	1	LS	$ 375	$ 375		Vendor quote
Utility Surveying	1	Day	$ 1,600	$ 1,600		Vendor quote
Per Diem	1	Ea	$ 150	$ 150		Vendor quote
IDW for MW Installation					$ 2,623	
Transportation of non-hazardous drilling waste	9	EA	$ 75	$ 675		Used waste estimator to determine # of drums
Disposal of non-hazardous drilling waste	9	EA	$ 28	$ 252		
Transportation of non-hazardous liquid waste	6	EA	$ 145	$ 870		Used waste estimator to determine # of drums
Disposal of non-hazardous liquid waste	6	EA	$ 27	$ 159		
TCLP VOCs (soil)	1	EA	$ 87	$ 87		1 sample per 20 drums
TCLP SVOCs (soil)	1	EA	$ 120	$ 120		1 sample per 20 drums
TCLP RCRA 8 Metals (soil)	1	EA	$ 39	$ 39		1 sample per 20 drums
Corrosivity (pH) (soil)	1	EA	$ 12	$ 12		1 sample per 20 drums
Total PCBs (soil)	1	EA	$ 43	$ 43		1 sample per 20 drums
Ignitability (soil)	1	EA	$ 14	$ 14		1 sample per 20 drums
TCLP Pesticides (soil)	1	EA	$ 74	$ 74		1 sample per 20 drums
VOCs (25-ml purge)	1	EA	$ 53	$ 53		1 sample per 20 drums
SVOCs	1	EA	$ 97	$ 97		1 sample per 20 drums
Pesticides	1	EA	$ 77	$ 77		1 sample per 20 drums
RCRA 8 Metals	1	EA	$ 39	$ 39		1 sample per 20 drums
Corrosivity (includes pH)	1	EA	$ 12	$ 12		1 sample per 20 drums
Subcontractor Well Survey (PDI and Post Extraction Well Installation)					$ 3,150	
Mobilization	1	Ea	$ -	$ -		Vendor quote
Well Survey	16	Ea	$ 150	$ 2,400		Vendor quote
Report	1	LS	$ 750	$ 750		Vendor quote
MNA Monitoring and Analytical Costs					$ 32,268	
VOC (8260C)	21	EA	$ 62	$ 1,302		Eurofins TA quote - 17 + 2FD + 1MS/SD
Metals (6010C)	21	EA	$ 76	$ 1,596		Eurofins TA quote - 17 + 2FD + 1MS/SD
Metals (6020)	21	EA	$ 76	$ 1,596		Eurofins TA quote - 17 + 2FD + 1MS/SD
Mercury, Total (SW7470A)	21	EA	$ 21	$ 441		Eurofins TA quote - 17 + 2FD + 1MS/SD
SVOC (8270D)	21	EA	$ 133	$ 2,793		Eurofins TA quote - 17 + 2FD + 1MS/SD
SVOC (8270-SIM)	21	EA	$ 96	$ 2,016		Eurofins TA quote - 17 + 2FD + 1MS/SD
Explosives (8330B)	21	EA	$ 180	$ 3,780		TA Savannah quote - 17 + 2FD + 1MS/SD
Methane, Ethane, Ethene (RSK-175)	11	EA	$ 48	$ 528		Eurofins TA quote - 8 + 1FD + 1MS/SD
Alkalinity	11	EA	$ 9	$ 99		Eurofins TA quote - 8 + 1FD + 1MS/SD
Total Organic Carbon	11	EA	$ 22	$ 242		Eurofins TA quote - 8 + 1FD + 1MS/SD
Chloride	11	EA	$ 11	$ 121		Eurofins TA quote - 8 + 1FD + 1MS/SD
Nitrate/Nitrite/Sulfate (9056)	11	EA	$ 39	$ 429		Eurofins TA quote - 8 + 1FD + 1MS/SD
PFAS (537 v1.1 and 4 additional in the Army 2018's PFAS guidance)	21	EA	$ 350	$ 7,350		Eurofins TA quote - 17 + 2FD + 1MS/SD
Baseline Residential COC - Radionuclides	21	EA	$100	$ 2,100		Eurofins TA quote - 17 + 2FD + 1MS/SD
Baseline Residential COC - Dioxins/Furans	21	EA	$375	$ 7,875		Eurofins TA quote - 17 + 2FD + 1MS/SD

Table C-2. Costs for Alternative 3: Groundwater Extraction and Treatment with MNA and LUCs

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

PDI for Extraction and Treatment Systems					$ 426,000	
Treatability Study (RSSCT w/ GAC)	2	EA	$ 13,000	$ 26,000		Engineer's estimate
Groundwater Extraction Pilot Test	1	LS	$ 400,000	$ 400,000		Engineer's estimate
--Installation of 2 Pilot Test Wells						
--Installation of 4 Temporary Monitoring Wells						
--Instlalation of 2 Piezometers						
--Pump Test (include installation of 4 wells)						
--Hydraulic Potential Testing						
--Jacobs Labor for Oversight						
--Groundwater Modeling						
Extraction Well Installation					$ 63,900	
Drill Extraction Column - 6" diam	400	LF	$ 70	$ 28,000		
Well Development	10	EA	$ 900	$ 9,000		
Extraction Wells - 4" PVC Perforated	300	LF	$ 14	$ 4,200		
Extraction Wells - 4" PVC Solid	100	LF	$ 12	$ 1,200		
Sand Pack	300	LF	$ 7	$ 2,100		
Extraction Well Head Completion	10	EA	$ 1,500	$ 15,000		
Bentonite Seal	100	LF	$ 8	$ 800		
Drums	45	EA	$ 80	$ 3,600		Waste estimator tool
IDW for Extraction Well Installation					$ 10,167	
Transportation and Disposal of non-hazardous drilling waste	45	EA	$ 200	$ 9,000		Used waste estimator to determine # of drums
TCLP VOCs (soil)	3	EA	$ 87	$ 261		1 sample per 20 drums
TCLP SVOCs (soil)	3	EA	$ 120	$ 360		1 sample per 20 drums
TCLP RCRA 8 Metals (soil)	3	EA	$ 39	$ 117		1 sample per 20 drums
Corrosivity (pH) (soil)	3	EA	$ 12	$ 36		1 sample per 20 drums
Total PCBs (soil)	3	EA	$ 43	$ 129		1 sample per 20 drums
Ignitability (soil)	3	EA	$ 14	$ 42		1 sample per 20 drums
TCLP Pesticides (soil)	3	EA	$ 74	$ 222		1 sample per 20 drums
System Installation - Conveyance System Piping and Fittings					$ 228,940	
Mobilization and Submittals	1	LS	$ 36,490.00	$ 36,490		Vendor quote
Contractor Management	1	LS	$ 35,100.00	$ 35,100		Vendor quote
Contractor Labor and Oversight	15	Days	$ 2,480.00	$ 37,200		Vendor quote
Per diem (4 staff)	60	Days	$ 145.00	$ 8,700		Vendor quote
Equipment Rental (skid steer, truck, mini-excavator)	15	Days	$ 1,340	$ 20,100		Vendor quote
Consumables	15	Days	$ 200	$ 3,000		Vendor quote
HDPE Welding Subcontractor	15	Days	$ 4,300	$ 64,500		Vendor quote
GPRS	2	Days	$ 900	$ 1,800		Vendor quote
PPE	15	Days	$ 100	$ 1,500		Vendor quote
4" HDPE	1100	FT	$ 8	$ 8,910		Vendor quote
1.5" HDPE	1100	FT	$ 2	$ 2,530		Vendor quote
1" HDPE	400	FT	$ 2	$ 840		Vendor quote
HDPE Fittings	1	LS	$ 3,200.00	$ 3,200		Vendor quote
1.5" Steel Line	100	FT	$ 21	$ 2,100		Vendor quote
Tracer Wire	2700	FT	$ 1	$ 2,970		Vendor quote
System Installation - Pump Station					$ 167,049	
Contractor Labor and Oversight	5	Days	$ 2,480	$ 12,400		Vendor quote
Per diem (4 staff)	20	Days	$ 145	$ 2,900		Vendor quote
Equipment Rental	5	Days	$ 1,340	$ 6,700		Vendor quote
Consumables	5	Days	$ 200	$ 1,000		Vendor quote
Concrete	25	CY	$ 225	$ 5,625		Vendor quote
Form Materials	1	LS	$ 4,500	$ 4,500		Vendor quote
Imported Fill	2	Loads	$ 325	$ 650		Vendor quote
Pre-Engineered Steel Car Port (20'x20')	1	LS	$ 14,000	$ 14,000		
Electrical Service (Pole, Overhead Line, Transformers, etc.)	1	LS	$ 75,000	$ 75,000		Engineer's estimate
5,000 gallon Equalization Tank	1	LS	$ 6,500	$ 6,500		Engineer's estimate
Level Transducers	2	EA	$ 1,700	$ 3,400		
Transfer pump (10-hp multistage centrifugal pump)	2	EA	$ 6,000	$ 12,000		Engineer's estimate
Control Panel	1	LS	$ 10,000	$ 10,000		Engineer's estimate
Piping/fittings/flanges	1	LS	$ 6,187	$ 6,187		Engineer's estimate
Valves and Gauges	1	LS	$ 6,187	$ 6,187		Engineer's estimate

