FINAL

United States Army Corps of Engineers
New England District

Phase II Remedial Investigation Work Plan and Quality Assurance Project Plan Addendum for Per- and Polyfluoroalkyl Substances

Area 1

Former Fort Devens Army Installation

Devens, Massachusetts

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Phase II Remedial Investigation Work Plan and Quality Assurance Project Plan Addendum for Per- and Polyfluoroalkyl Substances

Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

September 2023

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CERTIFICATION
I hereby certify that the enclosed Report, shown and marked in this submittal, is that proposed to be incorporated with Contract Number W912WJ-19-D-0014. This document was prepared in accordance with the U.S. Army Corps of Engineers (USACE) Scope of Work and is hereby submitted for Government approval.

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Acronyms and Abbreviations

°C	degree Celsius
>	greater than
'	foot
µg/kg	microgram per kilogram
AFFF	aqueous film-forming foam
AOC	area of contamination
Army	U.S. Army
BERS-Weston	BERS-Weston Services JVA, LLC
bgs	below ground surface
BR	bedrock
BRA	baseline risk assessment
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMR	Code of Massachusetts Regulations
COPC	constituent of potential concern
CSF	cancer slope factor
CSM	conceptual site model
CTE	central tendency exposure
Devens	former Fort Devens Army Installation
DoD	U.S. Department of Defense
DQO	data quality objective
DRFTA	Devens Reserve Forces Training Area
ELCR	excess lifetime cancer risk
EPC	exposure point concentration
ERA	ecological risk assessment
ESV	ecological screening value
FS	feasibility study
ft/day	foot per day
gpd	gallon per day
gpm	gallon per minute
GUVD	Groundwater Use and Value Determination
GZA	GZA GeoEnvironmental, Inc.
HHRA	human health risk assessment
HI	hazard index
HLA	Harding Lawson Associates
HQ	hazard quotient
ID	identification
INRMP	Integrated Natural Resources Management Plan
ITRC	Interstate Technology and Regulatory Council
J	estimated result
JV	joint venture

KGS	KOMAN Government Solutions, LLC
KOC	organic carbon-water coefficient
LHA	lifetime health advisory
LLC	Limited Liability Company
LOD	limit of detection
LTM	long-term monitoring
MAAF	Moore Army Airfield
MAARNG	Massachusetts Army National Guard
MassDEP	Massachusetts Department of Environmental Protection
MassDevelopment	Massachusetts Development and Finance Agency
max	maximum
MCP	Massachusetts Contingency Plan
mg/kg	milligram per kilogram
mg/L	milligram per liter
MMCL	Massachusetts maximum contaminant level
MW	monitoring well
NA	not applicable/not available
NAVD88	North American Vertical Datum of 1988
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ng/L	nanogram per liter
NPL	National Priorities List
NRWA	Nashua River Watershed Association
NWR	National Wildlife Refuge
OB	overburden
ORSG	Office of Research and Standards Guideline
OSD	Office of the Secretary of Defense
PA	preliminary assessment
PFAA	perfluoroalkyl acid
PFAS	per- and polyfluoroalkyl substances
PFAS6	perfluorooctanesulfonic acid, perfluorooctanoic acid, perfluoronanoic acid, perfluorohexanesulfonic acid, perfluoroheptanoic acid, and perfluorodecanoic acid
PFBA	perfluorobutanoic acid
PFBS	perfluorobutanesulfonic acid
PFDA	perfluorodecanoic acid
PFHpA	perfluoroheptanoic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonate or perfluorooctanesulfonic acid
PFPeA	perfluoropentanoic acid
ppt	part per trillion

ProUCL	ProUCL® version 5.2
PSCS	preliminary site characterization summary
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
RAO	remedial action objective
RC	reportable concentration
RfD	reference dose
RI	remedial investigation
RI WP	Remedial Investigation Work Plan
RME	reasonable maximum exposure
RQ	reportable quantity
RSL	regional screening level
SA	study area
SG	staff gage
SI	site inspection
SLERA	Screening Level Ecological Risk Assessment
SMDP	scientific/management decision point
SSSL	site-specific screening level
T&E	threatened and endangered
TBD	to be determined
TGI	technical guidance instruction
TOC	total organic carbon
TOP	total oxidizable precursor
UCL	upper confidence limit
U.S.	United States
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
UU/UE	unrestricted use/unlimited exposure
VP	vertical aquifer profile
WWTP	wastewater treatment plant

Executive Summary

This Phase II Remedial Investigation Work Plan (RI WP) for Per- and Polyfluoroalkyl Substances (PFAS) has been prepared on behalf of the United States (U.S.) Army Corps of Engineers (USACE) to further investigate PFAS impacts in Area 1 at the former Fort Devens Army Installation (Devens) located in Devens, Massachusetts. Activities completed under this RI WP are subject to and will be consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by Superfund Amendments and Reauthorization Act of 1986 (42 United States Code § 9601 et seq.), and the National Oil and Hazardous Substances Pollution Contingency Plan, with regulatory coordination of the Massachusetts Department of Environmental Protection and the United States Environmental Protection Agency (USEPA). This RI WP was prepared consistent with USEPA Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA 1988). All work will be conducted in accordance with procedures developed in the Uniform Federal Policy for Quality Assurance Project Plan for the Remedial Investigation of Per- and Polyfluoroalkyl Substances (PFAS QAPP), included as Appendix A of the Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances, Former Fort Devens Army Installation; KOMAN Government Services [KGS] 2020c), and the Uniform Federal Policy for Quality Assurance Project Plan, Addendum for Area 1 – Phase II, Remedial Investigation for Per- and Polyfluoroalkyl Substances (PFAS), Former Fort Devens Army Installation, Devens, Massachusetts (PFAS QAPP Addendum; provided as Appendix A).

Background

In 2016, a base-wide preliminary assessment (PA) of PFAS at Devens identified study areas (SAs) and areas of contamination (AOCs) where there was a potential for the use, storage, or disposal of aqueous film-forming foam (AFFF). The constituents of AFFF are collectively referred to as PFAS. The USEPA has identified PFAS as an emerging contaminant of concern. Subsequent investigations at Devens in 2017 confirmed the presence of PFAS in groundwater, soil, surface water, and sediment at several SAs and AOCs (BERS-Weston 2018). Sampling of existing long-term monitoring wells at select AOCs confirmed the presence of PFAS at some AOCs not identified in the Devens PFAS PA (KGS 2018a). In addition, PFAS were detected in public water supply wells associated with the Town of Ayer Grove Pond municipal wellfield, which is located adjacent to Devens, as well as the MacPherson, Patton, and Shabokin public water supply wells located within Devens. PFAS treatment has since been installed on these systems.

To expedite further field investigations in support of a remedial investigation, the identified AOCs; the Grove Pond wellfield; and the MacPherson, Patton, and Shabokin water supply well areas were grouped into three areas (Areas 1, 2, and 3). The three areas were designated for sequencing of field activities and did not reflect prioritization.

Between 2018 and 2020, the Army conducted RI field investigations at Devens in accordance with the Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS) (KGS 2018b [Draft] and 2020b [Final]) which included the PFAS QAPP. The RI field investigations were conducted at locations previously identified as impacted by PFAS and at uncharacterized AOCs to evaluate if PFAS was present and to support the CERCLA decision-making process related to PFAS impacts at Devens. Activities included sampling new and existing monitoring wells, collecting surface water and sediment samples, groundwater vertical aquifer profiling (VP) using direct-push technology, soil borings using direct-push technology, groundwater VP and soil borings using rotosonic drilling, installation of piezometers and monitoring wells, sampling of monitoring wells, and synoptic water level measurements. Planned field activities by site were detailed in Field Sampling Plans for Area 1, Area 2, and Area 3, prepared as addenda to the PFAS RI WP (KGS 2018b; 2020b).

The results of the investigations (considered to be Phase I activities) were presented in area-specific Preliminary Site Characterization Summary (PSCS) Reports. Results for Phase I Area 1 sites (AOCs 57, 74, and 75; and

Grove Pond wellfield) and some sites designated as part of Area 2 (AOCs 43G, and 43J; Shabokin well field; and Patton wellfield/AOC 40) were presented in the Area 1 Preliminary Site Characterization Summary Per- and Polyfluoroalkyl Substances (PFAS) Remedial Investigation (Area 1 PSCS; KGS 2020a) and Area 1 PSCS Addendum No. 1 (KGS 2020b). Phase I of the Devens PFAS RI included the drilling and sampling of 123 temporary VP sampling points, installation and sampling of 142 new and existing monitoring wells, and collection of 25 surface water/sediment samples to evaluate the presence and distribution of PFAS.

Data from the Phase I Area 1 PSCS are presented in Appendix B.

Objectives

The Phase I PFAS investigations focused on individual AOCs or documented release areas (BERS-Weston 2018 and KGS 2020a). The Phase I data indicated that PFAS in the Devens groundwater is widespread laterally and there are likely co-mingled PFAS plumes, rather than separate AOC-specific plumes. The PFAS contaminated groundwater discharges to surface water bodies (i.e., Cold Spring Brook, Grove Pond, Mirror Lake) and drinking water receptors (i.e., Grove Pond Wellfield, Patton supply well, Shabokin supply well). The soil data collected during the Phase I investigations confirmed that low levels of PFAS exceeding the site-specific screening levels (SSSLs) are present at AOCs sampled (AOC 43G, AOC 57, and the Grove Pond Area), but at low concentrations (at a maximum of 29 micrograms per kilogram [µg/kg] PFOS and 22 µg/kg PFOA). One reason for this may be due to prior environmental restoration activities performed at the same AOCs to remove soils containing other contaminants, which may have resulted in removal of some of the PFAS-containing soils, and because large area of Devens have been redeveloped.

This Phase II PFAS RI WP addresses only the following areas designated as Area 1, as demarcated based on groundwater flow boundaries. Additional Phase II work plans will be prepared for other areas (Area 2 and Area 3) under separate covers. Area 1 for Phase II includes the following:

- Historical Gas Station G (AOC 43G)
- Historical Gas Station J (AOC 43J)
- Former Vehicle Storage and Motor Repair Shops Site (AOC 57)
- Barnum Road Firefighting Exercise Site (AOC 74),
- Former Building T-1445 Warehouse Fire (AOC 75)
- Areas along Barnum Road and Queenstown Road
- Town of Ayer Grove Pond Wellfield
- Devens water supply wells
    - Patton (incorporating AOC 40 Cold Spring Brook Landfill)
    - Shabokin (incorporating AOC 43J Historical Gas Station J).

The goal of Phase I of the Devens PFAS RI (AOCs 43J, 57, 74, and 75; Grove Pond wellfield; Shabokin well field; and Patton wellfield/AOC 40) was to evaluate the presence and distribution of PFAS at Devens.

The goal of the Phase II PFAS RI is to identify exposure pathways and assess risk to human and ecological receptors associated with the presence of PFAS.

To support this goal, the objectives of the Area 1 PFAS RI field activities are to define the following:

- Representative exposure point concentrations (EPCs) for PFAS in groundwater, soil, sediment, and surface water: Establish EPCs for PFAS in groundwater at the locations of the highest (i.e., “worst-case”) potential exposures, and EPCs for soil, sediment, and surface water representative of average exposure conditions in accordance with USEPA risk assessment guidance.

- Pathway – Advance the conceptual site model by sampling soils and groundwater to refine the understanding of suspected PFAS release areas and to evaluate locations of discharge of, and/or human or ecological exposure to, PFAS in Area 1.
- Human and ecological impacts – Evaluate the risk to human and ecological receptors associated with PFAS at Devens by conducting human health and ecological risk assessments in accordance with CERCLA guidance.

This Area 1 PFAS RI WP contains the details regarding the proposed sampling program for Area 1 including the sampling design and rationale, and the sampling locations and procedures. It also includes a summary of previous investigations; the project data quality objectives; an updated conceptual site model; an analysis of data gaps; a description of the proposed activities and deliverables; and a project schedule. Documents summarizing previous investigation activities and sampling results are publicly available at https://www.nae.usace.army.mil/missions/projects-topics/former-fort-devens-environmental-cleanup/, as well as at the Town of Ayer library. The QAPP Addendum (provided as Appendix A to the RI WP) describes sampling and analysis procedures for implementation of the RI along with quality assurance/quality control criteria. The QAPP Addendum will facilitate the generation of data with acceptable precision, accuracy, representativeness, comparability, and completeness.

References

BERS-Weston. 2018. Final Site Inspection Report for Per-and Polyfluoroalkyl Substances (PFAS) at Former Fort Devens Army Installation, Devens, MA. May.

Grippo, M., Hayse, J., Hlohowskyj, I., and Picel, K. 2021. Derivation of PFAS Ecological Screening Values. Argonne National Laboratory. September.

KGS. 2018a. Final 2016 Annual Report Long-Term Monitoring, Former Fort Devens Army Installation BRAC Legacy Sites, Devens, Massachusetts. February.

KGS. 2018b. Draft Remedial Investigation Work Plan for Per and Polyfluoroalkyl Substances (PFAS). Former Fort Devens Army Installation, Devens, Massachusetts. June.

KGS. 2020a. Area 1 Preliminary Site Characterization Summary Per- and Polyfluoroalkyl Substances (PFAS) Remedial Investigation, Former Fort Devens Army Installation, Devens, MA. June.

KGS. 2020b. Final Uniform Federal Policy for Quality Assurance Project Plan for the Remedial Investigation of Per- and Polyfluoroalkyl Substances, Former Fort Devens Army Installation. December.

USEPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. Interim Final. EPA/540/G-89/004. October.

1 Introduction

The SERES-Arcadis Joint Venture, LLC (JV)[1], (hereafter referred to as the SERES-Arcadis JV) has prepared this Phase II Remedial Investigation Work Plan (RI WP) for Per- and Polyfluoroalkyl Substances (PFAS) on behalf of the United States (U.S.) Army Corps of Engineers (USACE) to conduct a Comprehensive Environmental Response, Compensation, and Liability Act- (CERCLA-) compliant remedial investigation (RI) for Area 1 at the former Fort Devens Army Installation (Devens) located in Devens, Massachusetts (Figure 1-1).

The U.S. Army Base Realignment and Closure Office (BRAC) is responsible for addressing potential contamination at former active Army installations that is the direct result of historic Army activities. Site identification, investigations, and any potential environmental remedies are in compliance with the CERCLA (42 United States Code [U.S.C.] §§9601 et. seq.), the Defense Environmental Restoration Program (10 U.S.C. §2701 et. seq.), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP, 40 Code of Federal Regulation [CFR] Part 300).

This RI WP was prepared consistent with the United States Environmental Protection Agency (USEPA) Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA 1988). The work described in this PFAS RI WP will be conducted in accordance with procedures developed in the Uniform Federal Policy for Quality Assurance Project Plan (UFP-QAPP) for the Remedial Investigation of Per- and Polyfluoroalkyl Substances (PFAS), included as Appendix A of the Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances, Former Fort Devens Army Installation (QAPP; KOMAN Government Solutions, LLC [KGS] 2020c), and the Addendum for Area 1 – Phase II to the UFP-QAPP, Remedial Investigation for Per- and Polyfluoroalkyl Substances (PFAS) (QAPP Addendum), which is provided as Appendix A.

This PFAS RI WP details the proposed additional investigation of areas at Devens where constituents of aqueous film-forming foam (AFFF), collectively referred to as PFAS, were detected in groundwater during previous investigations. Results from the most recent investigation are presented in the Area 1 Preliminary Site Characterization Summary Per- and Polyfluoroalkyl Substances (PFAS) Remedial Investigation (Area 1 PSCS; KGS 2020a). Data from the Area 1 PSCS are presented in Appendix B.

AFFF was developed in the mid-1960s in response to a need for firefighting foams better suited to extinguish Class B fuel-based fires. AFFF formulations consist of water, an organic solvent, up to 5 percent (%) hydrocarbon surfactants, and 1 to 3% PFAS (Interstate Technology Regulatory Council [ITRC] 2020a). The AFFF concentrate is designed to be diluted with water to become a 1, 3, or 6% foam. AFFF releases at U.S. Department of Defense (DoD) facilities may have occurred during firefighter training, emergency response actions, equipment testing, or accidental releases. Perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and other PFAS compounds are recognized by the USEPA as chemicals of emerging concern. As discussed in greater detail in Section 1.1.3, in 2016, the USEPA established lifetime health advisory (LHA) screening levels for PFOS and PFOA in tapwater (i.e., drinking water) (USEPA 2016); in 2022, the USEPA issued revised interim draft LHAs for PFOS and PFOA and new LHAs for perfluorobutanesulfonic acid (PFBS) and hexafluoropropylene oxide dimer acid (HFPO-DA). In 2020, the State of Massachusetts established soil and groundwater standards for PFOS, PFOA, perfluorohexanesulfonic acid (PFHxS), perfluoronanoic acid (PFNA), perfluoroheptanoic acid (PFHpA), and perfluorodecanoic acid (PFDA), collectively known as PFAS6 (MassDEP 2020). In May 2022, the USEPA published regional screening levels (RSLs) for PFOS, PFOA, PFNA, PFHxS, and HFPO-DA (USEPA 2022a). The RSLs were updated in May 2023 to include perfluorohexanoic acid (PFHxA) and perfluorobutanoic acid (PFBA) (USEPA 2023a).

During previous investigations (discussed in more detail in Section 1.1.2), PFAS were detected in groundwater, soil, sediment, and surface water at several study areas (SAs) and areas of contamination (AOCs) at Devens. In

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[1] The SERES-Arcadis JV is composed of protégé firm SERES Engineering & Services, LLC and its mentor, Arcadis U.S., Inc.

addition, PFAS were detected in public water supply wells associated with the Town of Ayer Grove Pond municipal wellfield, located adjacent to Fort Devens.

To expedite further field investigations for the RI, the identified AOCs; the Grove Pond wellfield; and MacPherson, Patton, and Shabokin water supply well areas were grouped into three areas (Areas 1, 2, and 3). The three areas were designated for sequencing of field activities and do not reflect prioritization. After completion of initial field activities to support completion of the RI (considered to be Phase I activities), results were presented in area-specific Preliminary Site Characterization Summary (PSCS) reports. Results for Phase I Area 1 sites (AOCs 57, 74, and 75; and Grove Pond wellfield) and some sites designated as part of Area 2 (AOCs 43G, and 43J; Shabokin well field; and Patton wellfield/AOC 40) were presented in the Area 1 Preliminary Site Characterization Summary Per- and Polyfluoroalkyl Substances (PFAS) Remedial Investigation (Area 1 PSCS; KGS 2020a) and Area 1 PSCS Addendum No. 1 (KGS 2020b). The three areas were regrouped for further (Phase II) field investigations.

This Phase II PFAS RI WP addresses only Phase II Area 1, as demarcated based on groundwater flow boundaries. Additional work plans will be prepared for other areas (Area 2 and Area 3) under separate covers. Area 1 includes the following:

- Historical Gas Station G (AOC 43G)
- Historical Gas Station J (AOC 43J)
- Former Vehicle Storage and Motor Repair Shops Site (AOC 57)
- Barnum Road Firefighting Exercise Site (AOC 74),
- Former Building T-1445 Warehouse Fire (AOC 75)
- Areas along Barnum Road and Queenstown Road
- Town of Ayer Grove Pond Wellfield
- Devens water supply wells
    - Patton (incorporating AOC 40 Cold Spring Brook Landfill)
    - Shabokin (incorporating AOC 43J Historical Gas Station J).

1.1 Site Background

1.1.1 Site Location and Historical Information

Devens is located in the Towns of Ayer and Shirley in Middlesex County, and the Towns of Harvard and Lancaster in Worcester County, Massachusetts, approximately 35 miles northwest of Boston, Massachusetts (Figure 1-1). The former installation occupied approximately 9,260 acres and was divided into the North Post, Main Post, and South Post. Route 2 divides the South Post from the Main Post. The Nashua River runs through the North, Main, and South Posts. The area surrounding the former installation primarily consists of rural residential properties. Portions of Devens have been redeveloped for commercial/industrial use. Several of the surrounding areas and portions of Devens are undeveloped, and consist of hardwood vegetated uplands, riparian corridors, old fields, wet meadows, emergent and forested wetlands, and open waters.

Camp Devens was established in 1917 as a temporary training area for soldiers during World War I. In 1932, the site was named Fort Devens and made a permanent installation with the primary mission of commanding, training, and providing logistical support for non-divisional troop units. Fort Devens was used for a variety of training missions between 1917 and 1990. Pursuant to the CERCLA, Fort Devens was placed on the National Priorities List on November 21, 1989 due to environmental contamination at several portions of the installation.

Fort Devens was identified for cessation of operations and closure under Public Law 101-510, the Defense BRAC Act of 1990, and was officially closed in March 1996. The Reuse Plan for Devens (Vanasse Hangen Brustlin, Inc. [VHB] 1994) identifies major reuse themes for Devens. The current and foreseeable future land use for the AOCs within Area 1 is primarily commercial/industrial use and open space recreation (VHB 1994). Land use is discussed in more detail in Section 3.4.1.

As part of the Devens BRAC Program, the U.S. Army (Army) retained portions of the property formerly occupied by Fort Devens for reserve forces training and renamed the area the Devens Reserve Forces Training Area (DRFTA). Areas not retained as part of the DRFTA were transferred to new owners (the Massachusetts Development and Finance Agency [MassDevelopment], U.S. Department of Labor, U.S. Department of Justice, and the U.S. Fish & Wildlife Service [USFWS]) for reuse and redevelopment. In 2009, the DRFTA was renamed the U.S. Army Garrison Fort Devens.

1.1.2 Previous Investigations

Multiple investigations related to PFAS have been conducted at Devens since 2016, as described below. A summary of the Army's past environmental investigations conducted at the Area 1 sites, including previous PFAS investigations, is provided in Appendix C. Exhibit 1-1 below indicates which sites were included in the previous PFAS investigations and the sites proposed for the Area 1 investigation. In addition, documents summarizing previous investigation activities and sampling results are publicly available at https://www.nae.usace.army.mil/missions/projects-topics/former-fort-devens-environmental-cleanup/, as well as at the Town of Ayer library.

- 2016 – Investigations related to PFAS at Devens began in 2016 with a base-wide preliminary assessment (PA) (KGS 2017) to determine if there were potential historical releases of PFAS associated with the former installation. The potential PFAS sources at Devens were evaluated using all available documents, interviews with current and former Devens workers, available sampling data, and findings from environmental database searches. The installation-wide assessment determined that potential sources of PFAS were limited to areas of the former North Post, South Post, and Main Post where AFFF may have been used, stored, or disposed, and that these areas warranted further investigation (KGS 2017).

- 2017 – The Army conducted a site inspection (SI) in 2017 to determine the presence or absence of PFAS in soil, groundwater, and/or sediment and surface water at selected sites at Devens that were identified in the PA as sites where AFFF-containing PFAS may have been used, stored, or released and further investigation was warranted (BERS-Weston Services, JVA, LLC [BERS-Weston] 2018a). The results of the SI confirmed the presence of PFAS at each of the AOCs and SAs included in the SI (AOCs 5, 32, and 50 and SAs 20, 21, 30, 31, 74, and 75). Based on the SI findings, an RI was recommended for each of the AOCs and SAs included in the SI to further delineate the nature and extent of PFAS contamination. In addition, based on the analytical results of groundwater samples collected near the Grove Pond wellfield, the SI also recommended that the RI should determine/evaluate the source and extent of PFAS impacting the Grove Pond wellfield and the MacPherson water supply well. SAs 20, 21, 30, 31, 74, and 75 were subsequently reclassified as AOCs (BERS-Weston 2018a). A subsequent SI found PFAS in both groundwater and soil samples collected from SA 76 - Devens Fire Station, and BERS-Weston recommended in its SI Report for this area that SA 76 be reclassified as an AOC and included in the previously recommended RI (BERS-Weston 2018b).

- 2017-2018 – Sampling of existing long-term monitoring (LTM) wells at select AOCs confirmed the presence of PFAS at some AOCs that were not identified in the PA (KGS 2018a). Samples were collected from 29 existing groundwater monitoring wells and one surface water location in AOCs 5, 32/43A, 43G, 43J, 50, and 57.

- 2018-2020 – RI field investigations (considered to be Phase I) were conducted at Devens at locations previously identified as impacted by PFAS to support the CERCLA decision-making process related to PFAS impacts at Devens. Field activities were conducted in accordance with the Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS) (PFAS RI WP which included the PFAS

QAPP; KGS 2018b[Draft] and 2020c[Final]). Activities included sampling new and existing groundwater monitoring wells, collecting surface water and sediment samples, groundwater vertical aquifer profiling (VP) using direct-push technology, soil borings using direct-push technology, groundwater VP and soil borings using rotosonic drilling, installation of piezometers and monitoring wells, sampling of monitoring wells, and synoptic water level measurements. Planned field activities by site were detailed in Field Sampling Plans for Area 1, Area 2, and Area 3, prepared as addenda to the PFAS RI WP (KGS 2018b, 2020c). The results of the investigations were presented in area-specific PSCS Reports. Results for Area 1 sites and some sites designated as part of Area 2 were reported in the Area 1 PSCS (KGS 2020a) and the Area 2 Preliminary Site Characterization Summary Per- and Polyfluoroalkyl Substances (PFAS) Remedial Investigation (Area 2 PSCS; KGS 2020b). Data from the Area 1 PSCS are presented in Appendix B.

- 2019-2020 - The Army conducted a time critical removal action (USACE 2019) for the Town of Ayer Grove Pond public water supply wells to prevent unacceptable risk to human health posed by PFOS/PFOA migrating or likely migrating from Devens toward public drinking water supply wells. The time-critical removal action was completed in June 2019 and involved installation of a temporary granular-activated carbon treatment filter to remove PFOS/PFOA from groundwater pumped by the public supply wells. In November 2020, an Army-funded permanent anion exchange filtration system came online at the Grove Pond water treatment plant, replacing the temporary carbon filtration system. Between August 2019 and March 2020, granular-activated carbon treatment filters were installed at the MacPherson, Patton, and Shabokin water supply wells by MassDevelopment. In addition, ion exchange contact chambers were installed at Patton and Shabokin wells for PFAS removal.

Exhibit 1-1: Devens PFAS Investigations by Site

Area of Post	Site Name	DEVENS AREAS INVESTIGATED FOR PFAS							
		2016 PA	2017 SI	2017 - 2018 LTM Wells Monitoring	2018 to 2020 RI (Phase I)			Proposed Sites (Phase II)	
					Area 1	Area 2	Area 3	Area 1	Area 2/3
North	AOC 50 Former Moore Army Airfield (MAAF)	x	x	x			x		x
	AOC 30 MAAF Drum Storage Area	SA30	AOC 30				x		x
	AOC 31 MAAF Fire Training Area	SA31	AOC 31				x		x
	SA19 Wastewater Treatment Plant (WWTP) Imhoff Settling Tanks	x	No further investigation warranted						
	AOC 20 WWTP Sand Filter Beds	SA20	AOC 20				x		x
	AOC 21 WWTP Sludge Drying Beds	SA21	AOC 21				x		x
South	AOC 25/26/27/28 Former Ranges	X	No further investigation warranted						
	AOC 46 Former Training Area 6D	X	No further investigation warranted						
Main	SA54 Building 2680	X	No further investigation warranted						
	AOC 5 Shepley's Hill Landfill	X	x	x		x			x
	AOC 32 Former Defense Reutilization and Marketing Office (DRMO)	X	x	X		x			x
	AOC 43A - Petroleum, Oil, Lubricants (POL) Storage Area			x		x			x
	AOC 43G Historical Gas Station G			x		x		x	
	AOC 43J Historical Gas Station J			x		x		x	
	AOC 40 Cold Spring Brook Landfill					x		x	
	AOC 57 Former Vehicle Storage and Motor Repair Shops Site			x	x			x	
	AOC 74 Barnum Road Firefighting Exercise Site	SA74	AOC 74		x			x	
	AOC 75 Former Building T-1445 Warehouse Fire	SA75	AOC 75		x			x	
	AOC 76 Devens Fire Station	SA76	AOC 76			x			x
Supply Wells	MacPherson Water Supply Well	X				x			x
	Grove Pond Wellfield				x			x	
	Patton Water Supply Well					x		x	
	Shabokin Water Supply Well					x		x	

NOTE: Orange shaded sites are included in the Area 1 Phase II PFAS RI WP.

1.1.3 Regulatory Framework

Activities completed under this RI WP are subject to and will be consistent with CERCLA, as amended by Superfund Amendments and Reauthorization Act of 1986 (42 U.S.C. § 9601 et seq.), and the NCP requirements, with regulatory coordination from the Massachusetts Department of Environmental Protection (MassDEP) and the USEPA. Regulatory guidance specific to the Phase II PFAS RI includes the following.

- In May 2016, USEPA issued the final Drinking Water LHA of 70 nanograms per liter (ng/L) for the combined or individual concentrations of PFOA and PFOS (USEPA 2016).
- In February 2018, USEPA Region 1 developed Fort Devens site-specific screening levels (SSSLs) for PFOS, PFOA, and PFBS via groundwater (ingestion), soil (dermal and ingestion), surface water (ingestion), sediment (dermal and ingestion), and fish consumption exposure pathways (USEPA Region 1 2018).
- Establishment of PFAS standards in Massachusetts began in 2018:
    - In June 2018, MassDEP issued an Office of Research and Standards Guideline (ORSG), which recommended contaminant levels in drinking water be protective against adverse health effects for all people consuming the water over a lifetime. An ORSG of 70 ng/L was set for the combined or individual concentrations of five PFAS (PFOA, PFOS, PFNA, PFHxS, and PFHpA).
    - In April 2019, MassDEP proposed draft amendments to the Massachusetts Contingency Plan (MCP) that included groundwater and soil cleanup standards for six PFAS compounds. In December 2019, Massachusetts finalized (under the MCP) formal PFAS cleanup standards for groundwater and specific PFAS limits for soil (MassDEP 2020). The groundwater standard is 20 ng/L for combined or individual concentrations of six PFAS (PFAS6: PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA). The criteria that determine the applicability of the groundwater and soil standards are described in regulation 310 Code of Massachusetts Regulations (CMR) 40.0932 and presented in the MCP Numerical Standards (MassDEP 2017). Specifically, the MCP categories of standards are:
        - Category GW-1: Concentrations based on the use of groundwater as drinking water, either currently or in the foreseeable future.
        - Category GW-2: Concentrations based on the potential for volatile material to migrate into indoor air.
        - Category GW-3: Concentrations based on the potential environmental effects resulting from contaminated groundwater discharging to surface water.
        - Category S-1: Concentrations based on sensitive uses of the property and accessible soil, either currently or in the foreseeable future. Additional criteria are established for the protection of groundwater, based on the leaching potential of the contaminated soil.
        - Category S-2: Concentrations based on property uses associated with moderate exposure and accessible soil, either currently or in the foreseeable future. Additional criteria are established for the protection of groundwater, based on the leaching potential of the contaminated soil.
        - Category S-3: Concentrations based on restricted access and property with limited potential for exposure, either currently or in the foreseeable future. Additional criteria are established for the protection of groundwater, based on the leaching potential of the contaminated soil.

  - In December 2019, MassDEP proposed draft PFAS maximum contaminant levels for public water supplies under the Massachusetts Drinking Water Regulations, 310 CMR 22.00 that were the same as the groundwater standards.
  - In January 2020, the ORSG was revised to be consistent with the proposed PFAS maximum contaminant levels for public drinking water supplies.
  - On October 2, 2020, the MassDEP promulgated final regulations in 310 CMR 22.00 establishing a Massachusetts maximum contaminant level (MMCL) for PFAS6 concentrations in drinking water (MCP groundwater category GW-1). In addition, MassDEP determined that based on available toxicity information, PFOS, PFOA, and related PFAS compounds are “hazardous materials” subject to regulations under the MCP. As such, MassDEP has established reportable concentrations (RCs) and reportable quantities (RQs) for PFAS6 under the MCP in 310 CMR 40.1600 for groundwater categories GW-1 (drinking water) and GW-2 (shallow groundwater) and soil categories S-1 (residential exposure) and S-2 (incidental exposure) (MassDEP 2020). The MCP category S-1 soil standards (310 CMR 40.0975(6)(a)) apply to soil associated with unrestricted use. The MCP category S-1 soil standards are based on a residential exposure scenario in which the potential receptor may come into contact with the contaminated soil in their yard while playing or gardening (MassDEP 2017). Within the MCP S-1 soil category there are further subcategories identified by groundwater type; the soil standards within these subcategories have been modified by the potential for a contaminant to leach and degrade the site groundwater (MassDEP 2017).

- In October 2019, the DoD’s Office of the Secretary of Defense issued guidance on the investigation of PFOS, PFOA, and PFBS at DoD locations in a memorandum titled Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program (DoD 2019). The memorandum provided risk-based screening levels for PFOS, PFOA, and PFBS in groundwater (tapwater) or soil, calculated using the USEPA’s RSL calculator for residential and industrial/commercial worker receptor scenarios. The memorandum indicated that, in the presence of only one PFAS, the screening level based on a target non-cancer hazard quotient (HQ) = 1.0 is used; in the presence of multiple PFAS, the more conservative screening level based on an HQ = 0.1 is used (DoD 2019). The memorandum was updated in September 2021 with new PFBS screening levels (DoD 2021).

- On May 18, 2022, the USEPA issued RSLs based on new toxicity values for PFOS, PFOA, PFNA, PFHxS, and HFPO-DA (sometimes called GenX; USEPA 2022a).

- Subsequently in June 2022, USEPA Region 1 updated the Devens SSSLs for PFOS, PFOA, PFBS, and included SSSLs for PFNA, PFHxS, and HFPO-DA for groundwater, soil, surface water, sediment, and fish tissue (USEPA Region 1 2022).

- On June 15, 2022, USEPA issued revised draft interim Drinking Water LHAs for the combined or individual concentrations of PFOA and PFOS and new Drinking Water LHAs for PFBS and HFPO-DA and its ammonium salt (together referred to as “Gen X chemicals”). PFBS was developed as a replacement for PFOS; HFPO-DA was developed as a replacement for PFOA (USEPA 2022b).

- On July 6, 2022, the DoD’s Office of the Secretary of Defense issued a revised memorandum (DoD 2022 Memo) that provided technical guidance related to the May 2022 USEPA RSLs for PFOS, PFOA, PFNA, PFHxS, and HFPO-DA, with screening levels for PFBS remaining unchanged since the previous update (DoD 2021). The 2022 memorandum notes that, “HFPO-DA has primarily been used as a replacement for PFOA in the manufacture of fluoropolymers, so it is not likely to have been released at the vast majority of DoD properties.” This memorandum became effective immediately and superseded and canceled the Assistant Secretary of Defense memorandum, "Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program," dated September 15, 2021 (DoD 2022).

- On May 4, 2023, USEPA added RSLs for PFBA and PFHxA (USEPA 2023a). On June 13, 2023, USEPA Region 1 issued updated Devens SSSLs for the previously listed PFAS compounds and added SSSLs for PFBA and PFHxA (USEPA Region 1 2023).

1.2 Remedial Investigation – Phase I

In addition to the PFAS-impacted AOCs identified during the 2017 SI, PFAS were detected in groundwater in public water supply wells at the Grove Pond wellfield, and MacPherson, Patton, and Shabokin public supply wells. Treatment was subsequently installed on the wells between June 2019 and March 2020.

To expedite field investigations for a Devens installation-wide PFAS RI, the identified AOCs; the Grove Pond wellfield; and the MacPherson, Patton, and Shabokin water supply well areas were grouped into three areas (Areas 1, 2, and 3). The three areas were designated for sequencing of field activities and did not reflect prioritization.

During field activities conducted from 2018 to 2020 to support the RI (considered to be Phase I activities), the Army collected more than 374 groundwater samples (from wells), and soil, surface water, and sediment samples. In addition, 910 groundwater samples were collected from 123 temporary VP points. The analytical data and hydraulic data collected from piezometers and wells provided data to support a conceptual understanding of the migration pathways for PFAS and allow for generation of a three-dimensional approximation of the PFAS groundwater plume.

PFAS in soil samples collected across Phase I Area 1 where PFAS releases were documented or suspected exceeded the June 2022 SSSLs at AOC 43G (three samples at two of eight soil borings), AOC 57 (two samples at two of 13 soil borings), and in the Grove Pond Area (five samples at three of nine soil borings). PFAS detected in soils indicate there may have been releases to the ground surface of PFAS-containing materials. No soil samples collected at AOC 40, AOC 74, or AOC 75 exceeded the applicable soil SSSLs for PFAS. Figure 1-2 shows the extent of PFAS in groundwater based on the SSSLs. Based on the Groundwater Use and Value Determination (GUVD) for the Devens area (MassDEP 2003), the groundwater across most of Area 1 is considered to be of high use and value.

While no hydrogeologic connection was established off post, the Army sampled private wells in the Towns of Ayer, Shirley, and Harvard (KGS 2020d, 2020e, 2020f). Of the 143 off-post wells sampled, the summed concentration of PFOA and PFOS at each of the 143 wells were below the USEPA LHA of 70 ng/L, with samples from 13 wells having combined concentrations of PFAS6 above the MCP category GW-1 standard of 20 ng/L. It is not known if the detected PFAS originated from Devens. The well construction details for the 13 wells with PFAS6 greater than 20 ng/L are provided in Table 1-1.

1.3 Remedial Investigation – Phase II

The Phase I PFAS investigations focused on individual AOCs or documented release areas (BERS-Weston 2018a; 2018b; KGS 2020a). The Phase I data indicate that PFAS in Devens groundwater is widespread laterally, and there are likely several co-mingled PFAS plumes rather than separate AOC-specific plumes. The PFAS contaminated groundwater likely discharges to surface water bodies (i.e., Cold Spring Brook, Grove Pond, Mirror Lake) and drinking water receptors (i.e., Grove Pond wellfield, Patton supply well, Shabokin supply well). Discharge to surface water is suggested based on upward vertical hydraulic gradients observed at monitoring well pairs adjacent to surface water bodies, and correlations in PFAS mixtures and concentrations of PFAS in groundwater to adjacent surface water samples. The soil data collected during the Phase I Area 1 investigations confirmed that low levels of PFAS are present in some locations within or near suspected PFAS release areas; but there are no obvious continuing soil source areas within Phase 1 Area 1. This is likely because prior environmental restoration activities performed to remove soils containing other contaminants resulted in removal of some volume of the PFAS-containing soils, and because of the amount of redevelopment that has occurred in this area of Devens.

1.3.1 Phase II - RI Purpose

The goal of the Area 1 Phase II PFAS RI is to address data gaps, identify exposure pathways, and assess risk to human and ecological receptors associated with the presence of PFAS in Area 1.

To support this goal, the objectives of the Area 1 Phase II PFAS RI field activities are to define the following:

- Representative exposure point concentrations (EPCs) for PFAS in groundwater, soil, sediment, and surface water: Establish EPCs for PFAS in groundwater at the locations of the highest (i.e., “worst-case”) potential exposures, and EPCs for soil, sediment, and surface water representative of average exposure conditions in accordance with USEPA risk assessment guidance.
- Pathway – Advance the conceptual site model by sampling soils and groundwater to refine the understanding of suspected PFAS release areas and to evaluate locations of discharge of, and/or human or ecological exposure to, PFAS in Area 1.
- Human and ecological exposure impacts: Evaluate the risk to human and ecological receptors associated with PFAS at Devens by conducting a human health risk assessment (HHRA) and screening level ecological risk assessment (SLERA) in accordance with CERCLA guidance.

The work proposed in this Area 1 Phase II PFAS RI WP includes:

- Collection of soil samples where Phase I identified PFAS in soils exceeding the SSSLs and in areas where soil samples have not yet been collected that are potentially associated with suspected PFAS release areas.
- Installation of monitoring wells and the collection of groundwater samples from these new wells and from previously installed wells for analysis of PFAS to evaluate human receptors and associated risk.
- Installation of stream gauges, piezometers, and monitoring wells, as well as the collection of surface water, sediment, and fish tissue samples, to assess discharge of groundwater containing PFAS to, and interaction with, surface water receptors, including Grove Pond, Cold Spring Brook, Robbins Pond, and Mirror Lake.
- Evaluation of potential PFAS transport through vertical migration and/or bedrock fractures, including:
    - Assessing PFAS concentrations and vertical hydraulic gradients.
    - VP sampling and analysis of overburden groundwater east of Cold Spring Brook for PFAS. VP sampling is the collection of discrete groundwater samples from multiple depths from a temporary borehole. Groundwater samples will be collected starting at the observed water table using a 4-foot screen, with near continuous sampling proposed in the upper 15 feet, followed by sampling every 10 feet in the deeper intervals. For example, if the water table is encountered at 10 feet below ground surface (bgs), the discrete sampling intervals would be: 10- to 14 feet, 15- to 19 feet, 20- to 24 feet, 30- to 34 feet, 40- to 44 feet, and so on.
    - Characterization of bedrock and sampling and analysis of bedrock groundwater.

1.3.2 Phase II – Applicable Regulatory Standards

During Phase II of the Area 1 PFAS RI, the Army will use the SSSLs for PFOS, PFOA, PFBS, PFNA, and PFHxS developed by the USEPA Region 1 in June 2023 (Appendix D) to evaluate potential human health risks via the groundwater, soil, sediment, surface water, and fish consumption exposure pathways.

Groundwater sample analytical results will also be screened against the applicable MCP groundwater standards for PFAS. Area 1 is located within an aquifer district defined as a potential drinking water source area and designated as MCP groundwater category GW-1. The MCP MMCL for category GW-1 is 20 ng/L for the sum of PFAS6. All of the Area 1 investigation sites except for AOC 43J are also within a Zone I or Zone II wellhead protection area (Figure 1-3), which are areas that recharge water supplies, as determined by the MassDEP Drinking Water Program. The drinking water supply protection zones are defined in the Massachusetts Drinking Water Regulation, 310 CMR 22.00[2]. As defined in 310 CMR 22.00:

- Zone I means the protective radius required around a public water supply well or Wellfield. For Public Water System wells with approved yields of 100,000 gallons per day (gpd) or greater, the protective radius is 400 feet. Wellfields and infiltration galleries with approved yields of 10,000 gpd or greater require a 250-foot protective radius.
- Zone II means that area of an aquifer that contributes water to a well under the most severe pumping and recharge conditions that can be realistically anticipated (180 days of pumping at approved yield, with no recharge from precipitation). It is bounded by the groundwater divides that result from pumping the well and by the contact of the aquifer with less permeable materials such as till or bedrock. In some cases, streams or lakes may act as recharge boundaries.
- Zone III means that land area beyond the area of Zone II from which Surface Water and groundwater drain into Zone II. The surface drainage area as determined by topography is commonly coincident with the groundwater drainage area and will be used to delineate Zone III. In some locations, where surface and groundwater drainage is not coincident, Zone III shall consist of both the surface drainage and the groundwater drainage areas.

Because groundwater in Area 1 is located within either a Zone II protection zone or a currently promulgated aquifer protection district, groundwater sample analytical results will be screened against the MCP groundwater category GW-1 PFAS standard.

Soil sample analytical results will also be screened against the MCP S-1/GW-1 standard for PFAS6 (i.e., PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA). As described in Section 1.1.3, MCP category S-1 soil standards (310 CMR 40.0975(6)(a)) apply to soil associated with unrestricted use. The S-1 soil concentrations were developed to be protective of sensitive uses of the property and accessible soil, either currently or in the foreseeable future. Potential receptors and exposure pathways (with respect to current and future land uses) are discussed in Section 3.4.1 and Section 4.3.1.2.

The non-cancer reference doses for PFOS, PFOA, PFBS, PFNA, and PFHxS and the oral cancer slope factor for PFOA will be used to conduct site-specific HHRAs in accordance with the USEPA Risk Assessment Guidance for Superfund (RAGS; USEPA 1989, 2001). The site-specific risk assessment results will be used to determine if remedial actions are required to protect human health in accordance with CERCLA, the Defense Environmental Restoration Program, and the NCP (DoD 2019).

To evaluate potential ecological risks, data will be screened against PFAS ecological screening values (ESVs) for the media and receptors presented in the September 2021, Derivation of PFAS Ecological Screening Values

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[2] Available online at: https://www.mass.gov/regulations/310-CMR-22-the-massachusetts-drinking-water-regulations.

Report prepared by Argonne National Laboratory on behalf of DoD (Argonne 2021), for use at DoD installations where PFAS have been detected in soils and surface waters.

1.3.3 Phase II – Area 1 Description

The results presented in the SI (BERS-Weston 2018a) and SI Addendum (BERS-Weston 2018b) along with the initial (Phase I) RI results indicated co-mingled PFAS plumes were present across Devens. Therefore, the current understanding of site history and hydrogeology (i.e., CSM) was used as a basis to logically define appropriate and practical boundaries for Area 1 (Figure 1-2). Because the overburden groundwater has been identified as the principal transport pathway (i.e., most impacted media that is hydraulically connected to surface water bodies and drinking water receptors), groundwater flow patterns within the overburden were used to delineate local-scale ‘watersheds’ that discharge to specific surface water bodies and/or water supply wells (see Section 3.2 and Figure 1-4). The boundaries for Area 1 were defined by the areas of overburden groundwater that either discharge to Cold Spring Brook or Grove Pond and/or would eventually be captured by the Shabokin, Patton, or Grove Pond water supply wells. Correspondingly, the following areas of Devens comprise Area 1 (Figure 1-2).

- PFAS-impacted AOCs:
    - AOC 40 Cold Spring Brook Landfill
    - AOC 43G Historical Gas Station G
    - AOC 43J Historical Gas Station J
    - AOC 57 Former Vehicle Storage and Motor Repair Shops Site
    - AOC 74 Barnum Road Firefighting Exercise Site
    - AOC 75 Former Building T-1445 Warehouse Fire
- Areas along Barnum and Queenstown Roads
- Impacted water supply wells:
    - Grove Pond wellfield;
    - Patton water supply well
    - Shabokin water supply well
- Potentially impacted surface waters:
    - Balch Pond
    - Bowers Brook
    - Cold Spring Brook
    - Cold Spring Brook Pond
    - Grove Pond
    - Mirror Lake
    - Nashua River
    - Plow Shop Pond
    - Robbins Pond
    - Unnamed Spring
    - Unnamed Tributary.

1.4 Report Organization

This PFAS RI WP is organized as follows:

- **Section 1 – Introduction**: Presents the project background, provides the site history, summarizes the previous investigations, describes the approach for and content of the Phase II RI, and presents the regulatory framework.
- **Section 2 – Project Approach and Data Quality Objectives**: Presents the data quality objectives (DQOs) of the RI and the principal study questions to be addressed by the RI.
- **Section 3 – Conceptual Site Model**: Summarizes the physical characteristics of Area 1, describes the regional hydrogeology, presents the nature and extent of known PFAS contamination, describes land use and PFAS fate and transport, and identifies potential receptors and exposure pathways.
- **Section 4 – Remedial Investigation Implementation**: Summarizes the planned Phase II RI activities, including field methodologies, HHRA, SLERA, and treatability studies for the possible treatment technologies.
- **Section 5 – Deliverables**: Identifies the deliverables that will be generated for the project.
- **Section 6 – Project Schedule**: Presents the Area 1 PFAS RI WP schedule.
- **Section 7 – References**: Provides a list of references cited throughout this Phase II RI WP. References cited in attached tables, figures, and appendices are provided in those documents and not repeated herein.

In addition, the following appendices are provided to supplement the RI WP:

- **Appendix A:** Addendum for Area 1 to Uniform Federal Policy QAPP for PFAS – Describes sampling and analysis procedures for implementation of the RI along with the chemical DQOs, field data-gathering methods, analytical methods and measurements, quality assurance/quality protocols necessary to achieve the DQOs, and data assessment procedures for the evaluation and the identification of any data limitations. The QAPP Addendum will facilitate the generation of data with acceptable precision, accuracy, representativeness, comparability, and completeness.
- **Appendix B:** Area 1 PSCS
- **Appendix C:** Detailed Site Histories
- **Appendix D:** USEPA Region 1 Site-Specific Screening Levels
- **Appendix E:** Regional Groundwater Flow Model of the Former Fort Devens, Massachusetts
- **Appendix F:** Area of Contamination-Specific Physical Characteristics and Hydrogeology
- **Appendix G:** Area of Contamination-Specific PFAS Fate and Transport
- **Appendix H:** Remedial Investigation Implementation Methodology.
- **Appendix I:** Response to Regulatory Comments on Draft and Draft Final Phase II Area 1 Remedial Investigation Work Plan

2 Project Approach and Data Quality Objectives

This section discusses the work plan approach and the DQOs for the project.

2.1 Work Plan Approach

As discussed above in Section 1.3, the Phase I data indicated that PFAS in the Devens Area 1 groundwater is widespread laterally, with areas of higher PFAS concentrations associated with some AOCs. The Phase I data also indicated that while low levels of PFAS are present in some locations within or near suspected PFAS release areas, there are no obvious continuing soil source areas within Phase 1 Area 1. However, there are some areas where data gaps concerning PFAS concentrations in soil remain.

This Area 1 Phase II PFAS RI WP addresses the data gaps associated with groundwater in the locations of the greatest PFAS concentrations (i.e., suspected release areas), the associated migration pathways, and discharge locations for groundwater within Area 1 at Devens, as presented in Section 1. In addition, this WP also addresses the remaining data gaps where PFAS in soil may have contributed, or continue to contribute, to PFAS concentrations in groundwater at the suspected release areas, as well as the presence of PFAS in surface water, sediment, and fish tissue in water bodies receiving groundwater discharge.

2.2 Data Quality Objectives

The DQOs are qualitative and quantitative statements that clarify study objectives, define the appropriate type of data, and specify the tolerable levels of potential decision errors that are used as the basis for establishing the quality and quantity of data needed to support decisions. These project-specific statements describe the intended data use, the data need requirements, and the means to achieve acceptable data quality for the intended use. Guidelines followed in the preparation of DQOs for CERCLA investigations are set out as steps in the Data Quality Objectives Process for Hazardous Waste Site Investigations (USEPA 2000). These seven steps are listed below:

- **Step 1. State the Problem**: Summarize the problem that will require environmental data, the resources required, and the preliminary site conceptual model.
- **Step 2. Identify the Decision (Project Goals):** Identify the decisions needed to solve the problem.
- **Step 3. Identify Information Inputs:** Identify the information and measurements needed to make the decisions.
- **Step 4. Define the Boundaries of the Study:** Identify the conditions such as spatial and temporal boundaries.
- **Step 5. Develop a Decision Rule:** Define the conditions under which the data will be utilized.
- **Step 6. Specify Limits on Decision Errors:** Identify the limits on decision errors to establish performance goals.
- **Step 7. Develop/Optimize the Plan for Obtaining Data:** Design an effective data collection strategy based on the previous steps.

The seven-step process was used to develop the DQOs for the Area 1 Phase II PFAS RI WP, which are presented below.

2.2.1 Step 1: State the Problem

PFAS have been detected in groundwater, soil, sediment, and surface water at several locations at Devens. An RI is required to assess the risk posed to human health and the environment resulting from the release of PFAS at Devens. Evaluation of the risk will require data on the concentration of PFAS in soil and groundwater, the extent to which it is present at concentrations greater than the applicable criteria, and the potential pathways through which human receptors could be exposed to the PFAS. During Phase I of the RI, the Army collected samples from AOCs for PFAS impacts identified in the Final Site Inspection Report for Per-and Polyfluoroalkyl Substances (PFAS) at Former Fort Devens Army Installation (BERS-Weston 2018a). Data were compiled from laboratory analysis of samples collected from groundwater (both temporary VP and permanent monitoring wells), soil, sediment, and surface water along with hydraulic data collected from piezometers and wells. This information was used to evaluate locations of the greatest concentrations of PFAS and migration pathways for PFAS in soil and groundwater. However, additional data are needed to assess the current understanding of the Area 1 PFAS plume and meet the project goals identified below.

2.2.2 Step 2: Identify the Decision (Project Goals)

Phase I of the PFAS RI, as reported in the Area 1 PSCS (Appendix B), included the drilling and sampling of 123 temporary VP sampling points, installation of new wells and sampling of 142 new and existing monitoring wells and piezometers, and collection of 25 sediment and surface water samples to evaluate the presence and distribution of PFAS.

The goal of the Area 1 Phase II PFAS RI is to address data gaps, identify exposure pathways, and assess risk to human and ecological receptors associated with the presence of PFAS in Area 1.

2.2.3 Step 3: Identify Information Inputs

The information inputs required to accomplish the project goal are:

- All information reviewed and gathered to date, including historical information on the storage, use, and disposal of PFAS-containing materials within Area 1 at Devens; the results of previous investigations, including the extensive Phase I data; and previous remedial actions completed.
- Analytical data from environmental media. These data may be collected through remote sensing/geophysical methods, installation of overburden and/or bedrock groundwater monitoring wells, sampling of new and existing monitoring wells, collection of soil samples, collection of sediment samples in locations previously not sampled, grab sample collection from surface water, and the collection of fish tissue that could be consumed by humans.
- Geologic, hydrogeologic/hydraulic, and chemical data required to evaluate PFAS fate and transport in groundwater, soil, sediment, and surface water.
- Existing, current toxicological data necessary to evaluate the risk of human exposure to PFAS in the groundwater, soil, sediment, surface water, or fish tissue.

To collect sufficient data to perform site-specific HHRAs and SLERAs, the following samples will be collected:

- Groundwater samples from temporary VP points and permanent monitoring wells to be installed to supplement the existing groundwater data and evaluate potential human exposure pathways.
- Soil samples from portions of Area 1 to supplement the existing soil data and/or investigate areas with limited historical soil data.

- Surface water samples from locations previously sampled during the Phase I RI, and from eight additional locations, to assess potential contribution of groundwater to surface water and to confirm previous results (although previous results showed no exceedances of SSSLs).
- Sediment samples from eight locations not sampled during the Phase I RI (in the Nashua River, Cold Spring Brook Pond, Cold Spring Brook, and Mirror Lake) to evaluate the effects of PFAS on benthic organisms.
- Fish tissue to evaluate the potential fish ingestion exposure pathway (Grove Pond, Plow Shop Pond, Cold Spring Brook, Cold Spring Brook Pond, Mirror Lake, Robbins Pond, and Nashua River).

2.2.4 Step 4: Define the Boundaries of the Study

The general areal boundaries for the investigation are the Devens Phase II Area 1 and adjacent areas that may affect conditions at Phase II Area 1 (and/or are affected by conditions at Area 1), including Grove Pond and Plow Shop Pond, and private properties adjacent to Area 1 (Figure 1-2). The vertical boundaries of the study will include overburden groundwater and/or bedrock groundwater to the extent necessary to evaluate the pathways through which human exposure to PFAS released from Devens are present.

2.2.5 Step 5: Develop a Decision Rule

All samples will be collected and analyzed in accordance with the technical guidance instruction (TGI) documents included in the QAPP Addendum (Appendix A) to ensure that subsequent decisions are made based on valid data. Decisions will be based on the criteria described in the subsections below.

2.2.5.1 *General*

The presence or absence of PFAS will be based on the laboratory limits of detection (LODs) presented in the QAPP Addendum (Appendix A).

Human health SSSLs will be used, among other criteria, to evaluate groundwater, surface water, sediment, and fish tissue data. As discussed above in Section 1.1.3, the MCP establishes PFAS standards for groundwater and soil. In June 2022, USEPA Region 1 updated the 2018 SSSLs for PFOA, PFOS, and PFBS, and calculated SSSLs for PFNA, PFHxS, and HFPO-DA for the Fort Devens NPL Site. In June 2023, USEPA Region 1 further updated the SSSLs for the Fort Devens NPL Site and calculated SSSLs for PFBA and PFHxA (Appendix D). Although USEPA Region 1 developed an SSSL for HFPO-DA, HFPO-DA was manufactured and used after 1995, when Fort Devens was identified for closure. Therefore, PFAS data will not be screened against the HFPO-DA SSSL.

The SSSLs were calculated with the online USEPA RSL calculator (USEPA 2023b), non-cancer toxicity values for PFOA, PFOS, PFNA, and PFHxS developed by the Agency for Toxic Substances and Disease Registry (ATSDR 2022), non-cancer toxicity values for PFBA and PFHxA from USEPA's Integrated Risk Information System (USEPA 2023c), and a non-cancer toxicity value for PFBS from USEPA's Center for Public Health and Environmental Assessment (USEPA 2021). The SSSLs were based on exposure scenarios and receptor-specific assumptions that are appropriate for screening the RI sample data. However, the scenarios and assumptions that will be used to calculate human health risks will be based on the site-specific human health CSM described in Section 4.3.1 and may be refined based on information gathered during the RI. The SSSLs are based on a target non-cancer HQ of 0.1. Use of an HQ of 0.1 is purposefully conservative to account for the presence of multiple chemicals in site media that may have cumulative non-cancer human health effects and assumes that the chemicals affect the same target organ or system. The SSSLs for Devens (including Phase II Area 1) are summarized in Table 2-1 and referenced in the following subsections.

Data for soil and surface water will also be screened against the PFAS ESVs for the media and receptors presented in the September 2021, "Derivation of PFAS Ecological Screening Values Report" prepared by

Argonne National Laboratory on behalf of DoD (Argonne 2021), for use at DoD installations where PFAS have been detected in soils and surface waters.

2.2.5.2 *Groundwater*

Decisions for the groundwater investigation will be based on the LODs and the lesser of the MCP GW-1 standard for PFAS6 (i.e., PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA) and the 2023 USEPA Region 1 SSSLs for PFAS compounds in tap water listed in Table 2-1. There is no MCP standard for PFBS; therefore, the SSSL will be used to screen data for PFBS. There are no SSSLs for PFHpA and PFDA; therefore, the MCP GW-1 standard will be used to screen data for PFHpA and PFDA. The following decision rules will be used for groundwater:

- If the PFAS compounds listed in Table 2-1 are not detected at concentrations greater than the LODs, the LODs are less than or equal to the appropriate screening value, and the data are judged to be acceptable through validation that has occurred, then they will be considered to not be present, and no further investigation will be required.
- If the PFAS compounds listed in Table 2-1 are detected at concentrations less than the SSSLs and PFHpA, and PFDA are detected at concentrations less than the MCP GW-1 PFAS6 standard, then no further investigative action will be required.
- If the PFAS compounds listed in Table 2-1 are detected at concentrations greater than SSSLs or PFHpA, and PFDA are detected at concentrations greater than the applicable MCP GW-1 PFAS6 standard and the migration pathway to receptors has not been defined, then further investigation will be conducted.

2.2.5.3 *Soil*

Decisions for soil investigation will be based on the LODs and the lesser of the MCP S-1/GW-1 standard for PFAS6 (i.e., PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA) and the 2023 USEPA Region 1 SSSLs for PFAS compounds listed in Table 2-1 in soil for commercial/industrial worker exposure to soil. There is no MCP standard for PFBS; therefore, the SSSL will be used to screen data for PFBS. There are no SSSL standards for PFHpA and PFDA; therefore, the MCP S-1/GW-1 standard will be used to screen data for PFHpA and PFDA. The following decision rules will apply:

- If the PFAS compounds listed in Table 2-1 are not detected at concentrations greater than the LODs, the LODs are less than or equal to the appropriate screening value, and the data are judged to be acceptable through validation that has occurred, then they will be considered to not be present, and no further investigation will be required.
- If PFAS6 are detected at concentrations less than the MCP S-1/GW-1 PFAS6 standards and the PFAS compounds listed in Table 2-1 are at concentrations less than the SSSLs, then no further investigative action will be required.
- If PFAS6 and the PFAS compounds listed in Table 2-1 are detected at concentrations greater than the applicable MCP S-1/GW-1 PFAS6 standard or SSSLs, then further investigation may be required to evaluate human health or ecological risk.

2.2.5.4 *Surface Water*

Decisions for the surface water investigation will be based on the LODs and the lesser of the applicable MCP GW-3 PFAS6 standard or the 2023 SSSLs for the child recreator exposure to surface water listed in Table 2-1. There is no MCP standard for PFBS; therefore, the SSSL will be used to screen data for PFBS. There are no

SSSL standards for PFHpA and PFDA; therefore, the MCP GW-3 standard will be used to screen data for PFHpA and PFDA. The following decision rules will be used for surface water:

- If the PFAS compounds listed in Table 2-1 are not detected at concentrations greater than the LODs, the LODs are less than or equal to the appropriate screening value, and the data are judged to be acceptable through validation that has occurred, then they will be considered to not be present, and no further investigation will be required.
- If the PFAS compounds listed in Table 2-1 are detected at concentrations less than SSSLs or PFHpA, and PFDA are detected at concentrations less than the applicable MCP GW-3 PFAS6 standard, then no further investigative action will be required.
- If the PFAS compounds listed in Table 2-1 are detected at concentrations greater than SSSLs or PFHpA, and PFDA are detected at concentrations greater than the applicable MCP GW-3 PFAS6 standard, then further investigation may be required to evaluate human health or ecological risk.

2.2.5.5 *Sediment*

While characterization of PFAS concentrations in sediment is not identified as a data gap for Area 1 because of the extensive sampling that was conducted during Phase I of the PFAS RI, eight additional sediment sample locations are proposed as part of the Phase II RI work, in areas not previously sampled.

A total of 31 sediment samples and seven field duplicates were collected from Phase I Area 1 locations in 2018 and 2020. Additionally, samples were collected outside of Phase I Area 1: one sediment sample was collected from Balch Pond upgradient of Devens, and six sediment samples were collected from Plow Shop Pond downstream of Grove Pond. These data are relatively recent, provide adequate characterization of nature and extent of PFAS in sediment, and are sufficient in number for use in the HHRA and SLERA. However, to provide additional sediment data, samples will be collected from eight locations not previously sampled.

There is no MCP standard for PFAS6 in sediment; therefore, sediment samples collected in 2018 and 2020 were compared to SSSLs. Detected concentrations of PFOA, PFOS and PFBS were below the 2018 SSSLs in all sediment samples.

For the RI, sediment samples collected in 2018 and 2020, and samples collected in 2023 will be compared to 2023 SSSLs for the PFAS compounds listed in Table 2-1. The following decision rules will be used for sediment during Phase II:

- If the PFAS compounds listed in Table 2-1 are not detected at concentrations greater than the LODs, the LODs are less than or equal to the appropriate screening value, and the data are judged to be acceptable through validation that has occurred, then they will be considered to not be present, and no further investigation will be required.
- If the PFAS compounds listed in Table 2-1 are detected at concentrations less than SSSLs, then no further investigative action will be required.
- If the PFAS compounds listed in Table 2-1 are detected at concentrations greater than SSSLs, then further investigation may be required to evaluate human health or ecological risk.

2.2.5.6 *Fish Tissue*

Decisions for the fish tissue investigation will be based on the LODs and the 2023 SSSLs for fish consumption (Table 2-1). The following decision rules will be used for concentrations of PFAS in fish tissue:

- If the PFAS compounds listed in Table 2-1 are not detected at concentrations greater than the LODs, the LODs are less than or equal to the appropriate screening value, and the data are judged to be acceptable through validation, which has occurred, then they will be considered to not be present, and no further evaluations will be required.

- If the PFAS compounds listed in Table 2-1 are detected at concentrations less than the SSSLs (Table 2-1), then no further evaluations will be required.
- If the PFAS compounds listed in Table 2-1 are detected at concentrations greater than the SSSLs (Table 2-1), a risk evaluation will be conducted to evaluate human health risk.

2.2.6 Step 6: Specify Limits on Decision Errors

The potential decision errors associated with this investigation include:

- The false presumption that PFAS6 and the PFAS listed in Table 2-1 are not present at concentrations greater than the applicable decision criteria, when in fact they are.
- The false presumption that PFAS6 and the PFAS listed in Table 2-1 are present at concentrations greater than the applicable decision criteria, when in fact they are not.

The data usability assessment process will be used to limit decision errors based on field and analytical data. This process is described in the QAPP Addendum (Appendix A).

2.2.7 Step 7: Develop/Optimize the Plan for Obtaining the Data

Investigations are proposed in this Area 1 PFAS RI WP to address the following data gaps where they have not already been characterized:

- Extent/presence of PFAS in soil, in areas where the PFAS fingerprint in groundwater varies compared to adjacent areas, and in areas where soil sampling to explore suspected PFAS release areas has not been performed.
- Bedrock and overburden groundwater interaction, including vertical flow gradients at key locations such as those adjacent to surface water bodies.
- Hydrogeologic relationship between Area 1 and private drinking water wells east and southeast of Cold Spring Brook.
- Relationship between PFAS in groundwater in Area 1 and PFAS in private drinking water wells east and southeast of Cold Spring Brook.
- Groundwater discharge locations and interaction to and with surface water and sediment.
- Potential impact of PFAS releases on fish that could be consumed by humans.

Installation and sampling of groundwater at overburden and bedrock monitoring wells will be conducted to:

- Assess PFAS concentrations detected during the Phase I VP point sampling.
- Assess vertical distribution of PFAS in groundwater.
- Evaluate human exposure pathways and associated human health risks.
- Establish a monitoring network from which repeatable data can be collected to support an HHRA.

3 Conceptual Site Model

This section presents a discussion of the preliminary CSM for Phase II Area 1 at Devens, including regional and local physical characteristics and hydrogeology. This section also presents an overview of PFAS fate and transport and identifies potential receptors.

To support this CSM, a site-wide three-dimensional numerical groundwater flow model was developed (constructed and calibrated) for Devens. Results from the calibrated model, along with the various components of the CSM presented herein, were used to characterize groundwater flow patterns, delineate Phase II Area 1, help identify data gaps, and guide the investigation activities outlined in this work plan. A detailed modeling report is included as Appendix E.

3.1 Regional Characteristics

This section describes the physical characteristics and hydrogeology of Devens and the surrounding area.

3.1.1 Physical Characteristics

Regionally, Devens lies within the Nashua River basin. The Nashua River flows north through the former North, Main, and South Posts, forming the eastern boundary on the former South Post and much of the western boundary of the former Main Post. Other notable surface water features at Devens include Grove Pond (located in the northeastern corner of Area 1 adjacent to the Grove Pond wellfield); Cold Spring Brook (located along the eastern boundary of Area 1 adjacent to AOCs 57 and 74); an unnamed tributary; and Robbins Pond, which discharges to Willow Brook (Figure 1-2).

The topography of Devens is characterized by undulating glacial terrain derived from glacial erosion and deposition on crystalline bedrock. Landforms at Devens include extensive flat uplands such as those found at the former MAAF and WWTP areas on the former North Post, and kame and kettle topography that range from areas of comparatively low topographic relief to elongated hills (i.e., drumlins) such as the areas encountered on the former South Post and former Main Post (Harding Lawson Associates [HLA] 2000a). The terrain at Devens generally falls into three types:

- **Bedrock Terrain:** Least common; generally consisting of crystalline bedrock topographical highs that are resistant to both glacial and fluvial erosion. Where bedrock is not directly exposed, a thin veneer of glacial sediments may be present.
- **Glacial Till:** More common; primarily consisting of highly variable sediments deposited by glaciers and conforming to the underlying bedrock surface.
- **Glacial-Meltwater Streams and Lake Deposits:** Most common; predominantly consisting of sediments deposited by glacial-meltwater outwash and ancient proglacial lake accumulations.

The major glacial sediment units consist of till, deltaic deposits from former glacial Lake Nashua, and deposits from glacial meltwater streams. Thickness of glacial till at Devens varies between 10 to 60 feet, consists of unstratified gravel to silt, and typically contains boulders. The glacial lake deposits consist mainly of sand and gravelly sand. Lake bottom deposits consist of sand, silt, and clay. Post-glacial deposits consist mainly of river terrace sands and gravels, fine alluvial sands, and silts, as well as peat, silt, and sands in swampy areas. Overburden deposits are up to 300 feet thick (areas along Cold Spring Brook), whereas lowland Nashua River floodplain deposits, consisting of sand, fine gravel, and silt, are up to 25 feet thick. Profiles showing overburden and bedrock are included on Figure 3-1.

The overburden at Devens is underlain by competent (unweathered) to slightly weathered, sparsely fractured, low-grade metasedimentary rocks, gneisses, and granites (HLA 2000a). Bedrock strikes and dips are variable across Devens due to the folded nature of the formations and the presence of numerous faults that align with major unit contacts. Across Area 1, the dominant structural alignment is generally oriented in a north-south/northeast-southwest direction. The bedrock units present across Devens are:

- **Oakdale Formation** – metamorphosed thin-bedded, pelitic and calcareous siltstone and muscovite schist;
- **Devens Gneiss Complex** – coarse-grained quartz-potassium (k)-spar biotite granite-gneiss (intruded by the Ayer Granite)
- **Worcester Formation** – carbonaceous slate and phyllite and minor metagraywacke
- **Berwick Formation** – thin- to thick-bedded metamorphosed calcareous sandstone, siltstone, and minor muscovite schist
- **Chelmsford Granite** – light gray, even and medium-grained muscovite-biotite granite
- **Ayer Granite** – two or three facies present:
    - **Clinton Facies** – porphyritic biotite granite with a non-porphyritic border phase; intrudes the Berwick Formation
    - **Devens-Long Pond Facies** – equigranular to porphyritic gneissic biotite granite and granodiorite.

Area 1 is underlain by the Oakdale Formation in the western half of the study area, while the Devens Gneiss Complex underlies the eastern half (Figure 3-2).

3.1.2 Hydrogeology

Regionally, groundwater and surface water bodies across Devens ultimately discharge into the Nashua River, whose tributaries include Nonacoicus Brook and Walker Brook on the former North Post. Cold Spring Brook, which is a tributary of Nonacoicus Brook via Grove Pond and Plow Shop Pond, and Willow Brook, another tributary to Nonacoicus Brook, flow through the former Main Post. Cold Spring Brook is sourced by wetlands located near AOC 40, then flows north along AOCs 57 and 74 into Grove Pond, being fed by surface water runoff, stormwater discharge, and groundwater discharge along the way. Bowers Brook enters Cold Spring Brook from the east in the area of AOC 57. Willow Brook originates from Robbins Pond and is fed by Robbins Pond, surface water runoff, stormwater discharge, and groundwater (Figures 3-2 and 3-3). Baseflow conditions for the numerous ponds, wetlands, and tributaries across Devens are maintained by groundwater discharge.

3.1.2.1 *Overburden*

Overburden (glacial meltwater deposits) constitutes the primary groundwater aquifer at Devens. Zones of highest transmissivity within the overburden are generally found in areas of thick glacial meltwater deposits on the former North and Main Posts (e.g., along Cold Spring Brook). Water supply wells, including the Shabokin, Patton, MacPherson, and Grove Pond water supply wells, are all completed within these meltwater deposits and can easily yield several hundred gallons per minute (gpm). Hydraulic conductivity values have been reported to vary between 30 to 300 feet per day (ft/day) in meltwater deposits, while lake bottom sediments are significantly less permeable, with reported hydraulic conductivities ranging from 0.002 to 0.3 ft/day (HLA 2000b). The depth to groundwater across Area 1 ranges from less than 1 foot below ground surface (bgs) to more than 60 feet bgs and averages approximately 15 feet bgs. Overburden groundwater is recharged in upland areas, and flow generally follows topography—from topographic highs to topographic lows, where it discharges to wetlands, ponds, streams, and directly into the Nashua River.

3.1.2.2 *Bedrock*

The zones of lowest groundwater transmissivity at Devens are typically associated with glacial till and fractured bedrock. Groundwater flow occurs in the underlying bedrock; however, it is more restrictive relative to the overburden because the bedrock lacks primary porosity and/or has been impacted by metamorphism. Groundwater in bedrock predominantly flows through secondary porosity features such as fractures, joints, and dissolution voids. While faulting and foliation of the bedrock align with major unit contacts (Figure 3-2), the fracture orientations are less systematic than the foliation patterns (Kopera et al. 2006; GZA GeoEnvironmental, Inc. [GZA] 2011a, 2011b). Therefore, groundwater flow paths in the bedrock are constrained by the resulting (sparse) fracture network and biased by the underlying bedrock fabric, which results in preferential movement along strike (i.e., north-south/northeast-southwest direction) (Kopera et. al. 2006). Domestic bedrock wells on hilltops in crystalline rock in Massachusetts (such as those in the Devens area) have a median yield of 6 gpm (USGS 1994). Observations from the Devens Pathfinder and the Ayer Pathfinder wells (Figure 3-2 and summarized below) support these conclusions.

- **Devens Pathfinder well** (GZA GeoEnvironmental 2011a):
    - Gneiss bedrock.
    - Open hole from 47 to 1,500 feet bgs.
    - Data were analyzed to identify depths at which flow rate changes are attributed to either inflow or outflow.
    - Three transmissive fractures (occurring at 134, 425, and 488 feet bgs) were associated with points of inflow during pumping. Based on borehole geophysics, 77% of the transmissivity was associated with the fracture at 134 feet bgs, 16% of the transmissivity was associated with the fracture at 425 feet bgs, and 7% of the transmissivity was associated with the fracture at 488 feet bgs.
    - Estimated well yield of 30 to 60 gpm based on drilling observations and pump test data analysis.
- **Ayer Pathfinder well** (GZA GeoEnvironmental 2011b):
    - Phyllite and quartzite.
    - Open hole from 220 to 1,506 feet bgs.
    - Data were analyzed to identify depths at which flow rate changes are attributed to either inflow or outflow.
    - Two transmissive fractures (occurring at 302 and 329 feet bgs) were associated with points of inflow during pumping. Based on borehole geophysics, 75% of the transmissivity was associated with the fracture at 302 feet bgs and 25% of the transmissivity was associated with the fracture at 329 feet bgs.
    - Estimated well yield of 70 to 175 gpm based on drilling observations and pump test data analysis.

For both Pathfinder wells, water-yielding bedrock fractures located in the upper 500’ of the boreholes exhibited greater transmissivity than deeper fractures. No distinct, continuous confining unit has been identified between overburden and bedrock. However, the combination of much higher overburden permeability and a limited fracture network in the bedrock (i.e., groundwater preferentially flows within the overburden) likely impedes vertical migration of potential contaminants. Bedrock areas that are most likely to be impacted are areas where there is a thin overburden cover and areas where the water table is within the bedrock. Additional overburden/bedrock well pairs along with additional sampling and analysis of groundwater for PFAS at depth are needed, where data gaps exist, to characterize vertical gradients and the potential for downward migration across Area 1. This is discussed in more detail in Section 3 (Exhibit 3-2) and Section 4 (Exhibit 4-1). Pumping from bedrock may induce localized gradient reversals; however, the flow rates attainable from bedrock supply wells are unlikely to alter overburden flow patterns and induce vertical migration to any meaningful degree.

3.2 Area 1-Specific Physical Characteristics and Hydrogeology

Section 1.3.3 discussed that the boundaries for Area 1 were defined by the areas of overburden groundwater that either discharge to Cold Spring Brook or Grove Pond and/or would eventually be captured by the Shabokin, Patton, or Grove Pond water supply wells. The key physical and hydrogeological characteristics within Area 1 are summarized in this section. A more detailed discussion on the physical characteristics and hydrogeology for each of the identified PFAS-impacted AOCs included in Area 1 is provided as Appendix F.

As described in the previous section (Section 3.1.2), from a regional perspective, groundwater and surface water at Devens generally flow to the north eventually discharging to the Nashua River. Locally, groundwater flow patterns and surface water flow dynamics vary across Area 1 due to the presence of local sources and sinks.

Figure 3-3 presents the overburden water level elevation contours within Area 1 from a synoptic gauging event conducted in March 2020. Except for a limited area in the upgradient portion of AOC 43J where the overburden is either not present or very thin, the water table is present entirely within the overburden across Area 1.

As shown on Figure 3-3, groundwater flow within the overburden generally follows topography—from topographic highs to topographic lows where it discharges to either surface water bodies/wetlands (e.g., Cold Spring Brook, Grove Pond, and Willow Branch), which eventually flow to the Nashua River northwest of Area 1, or is captured by the local water supply wells (e.g., Shabokin, Patton, and Grove Pond wells). Within Area 1, the topographic highs include AOC 43J to the southwest and the hill between AOC 75 and AOC 43G in the central portion of Area 1; whereas the topographic lows run along a northeast/southwest corridor from Mirror Lake then following Cold Spring Brook to Grove Pond. Surface topography on the eastern/southeastern side of Cold Spring Brook rises steeply, and the overburden thickness likely decreases accordingly as the bedrock (or till) and land surface increase in elevation further to the east/southeast.

This northeast/southwest corridor corresponds to a bedrock valley, which is evident on Figure 3-2. Within this bedrock valley, the overburden is relatively thick, with depth to bedrock generally varying between approximately 150 feet bgs to over 300 feet bgs (near Former Building T-1445 in AOC 75). The thickness of the overburden, along with the sequence of sand with gravel that comprise the overburden sediments within this bedrock valley, makes it a favorable location for high-yielding groundwater wells, which is why the Shabokin, Patton, and Grove Pond water supply wells are aligned with this feature. This bedrock valley also correlates with the alignment of Cold Spring Brook.

The local influence of the water supply wells and Cold Spring Brook on the groundwater flow patterns within the overburden are evident on Figure 3-3. The deflection of the water level contours around the Patton and Grove Pond water supply wells, as well as the various surface water bodies (Cold Spring Brook, Willow Branch, and Grove Pond), indicate that these features are acting as local groundwater sinks/discharge boundaries within the overburden. Note that, during the March 2020 gauging event, the Shabokin water supply well was not operational.

Also evident on Figure 3-3 is an apparent groundwater divide that also runs along a northeast/southwest trending line—following an approximate path from AOC 43 to Robbins Pond to AOC 75 to AOC 74. Except for the area around Grove Pond, groundwater south of this divide flows east/southeast towards the bedrock valley (i.e., Shabokin and Patton water supply wells and Cold Spring Brook), while the groundwater north of this divide generally flows to the north/northwest along Willow Branch toward the Nashua River. In the Grove Pond area, overburden groundwater flows to the north either discharging to Grove Pond or is captured by the Grove Pond water supply wells.

As discussed in the preceding section, because of the sparse fracture network present in existing deep bedrock wells (Devens Pathfinder and the Ayer Pathfinder wells) and corresponding low bulk transmissivity, the underlying bedrock across Devens does not appear to be a viable contaminant transport pathway; particularly in relation to the overburden. Furthermore, the bedrock most likely to be impacted are those areas where there is a thin overburden cover and/or areas where the water table is within the bedrock. Within Area 1, the only areas where these conditions exist are within the far upgradient areas of AOC 43J and AOC 43G.

Data collected from previous investigations performed within Area 1 have shown downward vertical hydraulic gradients (from the overburden to bedrock) in the upland areas where recharge likely occurs. However, as groundwater travels toward a surface water body such as Cold Spring Brook, the vertical gradients become upward (from the bedrock to the overburden), providing further evidence that Cold Spring Brook (and the surrounding wetlands) act as a discharge boundary. Additional bedrock monitoring wells are proposed to be installed, as discussed in Sections 3 and 4.

3.3 PFAS Fate and Transport

Once PFAS are released to the environment, they are subject to physical, chemical, and biological processes that influence their distribution in various environmental media. This section provides an overview of PFAS uses and presence in the environment, qualities of PFAS that contribute to their persistence in the environment, and potential routes of migration. This section also summarizes the PFAS mixtures (i.e., “fingerprints”) detected at each AOC to date in groundwater and surface water (if sampled). The data collected to date have been reviewed to identify if there are remaining data gaps (discussed in Section 3.5).

3.3.1 Uses and Presence in the Environment

PFAS are chemicals of anthropogenic origin that have been used in a wide range of industrial applications and in commercial products since the 1940s (U.S. Geological Survey 2021). PFAS, as a group, contains anionic perfluoroalkyl acids (PFAAs) including PFOA and PFOS. PFAS also contain a range of polyfluorinated compounds that can contain negative, positive, zwitterionic, or non-charged functional groups, in addition to a perfluoroalkyl functional group. These products include stain- and water-repellent materials, food packaging, and many retail products. Industrial products, including AFFF, are also known to contain PFAS (ITRC 2020a). The widespread use of PFAS and their persistence in the environment have led to PFAS being present in most environmental media at low levels world-wide (ITRC 2020b). PFAS have been detected at elevated concentrations at a wide variety of environmental sites, including manufacturing facilities and landfills, in addition to airports, military sites, and other large facilities where fires either have occurred or where training to fight fires has been conducted (Concawe 2016).

3.3.2 Contaminant Qualities and Persistence in the Environment

The fate and transport of PFAS can differ from that of other environmental contaminants. The main processes that contribute to these differences and that are more relevant to Area 1 transport are described below. How these processes may impact the Area 1 AOCs, based on Phase I data, is discussed below.

3.3.2.1 *Solubility and Partitioning*

Many individual PFAS, including all the PFAS6, have a high aqueous solubility (PFOA has a reported solubility of 9,500 milligrams per liter [mg/L] at 25 degrees Celsius [°C]; USEPA 2017) and are relatively mobile in groundwater. PFAAs typically have very low acid dissociation constants and are found in their anionic form in aqueous environmental systems. These compounds will hydrophobically partition to soils (organic carbon), electrostatically interact with charged surfaces, and tend to aggregate at air-water interfaces. These partitioning processes influence migration of PFAS through soils in the vadose zone following release, from soil to groundwater at the water table and capillary fringe, in groundwater through soils and sediment, and when discharging from groundwater to surface water (ITRC 2020b). As the perfluoroalkyl chain length increases, PFAAs generally become more sorptive to soils and less mobile in groundwater (Anderson et al. 2019). Generally, perfluoroalkyl carboxylates move more readily from soils to groundwater than perfluoroalkyl sulfonates with an equivalent carbon chain length (i.e., perfluoroalkyl carboxylates sorb less readily to soils) (Anderson et al. 2019).

3.3.2.2 *Leaching from Soils*

Based on the available historical information (Appendix B), the primary release mechanism of PFAS to the environment at AOCs in Area 1 was direct discharge of PFAS-containing materials to the ground surface (KGS 2020a). Leaching of PFAS, both vertically downward through unsaturated (vadose-zone) soils to groundwater can occur during percolation of precipitation, flooding, or irrigation through the soil column in a source area. Studies to date have shown that a significant portion of PFAS mass tends to be retained over time on shallow soils (Sepulvado et al. 2011; Stahl et al. 2013; Anderson et al. 2016; Adamson et al. 2020), particularly for the more retentive longer-chain PFAS and cationic and zwitterionic precursors (Adamson et al. 2020). As mentioned above, perfluoroalkyl carboxylates leach more readily than perfluoroalkyl sulfonates with an equivalent carbon chain length (Anderson et al. 2019).

3.3.2.3 *Transformation and Persistence in the Environment*

PFAAs have not been documented to transform or to degrade under typical ambient environmental conditions, including the environmentally relevant destruction processes of photolysis, hydrolysis, and microbial transformation. Polyfluorinated compounds are capable of partial transformation, initiated in the non-perfluorinated portion of the molecule. These transformations result in multiple transient or meta-stable intermediates, but ultimately generate PFAAs. Because polyfluoroalkyl substances are capable of transformation and transform terminally to PFAAs, they are often referred to as PFAA precursors, or simply precursors. Research as to the extent of PFAA precursors in the environment and their transformation is ongoing.

Two of the compounds currently regulated in groundwater by the USEPA (PFOS and PFOA), were historically manufactured in the greatest quantities, and the six PFAS included in the MMCL for PFAS6 (PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA) are PFAAs that are stable in the environment. Additionally, PFBS and HFPO-DA (GenX), both with SSSLs, are similarly stable in the environment. The total oxidizable precursor (TOP) assay method was run for select samples in Area 1 (KGS 2020a). This method is designed to chemically convert all precursors in a sample into PFAAs, which then can be measured (Houtz and Sedlak 2012; Houtz 2013). Use of the TOP assay can assist with managing PFAS by providing greater certainty over detection of a wide range of compounds within the class, allowing the effective development of CSMs and selection of appropriate management options.

TOP assay was run for a select number of samples collected from the northern AOCs in Area 1. Results were included in Appendix H-4 of the Area 1 PSCS (KGS 2020a) and are provided in Appendix B. Soil samples analyzed for the TOP assay generally exhibited substantial levels of precursors and more precursor mass corresponded to higher concentrations of total organic carbon (TOC) in surface soils. Potential precursors in soils are summarized below:

- A surface soil sample (0 to 0.5 foot bgs) collected from Area 2 of AOC 57 contained PFAA precursor mass, as demonstrated by the production of PFHpA, PFHxA, PFOA, PFBA, and perfluoropentanoic acid (PFPeA) during the TOP assay. The predominant generation of short-chain perfluorinated carboxylic acids suggested that most of the precursor mass contained short-chain polyfluoroalkyl groups. Some data quality issues were present with this sample pair, as both PFOS and PFDA mass declined in the post-TOP assay sample.

- A surface soil sample (0 to 0.5 foot bgs) and subsurface soil sample (3 to 7 feet bgs) collected from AOC 74 each contained PFAA precursor mass, as demonstrated by the production of PFHpA, PFHxA, PFNA, PFOA, PFBA, and PFPeA during the TOP assay. The concentration of total PFAS increased approximately 10-fold in the post-TOP assay sample for both samples, and the total PFAS measured post-TOP assay was approximately 30% higher in the subsurface sample. Both long- and short-chain precursors were indicated by the compounds generated during the TOP assay, but the subsurface sample contained a higher proportion of short-chain compounds. The concentration of TOC in the subsurface was only slightly less than that in the surface sample (11,000 milligrams per kilogram [mg/kg] and 13,000 mg/kg, respectively).

- A surface soil sample (0 to 0.5 foot bgs) collected from AOC 75 contained no detectable PFAS in the pre-TOP assay sample, and a small detection of PFBA post-TOP assay. Negligible PFAS, including precursors, were indicated by this sample.
- Three surface soil samples (0 to 0.5 foot bgs) collected from the Grove Pond area contained PFAA precursor mass, as demonstrated by the production of PFHpA, PFHxA, PFNA, PFOA, PFDA, PFBA, and PFPeA. The concentration of total PFAS increased 3- to 25-fold in the post-TOP assay samples for these samples. Both long- and short-chain precursors were indicated by the compounds generated during the TOP assay. In three subsurface samples (0.5 to 3, 15 to 17, and 26 to 28 feet bgs), post-TOP assay and pre-TOP assay concentrations were similar to one another, suggesting minimal precursor presence. The concentration of TOC in the subsurface (not detected at the LOD of 2,000 mg/kg) was less than the average concentration detected in the surface soils (approximately 14,200 mg/kg).

Potential precursors in select groundwater samples are summarized below:

- At AOC 57, there were minimal increases in the concentration of total PFAS post-TOP assay in the three groundwater samples analyzed by the TOP assay. Where increases were observed, they were predominantly in PFHxA in a sample collected from 20 to 30 feet bgs at the northwest corner of the 112 Barnum Road facility (5702MW-19-01A) and in a sample from 30 to 40 feet bgs downgradient of the Area 2 source area (5702MW-20-05A). This observation is consistent with the presence of minor amounts of short-chain precursors in these groundwater samples. In a sample collected from 30 to 40 feet bgs in the Area 3 source area (5703MW-20-02A), total PFAS did not increase post-TOP assay.
- At AOC 75, there were modest increases in the concentration of total PFAS post-TOP assay in the two groundwater samples analyzed by TOP assay. Increases occurred predominantly in PFHxA, PFPeA, and PFBA in groundwater collected at 37.5 to 47.5 feet bgs adjacent to the PFAS source area (75MW-19-02A) and from 20 to 30 feet bgs between the source area and Cold Spring Brook (75MW-19-04A). This observation is consistent with the presence of minor amounts of short-chain precursors in these groundwater samples.
- In the Grove Pond wellfield area, total PFAS concentrations were similar pre- and post- TOP assay results in the one sample analyzed for TOP assay (i.e., a sample collected from 45 to 55 feet bgs to the southwest of the Grove Pond wellfield [GPMW-19-01A]). Thus, negligible precursors were observed in this sample. This observation is consistent with the lack of precursors indicated by the TOP assay in the Grove Pond subsurface soil samples.

The presence of precursors in soil and to a lesser extent groundwater in the select areas mentioned above indicates a potential to observe stable or increasing concentrations of PFAAs both over time and, relatedly, with distance from a PFAS source area.

3.3.3 Potential Routes of Contaminant Migration

Known PFAS releases at Area 1 were primarily from direct discharge of AFFF or waste commercial/industrial products containing PFAS to the ground surface (e.g., during firefighting efforts or resulting from the storage and repair of vehicles), or discharge of waste containing PFAS to the subsurface via wet wells or cesspools before septic and stormwater systems were installed.

The potential routes of contaminant migration in Area 1 include:

- Releases to surface and subsurface soils → transport via leaching to groundwater → discharge to surface water → partitioning to sediment
- Releases to surface and subsurface soils → erosion/stormwater runoff → discharge to surface water → partitioning to sediment
- Potential uptake in aquatic biota (e.g., fish) from surface water.

These potential routes of PFAS migration and their effects on potential human exposure routes and scenarios are described further in Section 3.4.

3.3.4 Preliminary Summary of Contamination

The investigations conducted to date have identified individual PFAS compounds and their concentrations across soil, groundwater, surface water, and sediment samples within Area 1. The types and amounts of PFAS detected in an environmental sample reflect the PFAS source impacting the sample and the environmental processes that have caused PFAS to transform and migrate. Furthermore, the ratios of individual PFAS constituents detected in an environmental sample provide information that can help in identifying PFAS in groundwater related to separate sources. In soil, consistent relative percentages of specific PFAS across different samples may indicate common sources; the types and relative amounts of different PFAS in a sample are referred to herein as the PFAS "fingerprint." Differential transport and transformation of individual PFAS may partially account for a difference in PFAS fingerprints across multiple environmental samples located within the same area.

The relative concentrations and mixture of PFAS in soil and groundwater can help indicate the location and direction of a particular PFAS source, as described below:

- Total PFAS concentrations will typically be the highest in soil and groundwater near the source area and gradually decline along the hydraulically downgradient groundwater pathway (Adamson et al. 2020). Hydraulically upgradient, PFAS concentrations will typically be much lower than those observed near the source or immediately downgradient of the source.
- It is typical to see different fingerprints between co-located soil and groundwater samples due to different partitioning coefficients of individual PFAS.
- Relatedly, differential transport of PFAS due to sorption to soils and partitioning at the air-water interface (described in Section 3.3.2) can result in a change in the dominant PFAS compound(s) at the distal portion of a plume relative to the source area. PFAS with shorter carbon chains will, in general, migrate more readily into and in groundwater. For example, PFHxA has been documented to have a lower organic carbon-water partition coefficient (KOC) than PFOA (log KOC of 1.3 versus log KOC of 1.89 to 2.63, respectively; ITRC 2020b). If a groundwater sample was composed of 50% PFOA and 50% PFHxA in the source area, it is likely that PFHxA would be the more dominant compound in downgradient groundwater due to there being a higher degree of sorption to soil organic carbon by PFOA (thereby attenuating it from advective transport in groundwater) than PFHxA.
- PFAS precursor transformation to terminal products (PFAAs) via biotic and abiotic processes can also affect the PFAS fingerprint in groundwater with increasing distance from the source area. Aerobic conditions in groundwater generally support transformation of precursor PFAS, if present, to PFAAs.

AOC-specific discussions of PFAS fate and transport are included as Appendix G. The maximum detection of each PFAS at each location sampled for groundwater in Area 1 is shown on Figure 3-4a and in more detail on Figure 3-4b, Figure 3-4c, and Figure 3-4d. A pie chart showing the maximum detected PFAS concentration relative to other detections at that same location is shown where PFAS was measured, regardless of whether the concentration exceeded the MMCL for PFAS6.

Additional potential migration mechanisms of PFAS to surface water include overland flow from unpaved areas (such as during rain events that might carry soils with sorbed PFAS) or aerial deposition from non-Army sources. Low concentrations of PFAS have been detected in surficial soils across the globe (Brusseau et al. 2020), and are attributed to aerial deposition, among other transport mechanisms.

Groundwater, soil, surface water, sediment, and fish tissue data will be collected as part of the Phase II Area 1 activities. The samples collected during Phase II will be analyzed using USEPA Method 1633, which will provide an expanded list of PFAS parameters. Analytical PFAS results, along with the results from collection of field parameters, and results from other proposed activities (seismic surveying, borehole geophysics, packer testing, synoptic water level gauging) will be reported and compared to the assessments below.

3.3.4.1 *Northeastern Portion of Area 1*

The northeastern portion of Area 1 includes the northwest side of Cold Spring Brook, the southern shore of Grove Pond, and the areas of AOCs 75, 57, 74, and Grove Pond wellfield. As shown by Figure 3-3, groundwater in the areas of AOC 75, 57, and 74 flow toward and discharge to Cold Spring Brook to the southeast. Groundwater at AOC 74 also flows north toward the Grove Pond wellfield. Groundwater in the Grove Pond wellfield area and on the northern side of Barnum Road in the northeast portion of Area 1 generally flows to the north to discharge to Grove Pond, with groundwater in the southern portion of the MAARNG Property flowing to the Grove Pond wellfield. PFAS mixtures in this portion of Area 1 indicate:

- A variety of materials containing PFAS were released in this area. Generally, two primary mixtures are evident and result from different materials and activities:
    - Perfluoroalkyl carboxylates PFOA, PFHpA, and PFHxA are generally present in groundwater in the areas that were used for vehicle storage and motor repair (Building 3713 area, MAARNG property, Former Vehicle Storage and Motor Repair Shops [AOC 57]). Generally, PFHxA is more enriched in groundwater located hydraulically downgradient from the source areas, as it has the lowest KOC and is the most mobile in groundwater compared to PFOA and PFHpA.
    - To the north and south of those areas (AOC 75 and closer to the southern shoreline of Grove Pond), there is a mixture of (in order of maximum concentration) PFOS, PFHxS, and PFOA that are generally related to AFFF. PFOS, known to be a primary ingredient in 3M-branded AFFF formulations that were approved for use by MilSpec. Downgradient from the source area/release location in groundwater (at 75MW-19-04A for example), PFHxS is the dominant compound in the PFAS fingerprint. PFHxS is a minor component of the PFAS fingerprint in soil because it is readily desorbed to water. PFHxS is both an ingredient of and breakdown product of precursors found in 3M-branded AFFF formulations. PFOA is found in relatively similar ratios in both soil and groundwater, is a breakdown product and/or constituent of AFFF and is more mobile (has a lower estimated KOC) than PFOS.
- Groundwater from the areas of AOCs 75, 57, and 74 discharge to Cold Spring Brook (AOC 74 groundwater also flows north toward the Grove Pond wellfield). Surface water samples collected along the northwestern bank of Cold Spring Brook reflect the PFAS mixtures of upgradient groundwater mixtures: 1) downgradient of the area of AOC 75, PFHxS is the dominant compound; 2) downgradient of AOC 57, the concentration of PFAS in surface water increases and there is more PFOA, PFHxA, and PFHpA detected, which reflects the PFAS mixture in groundwater in the area of AOC 57 and; 3) in

surface water samples collected adjacent to the area of AOC 74, the concentration of PFAS decreases and PFOA and PFHxA are present more distinctly, as is the case in AOC 74 groundwater.