Table C-2. Costs for Alternative 3: Groundwater Extraction and Treatment with MNA and LUCs
OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Air Compressor System					$ 48,035	
Contractor Labor and Oversight	3	Days	$ 2,480	$ 7,440		Vendor quote
Per diem (4 staff)	12	Days	$ 145	$ 1,740		Vendor quote
Equipment Rental	3	Days	$ 1,085	$ 3,255		Vendor quote
Consumables	3	Days	$ 200	$ 600		Vendor quote
Rotary Screw (60 cfm) system	1	LS	$ 20,000	$ 20,000		Engineer's estimate
-120-gallon receiver tank						
-Integrated Controller/Aftercooler/Condensate drain						
-Air Treatment						
-Flow Control						
Rotary Screw (40 cfm) system	1	LS	$ 15,000	$ 15,000		Engineer's estimate
-120-gallon receiver tank						
-Integrated Controller/Aftercooler/Condensate drain						
-Air Treatment						
-Flow Control						
Groundwater Extraction Pumps					$ 39,190	
Contractor Labor and Oversight	2	Days	$ 2,480	$ 4,960		Vendor quote
Per diem (4 staff)	8	Days	$ 145	$ 1,160		Vendor quote
Equipment Rental	2	Days	$ 1,335	$ 2,670		Vendor quote
Consumables	2	Days	$ 200	$ 400		Vendor quote
QED AP-4+ Pumps	10	EA	$ 3,000	$ 30,000		Vendor quote
Carbon Vessels and Reactivation					$ 51,000	
FP1 Carbon Vessels with 1,000-lbs of F400	3	EA	$ 4,000	$ 12,000		Quote from Calgon
Carbon Replacement (assume replacement every 4 months)	3	EA	$ 4,000	$ 12,000		Quote from Calgon
FP1 Rental (per 3 units)	12	MONTHS	$ 2,250	$ 27,000		Quote from Calgon
Land Use Controls Planning					$ 16,000	
Project Manager	5	DAY	$1,200	$ 6,000		
Project Engineer	10	DAY	$1,000	$ 10,000		
CAPITAL COST SUBTOTAL					$ 1,101,532	
Contingency (15%)					$ 165,230	
CAPITAL COST TOTAL					$ 1,266,762	
Payment/Performance Bonds and Insurance (2%)					$ 22,031	Applied to the Subcontract subtotal.
Contractor Professional/Technical Services					$ 405,364	
Engineering/Design (12%)	1	LS	$ 152,011	$ 152,011		Exhibit 5-8 from EPA's Feasibility Costing Guide
Construction Management (8%)	1	LS	$ 101,341	$ 101,341		Exhibit 5-8 from EPA's Feasibility Costing Guide
Prime Contractor Markup (6%)	1	LS	$ 76,006	$ 76,006		EPA's Feasibility Costing Guide
Project Management (6%)	1	LS	$ 76,006	$ 76,006		Exhibit 5-8 from EPA's Feasibility Costing Guide
TOTAL ESTIMATED CAPITAL COST (FY 2022 Dollars)					$ 1,694,156	

Table C-2. Costs for Alternative 3: Groundwater Extraction and Treatment with MNA and LUCs
OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

ANNUAL SAMPLING COST

O&M Item		Units	Unit Cost	Subtotal	Total	
MNA Monitoring Analytical Cost					$ 22,293	
VOC (8260C)	21	EA	$ 62	$ 1,302		Eurofins TA quote - 17 + 2FD + 1MS/SD
Metals (6010C)	21	EA	$ 76	$ 1,596		Eurofins TA quote - 17 + 2FD + 1MS/SD
Metals (6020)	21	EA	$ 76	$ 1,596		Eurofins TA quote - 17 + 2FD + 1MS/SD
Mercury, Total (SW7470A)	21	EA	$ 21	$ 441		Eurofins TA quote - 17 + 2FD + 1MS/SD
SVOC (8270D)	21	EA	$ 133	$ 2,793		Eurofins TA quote - 17 + 2FD + 1MS/SD
SVOC (8270-SIM)	21	EA	$ 96	$ 2,016		Eurofins TA quote - 17 + 2FD + 1MS/SD
Explosives (8330B)	21	EA	$ 180	$ 3,780		TA Savannah quote - 17 + 2FD + 1MS/SD
Methane, Ethane, Ethene (RSK-175)	11	EA	$ 48	$ 528		Eurofins TA quote - 8 + 1FD + 1MS/SD
Alkalinity	11	EA	$ 9	$ 99		Eurofins TA quote - 8 + 1FD + 1MS/SD
Total Organic Carbon	11	EA	$ 22	$ 242		Eurofins TA quote - 8 + 1FD + 1MS/SD
Chloride	11	EA	$ 11	$ 121		Eurofins TA quote - 8 + 1FD + 1MS/SD
Nitrate/Nitrite/Sulfate (9056)	11	EA	$ 39	$ 429		Eurofins TA quote - 8 + 1FD + 1MS/SD
PFAS (537 v1.1 and 4 additional in the Army 2018's PFAS guidance)	21	EA	$ 350	$ 7,350		Eurofins TA quote - 17 + 2FD + 1MS/SD
Performance Monitoring (Effluent side on both carbon vessels)					$ 36,576	
VOC (8260C)	48	EA	$ 62	$ 2,976		2 samples per month from each carbon vessel
SVOC (8270D)	48	EA	$ 133	$ 6,384		2 samples per month from each carbon vessel
SVOC (8270-SIM)	48	EA	$ 96	$ 4,608		2 samples per month from each carbon vessel
Radionuclides	48	EA	$ 96	$ 4,608		2 samples per month from each carbon vessel
Dioxins/Furans	48	EA	$ 375	$ 18,000		2 samples per month from each carbon vessel
O&M ANNUAL SUBTOTAL					$ 58,869	
Contingency (15%)					$ 8,830	
O&M ANNUAL TOTAL					$ 67,699	
Payment/Performance Bonds and Insurance (2%)					$ 1,177	
Contractor Professional/Technical Services					$ 14,217	
Technical Support (15%)	1	LS	$ 10,155	$ 10,155		EPA's Feasibility Costing Guide
Project Management (6%)	1	LS	$ 4,062	$ 4,062		Exhibit 5-8 from EPA's Feasibility Costing Guide
TOTAL ESTIMATED ANNUAL SAMPLING COST (FY 2022 Dollars)					$ 83,094	

Table C-2. Costs for Alternative 3: Groundwater Extraction and Treatment with MNA and LUCs
OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Annual O&M Reactivation Costs							
O&M Item							
Carbon Replacement and Unit Rental						$ 39,000	
Carbon Replacement (assume replacement every 4 months)	3	EA	$	4,000	$ 12,000		
FP1 Rental (per 3 units)	12	MONTHS	$	2,250	$ 27,000		
O&M ANNUAL SUBTOTAL						$ 39,000	
Contingency (15%)						$ 5,850	
O&M ANNUAL TOTAL						$ 44,850	
Payment/Performance Bonds and Insurance (2%)						$ 780	
Contractor Professional/Technical Services						$ 9,419	
Technical Support (15%)	1	LS	$	6,728	$ 6,728		EPA's Feasibility Costing Guide
Project Management (6%)	1	LS	$	2,691	$ 2,691		Exhibit 5-8 from EPA's Feasibility Costing Guide
TOTAL ESTIMATED ANNUAL SAMPLING COST (FY 2022 Dollars)						$ 55,049	

PERIODIC COSTS (YEARS 5, 10, 15, 20, 25, 30)						
Periodic Cost Item	Quantity	Units	Unit Cost	Subtotal	Total	Basis
5-Year Review					$ 35,975	
Project Manager	5	DAY	$1,200	$ 6,000		
Project Engineer	20	DAY	$1,000	$ 20,000		
5-Year Review Sampling					$ 9,975	
Radionuclides	21	EA	$100	$ 2,100		Not analyzed as part of normal performance/LTM plan
Dioxins/Furans	21	EA	$375	$ 7,875		Not analyzed as part of normal performance/LTM plan
PERIODIC COST SUBTOTAL					$ 45,950	
Contingency (15%)					$ 6,893	
PERIODIC COST TOTAL					$ 52,843	
Payment/Performance Bonds and Insurance (2%)					$ 919	
Contractor Professional/Technical Services					$ 11,097	
Technical Support (15%)	1	LS	$ 7,926	$ 7,926		EPA's Feasibility Costing Guide
Project Management (6%)	1	LS	$ 3,171	$ 3,171		Exhibit 5-8 from EPA's Feasibility Costing Guide
TOTAL ESTIMATED ANNUAL PERIODIC COST (FY 2022 Dollars) - YEARS 5, 10, 15, 20, 25, 30					$ 64,858	

Table C-2. Costs for Alternative 3: Groundwater Extraction and Treatment with MNA and LUCs