- The PFAS mixture detected in Grove Pond surface water is approximately 32% PFOA, 20% PFHxA, 14% PFOS, and 13% PFHxS and PFHpA. This mixture includes more PFOA and less PFHxA and other compounds than the PFAS in groundwater detected in the upgradient Grove Pond wellfield area (MAARNG property), where PFHxA (33%) and PFHpA (31%) are the dominant PFAS. This difference indicates other contributions to Grove Pond, which includes flow from Cold Spring Brook.
- The PFAS mixture at the Grove Pond supply wells (pre-treated water) consists of approximately 31% PFHxA, 23% PFHpA, and 17% PFOA. This mixture nearly matches to the mixture of PFAS in Grove Pond wellfield area groundwater upgradient of the supply wells at depths of 50 to 100 feet bgs, at 35% PFHxA, 22% PFHpA, and 16% PFOS, indicating that groundwater from the Grove Pond wellfield area reaches the supply wells. Groundwater from AOC 74 partially contributes to this mixture.
- PFAS mixtures detected in off-post private wells to the southeast of Cold Spring Brook differ from those detected in Area 1, and differential transport of PFAS does not explain the mixture variation between the two areas. PFOA and PFOS are the most common PFAS detected in this area off-post, followed by PFBS. These data indicate that there may be off-post sources of PFAS that are impacting the off-post private supply wells.

3.3.4.2 *Southwestern Portion of Area 1*

The southwestern portion of Area 1 includes Robbins Pond, Cold Spring Brook Pond (the former location of AOC 40), Mirror Lake, and the Patton and Shabokin supply wells. This area also includes AOC 43G, former AOC 40, and AOC 43J. What is most notable about the southwestern portion of Area 1, as compared to the northeastern portion, is the difference in concentration of PFAS in groundwater (typically an order of magnitude less in the southwest than in the northeast) and the diffuse and widespread footprint of PFAS in groundwater exceeding the MMCL.

As shown by Figure 3-3, groundwater in the overburden at AOC 43G flows to the northeast to discharge to Robbins Pond and to travel along Willow Branch. Groundwater in the former AOC 40 area flows both to the northeast along Cold Spring Brook, and to the southwest toward Patton supply well and Mirror Lake. Groundwater to the southwest in the area of AOC 43J flows downhill to Mirror Lake. Shabokin supply well water looks to be primarily sourced from Mirror Lake, with some contributions from groundwater to the east and west (Appendix F shows this in much more detail).

PFAS mixtures in this portion of Area 1 indicate:

- The three primary PFAS in soil and groundwater are PFOS, PFOA, and PFHxS, which are generally consistently present in the PFAS fingerprints downgradient of the source area. There is one VP location to the north of Robbins Pond (43GVP-19-08) that exhibits a greater concentration of PFOS than adjacent locations associated with AOC 43G, which may indicate a separate source.
- The PFAS mixture detected in Patton well influent correlates with the mixture detected in groundwater at the former AOC 40 landfill, with a mixture of PFOA, PFHxS, and PFHxA dominating and the primary compound being PFOA. PFOA is detected in hydraulically upgradient AOC 40 at approximately 50% of the mixture.
- The PFAS mixture in the surface water of Cold Spring Brook Pond (the former location of AOC 40) matches that of local groundwater. Cold Spring Brook Pond is the source of Cold Spring Brook.
- Detections of PFAS in groundwater exceeding the MMCL and SSSLs to the northwest of Shabokin supply well are present at AOC 43J, where USTs and former dry wells and cesspools were in place in the past to support gas station, motor pool, and vehicle storage and maintenance at the property. Groundwater in

that area has PFOA as the dominant compound (30%), with PFHpA, PFOS, and PFHxA at lower concentrations. While AOC 43J is the furthest upgradient currently identified potential contributor to the northwest of Shabokin supply well, the concentration of PFAS in this area is similar to that detected in and adjacent to Shabokin supply well and the mixture of PFAS in the supply well is different, with greater than 50% of the PFAS detected at Shabokin supply well being PFHxS. PFAS mixtures can change along the flow path due to differential transport, but this mechanism does not account for this difference; PFHxS has not yet been confirmed to be a terminal biotransformation product of other PFAS. The PFAS detections in groundwater at this location are low in concentration both at and immediately downgradient of AOC 43J and throughout the entire Shabokin supply well area, and do not point to an ongoing source.

- Shabokin supply well has similar PFAS content as the adjacent groundwater (comprised in large party by PFHxS, PFOA, and PFHxA) and to upgradient Mirror Lake (PFHxS and PFOA are the highest concentration compounds detected in surface water).

Detections in off-post private wells located to the east of the AOC 40 and Patton supply well area have similar percentages of PFOA as part of the mixture, with some differences in other compounds (PFBS and PFHxS present in larger concentrations off-post) that cannot be explained by differential transport. There is also a difference between the aquifers this data has been collected from; AOC 40 area data is related to the overburden aquifer, while many of the off-post private wells are screened in bedrock. Bedrock investigation in the Blanchard Road area will be performed as part of Phase II.

3.4 Potential Receptors and Exposure Pathways

This section presents a preliminary, general understanding of potential human and ecological receptors and exposure pathways based on the current and most likely future land uses within PFAS Area 1.

3.4.1 Human Receptors and Exposure Pathways

Area 1 encompasses a portion of the former Main Post and is currently used for rail-, industrial-, or trade-related activities; recreational open space (including Red Tail Golf Course); and government/industrial purposes (VHB 1994). It is anticipated that future land use will be consistent with current land use (VHB 1994).

The Devens Reuse Plan identifies major reuse themes for Devens (VHB 1994). These themes and how they relate to Area 1 are:

- **Rail-, Industrial-, and Trade-related Uses:** Capitalize on the former Fort Devens unique rail, intermodal, and highway attributes and incorporates the existing rail yard in the northeast corner of the former Main Post. This applies to AOCs 57, 74, and 75. This land use is considered commercial/industrial.
- **Innovation and Technology Business:** Includes businesses that are growing and have new products, technologies, or services. This applies to AOCs 43G and 43J. This land use is considered commercial/ industrial.
- **Open Space and Recreation:** While large portions of Devens have been set aside for open space and recreation, the recreational uses of land within Area 1 are primarily limited to passive recreational activities, such as walking, picnicking, and running (Nashua River Watershed Association [NRWA] 2008). This applies to the lower Cold Spring Brook wetlands near AOCs 57, 74, and 75 and the upper Cold Spring Brook wetlands near AOC 40. Mirror Lake, located between the Patton and Shabokin water supply wells, is used for active recreation (e.g., fishing and swimming) and is permanently protected by a Conservation Restriction (NRWA 2008). No athletic fields or public hunting areas are located within Area 1.

Based on the current and reasonably anticipated future land uses, potential human receptors may include drinking water users from existing water supply wells, commercial/industrial workers, construction workers, utility workers, recreational users, and anglers. Residential development within Area 1 is not a realistic future scenario; however, a hypothetical future residential scenario (i.e., exposure to soil and groundwater used as a source of drinking water) will be included to evaluate an unrestricted use/unlimited exposure (UU/UE) scenario. .

The exposure media of concern for human receptors potentially include surface soil (0 to 0.5 foot bgs), subsurface soil (0.5 to 15 feet bgs [or the depth to groundwater, whichever comes first]), groundwater, surface water, sediment, and fish.

Generally, human exposure to PFAS in soil may potentially occur through incidental ingestion, dermal contact, and inhalation (particulates). However, inhalation of constituents in soil released to outdoor air as particulates is generally not evaluated because inhalation toxicity values are not currently available for PFAS.

Human exposure to PFAS in groundwater may occur through tapwater ingestion or dermal contact during hand washing and other uses of potable water. Devens receives drinking water from a municipal utility that sources raw water from groundwater wells. Evaluation of potential connections between locations of the greatest detected concentrations of PFAS in groundwater at Devens and drinking water resources both within Devens (Patton and Shabokin water supply wells) and surrounding areas (Grove Pond wellfield) is a primary objective of the PFAS Phase II RI. Engineering controls are in place to treat PFAS in municipal water wells located at Devens. Additionally, administrative controls (i.e., deed restrictions) prevent future well installations and potable use of groundwater at Devens. Although potential use of untreated groundwater as a potable water source is unlikely, the groundwater exposure pathway for drinking water users will be evaluated.

Direct exposure to DoD-related impacts in groundwater may occur through incidental ingestion and dermal contact if shallow groundwater (i.e., groundwater at depths less than 10 feet bgs) is encountered during site excavation for utility maintenance or repair.

Exposure to PFAS in surface water and sediment, in this case resulting from transport of groundwater containing PFAS to surface water and sediment, may occur via incidental ingestion and dermal contact. Although there are fish consumption advisories of “eat none” due to mercury impacts in Mirror Lake, Grove Pond, and Plow Shop Pond, potential exposure to PFAS through fish consumption may potentially occur. This exposure pathway will be evaluated using the fish tissue data (proposed for collection from Mirror Lake, Grove Pond, Plow Shop Pond, Cold Spring Brook, Cold Spring Brook Pond, Robbins Pond, Nashua River).

In summary, potential human receptors may include drinking water users from existing water supply wells, commercial/industrial workers, construction workers, utility workers, recreational users, and anglers. Human exposure may occur through incidental ingestion, dermal contact, and inhalation of PFAS in soil and sediment; through incidental ingestion of and dermal contact with PFAS in groundwater and surface water; and via fish consumption pathways.

3.4.2 Ecological Receptors and Exposure Pathways

Most of Area 1 is developed into buildings, paved areas, and maintained grassed areas. These areas provide limited habitat for ecological receptors. The undisturbed portions of Area 1 provide habitat and include wooded uplands and successional open fields.

The aquatic habitat at Area 1 includes lakes and ponds (e.g., Mirror Lake, Grove Pond), streams (e.g., Cold Spring Brook), wetland areas, and vernal ponds. Ecological receptors in aquatic areas may be exposed to PFAS in surface water and sediment. Aquatic plants, invertebrates, fish, amphibians, and reptiles may be exposed to PFAS in surface water and sediment through direct contact. Birds and mammals may be exposed to PFAS in sediment through incidental ingestion and to PFAS in surface water through drinking water ingestion. Birds and mammals may also be exposed to PFAS by uptake through the aquatic food web. The average depth to groundwater in Area 1 is approximately 15 feet bgs, thereby preventing potential ecological exposure.

3.5 Area 1 Remedial Investigation Data Gaps

Data gaps for the Area 1 PFAS RI were evaluated based on whether the following study questions, related to the DQOs described above, could be answered using Phase I RI data alone or if additional (Phase II) field investigation would be required to meet those objectives. The questions include:

1. Are there portions of Area 1 where soil sampling to assess suspected PFAS release areas has not been performed, or portions of Area 1 where the PFAS fingerprint in groundwater suggests the potential for a separate source of PFAS?
2. Are there monitoring wells that can be sampled to establish EPCs in places where the greatest PFAS concentrations in groundwater were identified during Phase I RI activities?
3. Have the migration pathways of PFAS from Area 1 to receptors been assessed?
4. Is there sufficient data to perform an HHRA and SLERA?

If the response to any of these questions is “No,” additional investigation is required, and the scope for the associated investigation is included in Section 4. The results of the DQO screening questions are shown in the subsections below.

3.5.1 Question 1: Are there portions of Area 1 where soil sampling to assess suspected PFAS releases has not been performed, or portions of Area 1 where the PFAS fingerprint in groundwater suggests the potential for a separate source of PFAS?

During the Phase I RI, soil samples were collected from portions of Area 1 identified in the Remedial Investigation Work Plan for PFAS (KGS 2020b). Sampling locations were based on the analysis of groundwater samples from existing long-term monitoring wells and/or interviews conducted as part of the Devens PFAS PA (KGS 2017). Exhibit 3-1 below summarizes whether the collection of additional soil samples is necessary, or if the existing soil data is sufficient.

Exhibit 3-1: Locations of Greatest PFAS Concentrations in Soil - Data Gap Analysis

Portion of Area 1	Data Gap?	Soil Sampling Locations Representative of Each Area, Collected During the Phase I RI
Northeast	No – Existing soil data is sufficient	• 19 soil samples were collected at AOC 57 Area 3 from four soil borings (5703SB-19-01 to 5703SB-19-04) during Phase I investigations, based on the analysis of PFAS in groundwater samples collected from existing LTM wells. No samples exceeded the SSSLs. • 35 soil samples were collected at AOC 74 from seven soil borings (74SB-19-01 to 74SB-19-07) during Phase I, based on the location of former firefighter activities behind Building 3773. No samples exceeded the SSSLs. • 48 soil samples were collected at AOC 75 from 10 soil borings (75SB-19-01 to 75SB-19-10), based on the location of the warehouse fire. No samples exceeded the SSSLs.

Exhibit 3-1: Locations of Greatest PFAS Concentrations in Soil - Data Gap Analysis (continued)

Portion of Area 1	Data Gap?	Soil Sampling Locations Representative of Each Area, Collected During the Phase I RI
Northeast (continued)	Yes – Additional soil sampling proposed	• Five soil borings (5702SB-23-01 to 5702SB-23-05) are to be installed in and adjacent to AOC 57 Area 2 to bound exceedances of the SSSLs in soil. Samples collected at two soil borings out of the 13 sampled exceeded the SSL: The PFOS SSL was exceeded at 5702SB-19-04 and 5702SB-19-07 from 0 to 0.5 feet bgs. These results are bounded vertically by samples at 0.5 to 3 feet bgs and deeper at both locations. • 22 soil borings (GPSB-23-01 to GPSB-23-22) are to be installed in the Grove Pond Wellfield Area, near the former pump house in the northeast corner of the area, and adjacent to former Building 3713, to the west-southwest of the area, to evaluate the presence of PFAS in soils. ▪ Numerous low volume releases are anticipated to have happened in the past across the MAARNG property, based on the use of these areas. In the Grove Pond Wellfield Area, samples collected at three soil borings out of the nine sampled exceeded the SSL: o The PFOS SSL was exceeded at GPSB-19-01 from 0 to 0.5 feet bgs. This result is bounded vertically by samples at 0.5 to 3 feet bgs and deeper. o The PFOS SSL was exceeded at GPSB-19-05 from 0 to 0.5 and 0.5 to 3 feet bgs. These results are bounded vertically by samples at 3 to 7 feet bgs and deeper. o The PFOS SSL was exceeded at GPSB-19-08 from 0 to 0.5 and 0.5 to 3 feet bgs. These results are bounded vertically by samples at 3 to 7 feet bgs and deeper. • Eight soil borings (75SB-23-01 to 75SB-23-08) are to be installed to the west of AOC 75, where PFAS are present exceeding the SSSLs and MMCLs in groundwater, but there was no documented activity related to AFFF use. The fingerprint of PFAS in groundwater in this area is similar to that of the fingerprint at downgradient AOC 75.
Southwest	Yes – Additional soil sampling proposed	• Four soil borings (PWSB-23-01 to PWSB-23-04) to be installed in and adjacent to former AOC-40. Previously sampled soils at PWSB-19-01 through PWSB-19-04 did not exceed the SSSLs. • Nine soil borings (43JSB-23-01 to 43JSB-23-09) are to be installed at AOC 43J, in locations where subsurface features such as USTs and dry wells were present in the past. • Three soil borings (43GSB-23-01 to 43GSB-23-03) to be installed in and adjacent to AOC 43G to bound SSSL exceedances. At AOC 43G, samples collected at two soil borings out of the eight sampled exceeded the SSL: ▪ The PFOS SSL was exceeded at 43GSB-19-02 from 0.5 to 3 feet bgs. This result is bounded vertically by samples at 3 to 7 feet bgs and deeper. ▪ The PFOS SSL was exceeded at 43GSB-19-03 from 0.5 to 3 feet bgs. This result is bounded vertically by samples at 3 to 7 feet bgs and deeper. ▪ The PFOA SSL was exceeded at 43GSB-19-03 at 7 to 15 feet bgs. This result is bounded vertically by samples at 3 to 7 feet bgs and shallower, and 23 to 25 feet bgs.

3.5.2 Question 2: Are there monitoring wells that can be sampled to establish EPCs in places where the greatest PFAS concentrations in groundwater were identified during Phase I RI activities?

During the Phase I RI, groundwater samples were collected both from monitoring wells and from temporary VP points sampling. Exhibit 3-2 below summarizes whether installation of a monitoring well to establish EPCs at each of the locations with the greatest concentrations of PFAS identified during Phase I is necessary, or if a monitoring well is already in place for this purpose.

Exhibit 3-2: Locations of Greatest PFAS Concentrations in Groundwater - Monitoring Well Data Gap Analysis

Portion of Area 1	Data Gap?	VP Location or Monitoring Well(s) Representative of the Highest Concentrations of PFAS Detected During Phase I
Northeast	No – Monitoring Well in Place	• Monitoring well 5702MW-20-05A (screened from 30 to 40 feet bgs, where PFAS6 was detected at 4,150 ng/L on February 24, 2020) is representative of the greatest concentration of PFAS in groundwater in AOC 57 Area 2. This monitoring well was installed during Phase I investigations based on the greatest PFAS6 results observed within Area 2 at VP location 5702VP-18-08. • Monitoring well 5703MW-20-02A (screened from 10 to 20 feet bgs, where PFAS6 was detected at 1,000 ng/L on February 13, 2020) is representative of the greatest concentration of PFAS in groundwater in AOC 57 Area 3. This monitoring well was installed during Phase I investigations based on the greatest PFAS6 results observed within Area 3 at VP location 5703VP-18-04. • Several monitoring wells are in place throughout the MAARNG Property that are representative of PFAS in groundwater in this area, including MNG-2R, MNG-5R, MNG-6R, GPMW-19-01A, and MNG-3R. Groundwater samples collected from these locations exhibit PFAS6 concentrations relatively the same as for the discrete samples collected from VPs across the area.
	Yes – Monitoring Well Installation is Proposed	• Monitoring well to be installed at Phase I VP locations 74VP-18-05, 74VP-18-09, and 74VP-20-01 adjacent to AOC 74. • Monitoring well to be installed to the northeast of AOC 74. • Monitoring well to be installed at Phase I VP location 75VP-19-01 adjacent to AOC 75. • Monitoring wells to be installed at Phase I VP locations 5703VP-20-01 and adjacent to location 5702MW-20-07A in AOC 57. • Monitoring well to be installed at Phase I VP location 5702VP-19-09 in the Former Building 3713 Area. • Monitoring wells to be installed at Phase I VP locations GPVP-19-08 and GPVP-19-10 on the MAARNG property. • Monitoring well to be installed at Phase I VP location GPVP-18-12, adjacent to the former pump house.
Southwest	No – Monitoring Well in Place	• Monitoring well XJM-94-07X (screened from 3.7 to 13.7 feet bgs, where 51 ng/L PFAS6 was detected on December 19, 2018) is representative of the greatest concentration of PFAS in groundwater in AOC 43J.
	Yes – Monitoring Well Installation is Proposed	• Monitoring well to be installed at Phase I VP location PWVP-19-04 in the area of the Patton supply well/former AOC 40.

Note: MMAARNG = Massachusetts Army National Guard

3.5.3 Question 3: Have the migration pathways of PFAS from Area 1 to receptors been assessed?

During the Phase I RI, soil and groundwater samples were collected from multiple depths at AOCs to determine the migration pathway of PFAS in the environment. At AOCs adjacent to surface water bodies, surface water samples, and in some cases sediment samples, were collected to determine if PFAS in groundwater were discharging to surface water. PFAS fingerprint data support the evaluation of migration pathways in groundwater and surface water where PFAS may be present from more than one area. For example, there are exceedances of the MassDEP PFAS6 criteria in VP groundwater samples from AOC 57 Area 1 that have a similar PFAS fingerprint to PFAS in groundwater associated with the AOC 75 AFFF release and can be attributed to releases at the AOC 75 source area rather than a release in the AOC 57 Area 1 (discussed in Appendix G). PFAS fingerprints in surface water samples collected hydraulically downgradient from groundwater containing PFAS have similar mixtures to that of the upgradient groundwater, indicating that groundwater is discharging to surface water at those locations.

Exhibit 3-3 below summarizes these preliminary findings and informs decisions about whether additional investigation is required based on the question, “Have the migration pathways of PFAS from Area 1 to receptors been assessed?”

Exhibit 3-3: Migration Pathway Data Gap Analysis

Portion of Area 1	Area	Have the migration pathways of PFAS to receptors been assessed?		How do the data support identification of the migration pathway(s) or what additional data are needed?
Northeast	Former Vehicle Storage and Motor Repair Shops Site (AOC 57)	Groundwater Aquifer (Vertical Extent)	Yes	• Monitoring well 5702MW-20-05B (screened from 70 to 80 feet bgs and located adjacent to high-concentration monitoring well 5702MW-20-05A) confirms the vertical extent of PFAS in AOC 57 Area 2. PFAS6 was detected at 0.510 ng/L in this well on February 28, 2020, and PFAS with SSSLs were either not detected or below the applicable SSSL. • VP 5703VP-18-04 (adjacent to high-concentration monitoring well 5702MW-20-05A) confirmed the vertical extent of PFAS in AOC 57 Area 3. PFAS6 was not detected from 62 to 82 feet bgs (total depth of VP), and PFAS with SSSLs were not detected.
		Discharge Location and Receptors	Yes and No	• Discharge of groundwater to Cold Spring Brook has been assessed based on hydrogeologic data and PFAS detections in Phase I VP samples and the fingerprint of PFAS detected in surface water. • One set of paired monitoring wells will be completed to verify the vertical hydraulic gradient adjacent to Cold Spring Brook in AOC 57 Area 2 (5702MW-23-01, to complement existing shallower screened monitoring wells 57M-03-03X, 57WP-06-02, 57M-03-04X, and 5702MW-20-07A) and Area 3 (proposed monitoring wells 5703MW-23-01A and 5703MW-23-01B). One in-stream piezometer (CSBPZ-23-02) will also be installed for measuring the hydraulic gradient. • To assess migration to receptors, VP sampling and installation of overburden and bedrock monitoring wells will be performed off post to the southeast of Cold Spring Brook. See Sections 4.2.3 and 4.2.4 for more detail.

Exhibit 3-3: Migration Pathway Data Gap Analysis (continued)

Portion of Area 1	Area	Have the migration pathways of PFAS to receptors been assessed?		How do the data support identification of the migration pathway(s) or what additional data are needed?
Northeast (continued)	Barnum Road Firefighting Exercise Site (AOC 74)	Groundwater Aquifer (Vertical Extent)	No	• The vertical extent of PFAS in groundwater will be confirmed through installation and sampling of monitoring well 74MW-23-01B, a deep overburden well to be co-located with the proposed high-concentration location monitoring well 74MW-23-01A at Phase I VP location 74VP-18-05.
		Discharge Location and Receptors	Yes and No	• Discharge of groundwater to Cold Spring Brook has been assessed based on hydrogeologic data and PFAS detections in Phase I VP samples and the fingerprint of PFAS detected in surface water. • One monitoring well will be installed adjacent to and screened deeper than monitoring well 74MW-19-04A, adjacent to Cold Spring Brook, to verify vertical hydraulic gradient. One in-stream piezometer (CSBPZ-23-03) will also be installed for measuring the hydraulic gradient. • VP sampling and installation of overburden and monitoring wells will be performed to the southeast of Cold Spring Brook to assess migration to receptors. See Sections 4.2.3 and 4.2.4 for more detail.
	Former Building T-1445 Warehouse Fire (AOC 75)	Groundwater Aquifer (Vertical Extent)	Yes	• The vertical extent of PFAS in groundwater has been confirmed to not extend into bedrock through installation of monitoring wells and sampling performed during Phase I. Monitoring well 75MW-19-02BR, screened from 308 to 318 feet bgs, exhibited a PFAS6 concentration of 2.8 ng/L on March 26, 2020, and PFAS with SSSLs were either not detected or below the applicable SSSL.
		Discharge Location and Receptors	Yes and No	• Discharge of groundwater to Cold Spring Brook has been assessed based on hydrogeologic data and PFAS detections in Phase I VP samples and the fingerprint of PFAS detected in surface water. • The vertical gradient was assessed during Phase I by installation, gauging, and sampling of paired monitoring wells (75MW-19-04A and 75MW-19-04B) upgradient of Cold Spring Brook. One in-stream piezometer (CSBPZ-23-01) will also be installed for measuring the hydraulic gradient. • VP sampling and installation of overburden and monitoring wells will be performed to the southeast of Cold Spring Brook to assess migration to receptors. See Sections 4.2.3 & 4.2.4 for more detail.
	Grove Pond Wellfield Area: MAARNG Property and Former Building 3713 Area	Groundwater Aquifer (Vertical Extent)	Yes and No	• The vertical extent of PFAS in groundwater was confirmed from Phase I VP samples and/or samples collected from existing monitoring wells in most locations, most notably at: o Bedrock monitoring wells GPMW-19-01BR (screened in bedrock from 175 to 185 feet bgs, PFAS6 was nondetect when sampled on December 4, 2019, and PFAS with SSSLs were either not detected or below the applicable SSSL), GF-1 (screened in bedrock from 116 to 121 feet bgs, PFAS6 was detected at 7.58 ng/L when sampled on October 5, 2018, and PFAS with SSSLs were either not detected or below the applicable SSSL), GF-2 (screened in bedrock from 114 to 121 feet bgs, PFAS6 was detected at 4.10 ng/L when sampled on October 5, 2018, and PFAS with SSSLs were either not detected or below the applicable SSSL).

Exhibit 3-3: Migration Pathway Data Gap Analysis (continued)

Portion of Area 1	Area	Have the migration pathways of PFAS to receptors been assessed?		o How do the data support identification of the migration pathway(s) or what additional data are needed?
Northeast (continued)	Grove Pond Wellfield Area: MAARNG Property and Former Building 3713 Area (cont'd)	Groundwater Aquifer (Vertical Extent)	Yes and No	o VP 5702VP-19-09 in the former Building 3713 area, where PFAS6 was below the MMCL and all PFAS with SSSLs were either nondetect or below the SSSLs from 67 feet bgs to the bottom of the borehole at 101 feet bgs. • The vertical extent of PFAS in groundwater at Phase I VP location GPVP-18-12, adjacent to the former pumphouse, will be confirmed through installation and sampling of deep overburden well, GPMW-23-01B. Bedrock well GPMW-23-01BR at that location will be installed if groundwater at well GPMW-23-01B exceeds the MMCL and/or SSSLs.
		Discharge Location and Receptors	Yes	• Discharge of groundwater to Grove Pond has been assessed based on hydrogeologic data and PFAS detections in Phase I VP samples and the fingerprint of PFAS detected in surface water. • Vertical upward gradient was assessed adjacent to Grove Pond during Phase I at paired monitoring wells GPMW-19-01A and GPMW-19-01BR. One in-pond piezometer (GPPZ-23-01) will also be installed for measuring the hydraulic gradient.
Southwest	Cold Spring Brook Landfill (AOC 40) and Patton Water Supply Well Area	Groundwater Aquifer (Vertical Extent)	No	• The vertical extent of PFAS in groundwater will be confirmed through installation and sampling of deep overburden well PWMW-23-01B, to be co-located with high-concentration location proposed monitoring well PWMW-23-01A at the Phase I VP location PWVP-19-04. Bedrock well PWMW-23-01BR at will be installed if PFAS in groundwater at well PWMW-23-01B exceeds the MMCL and/or SSSLs. • Several additional monitoring wells will be installed to the east of AOC 40 both on post and off post to assess for migration to off-post receptors.
		Discharge Location and Receptors	Yes and No	• Discharge of groundwater to Cold Spring Brook Pond has been assessed based on hydrogeologic data and PFAS detections in Phase I VP samples and the fingerprint of PFAS detected in surface water. Groundwater from the westernmost portion of this AOC also flows to the southeast toward the Patton supply well and Mirror Lake. • The vertical gradient will be verified by installation of one set of paired monitoring wells adjacent to Cold Spring Brook Pond, PWMW-23-01A and PWMW-23-01B. • Several monitoring wells are proposed to the east of AOC 40 along the Devens property boundary and beyond, along Blanchard Road (including vertical profiling along Blanchard Road), to assess if migration of PFAS from AOC 40 to off-post receptors is occurring. See Sections 4.2.3 and 4.2.4 for more detail.

Exhibit 3-3: Migration Pathway Data Gap Analysis (continued)

Portion of Area 1	Area	Have the migration pathways of PFAS to receptors been assessed?		How do the data support identification of the migration pathway(s) or what additional data are needed?
Southwest (continued)	Historical Gas Station J (AOC 43J) and Shabokin Water Supply Well Area	Groundwater Aquifer (Vertical Extent)	Yes and No	• The vertical extent of PFAS in groundwater will be confirmed through the installation and sampling of bedrock monitoring well 43JMW-23-01BR, to be screened deeper than adjacent overburden monitoring well SWMW-20-01A. • Hydraulically upgradient to the northwest at AOC 43J, PFAS results in groundwater at monitoring wells XJM-97-13X (screened from 41.5 to 51.5 feet bgs) and HA-4B (screened from 35.8 to 43.8 feet bgs) confirmed the vertical extent of PFAS when sampled in 2020 and 2019, respectively, due to being below both the PFAS6 and SSSLs. • The vertical extent of PFAS along the southern boundary of the area will be confirmed either with VP sampling or installation and sampling of monitoring well(s), as access enables, in the area of proposed location SWVP-23-01.
		Discharge Location and Receptors	Yes and No	• Discharge of groundwater to Mirror Lake has been assessed based on hydrogeologic data and PFAS detections in Phase I VP samples and the fingerprint of PFAS detected in surface water. • Additional VP locations and monitoring wells are proposed to characterize groundwater flow to the south and west of the area (SWVP-23-01, SWVP-23-03, and SWVP-23-04, as well as the associated proposed monitoring wells at those locations). • The spring located to the southeast of AOC 43J will be sampled for PFAS if flowing (proposed surface water sampling location SWSW-23-01). • Monitoring well SWMW-23-02 will be installed at Phase I VP location SWVP-19-03, where all samples (from 47 to 91 feet bgs) were below the MMCL and the SSSLs.

3.5.4 Question 4: Is there sufficient data to perform human health and screening level ecological risk assessments?

The Phase I data and the proposed Phase II samples were reviewed to ensure that a sufficient number of data points are collected to conduct an HHRA and SLERA. Table 3-1 summarizes the number of groundwater, soil, surface water, and sediment samples collected during Phase I, and the results of those samples compared to SSSLs. Proposed Phase II groundwater, soil, sediment, surface water, and fish tissue samples, and the purpose of the Phase II sampling are also summarized in the table. The findings of this review are as follows:

- Phase I analytical soil data indicate a lack of exceedances of SSSLs at AOC 57 Area 3, AOC 74, and AOC 75. No additional soil sampling is proposed in these areas and the Phase I soil data will be sufficient for risk assessment purposes. Soil sampling is proposed for AOC 57 Area 2; the Grove Pond Wellfield Area, near the former pump house, and adjacent to former Building 3713; an area upgradient of AOC 75; AOC 40; AOC 43G; and AOC 43J. The purpose of the soil sampling is to bound exceedances of SSSLs or characterize potential impacts in areas not previously sampled. These Phase II soil data in combination with Phase I soil data will be sufficient for risk assessment purposes.

- Phase I analytical surface water data indicate a lack of exceedances of SSSLs. While the quantity and locations of Phase I surface water samples are adequate for risk assessment purposes, another round of surface water sampling was deemed necessary to provide data concurrent with groundwater samples. Therefore, as part of the Phase II RI activities, surface water samples will be collected from each of the 31 locations sampled at Area 1 during Phase I plus eight new locations. These Phase II surface water data in combination with Phase I surface water data will be sufficient for risk assessment purposes.
- Phase I analytical sediment data indicate a lack of exceedances of SSSLs. While the quantity and locations of Phase I sediment samples are adequate for risk assessment purposes, eight additional sediment sample locations are proposed in areas not previously sampled. These Phase II sediment data in combination with Phase I sediment data will be sufficient for risk assessment purposes.
- Phase I analytical groundwater data were reviewed for the number and locations of monitoring wells. Additional monitoring wells will be installed as part of Phase II RI activities and will be placed to evaluate nature and extent of PFAS in groundwater, including the areas of highest groundwater impacts. VP sampling data will be used to determine PFAS presence or absence in groundwater and assist in placement of monitoring wells, but will not be used in the HHRA. Rather, data from the fixed monitoring wells, because of their reproducibility, will be used in the quantitative HHRA. The two rounds of groundwater data that will be collected from the existing and proposed monitoring wells will be sufficient for risk assessment purposes.
- Fish tissue samples for PFAS analysis were not collected during the Phase I RI. Fish will be sampled from Grove Pond, Plow Shop Pond, Cold Spring Brook, Cold Spring Brook Pond, Mirror Lake, Robbins Pond, and the Nashua River as part of Phase II RI activities. Two fish fillet samples (composed of fillets from at least five fish each) from sample locations in each water body are proposed. Two composite samples from each sample location in the seven water bodies will be sufficient to fill the identified data gap and characterize potential human exposure.

As summarized above in Exhibits 3-1 through 3-3, additional data collection is proposed to support the Phase II RI. The scope for the associated investigation is included in Section 4.

4 Remedial Investigation Implementation

This section presents the comprehensive project approach, methods, and operational procedures to be used for the Phase II RI. Detailed descriptions are presented in the QAPP Addendum (Appendix A). Proposed locations for sampling are discussed in Section 4.2.

4.1 Methodology

Field activities will be conducted in accordance with the following TGIs, which are included in the QAPP Addendum (Appendix A):

- TGI – Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling (all media) Guidance
- TGI – PFAS Sampling Procedures and Low-Flow Groundwater Purging for Monitoring Wells
- TGI – Equipment and Reagent Blank Sample Collection for PFAS Analysis
- TGI – Utility Location
- TGI – PFAS Drilling and Well Installation
- TGI – Monitoring Well Development
- TGI – Manual Water-Level Monitoring
- TGI – In-Situ and Ex-Situ Water Quality Parameters
- TGI – Sample Chain of Custody
- TGI – Investigation-Derived Waste Handling and Storage
- TGI – Groundwater and Soil Sampling Equipment Decontamination
- TGI – Soil Description
- TGI – Sediment, Surface Water, and Stormwater Sample Collection for PFAS Analysis
- TGI – Vertical Aquifer Profiling
- TGI – Fish Sampling Procedures
- TGI – Field Processing for Fish Samples Procedures
- TGI – Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells.

Additional details regarding the methodology of the investigation activities proposed are provided as Appendix H. These activities include:

- Site preparation – Conducted before any intrusive activities are conducted. Preparation activities will include (but are not limited to) notifying the Massachusetts Digsafe system, clearing each drilling location of utilities with ground-penetrating radar, conducting a detailed visual site inspection and reviewing existing plans, and using soft dig methods to a depth of 5 feet bgs.

- Seismic profile surveying – Conducted prior to the installation of proposed bedrock well installation locations, in order to obtain additional information on bedrock topography and depth to competent bedrock. Anticipated seismic methods will include seismic refraction and passive surface wave methods.
- Vertical groundwater profiling – Shallow vertical profile location methods will be installed using direct-push methods, and it is anticipated that deeper vertical profile locations will need to be installed using sonic drilling methods. As described on Exhibit 4-1 and Exhibit 4-2 in the following section, most vertical profile locations will be installed prior to the installation of permanent monitoring wells at their respective locations to assess concentrations in the respective area and determine the appropriate well screen interval(s) for permanent monitoring wells.
- Overburden monitoring well installation – Overburden monitoring wells will be installed using direct-push, sonic, or drive-and-wash techniques, depending on the specific drilling locations. As described in Exhibit 4-1 and Exhibit 4-2, some overburden well construction (screen interval) details have already been pre-determined based on previously collected groundwater data. However, the screen intervals on most proposed overburden well locations will be determined following the installation of vertical profile locations.
- Bedrock monitoring well installation, including borehole geophysics and packer testing – Bedrock monitoring well installation will generally occur after the installation of vertical profile locations and overburden monitoring wells. As described in Exhibit 4-3, some proposed bedrock monitoring wells are contingent based on the overburden groundwater analytical results. The construction details of bedrock wells will be determined based on borehole geophysics and packer testing.
- Monitoring well development – Well development will be completed following the installation of monitoring wells, using a submersible pump and surge block. Open bedrock borehole will be initially developed with the drill rig using air-lift methods.
- Soil sampling – Soil samples will be collected from several portions of Area 1. Soil descriptions will be recorded in accordance with the Unified Soil Classification System. The following will be recorded from each soil core at a minimum: depth interval, recovery, particle size (Udden-Wentworth), sorting, angularity/plasticity/dilatancy, principal and minor components, moisture, consistency/density, and color. When possible, the recovered soil cores will be photographed.
- Groundwater sampling and water level measurements – Groundwater samples will be collected during the installation of vertical profile borings. Groundwater samples will also be collected from all newly installed monitoring wells, in addition to a subset of existing monitoring wells in each investigation area during the spring (April/May; higher water table) and fall (October/November; lower water table).
- Surface water sampling - Surface water samples will be collected from locations that were previously sampled in 2018 and/or 2020 and from eight additional locations (Figure 4-12). Surface water samples will be collected from immediately below the water surface using the procedures appropriate given site conditions and may include direct collection in the sample jar and/or use of a peristaltic pump. Due to chemical properties of PFAS, concentrations of PFAS in the surface water near a discharge location may be higher at or near the surface. Collecting samples near the surface is considered a worst-case scenario (ITRC 2022).
- Sediment sampling – Sediment samples will be collected from eight locations not previously sampled in 2018 and/or 2020 Phase I RI work (Figure 4-12). Sediment sampling methods may include the use of Lexan liner sleeves, stainless steel sleeves, or Petite Ponar grab samplers.
- Fish tissue sampling – Fish tissue samples will be collected and analyzed to evaluate potential angler exposure via fish consumption. Sampling methods may include electrofishing, seining, gillnetting, trap netting, or angling.

- PFAS-specific field guidance – Special considerations will be made throughout each of the above field activities regarding PFAS-containing materials and cross-contamination potential.

- Waste management - Investigation-derived waste generated during the proposed activities will include purged groundwater and drill cuttings, as well as general site refuse. Waste management procedures are presented in Worksheet #17-12 of the QAPP and will be managed in accordance with previous waste management practices at Devens.

- Surveying - All sampling locations will be surveyed for the location, elevation of the ground surface, and top of well casing if a monitoring well was installed. In locations where monitoring wells are not being installed, locations will be marked and/or staked after drilling activities have been completed to ensure the accuracy of the survey.

The Site Safety and Health Plan that will guide the proposed investigation activities is provided as an attachment to Appendix A.

4.2 Proposed Phase II Remedial Investigation Activities

This section details the proposed investigation activities for seismic profile surveying, in addition to sampling of soil, overburden groundwater, bedrock groundwater, surface water, sediment, and fish tissue. All proposed soil investigation locations are shown on Figure 4-2 through Figure 4-7. All proposed groundwater investigation locations are shown on Figure 4-8 and are depicted with more detail on Figure 4-9a through Figure 4-10b. Proposed off-post sampling locations are shown on Figure 4-11. Surface water, sediment, and fish tissue sampling locations are shown on Figure 4-12.

4.2.1 Seismic Profile Surveying

The locations where seismic profile surveying will be performed are shown on Figure 4-1 (see Appendix H for details on the seismic profile methodology). A rationale for each of the proposed seismic survey lines shown on Figure 4-1 is detailed below in Exhibit 4-1:

Exhibit 4-1: Seismic Survey Line Rationale

Seismic Line Number	Proposed Seismic Method(s)	Number of PSW Segments	Total Length of PSW Data Collection Line (feet)	Number of 48-Geophone Refraction Spreads (20-foot spacing)	Total Length of Refraction Line including Far Off-set shots (feet)	Rationale for Seismic Data Collection
1	PSW	1	940	N/A	N/A	Data gap in bedrock depth information. The line spans an area near valley center with over 120 feet of overburden thickness. Will aid in positioning bedrock wells and improving bedrock elevation contour map.
2	PSW	1	940	N/A	N/A	Data gap in bedrock depth information. The line spans east slope of bedrock valley. Will aid in improving bedrock elevation contour map.
3	PSW	3	2820	N/A	N/A	Data gap in bedrock depth information. Line located in transition from bedrock high to the north to the bedrock valley to the south. Passes near Devens Pathfinder Well which will be used to calibrate the seismic data. Will aid in positioning bedrock well and improving bedrock elevation contour map.
4	PSW	2	1880	N/A	N/A	Data gap in bedrock depth information. The line lies on the east slope of bedrock valley. Will aid in positioning bedrock well and improving bedrock elevation contour map.
5	PSW	2	1880	N/A	N/A	Data gap in bedrock depth information. Line located in transition from bedrock high to the west to the bedrock valley to the east. Will aid in improving bedrock elevation contour map.
6	PSW	2	1880	N/A	N/A	Data gap in bedrock depth information. The line spans an area near bedrock valley center with between 100 to over 190 feet of overburden thickness. Will aid in positioning bedrock wells and improving bedrock elevation contour map.
7	PSW	2	1880	N/A	N/A	Data gap in bedrock depth information. The line spans an area near bedrock valley center with between 160 and 190 feet of overburden thickness. Will aid in positioning bedrock wells and improving bedrock elevation contour map.
8A	PSW	1	940	N/A	N/A	Data gap in bedrock depth information. The line spans an area near bedrock valley center with between 200 and 260 feet of overburden thickness. Will aid in improving bedrock elevation contour map.
8B	PSW	1	940	N/A	N/A	

Exhibit 4-1: Seismic Survey Line Rationale (continued)

Seismic Line Number	Proposed Seismic Method(s)	Number of PSW Segments	Total Length of PSW Data Collection Line (feet)	Number of 48-Geophone Refraction Spreads (20-foot spacing)	Total Length of Refraction Line including Far Off-set shots (feet)	Rationale for Seismic Data Collection
9	PSW	2	1880	N/A	N/A	Data gap in bedrock depth information. The line spans an area near bedrock valley center with between 120 and 180 feet of overburden thickness. Will aid in positioning bedrock wells and improving bedrock elevation contour map.
10	PSW	1	740	N/A	N/A	Data gap in bedrock depth information. The line spans an area southwest of the bedrock valley center in a potential bedrock high. Will be calibrated with information from nearby Shabokin Well. Will aid in improving bedrock elevation contour map.
11	PSW	4	2820	N/A	N/A	
12	Refraction & PSW	3	2820	3	3780	Data gap in bedrock depth information. These three lines are oriented within the bedrock valley. Data from the Ayers Pathfinder Well will be used to calibration the seismic. Will aid in positioning bedrock wells and improving bedrock elevation contour map.
13	Refraction & PSW	3	2820	3	3780	
14	Refraction & PSW	3	2820	3	3780	
15	Refraction & PSW	1	940	1	1900	Data gap in bedrock depth information. The line spans west slope of bedrock valley from 20 feet on the west to over 240 feet of overburden thickness to the east. Will aid in positioning bedrock wells and improving bedrock elevation contour map.
16	PSW	1	940	N/A	N/A	Data gap in bedrock depth information. The line spans an area near bedrock valley center with between 180 and 210 feet of overburden thickness. Will aid in improving bedrock elevation contour map.

4.2.2 Soil Sampling

Data gaps identified in Exhibit 3-1 above will be addressed through the installation of additional soil borings. These locations are shown on Figures 4-2 through 4-7, along with previously installed soil borings and a summary of historical soil quality in relation to the SSSLs. Exhibit 4-2 below details the proposed Phase II RI locations. Detailed figures showing the proposed locations are described below:

- Figure 4-2: Former Cold Spring Brook Landfill (AOC 40)
- Figure 4-3: Historical Gas Station G (AOC 43G)
- Figure 4-4: Historical Gas Station J (AOC 43J)
- Figure 4-5: Former Vehicle Storage and Motor Repair Shops (AOC 57) and Former Building 3713 Area
- Figure 4-6: Grove Pond Wellfield Area
- Figure 4-7: Former Building T-1445 Warehouse Fire (AOC 75)

Exhibit 4-2: Proposed Soil Sampling Locations

Figure	Data Gap to be Addressed	Proposed Location ID	Location	Estimated Depth to Groundwater (feet bgs)	Proposed Sampling Intervals (feet bgs)
4-2	Sample soils to the north and south of Cold Spring Brook Pond.	PWSB-23-01 to PWSB-23-04	AOC 40	5	0-0.5, 0.5-3, 3-7*, 7-15*
4-3	Sample soils to bound SSSL exceedances identified during Phase I.	43GSB-23-01 to 43GSB-23-03	AOC 43G	20	0-0.5, 0.5-3, 3-7, 7-15
4-4	Sample soils to evaluate presence/absence of PFAS. Soil borings are placed in locations where subsurface features (such as USTs and dry wells) were present in the past.	43JSB-23-01 to 43JSB-23-09	AOC 43J	6	0-0.5, 0.5-3, 3-7*, 7-15*
4-5	Sample soils to bound SSSL exceedances identified during Phase I.	5702SB-23-01 to 5702SB-23-05	AOC 57	8-20	0-0.5, 0.5-3, 3-7, 7-15*
	Sample soils to evaluate presence/absence of PFAS.	GPSB-23-23 to GPSB-23-30	Building 3713 Area	27	0-0.5, 0.5-3, 3-7, 7-15
4-6	Install borings near the former pump house in the northeast corner of the area, to evaluate the presence of PFAS in soils.	GPSB-23-01 to GPSB-23-03	Grove Pond Wellfield	15	0-0.5, 0.5-3, 3-7, 7-15
	Install borings to evaluate presence/absence of PFAS across Grove Pond Wellfield area and to bound SSSL exceedances identified during Phase I.	GPSB-23-04 to GPSB-23-22		20-35	0-0.5, 0.5-3, 3-7, 7-15
4-7	Sample soils to the west of AOC 75 to evaluate if PFAS is present in soils in this area where PFAS is present exceeding the SSSLs and MMCLs in groundwater.	75SB-23-01 to 75SB-23-08	AOC 75	20	0-0.5, 0.5-3, 3-7, 7-15

Note: * If the water table is encountered at a depth shallower than the bottom depth of these intervals, the deepest sample will end at the water table depth.

4.2.3 Investigation Activities to Assess Groundwater Exposure Point Concentrations and Migration Pathways (On Post)

Data gaps identified in Exhibits 3-2 and 3-3 above will be addressed through installation of additional VP profile points, monitoring wells, piezometers, and stream gages. These locations are shown on Figure 4-8. Exhibit 4-3 below includes the proposed Phase II RI locations, associated Phase I locations, and proposed well screen depths, if applicable. Detailed figures showing the proposed locations are described below:

- Figure 4-9a: Shows the northeastern most portion of Area 1 and includes the Grove Pond Wellfield Area and the Barnum Road Firefighting Exercise Site (AOC 74).
- Figure 4-9b: Shows the area just southwest of the northeastern portion of Area 1 and includes Former Vehicle Storage and Motor Repair Shops (AOC 57) and the Former Building T-1445 Warehouse Fire (AOC 75).
- Figure 4-10a: Shows the northeastern portion of the southwestern section of Area 1 and includes the Patton water supply well, former location of the Cold Spring Brook Landfill (AOC 40), Historical Gas Station G (AOC 43G), and the Queenstown Road area.
- Figure 4-10b: Shows the southwestern most portion of Area 1 and includes the Shabokin water supply well and Historical Gas Station J (AOC 43J).

Exhibit 4-3: On-Post Proposed Groundwater Investigation Locations

Figure	Data Gap to be Addressed	Proposed Location ID	Location Type	Phase I Reference Location(s)	Screen Interval (feet bgs)
4-9a	Install monitoring well to confirm PFAS concentrations in groundwater where it was detected at the highest concentrations during Phase I	74MW-23-01A	MW (OB)	74VP-18-05	45-55
	Install monitoring well to confirm the vertical extent of PFAS in groundwater	74MW-23-01B	MW (OB)		105-115
	Install monitoring well to confirm the vertical hydraulic gradient of groundwater adjacent to the location of surface water discharge	74MW-23-02	MW (OB)	74MW-19-04A	70-80
	Confirm the extent of PFAS concentrations in groundwater to the northeast of AOC 74, install monitoring well to confirm the lateral extent	74VP-23-01 74MW-23-03	MW (OB)	None	TBD
	Install monitoring well where PFAS was detected at the greatest concentration at the water table	74MW-23-04	MW (OB)	74VP-20-01	12-22
	Confirm surface water head (no sample collected for analysis)	CSBPZ-23-03	PZ	CSB-20-06	TBD
	Install monitoring well to confirm PFAS concentrations in groundwater where it was detected at the highest concentrations during Phase I	GPMW-23-01A	MW (OB)	GPVP-18-12	45-55
	Install monitoring well to confirm the vertical extent of PFAS in groundwater	GPMW-23-01B	MW (OB)		100-110

Exhibit 4-3: On-Post Proposed Groundwater Investigation Locations (continued)

Figure	Data Gap to be Addressed	Proposed Location ID	Location Type	Phase I Reference Location(s)	Screen Interval (feet bgs)
4-9a (cont'd)	Install monitoring well to confirm the vertical extent of PFAS in groundwater if GPMW-23-01B groundwater exceeds the MMCL	GPMW-23-01BR	MW (BR)		TBD
	Install monitoring well to confirm PFAS concentrations in groundwater where it was detected at the highest concentrations during Phase I	GPMW-23-02	MW (OB)	5702VP-19-09	25-35
	Assess if migration to off-site receptors is occurring	GPVP-23-01	VP	Southeast of GPVP-18-05	--
		GPMW-23-03	MW (OB)		TBD
		GPMW-23-03BR	MW (BR)		TBD
	Confirm PFAS concentration in groundwater and head at midpoint of Building 3713 and MAARNG area plumes	GPMW-23-04	MW (OB)	GPVP-19-08	42-52
	Confirm PFAS concentration in groundwater and groundwater elevation cross-gradient from the MAARNG area	GPMW-23-05	MW (OB)	GPVP-19-10	65-75
	Confirm surface water head (no sample collected for analysis)	GPPZ-23-01	PZ	GP-18-04	TBD
	Confirm the vertical hydraulic gradient of groundwater adjacent to the location of surface water discharge	5703MW-23-01A	MW (OB)	5703VP-20-01	30-40
		5703MW-23-01B	MW (OB)		70-80
4-9b	Confirm the vertical hydraulic gradient of groundwater adjacent to the location of surface water discharge	5702MW-23-01	MW (OB)	Adjacent to 5702MW-20-07A	70-80
	Confirm surface water head (no sample collected for analysis)	CSBPZ-23-02	PZ	CSB-20-04	TBD
	Install monitoring well to confirm PFAS concentrations in groundwater where it was detected at the highest concentrations during Phase I	75MW-23-01	MW (OB)	75VP-19-01	25-35
	Confirm surface water head (no sample collected for analysis)	CSBPZ-23-01	PZ	CSB-20-02	TBD
4-10a	Confirm the vertical extent of PFAS in groundwater and the vertical hydraulic gradient in bedrock at this local high	75MW-23-02BR	MW (BR)	75MW-19-01BR	TBD
	Confirm the vertical extent of PFAS in groundwater and the vertical hydraulic gradient in bedrock	43GMW-23-01BR	MW (BR)	XGM-20-01A	TBD
	Confirm PFAS concentrations in groundwater where it was detected at a high concentration in a different area than the release attributed to AOC 43G	43GMW-23-02	MW (OB)	43GVP-19-08	45-55
	Confirm the vertical extent of PFAS in groundwater (installation contingent on overburden monitoring well results)	43GMW-23-02BR	MW (BR)		TBD

Exhibit 4-3: On-Post Proposed Groundwater Investigation Locations (continued)

Figure	Data Gap to be Addressed	Proposed Location ID	Location Type	Phase I Reference Location(s)	Screen Interval (feet bgs)
4-10a (cont'd)	Confirm PFAS concentrations in groundwater at this location where the AOC 43G PFAS plume meets Willow Branch and the bedrock high to the east-northeast	43GMW-23-03	MW (OB)	43GVP-19-30	90-100
	Confirm the vertical extent of PFAS in groundwater (installation contingent on overburden monitoring well results)	43GMW-23-03BR	MW (BR)		TBD
	Confirm surface water head (no sample collected for analysis)	43GSG-23-01	SG	None	--
	Confirm the groundwater elevation in this area to better map the overburden groundwater flow direction (no sample collected for analysis)	43GPZ-23-01	PZ	None	TBD based on observed water table
	Confirm the vertical hydraulic gradient of groundwater adjacent to the location of surface water discharge (no sample collected for analysis)	CSBPSG-23-01	SG	None	--
	Install monitoring well to confirm PFAS concentrations in groundwater where it was detected at the highest concentrations during Phase I, and confirm the vertical hydraulic gradient of groundwater adjacent to the location of surface water discharge	PWMW-23-01A	MW (OB)	PWVP-19-04	20-30
	Install monitoring well to confirm the vertical extent of PFAS in groundwater, and confirm the vertical hydraulic gradient of groundwater adjacent to the location of surface water discharge	PWMW-23-01B	MW (OB)		100-110
	Install monitoring well to confirm the vertical extent of PFAS in groundwater if PWMW-23-01B groundwater exceeds the MMCL	PWMW-23-01BR	MW (BR)		TBD
	Assess if migration to off-site receptors is occurring	PWMW-23-02	MW (OB)	PWVP-19-11	5-15
		PWMW-23-02BR	MW (BR)		TBD
		PWMW-23-03	MW (OB)	East of PWVP-19-07	15-25
		PWMW-23-03BR	MW (BR)		TBD
	Confirm groundwater flow direction and the location of surface water discharge	PWMW-23-04	MW (OB)	PWVP-20-01	110-120
	Confirm groundwater flow direction and the horizontal extent of the OU north of Queenstown Road	PWVP-23-01	VP	North of Queenstown Road	--
		PWMW-23-05	MW (OB)		TBD
	Install monitoring well to confirm the vertical extent of PFAS in groundwater if PWMW-23-05 is dry or if groundwater there exceeds the MMCL	PWMW-23-05BR	MW (BR)		TBD

Exhibit 4-3: On-Post Proposed Groundwater Investigation Locations (continued)

Figure	Data Gap to be Addressed	Proposed Location ID	Location Type	Phase I Reference Location(s)	Screen Interval (feet bgs)
4-10b	Install monitoring well to confirm the vertical extent of PFAS in groundwater if SWMW-20-01A exceeds the MMCL when resampled.	43JMW-23-01BR	MW (BR)	SWMW-20-01A	TBD
	Confirm PFAS concentration in this area and groundwater flow direction	43JVP-23-01	VP	None	--
		43JMW-23-02	MW (OB)		TBD
	Confirm the vertical hydraulic gradient of groundwater adjacent to the location of surface water discharge (no sample collected for analysis)	MLSG-23-01	SG	None	--
	Assess if migration to off-site receptors is occurring, confirm the vertical extent of PFAS in groundwater	SWVP-23-01	VP	Southwest of Shabokin Well	--
		SWMW-23-01A	MW (OB)		TBD
	Install monitoring well to confirm the vertical extent of PFAS in groundwater if SWMW-23-01A exceeds the MMCL and/or SWVP-23-01 does not confirm the vertical extent of PFAS in groundwater	SWMW-23-01B	MW (OB)		TBD
	Confirm groundwater flow direction and assess if migration to off-site receptors is occurring	SWMW-23-02	MW (OB)	SWVP-19-03	TBD
	Confirm groundwater flow direction and the concentration of PFAS in groundwater to the northeast of the Shabokin supply well	SWVP-23-02	VP	Northeast of SWVP-19-05	--
		SWMW-23-03	MW (OB)		TBD
	Confirm groundwater flow direction and assess if migration to off-site receptors is occurring	SWVP-23-03	VP	West of SWVP-20-03	--
		SWMW-23-04	MW (OB)		TBD
		SWVP-23-04	VP	West of SWVP-19-06	--
		SWMW-23-05	MW (OB)		TBD

Notes:
AOC = Area of Contamination
BR = bedrock
feet bgs = feet below ground surface
MMCL = Massachusetts Maximum Contaminant Level
MW = monitoring well
NA = not applicable
OB = overburden
OU = operable unit
TBD = to be determined
VP = vertical aquifer profile

Existing monitoring wells to be sampled are included in Table 4-1. These locations will be sampled and water levels at each location will be measured twice, once in fall and once in spring.

4.2.4 Investigation Activities to Confirm Migration Pathways (Off Post)

As detailed in Exhibit 4-4 below and shown on Figure 4-11, six VP points, 10 monitoring wells, three piezometers, and three stream gauges are proposed to be installed to address data gaps off post.

Exhibit 4-4: Off-Post Proposed Groundwater Investigation Locations

Study Question	Proposed Location ID	Location Type	Proposed Screen Interval Depth (feet bgs)
Does underflow of PFAS in overburden groundwater exceeding the MMCL occur under Cold Spring Brook? If yes, have those PFAS migrated there from a release at Devens?	CSVP-23-01	VP	--
	CSMW-23-01	MW (OB)	TBD based on VP results
	CSVP-23-02	VP	--
	CSMW-23-02	MW (OB)	TBD based on VP results
	CSMW-23-03BR	MW (BR)	TBD based on geophysics / packer testing
	CSVP-23-03	VP	--
	CSMW-23-04	MW (OB)	TBD based on VP results
	CSVP-23-04	VP	--
	CSMW-23-05	MW (OB)	TBD based on VP results
	CSMW-23-06BR	MW (BR)	TBD based on geophysics / packer testing
	CSPZ-23-01	PZ	TBD based on observed water table
	CSPZ-23-02	PZ	TBD based on observed water table
	CSPZ-23-03	PZ	TBD based on observed water table
	CSSG-23-01	SG	--
	CSSG-23-02	SG	--
	CSSG-23-03	SG	--
Is PFAS exceeding the MMCL present in overburden groundwater along Blanchard Road, to the east of AOC 40? If yes, have those PFAS migrated there from a release at Devens?	BRVP-23-01	VP	--
	BRMW-23-01	MW (OB)	TBD based on VP results
	BRMW-23-01BR	MW (BR)	TBD based on geophysics / packer testing
	BRVP-23-02	VP	--
	BRMW-23-02	MW (OB)	TBD based on VP results
	BRMW-23-02BR	MW (BR)	TBD based on geophysics / packer testing

Notes:
-- = not applicable
SG = staff gage

Specific study questions to be addressed in this area with the proposed scope include:

- **Does underflow of PFAS in overburden groundwater exceeding the MMCL occur under Cold Spring Brook? If yes, have those PFAS migrated there from a release at Devens?** Vertical profiling of groundwater will be performed, followed by installation of overburden monitoring wells (CSMW-23-01, CSMW-23-02, CSMW-23-04, and CSMW-23-05). Overburden piezometers (CSPZ-23-01 to CSPZ-23-03) and stream gages (CSSG-23-01 to CSSG-23-03) will also be installed. Data from these locations will be used in conjunction with data from the western (Devens) side of Cold Spring Brook to evaluate groundwater flow and discharge patterns. Groundwater samples will be analyzed for PFAS, and fingerprint analysis will be conducted to evaluate the potentials sources of PFAS, where present.

- **Is PFAS exceeding the MMCL present in overburden groundwater along Blanchard Road, to the east of AOC 40? If yes, have those PFAS migrated there from a release at Devens?** Vertical profiling of groundwater will be performed, followed by installation of overburden monitoring wells (BRMW-23-01 and BRMW-23-02). Data from these locations will be used in conjunction with data from the former location of AOC 40 and Patton water supply well area, as well as data to be collected on post along the property boundary, between the former location of AOC 40 and Blanchard Road (off post). Groundwater samples will be analyzed for PFAS, and fingerprint analysis will be conducted to evaluate the potentials sources of PFAS, where present.

4.2.5 Investigation Activities to Confirm Migration Pathways in Fractured Rock

As summarized in Exhibit 4-5 below and shown on Figures 4-1 and 4-8, a total of 15 bedrock boreholes are proposed to be installed throughout Area 1. The installation of three of the 15 locations will be contingent upon PFAS concentrations in overburden groundwater.

Exhibit 4-5: Proposed Bedrock Monitoring Well Locations

Study Question	Proposed Location ID
Does PFAS detected in overburden and/or weathered bedrock exceeding the MMCL extend into competent bedrock at concentrations exceeding the MMCL?	43GMW-22-01BR
	43GMW-22-02BR
	43GMW-22-03BR
	43JMW-23-01BR
	75MW-23-02BR
Is PFAS exceeding the MMCL present in groundwater in bedrock along the Devens boundary and/or to the east of AOC 40? If yes, have those PFAS migrated there from a release at Devens?	BRMW-23-01BR
	BRMW-23-02BR
Is PFAS exceeding the MMCL present in the groundwater south-southeast of Cold Spring Brook? If yes, have those PFAS migrated there from a release at Devens?	CSMW-23-03BR
	CSMW-23-06BR
Does PFAS detected in overburden and/or weathered bedrock exceeding the MMCL extend into competent bedrock at concentrations exceeding the MMCL?	**Contingency location.** GPMW-23-01BR
Is PFAS exceeding the MMCL present in groundwater in bedrock at the northeast corner of Area 1?	GPMW-23-03BR
Does PFAS detected in overburden and/or weathered bedrock exceeding the MMCL extend into competent bedrock at concentrations exceeding the MMCL?	**Contingency location.** PWMW-23-01BR
Is PFAS exceeding the MMCL present in groundwater in bedrock along the Devens boundary and/or to the east of AOC 40? If yes, have those PFAS migrated there from a release at Devens?	PWMW-23-02BR
	PWMW-23-03BR
Does PFAS detected in overburden and/or weathered bedrock exceeding the MMCL extend into competent bedrock at concentrations exceeding the MMCL?	**Contingency location.** PWMW-23-05BR

Specific study questions to be addressed in bedrock with the proposed scope include:

- **Does PFAS detected in overburden and/or weathered bedrock exceeding the MMCL extend into competent bedrock at concentrations exceeding the MMCL?** The vertical extent of PFAS in bedrock groundwater downgradient of AOC 43J will be evaluated through installation and sampling of a bedrock monitoring well adjacent to, and screened deeper than, monitoring well SWMW-20-01A (proposed location 43JMW-23-01BR). This will be done only if PFAS6 at monitoring well SWMW-20-01A is sampled and continues to exceed the MMCL. In addition, contingent monitoring wells GPMW-23-01BR (Grove Pond wellfield), PWMW-23-01BR (Patton water supply well area), and PWMW-23-05BR (northwest of Queenstown Road) will be installed based on PFAS results in proposed co-located overburden groundwater sampling locations (temporary VP and/or permanent monitoring wells, as described in Exhibit 4-2).

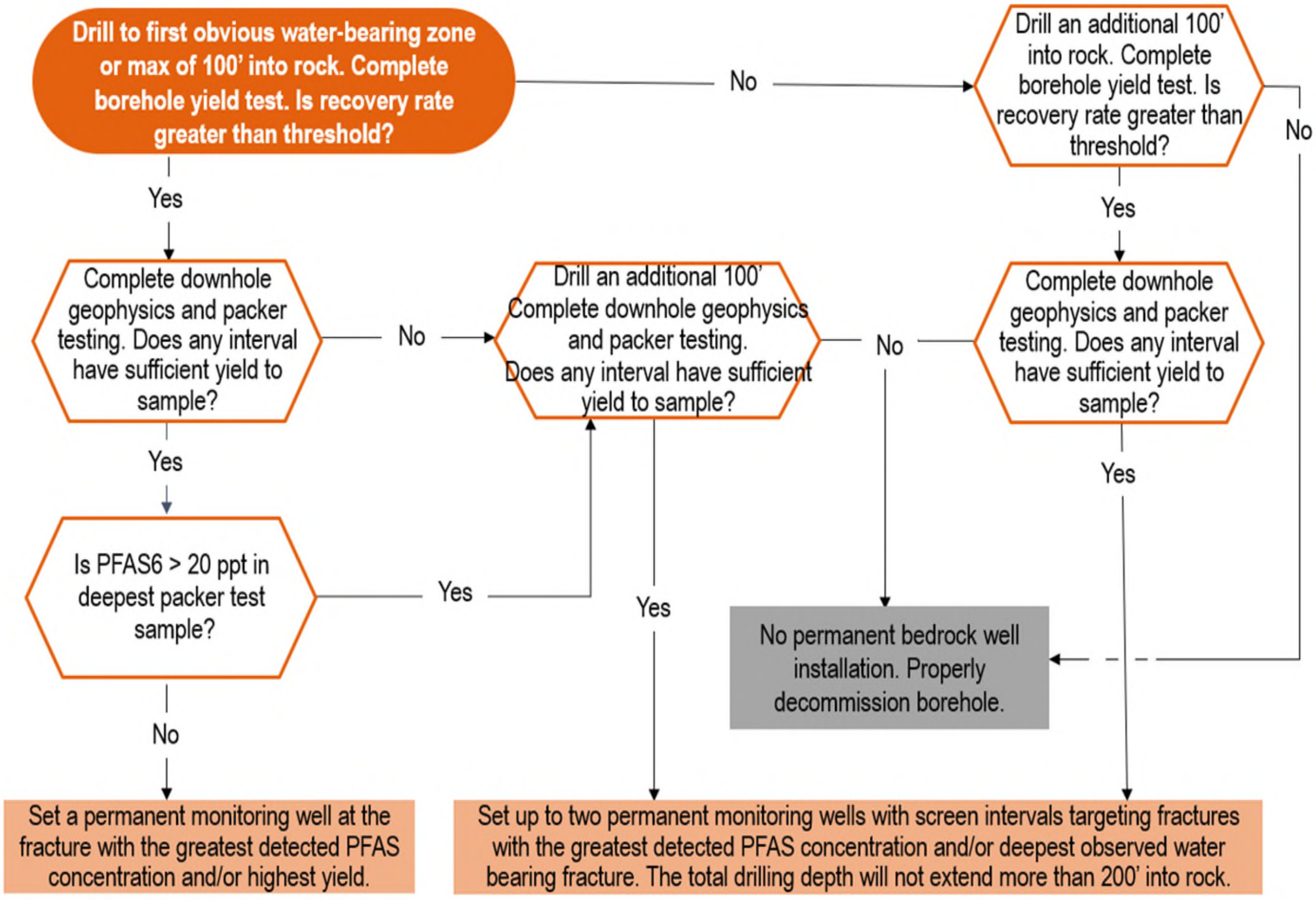
- **Is PFAS exceeding the MMCL present in groundwater in bedrock at the northeast corner of Area 1?** Installation of one bedrock monitoring well (GPMW-23-03BR) is proposed in this area. This location is along strike downgradient of the potential source areas in the northeast portion of Area 1.

- **Is PFAS exceeding the MMCL present in groundwater in bedrock south-southeast of Cold Spring Brook? If yes, have those PFAS migrated there from a release at Devens?** Groundwater samples will be collected from bedrock wells (CSMW-23-03BR and CSMW-23-06BR) and paired overburden wells installed on the south-southeast side of Cold Spring Brook. Sampling of these proposed monitoring wells will be performed concurrent with collection of groundwater samples from monitoring well locations on the western (Devens) side of Cold Spring Brook. These samples will be analyzed for PFAS, and fingerprint analysis will be conducted to evaluate the potential sources of PFAS, where present. In addition, water level data will be collected from monitoring wells and stream gages to determine the groundwater flow direction in this area.

- **Is PFAS exceeding the MMCL present in groundwater in bedrock along the Devens boundary and/or to the east of AOC 40? If yes, have those PFAS migrated there from a release at Devens?** Groundwater samples will be collected from paired overburden wells and bedrock wells installed to the east of AOC 40 (PWMW-23-02BR and PWMW-23-03BR), as well as from bedrock off post in the area of private wells along Blanchard Road (BRMW-23-01R and BRMW-23-02BR) concurrent with groundwater monitoring locations to the west, north, and south. These samples will be analyzed for PFAS, and fingerprint analysis will be conducted to evaluate the potentials sources of PFAS, where present. In addition, water level data will be collected from monitoring wells and stream gages to determine the groundwater flow direction in this area.

As presented in Exhibits 4-6 and 4-7 below, the bedrock well installation approach and target depths will differ based on the drilling location (i.e., potential source/plume versus post boundary/off post).

Exhibit 4-6: Bedrock Well Installation Flow Chart – Within Area 1



Notes:

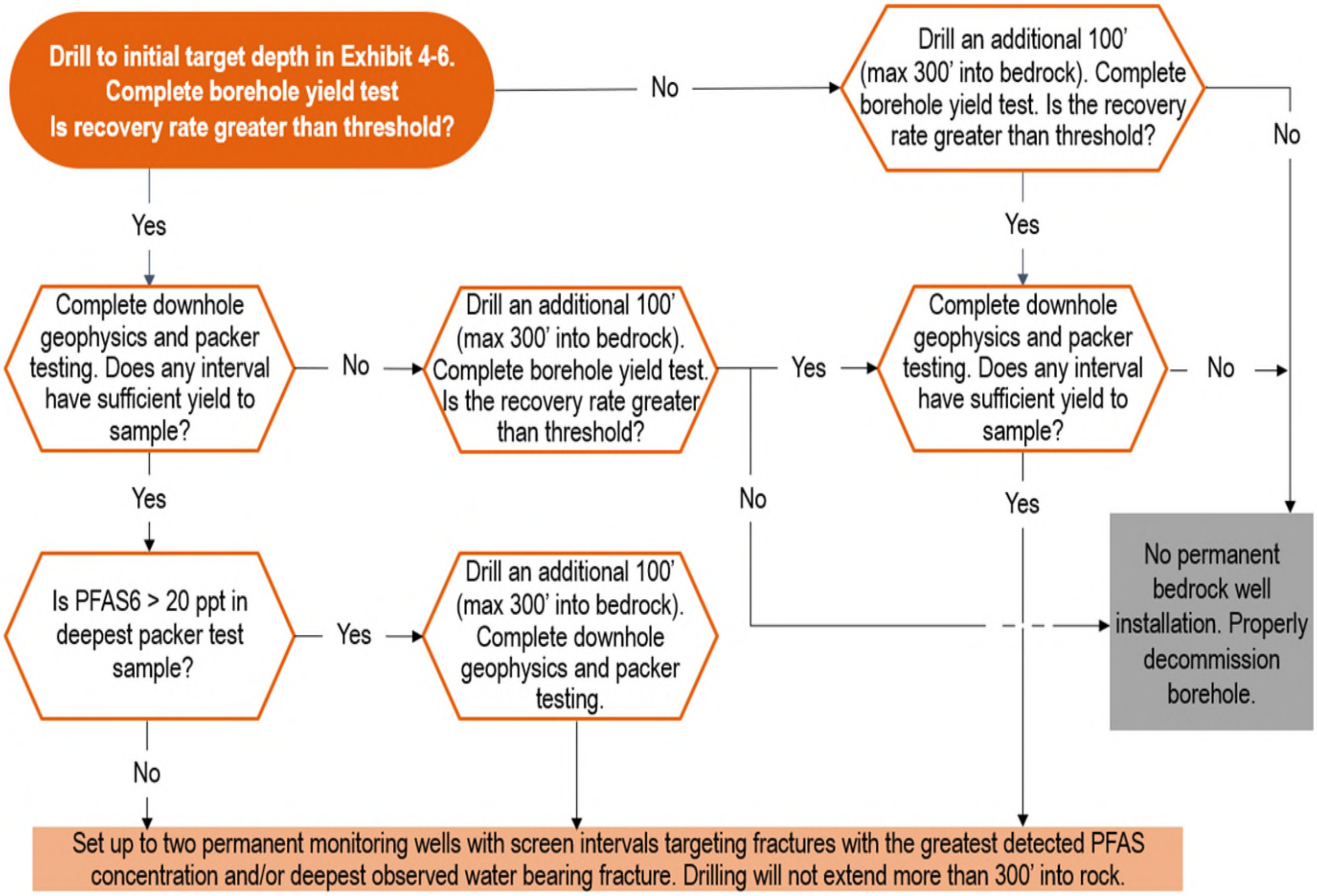
' = foot

max = maximum

> = greater than

ppt = part per trillion

Exhibit 4-7: Bedrock Well Installation Flow Chart – Devens Boundary and Off Post



Note: Devens Boundary wells will be installed prior to Off Post wells.

Additional information on the approximate bedrock elevations and target depths is included in Exhibit 4-8 below.

Exhibit 4-8: Proposed Bedrock Investigation Target Depths

Location	Location ID	Ground Surface Elevation (estimated) feet NAVD88	Bedrock Surface Elevation (estimated) feet NAVD88	Target Drilling Depth (estimated) feet NAVD88*	Target Drilling Depth (estimated) feet[a]
Area 1	43GMW-23-01BR	259.1	228.8	123.8	135
Area 1	43GMW-23-02BR	247.4	190.7	85.7	162
Area 1	43GMW-23-03BR	247.6	194.6	89.6	158
Area 1	43JMW-23-01BR	362.9	347.9	242.9	120
Area 1	75MW-23-02BR	259.4	233.4	128.4	131
Off Post	BRMW-23-01BR	324.3	253.4	48.4[b]	276[b]
	BRMW-23-02BR	367.2	357.9	152.9[b]	214[b]
	CSMW-23-03BR	247.0	162.0	-43.0[b]	290[b]
	CSMW-23-06BR	266.6	252.5	47.5[b]	219[b]
Area 1	GPMW-23-01BR	217.4	108.5	3.5	214
Area 1 Boundary	GPMW-23-03BR	242.8	114.2	-90.8	334
Area 1	PWMW-23-01BR	251.8	119.5	14.5	237
Area 1 Boundary	PWMW-23-02BR	243.9	113.9	-91.1	335
	PWMW-23-03BR	274.0	100.7	-104.3	378
	PWMW-23-05BR	322.5	32.8	184.7	138

Notes:
1. Bedrock surface elevations are estimated based on available information. Target drilling depths will be adjusted based on field observations.
[a] Target drilling depths assume that permanent well casing will be grouted 5 feet into competent rock.
[b] Target drilling depths for off-post locations will be adjusted to match adjacent on-post locations.
NAVD88 = North American Vertical Datum of 1988

4.2.6 Surface Water and Sediment Sampling

Surface water and sediment data collected during Phase I activities indicated that PFAS was present in Area 1 surface water bodies. While the quantity and locations of Phase I surface water and sediment samples are adequate for risk assessment purposes, another round of surface water sampling was deemed necessary to provide data concurrent with groundwater samples, and an additional eight locations are proposed at which both surface water and sediment will be collected. With the exception of the eight new proposed locations (CP-23-01, CP-23-02, CP-23-03, NR-23-01, ML-23-01, ML-23-02, ML-23-03, BB-23-01, and SW-23-01), all surface water samples will be collected from locations that were previously sampled in 2018 and/or 2020.

The surface water and sediment sampling will consist of one round of sampling, except at the eight new proposed locations, which will be sampled twice to provide an understanding of possible differences due to seasonality.

As detailed in Exhibit 4-9 below and shown on Figure 4-12, a total of 54 surface water samples are proposed from the water bodies listed below.

Exhibit 4-9: Area 1 Surface Water and Sediment Proposed Sampling Locations

Surface Water Body	Proposed Location ID	Surface Water Body	Proposed Location ID
Balch Pond	BP-18-01	Grove Pond	GP-18-01
Bowers Brook	*BB-23-01***		GP-18-02
Cold Spring Brook Pond	CP-20-01		GP-18-03
	CP-20-02		GP-18-04
	CP-20-03		GP-18-05
	*CP-23-01***	Mirror Lake	ML-20-01
	*CP-23-02***		*ML-23-01***
Cold Spring Brook	CSB-18-01		*ML-23-02***
	CSB-18-02		*ML-23-03***
	CSB-18-03	Nashua River	*NR-23-01***
	CSB-18-04	Plow Shop Pond	PSC-18-01
	CSB-18-05		PSC-18-02
	CSB-18-06		PSC-18-03
	CSB-18-07		PSC-18-04
	CSB-18-08		PSC-18-05
	CSB-20-01		PSC-18-06
	CSB-20-02	Robbins Pond	RP-18-01
	CSB-20-03		RP-18-02
	CSB-20-04		RP-18-03
	CSB-20-05	Unnamed Spring/Discharge (Northwest of the Shabokin water supply well)	*SW-23-01***
	CSB-20-06	Unnamed Tributary (discharging to Robbins Pond)	UT-18-01
	CSB-20-07		UT-18-02
	CSB-20-08		UT-18-03

** Locations highlighted in yellow are new proposed location, not sampled during the Phase I RI. Sediment samples will also be collected from these locations and analyzed for PFAS.

Specific study questions to be addressed in this area with the proposed scope include:

- **What is the potential contribution of PFAS from groundwater to surface water?** Proposed surface water sampling locations are placed throughout Area 1. These data will also be used to evaluate potential human health risks associated with surface water.
- **What is the relationship between PFAS concentrations in surface water versus fish tissue?** The proposed surface water sampling in Cold Brook Spring Pond and Plow Shop Pond will aid in interpreting the fish tissue data (e.g., possibly to calculate surface-water-to-fish bioconcentration factors).

4.2.7 Fish Tissue Sampling

Fish tissue samples will be collected and analyzed for PFAS. The objective of the fish tissue sampling is to collect sufficient data to determine the presence and extent of PFAS in fish tissue and to characterize potential human health risks (such as risks to recreational anglers). The data may also be used to inform remedial decision-making should that be required based on the results of the RI.

Fish sampling will be conducted at Grove Pond, Plow Shop Pond, Cold Spring Brook, Cold Spring Brook Pond, Mirror Lake, Robbins Pond, and the Nashua River and will target species and sizes of fish that are relatively common in the surface water bodies and may be consumed by human receptors. Sampling will focus on one composite sample from each of two species in Grove Pond (sample location GPFT-23-01), Plow Shop Pond (sample location PSFT-23-01), Cold Spring Brook (sample location CSBFT-23-01), Cold Spring Brook Pond (sample location CPFT-23091), Mirror Lake (sample location MLFT-23), Robbins Pond (sample location RPFT-23), and Nashua River (sample locations NRFT-23-01, NRFT-23-02, and NRFT-23-03) for a total of 18 fish tissue samples. The target species may include largemouth bass, bullhead, chain pickerel, or other species (based on availability). Each sample will be a composite of at least five individuals and will only include individuals of similar size of the same species. The fish will be analyzed as edible fillet portions.

Two composite samples per location will be sufficient to fill the identified data gaps and to characterize potential human health risk from fish ingestion. Proposed sampling locations are shown on Figure 4-12.

4.3 Baseline Risk Assessment

This section presents the intended approach and methodology for conducting the baseline risk assessment (BRA) for Devens. The BRA will evaluate the potential for adverse effects from exposure to constituents in soil, groundwater, surface water, sediment, and fish. The BRA will comprise a HHRA and SLERA.

A BRA will be conducted upon the completion of Area 1 PFAS RI activities and the receipt of validated analytical data. The objectives of the BRA will be to:

- Evaluate potential current and future human health and ecological risks in the absence of any major action to control or mitigate potential contamination (i.e., baseline risks).
- Provide a basis for deciding if remedial action is necessary to protect human health or ecological receptors.

The general approach for the HHRA and SLERA are described in the following sections.

4.3.1 Human Health Risk Assessment

The HHRA will be conducted in accordance with the USEPA Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual, Part A (USEPA 1989), Part D (USEPA 2001), and Part E (USEPA 2004), which is consistent with USACE guidance EM 200-1-4, Risk Assessment Handbook - Volume I: Human Health Evaluation (USACE 1999). The HHRA will be presented in a series of tables that follow the RAGS Part D (USEPA 2001) format.

The HHRA will consist of the four-step process typically used to assess potential human health risks. These steps are summarized below and further described in subsequent sections.

- Data Evaluation – Available data will be summarized by medium, and a data screening process will be used to identify constituents of potential concern (COPCs).
- Exposure Assessment – Actual and/or potential constituent release and transport mechanisms will be identified, potentially exposed human populations and possible exposure pathways will be described, concentrations of COPCs at potential points of human exposure will be determined, and human exposures to the COPCs will be estimated.
- Toxicity Assessment – Qualitative and quantitative toxicity information for each COPC will be summarized, and toxicity values used to characterize risk will be compiled.
- Risk Characterization – The likelihood and magnitude of adverse health effects, in the form of excess lifetime cancer risks (ELCRs) and non-cancer hazard indices (HIs), will be estimated. Sources of uncertainty in the HHRA will be noted and discussed.

The HHRA will consider the nature and extent of impacts to mapped groundwater resource areas defined by 310 CMR 22.00 (Massachusetts Drinking Water Regulation) (i.e., Zones I, II, III, and Interim Wellhead Protection Areas) when evaluating human health risk from exposure to drinking water. The MCP GW categories in Section 1.1.3 are equivalent to GUVD factors. In addition, potential productive aquifer and non-productive drinking water source area designations, defined by the MCP 310 CMR 40.0006, will be considered. These designations, existing land use, and aquifer/water resource protection overlay districts developed by the Devens Enterprise Commission and Town of Ayer will be considered. The Army, USEPA, MassDEP, and municipal stakeholders may then participate in developing site-specific GUVDs in accordance with USEPA Region 1 guidance (USEPA Region 1 1996) as the CERCLA process progresses to support finalizing the risk assessment and subsequent remedial decision-making.

4.3.1.1 *Data Evaluation*

The data evaluation focuses on the compilation of usable analytical data and the selection of human health COPCs in sampled environmental media. COPCs are generally identified as the constituents with detected concentrations that exceed human health risk-based screening levels.

4.3.1.1.1 *Data Usability*

The HHRA will be conducted using PFAS data collected during previous sampling events (SI, SI Addendum, and Phase 1 RI) and this Phase II RI. The analytical data collected during the previous sampling events were collected under USEPA-approved QAPPs and have undergone data validation. Sampling plans for collecting the Area 1 Phase II RI data are described in this work plan and the QAPP (Appendix A). Following sample collection and analysis, the laboratory analytical data will be validated in accordance with procedures outlined in the QAPP. Therefore, all environmental data included in the risk assessments will have a definitive level of data quality and, as such, will be determined “usable.” Also, the data from previous sampling events will be compared to the Phase II RI data, and if results appear anomalous, they will be further evaluated for overall data usability. Any uncertainty regarding the usability or validity of the historical data will be discussed in the uncertainty section of the risk assessment.

The samples collected during previous sampling events were analyzed for the list of PFAS presented in the USEPA-approved QAPPs. The samples collected during this Phase II RI will be analyzed for the PFAS identified in QAPP Worksheet #15 (Appendix A). Consistent with Army guidance (Department of the Army 2018), all detected PFAS will be identified in the data summaries; however, only PFAS that have toxicity values considered sufficient for use in DoD risk assessments will be evaluated in the HHRA (DoD 2022). Analytical data for other PFAS will be presented in an appendix to the RI and used to assist in development of the RI.

4.3.1.1.2 *Data Summaries*

Surface soil data for the HHRA will be defined as samples collected from 0 to 0.5 foot bgs. Subsurface soil samples will consist of unsaturated soil samples at 0.5 foot bgs to 15 feet bgs (or the depth to groundwater, whichever comes first). Previous subsurface investigations of Area 1 suggest that the depth to groundwater ranges from less than 1 foot bgs to more than 60 feet bgs and averages approximately 15 feet bgs. Overburden (glacial meltwater deposits) constitutes the primary groundwater aquifer at Devens. Zones of highest transmissivity within the overburden are generally found in areas of thick glacial meltwater deposits on the former North and Main Posts at Devens (e.g., along Cold Spring Brook). Water supply wells, including the Shabokin, Patton, and Grove Pond water supply wells, are all completed within these meltwater deposits. If the RI data support that the overburden and bedrock groundwater are in communication, all groundwater data (i.e., overburden and bedrock) data will be initially evaluated as a single aquifer to identify groundwater COPCs.

Once the HHRA datasets have been established, data summary tables will be prepared. Soil data will be grouped by AOC. Groundwater data will be grouped by aquifer or wellfield, as appropriate, based on results of the RI. Surface water, sediment, and fish tissue data will be grouped by AOC and/or water body, as appropriate. The following parameters will be presented for each analyte detected in at least one sample within a given dataset: minimum and maximum detected concentrations and associated data qualifiers, location of the maximum detected concentration, detection frequency, and range of reporting limits.

In summarizing the analytical data and calculating EPCs for the HHRA, results of duplicate samples will be combined as follows:

- If a constituent is detected in both the parent and corresponding duplicate sample, the analytical results will be averaged.
- If a constituent is detected in only one of the two samples, the detected concentration will be used.
- If a constituent is not detected in either sample, the reporting limits will be averaged.

4.3.1.1.3 *Human Health COPC Identification*

To focus the HHRA on those constituents that, if contacted, have the greatest potential to pose human health risks, detected concentrations will be compared to risk-based screening levels. USEPA Region 1 provided SSSLs for PFOA, PFOS, PFBS, PFNA, PFHxS, and HFPO-DA for Devens in June 2022 and added SSSLs for PFHxA and PFBA in June 2023. The screening levels are based on a HQ of 0.1. Use of a HQ of 0.1 is purposefully conservative to account for the presence of multiple chemicals in site media that may have cumulative non-cancer health effects and assumes that the chemicals affect the same target organ or system. The human health SSSLs for soil, groundwater, surface water, sediment, and fish tissue are summarized in Table 2-1.

If the maximum detected concentration is greater than the human health SSSL, the constituent will be identified as a COPC. Media where PFAS compounds are either not detected or concentrations are less than human health screening levels will not be quantitatively evaluated.

4.3.1.2 *Exposure Assessment*

The exposure assessment estimates the type and magnitude of human exposure to constituents at or originating from a site. This is accomplished by establishing assumptions about the potential for human exposure (e.g., exposed populations, exposure pathways, exposure frequency), calculating representative EPCs for each COPC and potentially complete pathway, and modeling human exposure in the form of daily intakes. These exposure estimates are combined in the risk characterization with toxicity values to calculate ELCRs and non-cancer hazards.

Potential exposure scenarios will be identified based on known current conditions/land use at Devens, the Devens ReUse Plan (VHB 1994), the Devens Open Space and Recreation Plan 2008-2013 (NRWA 2008), and surrounding land use in the Towns of Ayer, Harvard, and Shirley, Massachusetts. The exposure scenarios will be generally consistent with previous HHRAs conducted for non-PFAS constituents at Area 1 AOCs (e.g., 40, 43G, 43J, and 57). Potential exposure areas for each receptor type will be identified, and AOCs and associated data will be grouped accordingly.

4.3.1.2.1 *Current and Future Land Uses*

Area 1 encompasses a portion of the former Main Post and is currently used for rail-, industrial-, or trade-related activities; recreational open space (including Red Tail Golf Course); and government/industrial purposes (VHB 1994). It is anticipated that future land use will be consistent with Deven ReUse Plan (VHB 1994).

The Devens ReUse Plan identifies major reuse themes for Devens. These themes and how they relate to the Area 1 AOCs are:

- Rail-, Industrial-, and Trade-related Uses: Capitalizes on the Devens unique rail, intermodal, and highway attributes and incorporates the existing rail yard in the northeast corner of the former Main Post. This applies to AOCs 57, 74, and 75. This land use is considered commercial/industrial.
- Innovation and Technology Business: Includes businesses that are growing and have new products, technologies, or services. This applies to AOCs 43G and 43J. This land use is considered commercial/ industrial.
- Open Space and Recreation: While large portions of Devens have been set aside for Open Space and Recreation, the recreational uses of land within Area 1 are primarily limited to passive recreational activities such as walking, picnicking, and running (NRWA 2008). This applies to the lower Cold Spring Brook wetlands near AOCs 57, 74, and 75 and the upper Cold Spring Brook wetlands near AOC 40. Mirror Lake, located between the Patton and Shabokin water supply wells, is used for active recreation (e.g., fishing and swimming) and is permanently protected by a Conservation Restriction (NRWA 2008). No athletic fields or public hunting areas are located within the Area 1 AOCs.

4.3.1.2.2 *Potential Receptors and Exposure Pathways*

Based on the current and reasonably anticipated future land uses within Area 1, potential human receptors may include current/future drinking water users, commercial/industrial workers, utility workers, recreational users, and anglers. Future construction workers may be considered additional receptors in the event of site redevelopment. Residential development of the Area 1 AOCs is not a realistic future scenario; therefore, however, a hypothetical future residential scenario (i.e., exposure to soil and groundwater used as a source of drinking water) will be included to evaluate an UU/UE scenario.

As RI data concerning nature and extent of PFAS associated with each AOC become available, AOC-specific human health CSMs will be developed. For example, the need for including recreational users will be determined on an AOC-specific basis if PFAS determined to originate from Devens are present in surface soil, surface water, and/or sediment and the water body characteristics supports recreational activities. The AOC-specific CSMs will be presented to regulatory stakeholders to solicit input before being finalized to support risk assessment.

Generally, human exposure to PFAS in soil may potentially occur through incidental ingestion, dermal contact, and inhalation (particulates). However, inhalation of constituents in soil released to outdoor air as particulates is generally not evaluated because inhalation toxicity values are not currently available for PFAS.

Human exposure to PFAS in groundwater may occur through tapwater ingestion or dermal contact during hand washing and other uses of potable water. Devens receives drinking water from a municipal utility that sources raw water from groundwater wells. Evaluation of potential connections between existing AOCs at Devens and drinking water resources, both within Devens (AOC Patton Well and AOC Shabokin Well) and surrounding areas (AOC Grove Pond Wellfield), is a primary objective of the RI. Engineering controls are in place to treat PFAS in municipal water wells located at Devens. Additionally, administrative controls (i.e., deed restrictions) prevent future well installations (i.e., potable use of groundwater) at Devens. Although potential use of untreated groundwater as a potable water source is unlikely, the groundwater exposure pathway for drinking water will be evaluated.

Direct exposure to DoD-related impacts in groundwater may occur through incidental ingestion and dermal contact if shallow groundwater is encountered during site excavation for utility maintenance or repair. This exposure scenario may be evaluated if shallow groundwater (i.e., groundwater at depths less than 10 feet bgs) is encountered at an AOC.

Exposure to PFAS in surface water and sediment may occur via incidental ingestion and dermal contact. However, sediment covered with more than 3.5 to 4 feet of water year-round is generally not evaluated because of the low potential for direct contact. When surface water depths are approximately 3.5 to 4 feet deep, sediment typically will not adhere to skin but instead is washed off, thereby limiting dermal absorption.

Finally, exposure to PFAS may occur via fish ingestion. Although there are fish consumption advisories of “eat none” due to mercury impacts in Mirror Lake, Grove Pond, and Plow Shop Pond, potential exposure to PFAS via fish consumption may potentially occur. This exposure pathway will be evaluated using the fish tissue data proposed for collection from Mirror Lake, Grove Pond, Plow Shop Pond, Cold Spring Brook, and Cold Spring Brook Pond, Robbins Pond, and Nashua River.

Exposure Point Concentrations

The EPC is the chemical concentration within an exposure area (e.g., the AOC for soil or aquifer for groundwater) to which a receptor is exposed. Estimates of the EPC represent the concentration term used in the intake calculations.

EPCs for COPCs in Soil, Surface Water, Sediment, and Fish

To determine the constituent concentrations to which an individual might be exposed over many years, representative EPCs will be calculated from the useable data. The USEPA (1992, 1989) recommends that the arithmetic average concentration of the data be used for evaluating long-term exposure and that, because of the uncertainty associated with estimating the true average concentration at a site, the 95% upper confidence limit (UCL) on the arithmetic average be used as the EPC. The 95% UCL concentration provides reasonable confidence that the true average will not be underestimated. The USEPA also indicates that, where there is a question about the distribution of the data, a statistical test should be used to identify the best distributional assumption for the dataset (USEPA 1992).

The ProUCL® version 5.2 (ProUCL) program will be used to plot the data, test the distributional assumptions, and calculate 95% UCLs. When entering the data into ProUCL, if a COPC was not detected in a sample, the sample reporting limit will be entered as a proxy concentration, and the sample result will be coded as non-detect. ProUCL contains rigorous parametric and non-parametric statistical methods that can be used on full or uncensored datasets and on datasets with below detection limit observations (also called left-censored datasets). Depending on the distribution and 95% UCL estimation method, ProUCL will use only detected data or will incorporate reporting limits (Barnett et al., 2022).

EPCs for COPCs in Groundwater

The EPC used to evaluate the potable use scenario for each groundwater COPC will be estimated in accordance with USEPA OSWER Directive 9283.1-42 (USEPA 2014). Maximum detected concentrations (or the lesser of the maximum and 95% UCL where three or more data points are available for a monitoring well where the maximum concentration occurred) will be used as the EPC for each on-site groundwater COPC.

If the utility worker exposure to shallow groundwater scenario warrants quantitative evaluation, maximum detected concentrations of COPCs in monitoring wells identified as having depths to water less than 10 feet bgs will be used.