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

PRESENT VALUE ANALYSIS (30-YEAR)								
				Discount Rate =	0.5%			
		Non-Discounted Costs				Discounted Costs		
Year	Cost Type	Annual	Periodic	Total Cost Per	Discount	Discounted	Discounted	Annual Present
0	Capital Cost	$0	$0	$1,694,156	1.000	$0	$0	$1,694,156
1	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.995	$137,455	$0	$137,455
2	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.990	$136,771	$0	$136,771
3	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.985	$136,091	$0	$136,091
4	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.980	$135,413	$0	$135,413
5	Annual Cost - Annual Sampling, Carbon Replacement, and Periodic Costs	$138,142	$64,858	$203,001	0.975	$134,740	$63,261	$198,001
6	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.971	$134,069	$0	$134,069
7	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.966	$133,402	$0	$133,402
8	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.961	$132,739	$0	$132,739
9	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.956	$132,078	$0	$132,078
10	Annual Cost - Annual Sampling, Carbon Replacement, and Periodic Costs	$138,142	$64,858	$203,001	0.951	$131,421	$61,703	$193,124
11	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.947	$130,767	$0	$130,767
12	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.942	$130,117	$0	$130,117
13	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.937	$129,469	$0	$129,469
14	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.933	$128,825	$0	$128,825
15	Annual Cost - Annual Sampling, Carbon Replacement, and Periodic Costs	$138,142	$64,858	$203,001	0.928	$128,184	$60,183	$188,368
16	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.923	$127,547	$0	$127,547
17	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.919	$126,912	$0	$126,912
18	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.914	$126,281	$0	$126,281
19	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.910	$125,652	$0	$125,652
20	Annual Cost - Annual Sampling, Carbon Replacement, and Periodic Costs	$138,142	$64,858	$203,001	0.905	$125,027	$58,701	$183,728
21	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.901	$124,405	$0	$124,405
22	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.896	$123,786	$0	$123,786
23	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.892	$123,170	$0	$123,170
24	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.887	$122,558	$0	$122,558
25	Annual Cost - Annual Sampling, Carbon Replacement, and Periodic Costs	$138,142	$64,858	$203,001	0.883	$121,948	$57,255	$179,203
26	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.878	$121,341	$0	$121,341
27	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.874	$120,738	$0	$120,738
28	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.870	$120,137	$0	$120,137
29	Annual Cost - Annual Sampling and Carbon Replacement	$138,142	$0	$138,142	0.865	$119,539	$0	$119,539
30	Annual Cost - Annual Sampling, Carbon Replacement, and Periodic Costs	$138,142	$64,858	$203,001	0.861	$118,944	$55,845	$174,789
	TOTAL ALTERNATIVE COSTS	$4,144,263	$389,151	$6,227,570		$3,839,529	$356,948	$5,890,633
	PV OF ALTERNATIVE (FY 2022 Dollars)							$5,890,633

Note:
Contractor Professional/Technical Services Percentages are from EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study"

Table C-3. Costs for Alternative 4: PRB with MNA and LUCs

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

CAPITAL COSTS						
Capital Item	Quantity	Units	Unit Cost	Subtotal	Total	Basis
Monitoring Well Installation					$ 37,570	
Mobilization/Demobilization	1	LS	$ 1,460	$ 1,460		
Decontamination of Equipment	1	LS	$ 870	$ 870		Standby of Crew for 1.5 hours
HSA Drilling 2" Well	480	LF	$ 47	$ 22,560		6 wells down to 40 feet, 2" diameter well. Drilling Only
Well Development	6	Ea	$ 915	$ 5,490		Includes 10' PVC well screen, 1/2hp pump. 915 per well to develop
IDW Management	1	LS	$ 1,000	$ 1,000		
Crew Daily Rate (per diem)	10	Day	$ 495	$ 4,950		3 man crew with pickup, 155 per day per man, 30/day for pickup
55 gallon drums for IDW	31	Ea	$ 40	$ 1,240		11 drums estimated for soil, 18 for water; 2 extra just in case
Utility Locate					$ 2,125	
Mobilization/Demobilization	1	LS	$ 375	$ 375		Vendor quote
Utility Surveying	1	Day	$ 1,600	$ 1,600		Vendor quote
Per Diem	1	Ea	$ 150	$ 150		Vendor quote
IDW for MW Installation					$ 6,221	
Transportation of non-hazardous drilling waste	11	EA	$ 75	$ 825		Used waste estimator to determine # of drums
Disposal of non-hazardous drilling waste	11	EA	$ 28	$ 308		
Transportation of non-hazardous liquid waste	18	EA	$ 145	$ 2,610		Used waste estimator to determine # of drums
Disposal of non-hazardous liquid waste	18	EA	$ 27	$ 477		
TCLP VOCs (soil)	3	EA	$ 87	$ 261		1 sample per 20 drums
TCLP SVOCs (soil)	3	EA	$ 120	$ 360		1 sample per 20 drums
TCLP RCRA 8 Metals (soil)	3	EA	$ 39	$ 117		1 sample per 20 drums
Corrosivity (pH) (soil)	3	EA	$ 12	$ 36		1 sample per 20 drums
Total PCBs (soil)	3	EA	$ 43	$ 129		1 sample per 20 drums
Ignitability (soil)	3	EA	$ 14	$ 42		1 sample per 20 drums
TCLP Pesticides (soil)	3	EA	$ 74	$ 222		1 sample per 20 drums
VOCs (25-ml purge)	3	EA	$ 53	$ 159		1 sample per 20 drums
SVOCs	3	EA	$ 97	$ 291		1 sample per 20 drums
Pesticides	3	EA	$ 77	$ 231		1 sample per 20 drums
RCRA 8 Metals	3	EA	$ 39	$ 117		1 sample per 20 drums
Corrosivity (includes pH)	3	EA	$ 12	$ 36		1 sample per 20 drums
Subcontractor Well Survey (PDI and Post Injection Well Installation)					$ 9,150	
Mobilization	1	Ea	$ -	$ -		Vendor quote
Monitoring and injection Well Survey	56	Ea	$ 150	$ 8,400		Vendor quote
Report	1	LS	$ 750	$ 750		Vendor quote
MNA Monitoring and Analytical Costs					$ 36,244	
VOC (8260C)	21	EA	$ 62	$ 1,302		Eurofins TA quote - 17 + 2FD + 1MS/SD
Metals (6010C)	21	EA	$ 76	$ 1,596		Eurofins TA quote - 17 + 2FD + 1MS/SD
Metals (6020)	21	EA	$ 76	$ 1,596		Eurofins TA quote - 17 + 2FD + 1MS/SD
Mercury, Total (SW7470A)	21	EA	$ 21	$ 441		Eurofins TA quote - 17 + 2FD + 1MS/SD
SVOC (8270D)	21	EA	$ 133	$ 2,793		Eurofins TA quote - 17 + 2FD + 1MS/SD
SVOC (8270-SIM)	21	EA	$ 96	$ 2,016		Eurofins TA quote - 17 + 2FD + 1MS/SD
Explosives (8330B)	21	EA	$ 180	$ 3,780		TA Savannah quote - 17 + 2FD + 1MS/SD
Methane, Ethane, Ethene (RSK-175)	11	EA	$ 48	$ 528		Eurofins TA quote - 8 + 1FD + 1MS/SD
Alkalinity	11	EA	$ 9	$ 99		Eurofins TA quote - 8 + 1FD + 1MS/SD
Total Organic Carbon	11	EA	$ 22	$ 242		Eurofins TA quote - 8 + 1FD + 1MS/SD
Chloride	11	EA	$ 11	$ 121		Eurofins TA quote - 8 + 1FD + 1MS/SD
Nitrate/Nitrite/Sulfate (9056)	11	EA	$ 39	$ 429		Eurofins TA quote - 8 + 1FD + 1MS/SD
PFAS (537 v1.1 and 4 additional in the Army 2018's PFAS guidance)	21	EA	$ 350	$ 7,350		Eurofins TA quote - 17 + 2FD + 1MS/SD
4 Additional Wells	4	EA	$ 994	$ 3,976		Eurofins TA Quote
Baseline Residential COC - Radionuclides	21	EA	$ 100	$ 2,100		Eurofins TA Quote
Baseline Residential COC - Dioxins/Furans (8290)	21	EA	$ 375	$ 7,875		Eurofins TA Quote
Additional PDI and Pilot Testing					$ 50,000	Engineer's estimate
Initial Application of PlumeStop and ZVI					$ 1,681,000	Quote from Regenesis
PlumeStop (123,200 lbs)						
S-MZVI (10,300 lbs)						
50 Temporary Injection Wells Installation						
Chemical Mixing and Application (PlumeStop and S-MZVI)						

Table C-3. Costs for Alternative 4: PRB with MNA and LUCs

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

IDW for Injections					$ 2,389	
Transportation and Disposal of non-hazardous drilling waste	10	EA	$ 200	$ 2,000		Used waste estimator to determine # of drums (assumed DPT)
TCLP VOCs (soil)	1	EA	$ 87	$ 87		1 sample per 20 drums
TCLP SVOCs (soil)	1	EA	$ 120	$ 120		1 sample per 20 drums
TCLP RCRA 8 Metals (soil)	1	EA	$ 39	$ 39		1 sample per 20 drums
Corrosivity (pH) (soil)	1	EA	$ 12	$ 12		1 sample per 20 drums
Total PCBs (soil)	1	EA	$ 43	$ 43		1 sample per 20 drums
Ignitability (soil)	1	EA	$ 14	$ 14		1 sample per 20 drums
TCLP Pesticides (soil)	1	EA	$ 74	$ 74		1 sample per 20 drums
Land Use Controls Planning					$ 16,000	
Project Manager	5	DAY	$1,200	$6,000		
Project Engineer	10	DAY	$1,000	$10,000		
CAPITAL COST SUBTOTAL					$ 1,840,699	
Contingency (15%)					$ 276,105	
CAPITAL COST TOTAL					$ 2,116,804	
Payment/Performance Bonds and Insurance (2%)					$ 36,814	Applied to the Subcontract subtotal.
Contractor Professional/Technical Services					$ 529,201	
Engineering/Design (8%)	1	LS	$ 169,344	$169,344		Exhibit 5-8 from EPA's Feasibility Costing Guide
Construction Management (6%)	1	LS	$ 127,008	$127,008		Exhibit 5-8 from EPA's Feasibility Costing Guide
Prime Contractor Markup (6%)	1	LS	$ 127,008	$127,008		EPA's Feasibility Costing Guide
Project Management (5%)	1	LS	$ 105,840	$105,840		Exhibit 5-8 from EPA's Feasibility Costing Guide
TOTAL ESTIMATED CAPITAL COST (FY 2022 Dollars)					$ 2,682,819	
ANNUAL SAMPLING COST (MNA MONITORING + PERFORMANCE MONITORING)						
O&M Item		Units	Unit Cost	Subtotal	Total	Basis
MNA Monitoring Analytical Cost					$ 26,269	
VOC (8260C)	21	EA	$ 62	$ 1,302		Eurofins TA quote - 17 + 2FD + 1MS/SD
Metals (6010C)	21	EA	$ 76	$ 1,596		Eurofins TA quote - 17 + 2FD + 1MS/SD
Metals (6020)	21	EA	$ 76	$ 1,596		Eurofins TA quote - 17 + 2FD + 1MS/SD
Mercury, Total (SW7470A)	21	EA	$ 21	$ 441		Eurofins TA quote - 17 + 2FD + 1MS/SD
SVOC (8270D)	21	EA	$ 133	$ 2,793		Eurofins TA quote - 17 + 2FD + 1MS/SD
SVOC (8270-SIM)	21	EA	$ 96	$ 2,016		Eurofins TA quote - 17 + 2FD + 1MS/SD
Explosives (8330B)	21	EA	$ 180	$ 3,780		TA Savannah quote - 17 + 2FD + 1MS/SD
Methane, Ethane, Ethene (RSK-175)	11	EA	$ 48	$ 528		Eurofins TA quote - 8 + 1FD + 1MS/SD
Alkalinity	11	EA	$ 9	$ 99		Eurofins TA quote - 8 + 1FD + 1MS/SD
Total Organic Carbon	11	EA	$ 22	$ 242		Eurofins TA quote - 8 + 1FD + 1MS/SD
Chloride	11	EA	$ 11	$ 121		Eurofins TA quote - 8 + 1FD + 1MS/SD
Nitrate/Nitrite/Sulfate (9056)	11	EA	$ 39	$ 429		Eurofins TA quote - 8 + 1FD + 1MS/SD
PFAS (537 v1.1 and 4 additional in the Army 2018's PFAS guidance)	21	EA	$ 350	$ 7,350		Eurofins TA quote - 17 + 2FD + 1MS/SD
4 Additional wells	4	EA	$ 994	$ 3,976		4 additional wells installed as part of this alternative
Performance Monitoring Additional Parameter Analytical Cost					$ 5,094	
VOC (8260C)	6	EA	$ 62	$ 372		Eurofins TA quote
Metals (6010C)	6	EA	$ 76	$ 456		Eurofins TA quote
Metals (6020)	6	EA	$ 76	$ 456		Eurofins TA quote
Mercury, Total (SW7470A)	6	EA	$ 21	$ 126		Eurofins TA quote
SVOC (8270D)	6	EA	$ 133	$ 798		Eurofins TA quote
SVOC (8270-SIM)	6	EA	$ 96	$ 576		Eurofins TA quote
Explosives (8330B)	6	EA	$ 180	$ 1,080		TA Savannah quote
TOC	6	EA	$ 22	$132		Eurofins TA quote
Dissolved Fe and Mn	6	EA	$ 76	$456		Eurofins TA quote
Nitrate/Nitrite/Sulfate (9056)	6	EA	$ 39	$ 234		Eurofins TA quote
Alkalinity	6	EA	$ 9	$54		Eurofins TA quote
Chloride	6	EA	$ 11	$66		Eurofins TA quote
Methane, Ethane, Ethene, CO2	6	EA	$ 48	$288		Eurofins TA quote
O&M ANNUAL SUBTOTAL					$ 31,363	
Contingency (15%)					$ 4,704	
O&M ANNUAL TOTAL					$ 36,067	

Table C-3. Costs for Alternative 4: PRB with MNA and LUCs

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

O&M Item	Qty	Units	Unit Cost	Subtotal	Total	Basis
Payment/Performance Bonds and Insurance (2%)					$ 627	
Contractor Professional/Technical Services					$ 7,213	
Technical Support (15%)	1	LS	$ 5,410	$5,410		EPA's Feasibility Costing Guide
Project Management (5%)	1	LS	$ 1,803	$1,803		Exhibit 5-8 from EPA's Feasibility Costing Guide
TOTAL ESTIMATED ANNUAL O&M COST (FY 2022 Dollars)					$ 43,908	
ANNUAL SAMPLING COST (PERFORMANCE MONITORING - Year 1 Quarterly Monitoring)						
O&M Item		Units	Unit Cost	Subtotal	Total	Basis
MNA Monitoring Analytical Cost (Table C-1)					$ 78,807	4th event covered during baseline sampling/capital cost
VOC (8260C)	63	EA	$ 62	$ 3,906		Eurofins TA quote - 17 + 2FD + 1MS/SD
Metals (6010C)	63	EA	$ 76	$ 4,788		Eurofins TA quote - 17 + 2FD + 1MS/SD
Metals (6020)	63	EA	$ 76	$ 4,788		Eurofins TA quote - 17 + 2FD + 1MS/SD
Mercury, Total (SW7470A)	63	EA	$ 21	$ 1,323		Eurofins TA quote - 17 + 2FD + 1MS/SD
SVOC (8270D)	63	EA	$ 133	$ 8,379		Eurofins TA quote - 17 + 2FD + 1MS/SD
SVOC (8270-SIM)	63	EA	$ 96	$ 6,048		Eurofins TA quote - 17 + 2FD + 1MS/SD
Explosives (8330B)	63	EA	$ 180	$ 11,340		TA Savannah quote - 17 + 2FD + 1MS/SD
Methane, Ethane, Ethene (RSK-175)	33	EA	$ 48	$ 1,584		Eurofins TA quote - 8 + 1FD + 1MS/SD
Alkalinity	33	EA	$ 9	$ 297		Eurofins TA quote - 8 + 1FD + 1MS/SD
Total Organic Carbon	33	EA	$ 22	$ 726		Eurofins TA quote - 8 + 1FD + 1MS/SD
Chloride	33	EA	$ 11	$ 363		Eurofins TA quote - 8 + 1FD + 1MS/SD
Nitrate/Nitrite/Sulfate (9056)	33	EA	$ 39	$ 1,287		Eurofins TA quote - 8 + 1FD + 1MS/SD
PFAS (537 v1.1 and 4 additional in the Army 2018's PFAS guidance)	63	EA	$ 350	$ 22,050		Eurofins TA quote - 17 + 2FD + 1MS/SD
4 Additional wells	12	EA	$ 994	$ 11,928		4 additional wells installed as part of this alternative
Performance Monitoring Additional Parameter Analytical Cost					$ 20,376	
VOC (8260C)	24	EA	$ 62	$ 1,488		Eurofins TA quote
Metals (6010C)	24	EA	$ 76	$ 1,824		Eurofins TA quote
Metals (6020)	24	EA	$ 76	$ 1,824		Eurofins TA quote
Mercury, Total (SW7470A)	24	EA	$ 21	$ 504		Eurofins TA quote
SVOC (8270D)	24	EA	$ 133	$ 3,192		Eurofins TA quote
SVOC (8270-SIM)	24	EA	$ 96	$ 2,304		Eurofins TA quote
Explosives (8330B)	24	EA	$ 180	$ 4,320		TA Savannah quote
TOC	24	EA	$ 22	$528		Eurofins TA quote
Dissolved Fe and Mn	24	EA	$ 76	$1,824		Eurofins TA quote
Nitrate/Nitrite/Sulfate (9056)	24	EA	$ 39	$ 936		Eurofins TA quote
Alkalinity	24	EA	$ 9	$216		Eurofins TA quote
Chloride	24	EA	$ 11	$264		Eurofins TA quote
Methane, Ethane, Ethene, CO2	24	EA	$ 48	$1,152		Eurofins TA quote
O&M ANNUAL SUBTOTAL					$ 99,183	
Contingency (15%)					$ 14,877	
O&M ANNUAL TOTAL					$ 114,060	
Payment/Performance Bonds and Insurance (2%)					$ 1,984	
Contractor Professional/Technical Services					$ 22,812	
Technical Support (15%)	1	LS	$ 17,109	$17,109		EPA's Feasibility Costing Guide
Project Management (5%)	1	LS	$ 5,703	$5,703		Exhibit 5-8 from EPA's Feasibility Costing Guide
TOTAL ESTIMATED ANNUAL O&M COST (FY 2022 Dollars)					$ 138,856	
ANNUAL SAMPLING COST (PERFORMANCE MONITORING - Year 2 Semiannual Monitoring)						
O&M Item		Units	Unit Cost	Subtotal	Total	Basis
MNA Monitoring Analytical Cost					$ 26,269	2nd event covered during annual sampling
VOC (8260C)	21	EA	$ 62	$ 1,302		Eurofins TA quote - 17 + 2FD + 1MS/SD
Metals (6010C)	21	EA	$ 76	$ 1,596		Eurofins TA quote - 17 + 2FD + 1MS/SD
Metals (6020)	21	EA	$ 76	$ 1,596		Eurofins TA quote - 17 + 2FD + 1MS/SD
Mercury, Total (SW7470A)	21	EA	$ 21	$ 441		Eurofins TA quote - 17 + 2FD + 1MS/SD
SVOC (8270D)	21	EA	$ 133	$ 2,793		Eurofins TA quote - 17 + 2FD + 1MS/SD
SVOC (8270-SIM)	21	EA	$ 96	$ 2,016		Eurofins TA quote - 17 + 2FD + 1MS/SD
Explosives (8330B)	21	EA	$ 180	$ 3,780		TA Savannah quote - 17 + 2FD + 1MS/SD
Methane, Ethane, Ethene (RSK-175)	11	EA	$ 48	$ 528		Eurofins TA quote - 8 + 1FD + 1MS/SD
Alkalinity	11	EA	$ 9	$ 99		Eurofins TA quote - 8 + 1FD + 1MS/SD
Total Organic Carbon	11	EA	$ 22	$ 242		Eurofins TA quote - 8 + 1FD + 1MS/SD
Chloride	11	EA	$ 11	$ 121		Eurofins TA quote - 8 + 1FD + 1MS/SD