4.3.1.2.3 *Estimates of Constituent Intake*

Estimates of chemical intake will be developed to portray reasonable maximum exposure (RME) under current and reasonably anticipated future exposure scenarios. The RME scenario considers the highest exposure level that might reasonably be expected to occur; one that is well above the average case of exposure but within the range of possibility. Use of RME parameter values to model baseline human health risks is a conservative approach, in that it yields upper bound ELCR and non-cancer hazard estimates (USEPA 1989). If risks in excess of USEPA acceptable levels are determined for an exposure pathway, the pathway will also be evaluated using central tendency exposure (CTE) parameter values (where applicable) to evaluate the variance between the CTE and the upper-bound values specific to the RME analysis. Central tendency estimates may also be developed to represent more realistic or site-specific conditions. However, in accordance with USEPA guidance, the RME scenario will serve as the determination regarding risk management decisions.

4.3.1.3 *Toxicity Assessment*

The toxicity assessment, also termed the dose-response assessment, will characterize the relationship between the magnitude of exposure and the potential that an adverse health effect will occur. Toxicity assessment involves determining whether exposure to a constituent can cause an increase in the incidence of adverse health effects and characterizing the nature and strength of the evidence of causation. The toxicity information is then quantitatively evaluated, and the relationship between the dose of constituent received and the incidence of adverse health effects in the exposed population is evaluated.

The USEPA and other regulatory agencies have performed toxicity assessments for numerous chemicals, and the guidance they provide will be used in the HHRA. These include reference doses (RfDs) for the evaluation of non-carcinogenic health effects from chronic and sub-chronic exposure to chemicals and cancer potency slope factors (CSFs) for evaluating incremental cancer risk from lifetime exposure to chemicals (i.e., ELCRs).

4.3.1.3.1 *Sources of Toxicity Data*

The HHRA will obtain toxicological information and toxicity values from the following sources, in order of preference consistent with USEPA (2003) guidance:

- Tier 1 - Integrated Risk Information System (USEPA 2023c), an internet database containing current information on human health effects that may result from exposure to chemicals in the environment and has received internal and external scientific review.
- Tier 2 - Provisional Peer-Reviewed Toxicity Values (USEPA 2023d), developed by the USEPA Office of Research and Development/Center for Public Health and Environmental Assessment/Superfund Health Risk Technical Support Center and are available as chemical-specific issue papers.
- Tier 3 - Additional sources of toxicity information, including but not limited to the ATSDR minimal risk levels (ATSDR 2022).

Adverse, Non-cancer Health Effects

The NCP (USEPA 1990) indicates that acceptable exposure levels for chemicals with non-cancer health effects should represent concentration levels to which the human population, including sensitive subpopulations (e.g., the elderly, young children), may be exposed without adverse health effects during a lifetime or part of a lifetime, incorporating an adequate margin of safety. The potential for non-cancer health effects associated with oral and dermal exposures is evaluated by comparing an estimated chemical intake over a specified period with an RfD derived for a similar exposure period. The RfD is an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. Therefore, the ratio of the intake to the RfD, termed the HQ, assumes a level of exposure (i.e., the RfD) below which it is unlikely for even sensitive subpopulations to experience adverse health effects.

RfDs are not available to evaluate dermal exposure. In their absence, oral RfDs will be used and adjusted following USEPA (2004) guidance to reflect absorbed doses. This allows for comparison between exposures estimated as absorbed doses and toxicity values expressed as absorbed doses.

The potential for non-cancer health effects associated with inhalation exposures will not be evaluated due to the absence of inhalation reference concentrations for PFAS.

4.3.1.3.2 *Carcinogenic Effects*

Regardless of the mechanism of effect, risk evaluation methods employed by the USEPA generally derive from the hypothesis that thresholds for cancer induction by carcinogens do not exist, and that the dose-response relationship is linear at low doses. Based on this hypothesis, USEPA has derived estimates of incremental cancer risk from lifetime exposure to potential carcinogens. This is accomplished by establishing the carcinogenic potency of the chemical through critical evaluation of the various test data and fitting dose-response data to a low-dose extrapolation model. The CSF, which describes the dose-response relationship at low doses, is expressed as a function of intake (i.e., $[\text{mg/kg-day}]^{-1}$).

ELCRs will be estimated by multiplying an estimated daily intake prorated over 70 years by the CSF. The resulting risk estimate is expressed as a unitless probability (e.g., 2×10^{-5} or 2 in 100,000) of an individual developing cancer. The unitless probability represents the excess (or increased) lifetime cancer risk associated with the estimated exposure above the background risk of developing cancer. This linear equation is valid only at low risk levels (i.e., below estimated risks of 0.01). According to the USEPA (1989), this approach does not necessarily provide a realistic prediction of risk. The true value of the risk at trace ambient concentrations is unknown and may be as low as zero.

As with RfDs, USEPA has not derived CSFs to evaluate dermal exposure. In their absence, CSFs for oral exposure will be used and adjusted per USEPA guidance to reflect absorbed dose. This allows for risk estimation based on exposures estimated as absorbed doses and CSFs expressed as absorbed doses.

Cancer risk associated with inhalation exposures will not be evaluated due to the absence of inhalation unit risks for PFAS.

4.3.1.4 *Risk Characterization*

The risk characterization involves combining exposure estimates with toxicity information to assess the potential for adverse health effects for each human exposure scenario evaluated in the HHRA. In this section, the non-cancer hazards and ELCRs for each exposure scenario identified for Area 1 will be presented and discussed. Uncertainties associated with the HHRA process and their potential impacts on the HHRA conclusions will also be discussed.

4.3.1.4.1 *Non-cancer Hazards*

The potential for non-cancer health effects is evaluated by calculating the ratio of an estimated intake over a specified period with a chemical-specific RfD derived for a similar exposure period. The RfD is an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. The non-cancer HQ therefore assumes a level of exposure below which it is unlikely for even sensitive subpopulations to experience adverse health effects. The total individual HQs will be summed for each exposure pathway and scenario to yield HIs representative of the potential for adverse, non-cancer health effects from cumulative exposure. For the non-cancer assessment, exposure scenarios with an HI greater than 1 (i.e., 1E+00) will be of potential concern.

Where a pathway-specific HI exceeds 1, the HQs will be considered based on critical effect. That is, critical effect HIs will be developed by summing HQs of COPCs with RfDs based on toxic effects on the same target organ.

4.3.1.4.2 *Cancer Risks*

Individual cancer risks are expressed as unitless probabilities of a person developing cancer. The total individual (i.e., COPC-specific) ELCRs will be summed for each exposure pathway and scenario to arrive at an estimate of the potential for cancer risk from cumulative exposure. For known or suspected carcinogens, the NCP established that acceptable exposure levels are generally concentration levels that represent an excess upper-bound lifetime cancer risk in the range from 1×10^{-4} (i.e., 1E-04 or 1 in 10,000) to 1×10^{-6} (i.e., 1E-06 or 1 in 1,000,000) or less (USEPA 1990). The ELCRs estimated for each exposure scenario will be compared to this risk range established by the NCP.

4.3.1.4.3 *Uncertainty Discussion*

Risk assessment involves the integration of complex analyses of constituent concentrations, fate and transport, potential for human exposure, and constituent-specific potency and/or toxicity. Uncertainties exist with each component in this process.

Uncertainty in a risk assessment is typically accounted for by identifying the sources of uncertainty and characterizing whether the risks may be over- or under-estimated. Within this section, uncertainty will be qualitatively evaluated for each component of the HHRA including identification of COPCs, exposure assessment, toxicity assessment, and risk characterization. The key site-related variables and major assumptions used in the HHRA (e.g., fate and transport models, exposure parameter values) will be identified and described. If warranted, uncertainty analyses may be conducted to demonstrate whether risks are likely to be over- or under-estimated.

4.3.2 Screening Level Ecological Risk Assessment

A SLERA will be conducted to evaluate the likelihood of adverse ecological effects occurring as a result of exposure to PFAS associated with Fort Devens. The SLERA will follow relevant guidelines including guidance from USEPA (1997) Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments and USACE (2010) Environmental Quality – Risk Assessment Handbook, Volume II: Environmental Evaluation The SLERA will be performed using the PFAS ESVs for the media and receptors presented in the September 2021, Derivation of PFAS Ecological Screening Values Report prepared by Argonne National Laboratory on behalf of DoD (Argonne 2021), for use at DoD installations where PFAS have been detected in soils and surface waters. The soil screening values are protective of terrestrial plants, invertebrates, and mammalian and avian wildlife. The surface water values are protective of aquatic life and aquatic dependent wildlife.

4.3.2.1 ***Screening-Level Ecological Risk Assessment Approach***

The evaluation of ecological risks is typically a multi-step process that incorporates several scientific/management decision points (SMDPs). An SMDP requires a decision between the risk manager and risk assessment team to evaluate and approve or redirect the work up to that point. The SMDPs are intended to ensure that the SLERA proceeds in an acceptable direction.

This work plan assumes that the initial steps up through a SLERA will be completed for Fort Devens. The SLERA represents the first two steps of the USEPA (1997) eight-step ecological risk assessment (ERA) process. The eight-step process includes the following:

- Step 1 – Preliminary Problem Formulation and Toxicity Evaluation
- Step 2 – Preliminary Exposure Estimate and Risk Calculation
- Step 3 – Problem Formulation
- Step 4 – Study Design and Data Quality Objective Process
- Step 5 – Verification of Field Sampling Plan
- Step 6 – Site Investigation and Data Analysis
- Step 7 – Risk Characterization
- Step 8 – Risk Management.

As part of Step 1, ecologists will conduct a site habitat assessment to document habitat conditions. The habitat assessment will include the documentation of existing cover types and a survey to document potential ecological resources. The habitat assessment will build on existing information for Devens. For example, information from the USFWS and the most recent Integrated Natural Resources Management Plan (INRMP) for the adjacent Devens South Post will also be reviewed to determine the potential occurrence of threatened and endangered (T&E) species or critical habitats.

Step 2 of the ERA process is the screening-level exposure estimate and risk calculation. In the SLERA, risk will be conservatively estimated by comparing measured PFAS concentrations with ecotoxicological screening values. The data that will be used in the screening to characterize exposure concentrations will include only those data from areas of Devens that represent viable habitat for ecological receptors. Much of the northern portion of Area 1 consists of buildings, roads, parking lots, and managed vegetation. These areas provide limited habitat to ecological receptors; therefore, data from these areas will not be considered in the SLERA. Areas of viable habitat for each AOC, if present, will be identified based on the observations from the habitat assessment.

4.3.2.2 *Screening-Level Problem Formulation*

Problem formulation defines the goals and establishes the scope and focus of an ERA. The problem formulation includes a description of the environmental setting and a summary of available data. This information is used to identify the exposure pathways, target receptors, and potential effects, and serve as the focus for Step 2.

4.3.2.2.1 *Preliminary Ecological Characterization*

The ecological habitats on and within the vicinity of Devens include wooded uplands, successional open fields, and maintained areas of grass. Developed areas with paved, impervious surfaces that lack significant ecological habitat are also present. Vegetation communities within the vicinity of Devens consist of hardwood vegetated uplands, riparian corridors, old fields, wet meadows, emergent and forested wetlands, and eutrophic open waters (USFWS 2005; Gannett Fleming 2006). Detailed plant and wildlife surveys have been conducted for Grove Pond and Plow Shop Pond (Gannett Fleming 2006) and Oxbow National Wildlife Refuge (NWR) (USFWS 2005), and it is expected that the communities documented within those sections of the facility are representative of similar habitats that occur within the undisturbed portions of Devens. Devens is known to support a diversity of animal species. The wooded uplands provide habitat for migratory passerine birds, and the wetlands and open water provide foraging and breeding habitat for waterfowl and other bird species (USFWS 2005). Additionally, the Nashua River, Cold Spring Brook Pond, and Plow Shop Pond support a variety of fish species (USFWS 2005; ABB 1993b). Vernal pools, which Massachusetts identifies as a priority habitat type, have also been identified on site (USFWS 2005). Vernal pools found within the Oxbow NWR portion of the Devens facility are confirmed breeding habitat for bluespotted salamander, a state species of special concern, and spotted salamander, a state watch-list species (USFWS 2005).

The quality and the size of the available habitat at each AOC within Area 1 will be considered as an initial step of the SLERA for evaluating which portions of each AOC (and subsequently, which samples at each AOC) require further ecological evaluation. In addition to habitat size and quality, consideration will be given to the connectivity of the habitats (i.e., cannot exclude smaller areas of concern if they are part of a larger contiguous undeveloped area). The expected home ranges of the potential receptors will also be evaluated to determine the ecological exposure areas on site. Other considerations will include whether habitats are preferred by likely receptors or if they have been identified as critical habitats (e.g., vernal pools or endangered species breeding areas).

Wetlands, including several vernal pools, are found throughout the site and could potentially support terrestrial, semi-aquatic, and aquatic receptors. Thus, distinction between terrestrial versus aquatic habitat (i.e., soil versus sediment) in these areas may be needed. Wetlands are defined as, “those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil condition” (USACE 1987). This is consistent with USEPA guidance (USEPA 1997), in which sediments are defined as “particulate material lying below water” and MassDEP’s guidance (MassDEP 1996), in which sediments are defined as, “below the upper boundary of a bank, as defined in 310 CMR 10.54(2) which abuts and confines a water body.” Therefore, only areas that are below the boundary of bank or are fully inundated with water to support aquatic communities would be considered sediment, and all other wetland habitats (including those within the floodplain of a waterbody) would be considered soil. However, from an ecological perspective, transitional areas that are inundated or saturated only during a portion of the year can support terrestrial and aquatic organisms and in practice, the boundaries may shift throughout the year. Thus, in some areas, evaluating both types of ecosystems may be required. The results of the SLERA will identify which areas have clear and easily definable terrestrial/aquatic boundaries and which areas need to be evaluated, both due to a seasonally changing environment and community composition.

As described in the SLERA approach below, the preliminary ecological characterization will be verified and further refined based on a habitat field reconnaissance and ecological receptor survey.

4.3.2.2.2 *Potential Ecological Receptors and Exposure Pathways*

Ecological exposure pathways considered potentially complete include exposure of vegetation communities, terrestrial invertebrates, and wildlife to PFAS in soil, and ingestion of PFAS via the food chain by birds and mammals that may reside or forage in the habitats present on site. For areas of the site with aquatic habitat, potentially complete ecological exposure pathways include exposure of fish, aquatic invertebrates, amphibians, and reptiles to surface water and sediment. Potentially complete ecological exposure pathways for semi-aquatic wildlife (primarily birds and mammals) include exposure to PFAS present in sediment and surface water and ingestion of PFAS via the food chain by birds and mammals that may forage in aquatic areas.

The SLERA will include a review of existing ecological characterization for the site, site figures, and aerial photographs to identify areas with potential ecological habitat. Habitat characteristics will be further documented during a site visit to identify vegetative cover types and document potential ecological receptor species observed or expected to occur at the site based on available habitat.

According to the USFWS, the federally listed threatened northern long-eared bat and small whorled pogonia may be present at Devens (USFWS 2021). The 2019 INRMP (Bluestone Environmental Group, Inc. 2019) completed for the Devens Reserve Force Training Area (adjacent and overlapping with Area 1) lists the following state listed T&E animal and plant species: grasshopper sparrow, upland sandpiper, American bittern, Northern Harrier, Peregrine falcon, bald eagle, pied-billed grebe, vesper sparrow, twilight moth, ringed bogaunter, Blandings' turtle, cat-tail sedge, midland sedge, houghton's flatsedge, ovate spike-sedge, wild senna, and small bur-reed. Additional species are listed in the INRMP under other protections or consideration such as the Migratory Bird Protection Act, Bird of Conservation Concern, or Bald and Golden Eagle Protection Act, under review, or special concern, among others. A previous evaluation (USFWS 2005) identified the following state-listed T&E animal and plant species at the Oxbow NWR: pied-billed grebe, Blanding's turtle, ovate spike sedge, northern wild senna, and small bur-weed. This list may be updated following the habitat assessment planned in support of the SLERA.

<u>Preliminary Assessment Endpoints and Measurement Endpoints</u>

Assessment endpoints and measurement endpoints will be used to help guide the evaluation of ecological risks. Assessment endpoints are formal expressions of the actual environmental value to be protected from risk (Suter et al. 1993) and are typically tied directly to specific ecological values needing protection. The assessment endpoints identified for evaluation in the SLERA are based on the complete and significant exposure pathways. Measurement endpoints include measures of exposure and measures of effects and are quantitative expressions of observable or measurable changes that are used to evaluate the assessment endpoints (USEPA 1997). For this SLERA, the preliminary assessment endpoints will include potential impacts to soil invertebrates, plants, aquatic invertebrates, fish, reptiles/amphibians, birds, and mammals. The measurement endpoints will be based on a comparison to relevant screening benchmarks (as available).

It is important to note that the assessment of ecological risks to PFAS compounds is still under development, and benchmarks may not be available to adequately assess each of the assessment and measurement endpoints identified above. Additionally, previous ERAs (non-PFAS related) for Cold Spring Brook Pond (ABB 1993), AOC

40 (HLA 1999), and AOC 57 (HLA 2000a) included sediment toxicity testing, macroinvertebrate community assessments, and/or visual observations of fish health. The source and timing of PFAS releases at AOC 40 and AOC 57 have not been identified. However, assuming that PFAS releases at AOC 40 and AOC 57 and subsequent migration to surface water and sediment occurred previous to the 1990s, results from these evaluations may be used as additional lines of evidence in the SLERA regarding potential PFAS impacts on aquatic receptors.

4.3.2.3 *Screening-Level Exposure Estimate and Risk Calculation*

The SLERA will be conducted to compare PFAS concentrations in each environmental medium to ESVs. Historical PFAS analytical data for Area 1 are available in the Area 1 and Area 2 PSCS reports (KGS 2020a, 2020c). As described in the QAPP, additional sampling is proposed. Historical data will be combined with the RI sample data if it is determined that these data meet DQOs established in the QAPP and are representative of current conditions.

Based on the existing data, the relevant media for ecological receptors at Devens are expected to be soil (0 to 3 feet bgs), sediment, and surface water for those areas that represent viable habitat. Although most of Devens is expected to represent limited habitat, the analytical data from those areas of Devens that may provide habitat will be compared to relevant screening benchmarks as a preliminary assessment of potential ecological risks. The analytical data will be summarized in a manner generally consistent with the HHRA approach for calculating EPCs (e.g., handling duplicate samples) as described in Section 4.3.1.1.

4.3.2.3.1 *Ecological Screening Values*

The data for the areas of Devens that represent viable habitat will be compared to appropriate ecotoxicological screening values. The SLERA will be performed using the PFAS ESVs for the media and receptors presented in the September 2021, Derivation of PFAS Ecological Screening Values Report prepared by Argonne National Laboratory on behalf of DoD, for use at DoD installations where PFAS have been detected in soils and surface waters.

Additionally, food web models and toxicological endpoints may be used to evaluate potential risks for birds and mammals. For example, the fish tissue data will be used in the food web models to evaluate potential risks to piscivorous wildlife.

4.3.2.3.2 *Screening Level Risk Calculation*

In this step, the detected PFAS concentrations in site media will be compared with the corresponding ESVs to derive screening level risk estimates. Potential risks will be evaluated using the HQ method. HQs are calculated by dividing the appropriate EPC (for the SLERA, individual sample concentrations) by the corresponding medium-specific screening benchmark. HQs greater than or equal to 1 will be carried forward for additional evaluation in a refined SLERA and/or a BERA. Detected PFAS for which ESVs are not available may also be carried forward. If the maximum detected PFAS concentration is below the ESV, the PFAS compound is not considered to pose risk to ecological receptors for that medium.

4.3.2.4 *Scientific Management Decision Point*

The results from the SLERA will be presented in the RI report. The SLERA will describe ecological conditions at Area 1, and present the results from the screening-level exposure estimate and risk calculation. If the exposure estimate for a constituent is below the ESV, it is not considered to pose risk to ecological receptors. The SLERA will also discuss potential sources of uncertainty in the assessment.

The SLERA process will conclude with a SMDP, in which the risk manager and risk assessment team will decide one of the following conclusions:

1. Ecological threats are almost, or entirely, absent; therefore, no further characterization of ecological risk is needed.
2. Based on the conservative assumptions in the SLERA, there is the possibility of adverse ecological effects, and a more detailed assessment with more information about Area 1 is needed.

If the process continues with a more detailed assessment, then either a refined SLERA (BERA Step 3a) or a more complete BERA (Steps 3b through 7 of the USEPA's eight-step process) may be conducted. The results from the SLERA (Steps 1 and 2) will focus the more detailed assessment by identifying exposure pathways and eliminating those contaminants and exposure pathways that pose negligible risks. Further SLERA refinement in BERA Step 3a may incorporate exposure estimates using more realistic assumptions and additional methodologies to better estimate potential exposure. For example, Step 3a may involve refining risk calculations through food chain modeling based on both conservative exposure parameters (maximum food intake rates and bioaccumulation factors) as well as refined exposure parameters (average food intact rates and bioaccumulation factors). The results of Step 3a will identify if additional evaluation of ecological risk via a more complete BERA is necessary. Major sources of uncertainty in the ecological risk assessment process will also be documented.

4.4 Treatability Studies

The Guide for Conducting Treatability Studies Under CERCLA (USEPA 1992) outlines the following three-tiered approach for conducting treatability studies:

1. Remedy screening
2. Remedy-selection testing
3. Remedial design/remedial action testing.

Following the Phase II Area 1 RI, groundwater data will be used in support of remedy screening to evaluate the necessity of various treatability studies at the Area 1. Water treatability studies that may be evaluated include:

- Sub-micron powder-activated carbon/ceramic membrane filtration
- Fractionation with air and ozone
- Super critical water oxidation for PFAS destruction

5 Deliverables

This section describes the documents and deliverables that will be prepared upon completion of the Phase II RI.

5.1 Remedial Investigation/Feasibility Study Report

After completion of the Phase II Area 1 RI, a comprehensive RI/FS Report will be prepared. The objective of the RI portion of the report is to present and evaluate the efficacy of the data for meeting the stated RI objectives and will include an HHRA. The objectives of the FS portion of the report are to: 1) identify remediation requirements and establish cleanup levels as necessary to eliminate or prevent unacceptable risks to human health and the environment; and 2) identify, screen, and evaluate potential remedial alternatives. The various steps involved in the FS process are described below. The RI/FS Report will be prepared in accordance with the USEPA Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA 1988).

5.1.1 Remedial Investigation

The RI portion of the RI/FS Report will include the following:

- Site description to include climate, topography, vegetation, geology, hydrology and hydrogeology, and natural resources
- Site history and previous investigations for PFAS
- Description of the PFAS field activities to include groundwater, surface water, and fish sampling
- Results of the PFAS field activities
- Nature and extent of PFAS contamination
- Contaminant fate and transport
- Results of the HHRA
- Findings and conclusions
- Recommendations.

Soil and geologic logs, cross sections, geophysical test results, laboratory data, validation reports, and pertinent field data logs will be included as appendices to the RI portion of the report.

5.1.2 Feasibility Study

The FS portion of the RI/FS Report will include the following:

- Identification of remediation requirements and establishment of remedial action objectives (RAOs)
- Development and screening of remedial alternatives
- Detailed analysis of alternatives.

These FS components are described in the subsections below.

5.1.2.1 *Identification of Remediation Requirements and Establishment of Remedial Action Objectives*

The FS will identify areas and volumes of PFAS-impacted media for which remediation is required to eliminate or control conditions posing an unacceptable risk to human health and/or the environment within Area 1. For the areas where a remediation requirement is identified, RAOs and preliminary remediation goals will be developed. RAOs are site-specific, initial cleanup objectives established based on the nature and extent of impacts, the resources that are currently and potentially threatened, and the potential for human and environmental exposure. The preliminary remediation goals will be developed based on site-specific risk factors. Site-specific applicable or relevant and appropriate requirements will be identified and included in the detailed remedial alternatives analysis.

5.1.2.2 *Development and Screening of Remedial Alternatives*

The FS will identify and screen a set of remedial alternatives that have the potential to achieve the RAOs. Alternatives will then be developed to achieve RAOs. In the preliminary screening stage of the FS, remedial alternatives will be evaluated using three general criteria: effectiveness, implementability (technical and administrative), and cost. This step of the screening process will be conducted for the purpose of reducing the number of alternatives carried into the detailed analysis stage. Effectiveness refers to the ability of a remedial action to protect human health and the environment. The short-term impacts during remedial construction and implementation are considered at this stage, as well as the long-term effectiveness of the remedial action after it is completed.

The expected duration of the effectiveness is estimated for each alternative. Implementability refers to the realistic capability to implement an alternative. Technical implementability of a remedial alternative involves the ability to construct and operate the alternative, and to rely on the alternative to meet the performance requirements and consistently achieve the RAOs. Administrative implementability refers to the ability to obtain the required permissions and stakeholder approvals for the action, regulatory compliance, and the availability and capacity for off-post services such as treatment, storage, and disposal, as needed. Cost refers to the relative estimated cost of all aspects (i.e., design, capital costs, and operation and maintenance costs) to implement each alternative.

5.1.2.3 *Detailed Analysis of Alternatives*

A detailed analysis will be conducted for the remedial alternatives retained after the preliminary screening analysis. This detailed analysis will consist of an individual evaluation of each alternative against nine evaluation criteria listed in Section 300.430I of the NCP in accordance with USEPA (1988) guidance and a comparative evaluation of all options against the evaluation criteria with respect to one another:

These evaluation criteria include:

- Overall protection of human health and the environment
- Compliance with applicable or relevant and appropriate requirements
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

- State support/agency acceptance
- Community acceptance.

Following the individual assessment against the nine criteria listed above, a comparative analysis of the alternatives will be conducted to evaluate the relative performance of the alternatives in relation to each specific evaluation criterion. The purpose of the comparative analysis is to better inform the remedy selection process. The comparative analysis will discuss the advantages and disadvantages of the alternatives in relation to one another with respect to each criterion, and how reasonable variations of key uncertainties could change the expectations of their relative performance so that the important issues for final remedial action are clearly identified. The presentation of differences among alternatives will be measured either qualitatively or quantitatively, as appropriate, and will identify substantive differences (e.g., greater short-term effectiveness concerns, greater cost).

5.1.3 Recommendations

Based on the FS findings, a preferred remedial alternative will be identified and presented to the stakeholders and the public in a proposed plan. After public input is obtained during the proposed plan phase, the selected remedial alternative (including contingency plans) will be documented in a record of decision. .

6 Project Schedule

The anticipated project schedule is presented on Figure 6-1.

7 References

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Tables

Table 1-1
Private Well Construction Details (Locations with PFAS6 > 20 ng/L)
Phase II Remedial Investigation Work Plan for PFAS
Former Fort Devens Army Installation
Devens, Massachusetts

Town	Total Well Depth (ft bgs)	Depth to Bedrock (ft bgs)	Ground Surface Elevation (ft NAVD88)
Harvard	705	75	392.63
Harvard	UNK	UNK	367.31
Harvard	~80	UNK	363.11
Harvard	400	60	334.64
Harvard	UNK	UNK	332.45
Harvard	UNK	UNK	266.93
Harvard	~40	UNK	257.16
Harvard	130	24	264.00
Harvard	230	UNK	328.37
Harvard	155	UNK	328.25
Harvard	205	UNK	382.45
Harvard	~200-400	UNK	344.26
Shirley	UNK	UNK	NA

Notes and Abbreviations:

ft bgs = feet below ground surface

ft NAVD88 = feet North American Vertical Datum 1988

NA = not available

UNK = unknown

Table 2-1
Site-Specific Human Health Risk-based Screening Levels
Phase II Remedial Investigation Work Plan for PFAS
Former Fort Devens Army Installation
Devens, Massachusetts

Receptor	**Exposure Routes**	**Medium**	**Units**	**Devens Site-Specific Screening Levels Adult**								**Devens Site-Specific Screening Levels Child**							
PFAS Constituent				**PFOA**	**PFOS**	**PFBS**	**PFNA**	**PFHxS**	**HFPO-DA (GenX)**	**PFBA**	**PFHxA**	**PFOA**	**PFOS**	**PFBS**	**PFNA**	**PFHxS**	**HFPO-DA (GenX)**	**PFBA**	**PFHxA**
Resident	ingestion + dermal	soil	mg/kg									**1.9E-02**	**1.3E-02**	**1.9E+00**	**1.9E-02**	**1.3E-01**	2.4E-02	7.8E+00	**3.2E+00**
Resident	ingestion + dermal	groundwater	µg/L									6.0E-03	4.0E-03	6.0E-01	5.9E-03	3.9E-02	6.0E-03	1.9E+00	9.9E-01
Recreator	ingestion + dermal	sediment	mg/kg									**9.1E-02**	**6.1E-02**	**9.1E+00**	**9.1E-02**	**6.1E-01**	1.1E-01	3.7E+01	**1.5E+01**
Recreator	ingestion + dermal	surface water	µg/L									3.0E-01	2.0E-01	3.0E+01	2.9E-01	1.9E+00	3.0E-01	1.0E+02	4.9E+01
Commercial Worker (Outdoor Worker)	ingestion + dermal	soil	mg/kg	**2.5E-01**	**1.6E-01**	**2.5E+01**	**2.5E-01**	**1.6E+00**	3.5E-01	1.2E+02	**4.1E+01**								
Commercial Worker	ingestion + dermal	groundwater	µg/L	3.5E-02	3.5E-02	3.5E+00	3.5E-02	2.3E-01	3.5E-02	1.2E+01	5.8E+00								
Angler	ingestion	fish tissue	mg/kg	1.2E-03	8.0E-04	1.2E-01	1.2E-03	8.0E-03	1.2E-03	4.0E-01	2.0E-01	9.2E-04	6.1E-04	9.2E-02	9.2E-04	6.1E-03	9.2E-04	3.1E-01	1.5E-01
Construction Worker	ingestion + dermal	soil	mg/kg	**8.0E-02**	**5.4E-02**	**8.0E+00**	**8.0E-02**	**5.4E-01**	1.1E-01	3.5E+01	**1.3E+01**								

Notes:

Risk-based site-specific screening levels (SSSLs) for select PFAS were provided by USEPA Region 1 in June 2023. The SSSLs were calculated using the Regional Screening Level (RSL) online calculator, and calculator output are presented using three significant figures (see Appendix D). The SSSLs in Table 2-1 were rounded to two significant figures, to be consistent with published USEPA RSL tables (https://www.epa.gov/risk/regional-screening-levels-rsls).

BOLD values indicate SSSL is for the combined ingestion and dermal exposure routes because the dermal absorption fraction (ABSd) > 0.
Underlined values indicate SSSL is for the combined ingestion and dermal exposure routes because constituent is within the effective predictive domain (USEPA 2023).

PFAS - per- and polyfluoroalkyl substances.
PFBS - perfluorobutanesulfonic acid.
PFOA - perfluorooctanoic acid.
PFOS - perfluorooctanesulfonic acid.
PFNA - perfluorononanoic acid
PFHxS - perfluorohexanesulfonic acid
HFPO-DA - hexafluoropropylene oxide dimer acid
PFBA - perfluorobutanoic acid
PFHxA - perfluorohexanoic acid
mg/kg - milligrams per kilogram.
µg/L - micrograms per liter.

Table 4-1
Existing Monitoring Wells to be Sampled
Phase II Remedial Investigation Work Plan for PFAS
Former Fort Devens Army Installation
Devens, Massachusetts

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Associated Area	Location ID	Ground Surface Elevation (ft NAVD88)	Top of Casing Elevation (ft NAVD88)	Screen Interval Depth (ft bgs)
Former Vehicle Storage and Motor Repair Shops (AOC 57)	57M-03-06X	220.26	221.87	2 - 12
	57M-95-06X	232.64	234.39	12 - 22
	57M-95-07X	221.50	222.36	3 - 13
	5702MW-19-01A	247.72	247.37	20 - 30
	5702MW-19-01B	247.86	247.60	40 - 50
	5702MW-20-01A	219.59	222.23	30 - 40
	5702MW-20-01B	219.70	222.27	70 - 80
	5702MW-20-02A	241.65	244.32	30 - 40
	5702MW-20-03A	234.78	237.70	26 - 36
	5702MW-20-04A	232.69	235.62	70 - 80
	5702MW-20-05A	223.25	226.09	30 - 40
	5702MW-20-05B	223.29	226.07	70 - 80
	5702MW-20-07A	219.42	221.71	30 - 40
	5703MW-20-01A	225.25	228.18	2 - 12
	5703MW-20-01B	225.10	228.10	50 - 60
	5703MW-20-02A	233.46	235.75	10 - 20
	5703MW-20-04A	229.21	231.74	60 - 70
	57M-95-03X	230.80	232.79	7 - 17
	57M-96-11X	220.05	222.20	2 - 12
	57M-96-13X	223.23	225.58	2 - 12
Barnum Road Firefighting Exercise Site (AOC 74)	74MW-19-04A	222.07	225.48	18 - 28
Former Building T-1445 Warehouse Fire (AOC 75)	75MW-19-01BR	259.37	258.79	35 - 45
	75MW-19-02A	247.76	250.08	38 - 48
	75MW-19-02B	247.86	250.47	70 - 80
	75MW-19-02C	248.01	250.64	210 - 220
	75MW-19-02BR	247.87	250.78	308 - 318
	75MW-19-04A	228.06	230.51	20 - 30
	75MW-19-04B	227.99	230.57	50 - 60
Grove Pond Wellfield Area	92-4	251.55	254.56	67 - 71
	GF-3A	218.52	220.67	97 - 102
	GF-3B	218.61	220.63	8 - 13
	GF-4	224.29	225.93	79 - 84
	MNG-2R	233.50	236.08	14 - 24
	MNG-3R	251.50	254.36	55 - 65
	MNG-5R	233.50	235.91	10 - 20
	MNG-6R	249.70	252.39	30 - 40
	GPMW-19-01A	251.09	253.93	45 - 55
	GPMW-19-01BR	250.83	253.75	175 - 185
Historical Gas Station J (AOC 43J) & Shabokin Water Supply Well Area	SWMW-20-01A	362.96	362.55	5 - 15
	XJM-94-07X	361.40	364.24	4 - 14
Historical Gas Station G	AAFES-2	299.90	301.72	16 - 31
	AAFES-5	300.40	299.80	16 - 31
	AAFES-6R	296.77	298.74	15 -25
	AAFES-7	256.10	257.77	5 - 15
	XGM-93-02X	309.80	309.01	28 - 38
	XGM-94-04X	298.30	300.69	18 - 28
	XGM-94-06X	--	284.07	17- 27

Table 4-1
Existing Monitoring Wells to be Sampled
Phase II Remedial Investigation Work Plan for PFAS
Former Fort Devens Army Installation
Devens, Massachusetts

Associated Area	Location ID	Ground Surface Elevation (ft NAVD88)	Top of Casing Elevation (ft NAVD88)	Screen Interval Depth (ft bgs)
(AOC 43G)	XGM-94-07X	292.20	294.82	17 - 27
	XGM-94-08X	296.40	298.98	24 - 34
	XGM-94-10X	299.60	301.96	22 - 32
	XGM-97-12X	--	308.70	24 - 34
	XGM-20-01A	257.91	257.50	11 - 21
	XGM-20-02A	265.36	265.10	13 - 23
	XGM-20-03A	268.88	268.69	20 - 30

Notes and Abbreviations:

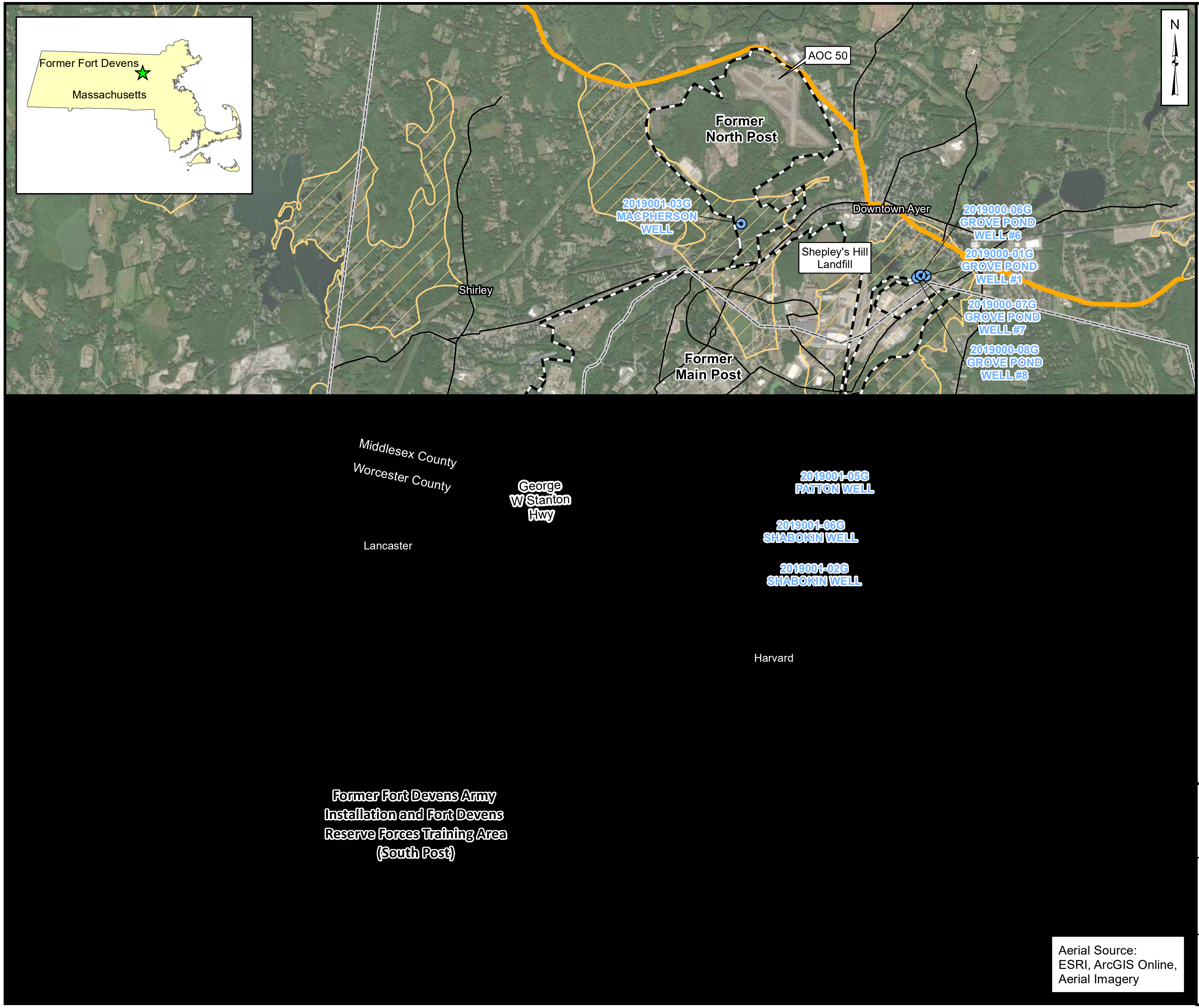
AOC = Area of Contamination

ft bgs = feet below ground surface

ft NAVD88 = feet North American Vertical Datum 1988

Figures

T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\Area 1 Phase 2 Work Plan\UPDATE\Update_Fig_Numbers\Figure 1-1 - Site Location.mxd 12/2/2021 12:11:42 PM User Name: MSMiller



Aerial Source:
ESRI, ArcGIS Online,
Aerial Imagery

Legend

⬚	Former Fort Devens Boundary
◉	Water Supply Well
- - -	County Line
━	Highway
—	Major Road
▨	MassDEP Zone II Wellhead Protection

MassDEP = Massachusetts Department of Environmental Protection

0 1 2
Miles

Phase II Remedial Investigation Work Plan - Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

Site Location
Former Fort Devens
Army Installation

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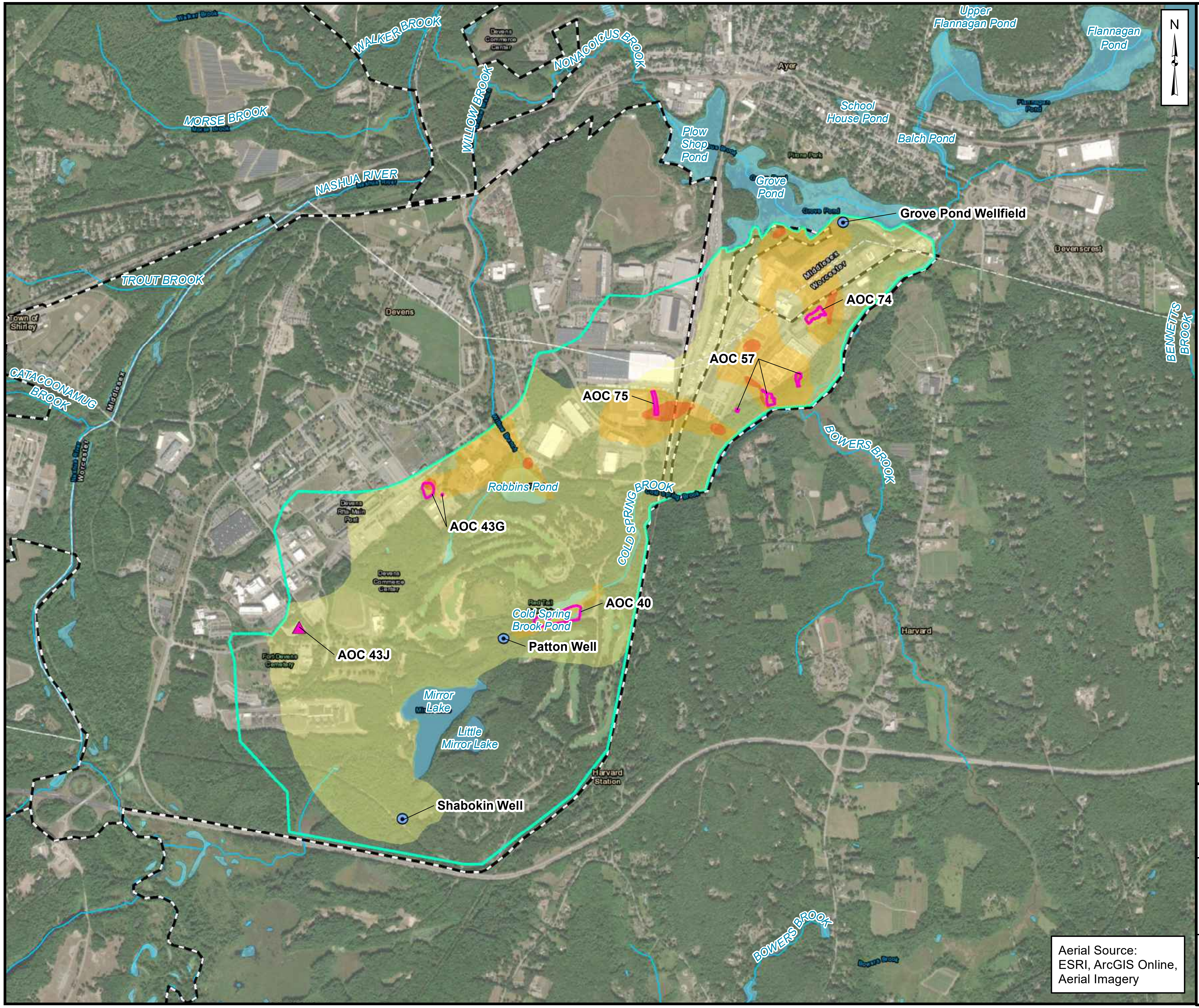
Figure
1-1



Aerial Source:
ESRI, ArcGIS Online,
Aerial Imagery

Legend

⬚	Former Fort Devens Boundary
●	Water Supply Location
▲	AOC Location
▭	AOC Area
▭	PFAS Groundwater Operable Unit Area 1
〰	Stream
▨	Waterbody
🟨	Approximate extent of the Area exceeding the Site-Specific Screening Levels (SSSLs)
🟧	Approximate extent of the Area > 10x SSSLs
🟥	Approximate extent of the Area > 100x SSSLs

AOC = area of contamination

0 1,500 3,000
Feet

Phase II Remedial Investigation Work Plan - Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

PFAS Groundwater Operable Unit Area 1

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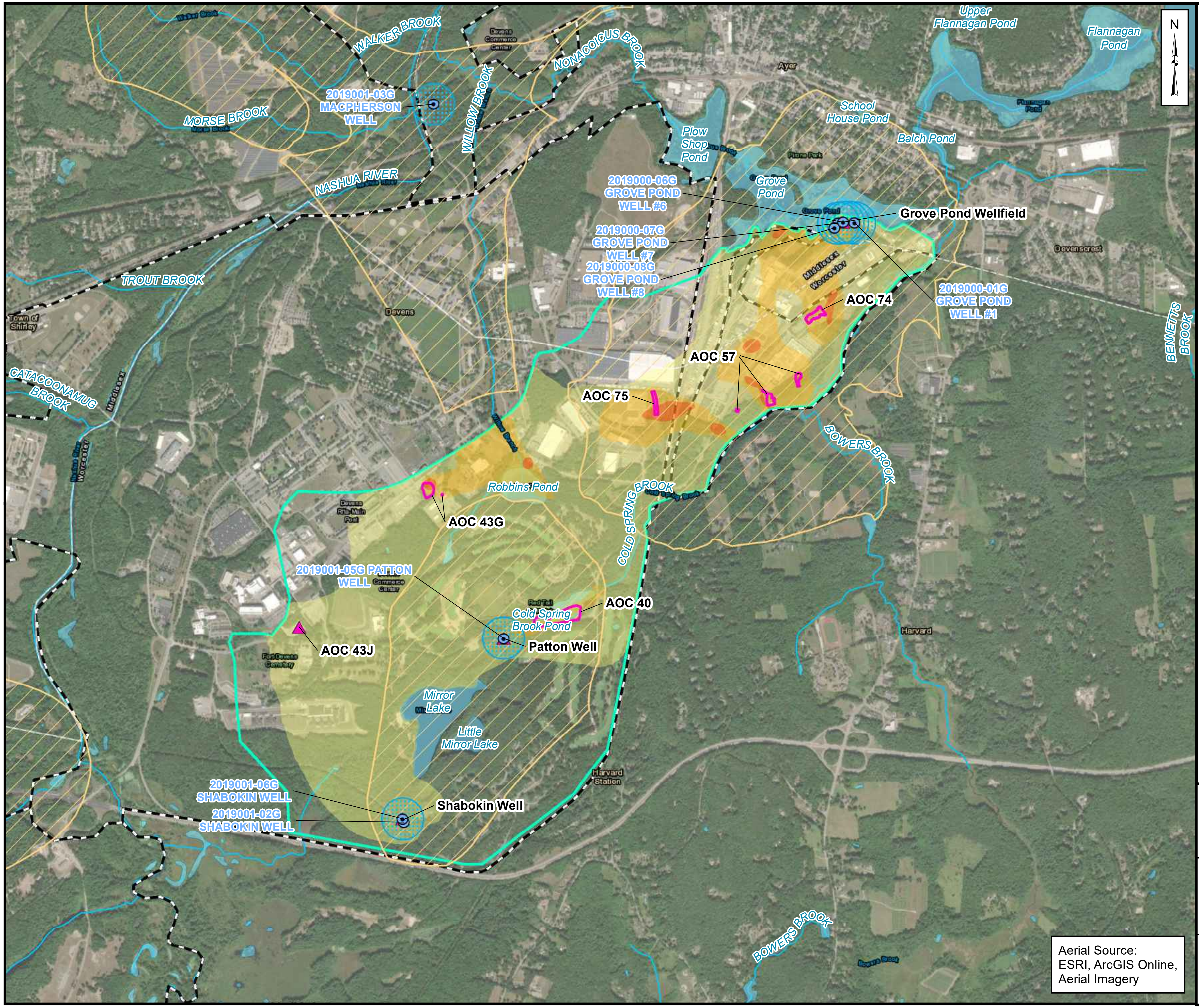
Figure
1-2

T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\Area 1 Phase 2 Work Plan\UPDATE\Update_Fig_Numbers\2022\Figure 1-2 - PFAS Groundwater Operable Unit Area.mxd 1/12/2023 12:04:53 PM User Name: ski01076



Aerial Source:
ESRI, ArcGIS Online,
Aerial Imagery

Legend

- ▭ Former Fort Devens Boundary
- ▲ AOC Location
- ⊙ Water Supply Well
- ▭ AOC Area
- ▭ PFAS Groundwater Operable Unit Area 1
- 〰 Stream
- ▨ Waterbody
- 🟨 Approximate extent of the Area exceeding the Site-Specific Screening Levels (SSSLs)
- 🟧 Approximate extent of the Area > 10x SSSLs
- 🟥 Approximate extent of the Area > 100x SSSLs
- ▦ MassDEP Zone I Wellhead Protection Area
- ▨ MassDEP Zone II Wellhead Protection Area

AOC = area of contamination

0 1,500 3,000
Feet

Phase II Remedial Investigation Work Plan - Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

Wellhead Protection Areas

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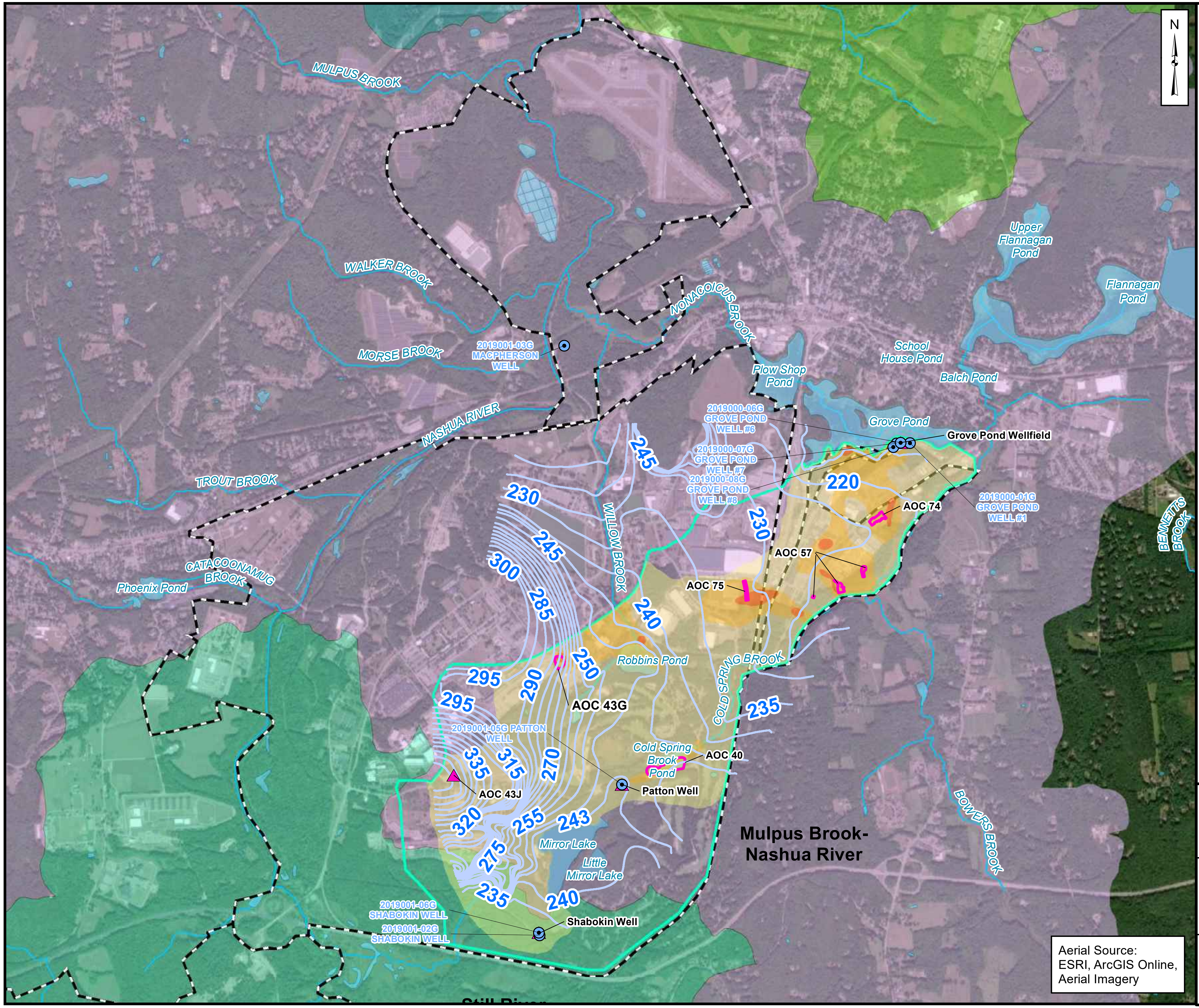
Figure
1-3

T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\Area 1 Phase 2 Work Plan\UPDATE\Update_Fig_Numbers\2022\Figure 1-3 - Wellhead Protection Areas.mxd 1/12/2023 12:06:57 PM User Name: ski01076



Aerial Source:
ESRI, ArcGIS Online,
Aerial Imagery

Legend

▭	Former Fort Devens Boundary
▲	AOC Location
⊙	Water Supply Well
▭	AOC Area
▭	PFAS Groundwater Operable Unit Area 1
〰	Stream
▨	Waterbody
🟨	Approximate extent of the Area exceeding the Site-Specific Screening Levels (SSSLs)
🟧	Approximate extent of the Area > 10x SSSLs
🟥	Approximate extent of the Area > 100x SSSLs

Watershed Boundary

🟪	Mulpus Brook-Nashua River
🟩	Still River-Nashua River
🟩	Unkety Brook-Nashua River
🟦	Witch Brook-Squannacook River

AOC = area of contamination

0 1,500 3,000
Feet

Phase II Remedial Investigation Work Plan - Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

Local-Scale Watersheds

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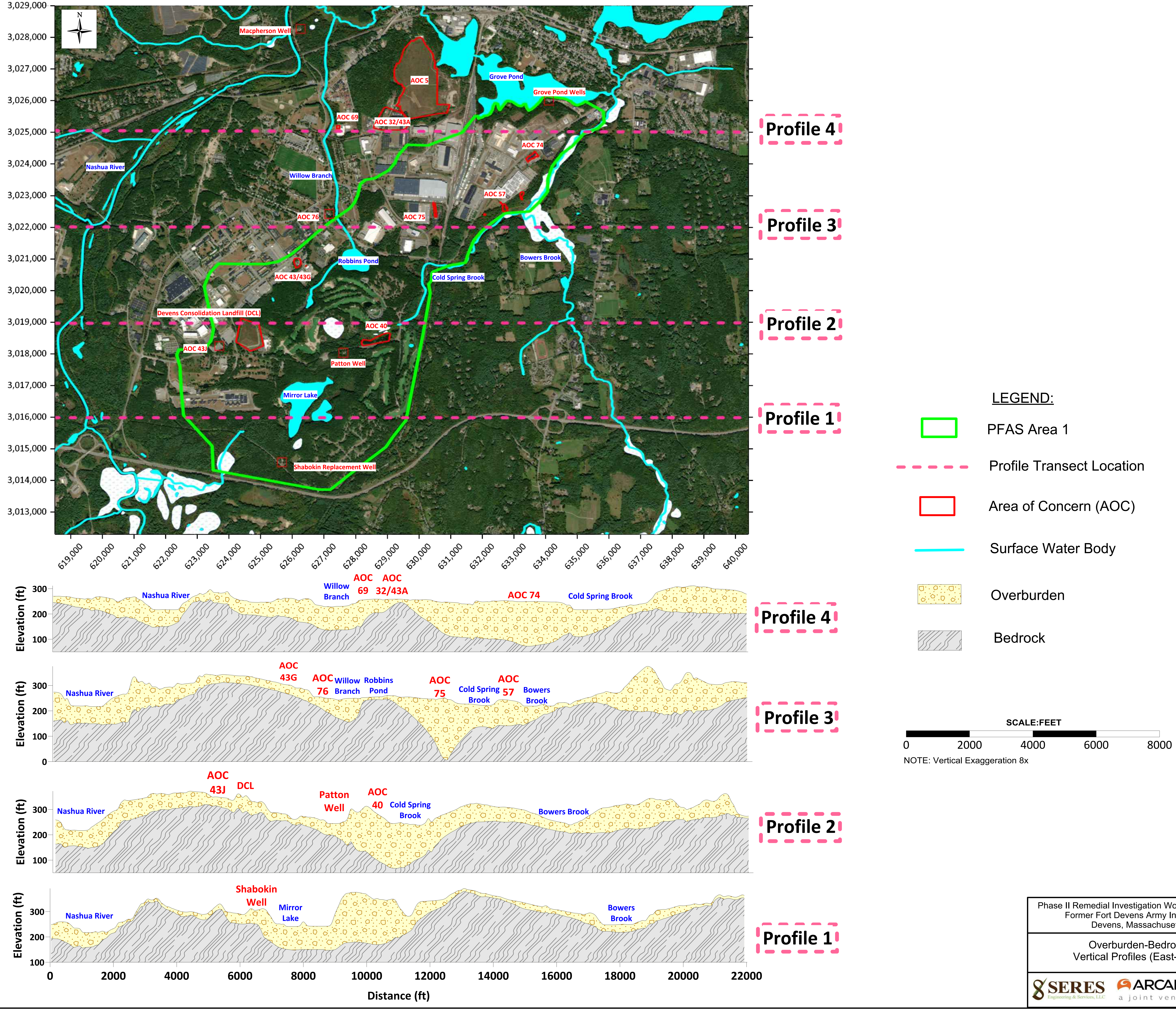
Figure
1-4

T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\Area 1 Phase 2 Work Plan\UPDATE\Update_Fig_Numbers\2023\Figure 1-4 - Local-Scale Watersheds.mxd 1/16/2023 6:33:10 PM User Name: ski01076



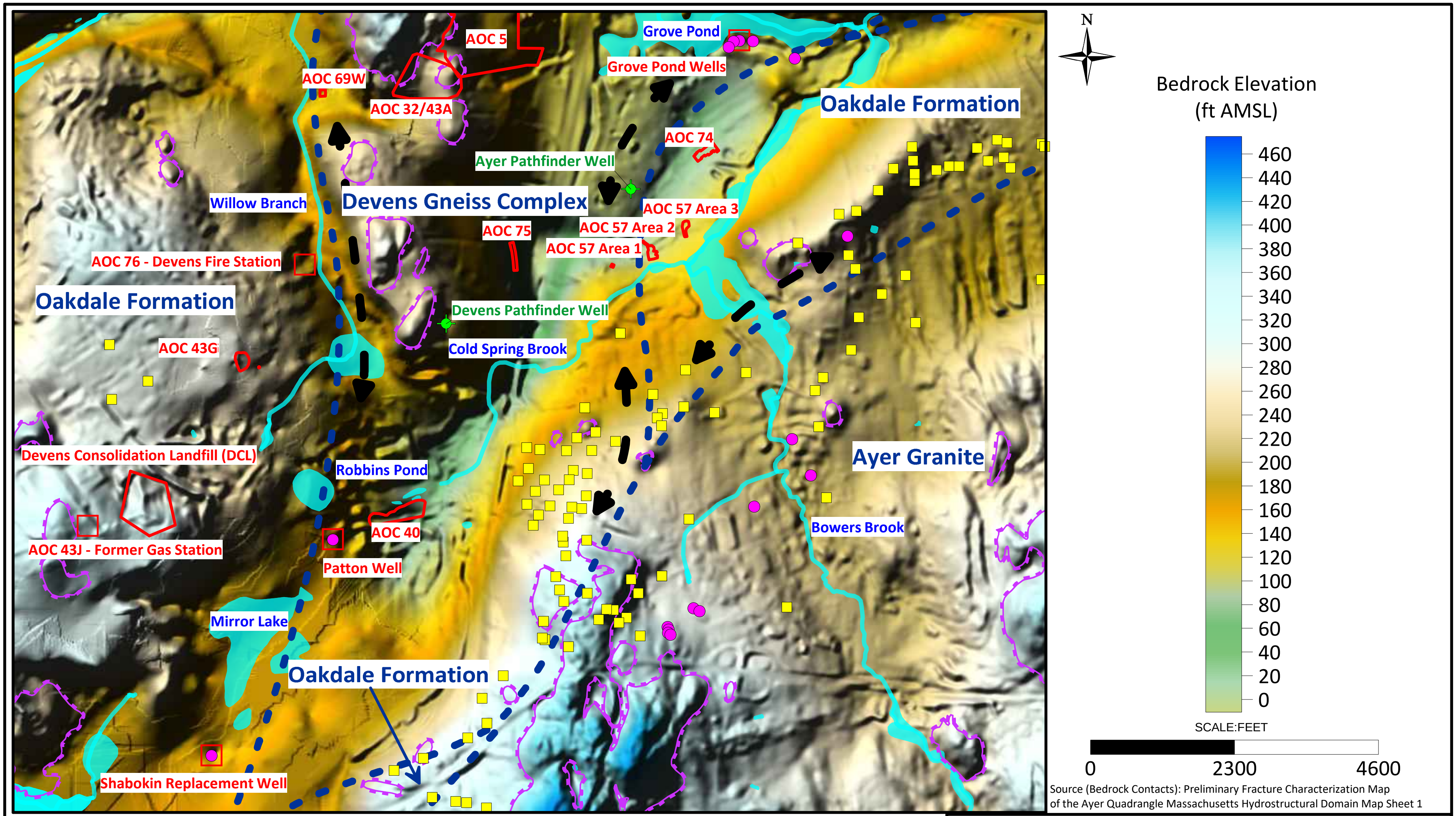
Phase II Remedial Investigation Work Plan - Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

Overburden-Bedrock
Vertical Profiles (East-West)

SERES Engineering & Services, LLC
ARCADIS a joint venture

FIGURE
3-1

PROJECT NAME -



Source (Bedrock Contacts): Preliminary Fracture Characterization Map of the Ayer Quadrangle Massachusetts Hydrostructural Domain Map Sheet 1

LEGEND:

- ▬ ▬ APPROXIMATE BEDROCK CONTACT
- ▬ ▬ ▬ SHALLOW OR EXPOSED BEDROCK
- ☐ AREA OF CONCERN (AOC)
- ▬ ▬ ▶ DOMINANT STRUCTURAL ALIGNMENT (STRIKE)
- ● COMMUNITY PRODUCTION WELL
- ■ PRIVATE RESIDENTIAL WELL
- ✦ PATHFINDER WELL

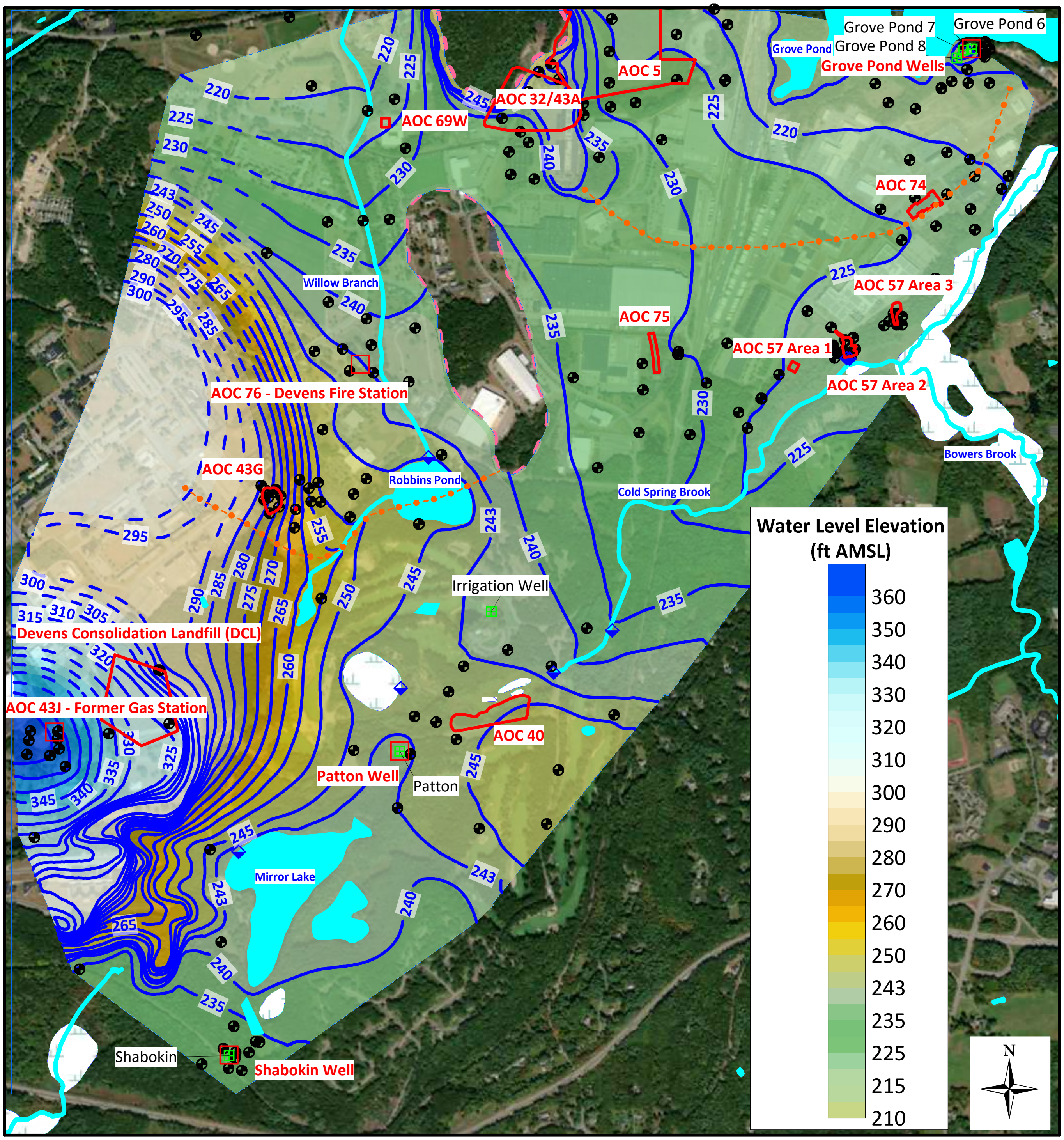
PROJECT NAME:

Phase II Remedial Investigation Work Plan - Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

Regional Bedrock Surface

SERES Engineering & Services, LLC
ARCADIS a joint venture

FIGURE
3-2



SCALE:FEET

0 850 1700

PROJECT NAME -

LEGEND:

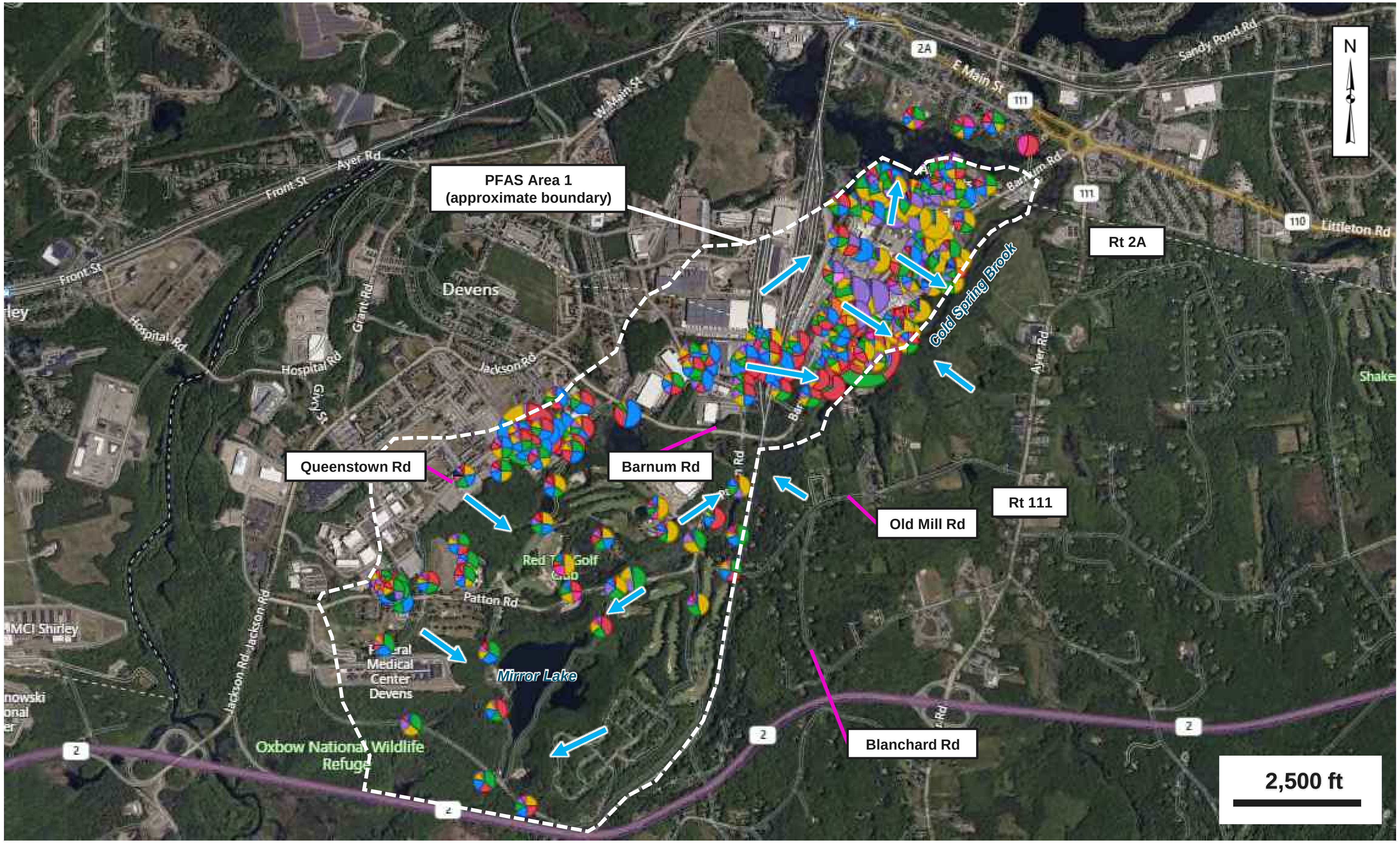
- ━ Groundwater Elevation Contour (ft AMSL) (Dashed Where Inferred)
- -●-●- Inferred Groundwater Flow Divide
- ☐ Area of Concern (AOC)
- ◐ Overburden Monitoring Well
- ◇ Surface Water/Stream Gauge
- ⊞ Water Supply Well
- ━ Surface Water Body
- ╍ Area of No or Negligible Overburden Thickness

Phase II Remedial Investigation Work Plan - Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

Overburden Water Level Elevation Contours (March 2020)

SERES Engineering & Services, LLC
ARCADIS
a joint venture

FIGURE
3-3



Maximum Detection of PFAS in Groundwater

Analyte

● 6:2 FtS
● 8:2 FtS
● EtFOSAA
● MeFOSAA
● PFBS
● PFDA
● PFHpA
● PFHxA
● PFHxS
● PFNA
● PFOA
● PFOS

Analyte Acronyms

1. 6:2 FtS = 6:2 fluorotelomer sulfonate
2. 8:2 FtS = 8:2 fluorotelomer sulfonic acid
3. EtFOSAA = N-ethyl perfluorooctane sulfonamidoacetic acid
4. NMeFOSAA = N-methylperfluorooctane sulfonamidoacetic acid
5. PFBS = perfluorobutanesulfonic acid
6. PFDA = perfluorodecanoic acid
7. PFHpA = perfluoroheptanoic acid
8. PFHxA = perfluorohexanoic acid
9. PFHxS = perfluorohexanesulfonic acid
10. PFNA = perfluorononanoic acid
11. PFOA = perfluorooctanoic acid
12. PFOS = perfluorooctanesulfonic acid

Notes

1. A pie chart showing the PFAS mixture at each sampled location is shown regardless of the concentration detected. Pie charts are shown at both locations that exceed and do not exceed the MMCL.
2. The size of the pie chart is proportional to the sum of the PFAS concentrations. Larger pie charts indicate higher total PFAS concentrations when compared to smaller pie charts.

→ Interpreted Groundwater Flow Direction (to be confirmed)

PHASE II REMEDIAL INVESTIGATION WORK PLAN - AREA 1
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

PFAS MIXTURES – PFAS AREA 1

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ARCADIS
a joint venture

FIGURE
3-4a

Maximum Detection of PFAS in Groundwater

Analyte

● 6:2 FtS	● PFHpA
● 8:2 FtS	● PFHxA
● EtFOSAA	● PFHxS
● MeFOSAA	● PFNA
● PFBS	● PFOA
● PFDA	● PFOS

Analyte Acronyms

1. 6:2 FtS = 6:2 fluorotelomer sulfonate
2. 8:2 FtS = 8:2 fluorotelomer sulfonic acid
3. EtFOSAA = N-ethyl perfluorooctane sulfonamidoacetic acid
4. NMeFOSAA = N-methylperfluorooctane sulfonamidoacetic acid
5. PFBS = perfluorobutanesulfonic acid
6. PFDA = perfluorodecanoic acid
7. PFHpA = perfluoroheptanoic acid
8. PFHxA = perfluorohexanoic acid
9. PFHxS = perfluorohexanesulfonic acid
10. PFNA = perfluorononanoic acid
11. PFOA = perfluorooctanoic acid
12. PFOS = perfluorooctanesulfonic acid

Notes

1. A pie chart showing the PFAS mixture at each sampled location is shown regardless of the concentration detected. Pie charts are shown at both locations that exceed and do not exceed the MMCL.
2. The size of the pie chart is proportional to the sum of the PFAS concentrations. Larger pie charts indicate higher total PFAS concentrations when compared to smaller pie charts.

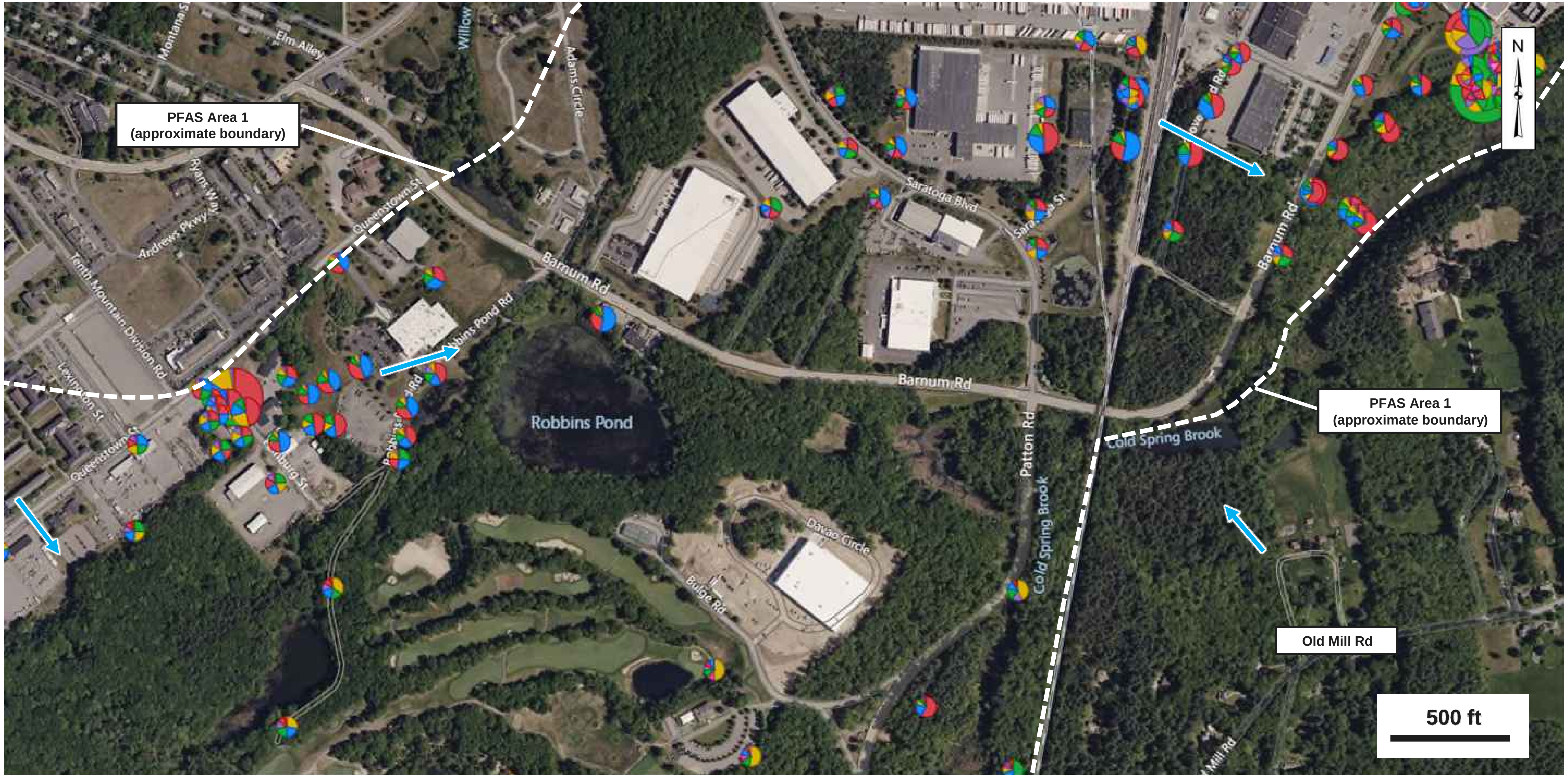
→ Interpreted Groundwater Flow Direction (to be confirmed)

PHASE II REMEDIAL INVESTIGATION WORK PLAN - AREA 1
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

PFAS MIXTURES –
AOC 57, AOC 74, GROVE POND WELLFIELD

SERES Engineering & Services, LLC
ARCADIS
a joint venture

FIGURE
3-4b



Maximum Detection of PFAS in Groundwater

Analyte

- ● 6:2 FtS
- ● 8:2 FtS
- ● EtFOSAA
- ● MeFOSAA
- ● PFBS
- ● PFDA
- ● PFHpA
- ● PFHxA
- ● PFHxS
- ● PFNA
- ● PFOA
- ● PFOS

Analyte Acronyms

1. 6:2 FtS = 6:2 fluorotelomer sulfonate
2. 8:2 FtS = 8:2 fluorotelomer sulfonic acid
3. EtFOSAA = N-ethyl perfluorooctane sulfonamidoacetic acid
4. NMeFOSAA = N-methylperfluorooctane sulfonamidoacetic acid
5. PFBS = perfluorobutanesulfonic acid
6. PFDA = perfluorodecanoic acid
7. PFHpA = perfluoroheptanoic acid
8. PFHxA = perfluorohexanoic acid
9. PFHxS = perfluorohexanesulfonic acid
10. PFNA = perfluorononanoic acid
11. PFOA = perfluorooctanoic acid
12. PFOS = perfluorooctanesulfonic acid

Notes

1. A pie chart showing the PFAS mixture at each sampled location is shown regardless of the concentration detected. Pie charts are shown at both locations that exceed and do not exceed the MMCL.
2. The size of the pie chart is proportional to the sum of the PFAS concentrations. Larger pie charts indicate higher total PFAS concentrations when compared to smaller pie charts.

→ Interpreted Groundwater Flow Direction (to be confirmed)

PHASE II REMEDIAL INVESTIGATION WORK PLAN - AREA 1
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

PFAS MIXTURES – AOC 75, AOC 43G

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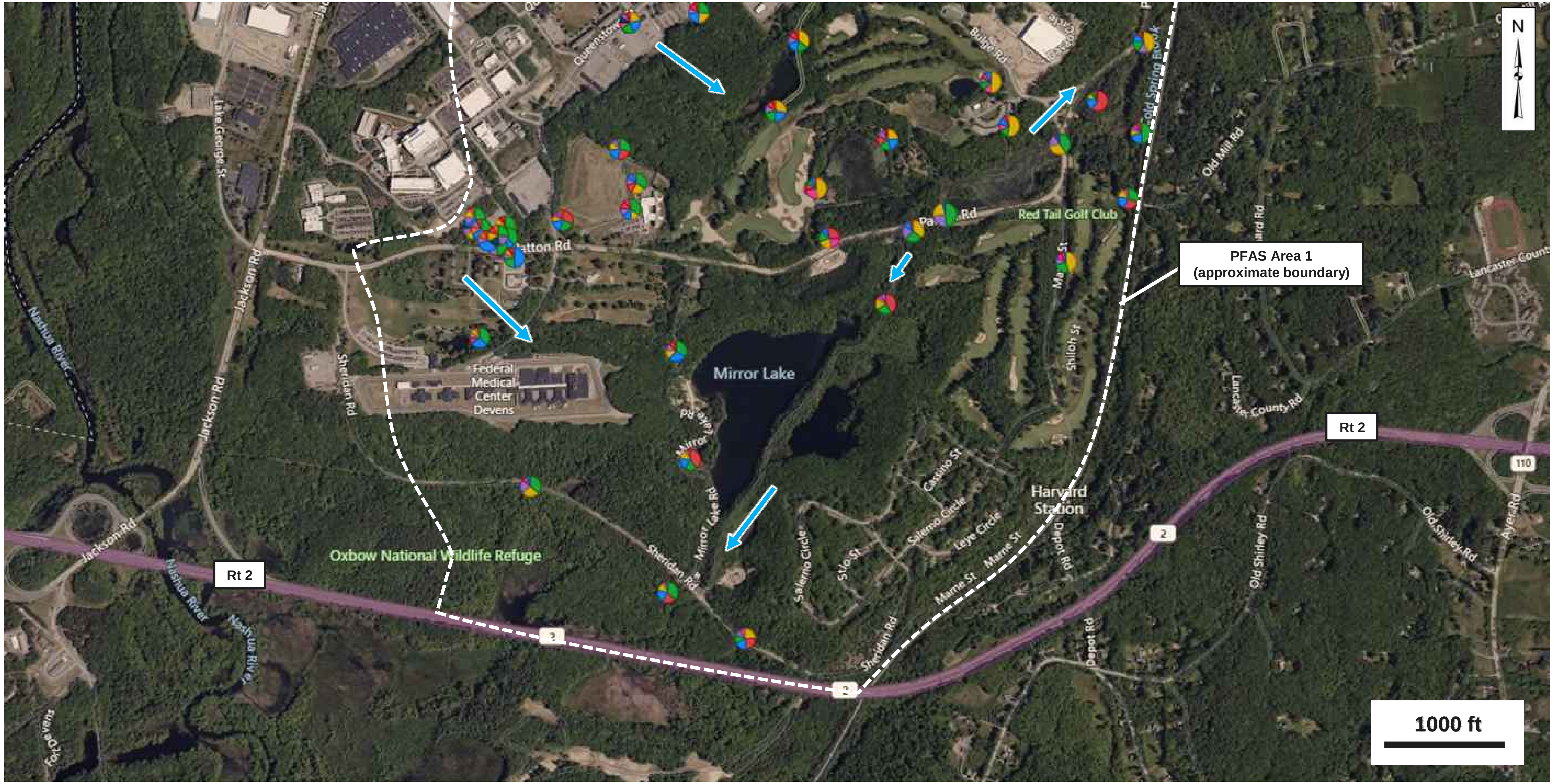
ARCADIS
a joint venture

FIGURE
3-4c



Maximum Detection of PFAS in Groundwater

Analyte

● 6:2 FtS	● PFHpA
● 8:2 FtS	● PFHxA
● EtFOSAA	● PFHxS
● MeFOSAA	● PFNA
● PFBS	● PFOA
● PFDA	● PFOS

Analyte Acronyms

1. 6:2 FtS = 6:2 fluorotelomer sulfonate
2. 8:2 FtS = 8:2 fluorotelomer sulfonic acid
3. EtFOSAA = N-ethyl perfluorooctane sulfonamidoacetic acid
4. NMeFOSAA = N-methylperfluorooctane sulfonamidoacetic acid
5. PFBS = perfluorobutanesulfonic acid
6. PFDA = perfluorodecanoic acid
7. PFHpA = perfluoroheptanoic acid
8. PFHxA = perfluorohexanoic acid
9. PFHxS = perfluorohexanesulfonic acid
10. PFNA = perfluorononanoic acid
11. PFOA = perfluorooctanoic acid
12. PFOS = perfluorooctanesulfonic acid

Notes

1. A pie chart showing the PFAS mixture at each sampled location is shown regardless of the concentration detected. Pie charts are shown at both locations that exceed and do not exceed the MMCL.
2. The size of the pie chart is proportional to the sum of the PFAS concentrations. Larger pie charts indicate higher total PFAS concentrations when compared to smaller pie charts.