Table C-3. Costs for Alternative 4: PRB with MNA and LUCs

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Nitrate/Nitrite/Sulfate (9056)	11	EA	$ 39	$ 429		Eurofins TA quote - 8 + 1FD + 1MS/SD
PFAS (537 v1.1 and 4 additional in the Army 2018's PFAS guidance)	21	EA	$ 350	$ 7,350		Eurofins TA quote - 17 + 2FD + 1MS/SD
4 Additional wells	4	EA	$ 994	$ 3,976		
Performance Monitoring Additional Parameter Analytical Cost					$ 5,094	2nd event covered during annual sampling
VOC (8260C)	6	EA	$ 62	$ 372		Eurofins TA quote
Metals (6010C)	6	EA	$ 76	$ 456		Eurofins TA quote
Metals (6020)	6	EA	$ 76	$ 456		Eurofins TA quote
Mercury, Total (SW7470A)	6	EA	$ 21	$ 126		Eurofins TA quote
SVOC (8270D)	6	EA	$ 133	$ 798		Eurofins TA quote
SVOC (8270-SIM)	6	EA	$ 96	$ 576		Eurofins TA quote
Explosives (8330B)	6	EA	$ 180	$ 1,080		TA Savannah quote
TOC	6	EA	$ 22	$132		Eurofins TA quote
Dissolved Fe and Mn	6	EA	$ 76	$456		Eurofins TA quote
Nitrate/Nitrite/Sulfate (9056)	6	EA	$ 39	$ 234		Eurofins TA quote
Alkalinity	6	EA	$ 9	$54		Eurofins TA quote
Chloride	6	EA	$ 11	$66		Eurofins TA quote
Methane, Ethane, Ethene, CO2	6	EA	$ 48	$288		Eurofins TA quote
O&M ANNUAL SUBTOTAL					$ 31,363	
Contingency (15%)					$ 4,704	
O&M ANNUAL TOTAL					$ 36,067	
Payment/Performance Bonds and Insurance (2%)					$ 627	
Contractor Professional/Technical Services					$ 7,213	
Technical Support (15%)	1	LS	$ 5,410	$5,410		EPA's Feasibility Costing Guide
Project Management (5%)	1	LS	$ 1,803	$1,803		Exhibit 5-8 from EPA's Feasibility Costing Guide
TOTAL ESTIMATED ANNUAL O&M COST (FY 2022 Dollars)					$ 43,908	
2nd Injection (YEAR 16)						
2nd Application of PlumeStop and ZVI					$ 1,681,000	Quote from Regenesis
PlumeStop (123,200 lbs)						
S-MZVI (10,300 lbs)						
50 Temporary Injection Wells Installation						
Chemical Mixing and Application (PlumeStop and S-MZVI)						
IDW for Injection					$ 2,389	
Transportation and Disposal of non-hazardous drilling waste	10	EA	$ 200	$ 2,000		Used waste estimator to determine # of drums
TCLP VOCs (soil)	1	EA	$ 87	$ 87		1 sample per 20 drums
TCLP SVOCs (soil)	1	EA	$ 120	$ 120		1 sample per 20 drums
TCLP RCRA 8 Metals (soil)	1	EA	$ 39	$ 39		1 sample per 20 drums
Corrosivity (pH) (soil)	1	EA	$ 12	$ 12		1 sample per 20 drums
Total PCBs (soil)	1	EA	$ 43	$ 43		1 sample per 20 drums
Ignitability (soil)	1	EA	$ 14	$ 14		1 sample per 20 drums
TCLP Pesticides (soil)	1	EA	$ 74	$ 74		1 sample per 20 drums
SUBCONTRACT SUBTOTAL					$ 1,683,389	
Contingency (15%)					$ 252,508	
SUBCONTRACT TOTAL					$ 1,935,897	
Payment/Performance Bonds and Insurance (2%)					$ 33,668	Applied to the Subcontract subtotal.
Contractor Professional/Technical Services					$ 483,974	
Engineering/Design (8%)	1	LS	$ 154,872	$154,872		Exhibit 5-8 from EPA's Feasibility Costing Guide
Construction Management (6%)	1	LS	$ 116,154	$116,154		Exhibit 5-8 from EPA's Feasibility Costing Guide
Prime Contractor Markup (6%)	1	LS	$ 116,154	$116,154		EPA's Feasibility Costing Guide
Project Management (5%)	1	LS	$ 96,795	$96,795		Exhibit 5-8 from EPA's Feasibility Costing Guide
TOTAL ESTIMATED 2ND INJECTION COST (FY 2022 Dollars)					$ 2,453,539	

Table C-3. Costs for Alternative 4: PRB with MNA and LUCs
OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

PERIODIC COSTS (YEARS 5, 10, 15, 20, 25, 30) Periodic Cost Item	Quantity	Units	Unit Cost	Subtotal	Total	Basis
5-Year Review					$ 26,000	
Project Manager	5	DAY	$1,200	$6,000		
Project Engineer	20	DAY	$1,000	$20,000		
5-Year Review Sampling					$ 9,975	
Radionuclides	21	EA	$100	$2,100		Not analyzed as part of normal performance/LTM plan
Dioxins/Furans	21	EA	$375	$7,875		Not analyzed as part of normal performance/LTM plan
PERIODIC COST SUBTOTAL					$ 35,975	
Contingency (15%)					$ 5,396	
PERIODIC COST TOTAL					$ 41,371	
Payment/Performance Bonds and Insurance (2%)					$ 720	
Contractor Professional/Technical Services					$ 8,274	
Technical Support (15%)	1	LS	$ 6,206	$6,206		EPA's Feasibility Costing Guide
Project Management (5%)	1	LS	$ 2,069	$2,069		Exhibit 5-8 from EPA's Feasibility Costing Guide
TOTAL ESTIMATED ANNUAL PERIODIC COST (FY 2022 Dollars) - YEARS 5, 10, 15, 20, 25, 30					$ 50,365	

PRESENT VALUE ANALYSIS (30-YEAR) — Discount Rate = 0.5%

Year	Cost Type	Non-Discounted Costs Annual	Non-Discounted Costs Periodic Cost	Non-Discounted Costs Total Cost Per	Discount	Discounted Costs Discounted	Discounted Costs Discounted	Annual Present
0	Capital Cost	$0	$0	$2,682,819	1.000	$0	$0	$2,682,819
1	Annual Cost - Performance Monitoring Year 1 (includes 4 MNA events)	$138,856	$0	$138,856	0.995	$138,165	$0	$138,165
2	Annual Cost - Performance Monitoring Year 2 + Annual Sampling	$87,816	$0	$87,816	0.990	$86,945	$0	$86,945
3	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.985	$43,256	$0	$43,256
4	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.980	$43,041	$0	$43,041
5	Annual Cost - Annual Sampling and Periodic Costs	$43,908	$50,365	$94,273	0.975	$42,827	$49,125	$91,951
6	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.971	$42,614	$0	$42,614
7	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.966	$42,402	$0	$42,402
8	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.961	$42,191	$0	$42,191
9	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.956	$41,981	$0	$41,981
10	Annual Cost - Annual Sampling and Periodic Costs	$43,908	$50,365	$94,273	0.951	$41,772	$47,915	$89,687
11	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.947	$41,564	$0	$41,564
12	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.942	$41,357	$0	$41,357
13	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.937	$41,152	$0	$41,152
14	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.933	$40,947	$0	$40,947
15	Annual Cost - Annual Sampling and Periodic Costs	$43,908	$50,365	$94,273	0.928	$40,743	$46,735	$87,478
16	Annual Cost - Annual Sampling and 2nd Application Cost	$43,908	$2,453,539	$2,497,448	0.923	$40,540	$2,265,354	$2,305,894
17	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.919	$40,339	$0	$40,339
18	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.914	$40,138	$0	$40,138
19	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.910	$39,938	$0	$39,938
20	Annual Cost - Annual Sampling and Periodic Costs	$43,908	$50,365	$94,273	0.905	$39,740	$45,583	$85,323
21	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.901	$39,542	$0	$39,542
22	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.896	$39,345	$0	$39,345
23	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.892	$39,149	$0	$39,149
24	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.887	$38,955	$0	$38,955
25	Annual Cost - Annual Sampling and Periodic Costs	$43,908	$50,365	$94,273	0.883	$38,761	$44,461	$83,222
26	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.878	$38,568	$0	$38,568
27	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.874	$38,376	$0	$38,376
28	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.870	$38,185	$0	$38,185
29	Annual Cost - Annual Sampling (MNA + Performance)	$43,908	$0	$43,908	0.865	$37,995	$0	$37,995
30	Annual Cost - Annual Sampling and Periodic Costs	$43,908	$50,365	$94,273	0.861	$37,806	$43,366	$81,172
	TOTAL ALTERNATIVE COSTS	$1,456,102	$2,755,729	$6,894,650		$1,358,335	$2,542,538	$6,583,691
	PV OF ALTERNATIVE (FY 2022 Dollars)							$6,583,691

Note:
Contractor Professional/Technical Services Percentages are from EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study"

Table C-4. Summary of Alternatives Cost Estimates

OU-4 Feasibility Study, Iowa Army Ammunition Plant, Iowa

Cost Type	Alternative 1 No Action	Alternative 2 MNA and LUCs	Alternative 3 Groundwater Extraction and Treatment with MNA and LUCs	Alternative 4 PRB with MNA and LUCs
Timeframe for Costing (Years)		30	30	30
Non-Discounted Costs				
Capital Costs	$0	$114,000	$1,694,000	$2,683,000
Sampling and O&M Costs	$0	$975,000	$4,144,000	$1,456,000
Periodic Costs	$0	$315,000	$389,000	$2,756,000
Total Costs	$0	$1,404,000	$6,227,000	$6,895,000
Discounted Costs (Discount Rate = 0.4 percent)				
Capital Costs	$0	$114,000	$1,694,000	$2,683,000
Sampling and O&M Costs	$0	$903,000	$3,840,000	$1,358,000
Periodic Costs	$0	$289,000	$357,000	$2,543,000
Total Present Value Costs	$0	$1,306,000	$5,891,000	$6,584,000
Cost Ranges (Discounted)				
-30 percent	$0	$914,000	$4,124,000	$4,609,000
+50 percent	$0	$1,959,000	$8,837,000	$9,876,000

Notes:

LUC - land use controls

O&M - operations and maintenance

Appendix D
Groundwater Modeling Assumptions Technical Memorandum

Jacobs

Subject	**Capture Zone Analysis in Support of a Feasibility Study for the Operable Unit 4 Inert Disposal Area**
Project Name	Iowa Army Ammunition Plant, Middletown Iowa
Date	May 19, 2022

1. Introduction

A screening-level analysis was performed to support a feasibility study (FS) for the Operable Unit 4 Inert Disposal Area at the Iowa Army Ammunition Plant (IAAAP). Contaminants in groundwater are migrating from the disposal area toward the downgradient ecological receptor (Long Creek). Contamination is found in the surficial aquifer, known as the overburden aquifer, underneath which is a thick clay confining unit. One alternative being evaluated as part of this FS is the construction of a groundwater extraction and treatment system, with which contaminated groundwater in the overburden aquifer would be hydraulically captured with extraction wells and treated before reaching Long Creek. The objectives of this technical memorandum are as follows:

- Provide a preliminary estimate of the extraction rate that would be required to capture groundwater across a 1,000-foot width downgradient from the Inert Disposal Area
- Estimate the number of wells that may be needed to achieve this extraction rate.

This technical memorandum describes the approach, results, and assumptions for this analysis.

2. Approach and Results

The overall approach for the current analysis was to use readily available site-specific data to calculate screening-level estimates of the extraction rate to capture the plume and the number of wells needed to achieve the estimated rate. To address the first objective, Darcy's Law was rearranged to calculate the underflow (Q) (i.e., combined volumetric extraction rate required) of an idealized volume of aquifer based on the transmissivity (T), hydraulic gradient (i), and desired capture width (w), as shown in Equation 1:

$$Q = T * i * w \tag{1}$$

Table 1 provides values for the parameters in Equation 1.

Table 1. Summary of Hydraulic Parameters

Parameter	Value	Source
Maximum horizontal hydraulic conductivity, K_h (feet per day)	4.3	Leidos and Jacobs (2022)
Maximum aquifer thickness, b (feet)	30	Leidos and Jacobs (2022)
Hydraulic gradient, i (feet per foot)	0.027	Jacobs (2022)
Transmissivity, T (square feet per day)	129	Calculated as $K_h \times b$
Capture width, w (feet)	1,000	Approximation
Flow rate, Q (cubic feet per day [ft^3/d] | gallons per minute)	3,483 | 18	Calculated

A target capture width of 1,000 feet is an adequate starting point based on the approximate width of the disposal area. Using the values in Table 1, the projected total groundwater extraction rate is approximately18 gpm without inclusion of any safety factor.

The second objective was to estimate the number of groundwater extraction wells that may be needed to achieve the total extraction rate of 18 gpm. To achieve this objective, drawdown calculations were performed using the MLU semianalytical model (Hemker and Post 2021). MLU calculates drawdown using an assigned set of aquifer parameters, but also can account for well losses inside each extraction well and interference drawdown from multiple extraction wells pumping simultaneously. The approach for achieving this objective was to use the same aquifer parameters listed in Table 1, combined with specific well design assumptions to project the number of wells that may be required to meet the 18 gpm extraction rate. Constraints and assumptions included in the MLU analysis are as follows:

- A target drawdown limit of 20 feet inside each extraction was assumed, thereby leaving approximately 10 feet of saturated thickness in the well bore.
- The overburden aquifer was represented by a single aquifer layer in MLU.
- Results are based on 30 days of continuous simultaneous pumping.
- Extraction well diameters equal nominal 4 inches.
- Extraction wells are spaced 200 feet apart along a single directional bearing.
- Well screen lengths equal 30 feet.
- Storativity equals to 0.01.
- A well skin factor of 8.6 was calculated based on an assumed well efficiency of 50 percent and the parameter values listed in Table 1 and values listed in the bullets above.

MLU results indicate that about six extraction wells may be required to achieve the desired extraction rate, given the assumptions above. Figure 1 shows the modeled drawdown curves at all six wells.

3. Evaluation Limitations

In addition to the assumptions listed above, the following limitations are provided, given how the MLU model was set up and used for this preliminary analysis:

- The modeled aquifer has a uniform (homogeneous) K_h and storativity.
- The model does not account for vertical flow.
- The modeled aquifer has a uniform nonpumping saturated thickness.
- The model does not account for areal groundwater recharge or surface water interactions.