→ Interpreted Groundwater Flow Direction (to be confirmed)

PHASE II REMEDIAL INVESTIGATION WORK PLAN - AREA 1
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

PFAS MIXTURES –
AOC 43J, AOC 40, PATTON WATER SUPPLY AND
SHABOKIN WATER SUPPLY WELL AREAS

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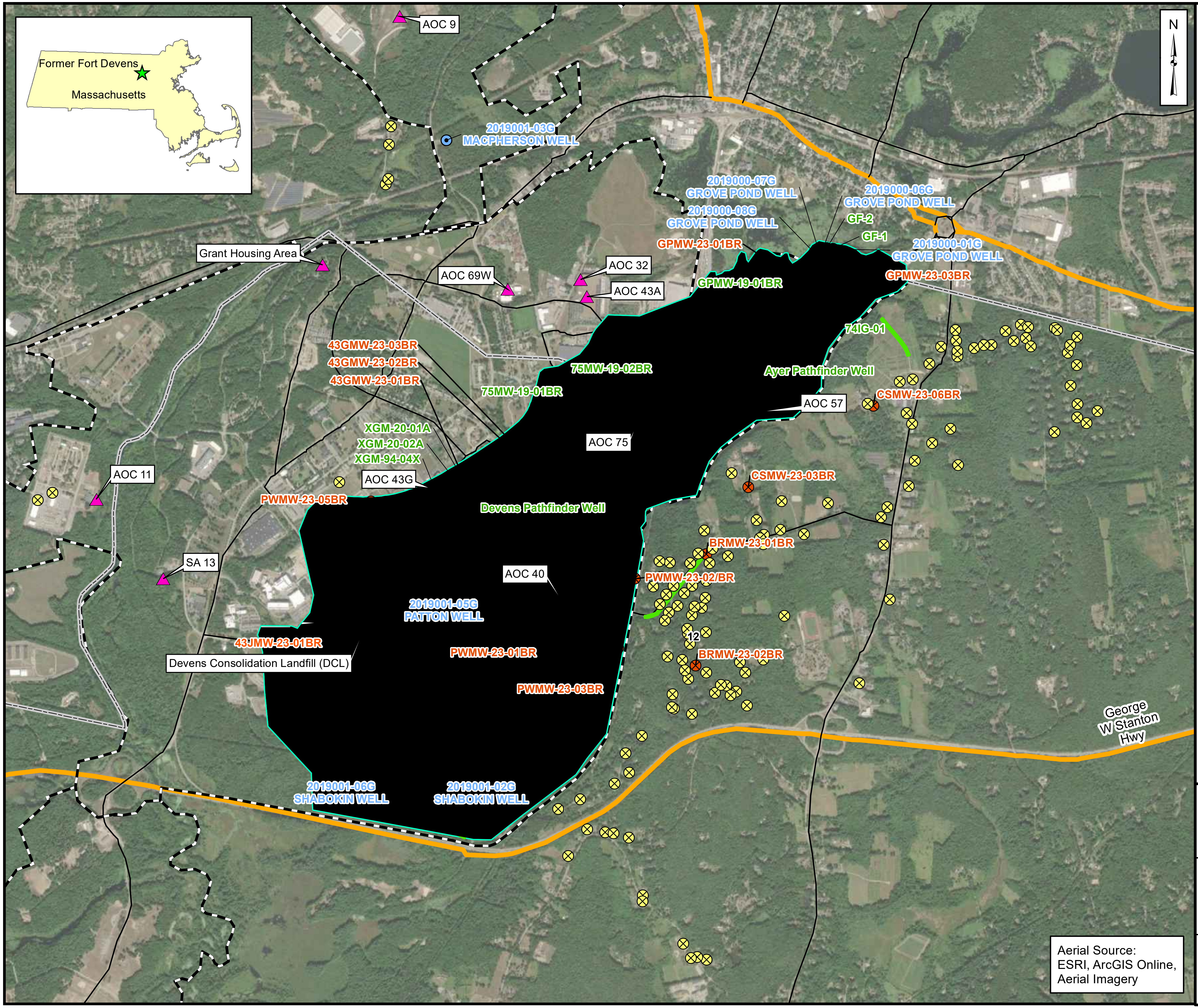
a joint venture

FIGURE
3-4d

Document Path: T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\Area 1 Phase 2 Work Plan\UPDATE\Update_Fig_Numbers\2022\Figure 4-1 - Proposed Investigation Locations.mxd Date Saved: 1/12/2023 11:08:10 AM User Name: ski01076



Aerial Source:
ESRI, ArcGIS Online,
Aerial Imagery

Legend

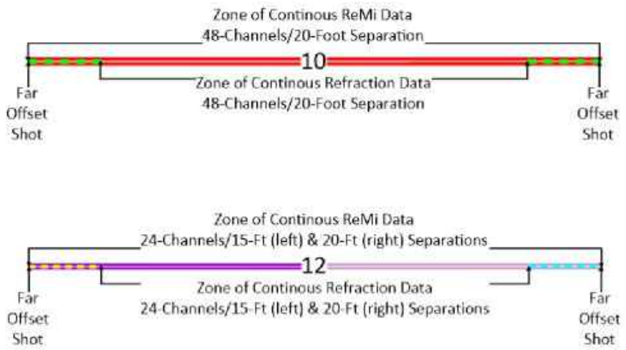
▭	Former Fort Devens Boundary
▲	AOC Location
⊙	Public Water Supply Well
⊗	Private Water Supply Well
⊗	Proposed Deep Bedrock Well
⊗	Existing Bedrock Well
▭	PFAS Groundwater Operable Unit Area
---	County Line
—	Highway
—	Major Road
🟨	Approximate extent of the Area exceeding the Site-Specific Screening Levels (SSSLs)
🟧	Approximate extent of the Area > 10x SSSLs
🟥	Approximate extent of the Area > 100x SSSLs

Seismic Survey Lines

—	Approximate Passive Surface Wave
—	Approximate Refraction Lines

AOC = Area of Environmental Concern
MassDEP = Massachusetts Department of Environmental Protection

Proposed Seismic Profile



0 0.5 1
Miles

Phase II Remedial Investigation Work Plan - Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

Seismic Profile Surveying Locations

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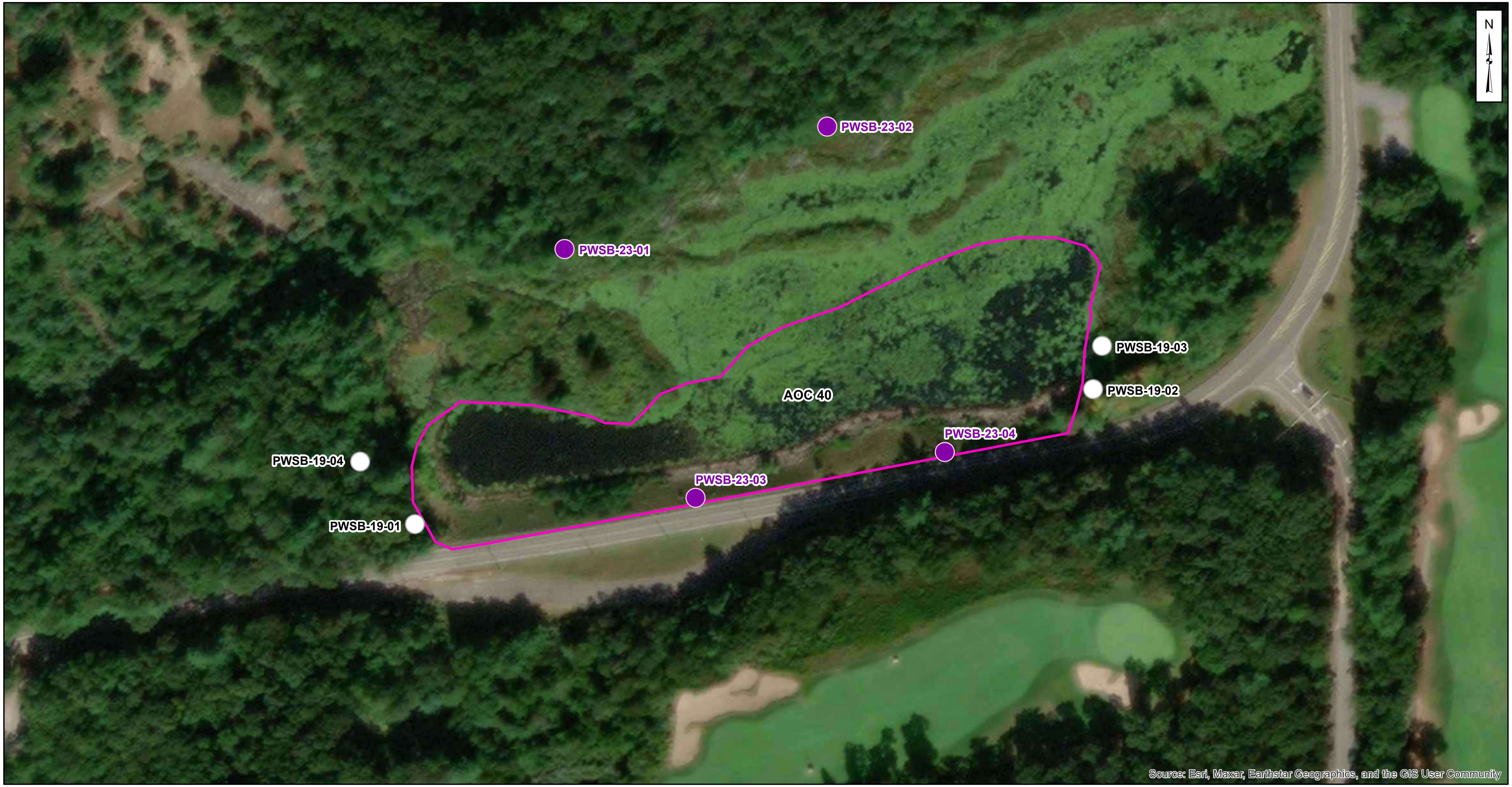
ARCADIS
a joint venture

Figure
4-1



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Legend

Phase 1 PFAS Investigation Locations

○ Completed Soil Boring Below SSSL

🟡 Completed Soil Boring Above SSSL

Proposed Soil Investigation Locations

🟣 Soil Boring

▭ Area of Contamination (AOC)

Notes and Abbreviations:

1. SSSL = Site Specific Screening Levels
2. ug/kg = micrograms per kilogram
3. Perfluorobutanesulfonic = PFBS
4. Perfluorohexane sulfonate = PFHxS
5. Perfluorononanoic acid = PFNA
6. Perfluorooctanesulfonic acid = PFOS
7. Perfluorooctanoic acid = PFOA
8. SSSLs are the May 2022 Devens SSSLs for Child Resident:
   PFBS – 1900 ug/kg, PFHxS – 126 ug/kg, PFNA – 19 ug/kg,
   PFOS – 12.6 ug/kg, PFOA – 19 ug/kg

0 125 250

SCALE IN FEET

AREA 1 PHASE 2 WORK PLAN
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

PROPOSED SOIL INVESTIGATION LOCATIONS AOC40

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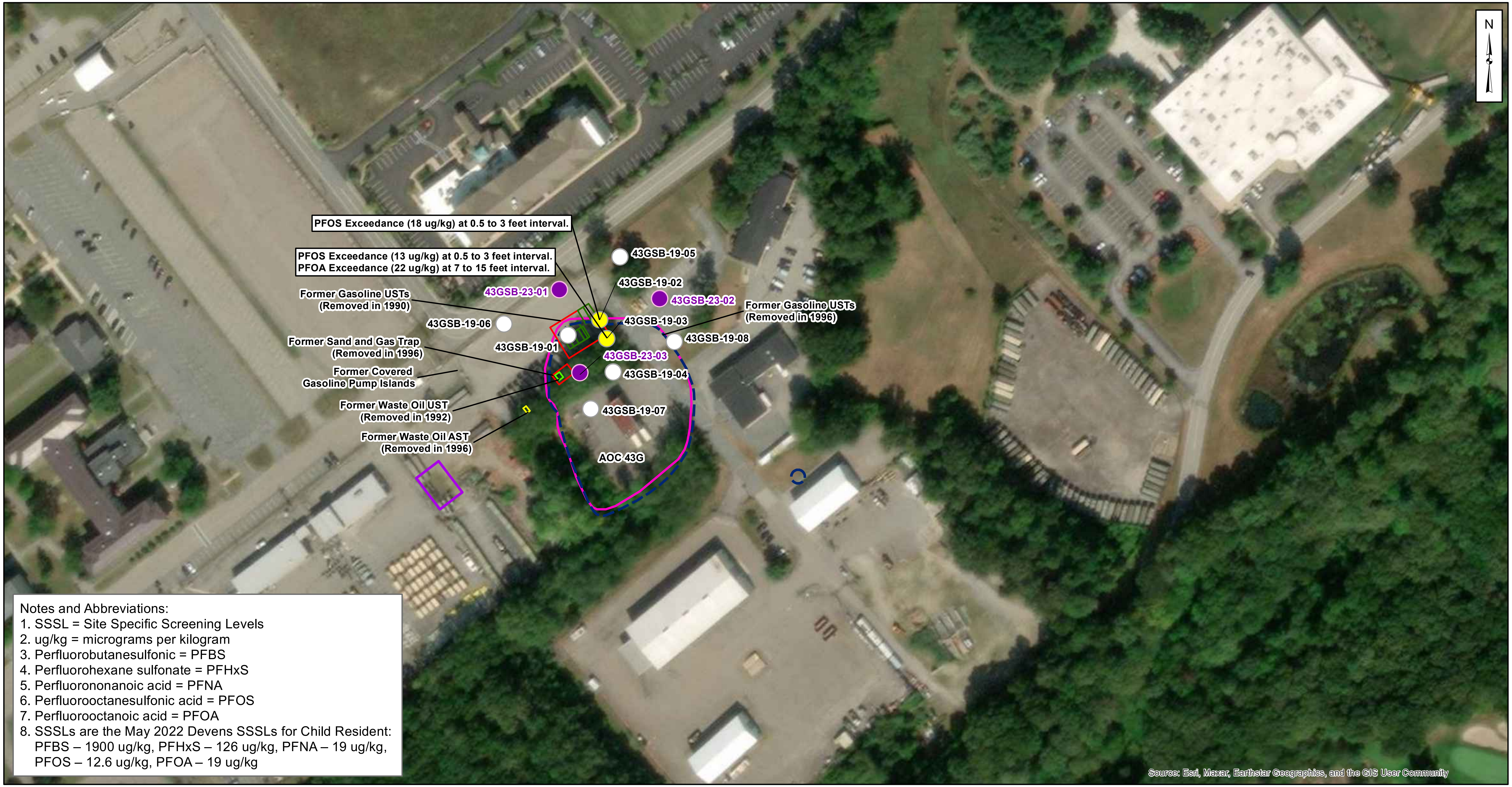
a joint venture

FIGURE
4-2

Project (Project #30048392)
T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\AOC40\Figure 4-2 - Proposed Soil Investigation Locations AOC 40.mxd 12/2/2022 10:35:22 AM



Notes and Abbreviations:
1. SSSL = Site Specific Screening Levels
2. ug/kg = micrograms per kilogram
3. Perfluorobutanesulfonic = PFBS
4. Perfluorohexane sulfonate = PFHxS
5. Perfluorononanoic acid = PFNA
6. Perfluorooctanesulfonic acid = PFOS
7. Perfluorooctanoic acid = PFOA
8. SSSLs are the May 2022 Devens SSSLs for Child Resident: PFBS – 1900 ug/kg, PFHxS – 126 ug/kg, PFNA – 19 ug/kg, PFOS – 12.6 ug/kg, PFOA – 19 ug/kg

Legend

Phase 1 PFAS Investigation Locations

○ Completed Soil Boring Below SSSL

● Completed Soil Boring Above SSSL

Proposed Soil Investigation Locations

● Soil Boring

☐ Area of Contamination (AOC)

☐ Approximate Historical Extent of Groundwater Contamination in Exceedance of Cleanup Goals (based on 1999 to 2008 analytical data) (2008 Annual Report, HGL, 2009)

☐ Area 1

☐ Former Gasoline UST(s)

☐ Former Waste Oil UST

☐ Former Waste Oil AST

☐ Former UST Area

0 125 250
SCALE IN FEET

AREA 1 PHASE 2 WORK PLAN
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

PROPOSED SOIL INVESTIGATION LOCATIONS AOC43G

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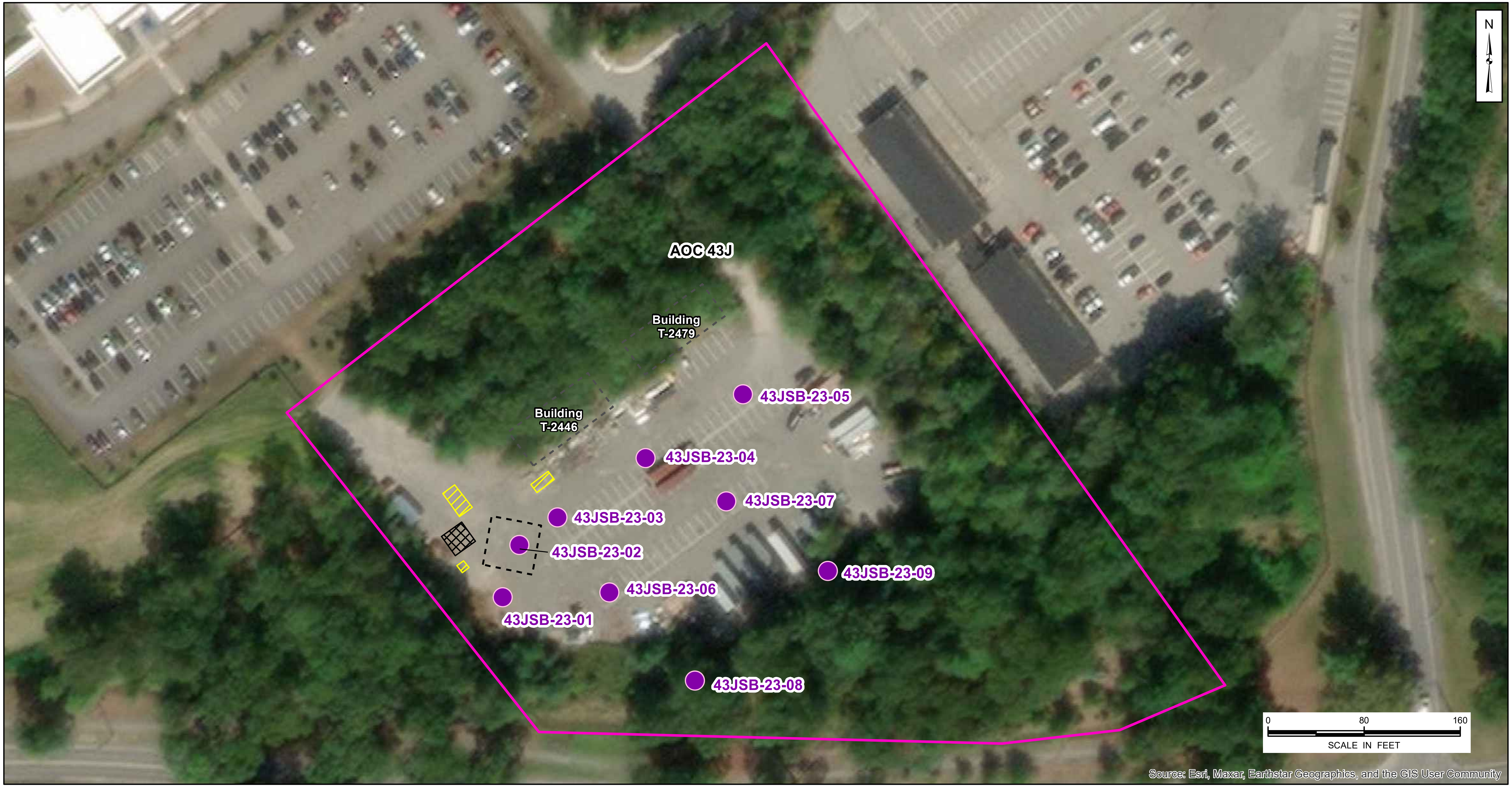
ARCADIS
a joint venture

FIGURE
4-3

Project (Project #30048392)
T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\AOC43G\Figure 4-3 - Proposed Soil Investigation Locations AOC 43G.mxd 1/12/2023 12:16:17 PM



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Legend

Phase 1 PFAS Investigation Locations

○	Completed Soil Boring Below SSSL
●	Completed Soil Boring Above SSSL

Proposed Soil Investigation Locations

●	Soil Boring
▭	Area of Contamination (AOC)
▨	Approximate Location of Former UST
⬚	Approximate Location of 2009 and 2010 Pilot Test Area
▩	Approximate Location of Pilot Test Mixing Equipment
⬚	Former Building

Notes and Abbreviations:

1. SSSL = Site Specific Screening Levels
2. ug/kg = micrograms per kilogram
3. Perfluorobutanesulfonic = PFBS
4. Perfluorohexane sulfonate = PFHxS
5. Perfluorononanoic acid = PFNA
6. Perfluorooctanesulfonic acid = PFOS
7. Perfluorooctanoic acid = PFOA
8. SSSLs are the May 2022 Devens SSSLs for Child Resident: PFBS – 1900 ug/kg, PFHxS – 126 ug/kg, PFNA – 19 ug/kg, PFOS – 12.6 ug/kg, PFOA – 19 ug/kg

AREA 1 PHASE 2 WORK PLAN
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

PROPOSED SOIL INVESTIGATION LOCATIONS
AOC43J

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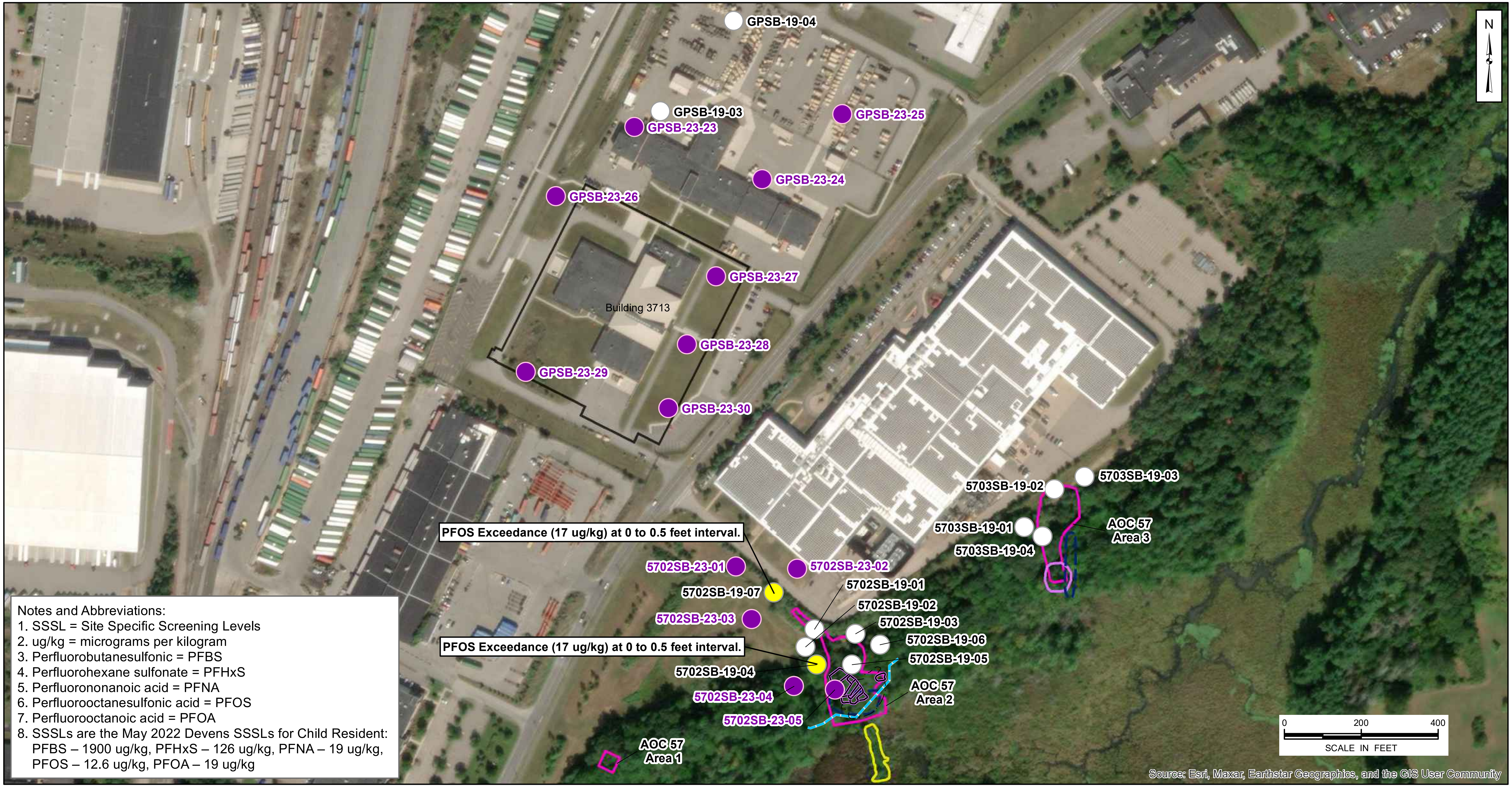
ARCADIS
a joint venture

FIGURE
4-4

Project (Project #30048392)
T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\AOC43J\Figure 4-4 - Proposed Soil Investigation Locations AOC 43J.mxd 12/2/2022 3:33:15 PM



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Notes and Abbreviations:

1. SSSL = Site Specific Screening Levels
2. ug/kg = micrograms per kilogram
3. Perfluorobutanesulfonic = PFBS
4. Perfluorohexane sulfonate = PFHxS
5. Perfluorononanoic acid = PFNA
6. Perfluorooctanesulfonic acid = PFOS
7. Perfluorooctanoic acid = PFOA
8. SSSLs are the May 2022 Devens SSSLs for Child Resident: PFBS – 1900 ug/kg, PFHxS – 126 ug/kg, PFNA – 19 ug/kg, PFOS – 12.6 ug/kg, PFOA – 19 ug/kg

Legend

Phase 1 PFAS Investigation Locations

○ Completed Soil Boring Below SSSL

● Completed Soil Boring Above SSSL

Proposed Soil Investigation Locations

● Soil Boring

▭ Area of Contamination (AOC)

— Final Excavation Limit (2003)

-·- Conti Excavation Limit (2002)

--- Flagged Wetland Limits

▭ Approximate Historical Extent of Groundwater Contamination in Exceedance of Cleanup Goals (based on fall 2003 to spring 2008 analytical data) (2008 Annual Report, HGL, 2009)

▭ Containment Dam

▭ Alternate III-2a Estimated Soil Excavation Area

▭ Former Building

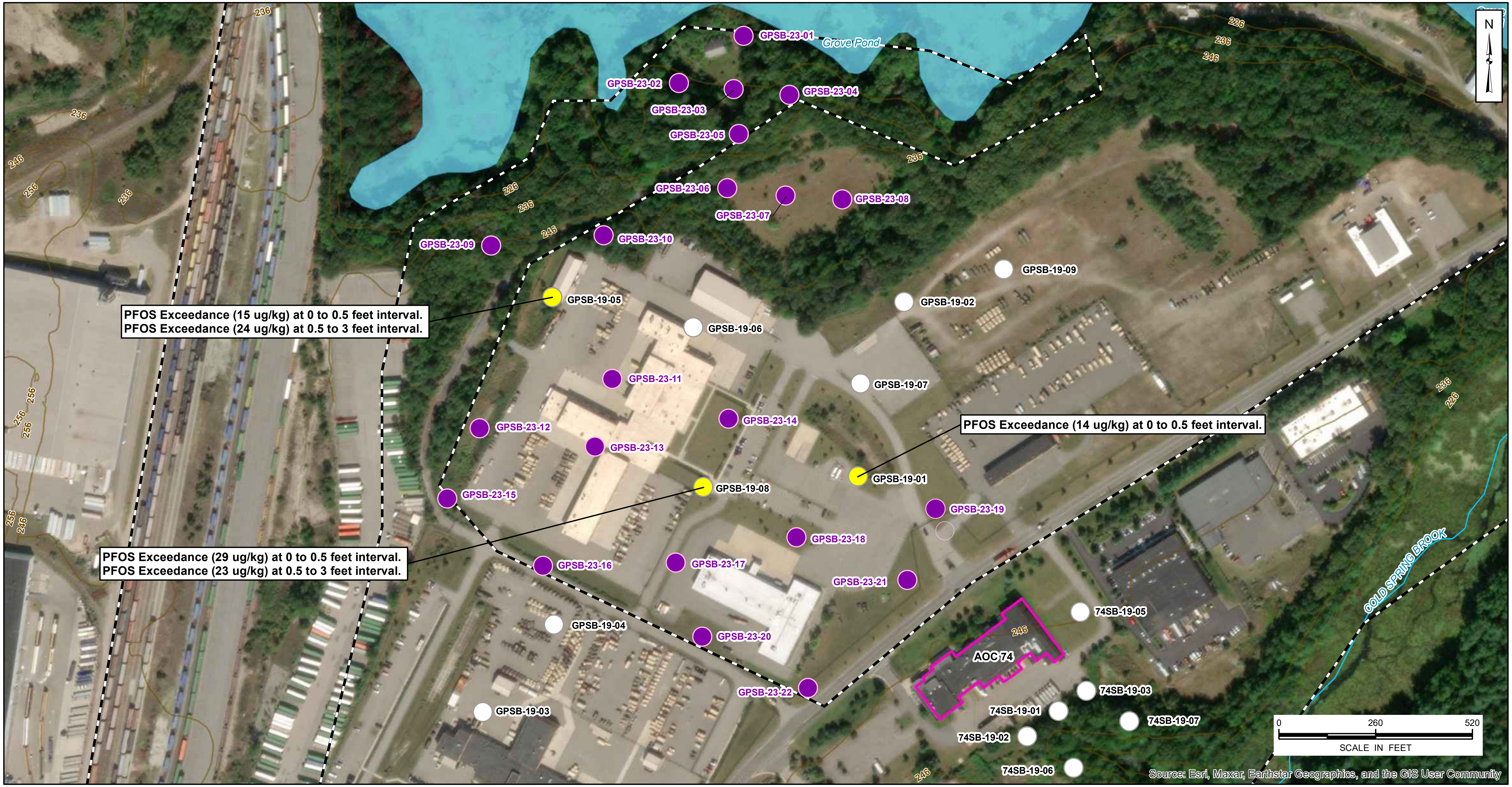
AREA 1 PHASE 2 WORK PLAN
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

PROPOSED SOIL INVESTIGATION LOCATIONS
AOC 57 AND BUILDING 3713 AREAS

SERES ARCADIS a joint venture

FIGURE 4-5

Project (Project #30048392)
T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\AOC57\Figure 4-5 - Proposed Soil Investigation Locations AOC 57.mxd 12/5/2022 11:51:01 AM



PFOS Exceedance (15 ug/kg) at 0 to 0.5 feet interval.
PFOS Exceedance (24 ug/kg) at 0.5 to 3 feet interval.

PFOS Exceedance (14 ug/kg) at 0 to 0.5 feet interval.

PFOS Exceedance (29 ug/kg) at 0 to 0.5 feet interval.
PFOS Exceedance (23 ug/kg) at 0.5 to 3 feet interval.

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Legend

Phase 1 PFAS Investigation Locations

- ○ Completed Soil Boring Below SSSL
- ● Completed Soil Boring Above SSSL

Proposed Soil Investigation Locations

- ● Soil Boring
- ▭ Area of Contamination (AOC)
- 〰 Stream
- ⌒ Topographic Contour (ft AMSL)
- ▨ Waterbody
- ⬚ Former Fort Devens Boundary

Notes and Abbreviations:

1. SSSL = Site Specific Screening Levels
2. ug/kg = micrograms per kilogram
3. Perfluorobutanesulfonic = PFBS
4. Perfluorohexane sulfonate = PFHxS
5. Perfluorononanoic acid = PFNA
6. Perfluorooctanesulfonic acid = PFOS
7. Perfluorooctanoic acid = PFOA
8. SSSLs are the May 2022 Devens SSSLs for Child Resident:
   PFBS – 1900 ug/kg, PFHxS – 126 ug/kg, PFNA – 19 ug/kg,
   PFOS – 12.6 ug/kg, PFOA – 19 ug/kg

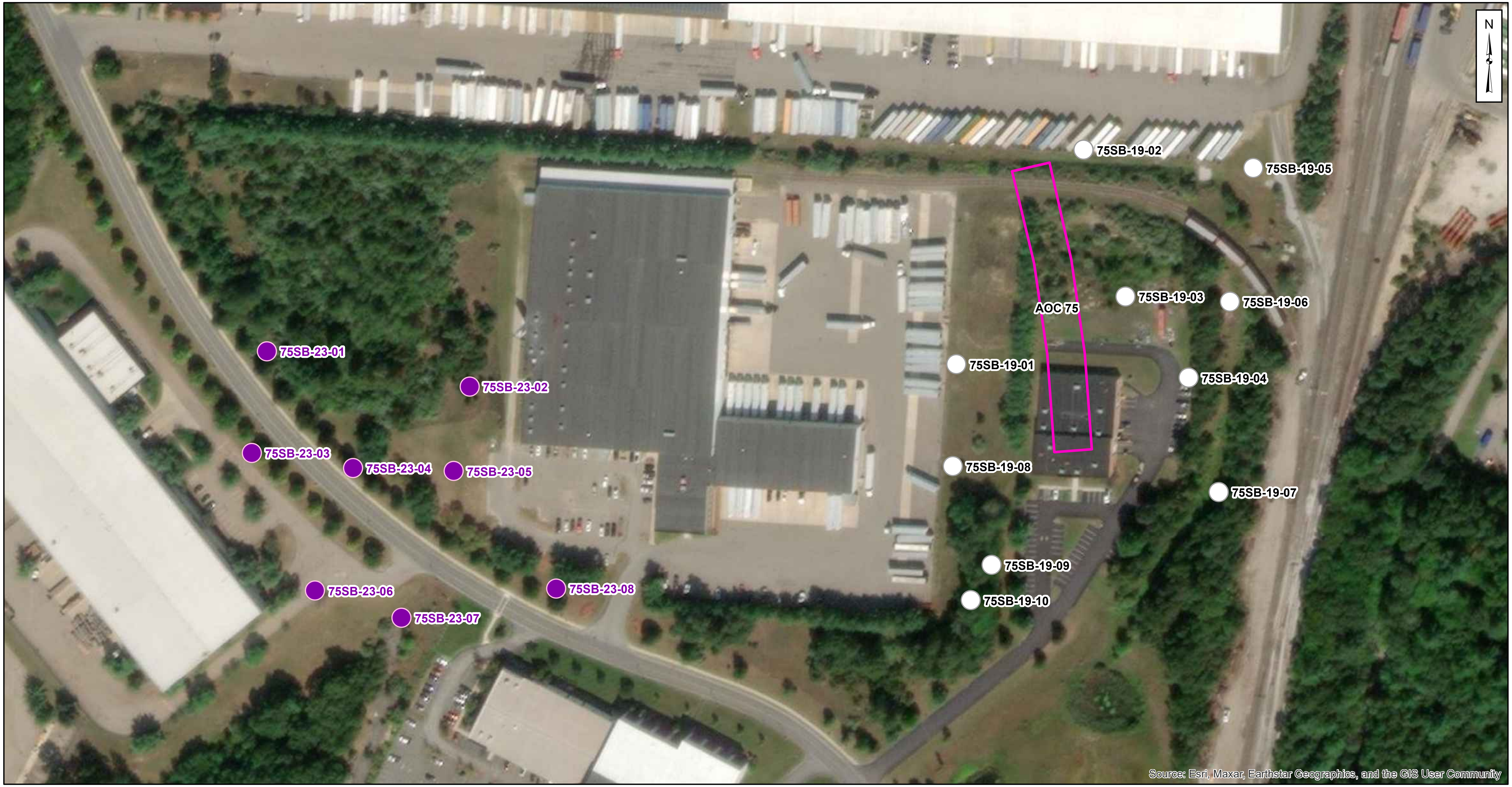
AREA 1 PHASE 2 WORK PLAN
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

GROVE POND WELLFIELD
PROPOSED SOIL INVESTIGATION LOCATIONS

SERES
ARCADIS
a joint venture

FIGURE
4-6

Project (Project #30048392)
T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\AOC74\Figure 4-6 - Grove Pond Wellfield Proposed Soil Investigation Locations AOC 74.mxd 12/2/2022 2:06:50 PM



Legend

Phase 1 PFAS Investigation Locations

○ Completed Soil Boring Below SSSL

🟡 Completed Soil Boring Above SSSL

Proposed Soil Investigation Locations

● Soil Boring

▭ Area of Contamination (AOC)

Notes and Abbreviations:
1. SSSL = Site Specific Screening Levels
2. ug/kg = micrograms per kilogram
3. Perfluorobutanesulfonic = PFBS
4. Perfluorohexane sulfonate = PFHxS
5. Perfluorononanoic acid = PFNA
6. Perfluorooctanesulfonic acid = PFOS
7. Perfluorooctanoic acid = PFOA
8. SSSLs are the May 2022 Devens SSSLs for Child Resident: PFBS – 1900 ug/kg, PFHxS – 126 ug/kg, PFNA – 19 ug/kg, PFOS – 12.6 ug/kg, PFOA – 19 ug/kg

0 150 300
SCALE IN FEET

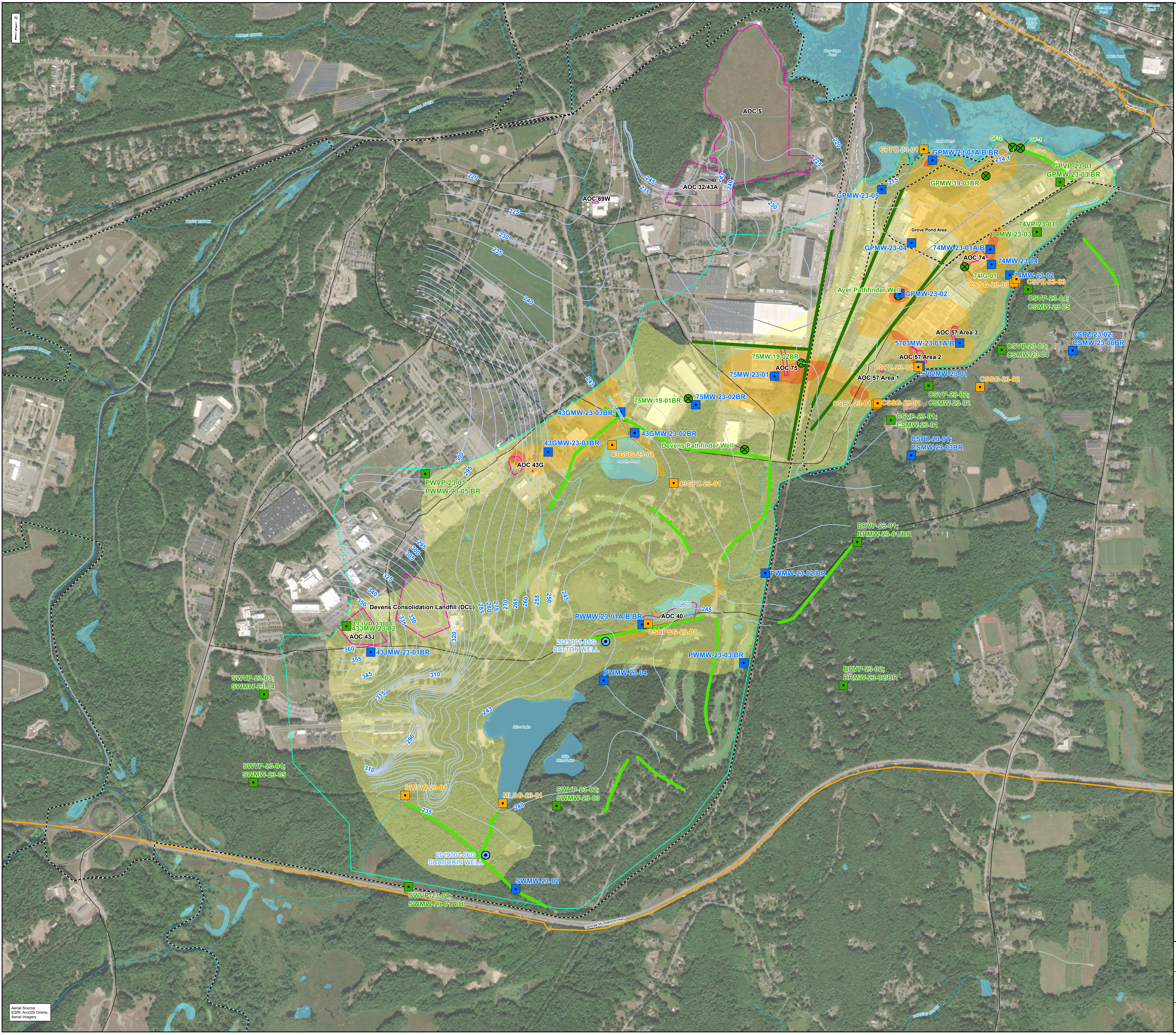
AREA 1 PHASE 2 WORK PLAN
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

PROPOSED SOIL INVESTIGATION LOCATIONS
AOC75

SERES
ARCADIS
a joint venture

FIGURE
4-7

Project (Project #30048392)
T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\AOC75\Figure 4-7 - Proposed Soil Investigation Locations AOC 75.mxd 12/2/2022 2:25:12 PM



Aerial Source:
ESRI, ArcGIS Online,
Aerial Imagery

Document Path: T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\Area 1 Phase 2 Work Plan\UPDATE\Update_Fig_Numbers\2022\Figure 4-8 - Area 1 Work Plan 34x44.mxd

Legend

⬚	Former Fort Devens Boundary
▭	Area of Contamination (AOC)
∿	Stream
▨	Waterbody
◉	Public Water Supply Well
⊗	Existing Bedrock Well Location
▭	PFAS Groundwater Operable Unit Area 1
---	County Line
—	Highway
—	Major Road
⋀	Overburden Water Level Elevation Contour (March 2020) (ft AMSL)
▨	Approximate extent of the Area exceeding the Site-Specific Screening Levels (SSSLs)
▨	Approximate extent of the Area > 10x SSSLs
▨	Approximate extent of the Are > 100x SSSLs

Seismic Survey Lines

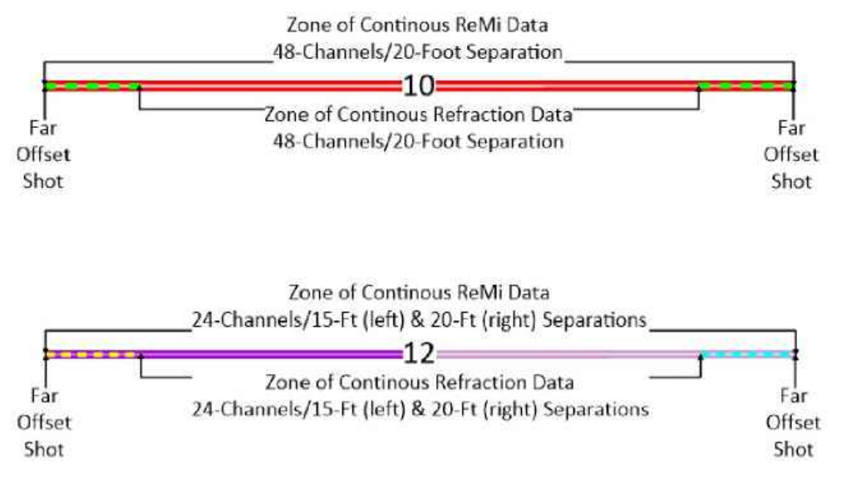
—	Approximate Passive Surface Wave (PSW)
—	Approximate Refraction Lines

Proposed Sample Locations

▣	Stream Gauge/Piezometer
▣	Monitoring Well
▣	Vertical Profile/Monitoring Well

AOC = Area of Environmental Concern
ft AMSL = feet above mean sea level
MassDEP = Massachusetts Department of Environmental Protection

Proposed Seismic Profile



0 0.2 0.4
Miles

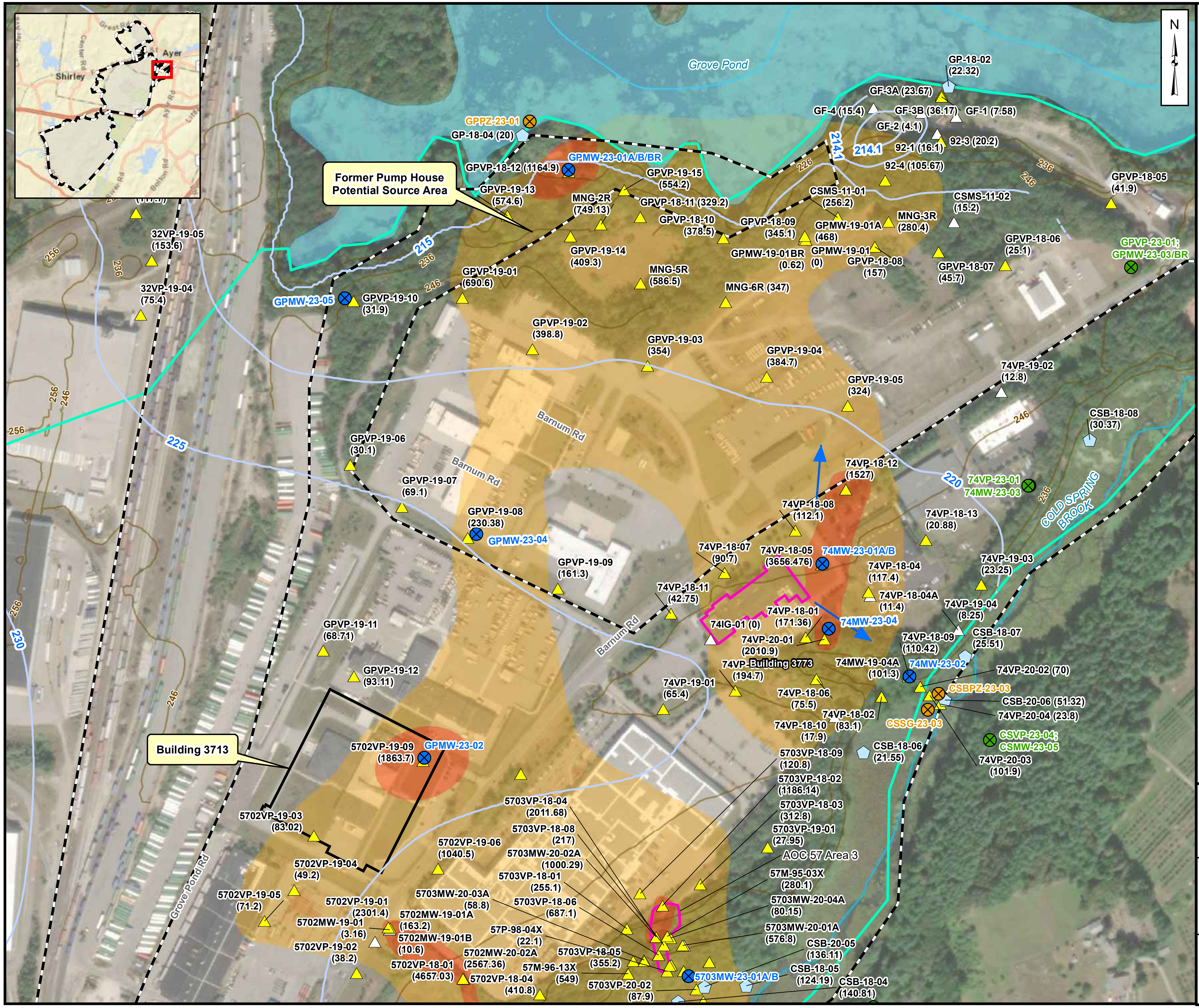
Phase II Remedial Investigation Work Plan - Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

Proposed Groundwater Investigation Locations

SERES
ARCADIS
a joint venture

Figure
4-8

T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\Area 1 Phase 2 Work Plan\UPDATE\Update_Fig_Numbers\2022\Figure 4-9a - Groundwater Investigation Locations - Northeast Portion of Operable Unit.mxd 12/5/2022 3:06:25 PM User Name: ski01076



Legend

- Former Fort Devens Boundary
- Area of Contamination (AOC)
- Overburden Water Level Elevation Contour (March 2020) (ft AMSL)
- PFAS Area 1
- Interpreted Direction of Groundwater flow
- Stream
- Waterbody
- Topographic Contour (ft
- Approximate extent of the Area > 10x SSSLs
- Approximate extent of the Area > 100x SSSLs

Phase 1 PFAS Investigation Locations

- △ Location Exceeding the MMCL (Groundwater)
- ⬠ Surface Water Sampling Location
- △ Location Below MMCL

Proposed Sample Locations

- ⊗ Stream Gauge/Piezometer
- ⊗ Monitoring Well
- ⊗ Vertical Profile/Monitoring Well

Notes and Abbreviations:
1. ft AMSL = feet above mean sea level
2. PFAS = per- and polyfluoroalkyl substances
3. SSSL = Site-Specific Screening Levels
4. MMCL = Massachusetts Department of Environmental Protection Maximum Contaminant Level of 20 ng/L total as a sum of the concentration of PFOA, PFOS, PFHxS, PFNA, PFHpA, and PFDA.
5. The maximum concentration of the sum of the six PFAS included in the MMCL per location is included in parentheses. Concentrations are in ng/L.

0 250 500
Feet

Aerial Source:
ESRI, ArcGIS Online,
Aerial Imagery

Phase II Remedial Investigation Work Plan - Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

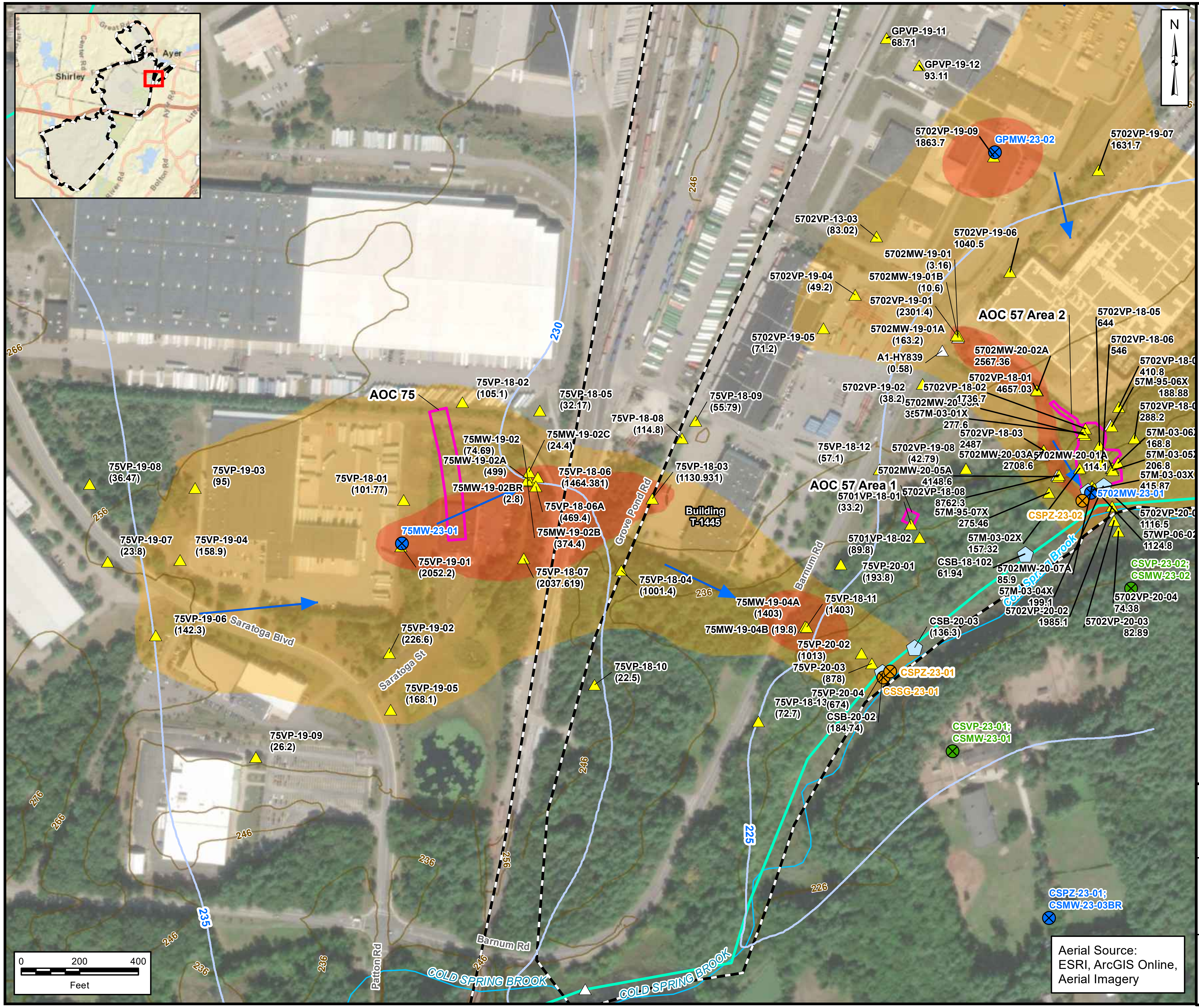
Groundwater Investigation Locations - Northeast Portion of PFAS Area 1 (Grove Pond Wellfield and AOC 74)

SERES ARCADIS a joint venture

Figure
4-9a

File: Figure 4-9a - Groundwater Investigation Locations - Northeast Portion of Operable Unit.mxd

T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\Area 1 Phase 2 Work Plan\UPDATE_Fig_Numbers\2023\Figure 4-9b - Groundwater Investigation Locations - Northeast Portion of Operable Unit.mxd 1/16/2023 6:50:23 PM User Name: ski01076



Aerial Source:
ESRI, ArcGIS Online,
Aerial Imagery

Legend

🟩	PFAS Groundwater Operable Unit Area 1
▭	Former Fort Devens Boundary
🟪	Area of Contamination (AOC)
—	Overburden Water Level Elevation Contour (March 2020) (ft AMSL)
→	Interpreted Direction of Groundwater flow
~	Stream
∧	Topographic Contour (ft
🟧	Approximate extent of the Area > 10x SSSLs
🟥	Approximate extent of the Area > 100x SSSLs

Phase 1 PFAS Investigation Locations

▲	Location Exceeding MMCL (Groundwater)
⬠	Surface Water Sampling Location
△	Location Below MMCL

Proposed Sample Locations

⊗	Stream Gauge/Piezometer
⊗	Monitoring Well
⊗	Vertical Profile/Monitoring Well

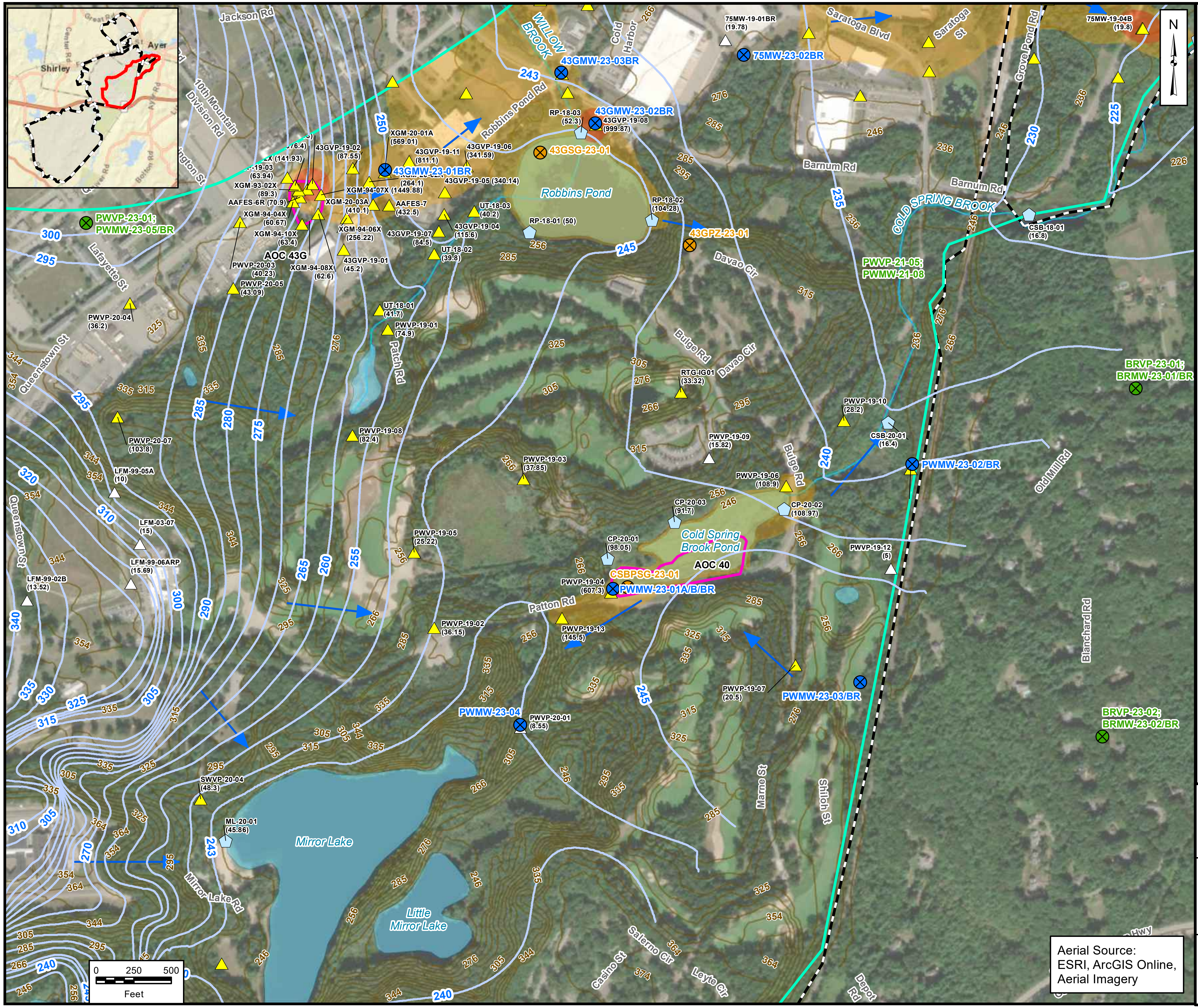
Notes and Abbreviations:
1. ft AMSL = feet above mean sea level
2. PFAS = per- and polyfluoroalkyl substances
3. 3. SSSL = Site-Specific Screening Levels
4. MMCL = Massachusetts Department of Environmental Protection Maximum Contaminant Level of 20 ng/L total as a sum of the concentration of PFOA, PFOS, PFHxS, PFNA, PFHpA, and PFDA.
5. The maximum concentration of the sum of the six PFAS included in the MMCL per location is included in parentheses. Concentrations are in ng/L.

Phase II Remedial Investigation Work Plan - Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

Groundwater Investigation Locations - Northeast Portion of Operable Unit

SERES
ARCADIS
a joint venture

Figure
4-9b



Aerial Source:
ESRI, ArcGIS Online,
Aerial Imagery

Legend

🟩	PFAS Groundwater Operable Unit Area 1
▭	Former Fort Devens Boundary
🟪	Area of Contamination (AOC)
—	Overburden Water Level Elevation Contour (March 2020) (ft AMSL)
→	Interpreted Direction of Groundwater flow
~	Stream
▨	Waterbody
⋀	Topographic Contour (ft
🟨	Approximate extent of the Area > 10x SSSLs
🟥	Approximate extent of the Area > 100x SSSLs

Phase 1 PFAS Investigation Locations

▲	Location Exceeding MMCL (Groundwater)
⬠	Surface Water Sampling Location
△	Location Below MMCL

Proposed Sample Locations

⊗	Stream Gauge/Piezometer
⊗	Monitoring Well
⊗	Vertical Profile/Monitoring Well

Notes and Abbreviations:

1. ft AMSL = feet above mean sea level
2. PFAS = per- and polyfluoroalkyl substances
3. SSSL = Site-Specific Screening Levels
4. MMCL = Massachusetts Department of Environmental Protection Maximum Contaminant Level of 20 ng/L total as a sum of the concentration of PFOA, PFOS, PFHxS, PFNA, PFHpA, and PFDA.
5. The maximum concentration of the sum of the six PFAS included in the MMCL per location is included in parentheses. Concentrations are in ng/L.

Phase II Remedial Investigation Work Plan - Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

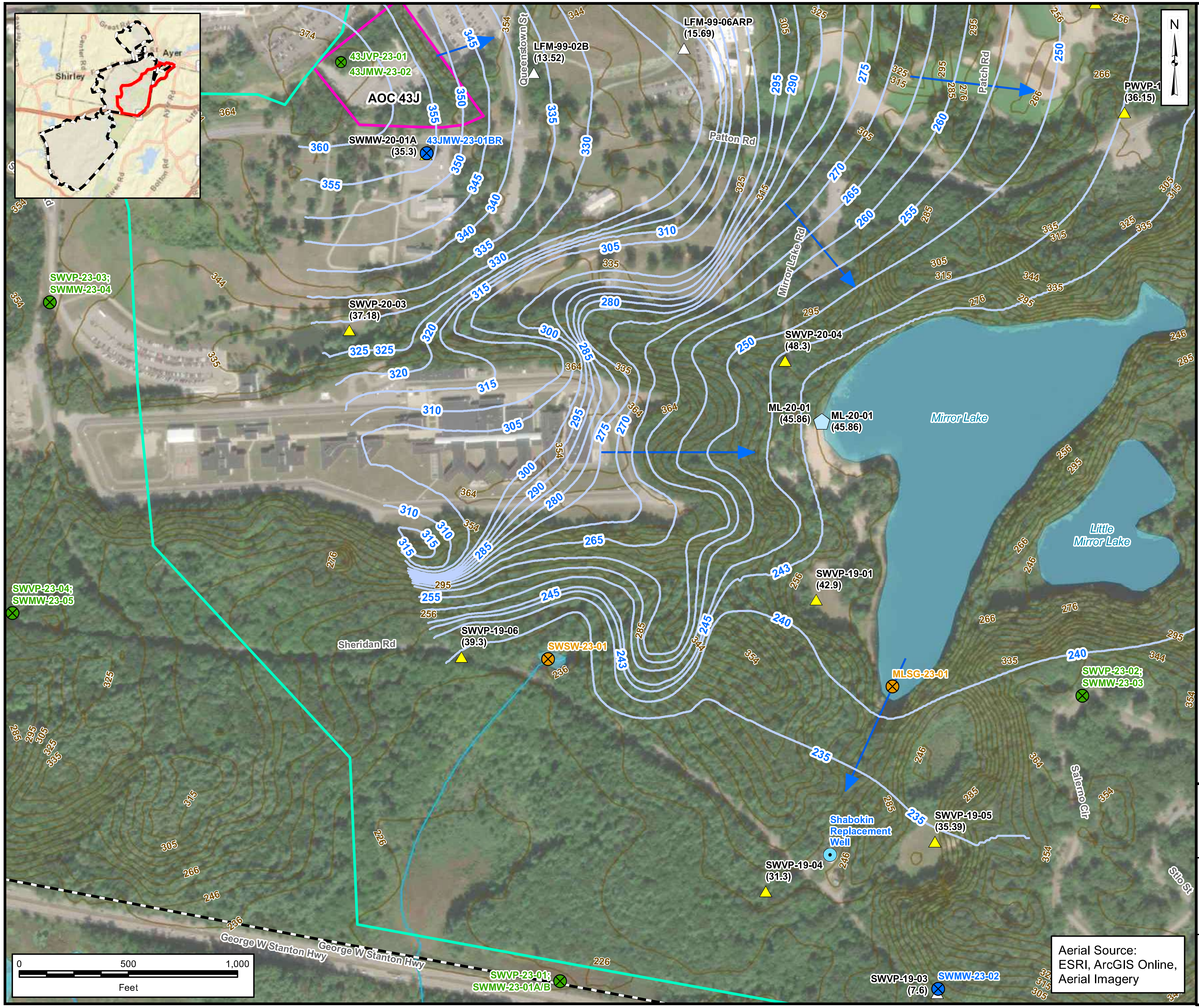
Groundwater Investigation Locations - Southwest Portion of Operable Unit

SERES ARCADIS a joint venture

Figure
4-10a

T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\Area 1 Phase 2 Work Plan\UPDATE\Update_Fig_Numbers\2023\Figure 4-10a - Groundwater Investigation Locations - Southwest Portion of Operable Unit.mxd 1/19/2023 2:51:50 PM User Name: ski01076

T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\Area 1 Phase 2 Work Plan\UPDATE\Update_Fig_Numbers\2022\Figure 4-10b - Groundwater Investigation Locations - Southwest Portion of Operable Unit.mxd 12/2/2022 5:32:16 PM User Name: ski01076



Aerial Source:
ESRI, ArcGIS Online,
Aerial Imagery

Legend

🟪	Area of Contamination (AOC)
⬚	Former Fort Devens Boundary
🟩	PFAS Area 1
—	Overburden Water Level Elevation Contour (March 2020) (ft AMSL)
〰	Stream
●	Waterbody
⋀	Topographic Contour (ft AMSL)
→	Interpreted Direction of Groundwater flow
🟧	Approximate extent of the Area > 10x SSSLs
🟥	Approximate extent of the Area > 100x SSSLs

Phase 1 PFAS Investigation Locations

▲	Location Exceeding MMCL (Groundwater)
⬠	Surface Water Sampling Location
△	Location Below MMCL
⊙	Water Supply Well

Proposed Sample Locations

⊗	Stream Gauge/Surface Water
⊗	Monitoring Well Only
⊗	VAP/Monitoring Well

Notes and Abbreviations:
1. ft AMSL = feet above mean sea level
2. PFAS = per- and polyfluoroalkyl substances
3. SSSL = Site-Specific Screening Levels
4. MMCL = Massachusetts Department of Environmental Protection Maximum Contaminant Level of 20 ng/L total as a sum of the concentration of PFOA, PFOS, PFHxS, PFNA, PFHpA, and PFDA.
5. The maximum concentration of the sum of the six PFAS included in the MMCL per location is included in parentheses. Concentrations are in ng/L.

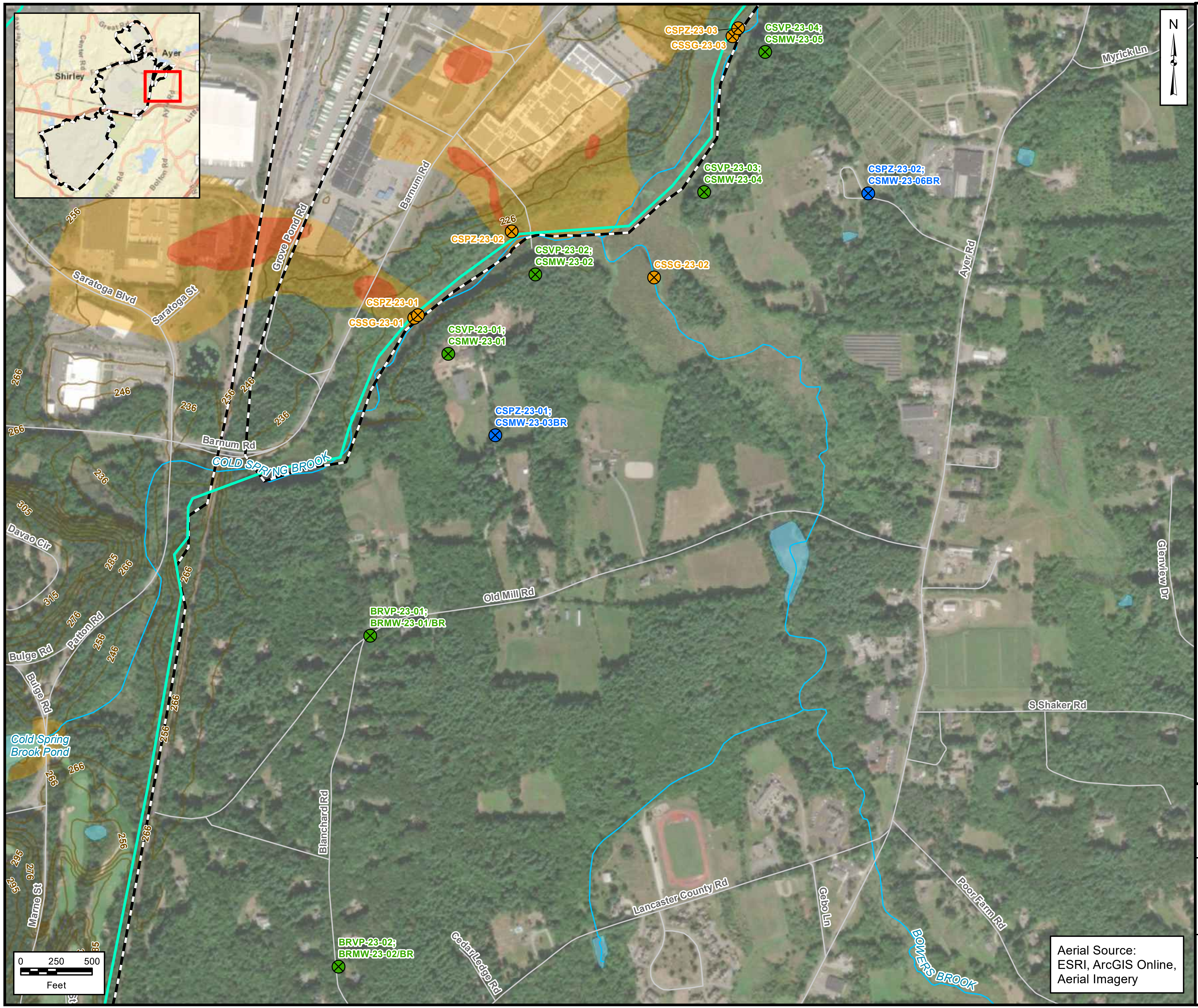
Phase II Remedial Investigation Work Plan - Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

Groundwater Investigation Locations - Southwest Portion of PFAS Area 1 (AOC 43J and Shabokin Water Supply Well Area)

SERES ARCADIS a joint venture

Figure
4-10b

File: Figure 4-10b - Groundwater Investigation Locations - Southwest Portion of Operable Unit.mxd



Aerial Source:
ESRI, ArcGIS Online,
Aerial Imagery

Legend

▭	PFAS Groundwater Operable Unit Area 1
⬚	Former Fort Devens Boundary
〰	Stream
🟦	Waterbody
⁄	Topographic Contour (ft AMSL)
🟨	Approximate extent of the Area > 10x SSSLs
🟥	Approximate extent of the Area > 100x SSSLs

Proposed Sample Locations

⊗	Stream Gauge/Piezometer
⊗	Monitoring Well
⊗	Vertical Profile/Monitoring Well

Notes and Abbreviations:
1. ft AMSL = feet above mean sea level
2. PFAS = per- and polyfluoroalkyl substances
3. SSSL = Site-Specific Screening Levels
4. MMCL = Massachusetts Department of Environmental Protection Maximum Contaminant Level of 20 ng/L total as a sum of the concentration of PFOA, PFOS, PFHxS, PFNA, PFHpA, and PFDA.
5. The maximum concentration of the sum of the six PFAS included in the MMCL per location is included in parentheses. Concentrations are in ng/L.

Phase II Remedial Investigation Work Plan - Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

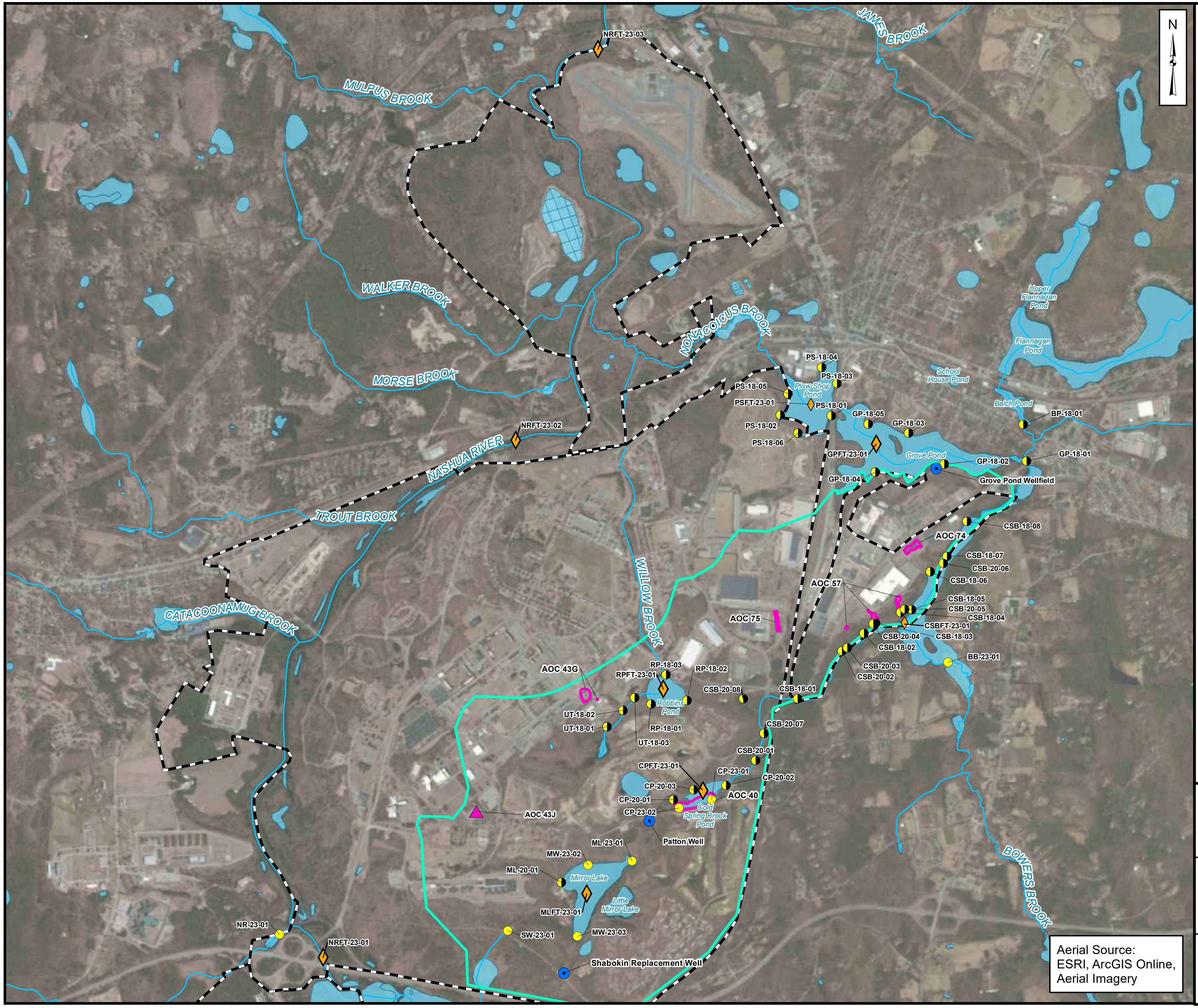
Off-Post Area Proposed Investigation Locations

SERES ARCADIS a joint venture

Figure
4-11

File: Figure 4-11 - Off-Post Area Proposed Investigation Locations.mxd

T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\Area 1 Phase 2 Work Plan\UPDATE\Update_Fig_Numbers\2023\Figure 4-11 - Off-Post Area Proposed Investigation Locations.mxd 1/16/2023 6:47:41 PM User Name: ski01076



Aerial Source:
ESRI, ArcGIS Online,
Aerial Imagery

Legend

🟩	PFAS Groundwater Operable Unit Area 1
▭	Former Fort Devens Boundary
◐	Proposed Surface Water Sample Location
●	Proposed Surface Water and Sediment Sample Location
⊙	Water Supply Well
◆	Proposed Fish Tissue Sampling Location
▲	AOC Location
▭	AOC Area
~	Stream
▨	Waterbody

Notes and Abbreviations:
1. AOC = area of contamination
2. Although Plow Shop Pond, Robbins Pond, and the Nashua River are outside the boundary of Area 1, surface water and fish tissue sampling in this area is proposed as part of the Area 1 investigation to assure continuity in sample collection and data analysis.

0 1,000 2,000
Feet

Phase II Remedial Investigation Work Plan - Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

Proposed Surface Water, Sediment and Fish Tissue Sample Locations

SERES ARCADIS a joint venture

Figure
4-12

Path: T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\Area 1 Phase 2 Work Plan\UPDATE\Update_Fig_Numbers\2022\Figure 4-12 - Proposed Surface Water, Sediment and Fish Tissue Sample Locations.mxd
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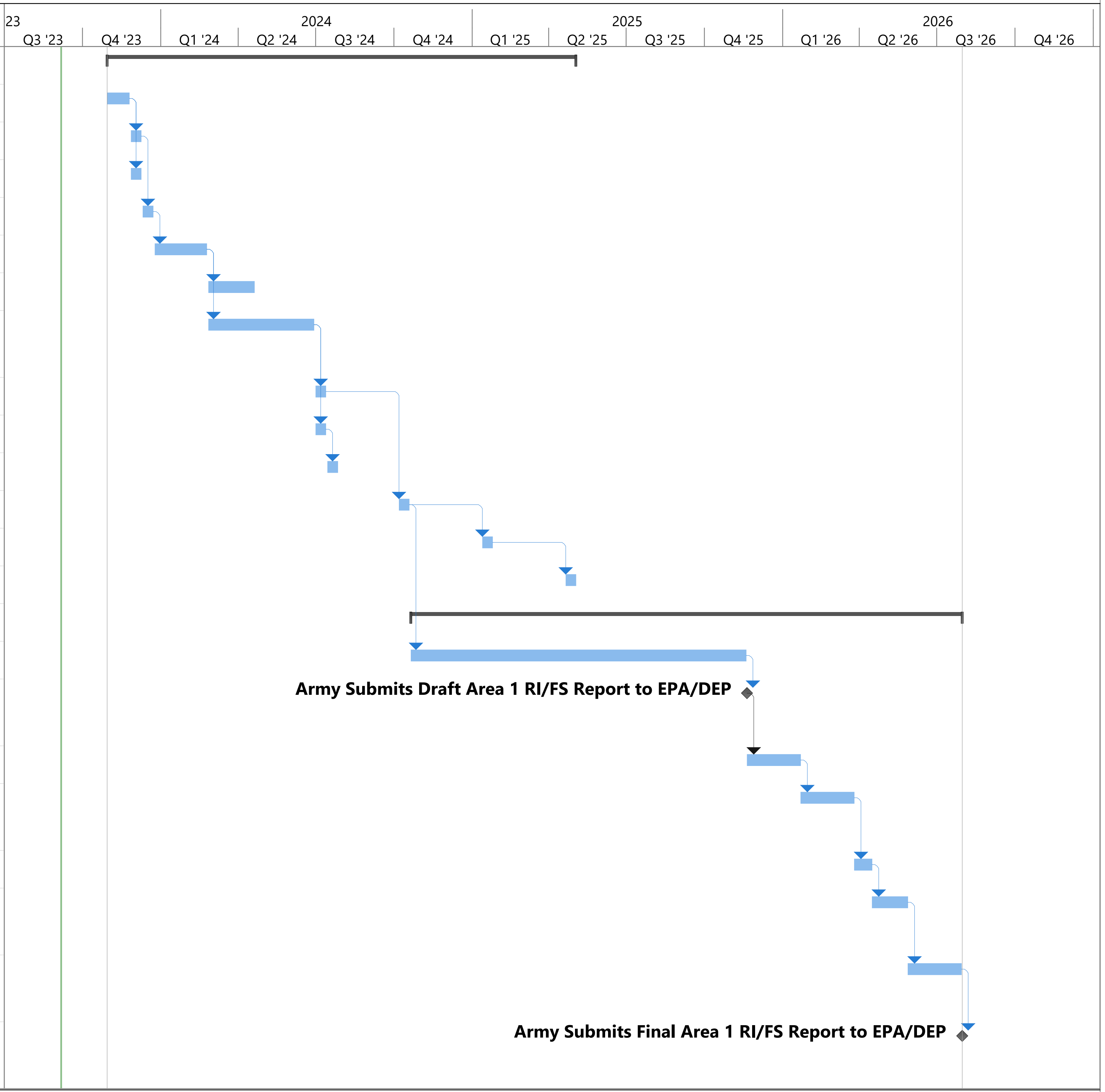
Figure 6-1
Anticipated Project Schedule
Area 1 Phase 2 PFAS RI/FS
Former Fort Devens, Massachusetts

ID	Task Name	Duration	Start	Finish
1	**Area 1 Phase 2 Remedial Investigation**	**395 days**	**Mon 10/30/23**	**Fri 5/2/25**
2	Right of Entry Agreements	20 days	Mon 10/30/23	Fri 11/24/23
3	Utility Clearance	10 days	Mon 11/27/23	Fri 12/8/23
4	Seismic Survey	10 days	Mon 11/27/23	Fri 12/8/23
5	Soil Borings	10 days	Mon 12/11/23	Fri 12/22/23
6	VAP Sampling	45 days	Mon 12/25/23	Fri 2/23/24
7	Overburden GW Monitoring Well Installation	40 days	Mon 2/26/24	Fri 4/19/24
8	Bedrock GW Monitoring Well Installation and Testing	90 days	Mon 2/26/24	Fri 6/28/24
9	Groundwater Sampling Event 1	10 days	Mon 7/1/24	Fri 7/12/24
10	Surface Water and Sediment Sampling	10 days	Mon 7/1/24	Fri 7/12/24
11	Fish Tissue Sampling	10 days	Mon 7/15/24	Fri 7/26/24
12	Groundwater Sampling Event 2	10 days	Mon 10/7/24	Fri 10/18/24
13	Groundwater Sampling Event 3	10 days	Mon 1/13/25	Fri 1/24/25
14	Groundwater Sampling Event 4	10 days	Mon 4/21/25	Fri 5/2/25
15	**Area 1 RI/FS Report (incl. BHRA)**	**464 days**	**Mon 10/21/24**	**Thu 7/30/26**
16	Preparation of Draft Area 1 RI/FS Report	282 days	Mon 10/21/24	Tue 11/18/25
17	Army Submits Draft Area 1 RI/FS Report to EPA/DEP	1 day	Wed 11/19/25	Wed 11/19/25
18	EPA/DEP Review of Draft Area 1 RI/FS Report	45 days	Thu 11/20/25	Wed 1/21/26
19	Army Issues Response Letter to Comments on Draft Area 1 RI/FS Report	45 days	Thu 1/22/26	Wed 3/25/26
20	EPA/DEP Review of Response Letter	15 days	Thu 3/26/26	Wed 4/15/26
21	Army Submits Draft Final Area 1 RI/FS Report to EPA/DEP	30 days	Thu 4/16/26	Wed 5/27/26
22	EPA/DEP Review of Draft Final Area 1 RI/FS Report	45 days	Thu 5/28/26	Wed 7/29/26
23	Army Submits Final Area 1 RI/FS Report to EPA/DEP	1 day	Thu 7/30/26	Thu 7/30/26



Appendix A

Addendum for Area 1 to UFP-QAPP for Remedial Investigation for PFAS

FINAL

VERSION 0

UNIFORM FEDERAL POLICY FOR QUALITY ASSURANCE PROJECT PLAN

ADDENDUM FOR AREA 1 – PHASE II

REMEDIAL INVESTIGATION FOR PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)

FORMER FORT DEVENS ARMY INSTALLATION DEVENS, MASSACHUSETTS

SEPTEMBER 2023

Contract No.: W912WJ-19-D-0014
Task Order No.: W912WJ-20-F-0105

Prepared For:

U.S. ARMY CORPS OF ENGINEERS, NEW ENGLAND DISTRICT
696 Virginia Road
Concord, Massachusetts 01742

Prepared By:

SERES-ARCADIS JV, LLC
669 Marina Drive, Suite B-7
Charleston, South Carolina 29492

Introduction

The SERES-Arcadis Joint Venture (JV), Limited Liability Company (LLC)[1] (hereafter referred to as the SERES-Arcadis JV) has prepared this Quality Assurance Project Plan (QAPP) Addendum under Contract No. W912WJ-19-D-0014, Task Order No. W912WJ-20-F-0022. The QAPP Addendum was prepared consistent with the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) on behalf of the United States (U.S.) Army Corps of Engineers (USACE) to conduct a Comprehensive Environmental Response, Compensation, and Liability Act- (CERCLA-) compliant Remedial Investigation (RI) of areas of the former Fort Devens Army Installation (Fort Devens), located in Devens, Massachusetts, that may have been impacted by per- and polyfluoroalkyl substances (PFAS), including constituents of aqueous film-forming foam (AFFF).

This QAPP Addendum was prepared consistent with the *Uniform Federal Policy for Quality Assurance Project Plan, for the Remedial Investigation of Per- and Polyfluoroalkyl Substances, Former Fort Devens Army Installation* (QAPP; KOMAN Government Services [KGS] 2018c [Draft] and 2020b [Final]) and in accordance with the following documents:

- EM 385-1-1, Safety and Health Requirements Manual (USACE 2014);
- United States Environmental Protection Agency (USEPA) guidance document 505-F-03-001, Intergovernmental Data Quality Task Force, Uniform Federal Policy for Implementing Environmental Quality Systems (USEPA 2005a);
- USEPA's Guidance for Quality Assurance Project Plans, CIO 2106-G-05 (USEPA 2012); and
- Other guidance documents as appropriate.

UFP-QAPP Worksheets are developed to systematically document the planning process, sampling rationale, sampling protocols, quality assurance (QA)/quality control (QC) procedures, and other relevant components. This QAPP Addendum was developed with the understanding that unanticipated conditions may dictate a change in the plan as currently written.

Staff who will be participating in project and field efforts are required to read this plan and understand the objectives of the work to be performed, as well as the procedures to be used for conducting the field investigation, performing the laboratory analyses, and evaluating and reporting the data that are collected. In addition, key personnel are responsible for mentoring assigned staff in aspects of this QAPP Addendum potentially impacting their assigned work to ensure project activities are executed in accordance with the plan.

The goal of the Phase II PFAS RI for Area 1 is to identify exposure pathways and assess risk to human and ecological receptors associated with the presence of PFAS in Area 1.

To support this goal, the objectives of the Area 1 Phase II PFAS RI Work Plan (WP) are to define the following:

- Source – Establish conservative exposure point concentrations (EPCs, i.e., "worst case") at known sources of PFAS in Area 1.
- Pathway – Advance the conceptual site model (CSM), by confirming locations of discharge of, and/or human or ecological exposure to, PFAS in Area 1 that are associated with releases from the former Fort Devens.

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[1] The SERES-Arcadis JV is composed of protégé firm SERES Engineering & Services, LLC (SERES) and its mentor Arcadis U.S., Inc. (Arcadis).

- Evaluate the risk to human and ecological receptors associated with PFAS at Devens by conducting human health and ecological risk assessments in accordance with CERCLA guidance.

In 2016, an installation-wide Preliminary Assessment (PA) of PFAS at Devens identified Study Areas (SAs) and Areas of Contamination (AOCs) where there was a potential for the use, storage, or disposal of aqueous film-forming foam (AFFF). The constituents of AFFF are collectively referred to as PFAS. The USEPA has identified PFAS as an emerging contaminant of concern. Subsequent site inspections at Devens in 2017 confirmed the presence of PFAS in groundwater, soil, surface water, and sediment at several Study Areas (SAs) and AOCs (BERS-Weston 2018a). Sampling of existing long-term monitoring wells at select AOCs confirmed the presence of PFAS at some AOCs not identified in the Devens PFAS PA (KGS 2018b). In addition, PFAS were detected in public water supply wells associated with the Town of Ayer Grove Pond municipal wellfield, which is located adjacent to Devens, as well as the MacPherson, Patton, and Shabokin public water supply wells located within Devens. The Army subsequently funded the installation of PFAS treatment systems for all of these wells, which were installed between June 2019 and March 2020.

To expedite further field investigations in support of the RI, the identified AOCs, the Grove Pond Wellfield, and the MacPherson, Patton, and Shabokin water supply well areas were grouped into three areas (Areas 1, 2, and 3). The three areas were designated for sequencing of field activities and do not reflect prioritization.

After completion of initial field activities to support completion of the RI (considered to be Phase I activities), the three areas were regrouped for further (Phase II) field investigation.

The Area 1 Phase II PFAS RI WP addresses the groundwater, soil, surface water, sediment and fish tissue associated with Area 1, as demarcated based on groundwater flow boundaries, including:

- Historical Gas Station G (AOC 43G);
- Historical Gas Station J (AOC 43J);
- Former Vehicle Storage and Motor Repair Shops Site (AOC 57);
- Barnum Road Firefighting Exercise Site (AOC 74);
- Former Building T-1445 Warehouse Fire (AOC 75);
- Areas along Barnum Road and Queenstown Road,
- Town of Ayer Grove Pond Wellfield; and
- Devens water supply wells,
    - Patton (incorporating AOC 40 Cold Spring Brook Landfill), and
    - Shabokin (incorporating AOC 43J Historical Gas Station J).

Investigation of other PFAS Areas will be detailed in a separate Phase II PFAS RI WPs.

The objectives of this QAPP Addendum are to generate project data that are technically valid, legally defensible, and useful in meeting the project goals, as well as to integrate the technical and QC requirements for future investigation activities. The RI will collect data sufficient to meet USACE and regulatory requirements and support remedial alternative decisions, if needed, for the PFAS-impacted sites at Fort Devens. The technical approach for the RI is designed to achieve the data quality objectives (DQOs) listed in **Worksheet #11**. This QAPP Addendum addresses four primary elements:

- Project management;
- Measurement and data acquisition;

- Assessment and oversight; and
- Data validation and usability.

The above elements incorporate QA/QC requirements cited within the following documents:

- USEPA Requirements for Quality Assurance Project Plans, USEPA QA/R-5 (USEPA 2001a);
- USEPA Guidance on Systematic Planning Using the Data Quality Objectives Process, QA/G-4 (2006);
- USEPA Uniform Federal Policy for Quality Assurance Project Plans, Final Version (USEPA 2005b);
- USEPA Guidance for Quality Assurance Project Plans, CIO-2106-G-05 (USEPA 2012);
- U.S. Department of Defense (DoD) Quality Systems Manual, Version 5.4 (DoD 2021) or later;
- DoD Quality Systems Manual, Version 5.3 (DoD 2019a);
- DoD General Data Validation Guidelines, November 2019, Revision 1 (DoD 2019b); and
- DoD Data Validation Guidelines Module 6: Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-24 (DoD 2022).

The optimized UFP-QAPP workbook format used for this QAPP Addendum implements the systematic planning process and was developed via collaboration between the USEPA, DoD, and the Department of Energy. In 2010, a subgroup composed of members from the participating agencies reviewed and optimized the UFP-QAPP workbook in close coordination with USEPA's 2012 update of QA/G5, Guidance for Quality Assurance Project Plans. The information contained in the worksheets captures the elements that would otherwise be included in related project planning documents, such as a Sampling and Analysis Plan and Field Sampling Plan. Table I is a crosswalk between the optimized UFP-QAPP worksheet numbers and titles and the USEPA's QAPP Guidance (USEPA 2012).

The following attachments are provided to supplement the information presented in this QAPP Addendum:

Attachment A	Accident Prevention Plan
Attachment B	Project Schedule
Attachment C	Field Standard Operating Procedures
Attachment D	Field Forms
Attachment E	Laboratory Quality Manuals, Standard Operating Procedures, Certifications, and Control Limits

Refer to the table of contents for the specific worksheets and attachments comprising this QAPP Addendum. In several cases, the attachments contain standalone documents; as such, reference to these documents, where applicable, is made in this QAPP Addendum.

Table I: Crosswalk: UFP-QAPP Workbook to 2106-G-05 QAPP

Worksheet Number(s)	Worksheet Title	CIO 2106-G-05 QAPP Guidance Section	
		Section	Title
1, 2	Title and Approval Pages	2.2.1	Title, Version, and Approval/Sign-Off
3, 5	Project Organization and QAPP Distribution	2.2.3	Distribution List
		2.2.4	Project Organization and Schedule
4, 7, 8	Personnel Qualifications and Sign-off Sheet	2.2.1	Title, Version, and Approval/Sign-Off
		2.2.7	Special Training Requirements and Certification
6	Communication Pathways	2.2.4	Project Organization and Schedule
9	Project Planning Session Summary	2.2.5	Project Background, Overview, and Intended Use of Data
10	Conceptual Site Model	2.2.5	Project Background, Overview, and Intended Use of Data
11	Project Data Quality Objectives	2.2.6	Data/Project Quality Objectives and Measurement Performance Criteria
12	Measurement Performance Criteria	2.2.6	Data/Project Quality Objectives and Measurement Performance Criteria
13	Secondary Data Uses and Limitations Table	Chapter 3	QAPP Elements for Evaluating Existing Data
14, 16	Project Tasks and Schedule	2.2.4	Project Organization and Schedule
15	Project Action Limits and Laboratory-Specific Detection/ Quantitation Limits	2.2.6	Data/Project Quality Objectives and Measurement Performance Criteria
17	Sampling Design and Rationale	2.3.1	Sample Collection Procedure, Experimental Design, and Sampling Tasks
18	Sampling Locations and Methods/ Standard Operating Procedures (SOPs)	2.3.1	Sample Collection Procedure, Experimental Design, and Sampling Tasks
		2.3.2	Sampling Procedures and Requirements
19, 30	Sample Containers, Preservation, and Hold Times	2.3.2	Sampling Procedures and Requirements
20	Field Quality Control Samples Summary Table	2.3.5	Quality Control Requirements
21	Project Sampling SOP References Table	2.3.2	Sampling Procedures and Requirements
22	Field Equipment Calibration, Maintenance, Testing, and Inspection	2.3.6	Instrument/Equipment Testing, Calibration, and Maintenance Requirements, Supplies and Consumables
23	Analytical Standard Operating Procedures	2.3.4	Analytical Methods Requirements and Task Description
24	Analytical Instrument Calibration	2.3.6	Instrument/Equipment Testing, Calibration, and Maintenance Requirements, Supplies and Consumables

Worksheet Number(s)	Worksheet Title	CIO 2106-G-05 QAPP Guidance Section	
		Section	**Title**
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection	2.3.6	Instrument/Equipment Testing, Calibration, and Maintenance Requirements, Supplies and Consumables
26, 27	Sample Handling, Custody, and Disposal	2.3.3	Sample Handling, Custody Procedures, and Documentation
28	Analytical Quality Control and Corrective Action	2.3.5	Analytical Quality Control and Corrective Action
29	Project Documents and Records	2.3.8	Documentation and Records Requirements
31, 32, 33	Assessments and Corrective Action	2.4	Assessments and Data Review (Check)
		2.5.5	Reports to Management
34	Data Verification and Validation Inputs	2.5.1	Data Verification and Validation Targets and Methods
35	Data Verification Procedures	2.5.1	Data Verification and Validation Targets and Methods
36	Data Validation Procedures	2.5.1	Data Verification and Validation Targets and Methods
37	Data Usability Assessment	2.5.2	Quantitative and Qualitative Evaluations of Usability
		2.5.3	Potential Limitations on Data Interpretation
		2.5.4	Reconciliation with Project Requirements

Table of Contents

Tables

Attachment s

Acronyms and Abbreviations

%	percent
ºC	degrees Celsius
ºF	degrees Fahrenheit
%	percent
%D	percent drift
%R	percent recovery
µg/kg	microgram per kilogram
µg/L	microgram per liter
AFFF	aqueous film-forming foam
amu	atomic mass unit
AOC	Area of Contamination
APP	accident prevention plan
Area 1 PSCS	Area 1 Preliminary Site Characterization Summary Per- and Polyfluoroalkyl Substances (PFAS) Remedial Investigation
Army	United States Army
ASTM	ASTM International
BA	Bachelor of Arts
BCEE	Board Certified Environmental Engineer
BEC	Base Realignment and Closure Environmental Coordinator
BERS-Weston	BERS-Weston Services, JVA, LLC
bgs	below ground surface
BRA	baseline risk assessment
BRAC	Base Realignment and Closure
BS	Bachelor of Science
CA	corrective action
Calare	Calare Properties/Hackman Capital Properties
CCV	continuing calibration verification
CENAE	United States Army Corps of Engineers, New England District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIH	Certified Industrial Hygienist
cm	centimeter
COPC	constituent of potential concern
COR	Contracting Officer's Representative
CSM	conceptual site model
CSP	Certified Safety Professional
DL	detection limit
DO	dissolved oxygen
DoD	U.S. Department of Defense
DOT	U.S. Department of Transportation
DPT	direct-push technology
DQCR	daily quality control report
DQE	data quality evaluation
DQI	data quality indicator
DQO	data quality objective
DRFTA	Devens Reserve Forces Training Area
EIS	extracted internal standard
ELAP	Environmental Laboratory Accreditation Program
EM	engineer manual

EPC	exposure point concentration
GPS	global positioning system
HAZWOPER	Hazardous Waste Operations and Emergency Response
HDPE	high-density polyethylene
H&S	health and safety
HHRA	human health risk assessment
HTRW	hazardous, toxic, and radioactive waste
ICAL	initial calibration
ICV	initial calibration verification
ID	Identification
IDA	isotope dilution analyte
IDW	investigation-derived waste
Inc.	Incorporated
ITRC	Interstate Technology Regulatory Council
JV	joint venture
KGS	KOMAN Government Solutions, LLC
LC/MS/MS	liquid chromatography with tandem mass spectrometry
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LDC	Laboratory Data Consultants, Inc
LEP	Licensed Environmental Professional
LHA	Lifetime Health Advisory
LLC	Limited Liability Company
LOD	limit of detection
LOQ	limit of quantitation
LTMMP	Long-Term Monitoring and Maintenance Plan
MAAF	Moore Army Airfield
MAARNG	Massachusetts Army National Guard
MassDEP	Massachusetts Department of Environmental Protection
MassDevelopment	Massachusetts Development and Finance Agency
MBA	Master of Business Administration
MCL	maximum contaminant level
MDL	method detection limit
mg/L	milligram per liter
ml	milliliter
MPC	measurement performance criteria
MS	matrix spike
MSD	matrix spike duplicate
NA	not applicable/not available
NAD 83	North American Datum of 1983
NAVD 88	North American Vertical Datum of 1988
ng/g	nanogram per gram
ng/L	nanogram per liter
NRWA	Nashua River Watershed Association
ORP	oxidation-reduction potential
OSHA	Occupational Safety and Health Administration
PA	preliminary assessment
PAL	project action limit
PE	Professional Engineer
PFAS	per- and polyfluoroalkyl substances

PFBA	perfluorobutanoic acid
PFBS	perfluorobutanesulfonate
PFDA	perfluorodecanoic acid
PFHpA	perfluoroheptanoic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanic acid
PFOS	perfluorooctane sulfonic acid
PG	Professional Geologist
PID	photoionization detector
PM	Project Manager
POC	point of contact
PSCS	Preliminary Site Characterization Summary
PVC	polyvinyl chloride
QA	quality assurance
QAPP	quality assurance project plan
QA/QC	quality assurance /quality control
QC	quality control
QSM	quality systems manual
RAGS	Risk Assessment Guidance for Superfund
RCA	root cause analysis
RI	remedial investigation
RME	reasonable maximum exposure
RPD	relative percent difference
RSD	relative standard deviation
SA	Study Area
Saint-Gobain	Saint-Gobain Ceramics & Plastics
SI	site inspection
SL	screening level
SLERA	screening level ecological risk assessment
SMDP	scientific management decision point
SOP	standard operating procedure
TBD	to be determined
TGI	Technical Guidance Instruction
TOC	total organic carbon
T&R	transformation and reduction
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
U.S.	United States
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
UST	underground storage tank
UU/UE	unrestricted use/unlimited exposure
VP	vertical profiling
VHB	Vanasse Hangen Brustlin, Inc.
WP	work plan
WWTP	wastewater treatment plant

QAPP Worksheets #1 & #2: Title and Approval Pages

(UFP-QAPP Manual Section 2.1)
(USEPA 2106-G-05 Section 2.2.1)

This worksheet identifies the principal points of contact for all organizations having decision authority in the project and documents their commitment to implement the UFP-QAPP. Signatories usually include the Project Manager (PM) and QA Manager, and individuals with approval or oversight authority. Signatures indicate that officials have reviewed the UFP-QAPP and concur with the implementation as written. It is the lead organization's responsibility to make sure all signatures are in place before work begins.

1. Project Identifying Information:
    a. Site name/project name: Former Fort Devens Army Installation (Fort Devens), Remedial Investigation
    b. Site location: Devens, Massachusetts
    c. Contract/work assignment number: W912WJ-19D-0014, Task Order W912WJ-20-F-0022
    d. Lead Organization: USEPA Region 1 and USACE
    e. Geographical Corps District: New England District
2. Department of Defense Organization(s):
    a. U.S. Army (Army), Base Realignment and Closure (BRAC)
        i. Name: Thomas Lineer
        ii. Title: BRAC Environmental Coordinator (BEC)
    b. USACE, New England District (CENAE)
        i. Name: Penelope Reddy
        ii. Title: USACE PM
        iii. Signature: Penelope Reddy Date: 2 Sep 2023
3. Contractor: SERES-Arcadis JV
    a. SERES-Arcadis JV PM
        i. Name: Andy Vitolins, Professional Geologist (PG)
        ii. Title: SERES-Arcadis JV PM
        iii. Signature: ______________ Date: 2 Sep 2023
4. Federal Regulatory Agency: USEPA Region I

5. State/Territory Regulatory Agency: Massachusetts Department of Environmental Protection (MassDEP)
6. Other Stakeholders:
    a. Massachusetts Development and Finance Agency (MassDevelopment)
    b. Restoration Advisory Board
    c. Local Residents and Businesses
7. Plans and reports from previous investigations in the following table:

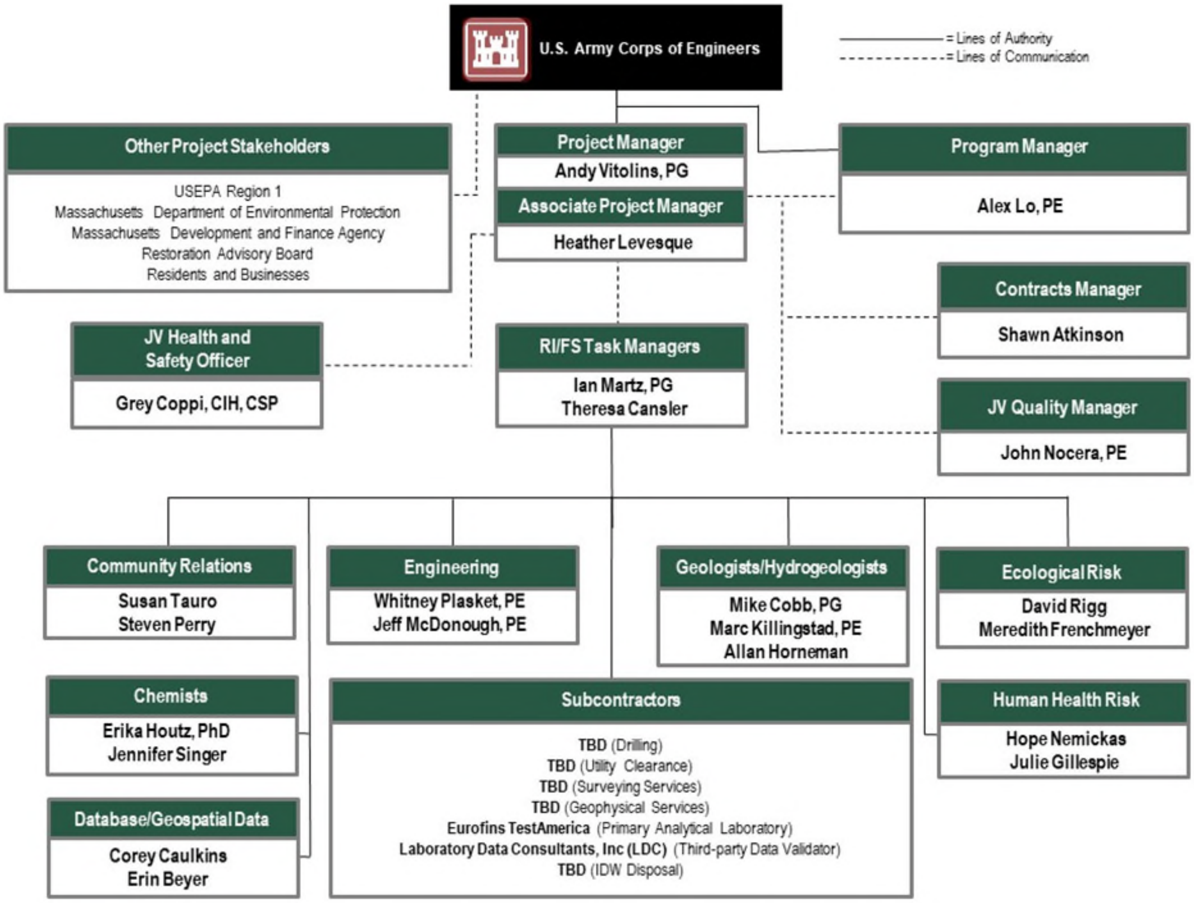
Plans and Reports from Previous Investigations Relevant to this Project:	2015	2015 Five-Year Review Report for Former Fort Devens Army Installation, BRAC Legacy Sites, Devens, Massachusetts.	H&S Environmental, Inc.
	2015	2014 Devens Annual Report and Remedial Strategy Evaluation AOC 43J.	Haley and Aldrich, Inc.
	2015	Long Term Monitoring and Maintenance Plan for Former Fort Devens and Sudbury Annex. Final.	Sovereign Consulting Inc./HydroGeoLogic, Inc.
	2017	Remedial Strategy Evaluation for AOC 43J.	Haley and Aldrich,
	2017	Final Base-Wide Preliminary Assessment for Evaluation of Perfluoroalkyl Substances, Former Fort Devens Army Installation BRAC Legacy Sites, Devens, Massachusetts.	KOMAN Government Solutions, LLC (KGS)
	2018	Final Site Inspection Report for Per-and Polyfluoroalkyl Substances (PFAS) at Former Fort Devens Army Installation, Devens, MA.	BERS-Weston Services, JVA, LLC (BERS-Weston)
	2018	Draft Site Inspection Report for Per- and Polyfluoroalkyl Substances (PFAS) at Area of Contamination (AOC) 76 – Devens Fire Department, Former Fort Devens Army Installation, Devens, MA.	BERS-Weston
	2018	Preliminary Treatment Study Memorandum PFOA and PFOS in Groundwater Supply.	CDM Smith
	2018	Final 2016 Annual Report Long-Term Monitoring, Former Fort Devens Army Installation BRAC Legacy Sites, Devens, Massachusetts.	KGS
	2018	Memorandum: Additional PFAS Sampling to Support the Development of the Remedial Investigation Work Plan, Former Fort Devens Army Installation, Devens, Massachusetts.	KGS
	2018	Letter to Massachusetts Department of Environmental Protection. Re: Ayer Grove Pond Well No. 8 Inactive.	Town of Ayer
	2018	Public Notice: Public Water System Important Information about Your Drinking Water.	Town of Ayer
	2019	Action Memorandum for Time-Critical Removal Action for Former Fort Devens, Devens, Massachusetts.	USACE
	2020	Area 1 Preliminary Site Characterization Summary Per- and Polyfluoroalkyl Substances (PFAS) Remedial Investigation.	KGS
	2020	Area 2 Preliminary Site Characterization Summary Per- and Polyfluoroalkyl Substances (PFAS) Remedial Investigation.	KGS
	2020	Area 3 Preliminary Site Characterization Summary Per- and Polyfluoroalkyl Substances (PFAS) Remedial Investigation.	KGS

Scoping Sessions:	USACE Kickoff Meeting: April 2020 Technical Project Planning Meetings: Biweekly since kickoff.	

QAPP Worksheets #3 & #5: Project Organization and QAPP Distribution

(UFP-QAPP Manual Sections 2.3 and 2.4)
(USEPA 2106-G-05 Sections 2.2.3 and 2.2.4)

This worksheet identifies key project personnel, as well as lines of authority and lines of communication among the Department of Defense (DoD) organization, prime contractor, subcontractors, and regulatory agencies. A list of QAPP recipients along with their contact information is provided in the table below.



Distribution List for Fort Devens PFAS QAPP

Project Delivery Team and QAPP Recipients	Title	Organization	Telephone Number	Email Address
Alex Lo	Program Manager	JV	(843) 388-7804	ahlo@seres-es.com
John Nocera	Corporate Quality Manager	JV	(251) 405-4560	john.nocera@arcadis.com
Grey Coppi	Health and Safety Officer	JV	(732) 661-3851	grey.coppi@arcadis.com
Andy Vitolins	PM	JV	(518) 461-3145	andy.vitolins@arcadis.com
Ian Martz	Field Operations Lead	JV	(978) 322-4526	ian.martz@arcadis.com
Theresa Cansler	RI/FS Task Leader	JV	(757) 873-4355	theresa.cansler@arcadis.com
Jennifer Singer	Project Chemist	JV	(716) 667-6664	jennifer.singer@arcadis.com
Heather Levesque	Associate PM	JV	(619) 370-0374	halevesque@seres-es.com
Kerri Sachtleben	Laboratory PM	Eurofins –Lancaster Laboratories	(717) 556-7376	kerri.sachtleben@et.eurofinsus.com
Pei Geng	Data Validation PM	Laboratory Data Consultants, Inc (LDC)	(760) 827-1110	pgeng@lab-data.com
Penelope Reddy	PM	USACE	(978) 318-8160	penelope.reddy@usace.army.mil
Yixian Zhang	Project Chemist	USACE	(978) 318-8730	yixian.zhang@usace.army.mil
Thomas Lineer	BEC	Army	703-545-2487 (Office) 703-371-6785 (Mobile)	thomas.a.lineer.civ@army.mil
Carol Keating	Remedial PM	USEPA Region I	(617) 918-1393	keating.carol@epa.gov
Joanne Dearden	Federal Sites Program	MassDEP	(781) 407-1595	Joanne.Dearden@state.ma.us

QAPP Worksheets #4, #7 & #8: Personnel Qualifications and Sign-off Sheet

(UFP-QAPP Manual Sections 2.3.2 – 2.3.4)
(USEPA 2106-G-05 Sections 2.2.1 and 2.2.7)

This worksheet identifies the key project personnel for the contractor performing tasks defined in this QAPP, which includes the prime contractor and laboratories.

ORGANIZATION: SERES-Arcadis JV

Name	Project Title/Role	Education/Experience	Specialized Training/ Certifications for the Project Title/Role[1]	Signature/Date[2]
Alex Lo, PE	Program Manager	BS, Geological Engineering, 27 years of experience managing hazardous, toxic, and radioactive waste (HTRW) investigation, remediation, construction and Military Munitions and Response Program responses, and 22 years of experience working at government installations	• Licensed Professional Engineer • Occupational Safety and Health Administration (OSHA) Initial 40-Hour Hazardous Waste Operations and Emergency Response (HAZWOPER), Annual 8-Hour Refreshers	Signature on file
Andy Vitolins, PG	PM	Master of Science, Environmental Science, Bachelor of Arts (BA), Geological Sciences, 24 years of experience. Experienced in the management of numerous comprehensive investigation and remediation projects throughout the eastern United States under federal and state environmental programs.	• OSHA Initial 40-Hour HAZWOPER • OSHA 8-Hour HAZWOPER Refresher • Construction Safety Awareness and Site Supervisor Safety Training • Arcadis Certified Federal PM	Signature on file
John Nocera, PE, BCEE	Corporate Quality Manager	Master of Engineering (ME) and Bachelor of Engineering (BE), 31 years of experience in environmental investigation and remedial design for USACE.	• OSHA Initial 40-Hour HAZWOPER • USACE Construction Quality Management for Contractors	Signature on file

Name	Project Title/Role	Education/Experience	Specialized Training/ Certifications for the Project Title/Role[1]	Signature/Date[2]
Shawn Atkinson	Federal Contracts Manager	Master of Business Administration (MBA), BS, Management, 12 years of experience managing both cost and fixed-price contracts for DoD, civilian agencies, and federal contractors. Solid understanding of the Federal Acquisition Regulation, various contract types and vehicles, and the entire acquisition process.	• Certified Professional Contracts Manager • Previously held Defense Acquisition Workforce Improvement Act Level III certification	Signature on file
Grey Coppi, CSP, CIH	Health and Safety Officer	Master of Science, Environmental Health Science, BS, Health Science, 25 years of facilities and environmental health and safety consulting experience.		Signature on file
Jennifer Singer	Project Chemist	MS, Environmental Pollution Control, BS, Biochemistry, 21 years of project chemistry experience in coordination with the Air Force Civil Engineer Center, USACE, and USEPA.		Signature on file
Whitney Plasket, PE (Maine)	Senior Environmental Engineer	BS, Environmental Engineering, 10 years of experience, specializing in preparing conceptual site models and evaluating remedial technologies. Diverse background in the remediation of contaminated soil and groundwater.	• OSHA Initial 40-Hour HAZWOPER • OSHA 8-Hour HAZWOPER Refresher	Signature on File
Mike Cobb, PG	Geologist	Master of Science/BS, Geology, 15 years of professional experience with a range of geologic/hydrogeologic investigations, with an emphasis in dense non-aqueous phase liquid sites, fractured rock, and karst. Experience developing conceptual site models in an array of hydrogeologic settings, ranging from bedrock and glacial terrains, to waterfront settings. Has coordinated major subsurface investigations throughout the eastern and central United States.	• OSHA Initial 40-Hour HAZWOPER • OSHA 8-Hour HAZWOPER Refresher	Signature on file

Name	Project Title/Role	Education/Experience	Specialized Training/ Certifications for the Project Title/Role[1]	Signature/Date[2]
Marc Killingstad, PE	Hydrogeologist	MS Civil Engineering, BS Civil Engineering, 31 years of experience, Director of the Hydrogeology Community of Practice as well as the technical lead for the Remediation Hydraulics Practice Area for Arcadis North America (NA).	• Licensed Professional Engineer • Occupational Safety and Health Administration (OSHA) Initial 40-Hour Hazardous Waste Operations and Emergency Response (HAZWOPER), Annual 8-Hour Refreshers	Signature on file
David Rigg	Ecological Risk Assessor	MS, Environmental Modeling and Risk Analysis, BS, Environmental Science, 30 years of experience in aquatic and terrestrial ecology, specializing in fish and wildlife impact assessments, ecological risk assessments, biological surveys, and aquatic and terrestrial community characterization. Has developed food web models to evaluate potential uptake and assess risks to various wildlife species.	• OSHA Initial 40-Hour HAZWOPER • OSHA 8-Hour HAZWOPER Refresher • United States Fish and Wildlife Service (USFWS) Electrofishing Certification	Signature on file
Julie Gillespie	Human Health Risk Assessor	MS, Environmental Policy, BS, Natural Resources Management, 15 years of experience conducting CERCLA baseline human health risk assessments and screening-level ecological risk assessments; provided risk assessment expertise to U.S. Army, Air Force, and Navy sites.	• OSHA Initial 40-Hour HAZWOPER • OSHA 8-Hour HAZWOPER Refresher	Signature on file

Notes:
[1] Training listed is required for the project title/role only and not the personnel holding that position.
[2] Signatures indicate personnel have read and agree to implement this QAPP as written (signatures required for final submittal only).

ORGANIZATION: Eurofins Lancaster Laboratories (primary laboratory)

Name	Project Title/Role	Education/Experience	Signature/Date[1]
Kerri Sachtleben	Laboratory PM	Representative for project laboratory.	Signature on file
Kenneth Boley	Laboratory QA Manager	Representative for project laboratory.	Signature on file

Note:
[1] Signatures indicate personnel have read and agree to implement this QAPP as written (signatures required for final submittal only).

ORGANIZATION: LDC (Data Validator)

Name	Project Title/Role	Education/Experience	Signature/Date[1]
Pei Geng	Data Validation PM	Representative for project data validation.	Signature on file

Note:
[1] Signatures indicate personnel have read and agree to implement this QAPP as written (signatures required for final submittal only).

PERSONNEL QUALIFICATIONS CERTIFICATION LETTER

Note: After the field schedule and personnel availability are confirmed, a letter will be submitted to the Contracting Officer for review of qualifications and approval of personnel proposed for the RI. The SERES-Arcadis JV will not be authorized to begin field work until the Contractor's personnel are accepted by the Government. The acceptance letter will be placed here when finalized.

QAPP Worksheet #6: Communication Pathways

(UFP-QAPP Manual Section 2.4.2)
(USEPA 2106-G-05 Section 2.2.4)

This worksheet documents specific issues (communication drivers) that will trigger the need to communicate with other project personnel or stakeholders. It ensures there are procedures in place for providing the appropriate notifications and generating the appropriate documentation when handling important communications, including those involving regulatory interfaces, unexpected events, emergencies, non-conformances, and stop-work orders. An organizational chart is included in Worksheets #3 & #5. **Attachment A** contains the Project Accident Prevention Plan (APP).

Communication Driver	Organization	Name/Role	Phone Number	Procedure (Timing, Pathways, Documentation, etc.)
Program issues and modifications	CENAE	Penny Reddy *CENAE PM*	978-318-8160 (Office)	The CENAE PM will communicate project management decisions and QAPP modifications to the USACE Contracting Officer's Representative (COR) and the SERES-Arcadis JV PM, as necessary. All approved QAPP modifications will be included in the amendments to the QAPP by the SERES-Arcadis JV and signed within seven working days.
Project issues	SERES-Arcadis JV	Andy Vitolins *SERES-Arcadis JV PM*	518-250-7359 (Office) 518-461-3145 (Mobile)	The SERES-Arcadis JV PM will notify the USACE Contracting Officer's Representative (COR) and PM of project issues within seven days by telephone or email.
BRAC	BEC	Thomas Lineer	703-545-2487 (Office) 703-371-6785 (Mobile)	Primary point of contact (POC) for Fort Devens
Regulatory agency interface (e.g., USEPA)	SERES-Arcadis JV	Andy Vitolins *SERES-Arcadis JV PM* Penny Reddy *CENAE PM*	518-250-7359 (Office) 518-461-3145 (Mobile) 978-318-8160 (Office)	Communication with the USEPA will include USACE representatives. At the direction of the USACE COR or PM, the SERES-Arcadis JV PM may communicate directly with regulatory agency representatives by phone or email. If this occurs, the USACE COR and PM will be copied on any communications and a summary of discussion points will be provided.
Field progress reports	SERES-Arcadis JV	Andy Vitolins *SERES-Arcadis JV PM*	518-250-7359 (Office) 518-461-3145 (Mobile)	The SERES-Arcadis JV PM will send weekly field status reports to the USACE COR and/or PM by email. Daily email updates will also be provided.
Stop work due to safety issues	SERES-Arcadis JV	Grey Coppi *SERES-Arcadis JV Federal Safety and Health Officer* Andy Vitolins *SERES-Arcadis JV PM*	732-225-5061 (Office) 908-917-6948 (Mobile) 518-250-7359 (Office) 518-461-3145 (Mobile)	Anyone may stop work at any time for any safety concern. Refer to the APP included as **Attachment A** to this QAPP for specifics related to health and safety (H&S). Persons other than the responsible entity may also stop work for safety concerns. All stop work issues will be recorded in the daily QC report (DQCR). The SERES-Arcadis JV PM will notify the USACE COR and PM, by phone within 24 hours, if there is a stop work situation. Email documentation will follow within 24 hours.

Communication Driver	**Organization**	**Name/Role**	**Phone Number**	**Procedure (Timing, Pathways, Documentation, etc.)**
QAPP changes prior to field work	SERES-Arcadis JV	Andy Vitolins *SERES-Arcadis JV PM*	518-250-7359 (Office) 518-461-3145 (Mobile)	The SERES-Arcadis JV PM will submit documented amendments within 10 working days to the USACE COR and PM for approval.
QAPP changes during project execution	SERES-Arcadis JV	Andy Vitolins *SERES-Arcadis JV PM*	518-250-7359 (Office) 518-461-3145 (Mobile)	The SERES-Arcadis JV PM will notify and obtain approval for QAPP modifications from the USACE COR and PM. The SERES-Arcadis JV will include all approved QAPP modifications in the amendments to the QAPP and sign them within seven working days.
Field corrective actions	SERES-Arcadis JV	Andy Vitolins *SERES-Arcadis JV PM*	518-250-7359 (Office) 518-461-3145 (Mobile)	The SERES-Arcadis JV PM will communicate field corrective actions within 24 hours to the USACE COR and PM by phone and email. Documentation of the corrective action will occur within seven working days.
Sample receipt variances	Eurofins Lancaster Laboratories	Kerri Sachtleben *Eurofins PM*	(717) 556-7376	The laboratory PM will report all project field sample variance issues to the SERES-Arcadis JV Project Chemist within 24 hours of identification of the technical concern. The SERES-Arcadis JV PM will report all field sample variance issues to the USACE COR and PM within 24 hours (by phone followed by a confirming email) of notification from the laboratory.
Laboratory quality control variances	Eurofins Lancaster Laboratories	Kerri Sachtleben *Eurofins PM*	(717) 556-7376	The laboratory PM will report all QC issues with project field samples to the SERES-Arcadis JV PM and Project Chemist within 24 hours of identification of the technical concern. The SERES-Arcadis JV PM will report all QC issues with project field samples to the USACE COR and PM within 24 hours (by phone followed by a confirming email) of notification by the laboratory.
Data verification issues (for example, incomplete records)	SERES-Arcadis JV and/or LDC	Jennifer Singer *SERES-Arcadis JV Project Chemist* Pei Geng *LDC Data Validator*	716-667-6664 (Office) 760-827-1110	The SERES-Arcadis JV Project Chemist or data validator (LDC) will report all verification issues to the SERES-Arcadis JV PM via email within 24 hours of identification of the technical concern. The SERES-Arcadis JV PM will report verification issues to the USACE COR and PM via email within 24 hours (by phone followed by a confirming email) of notification.

Communication Driver	Organization	Name/Role	Phone Number	Procedure (Timing, Pathways, Documentation, etc.)
Data validation issues (for example, non-compliance with procedures)	SERES-Arcadis JV and/or LDC	Jennifer Singer SERES-Arcadis JV *Project Chemist* Pei Geng *LDC Data Validator*	716-667-6664 760-827-1110	The LDC validator will report all validation issues to the SERES-Arcadis JV PM and Project Chemist via email within 24 hours of identification of the technical concern. The SERES-Arcadis JV PM will report all validation issues to the USACE COR and PM within 24 hours (by phone followed by a confirming email) of notification.
Data review corrective actions	SERES-Arcadis JV and/or LDC.	Jennifer Singer SERES-Arcadis JV *Project Chemist* Pei Geng *LDC Data Validator*	716-667-6664 760-827-1110	The SERES-Arcadis JV Project Chemist and/or LDC validator, as appropriate, will determine the need for data review corrective actions and document the actions in a memorandum to the SERES-Arcadis JV PM. The SERES-Arcadis JV PM will report data review corrective actions to the USACE COR and PM within 24 hours (by phone followed by a confirming email) of notification.

Points of Contact Information

Organization/Agency and Title/Project Function	Name	Contact Information
Army		
BRAC Environmental Coordinator	Thomas Lineer	703-545-2487 (Office) / 703-371-6785 (Mobile) thomas.a.lineer.civ@army.mil
CENAE		
Project PM	Penny Reddy	978-318-8160 penelope.w.reddy@usace.army.mil
Project Hydrogeologist	Mike Kulbersh	978-318-8088 michael.r.kulbersh@usace.army.mil
Project Engineer	Dan Groher	978-318-8404 Daniel.M.Groher@usace.army.mil
Project Chemist	Yixian Zhang	978-318-8730 (Office) yixian.zhang@usace.army.mil
Project Ecological Risk	Cheryl Montgomery	978-318-8088 (Office) Cheryl.R.Montgomery@usace.army.mil
Project Human Health Risk	Amy Rosenstein	978-318-8055 (Office) Amy.B.Rosenstein@usace.army.mil
USEPA Region 1		
Remedial PM	Carol Keating	617-918-1393 (Office) keating.carol@epa.gov
MassDEP		
Federal Sites Program PM	Joanne Dearden	781-407-1595 (Mobile) joanne.dearden@state.ma.us
SERES-Arcadis JV		
Program Manager	Alex Lo	843-388-7804 (Office) ahlo@seres-es.com
PM	Andy Vitolins, PG	518-250-7359 (Office) 518-461-3145 (Mobile) andy.vitolins@arcadis.com
Associate PM	Heather Levesque	619-370-0374 (Office) halevesque@seres-es.com;
Contracts Manager	Shawn Atkinson	303-471-3420 (Office) Shawn.Atkinson@arcadis.com
Corporate Quality Manager	John Nocera, PE, BCEE	251-405-4560 (Office) 251-689-7760 (Mobile) john.nocera@arcadis.com

Organization/Agency and Title/Project Function	Name	Contact Information
Health and Safety Officer	Grey Coppi, CIH, CSP	732-225-5061 (Office) 908-917-6948 (mobile) grey.coppi@arcadis.com
Senior Environmental Engineer	Whitney Plasket, PE	207-613-8447 (Office) whitney.plasket@arcadis.com
Ecological Risk Assessor	David Rigg	518-250-7379 (Office) david.rigg@arcadis.com
Hydrogeologist	Marc Killingstad, PE	410-923-7816 (Office) marc.killingstad@arcadis.com
Human Health Risk Assessor	Julie Gillespie	845-218-0749 (Office) julie.gillespie@arcadis.com
Chemist	Jennifer Singer	716-667-6664 (Office) jennifer.singer@arcadis.com
Geologist	Mike Cobb, PG	207-613-8351 (Office) 207-712-8843 (Mobile) michael.cobb@arcadis.com
Eurofins Lancaster Laboratories		
Laboratory PM	Kerri Sachtleben	717-556-7376 Kerri.sachtleben@et.eurofinsus.com
Laboratory QA Manager	Kenneth Boley	717-556-9413 Kenneth.boley@et.eurofinsus.com
LDC		
Data Validator	Pei Geng	760-827-1110 pgeng@lab-data.com
EMERGENCY NUMBERS		
Nashoba Valley Regional Emergency Communication Center	Not applicable (N/A)	978-772-1900
Devens Fire Department	N/A	911 978-772-4600 (non-emergency)
Ambulance Service	N/A	911
Work Care (SERES-Arcadis JV)	N/A	800-455-6155

QAPP Worksheet #9: Project Planning Session Summary

(UFP-QAPP Manual Section 2.5.1 and Figures 9–12)
(USEPA 2106-G-05 Section 2.2.5)

A kickoff teleconference was held in April 2020 for the Area 1 Phase II PFAS RI for Fort Devens. The purpose of the meeting was to:

- Confirm project stakeholders;
- Discuss communication tools and protocols;
- Review the RI objectives;
- Discuss the project schedule; and
- Review site information and Area 1 data gaps.

Since the kickoff teleconference, ongoing technical project planning teleconferences have been held approximately biweekly (every other week).

QAPP Worksheet #10: Conceptual Site Model

(UFP-QAPP Manual Section 2.5.2)
(USEPA 2106-G-05 Section 2.2.5)

10.1 Site Background and Location

The former Fort Devens is located in the Towns of Ayer and Shirley in Middlesex County and the Towns of Harvard and Lancaster in Worcester County, Massachusetts, approximately 35 miles northwest of Boston. The installation occupied approximately 9,260 acres. Fort Devens was divided into the North Post, Main Post, and South Post. Route 2 divides the South Post from the Main Post. The Nashua River runs through the North, Main, and South Posts. The area surrounding Fort Devens is primarily rural residential properties. Portions of Fort Devens have been redeveloped for commercial/industrial use.

10.2 Site History

Camp Devens was established in 1917 as a temporary training area for soldiers during World War I. In 1932, the site was named Fort Devens and made a permanent installation with the primary mission of commanding, training, and providing logistical support for non-divisional troop units. Fort Devens was used for a variety of training missions between 1917 and 1990. Pursuant to CERCLA, Fort Devens was placed on the National Priorities List on November 21, 1989, due to environmental contamination.

Fort Devens was identified for cessation of operations and closure under Public Law 101-510, the Defense Base Realignment and Closure Act of 1990, and officially closed in March 1996. As part of the Fort Devens BRAC program, portions of the property formerly occupied by Fort Devens were retained by the Army for reserve forces training and renamed the Devens Reserve Forces Training Area (DRFTA). Areas not retained as part of the DRFTA were transferred to new owners (MassDevelopment, U.S. Department of Labor, U.S. Department of Justice, and USFWS) for reuse and redevelopment. In 2009, the DRFTA was renamed U.S. Army Garrison Fort Devens.

10.3 Known or Suspected DoD-Related Releases of Aqueous Film-Forming Foam

Releases of AFFF may have occurred at Fort Devens during firefighter training, emergency response actions, equipment testing, or accidental releases. AFFF was developed in the mid-1960s in response to a need for firefighting foams better suited to extinguish Class B, fuel-based fires. AFFF formulations consist of water, an organic solvent, up to 5 percent (%) hydrocarbon surfactants, and 1 to 3% PFAS (Interstate Technology Regulatory Council [ITRC] 2020a). AFFF concentrate is designed to be diluted with water to become a 1%, 3%, or 6% foam. The constituents of AFFF are collectively referred to as PFAS. During previous investigations at Fort Devens, PFAS were detected in groundwater, soil, and surface water at several SAs and AOCs at Fort Devens. In addition, PFAS were detected in public water supply wells associated with the Town of Ayer Grove Pond municipal wellfield, located adjacent to Fort Devens.

10.4 Previous PFAS Site Investigations

10.4.1 2016 Preliminary Assessment

Investigations related to PFAS at Devens began in 2016 with a Base-wide Preliminary Assessment (PA) to determine if there were potential historical releases of PFAS associated with Fort Devens. The potential PFAS sources at Devens were evaluated using all available documents, interviews with both current and former Devens workers, available sampling data, and findings from environmental database searches. The installation-wide assessment determined that potential sources of PFAS were limited to areas of the former North Post, South Post, and Main Post where AFFF may have been used, stored, or disposed and warranted further investigation (KGS 2017b).

10.4.2 2017 Site Inspection and Site Inspection Addendum

The Army conducted a site inspection (SI) in 2017 to determine the presence or absence of PFAS in soil, groundwater, and/or sediment and surface water at selected sites at Devens previously identified in the PA as sites where AFFF containing PFAS may have been used, stored, or released and further investigation was warranted (BERS-Weston 2018a). The results of the SI confirmed the presence of PFAS at each of the AOCs and study areas (SAs) included in the SI (AOCs 5, 32, and 50 and SAs 20, 21, 30, 31, 74, and 75). Based on the SI findings, an RI was recommended for each of the AOCs and SAs included in the SI to further delineate the nature and extent of PFAS contamination. In addition, based on the analytical results of groundwater samples collected near the Grove Pond wellfield, the SI also recommended that the RI should determine/evaluate the source and extent of PFAS impacting the Grove Pond wellfield and the MacPherson water supply well. SAs 20, 21, 30, 31, 74, and 75 were subsequently reclassified as AOCs (BERS-Weston 2018a). A subsequent SI investigation found PFAS in both the groundwater and the soil samples collected from SA 76 - Devens Fire Station. The SI Addendum report recommended that SA 76 be reclassified as an AOC and included in the previously recommended RI (BERS-Weston 2018b).

10.4.3 2017-2018 Sampling of Long-Term Monitoring Locations

Sampling of existing long-term monitoring (LTM) wells at select AOCs confirmed the presence of PFAS at some AOCs not identified in the PA. Samples were collected from 29 existing groundwater monitoring wells and one surface water location in AOCs 5, 32/43A, 43G, 43J, 50, and 57.

10.4.4 2018-2020 Preliminary Site Characterization Summary of Areas 1, 2, and 3 PFAS Remedial Investigation (Phase 1)

RI field investigations (considered to be Phase I) were conducted at Devens at locations previously identified as impacted by PFAS to support the CERCLA decision-making process related to PFAS impacts at Devens. Field activities were conducted in accordance with the *Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (PFAS RI WP; KGS 2018c [Draft] and 2020c [Final]). Activities included sampling new and existing monitoring wells, collecting surface water and sediment samples, groundwater vertical profiling using direct-push technology (DPT), soil borings using DPT, groundwater vertical profiling and soil borings using rotosonic drilling, installation of piezometers and monitoring wells, sampling of monitoring wells, and synoptic water level measurements. Planned field activities by site were detailed in Field Sampling Plans for Area 1, Area 2, and Area 3, prepared as addenda to the PFAS RI WP (KGS 2018c [Draft] and 2020c [Final]). The results of the investigations were presented in Area-specific *Preliminary Site Characterization Summary (*PSCS) reports. Results for Area 1 sites and some sites designated as part of Area 2, were presented in the Area 1 PSCS (KGS 2020a) and the Area 2 PSCS (KGS 2020b). Data from the Area 1 PSCS are presented in Appendix B of the Area Phase II PFAS RI WP**.**

10.4.5 2019-2020 - Time Critical Removal Action

The Army conducted a time critical removal action (TCRA) for the Town of Ayer Grove Pond public water supply wells to prevent unacceptable risk to human health posed by PFOS/PFOA migrating or likely migrating from Devens toward public drinking water supply wells. The TCRA was completed in June 2019 and involved installation of a granular activated carbon (GAC) treatment filter to remove PFOS/PFOA from groundwater pumped by the public supply wells. Between August 2019 and March 2020, similar GAC treatment filters were installed at the MacPherson, Patton, and Shabokin water supply wells. In addition, ion exchange contact chambers were installed at Patton and Shabokin wells for PFAS removal.

10.5 Primary Release Mechanism/Fate and Transport Consideration

10.5.1 Source Area/Media

DoD-related impacts from PFAS are present in surface and subsurface soil, groundwater, and surface water at Fort Devens.

10.5.2 Release Mechanism/Activity

Once PFAS compounds are released to the environment, they are subject to physical, chemical, and biological processes that influence their distribution in various environmental media. This section provides an overview of PFAS uses and presence in the environment, qualities of PFAS compounds that contribute to their persistence in the environment, and potential routes of migration, and presents a summary of the PFAS mixtures (i.e., “fingerprints”) detected at each AOC to date in soil, groundwater, and surface water (if sampled). The data collected to date have been reviewed to identify any remaining data gaps (discussed in **Section 10.9**).

PFAS have been used in a wide range of industrial applications and in commercial products since the 1940s. These products include stain- and water-repellent materials, food packaging, and many retail products. Industrial products that include AFFF are also known to contain PFAS (ITRC 2020a). The widespread use of PFAS and their persistence in the environment have led to PFAS being present in most environmental media at low levels worldwide (ITRC 2020b). PFAS have been identified at a variety of environmental sites, including manufacturing facilities and landfills, in addition to airports, military sites, and other large facilities where fires have occurred or firefighting training has been conducted (Concawe 2016).

Analytical results for samples collected during the Area 1- Phase II field activities will be analyzed for the 40 PFAS currently listed in QSM 5.4 Table 24 for Method 1633, with results for PFOS, PFOA, PFBS, PFNA, PFHxS, PFHpA, PFDA, PFHxA, and PFBA screened against the project action limits (PALs) presented in Worksheets #15-1 through #15-6.

10.6 Potential Receptors and Exposure Pathways

A preliminary, general understanding of potential human and ecological receptors and exposure pathways based on the current and most likely future land uses within Area 1 is presented in Section 3.4 of the Area 1 Phase II PFAS RI WP and below. A screening level ecological risk assessment is not proposed at this time as there is insufficient toxicological information on the effects of PFAS in the environment to conduct such a study. However, information regarding ecological receptors and pathways is provided for future reference should the Army decide to evaluate ecological risk at a future date.

10.6.1 Human Receptors and Exposure Pathways

The current and foreseeable future land use for the Fort Devens Area 1 AOCs is primarily commercial/ industrial. Area 1 encompasses a portion of the former Main Post and is currently used for rail-, industrial-, or trade-related activities, recreational open space (including Red Tail Golf Course), and government/ industrial purposes (Vanasse Hangen Brustlin, Inc. [VHB] 1994). It is anticipated that future land use will be consistent with current land use (VHB 1994).

The Reuse Plan identifies major reuse themes for Fort Devens (VHB 1994). These themes and how they relate to Area 1 AOCs are:

- Rail-, Industrial-, and Trade-related Uses: Capitalizes on the Fort Devens unique rail, intermodal, and highway attributes and incorporates the existing railyard in the northeast corner of the former Main Post. This applies to AOCs 57, 74, and 75. This land use is considered commercial/industrial.
- Innovation and Technology Business: Includes businesses that are growing and have new products, technologies, or services. This applies to AOCs 43G and 43J. This land use is considered commercial/industrial.
- Open Space and Recreation: While large portions of Fort Devens have been set aside for open space and recreation, the recreational uses of land within Area 1 are primarily limited to passive recreational activities, such as walking, picnicking, and running (Nashua River Watershed Association [NRWA] 2008). This applies to the Lower Cold Spring Brook wetlands near AOCs 57, 74, and 75 and the Upper Cold Spring Brook wetlands near AOC 40. Mirror Lake, located between the Patton and Shabokin wells, is used for active recreation (e.g., fishing and swimming) and is permanently protected via a Conservation Restriction (NRWA 2008). No athletic fields or public hunting areas are located within the Area 1 AOCs.

Based on the current and reasonably anticipated future land uses, potential human receptors may include drinking water users, commercial/industrial workers, construction workers, utility workers, recreational users, and anglers. Future construction workers may be considered additional receptors in the event of site redevelopment. Residential development of the Area 1 is not a realistic future scenario; however, a hypothetical future residential scenario (i.e., exposure to soil and groundwater used as a source of drinking water) will be included to evaluate an unrestricted use/unlimited exposure (UU/UE) scenario.

The exposure media of concern for human health potentially include surface soil (0 to 0.5 foot bgs), subsurface soil (0.5 to 15 feet bgs [or the depth to groundwater, whichever comes first]), groundwater, surface water, sediment, and fish.

Generally, human exposure to PFAS in soil may potentially occur through incidental ingestion, dermal contact, and inhalation (particulates). However, inhalation of constituents in soil released to outdoor air as particulates is generally not evaluated because inhalation toxicity values are not currently available for PFAS.

Potential human receptors for groundwater at Devens may include drinking water users from existing water supply wells, commercial/industrial workers, construction workers, utility workers, recreational users, and anglers. Direct exposure to DoD-related impacts in groundwater may potentially occur through incidental ingestion and dermal contact if shallow groundwater (i.e., groundwater at depths less than 10 feet bgs) is encountered during site excavation for utility maintenance or repair. Although potential use of untreated groundwater as a potable water source is unlikely, the groundwater exposure pathway for drinking water users will be evaluated.

Exposure to PFAS in surface water and sediment may potentially could occur via incidental ingestion and dermal contact. Although there are fish consumption advisories due to mercury impacts in Mirror Lake, Grove Pond, and Plow Shop Pond, potential exposure to PFAS via fish consumption may potentially occur. This exposure pathway will be evaluated using the fish tissue data proposed for collection from Plow Shop Pond and Cold Spring Brook Pond.

10.6.2 Ecological Receptors and Exposure Pathways

Most of Devens Area 1 is developed into buildings, paved areas, and maintained grassed areas. These areas provide limited habitat for ecological receptors. The undisturbed portions of Area 1 provide habitat and include wooded uplands and successional open fields.

The aquatic habitat at PFAS Area 1 includes lakes and ponds (e.g., Mirror Lake, Grove Pond), streams (e.g., Cold Spring Brook), wetland areas, and vernal ponds. Ecological receptors in aquatic areas may potentially be exposed to PFAS in surface water and sediment. Aquatic plants, invertebrates, fish, amphibians, and reptiles may be exposed to PFAS in surface water and sediment through direct contact. Birds and mammals may be exposed to PFAS in sediment via incidental ingestion and to PFAS in surface water through drinking water ingestion. Birds and mammals may also be exposed to PFAS via uptake through the aquatic food web. The average depth to groundwater in Area 1 is approximately 15 feet bgs, thereby preventing potential ecological exposure.

10.7 Key Physical Aspects of the Site

10.7.1 Site Hydrology

Groundwater and surface water at Fort Devens regionally discharge into the Nashua River. The river's tributaries include Nonacoicus Brook and Walker Brook on the former North Post, Cold Spring Brook (also a tributary of Nonacoicus Brook via Grove Pond and Plow Shop Pond) on the former Main Post, and Willow Brook, another tributary to Nonacoicus Brook. Willow Brook originates from Robbins Pond and is also fed by surface water runoff, storm water discharge, and groundwater (**RI WP Figures 3-2 and 3-3**). The local groundwater flow direction at each AOC is addressed in Section 3.2 of the WP. Baseflow conditions for the numerous ponds, wetlands, and tributaries across Fort Devens are maintained by groundwater discharge. Groundwater is recharged in upland areas and flows generally from topographic highs to topographic lows, where it discharges to wetlands, ponds, streams, and directly into the Nashua River.

10.7.1.1 Overburden

Overburden glacial meltwater deposits constitute the primary groundwater aquifer at Fort Devens. The zones of highest transmissivity within the overburden are found in areas of thick glacial meltwater deposits on the former North and Main Posts at Fort Devens. Water supply wells, including the Shabokin, Patton, MacPherson, and Grove Pond water supply wells, are screened within these meltwater deposits. Hydraulic conductivity values vary between 30 to 300 feet per day) in meltwater deposits and 0.002 to 0.3 feet per day in lake-bottom sediments. The depth to groundwater across Fort Devens averages approximately 30 feet bgs.

10.7.1.2 Bedrock

The zones of lowest groundwater transmissivity at Fort Devens are typically associated with exposed till and the sparsely fractured bedrock. Groundwater flow in the underlying bedrock is more restrictive and moves predominantly in secondary porosity features, such as fractures, joints, and dissolution voids. The faulting and foliation of the bedrock align with major unit contacts (**RI WP Figure 3-2**), whereas fracture orientations are less systematic than the foliation patterns. Flow paths for bedrock groundwater are limited by sparse fracture connections and are biased by anisotropy from bedrock fabric that results in preferential movement along strike.

No distinct, continuous confining unit has been identified between overburden and bedrock, leaving bedrock groundwater potentially exposed to overburden releases. Additional details regarding the nature of bedrock at Fort Devens are provided in Section 3.1.2.2 of the WP.

10.7.2 Site Geology

The topography of Fort Devens is characterized by undulating glacial terrain that derived from glacial erosion and deposition on a crystalline bedrock terrain (**RI WP Figure 3-1**). Terrain types fall into three general types:

- **Bedrock Terrain –** Least common; generally consisting of crystalline bedrock topographical highs that are resistant to both glacial and fluvial erosion. Where bedrock is not directly exposed, a thin veneer of glacial sediments may be present.
- **Glacial Tills** – More common; primarily consisting of highly variable sediments deposited by glaciers and conforming to the underlying bedrock surface.
- **Glacial meltwater streams and lake deposits –** Most common; predominantly consisting of sediments deposited by glacial-meltwater outwash and ancient proglacial lake accumulations.

Landforms at Fort Devens include extensive flat uplands, such as those found at the former MAAF and WWTP areas on the former North Post, and kame and kettle topography that range from areas of comparatively low topographic relief to elongated hills (i.e., drumlins), such as the areas encountered on the former South Post and former Main Post (HLA 2000).

The major glacial sediment units consist of till, deltaic deposits from former glacial Lake Nashua, and deposits from glacial meltwater streams. Thickness of glacial till at Fort Devens varies between 10 to 60 feet, consists of unstratified gravel to silt, and typically contains boulders. The glacial lake deposits consist chiefly of sand and gravelly sand. Lake bottom deposits consist of sand, silt, and clay. Post-glacial deposits consist of river terrace sands and gravels, fine alluvial sands, and silts, as well as peat, silt, and sands in swampy areas. Overburden deposits are up to 300 feet thick (areas along Cold Spring Brook), whereas lowland Nashua River floodplain deposits, consisting of sand, fine gravel, and silt, are up to 25 feet thick.

The overburden at Fort Devens is underlain by competent (unweathered) to slightly weathered, sparsely fractured, low-grade metasedimentary rocks, gneisses, and granites (HLA 2000). Bedrock strikes and dips are variable across Fort Devens due to the folded nature of the formations and the presence of numerous faults that align with major unit contacts. Across Area 1, the dominant structural alignment is generally oriented in a north-south/northeast-southwest direction. The bedrock units present across various areas of Fort Devens are:

- Oakdale Formation – metamorphosed thin-bedded, pelitic and calcareous siltstone and muscovite schist;

- Devens Gneiss Complex – coarse-grained quartz-potassium (k)-spar biotite granite-gneiss (intruded by the Ayer Granite);
- Worcester Formation – carbonaceous slate and phyllite and minor metagraywacke;
- Berwick Formation – thin- to thick-bedded metamorphosed calcareous sandstone, siltstone, and minor muscovite schist;
- Chelmsford Granite – light gray, even and medium-grained muscovite-biotite granite;
- Ayer Granite – two or three facies present:
    - Clinton Facies – porphyritic biotite granite with a non-porphyritic border phase; intrudes the Berwick Formation;
    - Devens-Long Pond Facies – equigranular to porphyritic gneissic biotite granite and granodiorite.

10.8 Data Gaps

Data collected during the 2018-2020 RI field activities (Phase I) have been reviewed, and the CSM and data screened against the DQOs established in Section 2.2 of the Area 1 Phase II PFAS RI WP and in **Worksheet #11**. Several data gaps to be addressed during the Area 1 Phase II PFAS RI have been identified. The identified data gaps are discussed in Section 3.5 of the Area 1 Phase II PFAS RI WP.

QAPP Worksheet #11: Project/Data Quality Objectives

(UFP-QAPP Manual Section 2.6.1)
(USEPA 2106-G-05 Section 2.2.6)

The DQOs are qualitative and quantitative statements that clarify study objectives, define the appropriate type of data, and specify the tolerable levels of potential decision errors that are used as the basis for establishing the quality and quantity of data needed to support decisions. The JV utilized the DQO guidelines established in the Data Quality Objectives Process for Hazardous Waste Site Investigations, *EPA QA/G-4 HW (January 2000) EPA/600/R-00/007* (USEPA 2000) to develop the DQOs for the RI activities for Area 1 at Fort Devens, as summarized in the table below.

DQO	Problem Statement	Project Goals	Information Inputs	Study Boundaries	Decision Rules	Performance Criteria	Plan for Obtaining Data
Explanation	*Define the problem that necessitates this study*	*Identify study questions*	*Identify data and information needed to answer study questions*	*Specify the spatial and temporal boundaries.*	*Define the conditions under which the data will be utilized.*	*Specify the limits on decision errors*	*Design an effective data collection strategy based on previous steps*
Area 1 at Fort Devens, which includes the following areas: • AOC 43G Historical Gas Station GAOC 57 Former Vehicle Storage and Motor Repair Shops Site; • AOC 74 Barnum Road Firefighting	Synthesis of the data collected during Phase I investigations indicated that PFAS in groundwater is widespread laterally throughout Area 1 and there are likely several comingled PFAS plumes that behave as one, rather than separate, AOC-specific plumes. These comingled plumes discharge	The goal of the Phase II PFAS RI for Area 1 is to identify exposure pathways and assess risk to human receptors associated with the presence of PFAS in Area 1. To support this goal, the objectives of the Area 1 Phase II RI field activities are to define the following: • Source – Establish conservative exposure point concentrations (EPCs, i.e., “worst case”) at known sources of PFAS in	The information inputs required to accomplish the project goals are: • All information reviewed/gathered to date including the results of previous investigations, and previous remedial actions completed. • Analytical data from environmental media which	• The general areal boundaries for the Devens Area 1 RI are the Fort Devens PFAS Area 1 and adjacent areas that may affect conditions at Area 1 (and/or are affected by conditions at Area 1), including Grove Pond and Plow Shop Pond, and private properties adjacent to Area	• All samples will be collected and analyzed in accordance with the QAPP Addendum technical guidance instruction (TGI) and SOP documents included in the QAPP to ensure that subsequent decisions are made based on valid data. • Presence/ absence of PFAS will be	The potential decision errors associated with this RI include: • The false presumption that PFAS are not present at concentrations greater than the applicable decision criteria, when in fact they are. • The false presumption that PFAS are present at concentrations	The plan for obtaining the data necessary to meet the goals of the RI is presented in Section 4.0 of the Area 1 Phase II PFAS RI WP and in **Worksheet #17** of the QAPP.

DQO	Problem Statement	Project Goals	Information Inputs	Study Boundaries	Decision Rules	Performance Criteria	Plan for Obtaining Data
Exercise Site; • AOC 75 Former Building T-1445 Warehouse Fire; • Grove Pond Wellfield; • Patton Water Supply Well/AOC 40 Cold Spring Brook Landfill/ • Shabokin Water Supply Well/AOC 43J Historical Gas Station J.	to specific surface water bodies (i.e., Cold Spring Brook, Grove Pond, Mirror Lake, etc.) and drinking water receptors (i.e., Grove Pond Wellfield, Patton supply well, Shabokin supply well). An RI is required to assess human health and ecological risk resulting from potential exposures to PFAS in soil, groundwater, surface water, and sediment at Fort Devens.	Area 1 for use in human health risk assessment. • Pathway – Advance the CSM, by confirming locations of discharge of, and/or human or ecological exposure to, PFAS from Area 1 that are associated with releases from the former Fort Devens. • Human Exposure Impacts – Evaluate the risk to human receptors associated with PFAS releases from the former Fort Devens by conducting a human health risk assessment in accordance with CERCLA guidance. These data will then be used to update/refine the CSM, evaluate human health and ecological risk, and, subsequently, make decisions about the need for further action.	may include groundwater, soil, surface water, and/or biota samples. • Geologic, hydrogeologic/ hydraulic, and chemical data required to evaluate PFAS fate and transport. • Existing/ current toxicological data necessary to evaluate the risk of human exposure to PFAS in the environment.	1, including east/southeast of Cold Spring Brook. • The vertical boundaries of the study will include overburden groundwater and/or bedrock groundwater to the extent necessary to evaluate the pathways through which human exposure to PFAS released from the former Fort Devens are present.	based on the laboratory limits of detection (LODs) for PFAS presented in this QAPP in **Worksheet #15**. • More specific decision rules by media (i.e., groundwater, soil, surface water, and fish tissue) can be found in Section 2.2.5 of the Area 1 Phase II PFAS RI WP.	greater than the applicable decision criteria, when in fact they are not. The Data Usability Assessment Process will be used to limit decision errors based on field and analytical data. Project-specific MPCs, which are the criteria that collected data must meet to satisfy the DQOs, are presented in **Worksheet #12**.	

QAPP Worksheet #12: Measurement Performance Criteria

(UFP-QAPP Manual Section 2.6.2)
(USEPA 2106-G-05 Section 2.2.6)

Measurement performance criteria (MPC) for field QC sampling results are used to evaluate project data quality indicators (DQIs) such as accuracy/bias and precision. The following tables provide definition of different laboratory and field blanks that will be used as quality control measures to evaluate the site-specific DQIs. MPC are provided below by matrix and analytical group in **Worksheets #12a and #12b**.

QAPP Worksheet #12a: Measurement Performance Criteria (PFAS in Groundwater / Surface Water)

Matrix: Groundwater / Surface Water
Concentration Level: Low
Analytical Method: PFAS per USEPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24 / WI46412

DQIs	QC Sample of Measurement Performance Activity	MPC
Precision	Field Duplicates	Relative percent difference (RPD) ≤ 35%
Accuracy/Bias (contamination)	Reagent or Equipment Blanks as appropriate	No target analyte concentrations ≥1/2 limit of quantitation (LOQ) or > 1/10 the amount measured in any sample or 1/10th the regulatory limit, whichever is greater
Analytical Accuracy/Bias (laboratory)	Laboratory control sample (LCS)	%R must be within laboratory generated limits. If not determined, preliminary control limits are 40 to 150%. Lower limit of laboratory generated limits must not be less than 40%.
Analytical Accuracy/Bias (matrix interference)	Matrix spike (MS) and matrix spike duplicate (MSD)	%R same as LCS
Analytical Precision (laboratory)	Laboratory control sample duplicate (LCSD) and MSD	RPD ≤ 30%
Analytical Accuracy/Bias (laboratory)	Extracted internal standard (EIS)	%R must be within laboratory generated limits. If not determined, preliminary control limits are 20 to 150%. Lower limit of laboratory generated limits must not be less than 20%.
Sensitivity Check	LOQ Verification Sample (spiked at concentration of lowest calibration standard)	Recovery within ±30% of true value

Note: The table above complies with the requirements of USEPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24.

QAPP Worksheet #12b: Measurement Performance Criteria (PFAS in Soil / Sediment)

Matrix: Soil
Concentration Level: Low
Analytical Method: PFAS per USEPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24 / WI48593

DQIs	QC Sample of Measurement Performance Activity	MPC
Precision	Field Duplicates	RPD ≤ 50%
Accuracy/Bias (contamination)	Reagent or Equipment Blanks as appropriate	No target analyte concentrations ≥½ LOQ or > 1/10 the amount measured in any sample or 1/10th the regulatory limit, whichever is greater.
Analytical Accuracy/Bias (laboratory)	LCS	%R must be within laboratory generated limits. If not determined, preliminary control limits are 40 to 150%. Lower limit of laboratory generated limits must not be less than 40%.
Analytical Accuracy/Bias (matrix interference)	MS and MSD	%R same as LCS
Analytical Precision (laboratory)	LCSD and MSD	RPD ≤ 30%
Analytical Accuracy/Bias (laboratory)	EIS	%R must be within laboratory generated limits. If not determined, preliminary control limits are 20 to 150%. Lower limit of laboratory generated limits must not be less than 20%.
Sensitivity Check	LOQ Verification Sample (spiked at concentration of lowest calibration standard)	Recovery within ±30% of true value

Note: The table above complies with the requirements of USEPA 2nd Draft method 1633 and DoD QSM 5.4 Table B-24.

QAPP Worksheet #12c: Measurement Performance Criteria (Grain Size Analysis)

Matrix: Solids
Concentration Level: Low
Analytical Method: ASTM D422; WI11514

DQIs	QC Sample of Measurement Performance Activity	MPC
Precision	Lab Duplicate	Laboratory statistical RPD
Precision	Field Duplicate	RPD as set by project
Completeness	Reported Sample Data	As determined by the project
Bias/Holding Time	Reported Sample Data	NA

QAPP Worksheet #12d: Measurement Performance Criteria (PFAS in Fish Tissue)

Matrix: Fish Tissue
Concentration Level: Low
Analytical Method: PFAS per USEPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24 / WI49212

DQIs	QC Sample of Measurement Performance Activity	MPC
Accuracy/Bias (contamination)	Reagent blanks	No target analyte concentrations ≥½ LOQ or > 1/10 the amount measured in any sample or 1/10th the regulatory limit, whichever is greater.
Analytical Accuracy/Bias (laboratory)	LCS	%R must be within laboratory generated limits. If not determined, preliminary control limits are 40 to 150%. Lower limit of laboratory generated limits must not be less than 40%.
Analytical Accuracy/Bias (matrix interference)	MS and MSD	%R same as LCS
Analytical Precision (laboratory)	LCSD and MSD	RPD ≤ 30%
Analytical Accuracy/Bias (laboratory)	EIS	%R must be within laboratory generated limits. If not determined, preliminary control limits are 20 to 150%. Lower limit of laboratory generated limits must not be less than 20%.
Sensitivity Check	LOQ Verification Sample (spiked at concentration of lowest calibration standard)	Recovery within ±30% of true value

Note: The table above complies with the requirements of USEPA 2nd Draft method 1633 and DoD QSM 5.4 Table B-24.

QAPP Worksheet #13: Secondary Data Uses and Limitations

(UFP-QAPP Manual Section 2.7)
(USEPA 2106-G-05 Chapter 3: QAPP Elements for Evaluating Existing Data)

Secondary Data	Data Source (originating organization, report title and date)	Data Generator(s) (originating organization, data types, data generation / collection dates)	How Data Will Be Used	Limitations on Data Use
Previous Investigation Sampling Results	*Base-wide Preliminary Assessment (PA). 2016*	KGS. Prepared for USACE.	Background information on nature and distribution of potential historical releases of PFAS.	The historical analytical data are considered valid, and there are no known limitations regarding their use.
Previous Site Investigation Sampling Results	*Site Inspection. 2017*	BERS-Weston. Prepared for USACE.	Use site investigation background information on the presence or absence of PFAS in groundwater at certain sites and distribution of PFAS.	The historical analytical data are considered valid, and there are no known limitations regarding their use.
Previous Site Investigation Sampling Results	*Site-wide sampling of existing long-term monitoring wells at select AOCs. 2020*	USACE.	Sampling data of long-term monitoring wells at select AOCs that confirmed the presence of PFAS.	There are no known limitations regarding use of the historical information and findings in this report.
Annual Long-Term Monitoring Program Reports	Annual Reports for individual AOCs; AOC 32/ and 43A, , AOC 57, AOC 69W, DCL, Sudbury Annex, SHL, and AOC 50.	Historical groundwater, surface water, sump water, and leachate sampling summary data for respective AOCs: 2000 through current.	Compared to historical results to identify spatial and temporal trends at respective AOCs.	None, except as identified for individual data points in the associated data quality evaluation (DQE).

Secondary Data	Data Source (originating organization, report title and date)	Data Generator(s) (originating organization, data types, data generation / collection dates)	How Data Will Be Used	Limitations on Data Use
Long-Term Monitoring and Maintenance Plan (LTMMP)	Current LTMMPs for all AOCs.	LTMM Program groundwater sampling summary and analytical data.	Compared to current results to identify spatial and temporal trends at respective AOCs	None
Devens Consolidation Landfill Permit Compliance	Industrial Pretreatment Self-Monitoring Reports	Landfill leachate data: October 2006 through current.	Identify changes in discharge concentrations	None, except as identified for individual data points in the associated DQE

QAPP Worksheet #14 & 16: Project Tasks and Schedule

(UFP-QAPP Manual Section 2.8.2)
(USEPA 2106-G-05 Section 2.2.4)

The project schedule, including the specific task/activity and the person or group responsible for execution is provided in the following table. The complete schedule for this project timeline, including planning document preparation and field activities, report preparation, and meeting support, is presented in **Attachment B** of this QAPP. Note that the schedule is subject to updates and revisions based on field conditions.

Activity	Responsible Party	Deliverable(s)	Deliverable due date
DFW 1: Pre-Mobilization Activities			
Final QAPP including Final APP	Andy Vitolins *SERES-Arcadis JV PM*	Final QAPP	One week after resolution of Draft Final QAPP comments.
DFW 2: Mobilization/Site Preparation			
Mobilization	Ian Martz *SERES-Arcadis JV Field Supervisor*	Field notes, DQCR	Weekly submittals due Friday of the week following performance of the activity.
DFW 3: Environmental Data Collection			
RI Field Activities	Theresa Cansler *SERES-Arcadis JV Task Manager*	Data Package, including data validation summary	Twelve weeks after completion of field activities.
DFW 4: Final Report			
Draft RI/FS Report	Andy Vitolins *SERES-Arcadis JV PM*	Draft RI/FS Report	Approx. one year after completion of field activities.
Draft Final/Final RI/FS Report	Andy Vitolins *SERES-Arcadis JV PM*	Draft Final/Final RI/FS Report	45 days after receipt of Draft/Draft Final comment resolution.

QAPP Worksheet #15: Project Action Limits and Laboratory-Specific Detection/Quantitation Limits

(UFP-QAPP Manual Section 2.6.2.3)
(USEPA 2106-G-05 Section 2.2.6)

The following **Worksheet #15** tables identify the PALs and provide a comparison of the PALs to analytical laboratory reference limits (i.e., LODs and LOQs) for groundwater, surface water, and fish tissue per analytical method. The objective is for the laboratory to achieve LODs low enough to measure analytes at concentrations less than the PALs to obtain a dataset of known quality and sufficient sensitivity to meet project DQOs. The PALs represent the lowest of the relevant human health screening levels and other applicable criteria that may be used in the RI and later stages of the CERCLA process.

The human health PALs for Fort Devens PFAS sites include:

- Groundwater:
    - Applicable MCP PFAS groundwater standards (GW-1; groundwater used for drinking water) for individual or sum of the concentrations of six specific PFAS (PFAS6; PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA).
    - Site-specific groundwater SLs for resident child for PFOA, PFOS, PFBS, PFNA, PFHxS, PFHxA, and PFBA (USEPA Region 1 2023).
- Soil:
    - Applicable MCP PFAS soil standards for soil in an area where groundwater is used for drinking water (S-1/GW-1) for individual concentrations of PFAS6 (PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA).
    - Site-specific groundwater SLs for resident child for PFOA, PFOS, PFBS, PFNA, PFHxS, PFHxA, and PFBA (USEPA Region 1 2023).
- Surface Water:
    - Applicable MCP PFAS surface water standard (GW-3) for individual concentrations of the PFAS6.
    - Site-specific surface water SLs for recreational child for PFOA, PFOS, PFBS, PFNA, PFHxS, PFHxA, and PFBA (USEPA Region 1 2023).

- Sediment:
  - There is no applicable MCP standard for PFAS6 in sediment.
  - Site-specific sediment SLs for PFOA, PFOS, PFBS, PFNA, PFHxS, PFHxA, and PFBA (USEPA Region 1 2023).
- Fish Tissue:
  - There is no applicable MCP standard for PFAS6 in fish tissue.
  - Site-specific fish tissue SLs for angler child fish consumption for PFOA, PFOS, PFBS, PFNA, PFHxS, PFHxA, and PFBA (USEPA Region 1 2023).

The laboratory reference limits are provided by the preliminary laboratory: Eurofins Lancaster Laboratories. Reference limits will be updated, as necessary, for the selected laboratory.

The PALs are not intended to be used as cleanup levels. Concentrations above the PALs would not automatically trigger a response action but would suggest that further site-specific consideration is appropriate.

The analytical laboratory reference limits presented in **Worksheet #15** tables are as follows:

- LOD – The smallest concentration of a substance that must be present in a sample in order to be detected at the detection limit (DL) with 99% confidence. At the LOD, the false negative rate (Type II error) is 1%. A LOD may be used as the lowest concentration for reliably reporting a non-detect of a specific analyte in a specific matrix with a specific method at 99% confidence.
- LOQ – The lowest concentration of a substance that produces a quantitative result within specified limits of precision and bias.

The worksheets that follow include:

- Worksheet #15-1: PFAS in Groundwater
- Worksheet #15-2: PFAS in Soil
- Worksheet #15-3: Total Organic Carbon and Grain Size in Soil
- Worksheet #15-4: PFAS in Surface Water
- Worksheet #15-5: PFAS in Sediment
- Worksheet #15-6: PFAS in Fish Tissue

Worksheet #15-1: Reference Limits and Evaluation Table

Eurofins Lancaster Laboratories (PFAS in Groundwater)

(UFP-QAPP Manual Section 2.6.2.3) / (USEPA 2106-G-05 Section 2.2.6)

Analyte	CAS #	Project Action Limits (PALs)			Laboratory Achievable Detection Limits (ng/L)		
		MCP GW-1 [a] (ng/L)	MCP GW-3 [a] (ng/L)	USEPA Site-specific SL [b] (ng/L)	LOQ	LOD	DL
Analytical Group: PFAS per USEPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24							
Perfluorobutanoic acid (PFBA)	375-22-4	NA	NA	1,850	8.0	4.0	2.0
Perfluoropentanoic acid (PFPeA)	2706-90-3	NA	NA	NA	4.0	2.0	1.0
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	NA	NA	NA	2.0	1.00	.50
Perfluorohexanoic acid (PFHxA)	307-24-4	NA	NA	992	2.0	1.0	0.50
Perfluoroheptanoic Acid (PFHpA)	375-85-9	20	40,000,000	NA	2.0	1.0	0.52
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	NA	NA	NA	2.0	1.0	0.40
Perfluorooctanic Acid (PFOA)	335-67-1	20	40,000,000	6.02	2.0	1.3	0.64
Perfluorononanoic Acid (PFNA)	375-95-1	20	40,000,000	5.89	2.0	1.0	0.50
Perfluorononanesulfonic acid (PFNS)	68259-12-1	NA	NA	NA	2.0	1.0	0.40
Perfluorodecanoic Acid (PFDA)	335-76-2	20	40,000,000	NA	2.0	1.0	0.50
Perfluorodecanesulfonic acid (PFDS)	335-77-3	NA	NA	NA	2.0	1.0	0.50
Perfluoroundecanoic acid (PFUnA)	2058-94-8	NA	NA	NA	2.0	1.0	0.50
Perfluorododecanoic acid (PFDoA)	307-55-1	NA	NA	NA	2.0	1.0	0.50
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	NA	NA	NA	2.0	1.9	0.90
Perfluorotridecanoic Acid (PFTriA)	72629-94-8	NA	NA	NA	2.0	1.0	0.50
Perfluorotetradecanoic acid (PFTeA)	376-06-7	NA	NA	NA	2.0	1.0	0.50

Analyte	**CAS #**	**Project Action Limits (PALs)**			**Laboratory Achievable Detection Limits (ng/L)**		
		MCP GW-1 [a] (ng/L)	**MCP GW-3 [a] (ng/L)**	**USEPA Site-specific SL [b] (ng/L)**	**LOQ**	**LOD**	**DL**
Analytical Group: PFAS per USEPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24							
Perfluorobutanesulfonic acid (PFBS)	375-73-5	NA	NA	601	2.0	1.0	0.30
Perfluorohexane Sulfonic Acid (PFHxS)	355-46-4	20	500,000	39.4	2.0	1.1	0.57
Perfluoroctane Sulfonic Acid (PFOS)	1763-23-1	20	500,000	4.01	2.0	1.0	0.50
Perfluorooctanesulfonamide (PFOSA)	754-91-6	NA	NA	NA	2.0	1.0	0.50
Hexafluoropropylene oxide dimer acid (GenX)	13252-13-6	NA	NA	6.02	8.0	4.0	2.0
N-ethylperfluorooctane sulfonamidoacetic acid (NEtFOSAA)	2991-50-6	NA	NA	NA	2.0	1.4	0.70
N-methylperfluorooctane sulfonamidoacetic acid (NMeFOSAA)	2355-31-9	NA	NA	NA	4.0	2.4	1.0
N-Methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	NA	NA	NA	2.0	1.0	0.50
N-Ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	NA	NA	NA	2.0	1.0	0.50
N-Methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	NA	NA	NA	20	10	5.0
N-Ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	NA	NA	NA	20	10	5.0
4:2 flourotelomersulfonic acid (4:2 FTS)	757124-72-4	NA	NA	NA	8.0	3.8	1.7
6:2 flourotelomersulfonic acid (6:2 FTS)	27619-97-2	NA	NA	NA	8.0	7.6	2.5
8:2 flourotelomersulfonic acid (8:2 FTS)	39108-34-4	NA	NA	NA	8.0	7.7	2.6
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	NA	NA	NA	8.0	3.8	1.5
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	NA	NA	NA	4.0	2.0	0.50
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	NA	NA	NA	4.0	2.0	1.0
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	NA	NA	NA	4.0	2.0	1.0
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	NA	NA	NA	8.0	3.8	1.0

Analyte	**CAS #**	**Project Action Limits (PALs)**			**Laboratory Achievable Detection Limits (ng/L)**		
		MCP GW-1 [a] (ng/L)	**MCP GW-3 [a] (ng/L)**	**USEPA Site-specific SL [b] (ng/L)**	**LOQ**	**LOD**	**DL**
Analytical Group: PFAS per USEPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24							
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	NA	NA	NA	8.0	7.6	2.0
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	NA	NA	NA	4.0	1.8	0.50
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	NA	NA	NA	10	5.0	1.5
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	NA	NA	NA	50	25	10
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	NA	NA	NA	50	25	10

NOTE:

a. MCP PFAS groundwater standard for category GW-1 (groundwater used for drinking water) or GW-3 (groundwater to surface water) for individual or sum of the concentrations of six specific PFAS (PFAS6) (PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA).

b. Site-specific groundwater SLs for residential child scenario for PFOA, PFOS, PFBS, PFNA, PFHxS, PFHxA, and PFBA (USEPA Region 1 2023).

CAS = Chemical Abstract Service
LOQ = limit of quantitation
micrograms per kilograms (µg/kg) = nanograms per gram (ng/g)
LOD = limit of detection
NA = Not applicable
USEPA = United States Environmental Protection Agency

Worksheet #15-2: Reference Limits and Evaluation Table

Eurofins Lancaster Laboratories (PFAS in Soil)

(UFP-QAPP Manual Section 2.6.2.3) / (USEPA 2106-G-05 Section 2.2.6)

Analyte	CAS #	Project Action Limit (PAL)	Laboratory Achievable Detection Limits [b] (µg/kg)		
		USEPA site-specific SL [a] (µg/kg)	LOQ	LOD	DL
Analytical Group: PFAS per USEPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24					
Perfluorobutanoic acid (PFBA)	375-22-4	7,820	0.80	0.40	0.10
Perfluoropentanoic acid (PFPeA)	2706-90-3	NA	0.40	0.20	0.10
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	NA	0.20	0.10	0.050
Perfluorohexanoic acid (PFHxA)	307-24-4	3,160	0.20	0.12	0.059
Perfluoroheptanoic Acid (PFHpA)	375-85-9	NA	0.20	0.10	0.050
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	NA	0.20	0.10	0.050
Perfluorooctanic Acid (PFOA)	335-67-1	19	0.20	0.10	0.051
Perfluorononanoic Acid (PFNA)	375-95-1	19	0.20	0.10	0.050
Perfluorononanesulfonic acid (PFNS)	68259-12-1	NA	0.20	0.10	0.050
Perfluorodecanoic Acid (PFDA)	335-76-2	NA	0.20	0.10	0.050
Perfluorodecanesulfonic acid (PFDS)	335-77-3	NA	0.20	0.10	0.050
Perfluoroundecanoic acid (PFUnA)	2058-94-8	NA	0.20	0.10	0.050
Perfluorododecanoic acid (PFDoA)	307-55-1	NA	0.20	0.10	0.050
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	NA	0.20	0.10	0.050
Perfluorotridecanoic Acid (PFTriA)	72629-94-8	NA	0.20	0.10	0.050
Perfluorotetradecanoic acid (PFTeA)	376-06-7	NA	0.20	0.10	0.050

Analyte	**CAS #**	**Project Action Limit (PAL)**	**Laboratory Achievable Detection Limits [b] (µg/kg)**		
		USEPA site-specific SL [a] (µg/kg)	**LOQ**	**LOD**	**DL**
Perfluorobutanesulfonic acid (PFBS)	375-73-5	1900	0.20	0.10	0.050
Perfluorohexane Sulfonic Acid (PFHxS)	355-46-4	126	0.20	0.10	0.050
Perfluoroctane Sulfonic Acid (PFOS)	1763-23-1	12.6	0.20	0.10	0.051
Perfluorooctanesulfonamide (PFOSA)	754-91-6	NA	0.20	0.10	0.050
Hexafluoropropylene oxide dimer acid (GenX)	13252-13-6	24	0.80	0.40	0.10
N-ethylperfluorooctane sulfonamidoacetic acid (NEtFOSAA)	2991-50-6	NA	0.20	0.10	0.050
N-methylperfluorooctane sulfonamidoacetic acid (NMeFOSAA)	2355-31-9	NA	0.20	0.10	0.050
N-Methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	NA	0.20	0.10	0.050
N-Ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	NA	0.20	0.10	0.050
N-Methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	NA	2.0	1.0	0.50
N-Ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	NA	2.0	1.0	0.50
4:2 flourotelomersulfonic acid (4:2 FTS)	757124-72-4	NA	0.80	0.40	0.20
1H, 1H, 2H, 2H-perfluorooctane sulfonate (6:2 FTS)	27619-97-2	NA	1.0	0.80	0.35
1H, 1H, 2H, 2H-perfluoroecane sulfonate (8:2 FTS)	39108-34-4	NA	1.0	0.80	0.35
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	NA	0.80	0.40	0.20
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	NA	0.40	0.20	0.10
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	NA	0.40	0.20	0.10
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	NA	0.40	0.20	0.10

Analyte	CAS #	Project Action Limit (PAL)	Laboratory Achievable Detection Limits [b] (µg/kg)		
		USEPA site-specific SL [a] (µg/kg)	LOQ	LOD	DL
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	NA	0.80	0.40	0.20
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	NA	0.80	0.40	0.20
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	NA	0.40	0.20	0.10
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	NA	1.0	0.50	0.25
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	NA	5.0	2.5	1.0
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	NA	5.0	2.5	1.0

NOTE:

a. Site-specific soil SLs for residential child scenario for PFOA, PFOS, PFBS, PFNA, PFHxS, PFHxA, and PFBA (USEPA Region 1 2023).
b. Sample results will reported on a dry weight basis. The detection limits listed are based on wet weight. Actual reporting limits will vary based on sample weight and moisture content.

CAS = Chemical Abstract Service
LOQ = limit of quantitation
micrograms per kilograms (µg/kg) = nanograms per gram (ng/g)
LOD = limit of detection
NA = Not applicable
USEPA = United States Environmental Protection Agency

Worksheet #15-3: Reference Limits and Evaluation Table

Eurofins Lancaster Laboratories (Total Organic Carbon and Grain Size in Soil)

(UFP-QAPP Manual Section 2.6.2.3) / (USEPA 2106-G-05 Section 2.2.6)

Laboratory Specific Reporting Limits[a] (g/kg)														
Method and Analyte Description	**CAS #**	**Cleanup Goals (mg/L)[1]**	**RL**	**MDL**	**LOQ**	**DL**	**LOD**	**Units**	**LCS - Low**	**LCS-High**	**LCS - RPD %**	**MS-Low**	**MS-High**	**MS-RPD %**
9060A Total Organic Carbon (TOC)	7440-44-0	--	4.0	0.902	4.0	0.902	2.0	g/kg	46	130	20	46	130	20
Grain Size	NA	--	1.0	0.5	--	0.5	1.0	% passing	--	--	--	--	--	--

Notes:

a. Eurofins TestAmerica laboratory-specific limits for total organic carbon (TOC) for soil.

CAS = Chemical Abstract Service
RL = reporting limit
MDL = method detection limit
LOQ = limit of quantitation
DL = detection limit
LOD = limit of detection
g/kg = gram per kilogram

USEPA = United States Environmental Protection Agency

Worksheet #15-4: Reference Limits and Evaluation Table

Eurofins Lancaster Laboratories (PFAS in Surface Water)

(UFP-QAPP Manual Section 2.6.2.3) / (USEPA 2106-G-05 Section 2.2.6)

Analyte	CAS #	Project Action Limits (PALs)		Laboratory Achievable Detection Limits (ng/L)		
		MCP GW-3 [a] (ng/L)	USEPA Site-specific SL [b] (ng/L)	LOQ	LOD	DL
Analytical Group: PFAS per USEPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24						
Perfluorobutanoic acid (PFBA)	375-22-4	NA	101,000	8.0	4.0	2.0
Perfluoropentanoic acid (PFPeA)	2706-90-3	NA	NA	4.0	2.0	1.0
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	NA	NA	2.0	1.00	.50
Perfluorohexanoic acid (PFHxA)	307-24-4	NA	49,200	2.0	1.0	0.50
Perfluoroheptanoic Acid (PFHpA)	375-85-9	40,000,000	NA	2.0	1.0	0.52
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	NA	NA	2.0	1.0	0.40
Perfluorooctanic Acid (PFOA)	335-67-1	40,000,000	304	2.0	1.3	0.64
Perfluorononanoic Acid (PFNA)	375-95-1	40,000,000	287	2.0	1.0	0.50
Perfluorononanesulfonic acid (PFNS)	68259-12-1	NA	NA	2.0	1.0	0.40
Perfluorodecanoic Acid (PFDA)	335-76-2	40,000,000	NA	2.0	1.0	0.50
Perfluorodecanesulfonic acid (PFDS)	335-77-3	NA	NA	2.0	1.0	0.50
Perfluoroundecanoic acid (PFUnA)	2058-94-8	NA	NA	2.0	1.0	0.50
Perfluorododecanoic acid (PFDoA)	307-55-1	NA	NA	2.0	1.0	0.50
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	NA	NA	2.0	1.9	0.90
Perfluorotridecanoic Acid (PFTriA)	72629-94-8	NA	NA	2.0	1.0	0.50

Analyte	CAS #	Project Action Limits (PALs)		Laboratory Achievable Detection Limits (ng/L)		
		MCP GW-3 [a] (ng/L)	USEPA Site-specific SL [b] (ng/L)	LOQ	LOD	DL
Perfluorotetradecanoic acid (PFTeA)	376-06-7	NA	NA	2.0	1.0	0.50
Perfluorobutanesulfonic acid (PFBS)	375-73-5	NA	30,400	2.0	1.0	0.30
Perfluorohexane Sulfonic Acid (PFHxS)	355-46-4	500,000	1930	2.0	1.1	0.57
Perfluoroctane Sulfonic Acid (PFOS)	1763-23-1	500,000	203	2.0	1.0	0.50
Perfluorooctanesulfonamide (PFOSA)	754-91-6	NA	NA	2.0	1.0	0.50
Hexafluoropropylene oxide dimer acid (GenX)	13252-13-6	NA	304	8.0	4.0	2.0
N-ethylperfluorooctane sulfonamidoacetic acid (NEtFOSAA)	2991-50-6	NA	NA	2.0	1.4	0.70
N-methylperfluorooctane sulfonamidoacetic acid (NMeFOSAA)	2355-31-9	NA	NA	4.0	2.4	1.0
N-Methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	NA	NA	2.0	1.0	0.50
N-Ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	NA	NA	2.0	1.0	0.50
N-Methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	NA	NA	20	10	5.0
N-Ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	NA	NA	20	10	5.0
4:2 flourotelomersulfonic acid (4:2 FTS)	757124-72-4	NA	NA	8.0	3.8	1.7
6:2 flourotelomersulfonic acid (6:2 FTS)	27619-97-2	NA	NA	8.0	7.6	2.5
8:2 flourotelomersulfonic acid (8:2 FTS)	39108-34-4	NA	NA	8.0	7.7	2.6
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	NA	NA	8.0	3.8	1.5
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	NA	NA	4.0	2.0	0.50
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	NA	NA	4.0	2.0	1.0
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	NA	NA	4.0	2.0	1.0
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	NA	NA	8.0	3.8	1.0

Analyte	CAS #	Project Action Limits (PALs)		Laboratory Achievable Detection Limits (ng/L)		
		MCP GW-3 [a] (ng/L)	USEPA Site-specific SL [b] (ng/L)	LOQ	LOD	DL
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	NA	NA	8.0	7.6	2.0
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	NA	NA	4.0	1.8	0.50
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	NA	NA	10	5.0	1.5
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	NA	NA	50	25	10
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	NA	NA	50	25	10

Notes:

a. MCP PFAS groundwater standard for category GW-3 (groundwater to surface water) for individual concentrations of six specific PFAS (PFAS6) (PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA).

b. Site-specific surface water SLs for recreational child scenario for PFOA, PFOS, PFBS, PFNA, PFHxS, PFHxA, and PFBA (USEPA Region 1 2023).

CAS = Chemical Abstract Service
NA = Not applicable
LOD = limit of detection
ng/L = nanogram per liter
LOQ = limit of quantitation
USEPA = United States Environmental Protection Agency

Worksheet #15-5: Reference Limits and Evaluation Table

Eurofins Lancaster Laboratories (PFAS in Sediment)

(UFP-QAPP Manual Section 2.6.2.3) / (USEPA 2106-G-05 Section 2.2.6)

Analyte	CAS #	Project Action Limit (PAL)	Laboratory Achievable Detection Limits [c] (µg/kg)		
		USEPA site-specific SL [a] (µg/kg)	LOQ	LOD	DL
Analytical Group: PFAS per USEPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24					
Perfluorobutanoic acid (PFBA)	375-22-4	36,500	0.80	0.40	0.10
Perfluoropentanoic acid (PFPeA)	2706-90-3	NA	0.40	0.20	0.10
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	NA	0.20	0.10	0.050
Perfluorohexanoic acid (PFHxA)	307-24-4	15,200	0.20	0.12	0.059
Perfluoroheptanoic Acid (PFHpA)	375-85-9	NA	0.20	0.10	0.050
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	NA	0.20	0.10	0.050
Perfluorooctanic Acid (PFOA)	335-67-1	91.4	0.20	0.10	0.051
Perfluorononanoic Acid (PFNA)	375-95-1	91.4	0.20	0.10	0.050
Perfluorononanesulfonic acid (PFNS)	68259-12-1	NA	0.20	0.10	0.050
Perfluorodecanoic Acid (PFDA)	335-76-2	NA	0.20	0.10	0.050
Perfluorodecanesulfonic acid (PFDS)	335-77-3	NA	0.20	0.10	0.050
Perfluoroundecanoic acid (PFUnA)	2058-94-8	NA	0.20	0.10	0.050
Perfluorododecanoic acid (PFDoA)	307-55-1	NA	0.20	0.10	0.050
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	NA	0.20	0.10	0.050
Perfluorotridecanoic Acid (PFTriA)	72629-94-8	NA	0.20	0.10	0.050

Analyte	CAS #	Project Action Limit (PAL)	Laboratory Achievable Detection Limits [c] (µg/kg)		
		USEPA site-specific SL [a] (µg/kg)	LOQ	LOD	DL
Perfluorotetradecanoic acid (PFTeA)	376-06-7	NA	0.20	0.10	0.050
Perfluorobutanesulfonic acid (PFBS)	375-73-5	9140	0.20	0.10	0.050
Perfluorohexane Sulfonic Acid (PFHxS)	355-46-4	609	0.20	0.10	0.050
Perfluoroctane Sulfonic Acid (PFOS)	1763-23-1	60.9	0.20	0.10	0.051
Perfluorooctanesulfonamide (PFOSA)	754-91-6	NA	0.20	0.10	0.050
Hexafluoropropylene oxide dimer acid (GenX)	13252-13-6	110	0.80	0.40	0.10
N-ethylperfluorooctane sulfonamidoacetic acid (NEtFOSAA)	2991-50-6	NA	0.20	0.10	0.050
N-methylperfluorooctane sulfonamidoacetic acid (NMeFOSAA)	2355-31-9	NA	0.20	0.10	0.050
N-Methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	NA	0.20	0.10	0.050
N-Ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	NA	0.20	0.10	0.050
N-Methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	NA	2.0	1.0	0.50
N-Ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	NA	2.0	1.0	0.50
4:2 flourotelomersulfonic acid (4:2 FTS)	757124-72-4	NA	0.80	0.40	0.20
1H, 1H, 2H, 2H-perfluorooctane sulfonate (6:2 FTS)	27619-97-2	NA	1.0	0.80	0.35
1H, 1H, 2H, 2H-perfluoroecane sulfonate (8:2 FTS)	39108-34-4	NA	1.0	0.80	0.35
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	NA	0.80	0.40	0.20
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	NA	0.40	0.20	0.10
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	NA	0.40	0.20	0.10

Analyte	CAS #	Project Action Limit (PAL)	Laboratory Achievable Detection Limits [c] (µg/kg)		
		USEPA site-specific SL [a] (µg/kg)	LOQ	LOD	DL
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	NA	0.40	0.20	0.10
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	NA	0.80	0.40	0.20
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	NA	0.80	0.40	0.20
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	NA	0.40	0.20	0.10
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	NA	1.0	0.50	0.25
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	NA	5.0	2.5	1.0
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	NA	5.0	2.5	1.0

Notes:

a. MCP PFAS groundwater standard for category GW-3 (groundwater to surface water) for individual concentrations of six specific PFAS (PFAS6) (PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA).

b. Site-specific surface water SLs for recreational child scenario for PFOA, PFOS, PFBS, PFNA, PFHxS, PFHxA, and PFBA (USEPA Region 1 2023).

c. Sample results will reported on a dry weight basis. The detection limits listed are based on wet weight. Actual reporting limits will vary based on sample weight and moisture content.

CAS = Chemical Abstract Service
NA = Not applicable
LOD = limit of detection
ng/L = nanogram per liter
LOQ = limit of quantitation
USEPA = United States Environmental Protection Agency

Worksheet #15-6: Reference Limits and Evaluation Table

Eurofins Lancaster Laboratories (PFAS in Fish Tissue)

(UFP-QAPP Manual Section 2.6.2.3) / (USEPA 2106-G-05 Section 2.2.6)

Analyte	CAS #	Project Action Limit (PAL)	Laboratory Achievable Detection Limits (µg/kg)		
		USEPA site-specific SL [a] (µg/kg)	LOQ	LOD	DL
Analytical Group: PFAS per USEPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24					
Perfluorobutanoic acid (PFBA)	375-22-4	307	2.0	1.0	0.364
Perfluoropentanoic acid (PFPeA)	2706-90-3	NA	1.0	0.50	0.132
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	NA	0.50	0.24	0.092
Perfluorohexanoic acid (PFHxA)	307-24-4	153	0.50	0.48	0.166
Perfluoroheptanoic Acid (PFHpA)	375-85-9	NA	0.50	0.25	0.119
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	NA	0.50	0.25	0.124
Perfluorooctanic Acid (PFOA)	335-67-1	0.92	0.50	0.48	0.203
Perfluorononanoic Acid (PFNA)	375-95-1	0.92	0.50	0.48	0.153
Perfluorononanesulfonic acid (PFNS)	68259-12-1	NA	0.50	0.25	0.092
Perfluorodecanoic Acid (PFDA)	335-76-2	NA	0.50	0.48	0.215
Perfluorodecanesulfonic acid (PFDS)	335-77-3	NA	0.50	0.48	0.202
Perfluoroundecanoic acid (PFUnA)	2058-94-8	NA	0.50	0.48	0.129
Perfluorododecanoic acid (PFDoA)	307-55-1	NA	0.50	0.25	0.079
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	NA	0.50	0.25	0.109

Analyte	CAS #	Project Action Limit (PAL)	Laboratory Achievable Detection Limits (µg/kg)		
		USEPA site-specific SL[a] (µg/kg)	LOQ	LOD	DL
Perfluorotridecanoic Acid (PFTriA)	72629-94-8	NA	0.50	0.25	0.080
Perfluorotetradecanoic acid (PFTeA)	376-06-7	NA	0.50	0.25	0.105
Perfluorobutanesulfonic acid (PFBS)	375-73-5	92	0.50	0.45	0.173
Perfluorohexane Sulfonic Acid (PFHxS)	355-46-4	6.13	0.50	0.23	0.077
Perfluoroctane Sulfonic Acid (PFOS)	1763-23-1	0.61	0.50	0.25	0.123
Perfluorooctanesulfonamide (PFOSA)	754-91-6	NA	0.50	0.25	0.094
Hexafluoropropylene oxide dimer acid (GenX)	13252-13-6	0.92	2.0	1.0	0.263
N-ethylperfluorooctane sulfonamidoacetic acid (NEtFOSAA)	2991-50-6	NA	0.50	0.48	0.171
N-methylperfluorooctane sulfonamidoacetic acid (NMeFOSAA)	2355-31-9	NA	0.50	0.48	0.209
N-Methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	NA	0.50	0.25	0.075
N-Ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	NA	0.50	0.25	0.102
N-Methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	NA	5.0	2.5	0.681
N-Ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	NA	5.0	4.8	1.87
4:2 flourotelomersulfonic acid (4:2 FTS)	757124-72-4	NA	2.0	1.9	0.555
1H, 1H, 2H, 2H-perfluorooctane sulfonate (6:2 FTS)	27619-97-2	NA	3.0	2.8	1.39
1H, 1H, 2H, 2H-perfluoroecane sulfonate (8:2 FTS)	39108-34-4	NA	2.0	1.9	0.684
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	NA	2.0	1.0	0.40
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	NA	1.0	0.495	0.124

Analyte	CAS #	Project Action Limit (PAL)	Laboratory Achievable Detection Limits (µg/kg)		
		USEPA site-specific SL [a] (µg/kg)	LOQ	LOD	DL
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	NA	1.0	0.50	0.20
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	NA	1.0	0.90	0.389
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	NA	2.0	1.0	0.258
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	NA	2.0	1.0	0.25
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	NA	1.0	0.46	0.23
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	NA	2.5	1.5	0.722
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	NA	12.5	6.25	2.11
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	NA	12.5	6.25	2.98

Notes:

a. Site-specific fish tissue SLs for child consumption scenario for PFOA, PFOS, PFBS, PFNA, PFHxS, PFHxA, and PFBA (USEPA Region 1 2023).
b. Sample results are reported on a wet weight basis.

CAS = Chemical Abstract Service
LOD = limit of detection
LOQ = limit of quantitation
micrograms per kilograms (µg/kg) = nanograms per gram (ng/g)
USEPA = United States Environmental Protection Agency

QAPP Worksheet #17: Sampling Design and Rationale

(UFP-QAPP Manual Section 3.1.1)
(USEPA 2106-G-05 Section 2.3.1)

The RI field activities are intended to determine the nature and extent of PFAS impacts in groundwater at the former Fort Devens to support human health risk assessment.

17.1 Overall Investigation Approach Rationale

This worksheet describes the design for data collection and documents Step 7 of the DQO process. For each field task, this section summarizes the data gap, the rationale for data collection, and the approach for filling the data gap. The general process for the investigation will consist of identifying and delineating potentially PFAS-impacted areas of Fort Devens using groundwater sampling, surface water sampling, and fish tissue sampling.

Sampling will be conducted in accordance with the following SOPs (see also **Worksheet #21**):

- **RI-SOP-01:** SERES-Arcadis TGI – *PFAS Field Sampling Guidance* (Rev #7, 18 April 2021)
- **RI-SOP-02:** SERES-Arcadis TGI – *PFAS Sampling Procedures and Low-Flow Groundwater Purging for Monitoring Wells*, (Rev. #0, 19 June 2018)
- **RI-SOP-03:** USEPA – *Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells*, (Rev #4, 19 September 2017)
- **RI-SOP-04:** SERES-Arcadis TGI – *Equipment and Reagent Blank Sample Collection for PFAS Analysis* (Rev #0, 2 October 2018)
- **RI-SOP-05:** SERES-Arcadis TGI - *Ground Penetrating Radar* (Rev #4, 1 May 2020)
- **RI-SOP-06:** SERES-Arcadis TGI - *Manual Water-Level and NAPL Monitoring* (JV; Rev #1, 8 May 2018)
- **RI-SOP-07:** SERES-Arcadis TGI - *In-Situ and Ex-Situ Water Quality Parameters* (Rev #0, 16 October 2018)
- **RI-SOP-08:** SERES-Arcadis TGI - *Sample Chain of Custody* (Rev #2, 29 April 2020)
- **RI-SOP-09:** SERES-Arcadis TGI - *Investigation-Derived Waste Handling and Storage* (Rev #1, 15 May 2020)
- **RI-SOP-10:** SERES-Arcadis TGI - *Groundwater and Soil Sampling Equipment Decontamination* (Rev #1, 8 May 2020)
- **RI-SOP-11:** SERES-Arcadis TGI - *Monitoring Well Development* (JV; Rev #0, 24 April 2017)

- **RI-SOP-12:** SERES-Arcadis TGI – *PFAS-Specific Drilling and Monitoring Well Installation* (Rev #0, 12 October 2018)

- **RI-SOP-13:** SERES-Arcadis TGI **-** *Soil Description* (Rev #2, 16 February 2018)

- **RI-SOP-14:** SERES-Arcadis TGI – *Sediment, Surface Water, and Stormwater Sample Collection for PFAS Analysis*, (Rev #2, 15 October 2020)

- **RI-SOP-15:** SERES-Arcadis TGI – *Vertical Aquifer Profiling (VAP)*, (Rev #1, 11 May 2020)

- **RI-SOP-16:** SERES-Arcadis TGI – *Fish Sampling Procedures* (Rev #0, 3 November 2020).

- **RI-SOP-17:** SERES-Arcadis TGI – *Field Processing for Fish Samples Procedures* (Rev #0, 3 November 2020).

The sampling methods described in the SOPs establish equipment requirements, procedures for handling equipment and containers before sampling, sampling procedures under various conditions, collecting equipment blank samples, field duplicate requirements, and storing samples to ensure that sample contamination does not occur during collection, transport, and analysis.

These SOPs meet, or are more stringent than, sampling recommendations provided by the USEPA in Technical Brief EPA/600/F-17/022h, updated January 2020, *Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) Methods and guidance for sampling and analyzing water and other environmental media*.

The SOPs provide procedural guidance in general accordance with industry standards/guidelines and regulatory requirements. General and PFAS-specific field guidance documents (i.e., SOPs) are provided in **Attachment C**.

17.2 Utility Survey

A utility survey will be performed in accordance with **RI-SOP-05** to identify buried and overhead infrastructure that may be encountered during ground-intrusive activities, and to prevent damage to infrastructure assets and physical harm to field personnel and on-site workers. The utility survey will include:

- Notification of Dig Safe System, Inc./811;
- Completion of the Utility Location checklist provided in the field forms (**Attachment D**); and
- Identification of a minimum of three reliable lines of evidence including:
    - Private utility location, such as ground-penetrating radar, electromagnetic geophysical techniques, and/or other appropriate methods of detection;
    - Soft dig methods (i.e., air-knife) for clearing locations during drilling;
    - Review of public records, utility maps, and existing as-built-drawings; and
    - Site inspection of overhead utility infrastructure or ground infrastructure that indicates a buried utility.

17.3 Groundwater Investigation

Review of historical groundwater data has determined that there is incomplete horizontal and vertical delineation of the groundwater flow and impacts from potential source areas. Existing groundwater data are also limited in terms of numbers of sampling events conducted. Due to the uncertainty of potential contaminant transport/migration, data from previous evaluations are being used for guidance purposes only. The existing monitoring well network is limited or has yet to be developed in some areas. Therefore, 12 additional vertical profiling (VP) locations and 35 new overburden monitoring wells (some of which will be installed as couplets) are proposed. In addition, samples will be collected from 54 existing monitoring wells sampled previously by others for PFAS. Overburden wells will be drilled and installed using sonic or drive-and-wash drilling methods (including continuous sampling at select locations) to targeted intervals or the top of bedrock (depending on the location). Bedrock well locations are proposed at 15 locations (some of which may be installed as couplets) in the Grove Pond Wellfield Area, the Patton Well Area, and at off-post locations to the east of Cold Spring Brook and the Patton Well Area, respectively. Bedrock wells will be drilled to target depths of approximately 100-200 feet into competent rock, as detailed in the Area 1 Phase II PFAS RI WP. The field tasks associated with the groundwater investigation are outlined in the table below.

Table 17.3: Groundwater Investigation Tasks

Groundwater Investigation Task	Supporting Documents
Utility Survey	**RI-SOP-05:** SERES-Arcadis TGI - *Ground Penetrating Radar* (Rev #4, 1 May 2020)
Monitoring Well Installation	**RI-SOP-12**: SERES-Arcadis TGI - *PFAS-Specific Drilling and Monitoring Well Installation*, Rev. 1, 26 March 2019)
Monitoring Well Development and Water-Level Monitoring	**RI-SOP-06**: SERES-Arcadis TGI - *Manual Water-Level and NAPL Monitoring* (JV; Rev #1, 8 May 2018) **RI-SOP-11**: SERES-Arcadis TGI - *Monitoring Well Development* (JV; Rev #0, 24 April 2017)
Groundwater Sampling	**RI-SOP-01**: SERES-Arcadis TGI - *PFAS Field Sampling Guidance* (Rev #7, 18 April 2021) **RI-SOP-02:** SERES-Arcadis TGI - *PFAS Sampling Procedures and Low-Flow Groundwater Purging for Monitoring Wells*, (Rev# 0, 19 June 2018) **RI-SOP-03:** USEPA SOP - *Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells* (Rev #4, 19 September 2017) **RI-SOP-04:** SERES-Arcadis TGI - *Equipment and Reagent Blank Sample Collection for PFAS Analysis* (Rev #0, 2 October 2018) **RI-SOP-07**: SERES-Arcadis TGI - *In-Situ and Ex-Situ Water Quality Parameters* (Rev #0, 16 October 2018) **RI-SOP-08**: SERES-Arcadis TGI - *Sample Chain of Custody* (Rev #2, 29 April 2020) **RI-SOP-09**: SERES-Arcadis TGI - *Investigation-Derived Waste Handling and Storage* (Rev #1, 15 May 2020) **RI-SOP-10**: SERES-Arcadis TGI - *Groundwater and Soil Sampling Equipment Decontamination* (Rev #1, 8 May 2020**)** **RI-SOP-15**: SERES-Arcadis TGI - *Vertical Aquifer Profiling* (Rev #1, 11 May 2020**)**

17.4 VP Investigation and Groundwater Monitoring Well Installation

A total of 12 VP borings will be installed within Area 1 and at off-post locations to the east of Cold Spring Brook and the Patton Well Area, with the objective of investigating horizontal and/or vertical data gaps. Most VP borings will be installed adjacent to previously investigated locations. It is anticipated that shallow VP locations will be installed using DPT. Due to the presence of flowing sands, refusal encountered in some historical VP locations, and deeper groundwater levels in some areas of Area 1, is it anticipated that deeper VP locations will need to be installed using sonic drilling methods. Packer isolation sampling methods will be used to collect groundwater samples. This method involves deploying a stainless-steel screen and packer assembly setup inside the outer override sonic casing; 4-inch-diameter screens will be used to allow for higher purge rates and greater sample depths.