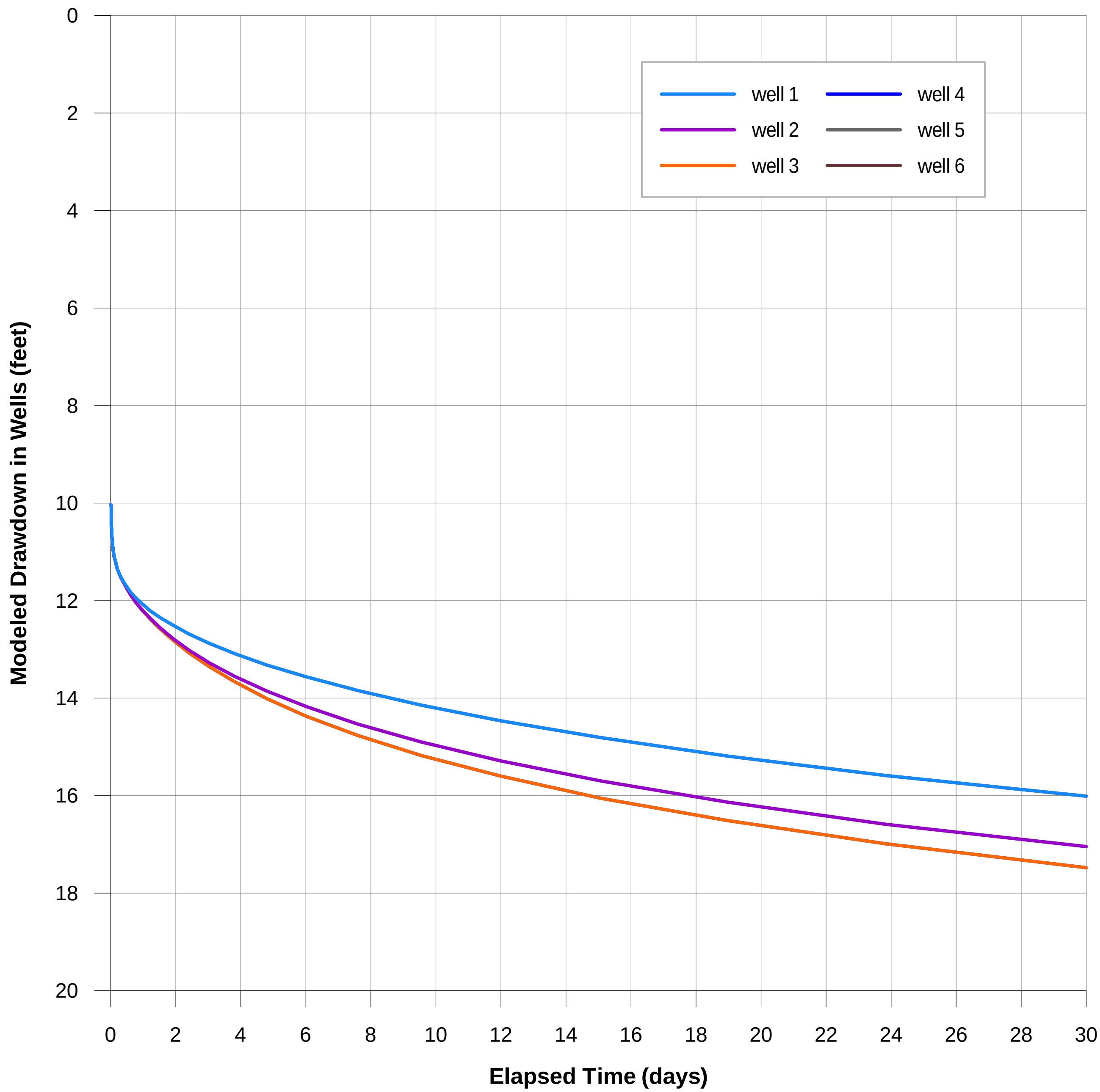
Given the simplifying assumptions and limitations of the current analysis, projections presented herein should be considered preliminary and should not be used for system design. Additional data collection and analyses should be performed prior to designing an extraction system at this site. If a groundwater extraction and treatment alternative is retained in the FS, then additional data collection should include construction and testing of wells at locations where the extraction system would be built to reduce uncertainty in aquifer conditions and well performance and support the design.

4. References

Hemker, C.J., and V.E.A. Post. 2021. MLU for Windows Version 2.25.78.

Jacobs. 2022. *2021 Annual Groundwater Monitoring Report, Ash Disposal Cell within Trench 5, Inert Disposal Area, Iowa Army Ammunition Plant, Middletown, Iowa*. Prepared for U.S. Army Corps of Engineers, Louisville District. February.

Leidos and Jacobs. 2022. *Remedial Investigation Report for Operable Unit 4 Inert Disposal Area, Iowa Army Ammunition Plant, Middletown, Iowa*. Prepared for U.S. Army Corps of Engineers, Louisville District. February.



Notes:

Modeled spacing between wells = 200 feet

Total modeled extraction rate approximately 18 gallons per minute

Figure 1
MLU Modeled Drawdown at Simulated Wells
Capture Zone Analysis
Iowa Army Ammunition Plant
Middletown, IA

Appendix E
Permeable Reactive Barrier Assumptions

REGENESIS

Remedial Cost Proposal

To: Jacobs Engineering 5/10/2022

From: Ryan Moore - Sr. Technical Manager / PFAS Program Manager
RMoore@regenesis.com (219) 286-4838
Owen Miller - Sr. Design Specialist
name@regenesis.com (630)-277-0855

Subject: ***Preliminary Design and Cost Estimate***

Site: *Operable Unit 4 Inert Disposal Area, Iowa Army Ammunition Plant*
Middletown, Iowa

Location: Dissolved Plume

Applicable Products	**Links to View/Download Product Information**
PlumeStop® Liquid Activated Carbon™	PlumeStop
Sulfidated MicroZVI™	S-MZVI

REGENESIS is pleased to present you with this design and cost estimate for the proposed treatment at your site utilizing the remediation technologies presented above. Included within this document you will find the following attachments supporting the proposed approach:

- Map Depicting Treatment Area
- Remedial Design and Cost Estimate
- Product Technical Sheets
- Suggested Performance Monitoring Parameters
- Standard Assumptions
- Terms and Conditions

Remedial Approach

This remedial design and cost estimate is to treat the dissolved phase contaminant impacts at the Iowa Army Ammunition Plant ("the site"). To treat these impacts, we are proposing the installation of the Permeable Reactive Barrier (PRB) to intercept and treat groundwater passing through. The proposed PRB utilizes In-Situ Sorption and In-Situ Chemical Reduction (ISCR) using PlumeStop® Liquid Activated Carbon™ (PlumeStop) and Sulfidated-MicroZVI (S-MZVI)® This combination will immediately remove the contaminants from the dissolved phase onto the surface of the carbon where S-MZVI will can degrade contaminants susceptible to ISCR degradation (e.g., TCE). The other contaminants of concern, such as PFAS, will be readily sorbed by PlumeStop. This approach assumes 10+ years of longevity with PlumeStop.

The costs presented assume the proposed remediation technologies will be applied by our Remediation Services Division (RRS). RRS will provide all personnel and equipment to complete the application including subcontracting of a direct push drilling rig and operator. Please refer to the attached standard RRS' assumptions for remedial applications.

Assumptions

In generating this design proposal REGENESIS relied upon professional judgment and site specific information provided by others. Using this information as input, we performed calculations based upon known chemical and geologic relationships to generate an estimate of the mass of product and subsurface placement required to affect remediation of the site. The attached design summary tables specify the assumptions used in preparation of this technical design. We request that these modeling input assumptions be verified by your firm.

REGENESIS developed this Scope of Work in reliance upon the data and professional judgments provided by those whom completed the earlier environmental site assessment(s). The fees and charges associated with the Scope of Work were generated through REGENESIS' proprietary formulas and thus may not conform to billing guidelines, constraints or other limits on fees. REGENESIS does not seek reimbursement directly from any government agency or any governmental reimbursement fund (the "Government"). In any circumstance where REGENESIS may serve as a supplier or subcontractor to an entity which seeks reimbursement from the Government for all or part of the services performed or products provided by REGENESIS, it is the sole responsibility of the entity seeking reimbursement to ensure the Scope of Work and associated charges are in compliance with and acceptable to the Government prior to submission. When serving as a supplier or subcontractor to an entity which seeks reimbursement from the Government, REGENESIS does not knowingly present or cause to be presented any claim for payment to the Government.

Closing

Please feel free to contact me if you need additional information or have any questions regarding our evaluation and/or this correspondence (contact info listed above). Thank you for considering REGENESIS as part or your remedial solution for this project.

REGENESIS

Project Info

Operable Unit 4 Inert Disposal Area, Iowa Army Ammunition Plant
Middletown, Iowa
Dissolved Plume

Prepared For:
Jacobs Engineering

Target Treatment Zone (TTZ) Info	Unit	Value
Barrier Length	ft	842
Top Treat Depth	ft	30.0
Bot Treat Depth	ft	40.0
Vertical Treatment Interval	ft	10.0
Treatment Zone Volume	ft^3	109,460
Treatment Zone Volume	cy	4,054
Soil Type	---	silty sand
Porosity	cm^3/cm^3	0.40
Effective Porosity	cm^3/cm^3	0.23
Treatment Zone Pore Volume	gals	327,527
Treatment Zone Effective Pore Volume	gals	188,328
Treatment Zone Pore Volume	liters	1,239,821
Treatment Zone Effective Pore Volume	liters	712,897
Fraction Organic Carbon (foc)	g/g	0.002
Soil Density	g/cm^3	1.7
Soil Density	lb/ft^3	104
Soil Weight	lbs	1.1E+07
Hydraulic Conductivity	ft/day	10.0
Hydraulic Conductivity	cm/sec	3.53E-03
Hydraulic Gradient	ft/ft	0.005
GW Velocity	ft/day	0.22
GW Velocity	ft/yr	79

Application Dosing	Unit	Value
PlumeStop to be Applied	**lbs**	**123,200**
S-MZVI to be Applied	**lbs**	**10,300**

PlumeStop® Application Design Summary

Dissolved Plume

PlumeStop + S-MZVI	
Treatment Type	**Barrier**
Distance Perpendicular to Flow (ft)	842
Spacing Within Rows (ft)	**Injection points to be determined from injection testing/pilot test prior to implementation**
Number of Rows	
DPT Injection Points	
Top Application Depth (ft bgs)	30
Bottom Application Depth (ft bgs)	40
PlumeStop to be Applied (lbs)	**123,200**
PlumeStop to be Applied (gals)	13,674
In Situ Chemical Reduction - S-MZVI	
S-MZVI to be added to PlumeStop (lbs)	**10,300**
S-MZVI to be added to PlumeStop (gals)	682
PlumeStop + S-MZVI Volume Totals	
Mixing Water (gal)	120,539
Total Application Volume (gals)	**134,984**

Technical Notes

Assumptions/Qualifications

In generating this preliminary estimate, Regenesis relied upon professional judgment and site specific information provided by others. Using this information as input, we performed calculations based upon known chemical and geologic relationships to generate an estimate of the mass of product and subsurface placement required to affect remediation of the site.