A total of 35 new overburden monitoring wells and 15 new bedrock monitoring wells are proposed in Area 1 and at off-post locations to the east of Cold Spring Brook and the Patton Well Area (**RI WP Figures 4-8, 4-9a/b, and 4-10a/b**), several of which will be installed as shallow/deep overburden couplets. Overburden monitoring wells will be drilled using sonic or drive-and-wash drilling techniques. Overburden soil will be logged at select drilling locations by a SERES-Arcadis JV field geologist. Each well will be screened from the bottom of the boring using 10 feet of 2-inch-inner-diameter, machine-slotted polyvinyl chloride (PVC) 0.010-inch screen and constructed in accordance with the procedures presented in the QAPP. In locations where a shallow/deep overburden well pair is planned, two PVC wells will be installed in the same borehole and separated with a bentonite seal. Shallow bedrock well locations will be installed using sonic drilling techniques in the bedrock portion of the well down to the first water-bearing zone. It is assumed that bedrock monitoring wells will be completed with screens because the competency of the shallow bedrock is unknown based on available information. Each well location will be finished with an 8- or 12-inch flush-mount roadbox or steel standpipe. Stick-up monitoring wells will have bollards installed around them for protection.

The rationale for each groundwater sampling location in Area 1 is provided in **Exhibits 4-3 to 4-5** of the RI WP.

17.5 Groundwater Well Development and Water-Level Monitoring

Wells will be developed before sampling using the methodology outlined in **RI-SOP-11.** The water will be containerized per the waste management protocol identified in **Section 17.12**.

Monitoring well measuring point elevations will be recorded by a MA-licensed professional surveyor to the nearest 0.010-inch North American Vertical Datum of 1988 (NAVD 88). Water levels in all wells will be measured from the established measurement point before each groundwater sampling event using a combination electronic water level and oil-water interface probe. Water levels will then be converted to water table elevations referenced to the measuring point elevations surveyed by a MA-licensed surveyor. A new groundwater contour map will be developed using survey and water-level data.

The Monitoring Well Development SOP (**RI-SOP-11)** and Water-Level Monitoring SOP (**RI-SOP-06)** are included in **Attachment C**.

17.6 Groundwater Sampling

Groundwater samples will be collected during the installation of VP borings in a manner similar to that of previous VP samples collected by KGS. Groundwater samples will be collected in 10-foot intervals (starting at the water table) with a peristaltic or bladder pump setup with dedicated tubing. Samples will be collected after a minimum of three casing volumes have been purged from within the drilling rods.

Two sets of groundwater samples will be collected from each of the newly installed monitoring wells. The first event is anticipated to occur immediately after the well installation scope has been completed, and the second 3 to 6 months after to confirm PFAS concentrations. As detailed in **Table 4-1** of the RI Work Plan, groundwater samples will also be collected from a subset of existing monitoring wells.

Wells will be purged with a low-flow peristaltic pump, with purging to be conducted by low-stress (flow) protocols. Field parameters (temperature, pH, conductivity, dissolved oxygen [DO], turbidity, and oxidation-reduction potential [ORP]) will be measured during groundwater sampling to ensure that a stable sample is collected. Purging will be considered complete after water quality parameters specified under the low-flow protocols can be demonstrated to be stabilized; stabilization is not a requirement for VP sampling. Sampling conditions will be noted in the sampling logs. Groundwater samples will be collected using the same flow rate at which the well was purged.

The PFAS-Specific Groundwater Sampling SOP (**RI-SOP-02)** and USEPA Low-Flow Guidance SOP (**RI-SOP-03)** are included in **Attachment C**. Groundwater samples will be shipped to Eurofins Lancaster Laboratories for PFAS analysis.

17.7 Soil Sampling

Surficial and subsurface soil samples will be collected from 59 locations in Area 1 where data gaps exist and analyzed for PFAS to supplement the existing soil data and/or investigate areas with limited historical soil data.. The soil sampling proposed in this QAPP is discrete sampling for the purposes of site investigation. Additional samples will be collected from these locations for grain size and TOC analyses, in addition to a subset of proposed monitoring well locations throughout Area 1 where continuous soil logging is planned. The field tasks associated with the soil investigation are outlined in the table below.

Table 17.7: Soil Investigation Tasks

Soil Investigation Task	Supporting Document
Utility Survey	**RI-SOP-05:** SERES-Arcadis TGI - *Ground Penetrating Radar* (Rev #4, 1 May 2020)
Surface and Subsurface Soil Sampling	**RI-SOP-01:** SERES-Arcadis TGI – *PFAS Field Sampling Guidance* (Rev#7, 18 April 2021) **RI-SOP-04:** SERES-Arcadis TGI – *Equipment and Reagent Blank Sample Collection for PFAS Analysis* (Rev #0, 2 October 2018) **RI-SOP-08:** SERES-Arcadis TGI - *Sample Chain of Custody* (Rev#2, 29 April 2020) **RI-SOP-09:** SERES-Arcadis TGI - *Investigation-Derived Waste Handling and Storage* (Rev#1, 15 May 2020) **RI-SOP-10:** SERES-Arcadis TGI - *Groundwater and Soil Sampling Equipment Decontamination* (Rev#1, 8 May 2020) **RI-SOP-12:** SERES-Arcadis TGI – *PFAS-Specific Drilling and Monitoring Well Installation* (JV; Rev#0, 12 October 2018) **RI-SOP-13:** SERES-Arcadis TGI - *Soil Description* (Rev #2, 16 February 2018)

If concentrations of PFAS in soil samples exceed the screening levels, then additional delineation samples may be collected following the completion of an initial risk evaluation and potential consultation with USACE and stakeholders.

Surficial and subsurface soil samples will be collected from up to 59 different locations listed in **Exhibit 4-2** of the RI Work Plan, and shown on **RI WP Figures 4-2 to 4-7,** and analyzed for PFAS.

A JV field geologist will oversee the work and record soil lithology and recovery; soil will be screened with a photoionization detector (PID) every 1 foot at the continuous logging locations. Soil descriptions will be recorded in accordance with the JV TGI, which incorporates elements from various standard systems such as ASTM D2488-06, Unified Soil Classification System, Burmister, and Wentworth. The following will be recorded from each soil core at a minimum: depth interval, recovery, particle size (Udden-Wentworth), sorting, angularity/plasticity/dilatancy, principal and minor components, moisture, consistency/density, and color. When possible, the recovered soil cores will be photographed.

Soil samples from the 59 proposed soil boring locations will be collected from the following discrete depth intervals and homogenized for sample collection: 0 to 0.5 foot, 0.5 to 3 foot, 3 to 7 feet, and 7 to 15 feet If the water table is encountered at a depth shallower than the bottom depth of these intervals, the deepest sample will end at the water table depth.

Additional soil samples will be collected for TOC (via Lloyd Kahn method) and grain size analysis (via ASTM Method D422) from a subset of locations where continuous soil logging is planned. It is anticipated that sampling intervals will be selected based on the soil lithology observed with the objective of collecting samples from different lithological layers (if observed).

17.8 Surface Water and Sediment Sampling

Surface water and sediment samples will be collected from up to 46 locations in 11 waterbodies and analyzed for PFAS compounds to provide data concurrent with groundwater samples. The field tasks associated with the surface water and sediment investigation are outlined in the table below.

Table 17.7: Surface Water and Sediment Investigation Tasks

Surface Water Investigation Task	Supporting Document
Surface Water Sampling	**RI-SOP-14:** SERES-Arcadis TGI – *Sediment, Surface Water, and Stormwater Sample Collection for PFAS Analysis,* (Rev #2, 15 October 2020)
Measurement of Water Quality Parameters	**RI-SOP-07**: SERES-Arcadis TGI - In-Situ and Ex-Situ Water Quality Parameters (Rev #0, October 2018)
Sediment Sampling	**RI-SOP-14:** SERES-Arcadis TGI – Sediment, Surface Water, And Stormwater Sample Collection for PFAS Analysis (Rev #2, 15 October 2020)

The surface water sampling will consist of a single round of sampling from the locations that were previously sampled in 2018 and/or 2020 (**RI WP Figure 4-12**) and eight new proposed locations (CP-23-01, CP-23-02, CP-23-03, NR-23-01, ML-23-01, ML-23-02, ML-23-03, BB-23-01, and SWSW-21-01), specifically: one location from Balch Pond, one location from Bowers Brook, five locations from Cold Spring Brook Pond, 16 locations from Cold Spring Brook, five locations from Grove Pond, three locations from Mirror Lake, one location from the Nashua River, six locations from Plow Shop Pond, three locations from Robbins Pond, one location from the unnamed spring/discharge to the west of the Shabokin Water Supply Well, and three locations from the Unnamed Tributary to the west of Robbins Pond.

Surface water samples will be collected from immediately below the water surface using the procedures appropriate given site conditions and may include direct collection in the sample jar and/or use of a peristaltic pump. Due to chemical properties of PFAS, concentrations of PFAS in the surface water near a discharge location may be higher at or near the surface. Collecting samples near the surface is considered a worst-case scenario (ITRC 2022). Surface water samples are anticipated to be collected from locations accessible by foot, and a boat/vessel will not be required.

Sediment samples will be collected from the eight new proposed locations using a hand-held scoop, trowel, or push core (Lexan or stainless steel) for shallow water depths (e.g., < 2 feet). A Petite Ponar grab sampler may be used for sampling in deeper water offshore, and/or if coarse sediment is present. Sediment sampling locations will be either accessed by wading or by boat. Push cores and grab samplers will be advanced approximately 4 inches below the sediment surface, with only the top 2 inches of sediment being used for laboratory testing.

Surface water and sediment samples will be analyzed for PFAS by Eurofins Lancaster Laboratories. Samples will be shipped on ice and handled with chain-of-custody documentation. Surface water samples will be analyzed for the 40 PFAS compounds indicated in **Worksheet #15-2** per DoD QSM 5.4 Table B-24. Internal laboratory QA/QC will also consist of one laboratory blank and one laboratory control sample (or blank spike) per batch of samples, and one laboratory duplicate indicated by the laboratory QA/QC procedures. Water quality parameters will be collected from each sampling location including DO, ORP, specific conductance, temperature, turbidity, and pH.

17.9 Fish Sampling

Fish tissue samples will be collected from Grove Pond, Plow Shop Pond, Cold Spring Brook, Cold Spring Brook Pond, Mirror Lake, Robbins Pond, and Nashua River (**Work Plan Figure 4-12**) and analyzed for PFAS compounds. The field tasks associated with the fish investigation are outlined in the table below.

Table 17.9: Fish Investigation Tasks

Fish Investigation Task	Supporting Document
Fish Sampling	**RI-SOP-16:** SERES-Arcadis TGI – *Fish Sampling Procedures* (Rev #0, 3 November 2020)
Fish Sample Processing	**RI-SOP-17:** SERES-Arcadis TGI – *Field Processing for Fish Samples Procedures* (Rev#0, 3 November 2020)

The sampling will target species and sizes of fish that are relatively common in the surface water bodies and may be consumed by human receptors. Sampling will focus on one composite sample from each of two species in Grove Pond (sample location GPFT-23), Plow Shop Pond (sample location PSFT-21-01), Cold Spring Brook (sample location CSBFT-231-01), Cold Spring Brook Pond (sample location CSBPFT-23), Mirror Lake (sample location MLFT-23-01), Robbins Pond (sample location RPFT-23-01), and Nashua River (sample locations NRFT-23-01, NRFT-21-02, and NRFT-23-03) for a total of 18 fish tissue samples. The target species may include largemouth bass, bullhead, chain pickerel, or other species (based on availability). The fish will be analyzed as edible fillet portions. Each sample will be a composite of at least five individuals and will only include similar-size individuals of the same species.

Fish will be collected using the appropriate sampling method(s) for the individual waterbody, which may include electrofishing, seining, gillnetting, trap netting (fyke/hoop nets), or angling. Fish will be processed in the field in preparation for shipment to the analytical laboratory for PFAS analysis. Whole-body fish tissue samples will be wrapped in aluminum foil and then placed in zip-loc bags (not plastic bottles) prior to being shipped to the laboratory for processing. Fish tissue samples will be analyzed for PFAS by Eurofins Lancaster Laboratories. Samples will be shipped on ice and handled with chain-of-custody documentation. Fish tissue samples for edible-size fish will be prepared as skin-on, scales-off fillets (bass, chain pickerel) or skin-off fillets (bullhead). Tissue samples will be homogenized and analyzed for the PFAS compounds indicated in **Worksheet#15-6** per DoD QSM 5.4 Table B-24 (2022) or later. One matrix spike (MS)/matrix spike duplicate (MSD) sample will be collected for every 20 fish tissue samples collected. Internal laboratory QA/QC will also consist of one laboratory blank and one laboratory control sample (or blank spike) per batch of samples, and one laboratory duplicate indicated by the laboratory QA/QC procedures. Fish tissue results will be reported on a wet-weight basis.

17.10 Equipment Decontamination

Sampling equipment is decontaminated before sample collection to ensure that the sampling equipment that contacts a sample or monitoring equipment that is brought into contact with environmental media to be sampled is free from analytes of interest and/or constituents that could interfere with laboratory analysis for analytes of interest. Sampling equipment must be appropriately cleaned before using for sampling or contacting environmental media to be sampled and following completion of the sampling event before shipment or storage. The effectiveness of the decontamination procedure will be verified by collecting and analyzing equipment blank samples.

The drilling contractor will provide a decontamination pad. Sampling equipment that may require decontamination include groundwater sampling tools, drilling equipment, water-quality meters, oil-water meters, and other activity-specific sampling equipment.

All non-disposable sampling equipment and downhole equipment that comes in contact with environmental media will be decontaminated before use and in between wells and/or sample locations in accordance with the Groundwater and Soil Sampling Equipment Decontamination TGI (**RI-SOP-10)** included in **Attachment C**.

17.11 Waste Management

Waste will be managed in accordance with state and federal regulations to ensure completeness, accuracy, and consistency of waste documentation and to protect employees and contractors from environmental and regulatory risk.

Investigative-derived waste (IDW), including drill cuttings, monitoring well development water, monitoring well purge water, and decontamination rinsate, will be managed in accordance with the Investigation-Derived Waste Handling and Storage TGI (**RI-SOP-09**) included in **Attachment C** and PFAS-specific IDW management guidelines provided by the USACE. Drill cuttings generated during the installation of monitoring wells will be returned to the ground adjacent to the site of generation or moved to nearby wooded areas located within the boundaries of Fort Devens. Groundwater generated (including drilling water, rinsate water, and well development water) will be discharged to the ground surface at the site of generation. Where drilling will take place along public rights-of-way or on private property east of Cold Spring Brook, drill cuttings and purge water will be containerized and transported to a central staging area for subsequent characterization.

If containerization of IDW is necessary in some areas, all drill cuttings, development/purge water, and decontamination fluids will be collected and stored in 55-gallon drums, 275-gallon totes, or 330-gallon totes, as appropriate, and will be properly labeled and stored in the manner and the not-to-exceed time requirements of the Resource Conservation and Recovery Act (RCRA) and applicable laws until sampled, tested, and treated/disposed. Decontamination waste generated on PFAS-impacted sites will not be commingled with any other waste.

All waste generated will be inventoried in the field at the point of generation. All waste containers must be U.S. Department of Transportation (DOT) approved, compatible with the waste stream, and appropriately labeled. Drums must be staged on a pallet and covered with poly-sheeting to protect the drums from precipitation. Waste characterization analytical parameters will be collected per the disposal facility requirements. A profile will be submitted to the disposal facility for approval. A manifest will be generated for transportation of the drums. All loading and transportation will be performed in accordance with DOT regulations. After transport and disposal of IDW, the USACE PM will be provided with all original l manifests, destruction/disposal documents, and any analytical results within 30 days of disposal. Copies of the manifests, destruction/disposal documents, and any analytical results will be maintained at the office of the Devens USACE PM and included as an appendix to the RI.

17.12 Surveying

All investigation locations (and relevant site features if needed) will be surveyed by a MA-licensed surveyor to the nearest vertical 0.01 foot and horizontal 0.1 foot. The survey will be referenced to the Massachusetts State Plane Coordinate System North American Datum of 1983 (NAD 83) for the horizontal datum and NAVD88 for the vertical datum. The elevations of the ground surface, measuring point (i.e., top of PVC riser), and top of protective casing at each monitoring well will be surveyed. A metes-and-bounds survey for the parcel will also be conducted.

17.13 Final Report

After completion of the PFAS RI field investigation, a comprehensive PFAS RI Report will be prepared to present and evaluate the efficacy of the data for meeting the stated PFAS RI objectives, compliant with CERCLA requirements. A baseline risk assessment (BRA) will be conducted to evaluate the potential for adverse effects from exposure to constituents in soil, groundwater, surface water, sediment, and fish. The BRA will comprise a human health risk assessment (HHRA) and screening level ecological risk assessment (SLERA).

The HHRA will be conducted to characterize human health risks associated with DoD-related impacts to groundwater that could prevail, currently and in the future, in the absence of remedial action. The HHRA will follow USEPA Risk Assessment Guidance for Superfund (RAGS; 1989, 2001b) methodology, which is consistent with USACE guidance EM 200-1-4, Risk Assessment Handbook - Volume I: Human Health Evaluation (1999). Additional details on the PFAS RI Report are provided in Section 5.1 of the Area 1 Phase II PFAS RI WP.

The SLERA will be conducted to evaluate the likelihood of adverse ecological effects occurring as a result of exposure to PFAS associated with Fort Devens. The SLERA will follow relevant guidelines including guidance from USEPA (1997) Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments and USACE (2010) Environmental Quality – Risk Assessment Handbook, Volume II: Environmental Evaluation The SLERA will be performed using the PFAS ESVs for the media and receptors presented in the September 2021, Derivation of PFAS Ecological Screening Values Report prepared by Argonne National Laboratory on behalf of DoD (Argonne 2021), for use at DoD installations where PFAS have been detected in soils and surface waters. The soil screening values are protective of terrestrial plants, invertebrates, and mammalian and avian wildlife. The surface water values are protective of aquatic life and aquatic dependent wildlife.

QAPP Worksheet #18: Sampling Locations and Methods/Standard Operating Procedure Requirements

(UFP-QAPP Manual Section 3.1.1 and 3.1.2)
(USEPA 2106-G-05 Section 2.3.1 and 2.3.2)

Sampling Location	Matrix	Sample Depth /Screening Interval (feet below ground surface)	Sample ID [a]	Analytes	Maximum Number of Soil Samples	Maximum Number of Surface Water Samples	Maximum Number of Sediment Samples	Maximum Number of Groundwater Samples	Maximum Number of Fish Samples	Sample Type	Sampling SOP Reference	Rationale for Sampling Location
AOC 57	Groundwater	See Table 4-1 of the RI WP for construction details of existing MWs (20) to be sampled. See Exhibit 4-3 of the RI WP for construction details of proposed MWs (3) to be sampled. Sample count assumes two rounds of sampling.	See Exhibit 4-3 of the RI WP	PFAS				46		Discrete	See Worksheet 17-3	See Exhibit 3-2 and Exhibit 3-2 of the RI WP
	Soil	See Exhibit 4-2 of the RI WP for sample depths of the 5 proposed soil borings.	5702SB-23-01 to 5702SB-23-05	PFAS	20							See Exhibit 3-1 of the RI WP
AOC 74	Groundwater	TBD – VP samples to be collected from 1 location based on observed depth-to-water, location-specific depths to commence sampling, and depth-to-bedrock	See Exhibit 4-3 of the RI WP	PFAS				8		Discrete	See Worksheet 17-3	See Exhibit 3-2 and Exhibit 3-2 of the RI WP
	Groundwater	See Table 4-1 of the RI WP for construction details of existing MWs (1) to be sampled. See Exhibit 4-3 of the RI WP for construction details of proposed MWs (5) to be sampled. Sample count assumes two rounds of sampling.	See Exhibit 4-3 of the RI WP	PFAS				12		Discrete	See Worksheet 17-3	See Exhibit 3-2 and Exhibit 3-3 of the RI WP
AOC 75	Groundwater	See Table 4-1 of the RI WP for construction details of existing MWs (7) to be sampled. See Exhibit 4-3 of the RI WP for construction details of proposed MWs (2) to be sampled. Sample count assumes two rounds of sampling.	See Exhibit 4-3 of the RI WP	PFAS				18		Discrete	See Worksheet 17-3	See Exhibit 3-2 and Exhibit 3-2 of the RI WP
	Soil	See Exhibit 4-2 of the RI WP for sample depths of the 8 proposed soil borings.	75SB-23-01 to 75SB-23-08		32					Discrete		See Exhibit 3-1 of the RI WP
Grove Pond Wellfield Area	Groundwater	TBD – VP samples to be collected from 1 location based on observed depth-to-water, location-specific depths to commence sampling, and depth-to-bedrock	See Exhibit 4-3 of the RI WP	PFAS				8		Discrete	See Worksheet 17-3	See Exhibit 3-2 and Exhibit 3-2 of the RI WP
	Groundwater	See Table 4-1 of the RI WP for construction details of existing MWs (10) to be sampled. See Exhibit 4-3 of the RI WP for construction details of proposed MWs (8) to be sampled. Sample count assumes two rounds of sampling.	See Exhibit 4-3 of the RI WP	PFAS				36		Discrete	See Worksheet 17-3	See Exhibit 3-2 and Exhibit 3-2 of the RI WP
	Soil	See Exhibit 4-2 of the RI WP for sample depths of the 22 proposed soil borings.	GPSB-23-01 to GPSB-23-22	PFAS	88					Discrete		See Exhibit 3-1 of the RI WP
Grove Pond	Fish Tissue	Two composite samples of edible fillet portions.	GPFT-23-01 GPFT-23-02	PFAS					2	Discrete	See Worksheet 17-8	See Worksheet Section 17.9

Sampling Location	Matrix	Sample Depth /Screening Interval (feet below ground surface)	Sample ID [a]	Analytes	Maximum Number of Soil Samples	Maximum Number of Surface Water Samples	Maximum Number of Sediment Samples	Maximum Number of Groundwater Samples	Maximum Number of Fish Samples	Sample Type	Sampling SOP Reference	Rationale for Sampling Location
Off-Base (east of Cold Spring Brook)	Groundwater	TBD – VP samples to be collected from 6 locations based on observed depth-to-water, location-specific depths to commence sampling, and depth-to-bedrock	See Exhibit 4-4 of the RI WP	PFAS				48		Discrete	See Worksheet 17-3	See Exhibit 4-4 of the RI WP
	Groundwater	See Exhibit 4-4 of the RI WP for construction details of proposed (10) MWs to be sampled. Sample count assumes two rounds of sampling.	See Exhibit 4-4 of the RI WP	PFAS				20		Discrete	See Worksheet 17-3	See Exhibit 4-4 of the RI WP
Plow Shop Pond	Fish Tissue	Two composite samples of edible fillet portions.	PSFT-23-01 PSFT-23-02	PFAS					2	Discrete	See Worksheet 17-8	See Worksheet Section 17.9
Patton Well Area AOC 40	Groundwater	TBD – VP samples to be collected from 1 location based on observed depth-to-water, location-specific depths to commence sampling, and depth-to-bedrock	See Exhibit 4-3 of the RI WP	PFAS				8		Discrete	See Worksheet 17-3	See Exhibit 3-2 and Exhibit 3-2 of the RI WP
	Groundwater	See Exhibit 4-3 of the RI WP for construction details of proposed MWs (10) to be sampled. Sample count assumes two rounds of sampling.	See Exhibit 4-3 of the RI WP	PFAS				20		Discrete	See Worksheet 17-3	See Exhibit 3-2 and Exhibit 3-2 of the RI WP
	Soil	See Exhibit 4-2 of the RI WP for sample depths of the 4 proposed soil borings.	PWSB-23-01 to PWSB-23-04	PFAS [a]	16					Discrete		See Exhibit 3-1 of the RI WP
Cold Spring Brook	Fish Tissue	Two composite samples of edible fillet portions.	CSBFT-23-01 CSBFT-23-02	PFAS					2	Discrete	See Worksheet 17-8	See Worksheet Section 17.9
Shabokin Well Area/ AOC 43J	Groundwater	TBD – VP samples to be collected from 5 locations based on observed depth-to-water, location-specific depths to commence sampling, and depth-to-bedrock	See Exhibit 4-3 of the RI WP	PFAS				40		Discrete	See Worksheet 17-3	See Exhibit 3-2 and Exhibit 3-2 of the RI WP
	Groundwater	See Table 4-1 of the RI WP for construction details of existing MWs (2) to be sampled. See Exhibit 4-3 of the RI WP for construction details of proposed MWs (8) to be sampled. Sample count assumes two rounds of sampling.	See Exhibit 4-3 of the RI WP	PFAS				20		Discrete	See Worksheet 17-3	See Exhibit 3-2 and Exhibit 3-2 of the RI WP
	Soil	See Exhibit 4-2 of the RI WP for sample depths of the 9 proposed soil borings.	43JSB-23-01 to 43JSB-23-09	PFAS [a]	36					Discrete		See Exhibit 3-1 of the RI WP
AOC 43G	Groundwater	See Table 4-1 of the RI WP for construction details of existing MWs (14) to be sampled. See Exhibit 4-3 of the RI WP for construction details of proposed MWs (5) to be sampled. Sample count assumes two rounds of sampling.	See Exhibit 4-3 of the RI WP	PFAS				38		Discrete		See Exhibit 3-2 and Exhibit 3-2 of the RI WP
	Soil	See Exhibit 4-2 of the RI WP for sample depths of the 3 proposed soil borings.	43GSB-23-01 to 43GSB-23-03	PFAS [a]	12					Discrete		See Exhibit 3-1 of the RI WP
Building 3713 Area	Soil	See Exhibit 4-2 of the RI WP for sample depths of the 8 proposed soil borings.	GPSB-23-23 to GPSB-23-30	PFAS [a]	32					Discrete		See Exhibit 3-1 of the RI WP
Mirror Lake	Fish Tissue	Two composite samples of edible fillet portions.	MLFT-23-01 MLFT-23-02	PFAS					2	Discrete	See Worksheet 17-8	See Worksheet Section 17.9
Robbins Pond	Fish Tissue	Two composite samples of edible fillet portions.	RPFT-23-01 RPFT-23-02	PFAS					2	Discrete	See Worksheet 17-8	See Worksheet Section 17.9

Sampling Location	Matrix	Sample Depth /Screening Interval (feet below ground surface)	Sample ID [a]	Analytes	Maximum Number of Soil Samples	Maximum Number of Surface Water Samples	Maximum Number of Sediment Samples	Maximum Number of Groundwater Samples	Maximum Number of Fish Samples	Sample Type	Sampling SOP Reference	Rationale for Sampling Location
Cold Spring Brook Pond	Fish Tissue	Two composite samples of edible fillet portions.	CSBFT-23-01 CSBFT-23-02	PFAS					2	Discrete	See Worksheet 17-8	See Worksheet Section 17.9
Nashua River	Fish Tissue	Two composite samples of edible fillet portions.	NRFT-23-01-01 NRFT-23-01-02 NRFT-23-02-01 NRFT-23-02-02 NRFT-23-03-01 NRFT-21-03-02	PFAS					6	Discrete	See Worksheet 17-8	See Worksheet Section 17.9
Various Previously Sampled Locations	Surface Water	Surface water samples will be collected from locations that were previously sampled in 2018 and/or 2020. Surface water samples will be collected from immediately below the water surface. One round of sampling assumed.	See Exhibit 4-9 and Figure 4-12 in the RI WP	PFAS		38				Discrete	See Worksheet 17-3	Previous sample locations
Various	Surface Water	Surface water samples will be collected from eight locations not previously sampled for PFAS. Surface water samples will be collected from immediately below the water surface. Two rounds of sampling assumed to account for seasonality.	See Exhibit 4-9 and Figure 4-12 in the RI WP	PFAS		16				Discrete		See Worksheet Section 17.8
Various	Sediment	Sediment samples will be collected from eight new surface water locations not previously sampled for PFAS. Two rounds of sampling assumed to account for seasonality.	See Exhibit 4-9 and Figure 4-12 in the RI WP	PFAS			16			Discrete		See Worksheet Section 17.8
Notes: a. A subset of soil samples will be analyzed for total organic carbon and grain size. SOP – standard operating procedure TBD – to be determined				**TOTAL:**	**236**	**54**	**16**	**322**	**18**			

QAPP Worksheet #19 & 30: Sample Containers, Preservation, and Hold Times

(UFP-QAPP Manual Section 3.1.2.2)
(USEPA 2106-G-05 Section 2.3.2)

Analytical SOP requirements for the analyses applicable to this PFAS QAPP Addendum are provided in the following table.

Laboratory (Name, sample receipt address, Point of Contact, email, and phone numbers):

Eurofins Lancaster Laboratories
2425 New Holland Pike,
Lancaster, Pennsylvania. 17601
Contact: Kerri Sachtleben
Phone: (717) 556-7376
Email: kerri.sachtleben@et.eurofinsus.com

DoD Environmental Laboratory Accreditation Program (ELAP) for Eurofins Lancaster Laboratories (Expiration Date: November 22, 2022) is included in **Attachment E**. A current ELAP certification will be provided prior to start of the field investigations.

- Level IV data packages to be delivered within 21 calendar days
- Sample Delivery Method: Federal Express

Parameter	Analytical and Preparation Method/ SOP Reference	Container(s) (Quantity, size, & type per sample)	Preservation	Preparation Holding Time	Analytical Holding Time
Groundwater / Surface Water					
PFAS	PFAS in accordance with EPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24 ELLE SOP WI46412	2 x 500 mL HDPE Bottles	Cool, 0 to 6 degrees Celsius (°C) Must be received within 48 hours of collection	28 days from collection to prep; 90 days from collection, when stored at ≤ -20ºC and protected from the light	28 days after extraction

Parameter	Analytical and Preparation Method/ SOP Reference	Container(s) (Quantity, size, & type per sample)	Preservation	Preparation Holding Time	Analytical Holding Time
Fish Tissue					
PFAS	PFAS in Accordance with EPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24/ / ELLE SOP WI49212	whole-body fish tissue samples will be wrapped in aluminum foil and then placed in ziploc bags	Cool, 0 to 6°C or stored in the dark at ≤ -20ºC	90 days from collection to prep	28 days after extraction
Sediment					
PFAS	PFAS in accordance with EPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24/ ELLE SOP WI48593	1 - 500 mL HDPE container	Cool, 0 to 6°C or stored in the dark at ≤ -20ºC	90 days from collection to prep	28 days after extraction
Soil					
PFAS	PFAS in accordance with EPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24/ ELLE SOP WI48593	1 - 500 mL HDPE container	Cool, 0 to 6°C or stored in the dark at ≤ -20ºC	90 days from collection to prep	28 days after extraction
TOC	TOC in Accordance with ASTM D422; ELLE SOP WI11514	1 x 4-ounce glass jar	Cool, ≤ 6° C	NA	28 days
Grain Size	Grain size in Accordance with ASTM D422; ELLE SOP WI11514	16-ounce glass jar, this must be a dedicated bottle for grain size only	Cool, 6º C	NA	NA

Notes: °C = degree Celsius L = liter ml = milliliter oz = ounce HDPE = high-density polyethylene

QAPP Worksheet #20: Field QC Sample Quantities and Control Frequencies

(UFP-QAPP Section 3.1.1 and 3.1.2)
(USEPA 2106-G-05 Section 2.3.5)

Matrix/ Analysis	Estimated Parent Sample Quantity[a]	Field QC Sample						Laboratory QC Sample				Total
		Field Duplicate		Field Blank		Equipment Blank		Matrix Spike		Matrix Spike Duplicate		
		Freq	Number	Freq	Number	Freq	Number	Freq [b]	Number	Freq [b]	Number	
Groundwater												
PFAS	322	1/10	33	1/cooler	38	1/day	45	1/20	17	1/20	17	472
Soil												
PFAS	236	1/10	21	1/cooler	8	1/day	15	NA	NA	NA	NA	280
TOC and Grain Size	59	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	59
Surface Water												
PFAS	54	1/10	6	NA*	NA*	NA*	NA*	1/20	3	1/20	3	66
Sediment												
PFAS	16	1/10	2	NA*	NA*	NA*	NA*	1/20	1	1/20	1	20
Fish Tissue												
PFAS	18	NA	NA	NA	NA	NA	NA	1/20	1	1/20	1	20

Notes:

a. Sample quantities are approximate.
b. Frequency for MS/MSD samples is 1 per 20 field samples, not including field blanks and field duplicates.
QC = quality control
NA = not applicable
*Field blanks and equipment blanks will be submitted concurrent with groundwater samples.

QAPP Worksheet #21: Field Standard Operating Procedure References

(UFP-QAPP Manual Section 3.1.2)
(USEPA 2106-G-05 Section 2.3.2)

Field SOPs are included in **Attachment C** of this QAPP Addendum.

SOP# or Reference	Title, Revision, Date, and URL (if available)	Originating Organization	SOP Option of Equipment Type (if SOP provides different options)	Modified for Field Work? (Yes/No)
RI-SOP-01	PFAS Field Sampling Guidance (Rev #7, 18 April 2021)	SERES-Arcadis JV	NA	No
RI-SOP-02	PFAS Sampling Procedures and Low-Flow Groundwater Purging for Monitoring Wells (Rev #0, 19 June 2018)	SERES-Arcadis JV	Sampling Supplies	No
RI-SOP-03	Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells (Rev #4, 19 September 2017)	USEPA	Sampling Supplies and Equipment	No
RI-SOP-04	Equipment and Reagent Blank Sample Collection for PFAS Analysis (Rev #0, 2 October 2018)	SERES-Arcadis JV	NA	No
RI-SOP-05	Utility Location (Rev #4, 1 May 2020)	SERES-Arcadis JV	NA	No
RI-SOP-06	Manual Water-Level and NAPL Monitoring (Rev #1, 8 May 2020)	SERES-Arcadis JV	NA	No
RI-SOP-07	In-Situ and Ex-Situ Water Quality Parameters (Rev #0, 16 October 2018)	SERES-Arcadis JV	NA	No
RI-SOP-08	Sample Chain of Custody (Rev #2, 29 April 2020)	SERES-Arcadis JV	NA	No
RI-SOP-09	Investigation-Derived Waste Handling and Storage (Rev #1, 15 May 2020)	SERES-Arcadis JV	NA	No
RI-SOP-10	Groundwater and Soil Sampling Equipment Decontamination (Rev #1, 8 May 2020)	SERES-Arcadis JV	NA	No
RI-SOP-11	Monitoring Well Development (Rev #0, 24 April 2017)	SERES-Arcadis JV	NA	No
RI-SOP-12	PFAS-Specific Drilling and Monitoring Well Installation (JV; Rev #0, 12 October 2018)	SERES-Arcadis JV	NA	No

SOP# or Reference	Title, Revision, Date, and URL (if available)	Originating Organization	SOP Option of Equipment Type (if SOP provides different options)	Modified for Field Work? (Yes/No)
RI-SOP-13	Soil Description (Rev #2, 16 February 2018)	SERES-Arcadis JV	NA	No
RI-SOP-14	Sediment, Surface Water, And Stormwater Sample Collection for PFAS Analysis (Rev #2, 15 October 2020)	SERES-Arcadis JV	NA	No
RI-SOP-15	Vertical Aquifer Profiling (JV; Rev #1, 11 May 2020)	SERES-Arcadis	NA	No
RI-SOP-16	Field Processing for Fish Samples Procedures (Rev #0, 3 November 2020) Fish Sampling Procedures (Rev #0, 3 November 2020)	SERES-Arcadis JV	NA	No
RI-SOP-17	Field Processing for Fish Samples Procedures (Rev #0, 3 November 2020)	SERES-Arcadis JV	NA	No

QAPP Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection

(UFP-QAPP Manual Section 3.1.2.4)
(USEPA 2106-G-05 Section 2.3.6)

Field equipment will be maintained, inspected, and tested as presented in the table below.

Requirement	Limited Applicability (Specific to Collection Method/Use)	Performance Standard	Frequency	Consequence of Failure
Global positioning system (GPS)	VP locations	Calibration within the manufacturer's specified range	Daily when instrument is being used	Redo until calibration results are with range.
Electric water level indicator	Groundwater samples	Calibration within the manufacturer's specified range	Daily when instrument is being used	Redo until calibration results are with range.
Turbidity meter	Groundwater samples	• Calibration within the manufacturer's specified range. • Acceptance Criteria: (± 5% of standard)	Daily when instrument is being used	Redo until calibration results are with range.
Multiparameter water quality meter	Groundwater samples	• Calibration within the manufacturer's specified range • Acceptance Criteria: o Dissolved Oxygen ▪ ± 0.5 milligrams per liter (mg/L) of sat. value ▪ < 0.5 mg/L for the 0 mg/L solution, but not a negative value o Specific Conductance (±5% of standard or ± 10 microSiemens per centimeter [µS/cm; whichever is greater]) o pH (± 0.3 pH unit with pH 7 buffer) o Oxidation Reduction Potential (± 10 mV) • Drift Check	• Daily when instrument is being used • End of the day	Redo until calibration results are with range.

Requirement	Limited Applicability (Specific to Collection Method/Use)	Performance Standard	Frequency	Consequence of Failure
Electric submersible pump	Groundwater samples	Working as designed	Daily when instrument is being used	Redo until calibration results are within range and if needed, replace pump
Bladder Pump	Groundwater samples	Working as designed	Daily when instrument is being used	Redo until calibration results are within range and if needed, replace pump.
Peristaltic Pump	Groundwater samples	Working as designed	Daily when instrument is being used	Redo until calibration results are within range and if needed, replace pump.
Photoionization Detector and/or other air monitoring equipment	Drilling, well installation, groundwater sampling	• Calibration using isobutylene within the manufacturer's specified range using a 10.6 eV lamp. • Acceptance Criteria: (zero fresh air recheck following calibration [100 to 2,000 parts per million]) • Drift Check	• Daily when instrument is being used • End of the day	Redo until calibration results are with range.

QAPP Worksheet #23: Analytical Standard Operating Procedure References

(UFP-QAPP Manual Section 3.2.1)
(USEPA 2106-G-05 Section 2.3.4)

All laboratory analytical SOPs pertinent to environmental investigations are included for reference in **Attachment E.** Lab SOPs included in **Attachment E** will be updated, as needed, for the final lab chosen for PFAS analyses.

SOP #	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix/ Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Yes/No)
WI46412	Analysis of Per and Polyfluoroalkyl Substances (PFAS) in Aqueous Samples by LC-MS/MS Using Draft Method 1633/QSM5.4 Table B24, Rev 2, Date: 8/31/2022	Definitive	Aqueous PFAS	LC/MS/MS	Eurofins Lancaster	No
WI48593	Analysis of Per and Polyfluoroalkyl Substances (PFAS) in Solid Samples by LC-MS/MS Using Draft Method 1633/QSM5.4 Table B24, Rev 2, Date: 10/2022	Definitive	Solid PFAS	LC/MS/MS	Eurofins Lancaster	No
WI49212	Analysis of Per and Polyfluoroalkyl Substances (PFAS) in Tissue Samples by LC-MS/MS Using Draft Method 1633/QSM5.4 Table B24, Rev 1, 10/27/2022	Definitive	Fish Tissue PFAS	LC/MS/MS	Eurofins Lancaster	No
WI23588	Preventative and Corrective Maintenance for the API 4000 and AB Sciex 4500 Liquid Chromatograph Mass Spectrometers (LC/MS/MS), Rev 2, effective 02/26/2021	N/A	N/A	LC/MS/MS	Eurofins Lancaster	No
WI7154	Food and Tissue Preparation, version 11.1, effective 10/15/2020	N/A	Fish Tissue	N/A	Eurofins Lancaster	No
WI11627	TOC and TC in Solids and Sludges by Combustion by SW-846 9060/9060A, Lloyd-Kahn, effective 11/4/22	Definitive	Solids	TOC Analyzer	Eurofins Lancaster	No
WI146354	Particle Size Distribution of Soils and Solids/Grain Size Classification by ASTM D422-63, effective 11/25/21	Definitive	Solids	Sieves, Hydrometer, Drying Oven, Analytical Balance	Eurofins Lancaster	No

Notes:

LC/MS/MS = liquid chromatography with tandem mass spectrometry
N/A = not applicable

QAPP Worksheet #24: Analytical Instrument Calibration

(UFP-QAPP Manual Section 3.2.2)
(USEPA 2106-G-05 Section 2.3.6)

WORKSHEET #24 Analytical Instrument Calibration

Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
Instrument: LC/MS/MS for PFAS					
Mass Calibration Verification	Daily, prior to sample analysis and after performing major maintenance, as required to maintain documented instrument sensitivity and stability performance.	The mass spectrometer must undergo mass calibration to ensure accurate assignments of m/z's by the instrument. Mass calibration must be performed using the calibration compounds and	Daily, prior to sample analysis and after performing major maintenance, as required to maintain documented instrument sensitivity and stability performance.	Lab Manager / Analyst	WI48593 WI46412WI49212
Instrument performance check (tune).	When the masses fall outside of the ±0.5 atomic mass unit of the true value.	Mass assignments of the tuning standard within 0.5 atomic mass unit of true value.	Retune instrument and verify	Lab Manager / Analyst	WI48593 WI46412 WI49212
Mass Spectral Acquisition Rate	Each analyte, Extracted Internal Standard Analyte.	A minimum of 10 spectra scans are acquired across each chromatographic peak.	NA	Lab Manager / Analyst	WI48593 WI46412 WI49212
Ion Transitions (Parent→Product)	Prior to initial calibration. See more details in DoD QSM 5.4 or later version, Table B-24.	In order to avoid biasing results high due to known interferences for some transitions, the transitions listed in Table 2 of USEPA 2nd Draft Method 1633 must be used for the quantification.	NA	Lab Manager / Analyst	WI48593 WI46412 WI49212

Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
Sample PFAS Identification	All analytes detected in a sample	The chemical derivation of the ion transitions must be documented. A minimum of two ion transitions (Precursor → quant ion and precursor → confirmation ion) and the ion transitions ratio per analyte are required for confirmation. Exception is made for analytes where two transitions do not exist. Documentation of the primary and confirmation transitions and the ion ratio is required. In-house acceptance criteria for evaluation of ion ratios must be used and must not exceed 50-150%. Signal to Noise Ratio must be ≥ 3 for all ions used for quantification and for confirmation. Quant ion and confirmation ion must be present and must maximize simultaneously (±2 seconds).	PFAS identified with Ion ratios that fail acceptance criteria must be flagged. Any quantitation ion peak that does not meet the maximization criteria shall be included in the summed integration and the resulting data flagged as "estimated, biased high".	Lab Manager / Analyst	WI48593 WI46412 WI49212
ICAL Standards containing both branched and linear isomers must be used when commercially available. Isotope Dilution or Internal Standard Calibration is required. Minimum five-point initial calibration for linear, or six-point calibration for quadratic.	ICAL at instrument set-up and after ICV or CCV failure, prior to sample analysis	One of the following two approaches must be used to evaluate the linearity of the instrument calibration. Weighting (typically 1/x or 1/x2) is allowed for linear and non-linear regressions. Signal to Noise Ratio: ≥ 3:1 for all ions used for quantification. Linearity Option 1 Average RF: Relative Standard Deviation (RSD) of the RFs for each analyte ≤ 20%. Option 2: Calculate relative standard error (RSE). RSE for all analytes must be ≤ 20%. Commercial PFAS standards available as salts are acceptable providing the measured mass is corrected to the neutral acid concentration. Results shall be reported as the neutral acid with appropriate CAS number.	Verify standard solutions still valid, perform instrument maintenance as needed, then repeat the ICAL	Lab Manager / Analyst	WI48593 WI46412 WI49212

Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
Retention Time Window Width	Every field sample, standard, blank, and QC sample.	RT should not vary from ICAL more than 0.4 minute for isotopically labeled compounds, 0.1 minute from their analog for native compounds with an exactly isotopically-labeled compound, or 0.4 minute from assigned analog for a native compound without an exact isotopically labeled compound.	Correct problem and reanalyze samples.	Lab Manager / Analyst	WI48593 WI46412 WI49212
Extracted Internal Standards (EIS)	Every field sample, standard, blank, and QC sample.	Preliminary in-house acceptance criteria of 20-150% must be used until in-house limits are generated in accordance with USEPA method 1633. Lower in-house limit cannot be <20%	Repeat ICAL if outside limits for the calibration standards.	Lab Manager / Analyst	WI48593 WI46412 WI49212
Non-extracted Internal Standards (NIS)	Every field sample, standard, blank, and QC sample.	EIS and NIS are used to establish the initial calibration of the analytical instrument. The concentration of the method analytes in the solutions varies to encompass the working range of the instrument, while the concentrations of the EIS and NIS remain constant. The RF for the EIS are quantified by NIS.	N/A	Lab Manager / Analyst	WI48593 WI46412 WI49212
ISC can serve as initial daily CCV	Prior to analysis and at least once every 12 hours	Analyte concentrations must be at LOQ; concentrations must be within ±30% of true value, and ±50% of true value for isotopically labeled compounds.	Correct problem, rerun ISC. If problem persists, repeat ICAL.	Lab Manager / Analyst	WI48593 WI46412 WI49212
ICV	Once after each ICAL; analysis of second source standard prior to sample analysis.	Analyte concentrations must be within ±30% of true value.	Correct problem, rerun ICV. If problem persists, repeat ICAL.	Lab Manager / Analyst	WI48593 WI46412 WI49212
CCV	Prior to sample analysis, after every 10 field samples, and at end of analytical sequence.	Analyze a mid-level calibration standard. Analyte concentrations must be within ±30% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. Otherwise, perform corrective action, repeat CCV (or ICAL) and reanalyze all associated samples since last successful CCV.	Lab Manager / Analyst	WI48593 WI46412 WI49212

Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
Instrument Blanks	Immediately following highest standard analyzed and daily prior to sample analysis.	Concentration of each analyte must be ≤ ½ the LOQ Instrument Blank must contain EIS and NIS to enable quantitation of contamination.	If acceptance criteria are not met after the highest calibration standard, calibration must be performed using a lower high standard until criteria is met. If sample concentrations exceed the highest allowed standard and the sample(s) following exceed this acceptance criteria (>1/2 LOQ), they must be reanalyzed	Lab Manager / Analyst	WI48593 WI46412 WI49212
LOD/LOQ Verification	Quarterly	LOD: Compound must be detected. LOQ: %R must be within ±50%	Reprep and reanalyzed LOD and LOQ, or revise LOD/LOQ	Lab Manager / Analyst	WI48593 WI46412 WI49212

QAPP Worksheet #25: Analytical Instrument and Equipment Maintenance, Testing, and Inspection

(UFP-QAPP Manual Section 3.2.3)
(USEPA 2106-G-05 Section 2.3.6)

The laboratory analytical instrumentation and equipment will be maintained, tested, and inspected following the procedures and frequency specified by the DoD Environmental Laboratory Accreditation Program-evaluated laboratory Quality Manual, analytical methods used, and in accordance with Section 5.5, Module 2, “Calibration Requirements,” of the *DoD QSM 5.4* (DoD 2021).

Instrument and equipment maintenance logs must be kept documenting analytical instrumentation and equipment maintenance, testing, and inspection activities. Instrument maintenance procedures documented in laboratory QA Manual and SOPs will be followed.

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[1]
LC/MS/MS	Replace columns as needed, check eluent reservoirs	PFAS Sensitivity check	Instrument performance and sensitivity	Daily or as needed	CCV pass criteria	Recalibrate	Lab Manager / Analyst	WI48593 WI46412 WI49212
	Backflush of column, injection port and pre-columns, cleaning of ion spray cone, adjustment of collision energies, others as needed	Calibration Check	Visual	As needed	Initial calibration or calibration verification passes method specifications	Perform additional maintenance before instrument calibration or calibration verification		

Notes:

[1] SOP reference numbers correspond to analytical SOPs in QAPP **Worksheet #23**.
LC/MS/MS = liquid chromatography with tandem mass spectrometry
SOP = Standard Operating Procedure

QAPP Worksheet #26 & 27: Sample Handling, Custody, and Disposal

(UFP-QAPP Manual Section 3.3)
(USEPA 2106-G-05 Section 2.3.3)

Sampling organization: SERES-ARCADIS JV
Laboratory: Eurofins Lancaster Laboratories
Method of sample delivery (shipper/carrier): Federal Express
Number of days from reporting until sample disposal: At least 60 days

Activity	Organization and title or position of person responsible for the activity	SOP reference
Sample labeling	SERES-Arcadis JV	See "Sample Identification System" below.
Chain-of-custody form completion	SERES-Arcadis JV	See RI-SOP-09. Also see "Sample Handling and Custody" below.
Packaging	SERES-Arcadis JV	See "Field Procedures" below.
Shipping coordination	SERES-Arcadis JV	See "Transfer of Custody and Shipment" below.
Sample receipt, inspection, and log-in	Eurofins Lancaster Laboratories	See "Laboratory Custody Procedures" below.
Sample custody and storage	Eurofins Lancaster Laboratories	See "Laboratory Custody Procedures" and "Final Evidence Files" below.
Sample disposal	Eurofins Lancaster Laboratories	See "Sample Holding Times" below and QAPP **Worksheet #19/30**.

Sample Identification System

A sample identification system will be established in accordance with naming conventions used previously by the USACE and previous investigations. A sample numbering system will be used to identify each sample; the sample numbers will be sequentially assigned to ensure that there is no duplicate of sample numbers. This system will provide a tracking procedure to allow retrieval of information about a particular sample and will ensure that each sample is uniquely numbered. The sample identification will consist of the components described below:

Location ID - The Location ID consists of the following elements:

Property - Location/QC Type - Year - Location Sequence - Depth Interval

Property (two to four alpha and/or numeric characters used to represent the specific Former Fort Devens property):

- 74 = AOC 74
- 75 = AOC 75
- 5702 = AOC 57 Area 2
- 5703 = AOC 57 Area 3
- 43G = AOC 43G
- 43J = AOC 43J

- BB = Bowers Brook
- BP = Balch Pond
- BR = Blanchard Road
- CP = Cold Spring Brook Pond
- CS/CSB = Cold Spring Brook
- GP = Grove Pond
- ML = Mirror Lake
- NR = Nashua River
- PS/PSC = Plow Shop Pond
- PW = Patton Well Area
- RP = Robbins Pond
- SW = Shabokin Well Area
- UT = Unnamed Tributary

Location Code for non-QC samples (two uppercase alpha characters designating the type of location) Location codes are not used for QC samples.

- VP = VP location.
- MW= monitoring well location
- SB = soil boring
- PZ = piezometer
- SG = stream gauge
- SW = surface water
- SD = sediment
- FT = fish tissue

QC Codes for QC samples only:

- DUP = field duplicate
- MS = matrix spike
- MSD = matrix spike duplicate.

Year: A two-digit number corresponding to the year of installation/sample collection (e.g., “23” = installed/collected in 2023).

Location Sequence: A sequential number corresponding with proposed location (e.g., 1 through 100).

Depth Interval: The depth interval in overburden monitoring wells from which the sample was collected will be represented by an alpha character where multiple sampling intervals/wells exist. The field notes will indicate the actual depth interval to which each alpha character corresponds.

- No letter = single depth interval
- A = top depth interval
- B = second depth interval

Well Type (as needed to distinguish overburden from bedrock)

Where both overburden and bedrock wells have been installed, the following alpha characters will be used to distinguish the screen placement relative to the geology of the location. Monitoring wells that do not have a depth interval (see above) or BR designation are automatically considered overburden wells.

- No letter, A, B, etc. (see above) = Overburden
- BR = bedrock.

Sample Handling and Custody

Sample custody procedures ensure the timely, correct, and complete analysis of each sample for all parameters requested. A sample is considered to be in someone’s custody if it:

- Is in his/her possession
- Is in his/her view, after being in his/her possession
- Is in his/her possession and has been placed in a secure location
- Is in a designated secure area

Sample custody documentation provides a written record of sample collection and analysis. The sample custody procedures provide for specific identification of samples associated with an exact location, the recording of pertinent information associated with the sample (including time of sample collection and any preservation techniques), and a chain-of-custody record that serves as physical evidence of sample custody.

The chain-of-custody documentation system provides the means to individually identify, track, and monitor each sample from the time of collection through final data reporting. Chain-of-custody procedures document pertinent sampling data and all transfers of custody until the samples reach the analytical laboratory. All chain-of-custody forms must be filled out and signed in ink. The following information is typically recorded on manual chain-of-custody forms:

- Project name and/or project number
- Signature of SERES-Arcadis JV field sampler collecting the samples
- Date and time of sample collection
- Discrete or incremental sampling sample designation
- Sample matrix
- Analyses required
- Preservation technique
- Signatures and dates for transfer of custody
- Air express/shipper’s bill of lading identification number.

The chain-of-custody form serves as an official communication to the laboratory detailing the specific analyses required for each sample. The chain-of-custody record will accompany the samples from the time of sampling through all transfers of custody. It will be kept on file at the laboratory, where samples are analyzed and archived. Three copies of the chain-of-custody form are created: one copy is retained by the SERES-Arcadis JV field sampler on site, one copy is forwarded electronically to the SERES-Arcadis JV PM, and one copy is sent to the laboratory with the samples. The on-site SERES-Arcadis JV staff completes a chain-of-custody record to accompany each shipment from the field to the laboratory. The completed chain-of-custody is placed in a zip-lock bag and taped to the inside cover of the sample shipping container. If there is more than one container in a shipment, copies of the chain-of-custody form will be placed in each container. The container is then sealed with custody seals, and custody is transferred to the laboratory. Commercial carriers are not required to sign off on the chain-of-custody form as long as the forms are sealed inside the sample cooler and the custody seals remain intact.

Samples will be packaged for shipment as outlined below:

- Securely affix the sample label to the outside of container with clear packing tape.
- Check the cap on the sample container to confirm that it is properly sealed.
- Wrap the sample container cap with clear packing tape or place the sample container in a plastic bag to prevent the label from becoming loose or separated from the sample container.
- Complete the chain-of-custody form with the required sampling information and confirm that the recorded information matches the sample labels. Note: If the designated sampler relinquishes the samples to other sampling or field personnel for packing or other purposes, the sampler will complete the chain-of-custody before this transfer. The appropriate personnel will sign and date the chain-of-custody form to document the sample custody transfer.
- Using duct tape, secure the outside drain plug at the bottom of the cooler.
- Wrap sample containers in bubble wrap or other cushioning material.
- Place 1 to 2 inches of cushioning material at the bottom of the cooler.
- Place the sealed sample containers into the cooler.
- Place ice in plastic bags and seal. Place loosely in the cooler beneath, around, and/or on top of the sample containers.
- Fill the remaining space in the cooler with cushioning material.
- Place chain-of-custody forms in a plastic bag and seal. Tape the plastic bag with the forms to the inside of the cooler lid.
- Close the lid of the cooler, lock if applicable, and secure with duct tape.
- Wrap packing or strapping tape around both ends of the cooler at least twice.
- Mark the cooler on the outside with the shipping address and return address, affix “Fragile” labels and draw (or affix) arrows indicating “This Side Up.” Cover the labels with clear plastic tape to prevent them from becoming loose or separated from the cooler.
- Place a signed custody seal (or two) over the sample cooler lid so tampering would be evident if the cooler is opened prematurely.

Field Procedures

The SERES-Arcadis JV field sampler is personally responsible for the care and custody of samples until they are properly dispatched. As few people as possible should handle the samples.

The SERES-Arcadis JV field sampler is responsible for entering the proper information in the field logbook including all pertinent information such as sample identification number, date and time of sample collection, type of analysis, description of sample location, and relevant observations. The information entered into the field logbook will be used to generate a chain of custody. Field logbooks will provide the means of recording the data collecting activities that are performed. As such, entries will be described in as much detail as possible so that persons going to the site could reconstruct a situation without reliance on memory. Entries will be made in ink with no erasures. If an incorrect entry is made, the information will be crossed out with one strike mark and initialed by the person making the entry.

All sample containers will be labeled with the project identification, sample number, matrix, analysis required, preservation used, and the sampler's initials. Sample labels will be completed using waterproof ink. The completed sample labels will be affixed to each sample bottle and covered with clear tape.

The SERES-Arcadis JV field sampler will review all sampling activities to determine whether proper custody procedures were followed during the field work and if additional samples are required.

Transfer of Custody and Shipment

The custody of samples must be maintained from the time of sampling through shipment and relinquishment to the laboratory. Instructions for transferring custody are given below.

A chain-of-custody form must accompany all samples. When transferring custody of samples, the individuals relinquishing and receiving will sign, date, and note the time on the chain-of-custody form. This form documents sample custody transfer from the SERES-Arcadis JV field sampler, through the shipper, to the analytical laboratory. Because a common carrier will usually not accept responsibility for handling chain-of-custody forms, the name of the carrier is entered under "Received by," the bill-of-lading number is recorded in the comments section, and the chain-of-custody form is placed in a zip-lock plastic bag and taped to the inside lid of the shipping cooler. Copies of the chain-of-custody form will be placed in each cooler included in the shipment. Copies of the chain-of-custody for and bill of lading will be retained by the SERES-Arcadis JV field sampler and placed into the project files, as well as sent to the SERES-Arcadis JV PM electronically.

Samples will be packaged for shipment and dispatched to the appropriate laboratory via overnight delivery service. Samples will be shipped within 24 hours of sampling if possible, or soon thereafter. Shipping containers will be sealed for shipment to the laboratory as described above. Custody seals will be applied to each cooler to document that the container was properly sealed, as well as to ensure that the container was not tampered with during shipment. The custody seals will be placed on the coolers in such a manner that the custody seal would be broken if the cooler were opened.

Laboratory Custody Procedures

A designated sample custodian will accept custody of the samples and verify that all information on the sample labels matches that on the chain-of-custody form. The sample custodian will document any discrepancies and will sign and date all appropriate receiving documents. The sample custodian will also document the condition of the samples upon receipt by the laboratory.

Once the samples have been accepted by the laboratory, checked, and logged in, they must be maintained in accordance with laboratory custody and security requirements.

To assure traceability of samples while in the possession of the laboratory, a unique laboratory identification number will be assigned to each sample.

The laboratory must document the following stages of analysis:

- Sample extraction/preparation
- Sample analysis
- Data reduction
- Data reporting.

Laboratory personnel are responsible for the custody of the samples until they are returned to the sample custodian.

Sample Holding Times

Information on sample holding times and required preservation for PFAS samples by media is provided in QAPP **Worksheet #19/30**.

Final Evidence Files

As the final phase of sample custody, the chain-of-custody records are archived in the project file. Laboratory custody forms, the sample preparation and analysis logbook, and data packages will become part of the laboratory final evidence file. Other relevant documentation, including records, reports, correspondence, logs, photographs, and data review reports, will be archived by SERES-Arcadis JV personnel.

QAPP Worksheet #28: Analytical Quality Control and Corrective Action

(UFP-QAPP Manual Section 3.4)
(USEPA 2106-G-05 Section 2.3.5)

This worksheet includes information for each sampling technique, analytical method/SOP, matrix, and analytical group.

QAPP Worksheet #28a: Analytical Quality Control and Corrective Action (PFAS in Soil/Aqueous/Fish Tissue)

Matrix: Soil/Aqueous
Concentration Level: Low
Analytical Method: PFAS per USEPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 or later versions Table B-24
Laboratory SOP: WI48593, WI46412, WI49212

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	Measurement Performance Criteria
Instrument Blanks	Immediately following the highest standard analyzed and daily before sample analysis.	Concentration of each analyte must be ≤ 1/2 the LOQ. Instrument blank must contain EIS to enable quantitation of contamination.	If acceptance criteria are not met after the highest calibration standard, calibration must be performed using a lower concentration for the highest standard until acceptance criteria are met. If sample concentrations exceed the highest allowed standard and the sample(s) following exceed this acceptance criteria (> 1/2 LOQ), they must be reanalyzed.	Analyst, Supervisor, QA Manager	Bias/ Contamination	Concentration of each analyte must be ≤ 1/2 the LOQ.

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	Measurement Performance Criteria
EISs	Added to every field sample, standard, blank, and QC sample.	Added to solid samples before extraction. EIS Analyte recoveries must be within preliminary in-house acceptance criteria of 20-150% until in-house limits are generated in accordance with method 1633. Lower limit must not be less than 20%..	If recoveries are acceptable for QC samples, but not for field samples, the field samples must be re-extracted and analyzed (greater dilution may be needed). Repeat the analysis using a fresh aliquot of the extract. If failure does not confirm, report the second analysis. If the failure confirms, follow the requirements listed in EPA Draft Method 1633, Section 15.3.2.	Analyst, Supervisor, QA Manager	Accuracy/Bias	EIS Analyte recoveries must be within preliminary in-house acceptance criteria of 20-150% until in-house limits are generated in accordance with method 1633. Lower limit must not be less than 20%.
NISs	Added to every field sample, standard, blank, and QC sample.	The NIS areas in the field samples and QC samples should be within 50 – 200% of the mean area of that NIS in the initial calibration standards. NIS areas must be greater than 30% of the average area of the calibration standards in undiluted sample extracts and sample extracts that required additional NIS to be added.	Repeat the analysis using a fresh aliquot of the extract. If failure does not confirm, report the second analysis. If the failure confirms, report both results and note in case narrative	Analyst, Supervisor, QA Manager	Accuracy/Bias	NIS areas in the field samples and QC samples should be within 50 – 200% of the mean area of that NIS in the initial calibration standards and must be greater than 30%.

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	Measurement Performance Criteria
Ion abundance ratio (IAR)	All analytes detected in a sample	The IAR for detected analytes must be within 50 to 150% of the IAR in the mid-point calibration standard or daily CCV standard.	Qualify the data and note in case narrative.	Analyst, Supervisor, QA Manager	Accuracy	The IAR for detected analytes must be within 50 to 150% of the IAR in the mid-point calibration standard or daily CCV standard.
Method Blank (MB)	One per preparatory batch.	No analytes detected > 1/2 LOQ or > 1/10 the regulatory limit, whichever is greater.	Correct problem. If required, re-extract and reanalyze MB and all QC samples and field samples processed with the contaminated blank. Samples may be re-extracted and analyzed outside of hold times, as necessary for CAs associated with QC samples.	Analyst, Supervisor, QA Manager	Bias/ Contamination	No analytes detected > 1/2 LOQ or > 1/10 the regulatory limit, whichever is greater.
LCS	One per preparatory batch. Blank spiked with all analytes at a mid-level calibration concentration.	Preliminary in-house acceptance criteria of 40-150% must be used until in-house limits are generated in accordance with USEPA method 1633. Lower control limit cannot be less than 40%.	Correct problem. If required, re-extract and reanalyze LCS and all samples associated with the preparatory batch for failed analytes if sufficient sample material is available. Samples may be re-extracted and analyzed outside of hold times, as necessary for CAs associated with QC samples.	Analyst, Supervisor, QA Manager	Accuracy/Bias	Preliminary in-house acceptance criteria of 40-150% must be used until in-house limits are generated in accordance with USEPA method 1633. Lower control limit cannot be less than 40%.

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	Measurement Performance Criteria
Low-level LCS (LLLCS)	One per preparatory batch. Blank spiked with all analytes at 2 times the LOQ.	Preliminary in-house acceptance criteria of 40-150% must be used until in-house limits are generated in accordance with USEPA method 1633. Lower control limit cannot be less than 40%.	Correct problem. If required, re-extract and reanalyze LLLCS and all samples associated with the preparatory batch for failed analytes if sufficient sample material is available. Samples may be re-extracted and analyzed outside of hold times, as necessary for CAs associated with QC samples.	Analyst, Supervisor, QA Manager	Accuracy/Bias	Preliminary in-house acceptance criteria of 40-150% must be used until in-house limits are generated in accordance with USEPA method 1633. Lower control limit cannot be less than 40%.
Field Blank	One per 20 field samples	No analytes detected > 1/2 LOQ	Qualify data as appropriate	Data Validator	Bias/ Contamination	No analytes detected > 1/2 LOQ
Equipment Blank	1 per sampling event for non-dedicated equipment	No analytes detected > 1/2 LOQ	Qualify data as appropriate	Data Validator	Bias/ Contamination	No analytes detected > 1/2 LOQ
MS	One pair per preparatory batch. Sample spiked with all analytes at a mid-level calibration concentration.	Preliminary in-house acceptance criteria of 40-150% must be used until in-house limits are generated in accordance with USEPA method 1633. Lower control limit cannot be less than 40%.	Quality data as appropriate	Analyst, Supervisor, QA Manager	Accuracy/Bias	Preliminary in-house acceptance criteria of 40-150% must be used until in-house limits are generated in accordance with USEPA method 1633. Lower control limit cannot be less than 40%.

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	Measurement Performance Criteria
MSD or Matrix Duplicate (MD)	For MSD: One per preparatory batch. Sample spiked at same concentration as MS.	%R same as MS. RPD ≤ 30% (between MS and MSD or sample and MD).	Quality data as appropriate	Analyst, Supervisor, QA Manager	Accuracy/Bias	%R same as MS. RPD ≤ 30%
Field Duplicate (not required for fish tissue)	One per 20 field samples	Soil: RPD ≤ 50% Water: RPD ≤ 35%	Qualify data as appropriate	Data Validator	Overall precision	Soil: RPD ≤ 50% Water: RPD ≤ 35%
Solid Sample Preparation	Each sample and associated batch QC samples.	Entire sample received by the laboratory must be homogenized prior to subsampling.	N/A	Analyst, Supervisor, QA Manager	Accuracy	Entire sample received by the laboratory must be homogenized prior to subsampling.

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	Measurement Performance Criteria
Sample Cleanup Procedure	Each sample and associated batch QC samples.	Carbon cleanup is required. Carbon cleanup may remove analytes if the sample has a very low organic carbon content. This will be apparent if the isotope dilution standard recoveries are significantly higher on the reanalysis. If the laboratory can demonstrate that the carbon cleanup is detrimental to the sample analysis (by comparing results when skipping the carbon cleanup during reanalysis), then the carbon cleanup may be skipped for that specific sample.	N/A	Analyst, Supervisor, QA Manager	Accuracy	Carbon cleanup is required. See QC Acceptance Limits for exceptions.

Notes:

1. LCS/LCSD used when MS/MSD are not client-supplied. No LCSD analyses are planned because MS/MSD will be collected and analyzed for all matrices.

QAPP Worksheet #28b: Analytical Quality Control and Corrective Action (TOC in Soil)

Matrix: Soil

Concentration Level: Low

Analytical Method: USEPA 9060A TOC

Laboratory SOP: DV-WC-0048

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1/Preparatory Batch (20 samples)	No Target Compounds >0.5 LOQ	If sufficient sample is available, re-analyze samples. Qualify data as needed. Report results if sample results >10x blank result or sample results ND.	Analyst / Section Supervisor	Accuracy/Bias-Contamination	No Target Compounds >0.5 LOQ
Laboratory Control Sample	1/Preparatory Batch (20 samples)	Lab determined historical limits but no wider than 80 to 120%	Re-analyze LCS once. If acceptable, report. If LCS has high bias and samples non-detect, report with case narrative comment. If LCS has low bias, evaluate, re-prep, and re-analyze the LCS and all samples in the associated prep batch for failed analytes if sufficient sample material is available.	Analyst / Section Supervisor	Accuracy/Bias	Laboratory % Recovery Control Limits
Matrix Spike/Matrix Spike Duplicate	1/Preparatory Batch (20 samples)	Recovery: Lab determined historical limits but no wider than 80 to 120% RPD: Lab determined historical limits but no wider than 20%	If not related to matrix interference, re-extract and re-analyze MS/MSD.	Analyst / Section Supervisor	Accuracy/Bias/ Precision	Laboratory % Recovery / RPD Control Limits

QAPP Worksheet #28c: Analytical Quality Control and Corrective Action (Grain Size Analysis)

Matrix: Soil/Sediment

Analytical Group: Grain Size/Particle Size Analysis

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Duplicate (when duplicate volume is provided)	1 per batch	Laboratory statistical RPD	No corrective action, matrix related	ELLE Analyst	Analytical Precision	Results within acceptance limits

QAPP Worksheet #28d: Analytical Quality Control and Corrective Action (PFAS in Soil/Aqueous/Fish Tissue)

Recovery and Precision Limits

Matrix: Water

Analytical Group: PFAS

Analyte	Acronym	CAS Number	Accuracy Limits (LCS/MS/MSD)[a] (%R)
PFAS – Groundwater and Surface Water USEPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24			
1H,1H,2H,2H-Perfluorohexanesulfonic acid	4:2FTS	757124-72-4	40-150
1H,1H,2H,2H-Perfluorooctanesulfonic acid	6:2 FTS	27619-97-2	40-150
1H,1H,2H,2H-Perfluorodecanesulfonic acid	8:2 FTS	39108-34-4	40-150
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	40-150
N-Ethyl-perfluorooctane sulfonamidoacetic acid	NEtFOSAA	2991-50-6	40-150
N-Methyl-perfluorooctane sulfonamidoacetic acid	NMeFOSAA	2355-31-9	40-150
N-Methyl perfluorooctanesulfonamide	NMeFOSA	31506-32-8	40-150
N-Ethyl perfluorooctanesulfonamide	NEtFOSA	4151-50-2	40-150
N-Methyl perfluorooctanesulfonamidoethanol	NMeFOSE	24448-09-7	40-150
N-Ethyl perfluorooctanesulfonamidoethanol	NEtFOSE	1691-99-2	40-150
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	40-150
Perfluorobutanoic acid	PFBA	375-22-4	40-150
Perfluorobutanesulfonic acid	PFBS	375-73-5	40-150
Perfluorodecanoic acid	PFDA	335-76-2	40-150
Perfluorodecanesulfonic acid	PFDS	335-77-3	40-150
Perfluorododecanoic acid	PFDoA	307-55-1	40-150
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	40-150
Perfluoroheptanoic acid	PFHpA	375-85-9	40-150
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	40-150
Perfluorohexanoic acid	PFHxA	307-24-4	40-150
Perfluorohexanesulfonic acid	PFHxS	355-46-4	40-150
Perfluorononanoic acid	PFNA	375-95-1	40-150
Perfluorononanesulfonic acid	PFNS	68259-12-1	40-150
Perfluorooctanoic acid	PFOA	335-67-1	40-150
Perfluorooctanesulfonic acid	PFOS	1763-23-1	40-150

Analyte	**Acronym**	**CAS Number**	**Accuracy Limits (LCS/MS/MSD)[a] (%R)**
PFAS – Groundwater and Surface Water USEPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24			
Perfluorooctanesulfonamide	PFOSA	754-91-6	40-150
Perfluoropentanoic acid	PFPeA	2706-90-3	40-150
Perfluoropentanesulfonic acid	PFPeS	2706-91-4	40-150
Perfluorotetradecanoic acid	PFTeDA	376-06-7	40-150
Perfluorotridecanoic acid	PFTrDA	72629-94-8	40-150
Perfluoroundecanoic acid	PFUnA	2058-94-8	40-150
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	40-150
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	40-150
Nonafluoro-3,6-dioxaheptanoic acid	PFDHA	151772-58-6	40-150
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS	756426-58-1	40-150
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9	40-150
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	40-150
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	40-150
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-49-3	40-150
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	40-150

NOTE: a. Consistent with **USEPA 2nd Draft Method 1633 compliant with DoD QSM 5.4 Table B-24** for water matrix

QAPP Worksheet #29: Project Documents and Records

(UFP-QAPP Manual Section 3.5.1)
(USEPA 2106-G-05 Section 2.2.8)

This worksheet provides the minimum specifications for all data management tasks and deliverables, as well as procedures for controlling project documents, records, and databases. Its purpose is to ensure data completeness, data integrity, and ease of retrieval.

29.1 Data Management Specifications

29.1.1 Data Recording/Data Entry

Analytical results will be provided by the analytical laboratory in both digital and pdf formats. The electronic data deliverable will be directly uploaded into the project database and will be used to directly produce tables, reducing the redundant manual entry of analytical results during report preparation and precludes transcription errors that may occur otherwise. Qualified technical personnel will review these electronic data against copies of final laboratory reports before releasing the data for validation. Any data manually transcribed from sampling logs or field books will be reviewed for accuracy by qualified staff other than staff who transcribed the data. The QA activities will be documented on a QA checklist.

29.1.2 Data Transformations and Data Reduction

Data transformation and reduction (data T&R) will be accomplished using EQuIS, ESRI ArcGIS, and Microsoft Excel. Data T&R will be reviewed for accuracy by qualified staff other than staff who performed the data T&R. The QA activities will be documented on a QA checklist.

29.2 Control of Documents, Records, and Databases.

All project documents and records will be generated, verified, and retained as shown in the Worksheet below.

Record	Generation	Frequency	Verification	Storage location/archival
Sample Collection and Field Records				
• Field logbook or data collection sheets • Chain-of-custody forms • Air bills • Contractor DQCRs • Deviations • CA reports • Correspondence • Field audit checklists	TBD, Field Sampler *SERES-Arcadis JV*	Daily or as needed	Andy Vitolins, PM *SERES-Arcadis JV*	Project file
• Data verification checklists	Jennifer Singer, Project Chemist, *SERES-Arcadis JV*	As needed	Andy Vitolins, PM *SERES-Arcadis JV*	Project file
• Non-chemistry data pertaining to sample locations, hydrogeological information, physical parameters, and monitoring well information.	Jennifer Singer, Project Chemist, or designee *SERES-Arcadis JV*	As needed	Jennifer Singer, Project Chemist or designee *SERES-Arcadis JV*	Project file
• Data validation report • Data usability assessment report	Pei Geng, *LDC Data Validator*	As needed	Jennifer Singer, Project Chemist *SERES-Arcadis JV*	Project file
Laboratory Records				
• Chain-of-custody records • Sample receipt records • Electronic data deliverables in Electronic Data Deliverable (EDD) Stage 2B deliverable format • Electronic data deliverables in EQuIS 7 (or most up-to-date version at the time of sample collection) 4-file format • Analytical results and supporting data • Sample data packages	Kerri Sachtleban *PM Eurofins*	As needed	Kenneth Boley QA Manager *Eurofins Lancaster Laboratories*	Project file
• Records of sample preparation • Records of sample analysis • Instrument calibration records • Raw data files	Laboratory analysts *Eurofins*	As needed	Kenneth Boley QA Manager *Eurofins Lancaster Laboratories*	Project file

QAPP Worksheet #31, 32, & 33 – Assessments and Corrective Actions

(UFP-QAPP Manual Sections 4.1.1 and 4.1.2)
(USEPA 2106-G-05 Section 2.4 and 2.5.5)

This worksheet is used to document responsibilities and procedures for conducting project assessments, documenting assessments, responding to assessment findings, and implementing corrective actions (CAs). Appropriately scheduled assessments allow management to implement CAs in a timely manner; thereby correcting non-conformances and minimizing their impact on DQOs/Project Quality Objectives.

ASSESSMENT

Different types of assessments are used for evaluating project activities including, but not limited to, laboratory assessments, field audits, and field documentation review. The tables below identify the type, frequency, and responsible parties of planned assessments that will be performed for the project.

CORRECTIVE ACTION

Once a process displays a characteristic out of specification with those required for the project or quality objectives, CA must be conducted to identify the cause of the deficiency or non-conformance. When the cause of the problem is identified, appropriate CA can be instituted and then monitored for effectiveness. Assessment response and CAs are specified in the tables below.

ROOT CAUSE ANALYSIS

Determining the root cause of a non-conformance is an integral part of the QC process. The depth and extent of the root cause analysis (RCA) depends on the situation; the root cause may be as simple (minor) as an overlooked step or procedure, or it may be complicated. RCA is the responsibility of the functional manager or a designee. Input can be obtained as necessary from field personnel and technical advisors to identify the factors that led to the problem. The root cause is almost always “upstream” from where the problem is detected.

A two-step strategy will be employed for determining the root cause of a deficiency or non-conformance for this project. First, the problem will be traced back to the source. Second, the cause will be evaluated using basic questions such as who, what, when, where, why, and how. This process will be repeated until the cause is identified.

IMPLEMENTATION OF CORRECTION ACTION

Following the RCA, the project personnel will undertake the most effective remedy to correct the problem. Potential remedies to be considered may include the following:

- Supplemental personnel training
- Changes of equipment or modification of equipment currently in use
- Acquisition of supplemental equipment
- Implementation of new procedures or modification of existing procedures
- Changes in QC procedures.

Successful implementation of CA will be documented on the Deficiency Notice or Non-conformance Report. Through follow-up phase surveillance, the SERES-Arcadis JV field sampler will verify that the CA implemented has rectified the non-conforming condition and is sufficient to prevent recurrence. The results of the CA will be presented in the RI Report.

Field procedure/documentation corrective actions and follow-up will be verbally discussed, then confirmed with an email between the SERES-Arcadis JV field sampler and SERES-Arcadis JV project manager.

Laboratory-related issues identified by the validator and associated corrective action and follow-up will be verbally discussed between the lab, validator, and SERES-Arcadis JV project chemist and project manager and confirmed with an email.

Assessment Type	Responsible Party & Organization	Number/Frequency	Estimated Dates	Assessment Deliverable	Deliverable Due Date
Review of QAPP, SOPs, and daily QC report with field staff	TBD *SERES-Arcadis JV*	Before sampling startup	Before sampling	Contained within daily QC report.	Before sampling
Daily logbook and field forms	TBD *SERES-Arcadis JV*	Daily	During field activities	Contained within written report	As part of Draft Report
Laboratory assessment for appropriate certifications and capacity; QAPP review with laboratory staff	Jennifer Singer *Project Chemist* *SERES-Arcadis JV*	Before sampling startup	Before sampling	Receipt of copies of certifications. Email traffic concerning laboratory capacity before sampling startup. QAPP sign-off sheet received from the laboratory.	Before sampling
Daily tailgate safety meeting	TBD *SERES-Arcadis JV*	Daily	During field activities	Verbal debriefing and daily sign-off log. If a safety violation occurs, an incident report is completed.	Last deliverable received no later than one week after field activities
Field sampling and chain-of-custody form review against QAPP requirements	TBD *SERES-Arcadis JV*	Daily	During field activities	Communication in the form of an email	Last email received no later than 24 hours after last sampling event
Laboratory report deliverables and analytical results review against QAPP requirements	Jennifer Singer *Project Chemist* *SERES-Arcadis JV*	Per sample delivery group (i.e., analytical samples received in each shipment)	Immediately following field sampling	Communication if the form of an email	Three weeks after receipt of data
Data verification	Jennifer Singer *Project Chemist* *SERES-Arcadis JV* and/or Pei Geng *LDC Data Validator*	Per sample delivery group (i.e., analytical samples received in each shipment)	Following analytical report	Communication in the form of an email requesting additional laboratory forms, backup data that may be missing, and/or clarification of the analytical report	Three weeks after receipt of data
Data validation	Pei Geng *LDC Data Validator*	Per sample delivery group (i.e., analytical samples received in each shipment)	Following analytical report	Communication in the form of an email requesting additional laboratory forms, backup data that may be missing, and/or clarification of the analytical report	Three weeks after receipt of data

Assessment Type	Responsibility for Responding to Assessment Findings	Assessment Response Documentation	Timeframe for Response	Responsibility for Implementing Corrective Action	Responsibility for Monitoring Corrective Action Implementation
Review of QAPP, SOPs, and daily QC report with field staff	Andy Vitolins *PM* *SERES-Arcadis JV*	Daily QC report will be amended with CA	Within 24 hours	TBD *SERES-Arcadis JV*	Andy Vitolins *PM* *SERES-Arcadis JV*
Daily logbook and field forms	TBD *SERES-Arcadis JV*	Daily QC report will be amended with CA	Within 24 hours	TBD *SERES-Arcadis JV*	Andy Vitolins *PM* *SERES-Arcadis JV*
Laboratory assessment for appropriate certifications and capacity; QAPP review with laboratory staff	Kenneth Boley *QA Manager* *Eurofins Lancaster Laboratories*	Response to email	Within 48 hours after notification	Kenneth Boley *QA Manager* *Eurofins Lancaster Laboratories*	Jennifer Singer *Project Chemist* *SERES-Arcadis JV*
Daily tailgate safety meeting	Andy Vitolins *PM* *SERES-Arcadis JV*	Included as part of the Incident Report	Within 48 hours after notification	TBD *SERES-Arcadis JV*	Andy Vitolins *PM* *SERES-Arcadis JV*
Field sampling and chain-of-custody form review against QAPP requirements	Andy Vitolins *PM* *SERES-Arcadis JV*	Response to email	Within 24 hours after sampling	TBD *SERES-Arcadis JV*	Andy Vitolins *PM* *SERES-Arcadis JV*
Laboratory report deliverables and analytical results review against QAPP requirements	Kenneth Boley *QA Manager* *Eurofins Lancaster Laboratories*	If required, laboratory reports will be amended and corrections noted in the case narrative	Within 72 hours of notification	Kenneth Boley *QA Manager* *Eurofins Lancaster Laboratories*	Jennifer Singer *Project Chemist* *SERES-Arcadis JV*
Data verification	Kenneth Boley *QA Manager* *Eurofins Lancaster Laboratories*	If required, laboratory reports will be amended and corrections noted in the case narrative	Up to 7 days	Kenneth Boley *QA Manager* *Eurofins Lancaster Laboratories*	Jennifer Singer *Project Chemist* *SERES-Arcadis JV*
Data validation	Kerri Sachtleban *PM* *Eurofins*	If required, laboratory reports will be amended, corrections noted in the case narrative, and documented in the validation report	Up to 7 days	Kerri Sachtleban *PM* *Eurofins*	Jennifer Singer *Project Chemist* *SERES-Arcadis JV*

QAPP Worksheet #34 –Data Verification and Validation Inputs

(UFP-QAPP Manual Section 5.2.1)
(USEPA 2106-G-05 Section 2.5.1)

This worksheet lists the inputs that will be used during data verification and validation. Inputs include all requirements documents (e.g., contracts, SOPs, planning documents), field records (both hard copy and electronic), and interim and final reports. Data verification is a completeness check that all specified activities involved in data collection and processing have been completed and documented and that the necessary records (objective evidence) are available to proceed to data validation. Data validation is the evaluation of conformance to stated requirements including those in the contract, methods, SOPs, and the QAPP. Required documents, as well as records subject to verification and validation, are listed below. See **Attachment C** for the field SOPs.

Item	Description	Verification (completeness)	Validation (conformance to specifications)
	Planning Documents/Records		
1	Approved QAPP	**X**	
2	Contract	**X**	
3	Field SOPs	**X**	
4	Laboratory SOPs	**X**	
	Field Records		
5	Field logbooks	**X**	**X**
6	Equipment calibration records	**X**	**X**
7	Chain-of-custody forms	**X**	**X**
8	Sampling diagrams/surveys	**X**	**X**
9	Relevant correspondence	**X**	**X**
10	Change orders/deviations	**X**	**X**
11	Field audit reports	**X**	**X**
12	Field CA reports	**X**	**X**
	Analytical Data Package		
13	Cover sheet (laboratory identifying information)	**X**	**X**
14	Case narrative	**X**	**X**
15	Internal laboratory chain-of-custody	**X**	**X**
16	Sample receipt records	**X**	**X**
17	Sample chronology (i.e., dates and times of receipt, preparation, and analysis)	**X**	**X**
18	Communication records	**X**	**X**
19	Project-specific proficiency testing sample results		
20	LOD/LOQ establishment and verification	**X**	**X**
21	Standards traceability	**X**	**X**

Item	Description	Verification (completeness)	Validation (conformance to specifications)
22	Instrument calibration records	**X**	**X**
23	Definition of laboratory qualifiers	**X**	**X**
24	Results reporting forms	**X**	**X**
25	QC sample results	**X**	**X**
26	CA reports	**X**	**X**
27	Raw data	**X**	**X**
28	Electronic data deliverable	**X**	**X**

QAPP Worksheet #35 –Data Verification Procedures

(UFP-QAPP Manual Section 5.2.2)
(USEPA 2106-G-05 Section 2.5.1)

Follow-up inspections are conducted to ensure that procedures are being correctly performed, no changed conditions exist that may impact the quality of work, and lessons learned are being applied as identified. The responsible individual will inspect the relevant follow-up items from the checklist in the appropriate SOP at least as often as specified in this worksheet. **Worksheets #31, 32,** and **33** describe actions to be taken if non-conforming conditions are observed during the QC inspections.

Records Reviewed	Required Documents	Process Description	Responsible Person, Organization
Field logbook (sampling methods and procedures)	• QAPP • Field SOPs	Establish that required sampling methods were used and documented. Establish that any required field monitoring was performed, and results are documented. Verify that the sampling procedures and field measurements met performance criteria and that any deviations were documented in the field logbook.	**Daily:** TBD *SERES-Arcadis JV* **At conclusion of field activities:** Jennifer Singer *Project Chemist* *SERES-Arcadis JV*
Field logbook (documentation)	• QAPP • Field SOPs	Verify that the records are present and complete for each day of field activities. Verify that all planned samples, including field QC samples, were collected and the sample collection locations are documented. Verify that meteorological data were provided for each day of field activities. Verify that changes/exceptions are documented and reported in accordance with requirements.	**Daily:** TBD *SERES-Arcadis JV* **At conclusion of field activities:** Jennifer Singer *Project Chemist* *SERES-Arcadis JV*

Records Reviewed	Required Documents	Process Description	Responsible Person, Organization
Chain-of-custody forms	• QAPP • Field SOPs • Laboratory SOPs/QA Manual	All samples to be analyzed by the laboratory will be shipped via overnight delivery service under chain-of-custody procedures. Before shipment of the samples to the laboratory, the chain-of-custody form will be checked by the SERES-Arcadis JV field sampler for completeness and correctness. Upon receipt at the laboratory, the sample custodian will check the chain-of-custody forms and shipping documentation for verification against the sample coolers they represent and will sign and date the chain-of-custody forms to acknowledge sample receipt. The laboratory is responsible for verifying the integrity of the custody seals and that the sample containers are received in good condition. The Laboratory Information Management System will provide evidence of sample custody from receipt by the laboratory until appropriate disposal.	**Daily:** TBD *SERES-Arcadis JV* **Upon receipt:** *Sample Custodian* *Eurofins Lancaster Laboratories*
Laboratory corrective action and report procedure	• QAPP • Laboratory SOPs/QA Manual	Routine CAs apply to all analytical QC parameters and analytical system specification defined in the laboratory SOPs. Bench analysts have full responsibility and authority for performing routine CAs, which are documented as part of the analytical record. Defective processes, holding time violations, systematic errors, and quality defects that occur are to be reported by the analyst to the laboratory supervisor and a non-conformance record initiated. The Laboratory PM will then notify the SERES-Arcadis JV Project Chemist and PM. All notifications must be made in a timely manner. The non-conformance record should become part of the analytical record.	**Before release:** Kenneth Boley *QA Manager* *Eurofins Lancaster Laboratories* **Upon receipt:** Jennifer Singer *Project Chemist* *SERES-Arcadis JV*
Analytical data package	• QAPP • Laboratory SOPs/QA Manual	All data produced by the laboratory will be required to undergo several levels of review, which will include two levels of management review at the laboratory. The laboratory will review the data packages internally for completeness and verification that all the required forms and raw data are included for each data package type. The laboratory QA Manager may also review randomly chosen data packages for additional internal audits. Any deviations should be documented in the report narrative.	Kenneth Boley *QA Manager* *Eurofins Lancaster Laboratories*

Records Reviewed	**Required Documents**	**Process Description**	**Responsible Person, Organization**
Analytical data package	• QAPP • Laboratory SOPs • USEPA National Functional Guidelines	The Project Chemist or Data Validator will verify that data have been received for all samples sent to the laboratory. The data will be evaluated to determine whether the laboratory met the QC requirements for the analysis as stated in the analytical method, laboratory SOPs, QAPP, DoD General Data Validation Guidelines, (DoD 2019b), and Data Validation Guidelines Module 6: Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-24 (DoD 2022). This verification should include (at a minimum): (1) review of dates of sample preparations and analyses to verify that they have been performed within applicable holding times, (2) review of associated blanks for potential contamination, (3) determination that project quantitation limits were achieved, and (4) review of QC sample performance criteria. Any deviations should be documented in the report narrative.	Jennifer Singer *Project Chemist* *SERES-Arcadis JV* Pei Geng *LDC Data Validator*
Laboratory electronic data deliverable	• QAPP	The electronic data deliverable will be reviewed for correctness and completeness.	Jennifer Singer *Project Chemist* *SERES-Arcadis JV* Pei Geng *LDC Data Validator*

QAPP Worksheet #36 –Data Validation Procedures

(UFP-QAPP Manual Section 5.2.2)
(USEPA 2106-G-05 Section 2.5.1)

RI actions will be documented and submitted for an overall data package certification. A certification package is prepared by the SERES-Arcadis JV for review by USACE. This package will document the steps taken to ensure the quality of the information relied upon to determine the nature and extent of PFAS impacts at Fort Devens.

Data Validator:	Pei Geng, LDC
Analytical group/method:	PFAS
Data deliverable requirements:	EDD Stage 2B EQuIS 7 4-file format
Analytical specifications:	PFAS by USEPA 2nd Draft method 1633 compliant with DoD QSM 5.4 or later versions
MPC	DoD QSM version 5.4(2021) or later (see **Worksheets #12 and #28**)
Percent of data packages to be validated:	100% Stage 2B
Percent of raw data reviewed:	As Needed
Percent of results to be recalculated:	As Needed
Validation procedures:	UFP-QAPP, DoD QSM version 5.4 (2021) or later, DoD General Data Validation Guidelines, (DoD 2019b), Data Validation Guidelines Module 6: Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-24 (DoD 2022).

QAPP Worksheet #37 – Data Usability Assessment

(UFP-QAPP Manual Section 5.2.3)

(USEPA 2106-G-05 Section 2.4)

The Data Usability Assessment will be performed by SERES-Arcadis JV for data associated with the former Fort Devens. LDC will perform third-party data validation to keep the data validation independent of the SERES-Arcadis JV project team. Documentation generated during the Data Usability Assessment will consist of data validation checklists with a summary of overall data usability and a summary table of qualified results. Data will be validated for the critical samples as defined in the UFP-QAPP, DoD QSM version 5.4 (2021) or later, DoD General Data Validation Guidelines, (DoD 2019b), DoD Data Validation Guidelines Module 6: Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-24 (DoD 2022) as appropriate.

The Data Usability Assessment process involves data verification and validation. Data verification is the process by which laboratory results are checked to confirm that the proper QC steps were performed and key items have met QC objectives (both analytical and contractual). Key steps of the data verification include:

- Identifying sample collection, handling, and analysis procedures
- Documenting handling and analysis activities (e.g., QC checklist)
- Verifying (internally, at the data generator level) all sampling, handling, on-site analytical laboratory data
- Verifying laboratory data (e.g., laboratory-qualified data)
- Verifying sampling, on-site analytical laboratory data
- Verifying data package deliverable completeness
- Reviewing the case narrative
- Presenting all analytical results
- Summarizing QC sample data.

All required data deliverables must be present in the data package to proceed to the next step of data validation.

Data validation entails a review of the sample collection, handling, and QC data to verify that the laboratory was operating within required limits, and which (if any) environmental samples were related to out-of-control QC samples. The objective of data validation is to identify any questionable or invalid laboratory measurements.

The DQIs used to evaluate conformance with the project DQOs are presented below.

DQIs are generally defined in terms of six parameters:

1. Representativeness
2. Comparability
3. Completeness
4. Precision

5. Accuracy
6. Sensitivity

Each parameter is defined below. Specific objectives for the site actions are presented in other sections of this QAPP Addendum as referenced below.

37.1 Representativeness

Representativeness is the degree to which sampling data accurately and precisely represent site conditions and is dependent on sampling and analytical variability and the variability of environmental media at the site. Actions have been designed to assess the presence of chemical constituents at the time of sampling. The QAPP presents the rationale for sample quantities and location. This QAPP presents field sampling and laboratory analytical methodologies. Use of the prescribed field and laboratory analytical methods with associated holding times and preservation requirements are intended to ensure that each individual sample accurately and precisely represents site conditions.

37.2 Comparability

Comparability is the degree of confidence with which one dataset can be compared to another. Comparability between phases of the actions (if additional phases are required) will be maintained through consistent use of the sampling and analytical methodologies set forth in this QAPP Addendum, established QC procedures, and use of appropriately trained personnel.

37.3 Completeness

Completeness is defined as a measure of the amount of valid data obtained from an event and/or investigation compared to the total amount obtained. Completeness of a field or laboratory dataset will be calculated using the equation below by comparing the number of valid sample results generated to the total number of results collected:

$$\text{Completeness} = \frac{\text{Number valid results}}{\text{Total number of results generated}} \times 100$$

As a general guideline, overall project completeness is expected to be at least 90%. The assessment of completeness will require professional judgment to determine data usability for intended purposes.

37.4 Precision

Precision is a measure of the reproducibility of sample results. The goal is to maintain a level of analytical precision consistent with the objectives of the action. To maximize precision, sampling and analytical procedures will be followed. All work for the site actions will adhere to established protocols presented in the QAPP. Checks for analytical precision will include the analysis of MS/MSD, laboratory duplicates, and field duplicates. Checks for field measurement precision will include duplicate field measurements.

The precision of data will be measured by calculating the RPD using the following equation:

$$RPD = \frac{(A-B)}{(A+B)/2} \times 100$$

Where:

A = Analytical result from one of two duplicate measurements.

B = Analytical result from the second measurement.

37.5 Accuracy

Accuracy is a measure of how close a measured result is to the true value. Both field and analytical accuracy will be monitored through initial and continuing calibration of instruments. In addition, reference standards, MSs, blank spikes, and surrogate standards will be used to assess the accuracy of the analytical data.

Accuracy will be calculated in terms of percent recovery as follows:

$$\%R = \frac{A-X}{B} \times 100$$

Where:

A = Value measured in spiked sample or standard.

X = Value measured in original sample.

B = True value of amount added to sample or true value of standard.

37.6 Sensitivity

Sensitivity is a quantitative measurement to determine if the analytical laboratory's procedures/methodologies and their associated detection limits can satisfy the project requirements as they relate to the project action limits. The detection limits (as described in DoD QSM 5.4) are DL, LOD, and LOQ. Analytes that are not detected are reported as less than the LOD. Detects less than the LOQ but greater than the DL are reported as estimated and J-flagged by the laboratory. The LOD and LOQ are verified by the laboratory quarterly. The current DoD DLs for the analytical laboratories are presented in **Worksheet #15**.

37.7 Data Validation and Usability

LDC will validate data generated using the UFP-QAPP, DoD QSM version 5.4 (2021) or later, DoD General Data Validation Guidelines (DoD 2019b), and Data Validation Guidelines Module 6: Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-24 (DoD 2022). These procedures and criteria may be modified, as necessary, to address project-specific and method-specific criteria, control limits, and procedures. Data validation will consist of data screening, checking, reviewing, editing, and interpretation to document analytical data quality and to determine whether the quality is sufficient to meet the DQOs.

The data validator will verify that laboratory reporting of analytical parameters is in accordance with the procedures specified for each analytical method and/or as specified in this QAPP Addendum. Deviations from the analytical methods/QAPP requirements will be detailed by the laboratory in the report case narrative. Changes to the reporting requirements specified in the QAPP will be communicated to the SERES-Arcadis JV project chemist and laboratory PM and also noted on the chain-of-custody form as appropriate.

Upon receipt of laboratory data, the data validator will execute the following procedures:

- Evaluate completeness of data package.
- Verify that field chain-of-custody forms were completed and samples were handled properly.
- Verify that holding times were met for each parameter. Holding time exceedances, should they occur, will be documented. Data for all samples exceeding holding time requirements will be flagged as either estimated or rejected. The decision as to which qualifier is more appropriate will be made on a case-by-case basis.
- Verify that parameters were analyzed according to the methods specified.
- Review QC data (i.e., confirm that duplicates, blanks, and spikes were analyzed on the required number of samples, as specified in the method, and verify that duplicate and MS recoveries are acceptable).
- Investigate anomalies identified during review. When anomalies are identified, they will be discussed with the PM and/or Laboratory Manager as appropriate.
- If data appear suspect, investigate the specific data of concern.

Deficiencies discovered because of the data review, as well as the CAs implemented in response, will be documented and submitted in the form of a written report addressing the following topics, as applicable to each method:

- Assessment of the data package
- Description of any protocol deviations
- Failures to reconcile reported data
- Assessment of any compromised data
- Overall appraisal of the analytical data
- Table of site name, sample quantities, matrix, and fractions analyzed.

It should be noted that qualified results do not necessarily invalidate data. The goal to produce the best possible data does not necessarily mean that data must be produced without QC qualifiers. Qualified data can provide useful information.

During the review process, laboratory qualified and unqualified data are verified against the supporting documentation. Based on this evaluation, qualifier codes may be added, deleted, or modified by the data reviewer. Results will be qualified with the following codes in accordance with DoD General Data Validation Guidelines, November 2019:

U	The analyte was not detected and was reported as less than the LOD or as defined by the customer. The LOD has been adjusted for any dilution or concentration of the sample.
J	The reported result was an estimated value with an unknown bias.
J+	The result was an estimated quantity, but the result may be biased high.
J-	The result was an estimated quantity, but the result may be biased low.

N The analysis indicates the presence of an analyte for which there was presumptive evidence to make a "tentative identification."

NJ The analyte has been “tentatively identified” or “presumptively” as present, and the associated numerical value was the estimated concentration in the sample.

UJ The analyte was not detected and was reported as less than the LOD or as defined by the customer. However, the associated numerical value is approximate.

X The sample results (including non-detects) were affected by serious deficiencies in the ability to analyze the sample and to meet published method and project quality control criteria. The presence or absence of the analyte cannot be substantiated by the data provided. Acceptance or rejection of the data should be decided by the project team (which should include a project chemist), but exclusion of the data is recommended.

It should be noted that no compound concentration, even if it has passed all QC tests, is guaranteed to be accurate. Strict QC serves to increase confidence in data, but any value potentially contains error.

Resolution of any issues regarding laboratory performance or deliverables will be handled between the laboratory and the data validator. Suggestions for re-analysis may be made by the SERES-Arcadis JV QC Manager at this point.

37.8 Validation Reports

The data validation reports will identify all deficiencies and the potential impact on the results. The SERES-Arcadis JV QC Manager (or his designee) will amend qualifiers generated during the validation process. The validation checklists and the database will be the primary locations of all applicable data qualifiers. Qualifiers will not be applied to the hard copy analytical reports.

37.9 Field Data Review

Field data are generated from in-field measurement, which may include a geophysical survey, well development, and groundwater sampling. The quality objective for the in-field measurement activities is to obtain accurate measurements of sample characteristics, including aqueous pH, conductivity, temperature, turbidity, and DO, using appropriate equipment. Data are recorded in field logbooks or on field sampling sheets and calibration logs. Calibration logs will be reviewed by the SERES-Arcadis JV field sampler with other field documentation to identify any potential impacts to data quality and usability. Field logbooks are reviewed as part of the QC inspections.

37.10 Reconciliation with Data Usability Requirements

Data results will be examined to determine the performance that was achieved for each data usability criterion. The performance will then be compared with the project objectives and DQOs. Deviations from objectives will be noted. Data that have been rejected will not be used. Data that have been qualified but not rejected will be considered useable (i.e., qualified as estimated) and definitive data. If further limitations must be placed on qualified data, the associated data are non-definitive data and should be used for screening purposes only.

Additional action may be warranted when performance does not meet performance objectives for critical data. Options for CA relating to incomplete information, questionable results, or inconsistent data may include any or all the following:

- Retrieval of missing information
- Request for additional explanation or clarification
- Re-analysis of sample from extract (when appropriate)
- Recalculation or reinterpretation of results by the laboratory.

These actions may improve the data quality, reduce uncertainty, and eliminate the need to qualify or reject data. If these actions do not improve the data quality to an acceptable level, the following additional actions may be taken:

- Extrapolation of missing data from existing data points
- Use of historical data
- Evaluation of the critical/non-critical nature of the sample.

If the data gap cannot be resolved by these actions, the data bias and potential for false negatives and positives can be evaluated. If the resultant uncertainty level is unacceptable, the following action must be taken: additional sample collection and analysis.

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QAPP Attachment A

Accident Prevention Plan

ACCIDENT PREVENTION PLAN
FOR
ENVIRONMENTAL REMEDIATION SERVICES
FORT DEVENS ARMY INSTALLATION
FORT DEVENS, MASSACHUSETTS

CONTRACT NUMBER: W912WJ19D0014

Prepared for

Department of the Army
U.S. Army Corps of Engineers
New England District
696 Virginia Road
Concord, MA 01742-2751

Prepared By

SERES
Engineering & Services, LLC
ARCADIS
a joint venture

May 2021

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FIGURES

ATTACHMENTS

LIST OF ABBREVIATIONS AND ACRONYMS

AHA	Activity Hazard Analysis
AOC	Area of Concern
APP	Accident Prevention Plan
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CIH	Certified Industrial Hygienist
COR	Contracting Officer’s Representative
CPR	Cardiopulmonary Resuscitation
CSHP	Corporate Safety and Health Program
DCL	Devens Consolidated Landfill
DRMO	Defense Reutilization Marketing Office
HAZWOPER	Hazardous Waste Operations and Emergency Response
JV	SERES-Arcadis SB JV, LLC
LTM	Long-Term Management
MAAF	Moore Army Airfield
MEC	Munitions and Explosives of Concern
O&M	Operation and Maintenance
OSHA	Occupational Safety and Health Administration
PM	Project Manager
PPE	Personal Protective Equipment
PWS	Performance Work Statement
RA(O)	Remedial Action-Operations
RC	Response Complete
SDS	Safety Data Sheet
SHM	Safety and Health Manager
SOW	Statement of Work
SOP	Standard Operating Procedure
SPIA	South Post Impact Area
SS	Site Superintendent
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
UXO	Unexploded Ordnance

Signature Sheet

Accident Prevention Plan
Fort Devens Army Installation
BRAC Legacy Sites, Massachusetts

I hereby certify that this Accident Prevention Plan is in accordance with contract documents and is submitted for U.S. Army Corps of Engineers (USACE) approval.

Plan Preparer: ______________________________, SERES-Arcadis SB JV, LLC; (484) 402-0740
Laura Kunas, Project Scientist

Plan Approver: ______________________________, SERES-Arcadis SB JV, LLC; (732) 225 5061
Grey Coppi, CIH, Safety and Health Manager

Plan Concurrence:_________________________ , SERES-Arcadis SB JV, LLC; (518) 250-7359
Andy Vitolins, Project Manager

Team personnel assigned to this project shall be familiar with the possible hazards involved, the safety procedures, and other information outlined in this plan. Prior to the commencement of work, the Team Leader/Site Safety and Health Officer will discuss additional procedures to be implemented, addressing any other site-specific conditions that may arise. All on-site personnel of SERES-Arcadis SB JV, LLC and all subcontractors must sign the following Plan Acknowledgement Form (**Attachment C**). By signing below, the undersigned certify they have had the opportunity to read and ask questions about this APP, and that they understand the procedures, equipment, and restrictions of this plan and agree to abide by them.

1 INTRODUCTION

SERES-Arcadis SB JV, LLC (the JV) recognizes a responsibility to provide employees with a safe and healthful workplace and to provide clients with safe and effective services. Through implementation of a project Accident Prevention Plan (APP) and Site Safety and Health Plan (SSHP), the JV seeks to take proactive measures to recognize, evaluate, and control workplace hazards and to implement preventive actions to minimize the potential for employee injuries and illnesses. The APP presents the contractor safety and health procedures to be implemented by the JV for services associated with the Environmental Remediation Services Contract at Fort Devens Army Installation – BRAC Legacy Sites.

The JV's APP along with the SSHP establishes the written safety and health program for personnel involved in project fieldwork and applies and interfaces in conjunction with requirements of the JV Corporate Safety and Health Program (CSHP). The SSHP is provided in **Attachment A**.

The APP has been prepared to meet the requirements of the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) standards, Title 29 Code of Federal Regulations (CFR) Part 1910 and 29 CFR Part 1926 and U.S. Army Corps of Engineers Safety and Health Requirements Manual (Engineer Manual-385-1-1). The primary objective of the APP is to provide the field team with a safe working environment during fieldwork. The APP contains the following major categories of information:

- Signature Sheet
- Background Information
- Statement of Safety and Health Policy
- Responsibilities and Lines of Authority
- Subcontractors and Suppliers
- Training
- Safety and Health Inspections
- Safety and Health Expectations, Incentive Programs and Compliance
- Accident Reporting
- Medical Support
- Personal Protective Equipment (PPE)
- Plans Required by the Safety Manual
- Contractor Information
- Site-Specific Hazards and Controls.

The APP will be primarily implemented by the JV's Project Manager (PM), the Site Safety and Health Officer (SSHO), and Safety and Health Manager (SHM) in coordination with the individual site Points of Contact. Compliance with the APP is required of all JV personnel, subcontractors, and associated third parties on site. A copy of the APP will be maintained on site during work activities and will be available for inspection and review by site or agency personnel. Field personnel will review applicable aspects of the APP before site work and will sign an “APP Review” acknowledgment form (**Attachment C**) indicating they have reviewed the pertinent aspects of the plan.

The content of the APP may be revised and/or amended should additional information become available regarding the hazards present at the site and/or should significant changes occur in the Statement of Work (SOW), operational procedures, site hazards, and/or hazard control measures. The APP may be modified by the SSHO upon review and approval of the PM. Field personnel are informed of changes to the APP and SSHP through safety meetings and written addendum or revision to the APP.

1.1 Contractor

SERES-Arcadis 8(a) JV2, LLC

1.2 Project Name

Environmental Remediation Services, Former Fort Devens Army Installation – Remedial Investigation for Per- And Polyfluoroalkyl Substances (PFAS)

1.3 Site Location

Fort Devens is located approximately 35 miles northwest of Boston, in Middlesex and Worcester Counties surrounded by the towns of Ayer and Shirley, and Harvard and Lancaster, respectively. See **Figures 1 and 2**.

1.4 Site Background and History

The Site, originally known as Camp Devens, was established on September 5, 1917 and declared a permanent installation, formally dedicated as Fort Devens, in 1932. The Base Realignment and Closure (BRAC) Office recommended that Fort Devens’ active-duty mission be eliminated, and a small reserve enclave and training area be maintained for use by the Reserve and National Guard in 1991. On March 31, 1996, Fort Devens was no longer an active-duty installation and was renamed Devens Reserve Training Facility. The Army closed portions of the Main and North Posts in May of 1996, and approximately 3,040 acres were conveyed to the Massachusetts Government Land Bank/Massachusetts Development and Finance Agency, Devens Commerce Center, subsequently renamed and presently known as Mass Development (MassDev).

1.5 Statement of Work

Based on results from the previous PFAS field investigations, the Army is conducting an RI under CERCLA at locations that may potentially be impacted by PFAS. To expedite further field investigations, the identified AOCs, the Grove Pond wellfield, and MacPherson, Patton, and Shabokin water supply well areas were grouped into three areas (Areas 1, 2, and 3).

The three areas were designated for sequencing of field activities and do not represent prioritization. After completion of initial field activities to support completion of the RI (considered to be Phase 1 activities), the three areas were re-grouped for further (Phase 2) field investigation.
Area 1 comprises:

- AOC 43G Historical Gas Station G
- AOC 43J Historical Gas Station J
- AOC 57 Building 3713 Fuel Oil Spill Site, including portions of AOC 44 (part of the Barnum Road Maintenance Yards)
- AOC 74 Barnum Road Firefighting Exercise Site
- AOC 75 Former Building T-1445 Warehouse Fire
- Grove Pond wellfield
- Patton water supply well / AOC 40 Cold Spring Brook Landfill / Area Requiring Environmental Evaluation (AREE) 61I/61H
- Shabokin water supply well

This Area 1 - Phase 2 PFAS RI addresses only Area 1 (AOCs 43G, 43J, 57 [including portions of AOC 44], 74, 75, Grove Pond Wellfield, and Fort Devens water supply wells Patton [incorporating AOC 40] and Shabokin). The other AOCs and areas of investigation for the RI will be addressed separately.

The three areas were designated for sequencing of RI field activities and do not represent prioritization. The goal of the RI is to:

- Determine the nature and extent of PFAS in groundwater, soil, surface water, and sediment.
- Determine whether PFAS sources at Devens are impacting public water supply wells.
- Evaluate whether PFAS are present in environmental media at concentrations that pose an unacceptable risk to human health or the environment.

After completion of initial field activities to support completion of the RI (considered to be Phase 1 activities), the three areas were re-grouped for further (Phase 2) field investigation. This Phase 2 PFAS RI WP addresses only Area 1 (AOCs 43G, 43J, 57 (including a portion of AOC 44), 74, 75, Grove Pond Wellfield, and Devens water supply wells Patton [incorporating AOC 40 and Area Requiring Environmental Evaluation (AREE) 61I/61H] and Shabokin). The other AOCs and areas of investigation at Devens that require an RI will be addressed separately.
The objective of the Area 1- Phase 2 RI WP is to collect data sufficient to meet USACE and regulatory requirements and support remedial alternative decisions, if needed.

Development and implementation of an exit or ramp-down strategy for all RA(O) activities at the site including transition from the current active remediation to a monitored natural attenuation strategy and the optimization of all capital and long-term operational costs, resolution of the site conceptual site model, the evaluation and selection of an alternate remedy through the CERCLA process, and implementation of the remedy Long-Term Monitoring and Maintenance Plan.

All administrative tasks will be completed in an office environment while the remaining tasks will be completed onsite with the use of various groundwater water sampling equipment and offsite using a fixed analytical laboratory.

1.6 Project Work Activities

For the purposes of this APP, the JV has organized project activities into the following primary field project work tasks:

- Mobilization and demobilization of all necessary materials, tools and equipment
- Drilling
- Determine the nature and extent of PFAS in groundwater, soil, surface water, and sediment.
- Determine whether PFAS sources at Devens are impacting public water supply wells.
- Evaluate whether PFAS are present in environmental media at concentrations that pose an unacceptable risk to human health or the environment.

2 STATEMENT OF SAFETY AND HEALTH POLICY

The JV has established this project APP to assist in providing a safe and healthful workplace. The JV recognizes a responsibility to provide employees with a safe and healthful workplace and to provide clients with safe and effective services. The JV considers safe operations and accident prevention to be a priority. One of the JV's goals for accident prevention is to maintain its excellent accident experience record.

Through implementation of this APP, the JV seeks to take proactive measures to anticipate, recognize, evaluate, and control workplace hazards and to implement preventive actions to minimize the potential for employee injuries and illnesses.

The safety of employees is considered to be of paramount concern in performance of company operations as employees are our most important asset and their wellbeing our greatest responsibility. The safety and health of every worker must be a primary consideration in every business decision and plan. JV management will maintain a safety and health program that conforms to the best practice of organizations of this type.

To be successful, such a program must encourage proper attitudes toward accident prevention on the part of both supervisors and employees. It also requires cooperation in all safety and health program aspects, not only between supervisors and employees, but also between employees and their fellow workers. Only through such a cooperative effort can an effective safety and health program be maintained.

One of the primary objectives of the JV Safety and Health Program is to prevent accident occurrence. There is no phase of company operations of greater importance than accident prevention. Accidents and injuries can be prevented. Our goal is zero accidents and injuries. A good safety record is evidence of effective managerial performance and preserves both human and economic resources of the company. It is the JV's policy to do everything reasonable to protect employees, subcontractors, clients, and the public from the results of accidents.

To establish and maintain an effective safety and health program, the following must be accomplished:

- Provide a safe work environment by having a safe workplace, equipment, and materials
- Establish safe work operations, safe work rules and procedures, and comply with accepted safe work practices and safety and health regulations
- Provide safety and health training to help personnel work safely and to promote an understanding that each individual has a duty and responsibility to protect themselves and others

Everyone in this organization must actively support and participate in the JV CSHP and accept the premise that "Accidents Can Be Prevented."

2.1 Safety and Health Goals and Objectives

Safety and health goals and objectives are to:

- Familiarize site personnel with the APP and seek their support in attaining safety and health goals.
- Provide a safety program that promotes safe working conditions and safe work practices.
- Prevent accidents, incidents, injuries, and illnesses.
- Create and reinforce safety conscious attitudes among employees.
- Provide a basis for continuing employee safety training.
- Identify persons with authority and responsibility for APP implementation.
- Establish a system for ensuring employee compliance with safe work practices.
- Establish procedures for identifying and evaluating workplace hazards.
- Implement procedures for reporting and investigating injuries and illnesses.
- Establish procedures for correcting unsafe workplace conditions and unsafe work practices.
- Provide safety and health training and instruction for employees.

2.2 Measures for Accomplishing Safety and Health Goals and Objectives

Measures for accomplishing safety and health goals and objectives are to:

- Anticipate, recognize, evaluate, and control potential accident-producing situations through preplanning of safety and health considerations into work activities.
- Implement a safety inspection program to identify and correct unsafe work conditions, work practices, and work procedures.
- Train employees to recognize hazards, implement safe work procedures, and use safe work practices.
- Develop and enforce safety and health rules and require employees to adhere to these rules as a condition of employment.
- Use engineering and administrative safety controls and supplement with necessary PPE for worker protection.
- Report and investigate accidents promptly to determine cause and take corrective action to prevent recurrence.

3 RESPONSIBILITIES AND LINES OF AUTHORITIES

Section 3.1 "*The JV Key Safety Personnel and Health and Safety Responsibilities*" provides the lines of authority, identifies the key project personnel, and provides a description of the JV personnel safety & health responsibilities. Listed personnel include those individuals serving in the following functions: SHM, PM, and SSHO.

The SSHO has a direct reporting relationship to the SHM regarding all Safety & Health matters. The SHM has a direct reporting relationship to the JV President. The resumes and qualifications for the JV SHM and SSHO are located in **Attachment D** of this APP. An Organizational Chart providing the lines of authority is located in **Attachment B** of this APP.

3.1 JV Key Safety Personnel and Health and Safety Responsibilities

3.1.1 Safety and Health Manager

The SHM, Grey Coppi, is a Certified Industrial Hygienist (CIH) whose Safety and Health responsibilities are:

- Oversee the development and approve the APP & SSHP
- Conduct Safety and Health inspections and audits as scheduled with the PM
- Provide Safety and Health technical assistance to the PM and SSHO

3.1.2 Project Manager

The PM, Andy Vitolins, is responsible for overall direction, coordination, technical consistency, and review of the project contract. PM Safety & Health responsibilities are:

- Direct, coordinate, and implement the project contract
- Review and approve the APP and SSHP
- Emphasize safety and hold personnel accountable for safe work performance
- Enforce implementation and compliance with the APP and SSHP
- Provide support to the SSHO for effective completion of duties
- Monitor and evaluate Safety & Health performance of project operations
- Communicate with the Contracting Officer's Representative (COR) to evaluate and resolve Safety & Health issues.

3.1.3 Site Safety and Health Officer

The SSHO staff for this event is to be determined.

The SSHO will be the OSHA competent person and will have successfully completed the OSHA 40-Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training. Training records are included in **Attachment D**. If the SSHO must be absent from the site, the Safety and Health duties will be delegated to another qualified person at the site.

SSHO Safety and Health responsibilities are:

- Review the APP & SSHP
- Maintain copies of the APP & SSHP on site during field activities
- Develop Activity Hazard Analysis (AHAs) and conduct pre-task AHA reviews with project personnel
- Implement provisions of the APP & SSHP and the JV CSHP
- Require that site personnel meet training and medical surveillance requirements
- Conduct site orientation training, APP & SSHP review, and daily safety meetings
- Emphasize safety and hold personnel accountable for safe work performance
- Review site hazards and establish safety control measures
- Maintain a hazardous substance inventory list
- Maintain copies of safety data sheets (SDSs)
- Maintain safety equipment and supplies
- Perform inspections for safe work operations
- Enforce implementation and compliance with the APP & SSHP
- Establish site control work zones and boundaries
- Determine PPE requirements and monitor proper use
- Direct decontamination procedures to be used
- Perform and/or coordinate site exposure monitoring
- Report safety violations or Safety and Health concerns promptly to the PM
- Ensure correction of unsafe work conditions and/or unsafe work practices
- Monitor and evaluate Safety and Health performance of project operations
- Maintain Safety and Health records
- Report and investigate accidents and incidents
- Communicate with the COR to evaluate and resolve Safety and Health issues

3.1.4 Munitions and Explosives of Concern/Unexploded Ordnance Quality Control

An Unexploded Ordnance (UXO) technician will be identified closer to the fall 2020 Sampling event to perform the MEC/UXO inspections at the appropriate Fort Devens locations.

This UXO technician will have successfully completed the OSHA 40-Hour HAZWOPER training, OSHA 30-Hour Construction Training, Certified Level I/II Munitions X-Ray Identification, U.S. Navy (1997), Update by U.S. Army Technical Escort Unit (2002), Mine Field Clearance Certified, On-the-Job-Training with U.S. Army (1988-1999), UXO Certification, USACE Huntsville Center (No. 0682; 1977). Training records are included in **Attachment D**. The JV and its subcontractors shall comply with MEC related guidance that includes, but is not limited to, the following:

(1) MEC includes: UXO, as defined in 10 U.S.C. 101(e)(5); discarded military munitions as defined in 10 U.S.C. 2710(e)(2); or Munitions Constituents, as defined in 10 U.S.C. 2710(e)(3), present in high enough concentrations to pose an explosive hazard.

(2) MEC distinguishes specific categories of military munitions that may pose unique explosives safety risks. Because MEC being actively managed may be determined to be hazardous waste, and some of the activities conducted pursuant to this Performance Work Statement (PWS) may take place at a facility listed on the National Priorities List, 29 CFR, Hazardous Waste Operations and Emergency Response, Section 1910.120 may apply.

Per the guidelines set forth in DoDI 4140.62 and Department of Defense Explosive Safety Board Technical Paper 18, UXO qualified personnel will be responsible for determining the explosive safety status of any material recovered that may pose an explosive hazard (i.e., material potentially presenting an explosive hazard.

(3) As specified in the task order PWS, should MEC be encountered during this response, UXO-qualified Contractor personnel will evaluate the explosive hazard and remove it, including by open detonation in place. This response will be conducted per the CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan, applicable state and federal regulation, and applicable DoD, U.S. Army policies and procedures.

3.2 Competent and/or Qualified Person(s)

JV personnel performing work under this scope of work will be considered a Competent and/or Qualified Person. All project personnel will have extensive knowledge, training and experience such that they have successfully demonstrated the ability to solve or resolve problems relating to the subject matter, the work, or the project.

3.3 Performance Requirements

No project site work shall be performed unless one of the Competent and/or Qualified Person(s) or their designee is onsite.

3.4 Pre-Task Safety and Health Analysis

Pre-Task Safety and Health Analysis will be reviewed with project personnel during the initial APP/SSHP review, before starting each Definable Feature of Work, and periodically during daily tailgate Safety & Health meetings. The Pre-Task Safety and Health Analysis, also known as AHA, is located in Appendix C of the SSHP (refer to **Attachment A**).

3.5 Lines of Authority

An Organizational Chart providing the lines of authority is located in **Attachment B** of this APP.

3.6 Policies/Procedures for Non-Compliance with Safety Requirements

Section 3.8 of the APP outlines the policy regarding non-compliance with Safety requirements.

3.7 Accountability Procedures for Managers and Supervisors

Under Section 3.8.1 of this APP, disciplinary action is taken for managers and supervisors who fail to follow safety requirements. Additionally, negative ratings for employee performance reviews that affect merit pay increases are also implemented for managers and supervisors.

3.8 Safety Compliance System

A safety compliance system is established to make sure that employees comply with safe work practices and safety and health policies and procedures. The system's effectiveness is highly dependent upon the involvement, direct supervision, and enforcement of safety requirements by supervisory personnel. The system includes:

- Safety and health Standard Operating Procedures (SOPs)
- Safety inspection program
- Recognition for employees who follow safe work practices
- Disciplinary actions for unsafe work performance

3.8.1 Disciplinary Action

The JV policy requires that employees adhere to established safe work practices and procedures. If employees violate safety procedures or rules, they will be disciplined in accordance with the severity of the infraction. Employees who exhibit unsafe work performance will receive disciplinary action from the PM and SSHO in consultation with the SHM. Disciplinary action can include the following, depending upon the severity of the safety infraction:

- Verbal warning
- Written warning notice
- Termination of employment
- Other disciplinary action

Similar disciplinary action is taken for managers and supervisors who fail to follow safety requirements. Additionally, negative ratings for employee performance reviews that affect merit pay increases are also implemented for managers and supervisors.

3.8.2 Safety Recognition

Safety recognition and safety incentive programs are initiated for specific projects to promote improvement in safety compliance and/or safety performance. Such programs are established by the PM and SSHO in consultation with the SHM. The JV implements a safety incentive program for field employees to help emphasize, promote, encourage, and reinforce safe work performance. The primary objectives of the program are to: help communicate the corporate commitment to safety and health, focus attention on safety and health at the field level, and to recognize, reward, and extend appreciation to those employees who have demonstrated safety consciousness and achieved incident-free work performance. The program is established for selected categories of field employees (hourly operators, laborers, technicians, and operations and maintenance staff).

3.9 Safety Communications System

A system for communication with employees regarding matters related to safety and health will be established and will include employee reporting of identified hazards, safety training, daily safety meetings, safety information postings, and written communications.

3.10 Employee Reporting of Identified Hazards

Employees are encouraged and required to inform the Site Superintendent (SS) and SSHO of unsafe or hazardous conditions that are identified. Additionally, employees are encouraged to report observed unsafe work practices by employees, supervisors, or other individuals. Employees may communicate directly with the PM, SSHO, and/or SHM regarding any safety matter. No employee will be disciplined or otherwise discriminated against for reporting or correcting an unsafe condition. Employees may make anonymous reports of unsafe conditions or violations of safety rules to the SSHO or SHM for follow-up action.

3.11 Safety Information Posting and Written Communications

Safety posters, articles, notices, and other safety-related information will be posted in an area designated for employee review. These postings may include safety posters; safety memorandums; safety inspections; incident investigation reports; safety notices and articles; safety training information; and posting of OSHA and labor law postings.

3.12 Personal Protective Equipment

PPE will be required for certain field operations based on the potential for site hazards. The SSHO and SHM will establish appropriate levels of protection for each work activity based on review of site information, existing contaminant data, and evaluation of the potential for exposure. The SSHO and SHM will establish action levels for upgrade or downgrade in the initial minimum levels of protection. The APP and SSHP addresses site conditions that require “Level D” PPE with provisions in place for an upgrade to Level C. If conditions are encountered that require upgrading to Level C, work will be stopped and the SHM and PM consulted. Work will not proceed until the necessary engineering controls have been implemented.

4 SUBCONTRACTORS AND SUPPLIERS

Subcontractors will be used to provide selected services associated with performance of project work. Subcontractors who come on site to perform fieldwork and/or enter controlled areas of the site are subject to SSHP requirements. The JV requirements for controlling and coordinating subcontractor compliance with safety and health requirements are detailed below.

- Subcontractors are required to follow applicable Federal, State, and local governmental regulations, applicable requirements of the JV APP/SSHP, and customer requirements for work at their facilities.

- Subcontractor workers are required to obey directives from the SSHO.

- Subcontractor personnel who do not comply with safety and health requirements may be immediately dismissed from the site by the PM, SS, and/or SSHO.

- Subcontractor personnel (or subcontractor representative) will attend daily safety meetings conducted by the SSHO prior to starting work to review work operations and to discuss pertinent site safety topics.

- Subcontractors will provide copies of required safety and health training and certification documents to the SSHO, as applicable (i.e., licenses, training certifications, medical clearance [fitness for duty] certification, first-aid/cardiopulmonary resuscitation [CPR] training, respirator fit testing).

- Subcontractors will provide, before site work, a hazardous substances inventory list and copies of applicable SDS to the SSHO for hazardous substances to be brought on site by the subcontractor.

- Subcontractors will provide AHAs for subcontractor work activities. A detailed AHA is required for every phase of operations from all participants. The detailed AHA will ensure that every phase and the tasks involved in those phases are considered to identify the associated hazards and risks during the operation. These task and hazard risk analyses must be modified as needed to address a changing work environment.

- Subcontractors will enforce applicable SSHP requirements with subcontractor employees.

- Subcontractors will review, understand, and comply with the SSHP and safety instructions from the SSHO or other competent authority.

- Subcontractors will observe the buddy system during work activities.

- Subcontractors will promptly report unsafe work conditions or unsafe work practices to the subcontractor supervisor and the SSHO.

- Subcontractors will immediately report all injuries or illnesses to the subcontractor supervisor and the SSHO.

The JV does not anticipate working in close proximity with other contractors who are not directly related to this project as no other known projects are underway at the planned project locations.

5 TRAINING

Mandatory site-specific training is required for this project and a description of Safety and Health training procedures and requirements are included below. Copies of safety and health training certificates will be reviewed and maintained by the SSHO. Personnel will not be allowed to perform fieldwork until the SSHO has determined this documentation to be complete and sufficient. Workers assigned to fieldwork on this project are required to have completed the following training:

5.1 SSHO

- OSHA 40-Hour HAZWOPER Training
- OSHA 8-Hour HAZWOPER Supervisor Training
- OSHA 8-Hour HAZWOPER Refresher Training
- OSHA 30-Hour Construction Safety and Health Training
- Bloodborne Pathogen Training
- First-Aid/CPR Training

5.2 Site Personnel

Safety Indoctrination Training – All employees involved in sampling activities must be 40-hour HAZWOPER trained and also trained on the potential hazards of the project including accident prevention awareness, general safety requirements including those contained in this APP/SSHP, a discussion of AHAs, location of medical facilities, location of fire extinguishers and first aid kits, accident reporting procedures, and any other training deemed to be pertinent. Daily safety tailgate attendance is also required.

5.3 Training and Safety Meetings

Employees receive safety training regarding potential hazards associated with their work assignments. All employees will attend a MEC General Awareness Training prior to any activities given the known possibility of encountering UXO at the site. After the meeting, employees will be able to identify MEC in order to stop work, if encountered. The SSHO and PM will be contacted immediately, and Army personnel will be notified of the potential hazards in order to contact the proper authorities.

UXO clearance should be undertaken before any ground-intrusive activities commence.

Copies of certificates of safety and health training for site personnel is reviewed and maintained by the SSHO. First Aid and CPR training certificates for the SSHO and alternate SSHO are provided in **Attachment D**. Personnel are not allowed to complete fieldwork requiring specific training until such documentation has been presented to the SSHO.

Site orientation safety meetings, that involve review of pertinent aspects of the APP, are completed for personnel before project fieldwork. Daily safety meetings are conducted for field operations and attendance is documented. Daily safety meetings held by the SSHO at the job site are designed to:

- Provide instruction regarding hazards specific to each employee's job assignment.
- Act as safety and health training program to instill safe and healthful work. practices.
- Remind employees that compliance with safe work practices is required.
- Instill a constant sense of safety-consciousness among supervisors and employees.
- Provide opportunity for employees to bring forward concerns and ideas about safety issues.
- Reassure employees to inform supervisors of work site hazards without fear of reprisal.

6 SAFETY AND HEALTH INSPECTIONS

Th JV will conduct safety inspections of its work operations. The JV anticipates conducting daily jobsite safety inspections and daily equipment inspections during the project. Inspections will be conducted and/or coordinated by the SSHO. No external safety inspections are planned for this scope of work.

6.1 Safety Inspections

The SHM, SSHO, and project supervisors complete safety inspections of project sites and work areas periodically. The SSHO will complete daily safety inspections of work sites to identify and correct hazards. Contractor quality control personnel, as part of their quality control responsibilities, conduct and document daily safety inspections. The SSHO records identified safety and health issues and deficiencies and will indicate the actions, timetable, and responsibility for correction of deficiencies. The SSHO conducts follow-up inspections to correct identified deficiencies and documents these inspections in a like manner.

Safety inspections include work areas, equipment, work practices, and work procedures. Noncompliance items with APP requirements are to be corrected immediately or in a timely manner based on the classification of the hazard as imminent or non-imminent. In the case of unsafe or hazardous machinery, the equipment or area will be “red-tagged” (shut down or evacuated) until the hazard has been corrected. Employees are responsible for inspecting their work areas and equipment for unsafe or hazardous conditions. Employees should correct all unsafe conditions and report them immediately to their supervisor. Maintenance employees must periodically inspect and/or test field equipment for safe and hazard-free operation.

The SHM may also conduct field safety inspections/audits of projects upon the request of the PM. The frequency of these inspections will be at the evaluation of the SHM and PM based on the type of job activities and potential hazards to be encountered on the project.

7 ACCIDENT REPORTING

Site Management will receive immediate verbal notification and written notification within 24 hours for incidents involving a serious injury, explosion, fire, or a spill/release of toxic materials. Important requirements for incident reporting and follow up are described below.

- All accidents and near misses shall be investigated by the Contractor. All work-related recordable injuries, illnesses and property damage accidents (excluding on-the-road vehicle accidents), in which the property damage exceeds $2,000.00, shall be verbally reported to the COR within 24 hours of the incident. Serious accidents as described in Engineer Manual-385-1-1 Section 01.D.02 shall be immediately reported to the COR. ENG Form 3394 shall be completed and submitted to the COR within five working days of the incident.

- Employees must immediately report all incidents, injuries and illnesses, property damage, liability exposure cases, spills, fires, and serious near miss incidents to their supervisor or the SSHO.

- In the event of a serious incident, supervisors are responsible for notifying the SS and SSHO, who in turn are responsible for notifying the JV PM and the SHM. The SHM should be contacted immediately in injury or illness cases to assist with coordination of required medical assistance and related workers' compensation case management follow up.

- If a serious injury occurs during the project, the SSHO will immediately report the incident to the PM, SHM, COR, and the appropriate government agencies. The JV will give the COR verbal notification and a follow-up email immediately following events such as, but not limited to, a lost workday injury, followed by a written notification within 24 hours.

- The SSHO and the supervisor(s) responsible for an activity involved in an incident will participate in a complete investigation and will inspect the area or equipment involved (as applicable).

- This includes completion of an "Incident Report by Supervisor," "Incident Statement by Employee," "Incident Statement by Witness," "Injury and Illness Report," "Property Damage, Loss, and General Liability Report," and "Vehicle Accident Report," as applicable, with the SHM within 24 hours of the injury (immediately to all incidents including minor and serious injuries or fatalities).

- In addition to those notified for a serious injury, the SHM must be notified immediately of any incident involving hospitalization, amputations, or loss of an eye, or fatality. The SHM will conduct an immediate investigation. The SHM is responsible for notifying the jurisdictional OSHA office as soon as possible and no later than 8 hours of a workplace fatality. (Note: This notification includes weekend days as 24-hour emergency reporting access is available). The SHM will also notify OSHA of all work-related in-patient hospitalizations, amputations and loss of an eye within 24 hours. The SHM will act as the agency interface upon their investigation. The report to OSHA must include: time and date of accident; employer's name, address, and telephone number; name and job title of person reporting the accident; address of the site of the accident; name of person to contact at the site of the accident; name and address of any injured employee(s); nature of injury; location where the injured employee was moved to; list and identity of other law enforcement agencies present at the site of the accident; and description of the accident and whether the accident scene has been altered.

- The SSHO will obtain a doctor's first report of injury for every injury or illness requiring medical treatment and will immediately forward to the SHM.

- An injured worker is not allowed back to work until a return-to-work notice issued by the treating physician and negative drug and alcohol test documentation (as applicable) are presented to the SSHO. Any injured worker issued a work restriction shall be under the direct supervision of the SSHO and shall be assigned work activities within the restriction until a full duty status clearance has been received.

- The SHM will make a telephone report for all claims covered under the JV Workers’ Compensation Policy. Reports are made to the workers’ compensation insurance claim- reporting center where an employer’s first report of injury or illness form is completed over the phone. After reporting a claim to the reporting center, the information is faxed by the reporting center to the claims service office to handle the claim. Any subsequent medical bills and reports received for the claim are forwarded to the SHM who will subsequently mail them to the claims service office.

- When a worker returns to work after an injury or illness, the SHM will contact the claims servicing office to advise them of the actual date of return to work. Questions or inquiries are to be directed to the Corporate Health and Safety Manger who will contact the claims service office or the JV insurance company, as needed

- The SHM records each injury or illness on the OSHA Form No. 300 “Log of Work-Related Injuries and Illnesses” and the OSHA Form 300A “Summary of Work-Related Injuries and Illnesses.” The OSHA 300 form is posted annually no later than February 1 (of the following year) and is kept posted for three months (until April 30).

8 PLANS REQUIRED BY THE SAFETY MANUAL

Plans that are applicable to project work are reviewed below.

- Emergency response plan: Procedures and tests
- Hazard communication program
- Respiratory protection program
- Health hazard control program
- Contingency plan for severe weather
- SSHP
- Alcohol and drug abuse prevention plan
- Site sanitation plan
- Fire prevention plan

8.1 Layout Plans for Temporary Structures

Not applicable.

8.2 Emergency Response Plan: Procedures and Tests

The JV SSHP (refer to **Attachment A**) details the JV project emergency response plan. Emergency procedures and tests including emergency services and personnel, emergency supplies, site and emergency communications, emergency hospital and route information, medical emergency incident response, fire or explosion incident response, chemical spill incident response, and incident reporting are detailed in the SSHP Section 8.

8.3 Emergency Response Plan: Posting of Emergency Telephone Numbers

SSHP Section 8.1 contains the JV requirements for posting of emergency telephone numbers, emergency hospital information, and the emergency hospital route. An Emergency Contact List, including Emergency Hospital and Route information, is included in the SSHP Figures and Appendix B respectively.

8.4 Emergency Response Plan: Man Overboard/Abandon Ship

All on-site project personnel will follow the associated Boating Accident Hazard Analysis (refer to Attachment D of the JV SSHP). Staff will don the appropriate personal floatation device and know the location and proper use of lifesaving devices (throw ring, throw bag, reach poles, cargo net, ladder).

8.5 Onsite Medical Support

All on-site project personnel will be first aid/CPR-trained.

8.6 Offsite Medical Support

The JV uses Concentra Occupational Health Services to provide occupational physician support services. Concentra physicians are Board-Certified (or Board-Eligible) and provide medical director services to the JV.

8.7 Alcohol and Drug Abuse Prevention Plan

The JV has a substance abuse policy that establishes requirements for a drug-free workplace. The JV requires that post-accident drug and/or alcohol testing be conducted when employees have caused or contributed to an on-the-job injury resulting in loss of work time or damage to property. A copy of the JV's policy is maintained at the Westborough, Massachusetts office.

8.8 Site Sanitation Plan

SSHP Section 6.7 "Sanitation" reviews the JV sanitation procedures.

8.9 Access and Haul Road Plan

Not applicable. Project does not require an Access and Haul Road Plan.

8.10 Respiratory Protection Plan

SSHP Section 10.0 "Air Monitoring Plan" reviews the JV's air monitoring requirements. The JV's "Respiratory Protection Program" (located in Appendix I of the SSHP) shall be referred to for respiratory protection guidance and requirements. It is anticipated that respiratory protection will not be required during site activities based on monitoring data from prior sampling events. Should the need arise during performance of site activities, respiratory protection will be implemented in accordance with OSHA standards.

8.11 Health Hazard Control Program

Health hazard controls are integrated in the AHAs for the project and are located in Appendix C of the SSHP.

8.12 Hazard Communication Program

SSHP Section 6 .4 "Hazard Communication" reviews the JV hazard communication procedures. The SSHO will maintain a hazardous substance inventory list and copies of SDSs for hazardous substances to be used during project work. Site personnel will be informed of the hazardous substances they will be working with through APP review and attendance at daily safety meetings.

8.13 Process Safety Management Plan

Not applicable. Storage or handling of highly hazardous materials is not required for this project.

8.14 Lead Abatement Plan

Not applicable. Lead abatement is not anticipated for this project.

8.15 Asbestos Abatement Plan

Not applicable. Asbestos abatement is not anticipated for this project.

8.16 Radiation Safety Program

Not applicable. Radiation exposure is not anticipated for this project.

8.17 Abrasive Blasting

Not applicable. Abrasive blasting is not anticipated for this project.

8.18 Heat/Cold Stress Monitoring Plan

SSHP Section 8.4 “Emergency Medical First Aid Procedures” reviews the JV heat/cold stress monitoring plan.

8.19 Crystalline Silica Monitoring Plan

Silicosis is a disabling, nonreversible and sometimes fatal lung disease caused by exposure to crystalline silica. Controlling exposure to silica dust at the source should be the primary means for protecting workers from silicosis. During well construction, drilling sand will be utilized which contains crystalline silica. Disposable respirators (NIOSH rating of N95 or higher as appropriate based on dust concentrations) will be available to be used by site workers to mitigate dust exposure if visible dust becomes present. Wet sawing or other engineering controls should be used to reduce the production of dust as to adequately protect site workers. Work areas will be cordoned off to minimize the number of employees who could potentially encounter dust hazards.

SSHP Section 10.0 “Air Monitoring Program” reviews the JV’s air monitoring requirements. The JV “Respiratory Protection Program” in Appendix I of the SSHP shall be referred to for guidance on appropriate respirator use.

8.20 Night Operations Lighting Plan

Not applicable.

8.21 Fire Prevention Plan

SSHP Section 8.3 “Emergency Response Procedures” reviews the JV fire prevention procedures. Procedures for fire hazards, fire protection, and hot work are reviewed. Emergency fire procedures are also reviewed in the emergency response plan section of the SSHP.

8.22 Emergency Response Plan: Wild Land Fire Prevention Plan

Not applicable.

8.23 Hazardous Energy Control Plan

Not applicable. Exposure to hazardous energy is not anticipated for this project.

8.24 Critical Lift Plan

Not applicable.

8.25 Contingency Plan for Severe Weather

SSHP Section 3.2.11 “Contingency Plan for Severe Weather” reviews the JV contingency for severe weather. Safety procedures for cases of inclement weather or other adverse environmental conditions (i.e., strong winds, rain, freezing, lightning, hurricane, tornado, and earthquake) are reviewed.

8.26 Float Plan

Not applicable.

8.27 Site Specific Fall Protection & Prevention Plan

SSHP Section 3.2 “Physical Hazards” lists and reviews the primary physical hazards anticipated for site work, including slips, trips, and falls.

8.28 Demolition Plan: Engineering and Asbestos Surveys

Not applicable.

8.29 Excavation and Trenching Plan

Not applicable.

8.30 Emergency Rescue: Tunneling

Not applicable.

8.31 Underground Construction Fire Prevention and Protection Plan

Not applicable.

8.32 Compressed Air Plan

Not applicable.

8.33 Formwork and Shoring Erection and Removal Plan

Not applicable.

8.34 Pre-Cast Concrete Plan

Not applicable.

8.35 Lift Slab Plans

Not applicable.

8.36 Steel Erection Plan

Not applicable.

8.37 Site Safety and Health Plan

A detailed SSHP has been prepared and is included as **Attachment A**.

8.38 Blasting Plan

Not applicable.

8.39 Diving Plan

Not applicable.

8.40 Confined Space Plan

The JV has provided a detailed confined space plan in section 3.2.10 of the SSHP (**Attachment A**). Though no confined space entry is anticipated for this work, guidelines provided in the plan will be followed if the need arises.

8.41 Unexploded Ordnance Plan (UXO)

Any required UXO screenings will be performed prior to the start of any intrusive work and/or excavating. This will be completed by a certified UXO Technician. UXO screenings will be completed in two-foot intervals during excavation work to ensure no hazards exist. The SOP for MEC Anomaly Avoidance is included as Appendix M in the Attached SSHP.

9 RISK MANAGEMENT

9.1 Hazard Identification and Evaluation System

For the project, the SHM and SSHO are responsible for establishing a system for identification and evaluation of workplace hazards. This system includes development of the APP, preparation of AHAs for work activities, and periodic safety inspections of job sites.

9.1.1 Accident Prevention Plan

Hazard identification and evaluation requirements are primarily accomplished through preparation and implementation of the APP. Project management personnel, SSHO, and the SHM review information relating to project work tasks to be completed; methods to be used; working conditions to be encountered; and chemical, physical and/or biological hazards present. A written site-specific APP is prepared that contains AHAs for primary project work tasks. The APP establishes site-specific safety protocols and contains information to protect employees from potential hazards. The APP is revised whenever additional information becomes available concerning the hazards present at the site and/or should significant changes occur in the scope of work, operational procedures, site hazards, and hazard control measures. This information is reviewed with site personnel at the jobsite before work operations begin. Additional hazards associated with project operations are also identified and evaluated through periodic safety inspections, accident investigations and follow-up, and employee reporting of unsafe or hazardous conditions.

9.2 Activity Hazard Analyses

AHAs are prepared before beginning each major phase of work (operations involving a type of work presenting hazards not experienced in previous operations or where a new subcontractor or work crew is to perform). The AHA reviews hazards and control measures for primary site tasks. The AHA defines the activities to be performed and identify the sequence of work, specific hazards anticipated, and control measures to be implemented to eliminate or reduce each hazard to an acceptable level. Work does not proceed on that phase of work until the AHA has been reviewed with all personnel involved with the activity. The AHA is continuously reviewed and modified when appropriate to address changing site conditions or operations. AHA modification occurs only with the concurrence of the SHM.

9.3 Hazard Correction System

An effective hazard correction system must be established for correction of unsafe or unhealthful work conditions, work practices, and work procedures. These corrective measures are required to be completed in a timely manner. If an imminent hazard is identified, the PM and SSHO are notified immediately. Corrective measures are then taken on an immediate basis to eliminate the hazard. If the imminent hazard cannot be immediately eliminated, personnel are to be removed from the work area and the SSHO will evaluate what safety procedures and corrective actions are to be implemented. If a non-imminent hazard is identified, the SSHO is notified and corrective actions implemented in a timely manner. Evaluation of the time period allowed for correction of the hazard is at the professional judgment of the SSHO in conjunction with the PM and SHM.

10 CONTRACTOR INFORMATION AND SITE-SPECIFIC HAZARDS AND CONTROLS

SSHP Section 3.0 “Potential Hazards” reviews anticipated site hazards and safety control measures for chemical, physical, and biological hazards.

10.1 Chemical Hazards

SSHP Section 3.1 “Chemical Hazards” reviews chemical hazards anticipated for project fieldwork.

Chemical substances with anticipated use during site work include:

- Fuels: Diesel and gasoline fuel for vehicles and equipment
- Fire extinguishing agent: Dry chemical for fire extinguishers
- Chemicals: Hydrochloric Acid, Nitric Acid, and Sulfuric Acid
- Chemicals: Isopropyl alcohol (methanol) and Alconox® for decontamination of equipment
- Isobutylene and methane calibration gases
- Inorganic, volatile and semi-volatile organic compounds from contaminated groundwater including the emerging contaminants PFAS.

10.2 Physical Hazards

SSHP Section 3.2 “Physical Hazards” lists and reviews the primary physical hazards anticipated for site work:

- Fire hazards
- Vehicle and pedestrian hazards
- Equipment hazards
- Tools, machinery, and equipment use
- Electrical hazards
- Noise hazards
- Heat/cold stress
- MEC/UXO
- Inclement weather and other adverse environmental conditions
- Slips, trips, and falls.

10.3 Biological Hazards

- SSHP Section 3.2 “Physical Hazards” and Section 3.2.4 “Biological Hazards” lists and reviews biological hazards that may potentially be encountered during site work:

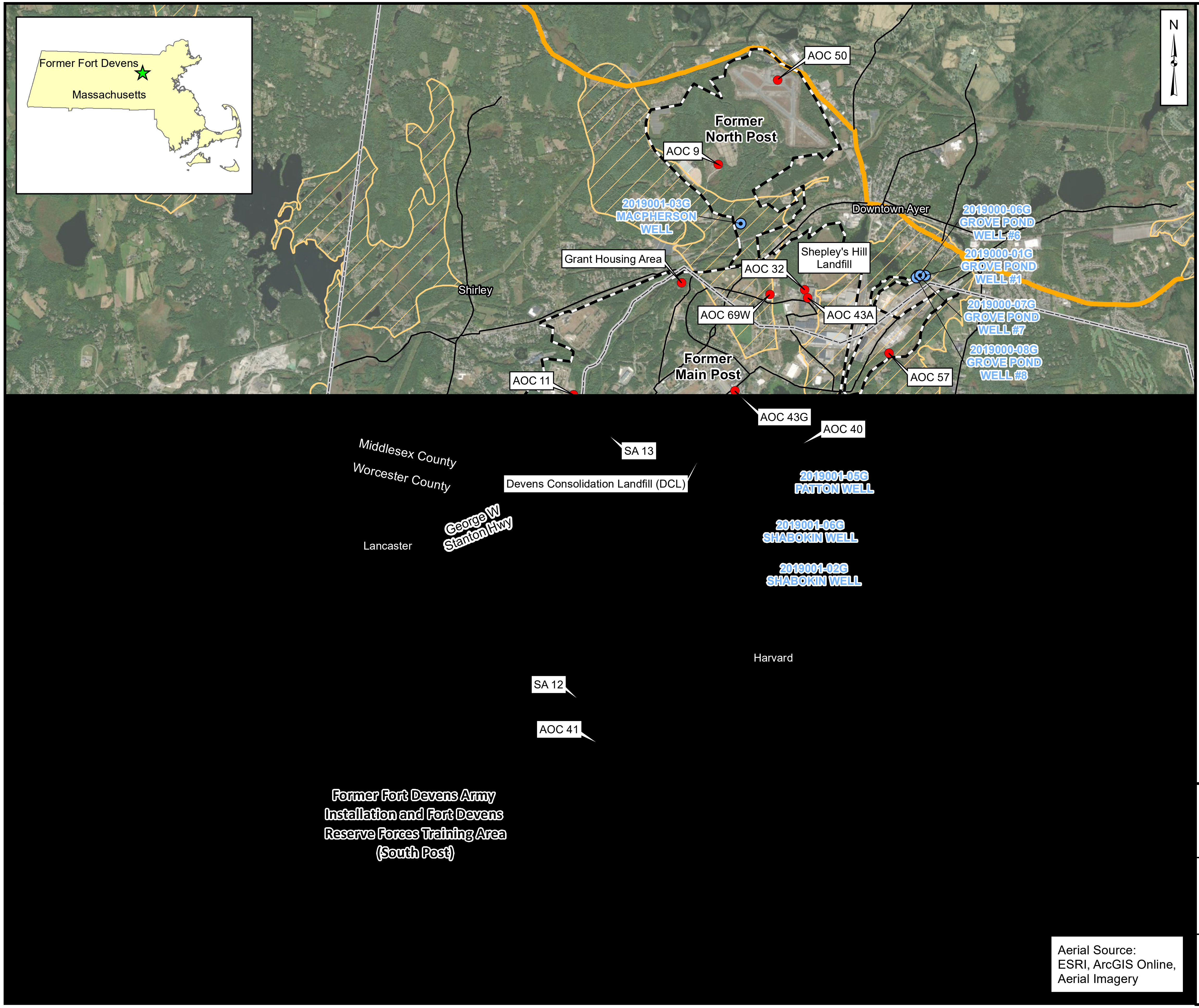
- Poisonous plants
- venomous snakes/spiders
- Rodents
- Insects
- Ticks
- Mosquitoes

10.4 Activity Hazard Analyses

Activity Hazard Analyses have been prepared for the following primary site tasks and are provided in Appendix C of the SSHP.

- Mobilization and Demobilization and Site Preparation
- Groundwater and Surface Water Sampling
- Drilling
- Field Guidance Pertaining to COVID-19
- Boating
- Crystalline Silica

FIGURES



Aerial Source:
ESRI, ArcGIS Online,
Aerial Imagery

Legend

▭	Former Fort Devens Boundary
●	Area of Contamination (AOC)
⊙	Water Supply Well
- - -	County Line
━	Highway
—	Major Road
▨	MassDEP Zone II Wellhead Protection Area

MassDEP = Massachusetts Department of Environmental Protection

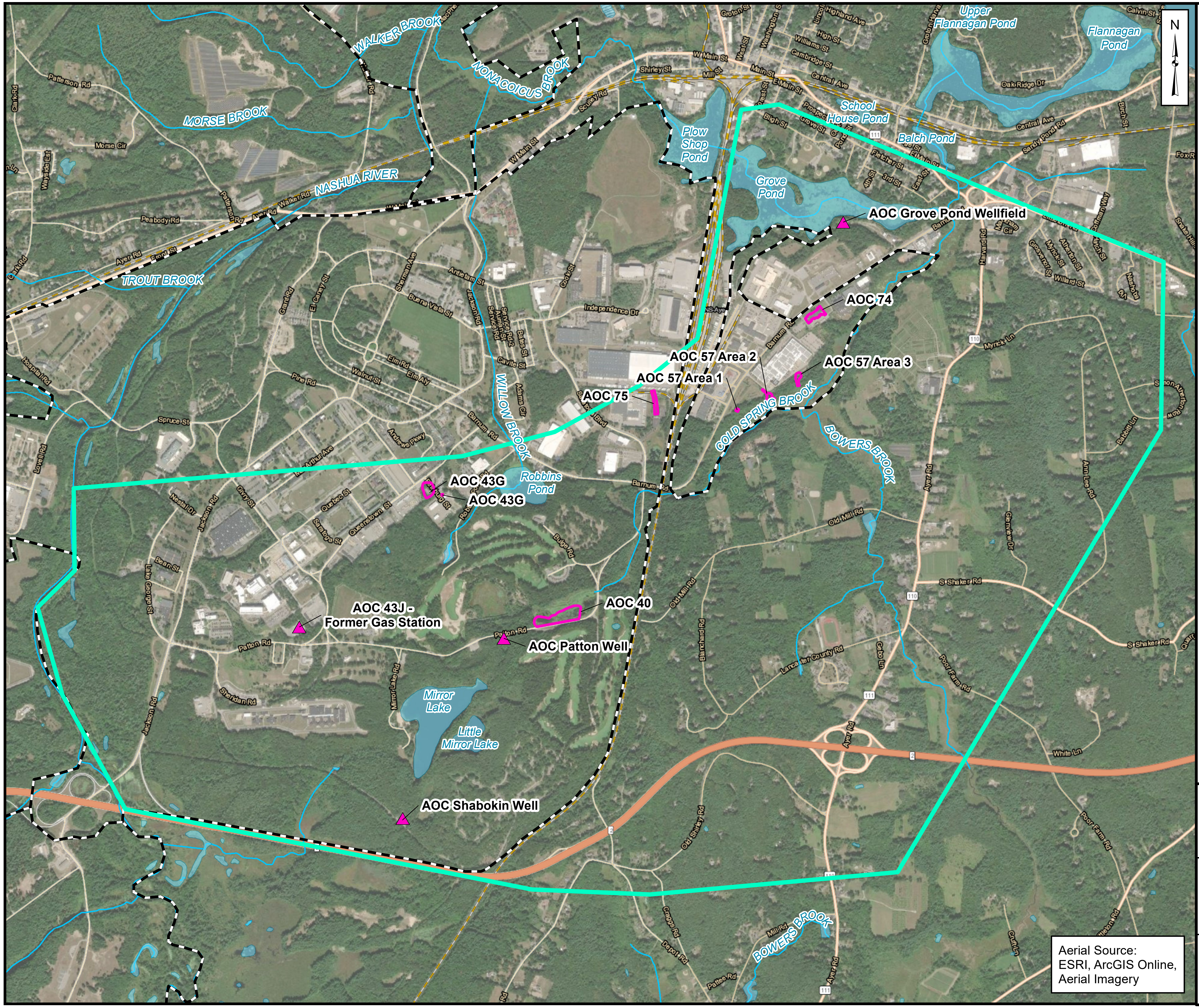
0 1 2
Miles

2020 Main Post Annual Report
Former Fort Devens Army Installation
Devens, Massachusetts

Site Location
Former Fort Devens
Vicinity

SERES Engineering & Services, LLC
ARCADIS
a joint venture

Figure
1



Aerial Source:
ESRI, ArcGIS Online,
Aerial Imagery

Legend

⬚	Former Fort Devens Boundary
▭	Area 1
▲	AOC Location
▭	AOC Area
〰	Stream
●	Waterbody

AOC = area of contamination

0 1,500 3,000
Feet

Area 1 Phase 2 Work Plan
Former Fort Devens Army Installation
Devens, Massachusetts

Fort Devens PFAS
Remedial Investigation Areas

SERES
ARCADIS
a joint venture

Figure
2

File: Figure X - Area 1 AOCs.mxd

Attachment A Site Safety and Health Plan

SERES
Engineering & Services, LLC
ARCADIS
a joint venture

SITE SAFETY AND HEALTH PLAN
REVISION 00

Environmental Remediation Services
Fort Devens Army Installation
Fort Devens, Massachusetts

May 2021

SAFETY AND HEALTH PLAN

ENVIRONMENTAL REMEDIATION SERVICES
DEVENS, MA

PLAN IDENTIFICATION AND APPROVALS

Project Title:	Environmental Remediation Services, Fort Devens Army Installation
Project Locations:	Fort Devens, Massachusetts
Contract No.:	W912WJ19D0014
Prepared By:	
Date Prepared:	May 2021
Revision No.:	00

APPROVALS:

Grey Coppi, CIH Date
Safety and Health Manager

Andy Vitolins Date
Project Manager

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LIST OF ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AHA	Activity Hazard Analysis
ANSI	American National Standards Institute
AOC	area of contamination
APR	air-purifying respirator
AREE	Area Requiring Environmental Evaluation
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Contaminant of Concern
COR	Contracting Officer’s Representative
CPR	cardiopulmonary resuscitation
dBA	decibels on the A-weighted scale
DEET	N,N-diethyl-meta-toluamide
DOI	Department of the Interior
DOJ	Department of Justice
DOL	Department of Labor
DRFTA	Devels Reserve Forces Training Area
EMS	Emergency Medical Service
FFA	Federal Facility Agreement
GFCI	ground fault circuit interrupter
HAZWOPER	Hazardous Waste Operations and Emergency Response
HEPA	high-efficiency particulate air
H&S	H&S Environmental, Inc.
HSP	Heat Stress Prevention
IDW	investigation-derived waste
JSA	Job Safety Assessment
JV	SERES-Arcadis 8(a) JV2, LLC
kV	kilovolt
LEL	lower explosive level
LTGM	long-term groundwater monitoring
LTM	long-term monitoring
MassDEP	Massachusetts Department of Environmental Protection
MassDev	MassDevelopment
MDFA	Massachusetts Development and Finance Agency
MEC	munitions and explosives of concern
MMRP	Military Munitions Response Program
MEC	National Electric Code
NIOSH	National Institute for Occupational Safety and Health
NPL	National Priorities List
O&M	operation and maintenance
OSHA	Occupational Safety and Health Administration
PEL	permissible exposure limit

PFAS	per- and polyfluoroalkyl substances
PID	photoionization detector
PM	Project Manager
PPE	personal protective equipment
ppm	part per million
PVC	polyvinyl chloride
RI	Remedial Investigation
SDS	Safety Data Sheet
SHM	Safety and Health Manager
SOP	Standard Operating Procedure
SPIA	South Post of Fort Devens
SSHO	Site Safety and Health Officer
SSHP	Site Specific Safety and Health Plan
TCE	trichloroethene
TLV	threshold limit value
TOC	total organic carbon
TOV	total organic vapor
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USEPA	United States Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UXO	unexploded ordnance
VOC	volatile organic compound
WP	work plan

1.0 BACKGROUND

1.1 Introduction

The U.S Army Corps of Engineers (USACE) has retained SERES-Arcadis 8(a) JV2, LLC (the JV) under Contract W912WJ19D0014 to perform environmental remediation tasks located at Fort Devens, Massachusetts. This Site Safety and Health Plan (SSHP) presents the health and safety procedures that are intended to guide tasks performed in the field by the JV.

This SSHP was prepared in accordance with the Occupational Safety and Health Administration (OSHA) Part 1910 of Title 29, of the Code of Federal Regulations (CFR). Guidelines, procedures, and permit requirements as outlined in the JV Safety and Health Program have also been incorporated into this plan. This SSHP addresses site conditions that require "Level D" personal protective equipment (PPE), which is anticipated based on historical groundwater data. If conditions are encountered that require upgrading to Level C, work will be stopped, and the Safety and Health Manager (SHM) and Project Manager (PM) will be consulted to determine the necessary actions to be taken. Work will not proceed until the necessary engineering controls have been implemented.

The content of the SSHP may be revised and/or amended should additional information become available concerning the hazards present at the site or should significant changes occur in the scope of work, operational procedures, site hazards, and/or hazard control measures. Field personnel will be informed of any changes to the SSHP through safety meetings and/or written addenda to the SSHP. A copy of this SSHP will be continually maintained in the following locations:

- The JV Office – Charleston, South Carolina;
- Maintained On-Site by the JV Site Safety and Health Officer (SSHO).

The JV will implement the SSHP during remedial investigation activities conducted at Fort Devens. Any on-site subcontractors will also be required to review and comply with the provisions of the SSHP before initiating work. Subcontractors must sign a Health and Safety Affidavit form (*Appendix A*) indicating that they have reviewed the SSHP and will comply with its conditions.

Subcontractors with scopes of work materially different from that covered within this SSHP will be required to prepare a task-specific plan addressing health and safety for their own employees that will comply with applicable federal, state, and local health and safety regulations including, but not limited to, OSHA regulations 29 CFR 1910 and 29 CFR 1926.

1.2 Site Location

The roughly 9,260-acre site is located in the Towns of Ayer and Shirley in Middlesex County and Harvard and Lancaster in Worcester County, Massachusetts, approximately 35 miles northwest of Boston, Massachusetts. Under the Defense BRAC Act of 1990, Fort Devens was identified for cessation of operations and officially closed in March 1996. As part of the Fort Devens BRAC program, portions of the property formerly occupied by Fort Devens were retained by the U.S.

Army (Army) for reserve forces training and renamed the Devens Reserve Forces Training Area (DRFTA). 3,040.4 acres were either leased (686.4 acres) or transferred (2,354 acres) to the Massachusetts Development and Finance Agency, Devens Commerce Center (MDFA), now known as MassDevelopment (MassDev). In 1997, a total of 1079.62 acres were transferred to other federal agencies (221.62 acres to the Department of Justice [DOJ] Bureau of Prisons and 22 acres to the Department of Labor [DOL] - Job Corps Center). Also in 1999, 836 acres along the Nashua River Area of the former Fort Devens was transferred to the Department of the Interior (DOI) U.S. Fish and Wildlife Service (USFWS) for use as an open space as part of the Oxbow National Wildlife Refuge. Before the official base closure, Fort Devens was divided into the North Post, Main Post, and South Post. Route 2 divides the South Post from the Main Post.

1.3 Site Background and History

Residences and farmland occupied the site before the establishment of Fort Devens in 1917 as a temporary training area for soldiers during World War I. In 1931, Fort Devens then became a permanent installation with the primary mission of commanding, training, and providing logistical support for non-divisional troop units. The installation also supported the Army Readiness Regional and National Guard units in the New England area. Fort Devens was used for a variety of training missions between 1917 and 1990. The site was placed on the National Priorities List (NPL) on December 21, 1989, pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act because of environmental contamination at several sites on Fort Devens.

The Installation was placed on the NPL on November 21, 1989. In accordance with Section 120 of CERCLA, a Federal Facility Agreement (FFA) was entered into by the Army and the United States Environmental Protection Agency (USEPA) in 1991 and amended in 1996. The FFA contains the basis on which all environmental investigations and remedial actions are required to be undertaken at Fort Devens. The FFA establishes roles and responsibilities for both the USEPA and the Army and lays out a procedural framework and timetable for developing, implementing, and monitoring appropriate response actions at Fort Devens in accordance with CERCLA. The Commonwealth of Massachusetts opted to take a “participatory role” in the Fort Devens remediation efforts and is represented by the Massachusetts Department of Environmental Protection (MassDEP).

1.4 Scope of Work

Based on results from previous per- and polyfluoroalkylated substances (PFAS) field investigations, the Army is conducting a Remedial Investigation (RI) under CERCLA at locations that may potentially be impacted by PFAS. To expedite further field investigations, the identified areas of contamination (AOCs); the Grove Pond wellfield; and MacPherson, Patton, and Shabokin water supply well areas were grouped into three areas (Areas 1, 2, and 3). The three areas were designated for sequencing of RI field activities and do not represent prioritization. The goals of the RI are to:

- Determine the nature and extent of PFAS in groundwater, soil, surface water, and sediment.

- Determine whether PFAS sources at Fort Devens are impacting public water supply wells.
- Evaluate whether PFAS are present in environmental media at concentrations that pose an unacceptable risk to human health or the environment.

After completion of initial field activities to support completion of the RI (considered to be Phase 1 activities), the three areas were regrouped for further (Phase 2) field investigation. This Phase 2 PFAS RI Work Plan (WP) addresses only Area 1 (AOCs 43G, 43J, 57 [including a portion of AOC 44], 74, 75, Grove Pond Wellfield, and Fort Devens water supply wells Patton [incorporating AOC 40 and Area Requiring Environmental Evaluation {AREE} 61I/61H] and Shabokin). The other AOCs and areas of investigation at Fort Devens that require an RI will be addressed separately.

The objective of the Area 1- Phase 2 RI WP is to collect data sufficient to meet USACE and regulatory requirements and support remedial alternative decisions if needed. Table 1 below summarizes the sites that are subject to this RI WP and the activities planned for Phase 2.

Table 1. Summary of Sites and Activities

AOC Name	Planned Activities
AOC 43G Historical Gas Station G	• Install 146 new monitoring wells and collect groundwater samples. • Install 42 additional vertical aquifer profiling (VAP) locations. • Collect groundwater samples from 49 existing monitoring wells . • Collect soil samples from monitoring well borings. • Collect surface water samples from streams and ponds. • Collect fish tissue samples from two ponds.
AOC 43J Historical Gas Station J	
AOC 57 Building 3713 Fuel Oil Spill Site	
AOC 74 Barnum Road Firefighting Exercise Site	
AOC 75 Former Building T-1445 Warehouse Fire	
Grove Pond Wellfield	
Patton Water Supply Well/AOC 40 Cold Spring Brook Landfill	
Shabokin Water Supply Wells	

2.0 KEY PERSONNEL & RESPONSIBILITIES

This section provides information regarding company and project personnel and a description of JV personnel health and safety responsibilities and is intended to address the requirements of 29 CFR 1910.120 (b)(2).

2.1 Key Personnel

The JV will provide project management and implementation of field activities during the project. During each portion of scheduled field activities, the JV will assign one individual to serve as the SSHO. The SSHO is responsible for ensuring that site personnel and activities conform to the protocols defined in this document. The SSHO may at any time stop a field activity if health and safety procedures are being compromised or if safety measures are insufficient. The SSHO will maintain direct communication with the PM and Project Engineer. The key personnel responsible for the implementation of this SSHP are listed below.

Safety and Heath Manager (SHM):

Name:	Grey Coppi, CIH
Office Phone:	(908) 917-6948
Cell Phone:	(908)-917-6948

Project Manager (PM):

Name:	Andy Vitolins
Office Phone:	(518)-250-7359
Cell Phone:	(518)-461-3145

Site Safety and Health Officer (SSHO)

Name:	Diane Champagne
Office Phone:	(978)-937-9999
Cell Phone:	(978)-505-1120

Alternate Site Safety and Health Officer (SSHO)

Name:	Adam Finkelman
Office Phone:	(401)- 285 2295
Cell Phone:	(401)-743 3373

2.2 JV Personnel Health and Safety Responsibilities

The JV is responsible, through the SSHO, for ensuring that health and safety programs are adhered to by all employees and subcontractors. With regard to on-site work, the PM will review and approve this document. The SSHO will also serve as a site safety inspector in order to ensure that employees and subcontractors are adhering to the requirements of the SSHP. Other individuals responsible for the project's implementing the SSHP include the PM and Project Engineer.

The ultimate responsibility for project health and safety lies with the PM and the SSHO. In fulfillment of this responsibility, the PM and the SSHO will work to ensure that site health and safety programs are implemented and adhered to. The PM and SSHO will also approve this SSHP and will act to promote the <u>SAFE</u> completion of the project.

2.3 Visitors

Only visitors authorized by the SSHO will be permitted access to the site. Visitors will be required to follow policies and procedures outlined in this SSHP. Any visitor entering the job site will be expected to sign in with the SSHO and comply with OSHA standards. An SSHP Affidavit is provided in *Appendix A*. Visitors will be required to don PPE. Visitors will be provided work area-specific orientation/training.

If a visitor does not adhere to the provisions of this SSHP, the SSHO will record non-conformance in the Safety Inspection Report (*refer to Appendix G*). If the SSHO deems that the non-conformance is threatening to the health and safety of personnel, he/she may decide to temporarily suspend site operations until the visitor has left the area of concern.

3.0 POTENTIAL HAZARDS

3.1 Chemical Hazards

Chemical hazards may be encountered during field work where there is the potential for exposure to impacted groundwater, soil, and materials. The primary contaminants of interest during the RI field activities at Fort Devens are PFAS, but other potential contaminants include Total Petroleum Hydrocarbons (TPH) – Gasoline, Arsenic, Cadmium, Chromium, Copper, Cyanide, Lead, Nickel, PCBs (Aroclor 1248, Aroclor 1254), Tetrachloroethylene, Toluene, and Zinc.

Attached Table 1 provides occupation exposure limits and toxicological properties for constituents of potential concern (COPCs). Pathways that are known to or may exist on and off the site include: ingestion, direct contact, and inhalation of dusts when disturbing surfaces as part of typical work.

3.1.1 Chemicals for Equipment Calibrations and Decontamination Operations

The following chemicals are typically supplied by the field team for sample collection:

- Isopropyl alcohol (methanol);
- Sample preservatives (hydrochloric acid);
- Isobutylene calibration gas;
- Alconox®;
- Fuel (gasoline).

These chemicals will be used for equipment calibration, operation, and sampling equipment decontamination. Minimal quantities will be used under contained environments. Chemicals used during the field activities will be properly contained and labeled. The Field Manager will keep the material safety data sheets (SDS) on site. They are also attached to this document. The decontamination wastewater will be containerized as part of the investigation-derived waste (IDW) where required by regulations. Occupational exposures will be negligible.

3.1.2 Chemical Exposure during Field Activities

Personnel may receive exposure to COPCs through inhalation of vapors and skin absorption/contact with contaminated groundwater/dust/soils. These exposures could occur during well/boring installation, groundwater sample collection, soil sample collection, and surface water sample collection.

The risk of employee exposure to these compounds varies based on the location and degree of employee contact with contaminated media.

3.2 Physical Hazards

Physical hazards can potentially be present during field activities. These physical hazards may include, but are not limited to:

- Fire/explosion hazards;
- Heat/cold stress;
- Biological hazards;
- Vehicle and pedestrian hazards;
- Noise hazards;
- Electrical hazards;
- Utilities;
- Weather hazards;
- Unexploded ordnance (UXO).

The site will be visually inspected for the presence of general safety hazards (e.g., trip/slip hazards, unstable surfaces or steep grades, and sharp objects) before beginning work. If hazards are present, they will be recorded and precautionary measures taken to prevent injury. *Attached Table 2* summarizes biological/physical hazards and their associated risks.

3.2.1 Fire/Explosion Hazards

The potential for fire and/or explosion emergencies is always present and should be noted. Workers must continuously monitor any enclosed works areas where gases may accumulate for combustible or explosive gases when operations have the potential to generate sparks. Employees should always be alert for unexpected events, such as ignition of chemicals or sudden release of materials under pressure, and be prepared to act in these emergencies.

Procedures for prevention of fire hazards and fire protection include:

- Smoking is <u>not</u> allowed in areas where flammable or combustible materials are present.
- Static electricity-generating equipment requires bonding and grounding when transferring flammable or combustible liquids or when working in areas where these materials are present.
- Any on-site temporary storage of fuel will be coordinated with the base fire department to make sure the requirements are met.

Field vehicles will be equipped with an ABC fire extinguisher, and additional fire extinguishers will be available at appropriate locations throughout the work site. Employees must be trained in the proper use of fire suppression equipment. However, professionals should handle large fires that cannot be controlled with a fire extinguisher. The on-base fire authorities should be notified in these instances.

3.2.2 Heat Stress and Heat-Related Illness

The effects of heat stress and illness are possible during the performance of field activities at the Fort Devens Army Installation. Injury from heat exposure may occur to persons working outdoors during a period of high temperature conditions and when personnel are working in PPE clothing. The body's principal means of cooling is through the evaporation of sweat. When personnel are working in PPE, sweat is trapped inside the clothing and cannot evaporate, thus raising the body's core temperature and resulting in a heat-related illness. Only Level D PPE is anticipated to be needed for this project.

Illness resulting from exposure to extreme heat is possible during field operations. Personnel will be familiar with the signs and symptoms of heat stress including:

- **Heat Cramps -** Muscle spasms in the abdomen or limbs;
- **Heat Exhaustion -** Dizziness, light-headedness, slurred speech, rapid pulse, confusion. fainting, fatigue, copious perspiration, cool skin that is sometimes pale and clammy, and nausea;
- **Heat Stroke -** Hot, dry, flushed skin; delirium; and coma (in some cases). Heat stroke is a life-threatening event and requires immediate medical attention.

Some preventive measures to avoid heat stress include:

- Frequent resting in cool or shaded areas;
- Consumption of large quantities of fresh potable water or diluted electrolyte beverages.

A suggested work-rest regimen is as follows:

Ambient Temperature	Work	Rest
70°F	3 hours	15 minutes
75°F	2.5 hours	15 minutes
80°F	2 hours	15 minutes
85°F	1.5 hours	15 minutes
90°F	1 hour	15 minutes

Other factors, such as a worker's acclimatization, level of physical fitness, and age, may increase or decrease a worker's susceptibility to heat stress. Before assigning a task to an individual worker, these factors will be taken into account to ensure that the task will not endanger the worker's health.

If a heat-related illness is suspected or observed, the affected person must be moved to a cool or shaded area and given plenty of liquids to consume. If symptoms of a heat stroke are observed, the victim will be cooled immediately and transported to the hospital. Liquids will be readily available to ensure that workers stay hydrated.

3.2.3 Effects of Cold Exposure

The effects of cold exposure are possible during the performance of field activities. Injury from cold exposure may occur in persons working outdoors when temperatures average below freezing. The extremities, such as fingers, toes, and ears, are the most susceptible to frostbite.

Personnel will be informed about the various forms of cold stress (e.g., hypothermia, frostbite) and the symptoms of exposure, which are:

- **Cold Stress**: Cold stress can occur upon exposure to cold environments where there is heat loss from the body, feet, hands, and/or head. Primary cold stress injuries are hypothermia and frostbite. Cold can also adversely affect mental capabilities resulting in accidents or injuries. The body’s initial response to cold is shivering, vasoconstriction, increased oxygen consumption, accelerated respiration and pulse, and increased heart output and blood pressure.
- **Hypothermia**: Hypothermia occurs when the body core temperature falls below 96.8ºF. Symptoms include intense uncontrollable shivering, sluggish thinking, difficulty speaking, muscular rigidity, blue puffy skin, poor coordination, cessation of shivering, dulled thinking, irrational stupor, unconsciousness, erratic heartbeat, slowed respiration, cardiac and/or respiratory failure, lung edema, and death. Treatment for hypothermia is to re-warm the body trunk, immerse in warm water (105ºF), or use heat packs.
- **Frostbite**: Frostbite occurs due to freezing of fluid that surrounds tissues. It occurs at less than 30ºF, and more rapidly with wind exposure. Frostbite affects the ears, chin, nose, fingers, and toes. Frostbite first appears as blanched skin or waxy or white skin that is firm to the touch with resilient tissue beneath. With deep frostbite, tissues are cold, pale, solid, and may turn black. Treatment for frostbite is to re-warm with warm water (105ºF) (do not rub with snow) and prevent refreezing of affected body parts.

To prevent cold stress conditions and exposure symptoms, the use of personal protection by dressing for warmth, wind, and wet conditions is necessary. Wear layered clothing (i.e., wear thinner, lighter clothing next to the body with heavier clothing layered outside the inner clothing). Stay active, as activity generates heat. Provide a warm break area when working in cold environments. Have first aid equipment available. At temperatures lower than 25ºF, do not permit continuous cold exposure to exposed skin. At temperatures lower than 45ºF, wear warm clothing to include, as needed: boots, heavy socks (e.g., wool or polypropylene), mittens or insulated gloves, insulated head covers, thermal underwear, and insulated coveralls. Workers who are immersed in water or whose clothing becomes wet will be immediately provided with a change of clothing and be treated for hypothermia if symptoms become evident.

3.2.4 Biological Hazards

Biological hazards that may potentially be encountered during site work include:

- Poisonous plants;
- Venomous snakes;

- Venomous spiders;
- Rodents;
- Insects;
- Ticks;
- Mosquitoes.

Poisonous Plants

Contact with poisonous plants, such as poison oak, poison ivy, or poison sumac, can result in dermatitis. Poison oak and poison ivy are a biological hazard that causes reaction in more than 50 percent of the population. Poison oak/ivy has green leaves in the spring and summer and red and yellow leaves in the fall that are found in sets of three. This trait is easily remembered by an old rhyme, “leaves of three, let them be.” Black dots of dried sap (resin) on the leaves are also characteristic of the plant. It is the resin, called “urushiol,” derived from the Japanese word for “sap,” that poses a threat to sensitive individuals. The skin reacts to the resin upon contact causing dermatitis characterized by linear streaks and red bumps where the plant has brushed against the skin. Contact with the smoke from burning poison oak also causes severe reactions in the respiratory tract and exposed skin in sensitive individuals. Signs and symptoms of exposure are redness, swelling, blisters, and intense itching. Blisters form within 24 hours; weeping, crusting, and scaling of the blisters within a few days; and complete healing occurs in about 10 days.

Poison oak/ivy first aid procedures are: Washing, without scrubbing, of the affected area with mild soap and water; application of a paste of baking soda and water on the area several times a day; or application of an anti-cortical cream or lotion (such as Calamine or Caladryl) to help soothe the area. Antihistamines, such as Benadryl, may also help dry up the sores. If the condition worsens or persists and affects large areas of the body or the face, see a doctor. It may be necessary to give anti-inflammatory drugs, such as corticosteroids or other medications, to relieve discomfort.

Venomous Snakes

Venomous snakes, primarily the copperhead, may be encountered during site work. The copperhead has a series of dark and light bands near the tail just before the rattles that are different from the rest of the body. Copperhead bite signs and symptoms of envenomation include: fang marks, metallic or rubbery taste in mouth, tingling of the tongue, numbness, swelling within 10 minutes of bite, nausea, weakness, temperature change, and discoloration within 3 to 6 hours.

Copperhead precautions include: Avoid walking in areas known to be populated with snakes; avoid traveling on foot at night; avoid traveling off trails or paths in grassy or brush-laden areas; do not climb into rocky areas without visual inspection for snakes; be alert when moving debris, as snakes seek shelter in shaded areas; wear high-top boots and long pants when walking in grassy areas; clear brush from around buildings, check/repair leaky faucets, and keep trash in containers with secure lids. If a snake is encountered, look around. There may be others. Then turn around and walk away on the same path traveled.

Copperhead bite first aid procedures are: Summon emergency medical help immediately; have victim stay calm and remain motionless; position victim so that bite is kept below heart level; do not use ice, cold packs, sprays, alcohol, or any drugs; do not use a tight tourniquet but instead apply a light constricting band above the bite (be able to insert finger under band) and do not release the band unless it is too tight from swelling; do not make an incision across the bite to suck out the venom; and do not wait to see if symptoms develop. Seek medical attention as soon as possible.

Venomous Spiders

Venomous spiders, such as the black widow spider or the brown recluse spider, may be encountered during site work. Spiders are usually found in dark, cool, protected areas, and such areas should be inspected before placing hands or feet in these areas. Poisonous spiders are commonly found in woodpiles, sheds, basements, garages, and privies.

The primary species of black widow spider encountered has a glossy black appearance with an orange-red hourglass shape on the underside of the body. Black widow spider bite signs and symptoms are: Initial pain followed by dull, occasionally numbing pain in the affected extremity; pain and cramps in one or several of the large body muscles; abdominal pain and cramping; sweating, increased salivation, anxiety, weakness, headache, and dizziness; and severe cases can result in uncontrollable muscle spasms, coma, and respiratory failure. Black widow spider bite first aid procedures are: wash the wound; apply a cold pack; and get medical care (e.g., muscle relaxants, antivenin).

The brown recluse spider is also known as the "violin or fiddle back" spider and is light brown in color with a darker brown violin-like marking on the top of the body. The brown recluse spider is non-aggressive, and most bites occur when the spider is trapped in clothing being put on, stepped on, and upon disturbance of areas where the spider resides. Brown recluse spider bite signs and symptoms are: Localized burning sensation within 2 to 8 hours with itching and redness; small, blanched area around the immediate bite area appears; reddened area enlarges and becomes purple during subsequent 1 to 8 hours; and fever, malaise, stomach cramps, nausea, vomiting, and some cases have resulted in death. Brown recluse spider bite first aid procedures are: wash the wound; apply a cold pack; and seek immediate medical care.

Rodents

Rodents include rats, mice, squirrels, and other related mammals characterized by gnawing and nibbling traits. Rodents can act as a vector for many diseases that may be transmitted directly or through other vectors such as fleas or ticks. Diseases that can be transmitted include plague, typhus, Leptospirosis, relapsing fever, and others including Hantavirus pulmonary syndrome. A discussion of Hantavirus pulmonary syndrome is presented below, as it is a relatively recent disease transmitted by rodents.

Hantavirus Pulmonary Syndrome: Hantavirus pulmonary syndrome is a serious, often deadly, respiratory disease that has been found mostly in rural areas of the western United States. The disease is caused by a Hantavirus carried by rodents and passed on to humans through infected rodent urine, saliva, or droppings. The deer mouse is the primary carrier of the virus that causes Hantavirus pulmonary syndrome. This type of rodent is found throughout the United States, except in the Southeast and East Coast. In the Southeast, the cotton rat is known to carry Hantavirus. A deer mouse is 4 inches to 9 inches long from head to tip of tail. It is pale gray to reddish brown; has white fur on its belly, feet, and underside of the tail; and has oversized ears. A mouse nest (burrow) is usually a pile of material under which the mouse lives. This pile can contain many different materials, such as twigs, insulation, Styrofoam, and grass.

Hantavirus is spread from wild rodents to people. The virus gets in the air as mist from urine and saliva or dust from feces. Breathing in the virus is the most common way of becoming infected; however, infection can also occur by touching the mouth or nose after handling contaminated materials. A rodent's bite can also spread the virus. Hantavirus is <u>not</u> spread from person to person. Infection will <u>not</u> occur from being near a person who has Hantavirus pulmonary syndrome. The virus, which can survive in the environment (e.g., contaminated dirt and dust), can be killed by most household disinfectants, such as chlorine bleach or alcohol.

Symptoms of Hantavirus pulmonary syndrome usually appear within 2 weeks of infection but can appear as early as 3 days to as late as 6 weeks after infection. First symptoms are general and flu-like: Fever (101 to 104ºF); headache; abdominal, joint, and lower back pain; sometimes nausea and vomiting. However, the primary symptom of this disease is difficulty breathing, which is caused by fluid buildup in the lungs and quickly progresses to an inability to breathe.

Precautionary measures to avoid exposure to Hantavirus include: avoid and/or be cautious when working near wood piles, inside sheds, or in other known deer mouse habitats; when evidence of deer mice is observed, stop work and notify supervisor immediately; establish specific work procedures, protective clothing, respiratory protection, and decontamination protocol for work in the area, and review hazards and control measures with workers; spray a concentrated solution of chlorine bleach (10 percent minimum) on areas where rodent feces or nesting materials are present and let the disinfectant sit for a period of time before working in the area; wear protective clothing (i.e., disposable coveralls, gloves, boots, or booties) and respirator (air-purifying respirator [APR] with high-efficiency particulate air [HEPA] filter); remove contaminated materials carefully; minimize dust generation; use HEPA filter vacuum equipment as needed; collect contaminated materials and place in plastic bags/seal for disposal as directed by the SSHO; upon exit from the work area; wash gloved hands in 1 percent chlorine bleach solution; remove clothing, being careful <u>not</u> to contact potentially contaminated surfaces; and thoroughly wash with soap and water immediately following removal of PPE.

<u>Insects</u>

Ant bites and bee stings can be deadly to those who are hypersensitive. Anaphylactic shock can occur to sensitized individuals upon stinging. Signs and symptoms of envenomation are usually local pain, redness, itching, and swelling. Sensitive individuals may have more serious symptoms such as welts, itching palms and feet, headache, nausea, vomiting, labored breathing, and in severe cases respiratory paralysis or heart failure. Bee precautions include: Conduct a reconnaissance of areas where bee, hornet, and wasp hives may be encountered (i.e., clearing and grubbing) before beginning work in an area; apply insecticide (where allowed) to rid the work area of bees; ensure that site personnel who have a recent history of reactions to bee, hornet, and/or wasp stings have reported this to the SSHO; hypersensitive individuals should carry a bee sting injection kit prescribed by the physician with them in case of emergency; and over-the-counter antihistamine medication should be available in case of a bee sting.

Infected mosquitoes can act as a vector for many diseases including West Nile Virus. The increased spread of the West Nile Virus in the United States is a major health concern. West Nile Encephalitis is caused by the West Nile Virus, a flavivirus commonly found in Africa, West Asia, and the Middle East. Encephalitis is an inflammation of the brain and can be caused by viruses and bacteria including viruses transmitted by mosquito bites. Transmission is a vicious circle. Mosquitoes become infected when they feed on infected birds. The virus transmits into the mosquito's salivary glands. Then the mosquito bites a human or an animal, injecting the virus, which can multiply and cause illness. Symptoms vary depending on the severity of the infection. Mild infections include flu-like symptoms: fever, headaches and body aches, skin rash, and swollen lymph glands. Severe infections include symptoms such as higher fever, neck stiffness, disorientation, coma, paralysis, convulsions, and muscle weakness. The methods of reducing risks of transmission of West Nile Virus include staying indoors at dawn, dusk, and in the early evening; wearing long-sleeved shirts and long pants when outdoors; spraying clothing with repellents containing permethrin or N,N-diethyl-meta-toluamide (DEET); and applying insect repellent sparingly to exposed skin.

Ticks

Infected wood ticks and dog ticks can act as a vector for many diseases including Rocky Mountain Spotted Fever, Q Fever, Relapsing Fever, Lyme Disease, and Tularemia. Adult ticks are reddish-brown in color and may have white markings on the back. They are usually 0.25 inch long, are oblong or seed-shaped, and have eight legs. The adult wood tick appears during the spring and early summer months in the northwestern states, and the dog tick appears throughout the summer in the eastern and southern states. The disease-carrying organism is transmitted to humans through the bite of the tick or by contact with crushed tick blood or feces through a scratch or wound.

The early signs and symptoms of Lyme Disease are a bull’s eye rash, fever or chills, and fatigue or body aching. Later skin lesions may develop as well as heart, neurological, or muscle complications. It is often difficult to diagnose because people often do not notice the tick bite, rashes may not appear, or symptoms imitate other diseases or infections.

To avoid contact with ticks, wear clothing that fully covers the legs, arms, and hands. Avoid walking in wooded or brush-laden areas whenever possible. Inspect the body and clothing during rest periods and immediately remove any ticks found, being careful not to crush them. Have someone else help to inspect the neck, back, head, and other hard-to-see areas of the body. If ticks are found on the body, try to remove the tick without crushing or leaving any part of the tick in the wound. Use fine-pointed tweezers for tick removal by insertion under the tick. Do not crush the tick on your body or between the fingers. Apply gentle but firm traction on the tick, being careful not to leave the mouthparts in the skin. Do not use force; a slow steady pull is required. Wash hands thoroughly with soap and warm water after handling ticks, apply antiseptic to the wound with iodine, mercurochrome, or merthiolate and apply a corticosteroid lotion.

Mosquitoes

Mosquitoes present health hazards primarily due to their potential for transmitting diseases including Dengue Fever and several forms of encephalitis including St. Louis Encephalitis and West Nile Encephalitis. Recently, mosquitoes have posed an increased risk due to their transmittal of West Nile Virus.

All of the mosquito-borne diseases can cause flu-like symptoms including fever, headache, and fatigue. Dengue Fever can also cause blood hemorrhaging. Encephalitis (including the West Nile, St. Louis, Eastern Equine, and LaCross-California varieties) is an infection of the brain, causing inflammation, swelling, and destruction of nerve cells. Symptoms include high fever, headache, neck stiffness, stupor, disorientation, and tremors and can lead to convulsions, coma, paralysis, and death. Anyone experiencing several of these symptoms after being bitten by mosquitoes should seek medical attention immediately. There is no vaccine for West Nile Virus.

The best protection from mosquito-borne diseases includes wearing long-sleeved shirts and pants, applying a mosquito repellent containing 20 percent to 30 percent DEET, and avoiding perfumes and colognes when outdoors for any prolonged time.

3.2.5 Heavy Equipment Hazards

Heavy equipment will be utilized in the form of a sonic drill rig during monitoring well installations, vertical aquifer profiling, and soil sampling field activities. Work must be conducted only by trained, experienced, and licensed/certified personnel. If possible, personnel must remain outside the turning radius of large, moving equipment. At a minimum, personnel must maintain visual contact with the equipment operator. No guards, safety appliances, or other devices may be removed or rendered ineffective unless repairs or maintenance are required, and then only after power has been shut off, tagged, and locked out. Safety devices must be replaced once repair or maintenance is complete. Exhaust from equipment must be directed so that it does not endanger workers or obstruct the view of the operator. When not operational, equipment must be set and locked so that it cannot be activated, released, dropped, or otherwise engaged.

Heavy equipment operation safety procedures include:

- Only experienced personnel will operate equipment on site.
- Heavy equipment will have rollover protection, seat belts, good functioning brakes, fire extinguisher, and operating backup alarms and horns. Equipment will be checked daily at the beginning of each work shift and recorded by the equipment operator on a “Heavy Equipment Inspection Report” form to document that the following systems and parts are in good working order: Service, emergency, and parking brakes; tires/tracks; horn; steering mechanism; coupling devices; seat belts; operating controls; safety devices; fire extinguisher; and backup alarms.
- Drilling work areas will be properly marked and guarded with barriers and/or caution tape to prevent unauthorized personnel entry and to prevent personnel slips, trips, or falls.

- Workers will be required to wear high-visibility safety vests with reflective striping when working around heavy equipment.
- Workers will be cautioned to look carefully where they walk to avoid moving equipment. Concurrent operations will be curtailed to prevent workers from being placed in dangerous proximity to moving heavy equipment.
- Before entering the swing radius of operated heavy equipment, ground personnel must obtain unobstructed eye contact with the equipment operator. Unobstructed eye contact with the equipment operator must be maintained at all times while working within the swing radius of the equipment. As a courtesy, ground personnel should “signal” the equipment operator when they are exiting the swing radius of the heavy equipment.
- Personnel are not permitted to ride as passengers on heavy equipment.
- When equipment is parked, the parking brake will be set, and wheels will be chocked when on inclines. Bulldozer blades, hoe buckets, truck beds, and the like will be fully lowered or blocked when not in use. Parts of machinery held aloft, such as hoe buckets or truck beds, will be blocked or cribbed before employees are allowed to work under or between them.
- Dust control measures (i.e., water application) will be used as needed to minimize airborne dust during heavy equipment operation.

Due to the potential for the presence of munitions and explosives of concern (MEC) below the ground surface, drilling should proceed with extreme caution only after the UXO-qualified contractor has cleared the area. Also, the MEC General Awareness Training must be conducted for all site personnel.

3.2.6 Vehicle/Traffic Hazards

Work locations that will be accessed through and/or obstruct existing roadways will be cordoned off with reflective safety barriers to protect workers from the surrounding traffic hazards and also to prevent pedestrians from coming too close to work activities.