REGENESIS developed this Scope of Work in reliance upon the data and professional judgments provided by those whom completed the earlier environmental site assessment(s). The fees and charges associated with the Scope of Work were generated through REGENESIS' proprietary formulas and thus may not conform to billing guidelines, constraints or other limits on fees. REGENESIS does not seek reimbursement directly from any government agency or any governmental reimbursement fund (the "Government"). In any circumstance where REGENESIS may serve as a supplier or subcontractor to an entity which seeks reimbursement from the Government for all or part of the services performed or products provided by REGENESIS, it is the sole responsibility of the entity seeking reimbursement to ensure the Scope of Work and associated charges are in compliance with and acceptable to the Government prior to submission. When serving as a supplier or subcontractor to an entity which seeks reimbursement from the Government, REGENESIS does not knowingly present or cause to be presented any claim for payment to the Government.

Prepared by: Owen Miller - Sr. Design Specialist
Date: 5/10/2022

REGENESIS

Purchasing Information		
Operable Unit 4 Inert Disposal Area, Iowa Army Ammunition Plant	--	Dissolved Plume
PlumeStop Required	lbs	123,200
S-MZVI to be Applied	lbs	10,300
Total Estimated Project Cost Range**	Min	$1,556,000
	Max	$1,681,000
Estimated RRS Days to Apply	--	45

*Note that the combined tax and freight costs are preliminary estimates only. Please contact your local sales manager or Customer Service at 949-366-8000 to obtain a shipping quote. You will be asked to provide a ship-to address and estimated time of delivery.

Currently Available Packaging Options
Package Type***
PlumeStop-2,000 lb reinf. plastic totes
PlumeStop-400 lb poly drums
S-MZVI-50 lb HDPE Pails
S-MZVI-500 lb poly drums
S-MZVI-2,000 lb reinforced plastic totes

**Total Project cost is only an estimate; actual project cost may change as the final scope and/or RRS proposal are developed.

***Available Package Types are subject to change.

PlumeStop® Liquid Activated Carbon™ Technical Description

PlumeStop Liquid Activated Carbon is an innovative groundwater remediation technology designed to rapidly remove and permanently degrade groundwater contaminants. PlumeStop is composed of very fine particles of activated carbon (1-2µm) suspended in water through the use of unique organic polymer dispersion chemistry. Once in the subsurface, the material behaves as a colloidal biomatrix, binding to the aquifer matrix, rapidly removing contaminants from groundwater, and expediting permanent contaminant biodegradation.

This unique remediation technology accomplishes treatment with the use of highly dispersible, fast-acting, sorption-based technology, capturing and concentrating dissolved-phase contaminants within its matrix-like structure. Once contaminants are sorbed onto the regenerative matrix, biodegradation processes achieve complete remediation at an accelerated rate.

Distribution of PlumeStop in water

To see a list of treatable contaminants with the use of PlumeStop, view the Range of Treatable Contaminants Guide.

Chemical Composition

- Water - CAS# 7732-18-5
- Colloidal Activated Carbon ≤2.5 - CAS# µm 7440-44-0
- Proprietary Additives

Properties

- Physical state: Liquid
- Form: Aqueous suspension
- Color: Black
- Odor: Odorless
- pH: 8 - 10

Storage and Handling Guidelines

Storage
Store in original tightly closed container
Store away from incompatible materials
Protect from freezing

Handling
Avoid contact with skin and eyes
Avoid prolonged exposure
Observe good industrial hygiene practices
Wash thoroughly after handling
Wear appropriate personal protective equipment

PLUME STOP
Liquid Activated Carbon

PlumeStop® Liquid Activated Carbon™ Technical Description

Applications

PlumeStop is easily applied into the subsurface through gravity-feed or low-pressure injection.

Health and Safety

Wash hands after handling. Dispose of waste and residues in accordance with local authority requirements. Please review the Material Safety Data Sheet for additional storage, usage, and handling requirements here: PlumeStop SDS.

REGENESIS

www.regenesis.com
1011 Calle Sombra, San Clemente CA 92673
949.366.8000

S-MicroZVI Specification Sheet

S-MicroZVI Technical Description

S-MicroZVI™ is an *In Situ* Chemical Reduction (ISCR) reagent that promotes the destruction of many organic pollutants and is most commonly used with chlorinated hydrocarbons. It is engineered to provide an optimal source of micro-scale zero valent iron (ZVI) that is both easy to use and delivers enhanced reactivity with the target contaminants via multiple pathways. S-MicroZVI can destroy many chlorinated contaminants through a direct chemical reaction (**see Figure 1**). S-MicroZVI will also stimulate anaerobic biological degradation by rapidly creating a reducing environment that is favorable for reductive dechlorination.

Sulfidated ZVI

S-MicroZVI is composed of colloidal, sulfidated zero-valent iron particles suspended in glycerol using proprietary environmentally acceptable dispersants. The passivation technique of sulfidation, completed using proprietary processing methods, provides unparalleled reactivity with chlorinated hydrocarbons like PCE and TCE and increases its stability and longevity by minimizing undesirable side reactions.

S-MicroZVI is Best in Class For

- ☑ Longevity
- ☑ Reactivity
- ☑ Transport

In addition to superior reactivity, S-MicroZVI is designed for easy handling that is unmatched by any ZVI product on the market. Shipped as a liquid suspension, S-MicroZVI requires no powder feeders, no thickening with guar, and pneumatic or hydraulic fracturing is not mandatory. When diluted with water prior to application, the resulting suspension is easy to inject using either direct push or permanent injection wells.

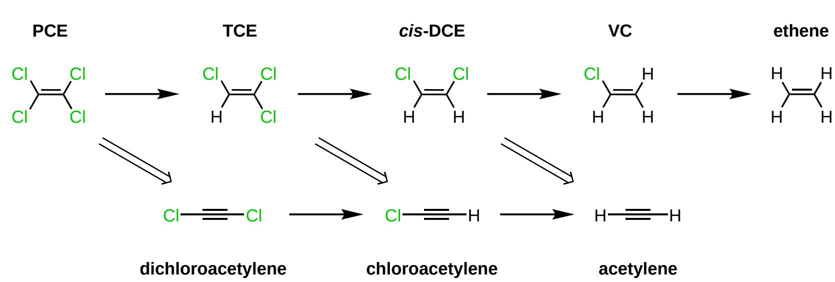


Figure 1: *Chlorinated ethene degradation pathways and products. The top pathway with single line arrows represent the reductive dechlorination (hydrogenolysis) pathway. The lower pathway with downward facing double line arrows represent the beta-elimination pathway.*

To see a list of treatable contaminants, view the S-MicroZVI treatable contaminants guide.

S-MicroZVI Specification Sheet

Chemical Composition

Iron, powders CAS 7439-89-6
Iron (II) sulfide CAS 1317-37-9
Glycerol CAS 56-81-8

Properties

Physical State: Liquid
Form: Viscous metallic suspension
Color: Dark gray
Odor: Slight
pH: Typically 7-9 as applied
Density: 15 lb/gal

Storage and Handling Guidelines

Storage:

- Use within four weeks of delivery
- Store in original containers
- Store at temperatures below 95F°
- Store away from incompatible materials

Handling:

- Never mix with oxidants or acids
- Wear appropriate personal protective equipment
- Do not taste or swallow
- Observe good industrial hygiene practices

Applications

S-MicroZVI is diluted with water on site and easily applied into the subsurface through low-pressure injections. S-MicroZVI can also be mixed with products like 3-D Microemulsion® or PlumeStop® prior to injection.

Health and Safety

The material is relatively safe to handle; however, avoid contact with eyes, skin and clothing. OSHA Level D personal protection equipment including: vinyl or rubber gloves and eye protection are recommended when handling this product. Please review the Safety Data Sheet for additional storage, and handling requirements here: S-MicroZVI SDS.

REGENESIS®

www.regenesis.com

Corporate Headquarters
1011 Calle Sombra, San Clemente CA 92673 USA
Tel: +1 949.366.8000

European Offices (UK, Ireland, Belgium and Italy)
Email: europe@regenesis.com
Tel: +44 (0)1225 61 81 61

REGENESIS

In-Situ Anaerobic Bioremediation Performance Monitoring Parameters

Analytical Parameter	Method
Contaminants of Concern (COC's)	Varies
pH	Meter reading taken in flow-through cell (DO can also be measured with a Hach kit)
Dissolved Oxygen (DO)	
Oxidation Reduction Potential (ORP)	
Total Fe	Colorimetric Hach Method or EPA 6000 series with filtered and unfiltered samples
Total Mn	
Dissolved Fe	
Dissolved Mn	
Sulfate	EPA 375.3 or EPA 9056
Sulfide	EPA 376.1
Nitrate	EPA 353.1 or EPA 9056
Total Organic Carbon (TOC)	EPA 415.1 or EPA 9060
Alkalinity	EPA 310.2
Chloride	EPA 300
Methane, Ethane, Ethene, CO2	ASTM D1945