3.2.7 Noise Hazards

Noise hazards will be generated mostly from the use of heavy equipment. Work around large equipment often creates excessive noise. Noise can cause workers to be startled, annoyed, or distracted; can cause physical damage to the ear, pain, and temporary and/or permanent hearing loss; and can interfere with communication. If workers are subjected to noise exceeding an 8-hour time-weighted average sound level of 85 decibels on the A-weighted scale (dBA), hearing protection will be selected with an appropriate noise reduction rating to comply with 29 CFR 1910.95 and to reduce noise levels to or below the permissible values. Therefore, hearing protection will be used during field activities for which workers are using heavy equipment (e.g., drill rigs and backhoes).

3.2.8 Electrical Hazards

Overhead power lines, electrical wiring, electrical equipment (electrical generators), and buried cables pose risks to workers of electric shock, burns, muscle twitches, heart fibrillation, and other physical injuries, as well as fire and explosion hazards. Workers will take appropriate protective measures when working near live electrical parts, including inspection of the work area, to identify potential spark sources, maintenance of a safe distance, proper illumination of the work areas, provision of barriers to prevent inadvertent contact, and use of non-conductive equipment. An underground utility survey will be conducted and the appropriate permits secured before site mobilization in order to identify any potential underground electrical hazards. If overhead lines cannot be de-energized before the start of work, a 10-foot distance must be maintained between overhead energized power lines with a voltage of 50 kilovolts (kV) and elevated equipment parts. This distance will be increased 4 inches for every 10 kV greater than 50 kV. For example, workers must maintain a distance of 11.7 feet from energized power lines with a voltage of 100 kV.

3.2.9 Utilities

Underground utilities pose hazards to workers involved in excavation and other invasive operations. These hazards include electrical hazards, explosion, and asphyxiation, as well as costly hazards associated with damaging communication, sewer, and water lines. USACE and surrounding building personnel will be given at least 3 days’ notice before intrusive activities on the site. In addition, a utility locating service will be retained to better delineate any underground utilities that may be encountered during construction.

Personnel should be aware that, although an area may be cleared, it does not mean that unanticipated hazards will not be encountered. Workers should always be alert for unanticipated events such as snapping cables, excavating into unmarked underground utilities, and excavating into a heavily contaminated zone. Such occurrences should prompt involved individuals to halt work immediately and take appropriate corrective measures to gain control of the situation.

3.2.10 Confined Space Hazards

Although confined space entry is not anticipated during this project, it is discussed here as a precaution. Should a confined space hazard be identified, all personnel will abide by the policies and procedures outlined in Section 9.0 of this SSHP. Identification of a confined space will be the responsibility of all personnel on site during the project. The SSHO will be notified of a confined space hazard as soon as it is identified. Upon notification of a potential confined space hazard, JV personnel will ensure that the necessary permits and other documents are filed and followed. Potential hazards include:

- Explosive/Flammable atmospheres;
- Toxic atmospheres;
- Engulfment;
- Asphyxiation;

- Entrapment;
- Slips and falls;
- Chemical exposure;
- Electric shock;
- Thermal/Chemical burns;
- Noise and vibration.

3.2.11 Contingency Plan for Severe Weather

Adverse weather and natural disasters can take many forms. Thunder and lightning storms, hail, high winds, and tornadoes are a few examples. Sudden changes in the weather, extreme weather conditions, and natural disasters can create subsequent hazards. Natural disasters can create many secondary hazards, such as release of hazardous materials to the environment, structure failure, and fires.

Routinely monitoring weather conditions and reports may help reduce the impact of severe weather and natural disasters. It may be necessary to halt certain hazardous operations or stop work altogether to allow the situation to pass. The SSHO must decide what operations, if any, are safe to perform based on existing and anticipated conditions.

The best protection against most severe weather episodes and natural disasters is to avoid them. This means seeking shelter before the storm hits. Stay away from pipes and electrical equipment, including telephones, should lightning be a threat, and watch for damage caused by lightning strikes nearby.

3.2.12 Drilling Hazards

All personnel involved in drilling will be trained in the requirements of this program. All employees, including contractor personnel, who work in or around drilling operations must comply with the requirements of this program. Employees are responsible for reporting hazardous practices or situations to JV management, as well as reporting incidents that cause injury to themselves or other employees.

Before the start of drilling, the site will be thoroughly inspected to determine if special safety measures must be taken. The locations of sewer, telecommunications, fuel, electric, water, or any other underground installations or wires that may be encountered during drilling will be determined and marked before the start of any drilling. Arrangements will be made as necessary with the appropriate utility entity for the protection, removal, shutdown, or relocation of underground installations. Utility shut-offs will be located before the start of any drilling if required.

Traffic control measures are not anticipated to be required at the site, but proper hazard mitigation devices will be used if required. These would consist of barricades to cordon off the work areas.

All traffic control measures will follow all applicable OSHA regulations, EM 385-1-1 standards, and proceed in such a way to minimize any disturbances to the surrounding buildings/pedestrians.

No employee is permitted underneath loads being handled by lifting or drilling equipment. Employees are required to stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded when the vehicles provide adequate protection for the operator during loading and unloading operations.

3.2.12.1 Task Evaluation

Each task that requires the use of chemicals should be evaluated to determine the potential hazards associated with the work. This hazard evaluation must include the chemical or combination of chemicals that will be used in the work, as well as other materials that will be used near the work.

3.2.12.2 Chemical Storage

The separation of chemicals (solids or liquids) during storage is necessary to reduce the possibility of unwanted chemical reactions caused by accidental mixing. Explosives should be stored separately outdoors. Use either distance or barriers (e.g., trays) to isolate chemicals into the following groups:

- Flammable Liquids: Store in approved flammable storage lockers.
- Acids: Store separately from bases, oxidizers, and flammable liquids.
- Bases: Do not store bases with acids or any other material.
- Other liquids: Ensure that liquids are compatible with other chemicals in the same area.

3.2.12.3 Container Labels

It is extremely important that all containers of chemicals are properly labeled, and the following requirements apply:

- All containers will have the appropriate label, tag, or marking prominently displayed that indicates its identity, safety, and health hazards.
- Portable containers that contain a small amount of chemical need not be labeled if they are used immediately during that shift but must be under the strict control of the employee using the product.
- All warning labels, tags, and other markings must be maintained in a legible condition and not be defaced. Facility weekly supervisor inspections will check for compliance of this rule.
- Incoming chemicals are to be checked for proper labeling.

3.2.12.4 Emergencies and Spills

In case of an emergency, implement the proper Emergency Action Plan:

- Evacuate people from the area.
- Isolate the area.
- If the material is flammable, turn off ignition and heat sources.
- Only personnel specifically trained in emergency response are permitted to participate in chemical emergency procedures beyond those required to evacuate the area.
- Call for Emergency Response Team assistance if required.

3.2.12.5 Housekeeping

- Maintain the smallest inventory of chemicals to meet immediate needs.
- Periodically review the stock of chemicals on hand.
- Ensure that storage areas, or equipment containing large quantities of chemicals, are secure from accidental spills.
- Rinse emptied bottles that contain acids or inflammable solvents before disposal.
- Recycle unused laboratory chemicals wherever possible.
- *DO NOT* place hazardous chemicals in salvage or garbage receptacles.
- *DO NOT* pour chemicals onto the ground.
- *DO NOT* dispose of chemicals through the storm drain system.
- *DO NOT* dispose of highly toxic, malodorous chemicals down sinks or sewer drains.

3.2.13 UXO/MEC Hazards

Munitions and explosives of concern may be present and identified during intrusive site activities such as drilling. If encountered, UXO-qualified personnel will follow the requirements of the JV Safety Program and the Basic Safety Concepts and Considerations for Ordnance and Explosives Operations, which outline the safety and health precautions to be taken if MEC are encountered. This is considered an MEC avoidance operation; therefore, no MEC is expected to be moved or handled in any way. All non-UXO qualified personnel will follow the safe work practices listed below:

- Non-UXO qualified personnel will receive site-specific MEC recognition training before participation in site activities.
- Non-UXO qualified personnel will be escorted on-site by UXO-qualified personnel.

- Non-UXO qualified personnel will not touch or disturb any object that could potentially be MEC-related and will immediately notify the nearest UXO-qualified person of the presence of the object.

3.3 Hazard Assessment and Activity Hazard Analyses

This section identifies health and safety risks or hazards that may be encountered while performing on-site field work and is intended to address these risks or hazards as required by 29 CFR 1910.120 (b)(4). Hazards are categorized into chemical hazards, physical hazards, and biological hazards. Activity Hazard Analysis (AHA) forms for all anticipated field tasks and activities are included in *Appendix D*. Before the start of each new work activity, an AHA will be completed by the SSHO, approved by the PM, and reviewed with all site personnel. No new project tasks will be started without an accompanying AHA, which will be maintained with this SSHP. In addition to continual monitoring by the site health and safety representatives, spot safety inspections will routinely be conducted by the JV Corporate Health and Safety personnel.

4.0 EXPOSURE & MEDICAL MONITORING

Under the requirements of 29 CFR 1910.120 (f)(2), personnel who are or may be exposed to hazardous substances or health hazards at or above the established permissible exposure limit, above the published exposure levels for these substances, without regard to the use of respirators, for 30 days or more a year will receive an annual medical assessment by licensed professional medical personnel in compliance with 29 CFR 1910.120 (f)(4). The JV field personnel are required by company policy to undergo annual medical monitoring in accordance with the above requirements.

5.0 NOISE MONITORING

This project will follow the JV’s *Hearing Conservation Program*. All on-site JV and subcontractor personnel will wear hearing protection, with a noise reduction rating of at least 25, when noise levels exceed 85 dBA. Where decibel levels are 103 dBA or greater, double hearing protection may be required. Subcontractors’ own hearing conservation programs must meet or exceed the JV’s policy.

Based on previous noise dosimetry and sound level monitoring by the JV’s SHM, hearing protection will be required within 20 feet of any drilling operations. Hearing protection will be required with the use of chainsaws, chippers, mowers, and other similarly loud equipment. The JV’s policy will be followed.

6.0 ENGINEERING CONTROLS & SAFETY WORK PRACTICES

Personnel working on the site will work in a safe manner at all times and ensure that a safe work environment is maintained. This includes, but is not limited to, the following actions.

6.1 Electrical Hazards

Electrical installations will comply with the State Code and National Electrical Code (NEC) regulations. In addition, the JV and its subcontractors will implement the following safe work practices:

- Portable generators and welding machines will be grounded.
- Extension cords will be the hard usage type or better and will contain the number of conductors required for the service plug and the equipment ground wire.
- Electrical equipment will be connected to a ground fault circuit interrupter (GFCI).
- Electrical tools, fuse boxes, and other equipment with conducting surfaces that could be energized will be grounded.
- Electrical boxes/outlets will be covered as appropriate.

6.2 Hand and Power Tools

Hand and power tools will be kept in good repair and used only for the purpose for which they are designed. Tools that have defects that will impair their strength or render them unsafe for use will be removed from service. In addition, the JV and its subcontractors will implement the following safe work practices:

- Power tools will be inspected, tested, and determined to be in safe operating condition and properly maintained.
- Circular saws will be equipped with guards that automatically and completely enclose the cutting edges, splinters, and anti-kickback devices. Power saws will not be left running unattended.
- Safety clips or retainers will be installed and maintained in pneumatic impact tools.
- Pressure will be shut off and exhausted from the line before disconnecting the line from any tool or connection. Safety lashing will be provided at connections between tool and hose, and at all quick makeup type connections.
- Impact wrenches will be provided with a locking device for retaining the socket.
- The idle speeds of chain saws will be adjusted so that the chain does not move when the engine is idling.
- Proper PPE will be worn for all power equipment operation.

6.3 Safe Work Practices

To prevent injuries and to minimize potential exposure to contaminated surfaces and materials, the following safe work practices will be adhered to by all personnel at the site.

- Tailgate safety meetings will be conducted each day before work commences for all site personnel. A Project Sign-In Sheet is provided in *Appendix D*.
- All prescription eyeglasses in use on this project will be safety glasses and will be compatible with respirators.
- All disposable or reusable gloves worn on the site will be approved by the SSHO.
- During prolonged respirator usage in contaminated areas, respirator filters will be changed via a change-out schedule. Respirator filters will always be changed daily.
- Protective coveralls that become torn or badly soiled will be replaced immediately.
- The JV will ensure that all project personnel have vision or corrected vision to at least 20/40 in one eye.
- All respirators will be individually assigned and not interchanged between workers without cleaning and sanitizing.
- Site activities will be suspended during thunder and lightning storms as directed by the JV.
- Eating, drinking, chewing gum or tobacco, taking medication, and/or smoking is prohibited in any area where the possibility of contact with the contaminated surfaces and/or materials exists.
- All contact with potentially contaminated surfaces and/or materials will be avoided unless appropriate PPE is donned.
- Site personnel will avoid, whenever possible, kneeling on the ground, leaning or sitting on drums, equipment, or the ground.
- A stocked industrial first aid kit, a fire extinguisher, and an eyewash kit will be located and accessible on site.
- All accidents and incidents will be immediately reported to the SSHO and PM. Further reporting to be initiated by the PM may be required depending on the nature and severity of the incident.
- All project personnel who are on medication will report it to the SSHO, who will determine whether or not the individual will be allowed to work and in what capacity.
- Any individual who fails to adhere to this plan will not be permitted to work at the site.

6.4 Hazard Communication

6.4.1 Safety Meetings

JV Personnel must attend safety meetings as follows: Before assignment (i.e., employees who have not performed these tasks before), daily before commencement of work activities. New employees will also be briefed upon entering the site. The SSHO will conduct daily safety meetings for each work shift that will be mandatory for all project personnel. The meetings will provide refresher courses for existing equipment and protocols and will examine new site conditions as they are encountered. (Note: Refer to Section 8.3 – Safety Meetings.)

6.4.2 Safety Data Sheets

Copies of SDSs for hazardous substances that may be encountered at this site will be maintained at the job site in a three-ring binder. In addition, *Attached Table 1* provides occupation exposure limits and toxicological properties for COCs identified for the site.

6.4.3 Hazardous Substances

Applicable personnel will be informed of the hazardous substances that they may encounter through review of the SSHP and attendance at safety meetings.

6.4.4 Container labeling

All containers will be properly labeled with the product identity, hazard ratings, and PPE requirements indicated.

6.5 Reporting of Hazards

Field personnel are required to immediately report unsafe work conditions or observed unsafe work practices to the SSHO. Periodic safety inspections may be performed by the SSHO and/or the SHM or PM.

6.6 Personal Protective Equipment

- PPE is required for personnel who are working in contaminated or potentially contaminated areas and/or near operating machinery.
- Personnel are responsible for the proper inspection, use, storage, and cleaning of required PPE.
- Torn or damaged PPE will be immediately repaired or replaced.
- Contaminated PPE will not be removed from the site until it has been decontaminated or appropriately packaged, labeled (if required), and disposed of (as a contaminated waste, if required).
- PPE will be selected on a task-specific basis through the completion of a hazard analysis.

6.6.1 Levels of Protection

The USEPA terminology for PPE used on this project is Levels D, C, B, and A. The level of protection for each task has been assigned in accordance with *Tables 2* and *3*. Project personnel will use Modified Level D protective clothing for project activities. If monitoring results indicate the need, an upgrade to Level C will be made.

Table 2. HTRW Activity/Level of Protection

Activity	Initial Level of PPE
Mobilization/Demobilization	D
Well Point Installation (permanent)	D
Drilling	D
Groundwater Sampling	D
Surface Water Sampling	D
Fish Tissue Sampling	D

Table 3. MMRP Sites - MEC Anomaly Avoidance Activity/Level of Protection [a]

Task	Activity	Initial Level of PPE
1	Mobilization	D
2	Geophysical investigation	D
3	Demobilization	D

Note:

As site activities progress, levels of PPE are subject to change or modification. Upgrading of PPE can occur when action levels are exceeded or when the need arises to protect the safety and health of site personnel. Levels of PPE will not be downgraded without previous approval from the SHM.

a. Military Munitions Response Program (MMRP) sites are NOT included in this SSHP; however, MMRP activity levels of protection are provided in case MMRP activity is required for any future project scope of work.

6.6.1.1 Level D Protection

Level D PPE, at a minimum, will consist of:

- Standard work uniform or coveralls;
- Non-steel-reinforced toe, high-topped work boots;
- Safety glasses;
- Hard hat;
- Hearing protection when working around loud equipment or machinery;
- Leather-palm gloves when handling tools or other equipment;
- High-visibility vest (minimum American National Standards Institute [ANSI] Class 2) when working around vehicle traffic or equipment.

6.6.1.2 Modified Level D Protection

Modified Level D PPE, at a minimum, will consist of:

- Standard work uniform or coveralls;
- Steel-toed, high-topped work boots;
- Safety glasses;
- Hard hat;
- Hearing protection when working around loud equipment or machinery;
- Splash shield when working with chemicals;
- Leather-palm gloves when handling tools or other equipment;
- Chemical-resistant gloves when working with chemicals;
- High-visibility vest (minimum ANSI Class 2) when working around vehicle traffic or equipment;
- Tyvek coveralls, elastic wrists, and elastic ankles when working in areas where contact with ticks, poison ivy, and/or poison oak is a potential risk.

6.6.1.3 Level C Protection

Level C PPE, at a minimum, will consist of:

- Full-face APR;
- Combination filter/cartridge providing protection against organic compounds and particulates (this PPE may vary based on potential chemical exposures of concern and will be determined by the JV SHM or PM);
- Steel-toed work boots or steel-toed polyvinyl chloride (PVC) boots (if liquids are encountered);
- Tyvek (or equivalent materials) coveralls with hoods and elastic wrists and ankles (if low toxicity, solid contaminants will be encountered);
- Chemical-resistant coveralls (Saranex; if moist contaminants or liquids will be encountered);
- Latex or nitrile gloves (inner) and nitrile gloves (outer; if liquids will be encountered);
- Hearing protection (if necessary);
- Hard hat;
- PPE for work where contact with poison oak is a potential risk will consist of Tyvek coveralls with hoods, elastic wrists, and elastic ankles. Nitrile gloves also will be worn, and all glove/coverall interfaces taped securely;

- Contact with heavy brush that may puncture or tear the Tyvek will require that Saranex coveralls be worn; and
- High-visibility (minimum ANSI Class 2) vest when working around vehicle traffic or mobile equipment.

6.6.2 Respiratory Protection

It is not anticipated that respiratory protective equipment will be required for site activities. If site conditions change that necessitate respiratory protection, all site work will cease, and the area will be evacuated. Site conditions will be reassessed with the Contracting Officer's Representative (COR) and USACE Safety Manager.

6.6.3 Personal Protective Equipment for Visitors

An adequate supply of hard hats, safety glasses, and other basic PPE will be maintained on site for government personnel and visitors use. This does not apply to other government contractors who must supply all of their own PPE. Visitors are not to be supplied with chemical protective clothing without previous approval by the PM and documentation of proper training. Respirators will not be issued to non-JV personnel.

6.7 Sanitation

- Sanitation facilities will be provided.
- Contact with contaminated soil is not anticipated for this project. Limited contact with contaminated groundwater may occur. Disposal PPE will be used as indicated.
- Personnel must wash their hands and face before breaks and lunch.
- A break area will be identified.

6.8 Site Control and Decontamination

Limited exposure to contaminated soil during drilling is anticipated, and limited exposure to contaminated groundwater is anticipated during groundwater monitoring. Disposable PPE will be used. Sampling equipment decontamination and IDW management will be performed in accordance with the Sampling and Analysis Plan (H&S 2013). Peristaltic pumps with dedicated tubing for each sampling location will be used for groundwater sampling; therefore, only a dry Level D decontamination is planned for this project. Areas surrounding drilling operations or open monitoring wells will be secured to limit unauthorized access. Wet decontamination procedures and associated control zones described below are included for reference should they become necessary.

6.8.1 Site Control Work Zones

If needed, the JV will establish a Secured Zone, Support Zone, Exclusion Zone, and Decontamination Zone. Appropriate signage boundaries and barriers will be constructed to ensure that personnel exiting the Exclusion Zone pass through the Decontamination zone before entering the Support Zone and exiting the site. Work and Support Zones will be established in order to contain contamination within the smallest area possible. The JV will verify that each employee has the proper PPE for the area or zone in which he/she is to perform work. The following areas will be delineated by the on-site Site Supervisor as necessary to maintain cleanliness:

- Exclusion Zone;
- Decontamination Zone;
- Secured Zone;
- Support Zone.

These areas will conform to guidelines as published by USEPA: "Standard Operating Safety Guidelines," 1984 as published by National Institute of Occupational Safety and Health (NIOSH)/OSHA/U.S. Coast Guard (USCG)/USEPA in Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities: 1985. The areas will be delineated by barricades and/or safety fencing.

6.8.2 Decontamination

At the conclusion of an activity, or before leaving the site, all personnel and equipment will be properly decontaminated following all applicable OSHA standards. If Site Control Work Zones are established, decontamination will occur at a central location within the boundaries of the project site in a Contamination Reduction Zone that is properly cordoned off and contains applicable signage. Either wet or dry decontamination methods will be used based on the activity or equipment being used. If a dry decontamination method is used, brooms or other hand tools will be used to remove soil/sediment and any other residual materials from tires, undercarriages, and other areas. If dry decontamination proves to be ineffective, wet decontamination methods will be used. If wet decontamination is used, all equipment will be washed using a brush, detergent, and a potable water rinse. Any water and/or debris will be collected and containerized for proper disposal at a later date.

Personnel and Small Equipment

When exiting an Exclusion Zone, tools and other non-essential safety items will be removed or disposed (containerized) in the Contamination Reduction Zone. For levels C and D decontamination, outer garments and tools will be decontaminated in the Contamination Reduction Zone by washing with a detergent solution, followed by a water rinse as necessary. On crossing the boundary of the Exclusion Zone, personnel may remove and discard outer boot covers and outer gloves. The next step is to remove outer garments and protective clothing. The last step is to remove eye protection. A portable wash water station will be provided for washing face and hands. The eye wash station will also be located as close to the source of the hazard as practical. The following decontamination sequences will be followed, as appropriate, for the level of protection being used:

- **Level D Decontamination:**

Step 1 Remove and dispose of outer boot covers.

Step 2 Remove outer gloves.

Step 3 Remove surgical gloves.

Step 4 Wash and rinse hands with Alconox and tap water.

- **Level C Decontamination:**

  Step 1 Remove and dispose of outer boot covers.

  Step 2 Remove and dispose of outer gloves.

  Step 3 Remove chemical-resistant coveralls.

  Step 4 Remove air-purifying respirator.

  Step 5 Remove and dispose of inner gloves.

  Step 6 Wash and rinse hands with Alconox and tap water.

Vehicle Decontamination

The JV will inspect and decontaminate vehicles, if necessary, before the vehicles exit the site onto public streets. The JV may use brushes and/or pressure washers to decontaminate vehicles within the Decontamination Zone. If warranted, the JV will employ the use of detergents and/or surfactants in the decontamination process.

Disposition of Decontamination Wastes

All equipment and solvents used for decontamination will be decontaminated or disposed of properly as IDW per site-specific protocols.

Work Clothes

The JV will provide for the proper personal protective clothing.

6.8.3 Security

Site security of JV work areas will be maintained by the JV during work hours.

The JV will maintain a log of security incidents and visitor access granted. Visitors will be required to sign the daily sign-in log.

7.0 SUBCONTRACTOR SAFETY

The JV will evaluate subcontractors before selection for on-site or off-site work. Subcontractors will be subject to evaluation and approval by the SSHO and PM. Health and safety considerations that will be considered when selecting subcontractors include:

- Company experience, expertise, and reputation;
- Written health and safety program;
- OSHA citation and JV-related litigation history;
- Experience and qualifications of personnel.

7.1 Safety and Health Plan Review and Documentation

Subcontractors involved in the investigation of hazardous wastes working on site or those working off site that are directly exposed to impacted or potentially impacted groundwater or soil must comply with the following provisions:

- Provide Hazardous Waste Operation and Emergency Response (HAZWOPER) training documentation and medical fitness-for-duty documentation (as applicable) to the JV before initiating work.
- Provide and implement an Emergency Response Plan and/or AHA addressing the hazards associated with the work that they will be performing.
- Sign a statement attesting to their having read and understood the SSHP and agreement to comply with the plan (*Appendix A*).
- Subcontractors may be required to submit a copy of their corporate health and safety manual to the JV upon request.

7.2 General Safe Work Practices

Subcontractors must comply with the provisions of the SSHP including, but not limited to, the following:

- All subcontractors will obey the directives of the JV.
- Subcontractor personnel who do not comply with the safety requirements may be immediately dismissed as required by the JV.
- On-site subcontractor personnel will work in teams of at least two persons (buddy system) and visual contact between team members must be maintained.
- JV personnel may be engaged to complete a team, provided advance notice is given to the JV.
- JV personnel must escort on-site subcontractor personnel unless they have been issued clearance to conduct work without such an escort.

8.0 EMERGENCY RESPONSE PLAN

This section outlines the JV's Emergency Response Plan in accordance with 29 CFR 1910.120 (l)(1). For major emergency events (e.g., large fires, explosions, and uncontained chemical spills) personnel will be evacuated to a designated refuge area, and local fire, police, and/or emergency medical service personnel will be notified. For other than small fires and contained spills, local emergency response agencies will be relied upon to provide containment and control functions.

- No visitors will be permitted on site unless cleared by the JV and provided with the site-specific emergency response procedures.

8.1 Emergency Communications

A list of emergency contact numbers is included as *Appendix C*. The hospital location, map, and directions are included as *Appendix C*.

Communications are critical to allow for expedient communication of operational instructions, safety information, and emergency alerts, and will include:

- Cellular phones may be used for emergency communications. Emergency contact numbers will be posted at the site. Emergency communication has priority over all other communications.
- Two-way radios may serve as an alternate method for field and emergency communications. Emergency communication has priority over all other communications.
- The 911 Emergency Number System will be used to contact the appropriate assistance (medical, fire, police) for any type of site emergency that is beyond the capabilities of personnel present.
- If personnel are working in different locations, and are not in visual contact, two-way radios may be used to keep teams informed of emergency situations.
- Hand signals to communicate emergency conditions include:
  - Clutching Throat – CANNOT BREATHE;
  - Thumbs Up – OK/AFFIRMATIVE;
  - Thumbs Down – TROUBLE/ NEGATIVE;
  - Wave Arms Above Head – NEED HELP.

The standard order of emergency communications is as follows:

1. Alert all other field personnel of the emergency situation, including response instructions (e.g., evacuate, need help), and evacuate if necessary.
2. Summon outside emergency medical service (EMS) if required by calling 911.
3. Summon outside non-medical EMS service (if required) by calling 911.

4. Notify the SSHO, inform of the situation, and obtain further instructions.
5. The SSHO will promptly inform the Site Supervisor.

8.2 Emergency Supplies

The following emergency supplies will be maintained at the job site:

- First aid kit;
- Emergency eye wash supplies;
- Portable multi-purpose (ABC) dry chemical fire extinguisher (to be kept within 75 feet of work activities where flammable/combustible materials and an ignition source are present [refer to *Section 3.2.3*])

Field personnel are responsible for maintaining emergency supplies.

8.3 Emergency Response Procedures

This section addresses personnel response procedures to non-medical emergencies. If an emergency situation is beyond the capabilities of field personnel, the appropriate emergency agency should be immediately contacted by calling 911. The Senior Engineer will promptly be notified in the event of any emergency response.

8.3.1 Response to Fire

JV employees will not respond to explosives fires. In the event of an explosives fire, JV employees will evacuate to a refuge area and contact the fire department immediately. In the event of a fire, the following procedures will be implemented:

- In the event of a large fire (beyond the immediate control of a small fire extinguisher):
    - Notify all field personnel via emergency communications.
    - Immediately evacuate the work area and reassemble at a pre-determined safe, upwind location (to be announced at daily health and safety meetings).
    - Notify the fire department by calling 911.
    - Notify JV Management.
    - Personnel will not re-enter the fire area. Personnel will remain in a safe location until the fire department arrives and gives further instructions, or as directed by the fire department.
- In the event of a small fire:
    - Notify all site personnel via emergency communications.
    - Trained personnel will extinguish the fire using fire extinguishers.

8.4 Emergency Medical First Aid Procedures

This section addresses personnel response to medical emergencies. If an emergency situation is beyond the capabilities of field personnel, the appropriate emergency agency should be immediately contacted by calling 911. The Site Supervisor will promptly be notified after any medical emergency. (*Refer to Figure 1 for Hospital Location and Route Map.*)

8.4.1 Heat Exhaustion

- If the victim is pale, has faintness, cramps, and is actively sweating (not merely wet from previous sweat), the victim must be moved to a cool place as soon as possible.
- Remove as much clothing from the victim as possible.
- Allow victim to take in electrolyte replacement fluids.
- Monitor the victim for shock and any further symptoms of failure to cool down.
- Seek professional medical assistance if necessary.

8.4.2 Heat Stroke

- If the victim has dry, flushed skin, loss of consciousness, dilated pupils, or muscular twitching, the victim must be cooled as rapidly as possible.
- Remove outer clothing and place the victim under ice-cold water, cold packs, or cold towels immediately.
- Fan air across the victim to assist in evaporative heat loss.
- Decontaminate the victim as required and call 911 for immediate medical assistance.

8.4.3 Hypothermia

- If victim is shivering uncontrollably, has sluggish thinking, difficulty speaking, muscular rigidity, blue puffy skin, poor coordination, and/or erratic heartbeat, the victim’s body trunk (only) must be warmed immediately.
- Remove outer clothing and immerse victim in warm (105°F) water or use heat packs on the body trunk.
- Alternatively, remove clothing from the victim’s upper body and provide body-to-body contact for heat transfer.
- Decontaminate the victim as required and call 911 for immediate medical assistance.

8.4.4 Frostbite

- If victim has blanched skin or waxy, white skin that is firm to the touch or (more severe) firm, pale, or black skin and complete loss of sensation, immediately move the victim to a warm shelter.

- Warm the affected areas with warm (105°F) water. DO NOT RUB. Prevent re-freezing of affected areas.
- Seek professional medical assistance.

8.4.5 Miscellaneous Emergency Signs, Symptoms, and Treatments

Table 4 (found in Attachment L) provides a general summary of potential medical emergencies (not identified above) that could occur on this project.

8.5 Incident Reporting

Promptly after any emergency incident, the SSHO and/or PM will prepare a written report of the emergency incident and initiated response. Incident Report Forms are included in *Appendix E*. The JV PM will coordinate necessary reporting with health and safety personnel as required.

8.6 Training

Training requirements of JV Personnel and subcontractors are provided in *Section 8.0* of the SSHP. Emergency Response Plan provisions and procedures will be discussed and reviewed at health and safety meetings. Personnel knowledge and Emergency Response Plan procedures will be evaluated and addressed in health and safety meetings and/or Emergency Response Plan/SSHP revisions or addenda.

8.7 Plan Review

Periodically, emergency incident reports, training evaluations, personnel comments, and safety inspections will be used for the critique and review of the provisions set forth in the SSHP and Emergency Response Plan.

This review may be performed by the Senior Project Manager or PM. Upon approval of the PM, the SSHP and/or Emergency Response Plan may be revised or addended to address health and safety issues or emergency response procedures that are inadequately described or provided for in the SSHP.

9.0 TRAINING

The JV will review and maintain copies of certificates of health and safety training (e.g., HAZWOPER) for field personnel, and these will be made available for inspection as requested. Personnel will not be allowed to perform field activities until such documentation has been presented to the JV.

9.1 HAZWOPER Training

All personnel performing on-site field activities or off-site field activities (if they involve investigation of hazardous waste) must have completed HAZWOPER training as required by 29 CFR 1910.120 (e)(3). Required HAZWOPER training includes:

- Basic Site Personnel Training: 40 hours of off-site training and 3 days of supervised field experience [29 CFR 1910.120 (e)(3)(i)];
- Management and Site Supervisory Training: 40 hours of off-site training plus 8 additional hours of manager and supervisory training [29 CFR 1910.120 (e)(4)]. Additionally, management and supervisory personnel must have sufficient experience to perform the requirements of their positions.
- Refresher Training: 8 hours of refresher training will be required annually [29 CFR 1910.120 (e)(8)].

9.2 Authorized Facility Visitor Training Requirements

Only visitors authorized by the SSHO will be permitted access to the site. Visitors will be required to follow policies and procedures outlined in this SSHP. Any visitor entering the job site will be expected to sign in with the SSHO and comply with OSHA standards. An SSHP Affidavit is provided in *Appendix A*. Visitors will be required to don PPE. Visitors will be provided work area-specific orientation/training.

9.3 Safety Meetings

9.3.1 Project Safety Orientation Meeting

Personnel required to attend a safety orientation meeting will do so before initiating work. The meetings will be conducted by the JV. The following topics may be discussed during the meeting:

- Project background;
- SSHP provisions including the Emergency Response Plan;
- Facility layout and emergency documentation/information locations;
- Anticipated hazards and required PPE;
- Evacuation and emergency communication procedure;
- Other specific health and safety requirements.

Project safety orientation meetings will be documented by the JV on the form provided in *Appendix F* as appropriate. Additionally, new personnel, subcontractors, and visitors will be required to complete an SSHP Acknowledgement and Compliance Form provided in *Appendix A*. Safety orientations must be performed annually.

9.3.2 Daily Safety Meetings/Tool Box Talks

Personnel will be required to attend a mandatory Daily Safety Meeting/Tool Box Talk each morning before initiating daily work. Daily Safety Meetings/Tool Box Talks meetings will be documented by the JV as appropriate. The topics discussed will be noted on the JV Daily Report. New Job Safety Assessment (JSAs) will also be reviewed and discussed by the entire crew. At that time, an update of personnel and community air monitoring results will be provided and discussed.

9.3.3 Health and Safety Meetings

The Senior Engineer or authorized JV personnel will conduct a health and safety meeting for required personnel before the commencement of work. The purpose of these meetings is to:

- Describe the daily assigned tasks and their potential hazards.
- Coordinate activities.
- Identify methods and precautions to prevent injuries.
- Plan for emergencies.
- Describe any changes in the SSHP.
- Obtain personnel feedback on conditions affecting health and safety.
- Obtain personnel feedback on how well the provisions of the SSHP are working.

Health and safety meetings will be documented using the form provided in *Appendix F*. These forms will also serve as a sign-in sheet for personnel performing work.

9.3.4 Munitions and Explosives of Concern General Awareness Training

A MEC general awareness training meeting will be conducted before any site work begins. With the possibility of UXO at this site, all personnel will be required to attend this meeting. After the meeting, employees will be able to identify UXO and stop work when required. If UXO is encountered during project work, the SSHO and PM will be contacted immediately, and Army personnel will be notified of the potential hazards in order to contact the proper authorities.

9.4 Medical Response Training

JV personnel working on site or off site for more than 30 days will maintain current cardiopulmonary resuscitation (CPR) and first aid training. At least one person with current CPR and first aid training will be present during field work.

10.0 AIR MONITORING PLAN (AMO)

Air monitoring will be conducted in Work Zones in order to determine baseline data on potential hazards and periodically to evaluate any changes in conditions of the specific work area. Each work area must be screened for ambient levels of contamination before initiating work activities.

A photoionization detector (PID) equipped with a 10.2 eV lamp will be used to monitor the worker breathing zone for total organic vapor (TOV) levels during all work activities that might be performed in the presence of volatile organic compound (VOC) gases. PID monitoring will be performed continuously during the implementation of the work, and the results will be recorded at a minimum frequency of once per hour.

In addition, the JV will use a four-gas meter to take oxygen, carbon monoxide, hydrogen sulfide, and lower explosive level (LEL) readings for any activity to be conducted in a confined or poorly ventilated area.

10.1 Air Monitoring Program

Air monitoring is essential to ensure that all field personnel are adequately protected from airborne contaminants. When work is performed that might generate gases, vapors, dusts, fumes, mists, or other airborne hazardous materials, air monitoring will be conducted.

Threshold limit values (TLVs) and permissible exposure limits (PELs) refer to airborne concentrations of substances that represent conditions to which nearly all employees may be repeatedly exposed for up to 8 hours per day, 5 days per week, without adverse effect. It is the JV's policy to use the stricter of these two exposure standards, generally those of the American Conference of Governmental Industrial Hygienists (ACGIH) TLV (ACGIH 2018). However, whenever applicable, even stricter guidelines may be used. Exposure limits for COCs are provided in *Attached Table 1*. *Table 5* provides air monitoring action levels.

Air monitoring will be used to:

- Determine the effectiveness of engineering controls in place to keep the readings below action levels.
- Facilitate proper selection of PPE, evaluate the need for more aggressive control methods, and determine the effectiveness of PPE in use.
- Determine real-time breathing zone results during work.
- Provide real-time results for the area.

10.1.1 Air Monitoring Requirements

The following activities are required during air monitoring:

- A PID will be used to measure gases and organic vapors in the work area (primarily monitoring well headspace).

- All air monitoring results will be documented in project field notes.
- Monitoring and equipment calibrations will be performed according to manufacturer's instructions and guidelines.
- Monitoring and equipment calibrations will be performed only by JV employees qualified by education and training to do so.
- Equipment calibrations will be performed daily at a minimum and will be documented in the project logs.

The SHM or PM will determine the need for personal exposure monitoring.

10.1.2 Locations to be Monitored

Integrated air monitoring samples and direct instrumentation readings taken for the purpose of determining appropriate safety and health precautions will be collected or taken in the "breathing zone" of site personnel during drilling. Additional sample locations should include those that are "worst case," (i.e., likely to contain the highest concentrations and the perimeter of the work area – particularly the downwind direction).

10.1.3 Monitoring Frequency

Background concentrations will be identified before startup of any equipment, sampling, or drilling. This is necessary for obtaining accurate results.

Area and personal breathing zone air monitoring will be conducted at the beginning of any intrusive work. Additionally, air monitoring will be conducted throughout the work shift in 30-minute intervals. If results reach or exceed the action level during PID usage, detector tubes may be used to determine concentrations of the COPCs.

The SSHO will provide air monitoring data to the PM/SHM. The SHM will evaluate the results and, when possible, alter the health and safety requirements in order to complete the sampling plan. All readings must be documented, even if contaminant concentrations are "non-detectable" or zero in value.

10.1.4 Activities to Monitor

All work with the potential to generate contaminant exposures, mainly drilling activities, will be monitored with direct-reading instruments.

10.1.5 Job Site-Specific Air Monitoring Requirements

A PID will be used to monitor total VOC levels during drilling or other vapor-producing activities. Action levels are based on readings sustained for a 30-minute period in the employee's breathing zone.

Common work practices used to minimize employee exposure to contaminants include:

- Ensuring that employees work upwind of the contamination source;
- Continuously monitoring if PID readings approach action levels;
- Stepping back to allow headspace vapors to diffuse and disperse;
- Moving on to another well if necessary

10.2 Monitoring Equipment Maintenance and Calibration

If used, all air monitoring equipment (e.g., PIDs, combustible gas indicator, colorimetric pumps,) will be maintained in accordance with the specific manufacturer's instructions. Equipment will be calibrated before and after each day’s use. Calibration gases used for the PID and combustible gas detector will have properties similar to the contaminants anticipated. The PID will be calibrated with isobutylene. The combustible gas detector will be calibrated with methane.

Calibration will be conducted in a clean environment similar to the actual work environment in terms of temperature, pressure, humidity, and "background noise." Before actual use, each instrument will be allowed sufficient time to warm up and will be "zeroed" as applicable. All air monitoring equipment calibrations and maintenance will be documented on the JV Daily Field Log and a PID Calibration Log.

Table 5. Air Monitoring Action Levels

Work Activity	Monitoring Method	Frequency of Monitoring	Location of Monitoring	Action Level	Corrective Action
Mobilization	PID	Before commencement of vapor-producing activities	Breathing zone, “worst case,” perimeter, down wind	NA	Identify and record background concentrations.
Vapor-producing activities: • Groundwater Sampling • Soil Sampling • IDW Sampling	PID	Initially, then at least every 30 minutes if contaminant is detected Visible dust present Moist/discolored/odorous soil is present	Breathing zone, “worst case,” perimeter, down wind	> 3 units above background (sustained for 5 minutes)	Measure for benzene with colorimetric tube. Locate source of contamination if possible, remain upwind.
				>25 units above background (sustained for 5 minutes)	Measure for TCE with colorimetric tube or assign all PID readings as TCE. Locate source of contamination if possible, remain upwind.
	Colorimetric Tube (Benzene)	When PID readings exceed 3 units above background (sustained for 5 minutes in breathing zone)	Breathing zone, “worst case,” perimeter, down wind	>3 ppm benzene in breathing zone	Upgrade to Level C, locate source of contamination if possible, remain upwind, contact PM.
				>6 ppm benzene in breathing zone	Stop work. Contact PSHM.
	Colorimetric Tube (TCE)	When presence of benzene has been ruled out and when PID readings exceed 25 units above background (sustained for 5 minutes in breathing zone) Alternative to collecting TCE tube, if benzene has been ruled out: assume that all PID readings are TCE	Breathing zone, “worst case,” perimeter, down wind	25 ppm TCE in breathing zone	Upgrade to Level C, locate source of contamination if possible, remain upwind, contact PM.
				>50 ppm TCE in breathing zone	Stop work. Contact PM.
Demobilization	NA				

Notes:

NA = Not applicable ppm = part per million TCE = trichloroethene

11.0 POSTING REGULATIONS

When required, the JV will post signs at the perimeter of the Exclusion Zone that state “Warning, Hazardous Work Area, Do Not Enter Unless Authorized.” In addition, a notice directing visitors to sign in will be posted at the project site.

12.0 JV HEALTH AND SAFETY POLICIES

The JV has developed additional health and safety policies and procedures applicable to all JV employees while on JV premises and also for work performed by JV employees on JV jobsites.

The JV's company policy is that all JV employees be provided with a safe and healthful place of employment.

TABLES

TABLE 1

OCCUPATIONAL EXPOSURE LIMITS AND TOXICOLOGICAL PROPERTIES FOR CONSTITUENTS OF POTENTIAL CONCERN

(Page 1 of 2)

COPC	OSHA PEL	ACGIH TLV	Chemical Properties	Target Organs	Route of Exposure	Symptoms of Exposure
Total petroleum hydrocarbons (represented as gasoline because it is the closest compound with occupational exposure limits) Gasoline	NA	300 ppm	Clear liquid with a characteristic odor. Incompatible with strong oxidizers, many fluorides and perchlorates, nitric acid. Flashpoint: -45°F LEL: 1.4%	Eyes, skin, resp sys, liver, CNS, kidneys	Inhalation Ingestion Contact Absorption	Irritant to eyes, skin and mucous membranes; dermatitis; headache, fatigue, blurred vision, dizziness, slurred speech, confusion, convulsions; chemical pneumonia; possible liver, kidney damage; CARCINOGEN.
Arsenic	0.5 mg/m^3 organic 0.01 mg/ m^3 0.02 inorganic [29CFR 1910.1027]	0.2 mg/m^3 inhalable	Silver gray – tin white Flashpoint: NA LEL: NA	Skin, eyes, lungs, blood, peripheral nervous system	Inhalation Ingestion Contact	Sensory irritant, lung and skin cancer, aplastic anemia, numbness
Cadmium	0. 005 mg/m^3 [29CFR 1910.1027]	0. 01 mg/m^3 inhalable 0. 002 mg/m^3 respirable	Silver white, blue tinged, lustrous, odorless Incompatible with strong oxidizers, elemental sulfur, selenium, tellurium Flashpoint: NA LEL: NA	Respiratory system, kidneys, prostate, blood	Inhalation Ingestion	Pulmonary edema, dyspnea, cough, tight chest, substernal pain, headache, chills, muscular aches, nausea, vomiting, diarrhea, anemia
Chromium	CRIII 0.5 mg/m^3 CRVI 0.1 mg/m^3	CRIII 0.5 mg/m^3 CRVI 0.001 mg/m^3	Flashpoint: N/A LEL: N/A	CR III Eye irritant, sens derm. CRVI irr resp system, liver, kidney damage, sens derm	Inhalation Ingestion Contact	CR III Eyes, skin CR VI Blood, resp sys, liver, kidneys, eyes, skin CARCINOGEN
Copper	0.1 mg/m^3	0.1 mg/m^3	Flashpoint: N/A LEL: N/A	Eyes, skin, resp sys	Inhalation Contact	Irrit eyes, upper resp sys, metal fume fever, chills, mus ache, naus, fever, dry throat, cough, weak, lass, metallic or sweet taste, discoloration skin, hair
Cyanide	10 ppm	4.7 ppm	Flashpoint: N/A LEL: N/A	CNS, CVS, thyroid, blood	Inhalation, Ingestion, Contact	Eye irritant, asphyxia, headache, confusion, nausea, thyroid, blood changes, slow gasping
Lead	0.05 mg/m^3 [29CFR 1910.1025]	0.05 mg/m^3 A3 carcinogen [confirmed animal]	Heavy, ductile, soft, solid Incompatible with strong oxidizers Flashpoint: N/A LEL: N/A	Eyes, GI tract, central nervous system, kidneys, blood, gingival tissue	Inhalation Ingestion Contact	Weakness, lassitude, insomnia, facial pallor, anorexia, constipation, abdominal pain, anemia, gingival lead line, tremors, encephalopathy, eye irritation, hypotension, pale eyes, malnutrition, colic, paralysis of wrist & ankles, nephropathy
Nickel	1 mg/m^3	0.015 mg/m^3	Lustrous, silvery, odorless solid Incompatible with strong acids, sulfur, selenium, wood and other combustibles	Nasal cavities, lung, skin [lung and nasal cancer]	Inhalation Ingestion Contact	Ses derm, allergic asthma, pneumonitis CARCINOGEN

TABLE 1

OCCUPATIONAL EXPOSURE LIMITS AND TOXICOLOGICAL PROPERTIES FOR CONSTITUENTS OF POTENTIAL CONCERN

(Page 2 of 2)

COPC	OSHA PEL	ACGIH TLV	Chemical Properties	Target Organs	Route of Exposure	Symptoms of Exposure
PCBs - Aroclor 1254	0.5 mg/m^3 (skin)	0.5 mg/m^3 (skin)	Colorless to light colored, viscous liquid with a mild hydrocarbon odor Incompatible with strong oxidizers Flashpoint: N/A LEL: NA	Skin, eyes, liver, reproductive system	Inhalation Absorption Ingestion Contact	Irritant to eyes, acne-form dermatitis, chloracne, liver damage, reproductive effects. Potential carcinogen
PCBs - Aroclor 1248	none	.001 mg/m^3 (skin)	Colorless to light colored, with a mild hydrocarbon odor	Liver, skin	Inhalation Absorption Ingestion Contact	Liver damage, nausea, abdominal pain
PFAS	--	--	--	Liver, reproductive (adverse developmental outcomes), endocrine system, immune system	Inhalation Ingestion Contact Absorption	Association between exposure and adverse reproductive, developmental, and systemic effects; reasonably anticipated to be carcinogenic
Tetrachloroethylene	100 ppm	25 ppm	Colorless liquid, with sweet characteristic odor Flashpoint: NA	Central nervous system (CNS), kidney, liver, blood.	Inhalation Absorption Ingestion Contact	Irritation to skin and eyes, drowsiness or dizziness, damage to CNS, kidneys, liver, and blood
Toluene	200 ppm	50 ppm	Colorless liquid with sweet pungent odor	Eyes, skin, resp system, CNS, liver, kidneys	Inhalation Absorption Ingestion Contact	Irritant to eyes, skin, and mucous membranes; headache, fatigue, blurred vision, dizziness, slurred speech, confusion, convulsions; liver, kidney damage
Zinc	5 mg/m^3	5 mg/m^3	White odorless solid. Incompatible with chlorinated rubber Flashpoint: NA LEL: NA	Resp sys	Inhalation	Metal fume, fever, chills, musc ache, nau, fever, dry throat, cough, weak, lass, metallic taste, head, blurred vision, low back pain, vomit, ftg, tight chest, dysp

Notes:

ACGIH = American Conference of Governmental Industrial Hygienists
CNS = central nervous system
COPC = constituent of potential concern
CRIII = trivalent chromium
CRVI = hexavalent chromium
CVS = cardiovascular system
GI = gastrointestinal
LEL = lower explosive level
mg/m^3 = milligram per cubic meter
NA = Not applicable
N/A = Not available
OSHA = Occupational Safety and Health Administration
PCB = polychlorinated biphenyl
PEL = permissible exposure limit
PFAS = per- and polyfluoroalkyl substances
ppm = part per million
TLV = threshold limit value

TABLE 4

SUMMARY OF BIOLOGICAL/PHYSICAL HAZARDS AND RISKS

(Page 1 of 2)

Hazards	Associated Tasks	Recommended Exposure Limits	Routes of Exposure	Preventative and Control Measures	Acute Symptoms or Associated Hazards
Animals (Rats and Bats), Insects and Poisonous Plants	All	Dependent on individual's sensitivity	Skin Contact/Physical Contact	• Limit exposure • Avoid contact • Wear protective clothing • Use insect repellent • Training (Recognition)	Localized skin redness and swelling, nausea, contact dermatitis, allergic responses, headache, and rabies (if bitten)
Back Injury	• Material Handling • Lifting • Falls, Slips	Dependent on individual's size	Improper lifting or handling oversized loads	• Ergonomics training • Use mechanical equipment • Use proper lifting techniques	Strains and sprains
Engulfment	• Excavation • Trenching	NA	Entering holes deeper than 4 feet	• Follow Trenching & Excavation SOPS • Sloping, Shoring, Trench Boxes	Bodily harm
Explosive Atmospheres	• Field Monitoring • Trench Entry • Hazardous Materials	< 20% of LEL	Proximity to hazard area (i.e., breaking the plane of the trench or excavation), electrical hazards, chemical release	• Monitor area with LEL meter • Follow Trench & Excavation SOPs • Use Buddy System • Leave area	Bodily harm
Fires	All	NA	• Flammable vapors • Combustible materials at job site • Sources of ignition • Electrical hazard • Equipment malfunction	• Remove ignition sources (site inspection) • No smoking at jobsite • No lighters, matches in work area • Keep trash and debris to a minimum • Air monitoring for flammable vapors and dust • Post emergency numbers	Bodily harm
Frost Injuries Hypothermia	All	NA	Exposure to cold weather	• Wear warm clothing • Avoid long-term exposure to cold hazards • Drink fluids • Work/Warming regimens	• Numbness • Discoloration of skin • Confusion/Disorientation
Hand and Power Tools	All	NA	• Pinchpoints • Unexpected movement • Electrical hazards	• Periodic inspections • Guards • Training • Personal protective equipment	Bodily harm
Heavy Equipment	• Excavation • Trenching • Drilling	NA	• Pinchpoints • Falling from heights • Objects falling from overhead • Rollover • Unexpected movement	• Training • Personal protective equipment • Minimize workers in work area • Inspect equipment daily • Rollover protection • Leave equipment in down position when not in use	Bodily harm
Molds & Fungus	• Sampling • Excavation	NA	Inhalation	• Limit exposure • Avoid contact	Irritation eyes, lungs, and mucus membranes

TABLE 4

SUMMARY OF BIOLOGICAL/PHYSICAL HAZARDS AND RISKS

(Page 2 of 2)

Hazards	Associated Tasks	Recommended Exposure Limits	Routes of Exposure	Preventative and Control Measures	Acute Symptoms or Associated Hazards
	• Remedial activities			• Wear protective clothing • Training (Recognition)	
Noise	All	85 decibels	• Heavy equipment • Power tools	• Wear hearing protection	Hearing loss
Oxygen Level	• Field Monitoring • Trench Entry	>19.5% but <23.5%	• Unventilated areas (trench or excavation) • Displacement or consumption of O_2 by a chemical (trench or excavation	• Monitor area with oxygen meter - Retreat from area with low/high oxygen • Use buddy system	• Confusion • Unconsciousness • Increased risk of combustion hazard.
Guano	• Sampling • Excavation • Remedial activities	NA	Inhalation	• Limit exposure • Avoid contact • Wear protective clothing • Training (Recognition)	Malaise, fever, chest pain, cough, headache, loss of appetite, muscle pain
Sunburn	All outdoor tasks	NA	Exposure to sunlight	• Minimize exposure to sun • Wear sunscreen and protective clothing	• Red skin • Dizziness
Trips, Slips and Falls (physical hazards)	All	NA	• Heavy equipment • Power tools • Hand tools	• Eliminate or minimize trip hazards • Use safe work practices • Adhere to Local Safety Plan procedures	• Scrapes, cuts, bruises • Broken bones • Sprains and strains
Unexploded Ordnance (UXO)	• Chemical injections • Drilling	NA	Intrusive activities such as drilling	• On-site MEC training • UXO Technician support during intrusive activities in MEC Areas	Bodily harm

Notes:

LEL = lower explosive level

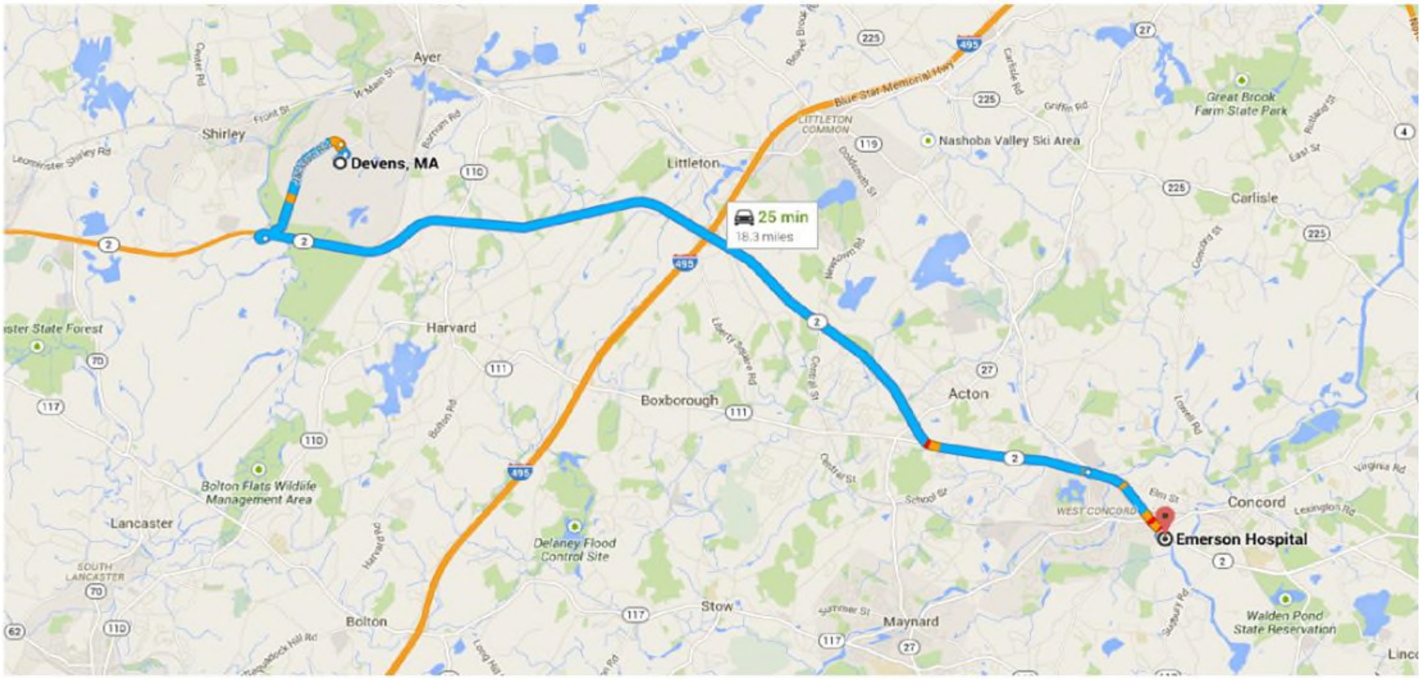
MEC = munitions and explosives of concern

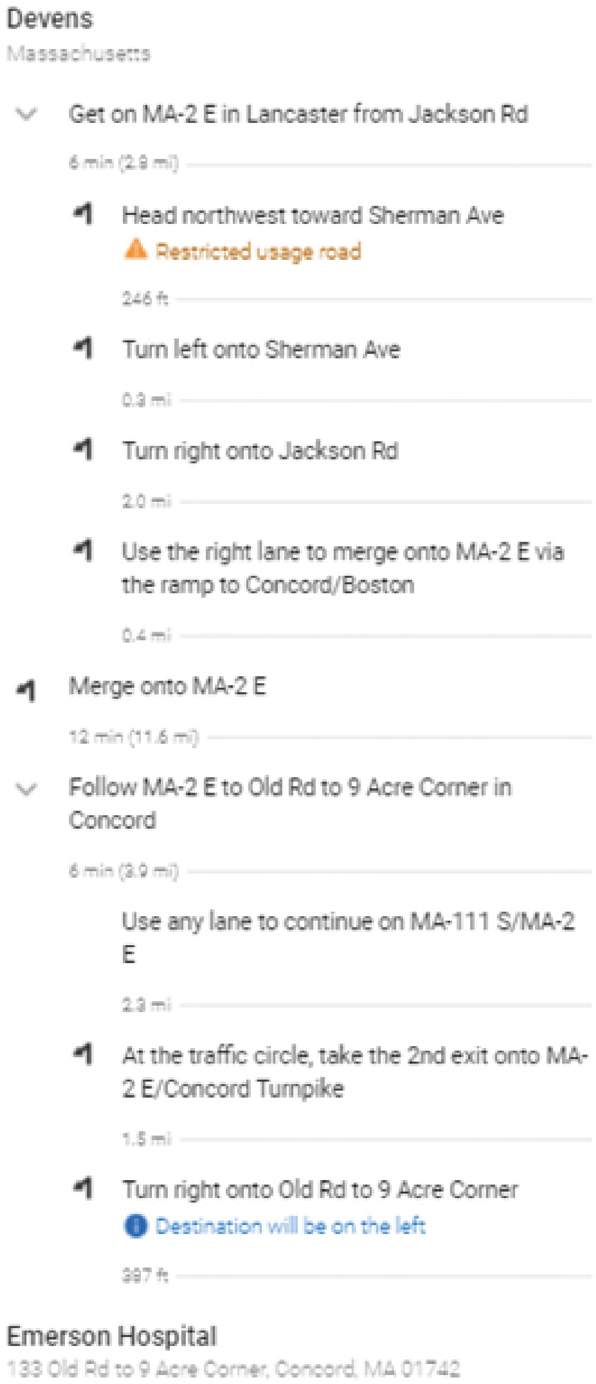
NA = Not applicable

SOP = Standard Operating Procedure

FIGURES

Directions from **Devens, MA** to **Emerson Hospital**





Devens

Massachusetts

Get on MA-2 E in Lancaster from Jackson Rd

6 min (2.8 mi)

Head northwest toward Sherman Ave

⚠ Restricted usage road

246 ft

Turn left onto Sherman Ave

0.3 mi

Turn right onto Jackson Rd

2.0 mi

Use the right lane to merge onto MA-2 E via the ramp to Concord/Boston

0.4 mi

Merge onto MA-2 E

12 min (11.6 mi)

Follow MA-2 E to Old Rd to 9 Acre Corner in Concord

6 min (3.9 mi)

Use any lane to continue on MA-111 S/MA-2 E

2.3 mi

At the traffic circle, take the 2nd exit onto MA-2 E/Concord Turnpike

1.5 mi

Turn right onto Old Rd to 9 Acre Corner

ⓘ Destination will be on the left

397 ft

Emerson Hospital

133 Old Rd to 9 Acre Corner, Concord, MA 01742

Appendix A

Health and Safety Affidavit

SITE SAFETY AND HEALTH PLAN REVIEW

Project Name: ______________________________

Project Location: ______________________________

Date: ______________________________

Conducted By: ______________________________

I have reviewed the JV Site Safety and Health Plan for the above indicated site and understand the hazards and control measures required on this project.

I agree to follow the procedures outlined in this plan and to inform the JV Project Manager, Project Superintendent, and/or Site Safety and Health Officer should any unsafe condition be noted.

I understand that failure to follow safety regulations can be reason for removal from this project.

Date	Name	Signature	Company

Appendix B

Project Personnel & Emergency Contact Information

ENVIRONMENTAL REMEDIATION SERVICES
FORT DEVENS ARMY INSTALLATION
BRAC LEGACY SITES, MASSACHUSETTS
CONTRACT NUMBER: W912WJ19D0014

Emergency Contact Information

IN CASE OF FIRE OR EMERGENCY DIAL 911

Andy Vitolins, Project Manager SERES-Arcadis 8(a) JV2, LLC 1 Executive Drive, Suite 303 Chelmsford MA 01824	Office: (518) 461-3145 Cell: (518) 250-7359
Diane Champagne, Project Scientist, SSHO SERES-Arcadis 8(a) JV2, LLC 1 Executive Drive, Suite 303 Chelmsford MA 01824	Office: (978) 937-9999 Cell: (987) 505-1120
Penelope Reddy, PM US Army Corps of Engineers, New England District 696 Virginia Road Concord, MA 01742	Office: (978)-937-9999 Cell: (978)-505-1120
Robert Simeone US Army Building 666 Fort Devens, Devens, MA	Office (978) 796-2205
Ron Ostrowski MassDevelopment 33 Andrews Parkway Devens, MA	Office (978) 784-2900
Nashoba Valley Regional Emergency Communication Center 270 Barnum Road Devens, MA 01434	(978)772-1900
Devens Fire Department 182 Jackson Road Devens, MA 01434	(978) 772-4600
Poison Control – US	1-800-222-1222

Appendix C

Activity Hazard Analysis Forms & Job Safety Analysis Forms

Activity Hazard Analysis (AHA)

ACTIVITY/WORK TASK:	**Mobilization and Site Preparation**
DATE:	May 2021
LOCATION:	Devens BRAC Legacy Sites
CONTRACT NUMBER:	W912WJ19D0014
PRIME CONTRACTOR:	SERES-Arcadis 8(a) JV2, LLC
SUBCONTRACTOR:	Subcontractors : To Be Determined (TBD)
PROJECT MANAGER	Andy Vitolins
SITE SAFETY AND HEALTH OFFICER	Diane Champagne

Overall Risk Assessment Code (RAC) (Use highest code)			**M**
Activity #	1	AHA #	**1**

Risk Assessment Code (RAC) Matrix

Severity	**Probability**				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	**E**	**E**	**H**	**H**	**M**
Critical	**E**	**H**	**H**	**M**	**L**
Marginal	**H**	**M**	**M**	**L**	**L**
Negligible	**M**	**L**	**L**	**L**	**L**

Review each **"Hazard"** with identified safety **"Controls"** and determine (RAC)

E = EXTREMELY HIGH (PWO/OICC/ROICC)	🟥
H = HIGH RISK (FEAD DIRECTOR)	🟧
M = MODERATE RISK (CM or ET or PAR)	🟨
L = LOW RISK (ET or PAR)	🟩

Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" .Place the highest RAC at the top of AHA. This is the overall risk assessment code for this activity

"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible after controls are in place

"Probability" is the likelihood to cause an incident, near miss, or accident did occur and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely after controls are put in place.

Job Steps	Hazards	Controls	RAC
General Safety Requirements - all Steps	Exposure to Cold or Heat Stress	**Minimum Personal Protective Equipment Dress:** • Long Pants • High Visibility • Hardhat • Work Gloves • Shirts with Sleeves • Covered Shoes (Steel Toe Preferred) • Safety Glasses • Hearing Protection (as required)	**L**
	Weather	**Weather:** • Wear appropriate clothing for hot or cold weather • Sun block • Lip balm	**L**

Job Steps	Hazards	Controls	RAC
General Safety Requirements - all Steps	Dehydration	**Dehydration:** • Drink at least $^1/_2$ liter of water per hour.	**L**

	Eye Protection NOTE: The above hazards are not all inclusive. The SSHO and QAR shall review all AHAs daily and modify as necessary.	• Refer to APP/SSHP, SOPs, plan, etc. for specific details on heat stress signs and symptoms. **Eye Protection:** • Minimum eye protection is OSHA approved safety glasses with side shields. • Approved face shields must also be worn when flying particles or chemical splashes could contact the face.	**L**
Transportation to and from site	1. Traffic accidents	*1. Follow safe driving practices. Stay alert.*	**L**
Driving onsite	1. Risk of striking pedestrians, deer, other vehicles, or site appurtenances.	*1. Stay alert. Look before backing. Drive at reduced speeds (as posted). Workers in open areas should don reflective clothing so they are noticeable.*	**L**
Loading and unloading equipment/supplies	1. Slip trips or fall risk. Lifting hazards. Pinch hazards.	*1a. Evaluation of exposures in surrounding area (both interior and exterior).* *1b. Mark out of any utilities near area being repaired* *1c. De-energize and lockout tag out electrical services or double block and bleed utilities that could be impacted by demolition work in accordance with the SSHP Section 12.* *1d. Refer to EM 385-1-1, Section 11 for Electrical hazards protection requirements. Consult with Safety Officer.* *1e. Utilize proper lifting techniques. Lift with knees not back.* *1f. Size up load before lifting.* *1g. Ask for help when lifting heavy items more than 50 lbs.* *1h. Use legs and hold loads close to body when lifting.* *1i. Follow good housekeeping practices.* *1h. Stow equipment away safely.* *1j. Stow chemicals appropriately. Flammables may only be stored in flammable storage lockers.* *1k. Forklift may only be operated by trained persons.* *1l. Use carts, dollies or other material handling equipment to move materials over longer distances*	**L**
	2. Biological Hazards: Potential Exposure to poisonous plants, snakes, spiders, rodents, insects, ticks, and mosquitos	*2a. Watch for, and avoid contact with, poisonous plants, snakes, spiders, rodents, insects, ticks and mosquitoes.* *2b. Do not drink the water on site.* *2c. Wear long sleeves and pants, tuck pantlegs into boots.* *2d. Wear insect repellant with DEET.*	**L**
	3. Physical Hazards: Fire protection	*3a. Fire Hazards: Gasoline and diesel fuel will be used for vehicle operation.*	**L**

		3b. Require fire extinguishers for each site location. *3c. Allow smoking only in designated areas.* *3d. OSHA-approved metal safety cans, painted red with a yellow stripe, that have self-closing lids and flame arrestors must be used to store small amounts of flammable liquids.* *3e. Hot work is prohibited in areas where flammable materials, equipment containing flammable materials, and contaminated soil air emissions may be present.*	
	4. Physical Hazards: Overhead utilities	*4a. Overhead utilities will be present.* *4b. Survey for overhead utilities before bringing equipment with high extensions into a work area.* *4c. Do not operate equipment within 10 feet of overhead lines*	**L**
	5. Physical Hazards: Vehicle and Equipment Traffic	*5a. Concurrent use of vehicles and ground personnel will occur.* *5b. Establish traffic control procedures when there is vehicle and/or pedestrian traffic present.* *5c. Have workers wear high-visibility safety vests with reflective striping when working near traffic areas.* *5d. Advise workers to look carefully where they walk to avoid vehicles and moving equipment.* *5e. Use traffic control devices as needed*	**L**
	6. Physical Hazards: Material Handling	*6a. Wear work gloves when handling materials.* *6b. Watch for items that can cut, puncture, pinch, or crush.* *6c. Use proper lifting technique.* *6 . Size up load, get help for heavy or awkward items, get good grasp on object to be lifted, keep load close to body, keep back straight, lift with legs not with back, and do not twist when lifting.* *6a. Review material handling procedures during safety meetings.*	
	7. Physical Hazards: Hand and Power Tools	*7a. Use the proper tool for the job.* *7b. Use GFCIs for power tool operation.* *7c. Use safety glasses.* *7d. Do not use damaged tools.*	

		7e. Properly secure materials when working on them. *7f. Inspect electrical cords.*	
	8. Physical Hazards: Generators, Machinery and Electrical Equipment use	*8a. Use GFCIs for portable electrical equipment. Inspect electrical extension cords for damage and ground plugs.* *8 . Keep electrical equipment/cords away from water and fuel materials.* *8b. Use lockout/tagout procedures.*	
	9. Physical Hazards: Noise Exposure	*9a. Noise exposure above 85 dBA is expected when near or operating machinery and equipment.* *9b. Monitor for noise levels.* *9c. Wear earplugs or muffs for protection.*	
	10. Physical Hazards: Heat/Cold Stress, Adverse Environmental conditions	*10a. Heat stress may occur when elevated ambient temperatures, moderate to heavy workloads, and/or use of impermeable protective clothing occur.* *10b. Adjust work-rest schedules as needed.* *10c. Work at a steady pace.* *10d. Drink fluids.* *10e. Take rest breaks and use shaded rest area.* *10f. Know the signs and symptoms of heat exposure and emergency treatment.* *10g. Cold stress may occur during the winter/fall/spring months.* *10h. Minimize exposures to cold temperatures below 45ºF.* *10i. Wear insulated clothing.* *10j. Know the signs and symptoms of cold exposure and emergency treatment.*	

Equipment to be Used	Training Requirements/Competent or Qualified Personnel name(s)	Inspection Requirements
Hand Tools Portable Generator First Aid Kit Safety Shoes	Competent/Qualified Personnel: **Diane Champagne** – CP/SSHO and Fall **Diane Champagne** – QP/First Aid and CPR Training Requirements: OSHA 40 HAZWOPER First Aid/CPR Training Project Indoctrination Training Daily/Monthly safety toolbox meetings Heat or Cold Hazards Use of Power Tools and Equipment Electric Fire Extinguishers	Daily site safety inspections by SSHO. Daily Housekeeping of work areas. Inspect power cord sets prior to use. Inspect temporary power panel box, circuit breakers, grounding, etc. at least monthly. Inspect first aid kit at least monthly. Inspect heavy equipment daily in accordance with operation manual and operator experience Inspect equipment prior to use to ensure equipment is operational, the electrical connections are not damaged and all guards and equipment are in place. Ensure equipment is properly grounded and maintained in accordance with manufacturers recommendations

Activity Hazard Analysis (AHA)

ACTIVITY/WORK TASK:	**Groundwater and Surface Water Sampling**
DATE:	May 2021
PWD/OICC/ROICC OFFICE NAME & DATE ACCEPTED BY GDA:	Devens BRAC Legacy Sites
CONTRACT NUMBER:	W912WJ19D0014
PRIME CONTRACTOR:	SERES-Arcadis 8(a) JV2, LLC
SUBCONTRACTOR:	To Be Determined (TBD)
PROJECT MANAGER:	Andy Vitolins
SITE SAFETY and HEALTH OFFICER	Diane Champagne

Overall Risk Assessment Code (RAC) (Use highest code)			**M**
Activity #	2	AHA #	**2**

Risk Assessment Code (RAC) Matrix

Severity	**Probability**				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	**E**	**E**	**H**	**H**	**M**
Critical	**E**	**H**	**H**	**M**	**L**
Marginal	**H**	**M**	**M**	**L**	**L**
Negligible	**M**	**L**	**L**	**L**	**L**

Review each **"Hazard"** with identified safety **"Controls"** and determine (RAC)

E = EXTREMELY HIGH (PWO/OICC/ROICC)	🟥
H = HIGH RISK (FEAD DIRECTOR)	🟧
M = MODERATE RISK (CM or ET or PAR)	🟨
L = LOW RISK (ET or PAR)	🟩

Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" .Place the highest RAC at the top of AHA. This is the overall risk assessment code for this activity

"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible after controls are in place

"Probability" is the likelihood to cause an incident, near miss, or accident did occur and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely after controls are put in place.

Job Steps	Hazards	Controls	RAC
General Safety Requirements - all Steps	Exposure to Cold or Heat Stress	**Minimum Personal Protective Equipment Dress:** • Long Pants • High Visibility shirts with long sleeves • Hardhat • Work Gloves • Covered Shoes • Safety Glasses • Hearing Protection	L
	Weather	**Weather:** • Wear appropriate clothing for hot or cold weather • Sun block • Lip balm	

Job Steps	Hazards	Controls	RAC
General Safety Requirements - all Steps	Dehydration	**Dehydration:** • Drink at least $^1/_2$ liter of water per hour. • Refer to APP/SSHP, SOPs, plan, etc. for specific details on heat stress signs and symptoms.	**L**
	Eye Protection	**Eye Protection:** • Minimum eye protection is OSHA approved safety glasses with side shields. • Approved face shields must also be worn when flying particles or chemical splashes could contact the face.	**L**
	NOTE: The above hazards are not all inclusive. The SSHO and QAR shall review all AHAs daily and modify as necessary.		
Check for insects/animals around monitoring wells.	1. Chemical Hazards: Minor potential exposure to site low-level VOC concentrations (PPE, air monitoring).	*1a. Chemical Hazards: A limited chemical contact hazard from surface water is expected.* *1b. Use prescribed levels of protection described in the PPE section of the SSHP.* *1c. Properly don and doff protective clothing.* *1d. Conduct monitoring as described in the “Exposure Monitoring” section of the HASP.*	**M**
	2. Biological hazards: Potential exposure to poisonous plants, snakes, spiders, rodents, insects, ticks, and mosquitoes.	*2a. Biological hazards may be present.* *2b. Watch for, and avoid contact with, poisonous plants, snakes, spiders, rodents, insects, ticks, and mosquitoes.* *2c. Do not drink the water onsite.*	
Purge groundwater. Collect groundwater samples. Prepare samples for shipment. Don waders / hip boots and walk into surface water to a location greater than two feet deep.	1. Physical Hazards: Fire protection and hot work	*1a. Gasoline and diesel fuel will be used for vehicle operation.* *1b. Require fire extinguishers for each site location.* *1c. Allow smoking only in designated areas.* *1d. OSHA-approved metal safety cans, painted red with a yellow stripe, that have self-closing lids and flame arrestors must be used to store small quantities of flammable liquids.* *1e. Hot work is prohibited in areas where flammable materials, equipment containing flammable materials, and air emissions from contaminated soil may be present.* *1f. Use hot work safety procedures, hot work permit and fire watch for hot work.*	**L**
Quickly collect surface water sample ahead of the sediment plume that is caused from wading into the water	2. Physical Hazards: Overhead Utilities	*2a. Overhead utilities will be present.* *2b. Survey for overhead utilities before bringing equipment with high extensions (i.e., heavy equipment, dump truck, roll-off bin truck) into a work area.*	**L**
	3. Physical Hazards: Vehicle and equipment traffic	*3a. Concurrent use of vehicles and ground personnel will occur.* *3b. Establish traffic control procedures when there is vehicle, heavy*	**L**

		equipment, and/or pedestrian traffic present. *3c. Have workers wear high-visibility safety vests with reflective striping when working near traffic areas.* *3d. Advise workers to look carefully where they walk to avoid vehicles and moving equipment.* *3e. Use traffic control devices as needed.*	
	4. Physical Hazards: Material handling	*4a. Material handling involving lifting and carrying will be required.* *4b. Wear work gloves when handling materials.* *4 . Watch for items that can cut, puncture, pinch, or crush. Use proper lifting technique.* *4a. Size up load, get help for heavy or awkward items, get good grasp on object to be lifted, keep load close to body, keep back straight, lift with legs not with back, and do not twist when lifting.* *4c. Review material handling procedures during safety meetings.*	**L**
	5. Physical Hazards: Tools, machinery, and equipment use	*5a. Hand and power tools may be used.* *5b. Use the proper tool for the job.* *5c. Use GFCIs for power tool operation.* *5d. Use safety glasses.* *5 . Do not use damaged tools. Inspect tools including electrical cords.* *5e. Properly secure materials when working on them.* *5f. Make sure area is adequately clear when using equipment.*	**M**
	6. Physical Hazards: Electrical equipment and lockout/tagout	*6a. Generators may be used to provide electrical power.* *6b. Use GFCIs for portable electrical equipment.* *6c. Inspect electrical extension cords for damage and ground plugs.* *6 . Keep electrical equipment/cords away from water and fuel materials.* *6d. Follow lockout/tagout procedures.*	**M**
	7. Physical Hazards: Noise Exposure	*7a. Noise exposure above 85 dBA is expected when working near or operating machinery and equipment.* *7 . Monitor for noise levels.* *7a. Wear earplugs for protection*	**L**

	8. Physical Hazards: Drowning 9. Physical Hazards: Heat/cold stress	*8a. Wear a personal flotation device (PFD) whenever near or in a water body* *8b. Have a dedicated person/buddy watching your activities on the shore. This person will also wear a PFD and have a communication device to call for help in the event of an emergency.* *9a. Heat stress may occur when elevated ambient temperatures, moderate to heavy workloads, and/or use of impermeable protective clothing occur.* *9b. Adjust work-rest schedules as needed.* *9c. Work at a steady pace.* *9d. Drink fluids.* *9e. Take rest breaks and use shaded rest area.* *9f. Know the signs and symptoms of heat exposure and emergency*	**L**
	10. Physical Hazards: Inclement weather and adverse environmental conditions 11. Physical Hazards: Slips, trips, and falls and other miscellaneous physical hazards.	*treatment.* *9g. Cold stress may occur during the winter/fall/spring months.* *9h. Minimize exposures to cold temperatures below 45ºF.* *9i. Wear insulated clothing.* *9j. Know the signs and symptoms of cold exposure and emergency treatment.* *10a. Inclement weather conditions such as strong winds, heavy rain or lightning, and snow may occur during outdoor operations.* *10b. Suspend outdoor operations during inclement weather or when other adverse environmental conditions exist.* *11a. General safety hazards will be present during all site tasks.* *11b.Use PPE for head, eye, hand, foot, and body protection as needed.* *11c. Follow safe work practices.* *11d. Watch for slip, trip, and fall hazards from uneven, wet, slippery ground surfaces.* *11e. Keep ground areas clear of tripping hazards such as hoses, cords, boxes, and debris.* *11f. Maintain good housekeeping.* *11g. Look where walking.* *11h. Maintain three-point contact when stepping off equipment.*	**L** **M**

		11i. Maintain balance. Use short steps when walking on slippery surfaces. *11j. Communicate general safety information during safety meetings.*	**M**
		11k. Compressed Gas Cylinders: Compressed gas cylinders will be used for hot work (if needed). *11l. Gas cylinders will be moved with caps installed, and stored upright and secured with rope of chain.* *11m. Acetylene and oxygen cylinders must be stored a minimum of 20 feet away from each other or separated by a 5-foot fire rated wall.*	**M**
		11n. Vacuum Truck Operation: A vacuum truck may be used to pump out liquids. *11o. Use PPE especially gloves and splash protection* *11p. Use proper technique in handling hoses* *11q. Securely ground vacuum truck during transfer of flammable or combustible liquids to prevent discharge of static electricity sparks* *11r. Use hose on pump exhaust and direct away from the work*	**M**

		area as needed *11s. Clear hoses and use bucket to prevent spills when disconnecting hoses.* *11t. Pressure Washer Operation: Pressure washer equipment may be used for equipment cleaning.* *11u. Use gloves, face, and eye protection during pressure washer operation.* *11v. Use metatarsal guards as necessary.* *11w. Keep area clear when washing.* *11x. Do not clean boots with pressure washer.* *11y. Watch for slippery surfaces and handling of slippery materials.* *11z. Have fire extinguisher and emergency eyewash supplies immediately available.*	**M**
	12. Site Emergencies	*16a. Preparation for site emergencies is always a requirement for site work.* *16b. Set-up emergency communications.* *Prepare emergency supplies.* *16c. Post emergency contact and hospital route information.* *16d. Maintain emergency phone list/hospital location/route map on site.* *16e. Have first-aid kit, fire extinguisher, and safety supplies available.* *16f. Have cell phones available.* *16g. Designate evacuation location and emergency signals.* *16h. See the "Emergency Response Plan" section of HASP*	

Equipment to be Used	**Training Requirements/Competent or Qualified Personnel name(s)**	**Inspection Requirements**
Hand Tools Power Tools Heavy Equipment Hand Sprayer 5 Gallon Buckets 55 Gallon Drum Pressure Washer Trash Pump	Competent/Qualified Personnel: **Diane Champagne** – SSHO Training Requirements: OSHA 40 HAZWOPER	Daily site safety inspections by SSHO. Daily Housekeeping of work areas. Inspect power cord sets prior to use. Inspect temporary power panel box, circuit breakers, grounding, etc. at least monthly.

Vacuum Pump Spill Kit Portable Generator	First Aid/CPR Training Project Indoctrination Training Daily/Monthly safety toolbox meetings	Inspect first aid kit at least monthly.
5 Ma GFCIs Power Cords First Aid Kit Safety Shoes Vehicles	Heat or Cold Hazards Use of Power Tools and Equipment Electric Fire Extinguishers	Inspect heavy equipment daily in accordance with operation manual and operator experience Inspect equipment prior to use to ensure equipment is operational, the electrical connections are not damaged and all guards and equipment are in place. Ensure equipment is properly grounded and maintained in accordance with manufacturers recommendations GFCI - visual inspection before each day's use and a scheduled inspection of grounding and continuity connections every 6 months. Grounding and continuity testing is also required before first use, after any repairs or when damage is suspected. Inspect fall protection equipment daily in accordance with manufacturer's specifications

Activity Hazard Analysis (AHA)

ACTIVITY/WORK TASK:	**Groundwater and Surface Water Sampling**	Overall Risk Assessment Code (RAC) (Use highest code)	**M**
DATE:	May 2021	Activity # 3	AHA # **3**
PWD/OICC/ROICC OFFICE NAME & DATE ACCEPTED BY GDA:	Devens BRAC Legacy Sites		
CONTRACT NUMBER:	W912WJ19D0014		
PRIME CONTRACTOR:	SERES-Arcadis 8(a) JV2, LLC		
SUBCONTRACTOR:	To Be Determined (TBD)		
PROJECT MANAGER:	Andy Vitolins		
SITE SAFETY and HEALTH OFFICER	Diane Champagne		

Risk Assessment Code (RAC) Matrix

Severity	Probability				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	E	E	H	H	M
Critical	E	H	H	M	L
Marginal	H	M	M	L	L
Negligible	M	L	L	L	L

Review each **"Hazard"** with identified safety **"Controls"** and determine (RAC)

E = EXTREMELY HIGH (PWO/OICC/ROICC)	🟥
H = HIGH RISK (FEAD DIRECTOR)	🟧
M = MODERATE RISK (CM or ET or PAR)	🟨
L = LOW RISK (ET or PAR)	🟩

Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" .Place the highest RAC at the top of AHA. This is the overall risk assessment code for this activity

"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible after controls are in place

"Probability" is the likelihood to cause an incident, near miss, or accident did occur and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely after controls are put in place.

Job Steps	Hazards	Controls	RAC
General Safety Requirements - all Steps	Exposure to Cold or Heat Stress	**Minimum Personal Protective Equipment Dress:** • Long Pants • Shirts with Sleeves • Hardhat • Work Gloves • Covered Shoes (Steel Toe Preferred) • Safety Glasses (Potential Eye Hazard Areas) • Hearing Protection (as required) • Reflective Safety Vests	L
	Weather	• Wear appropriate clothing for hot or cold weather. • Sun block • Lip balm	

Job Steps	Hazards	Controls	RAC
General Safety Requirements - all Steps	Dehydration Eye Protection NOTE: The above hazards are not all inclusive. The SSHO and QAR shall review all AHAs daily and modify as necessary.	**Dehydration:** • Drink at least $^1/_2$ liter of water per hour. • Refer to APP/SSHP, SOPs, plan, etc. for specific details on heat stress signs and symptoms. **Eye Protection:** • Minimum eye protection is OSHA approved safety glasses with side shields. • Approved face shields must also be worn when flying particles or chemical splashes could contact the face.	**L** **L**
Decontaminate equipment used for event tasks.	1. Chemical Hazards: Minor potential exposure to contaminants in decontamination fluids. 2. Biological hazards: Potential exposure to poisonous plants, snakes, spiders, rodents, insects, ticks, and mosquitoes.	*1a. Chemical Hazards: A limited chemical contact hazard from decontamination chemicals is expected.* *1b. Use prescribed levels of protection described in the PPE section of the SSHP.* *1c. Properly don and doff protective clothing.* *1d. Conduct monitoring as described in the “Exposure Monitoring” section of the HASP.* *1e. Use prescribed decontamination measures.* *2a. Biological hazards may be present.* *2b. Watch for, and avoid contact with, poisonous plants, snakes, spiders, rodents, insects, ticks, and mosquitoes.* *2c. Do not drink the water onsite.*	**M**
Line decontamination station with polysheeting, if necessary. Containerize and label purge and decontamination liquids properly.	1. Physical Hazards: Fire protection and hot work 2. Physical Hazards: Overhead Utilities 3. Physical Hazards: Vehicle and equipment traffic	*1a. Gasoline and diesel fuel will be used for vehicle operation.* *1b. Require fire extinguishers for each site location.* *1c. Allow smoking only in designated areas.* *1d. OSHA-approved metal safety cans, painted red with a yellow stripe, that have self-closing lids and flame arrestors must be used to store small quantities of flammable liquids.* *1e. Hot work is prohibited in areas where flammable materials, equipment containing flammable materials, and air emissions from contaminated soil may be present.* *1f. Use hot work safety procedures, hot work permit and fire watch for hot work.* *2a. Overhead utilities will be present.* *2b. Survey for overhead utilities before bringing equipment with high extensions (i.e., heavy equipment, dump truck, roll-off bin truck) into a work area.* *3a. Concurrent use of vehicles and ground personnel will occur.* *3b. Establish traffic control procedures when there is vehicle, heavy equipment, and/or pedestrian traffic present.* *3c. Have workers wear high-visibility safety vests with reflective*	**L** **L** **L**

		striping when working near traffic areas. *3d. Advise workers to look carefully where they walk to avoid vehicles and moving equipment.* *3e. Use traffic control devices as needed.*	
	4. Physical Hazards: Material handling	*4a. Material handling involving lifting and carrying will be required.* *4b. Wear work gloves when handling materials.* *4b. Watch for items that can cut, puncture, pinch, or crush. Use proper lifting technique.* *4c. Size up load, get help for heavy or awkward items, get good grasp on object to be lifted, keep load close to body, keep back straight, lift with legs not with back, and do not twist when lifting.* *4c. Review material handling procedures during safety meetings.*	**L**
	5. Physical Hazards: Tools, machinery, and equipment use	*5a. Hand and power tools may be used.* *5b. Use the proper tool for the job.* *5c. Use GFCIs for power tool operation.* *5d. Use safety glasses.* *5a. Do not use damaged tools. Inspect tools including electrical cords*. *5e. Properly secure materials when working on them.* *5f. Make sure area is adequately clear when using equipment.*	**M**
	6. Physical Hazards: Electrical equipment and lockout/tagout	*6a. Generators may be used to provide electrical power.* *6b. Use GFCIs for portable electrical equipment.* *6c. Inspect electrical extension cords for damage and ground plugs.* *6a. Keep electrical equipment/cords away from water and fuel materials.* *6d. Follow lockout/tagout procedures.*	**M**
	7. Physical Hazards: Noise Exposure	*7a. Noise exposure above 85 dBA is expected when working near or operating machinery and equipment.* *7b. Monitor for noise levels.* *7c. Wear earplugs for protection*	**L**
	8. Physical Hazards: Heat/cold stress	*8a. Heat stress may occur when elevated ambient temperatures, moderate to heavy workloads, and/or use of impermeable protective clothing occur.* *8a. Adjust work-rest schedules as needed.* *8b. Work at a steady pace.* *8c. Drink fluids.* *8d. Take rest breaks and use shaded rest area.* *Know the signs and symptoms of heat exposure and emergency treatment.* *8e. Cold stress may occur during the winter/fall/spring months.*	**L**

		8g. Minimize exposures to cold temperatures below 45ºF. *8h. Wear insulated clothing.*	
Job Steps	**Hazards**	**Controls**	**RAC**
	9. Physical Hazards: Inclement weather and adverse environmental conditions	*9a. Inclement weather conditions such as strong winds, heavy rain or lightning, and snow may occur during outdoor operations.* *9b. Suspend outdoor operations during inclement weather or when other adverse environmental conditions exist.*	**L**
	10 Physical Hazards: Slips, trips, and falls and other miscellaneous physical hazards.	*10a. General safety hazards will be present during all site tasks.* *10b. Use PPE for head, eye, hand, foot, and body protection as needed.* *10c. Follow safe work practices.* *10 . Watch for slip, trip, and fall hazards from uneven, wet, slippery ground surfaces.* *10a. Keep ground areas clear of tripping hazards such as hoses, cords, boxes, and debris.* *10d. Maintain good housekeeping.* *10e. Look where walking.* *10f. Maintain three-point contact when stepping off equipment.* *10b. Maintain balance. Use short steps when walking on slippery surfaces.* *10c. Communicate general safety information during safety meetings.*	**L**
	11. Site Emergencies	*11a. Preparation for site emergencies is always a requirement for site work.* *11 . Set-up emergency communications.* *Prepare emergency supplies.* *11a. Post emergency contact and hospital route information.* *11b. Maintain emergency phone list/hospital location/route map on site.* *11c. Have first-aid kit, fire extinguisher, and safety supplies available.* *11b. Have cell phones available.* *11c. Designate evacuation location and emergency signals.* *11d. See the “Emergency Response Plan” section of HASP*	**M**

Equipment to be Used	Training Requirements/Competent or Qualified Personnel name(s)	Inspection Requirements
Hand Tools Power Tools Sampling Equipment 5 Gallon Buckets 55 Gallon Drum Sample bottles with chemical preservatives Spill Kit Portable Generator First Aid Kit Safety Shoes Vehicles	Competent/Qualified Personnel: **Diane Champagne** – SSHO Training Requirements: OSHA 4 Hour HAZWOPER First Aid/CPR Training Project Indoctrination Training Daily/Monthly safety toolbox meetings Heat or Cold Hazards Use of Power Tools and Equipment Electric Fire Extinguishers	Daily site safety inspections by SSHO. Daily Housekeeping of work areas. Inspect power cord sets prior to use. Inspect temporary power panel box, circuit breakers, grounding, etc. at least monthly. Inspect first aid kit at least monthly. Inspect heavy equipment daily in accordance with operation manual and operator experience Inspect equipment prior to use to ensure equipment is operational, the electrical connections are not damaged and all guards and equipment are in place. Ensure equipment is properly grounded and maintained in accordance with manufacturers recommendations GFCI - visual inspection before each day’s use and a scheduled inspection of grounding and continuity connections every 6 months. Grounding and continuity testing is also required before first use, after any repairs or when damage is suspected. Inspect fall protection equipment daily in accordance with manufacturer’s specifications

Activity Hazard Analysis (AHA)

ACTIVITY/WORK TASK:	**Drilling**	Overall Risk Assessment Code (RAC) (Use highest code)	**L**
DATE:	May 2021	Activity # 4	AHA # **4**
PWD/OICC/ROICC OFFICE NAME & DATE ACCEPTED BY GDA:	Devens BRAC Legacy Sites		
CONTRACT NUMBER:	W912WJ19D0014		
PRIME CONTRACTOR:	SERES-Arcadis 8(a) JV2, LLC		
SUBCONTRACTOR:	To Be Determined (TBD)		
PROJECT MANAGER:	Andy Vitolins		
SITE SAFETY and HEALTH OFFICER	Diane Champagne		

Risk Assessment Code (RAC) Matrix

Severity	**Probability**				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	**E**	**E**	**H**	**H**	**M**
Critical	**E**	**H**	**H**	**M**	**L**
Marginal	**H**	**M**	**M**	**L**	**L**
Negligible	**M**	**L**	**L**	**L**	**L**

Review each **"Hazard"** with identified safety **"Controls"** and determine (RAC)

E = EXTREMELY HIGH (PWO/OICC/ROICC)	🟥
H = HIGH RISK (FEAD DIRECTOR)	🟧
M = MODERATE RISK (CM or ET or PAR)	🟨
L = LOW RISK (ET or PAR)	🟩

Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" .Place the highest RAC at the top of AHA. This is the overall risk assessment code for this activity

"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible after controls are in place

"Probability" is the likelihood to cause an incident, near miss, or accident did occur and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely after controls are put in place.

Job Steps	Hazards	Controls	RAC
Well Drilling and Installation	Exposure to Cold or Heat Stress	**Minimum Personal Protective Equipment Dress:** • Long Pants • Shirts with Sleeves • High Visibility • Hardhat • Work Gloves • Covered Shoes (Steel Toe Preferred) • Safety Glasses (Potential Eye Hazard Areas) • Hearing Protection (as required)	**L**
	Weather	• Wear appropriate clothing for hot or cold weather • Sun block • Lip balm	**L**

Job Steps	Hazards	Controls	RAC
General Safety Requirements - all Steps	Dehydration Eye Protection NOTE: The above hazards are not all inclusive. The SSHO and QAR shall review all AHAs daily and modify as necessary.	**Dehydration:** • Drink at least $^1/_2$ liter of water per hour. • Refer to APP/SSHP, SOPs, plan, etc. for specific details on heat stress signs and symptoms. **Eye Protection:** • Minimum eye protection is OSHA approved safety glasses with side shields. • Approved face shields must also be worn when flying particles or chemical splashes could contact the face.	**L** **L**
Decontaminate equipment used for event tasks.	1. Chemical Hazards: Minor potential exposure to contaminants in decontamination fluids.	*1f. Chemical Hazards: A limited chemical contact hazard from decontamination chemicals is expected.* *1g. Use prescribed levels of protection described in the PPE section of the SSHP.* *1h. Properly don and doff protective clothing.* *1i. Conduct monitoring as described in the “Exposure Monitoring” section of the HASP.* *1j. Use prescribed decontamination measures.*	**M**
Drilling and Well Installation Safety	1. Biological hazards: Potential exposure to poisonous plants, snakes, spiders, rodents, insects, ticks, and mosquitoes. 2. Physical Hazards: Fire protection and hot work 3. Physical Hazards: Overhead Utilities	*1. Biological hazards may be present.* *2. Watch for, and avoid contact with, poisonous plants, snakes, spiders, rodents, insects, ticks, and mosquitoes.* *1. Do not drink the water onsite.* *2. Gasoline and diesel fuel will be used for vehicle operation.* *3. Require fire extinguishers for each site location.* *4. Allow smoking only in designated areas.* *5. OSHA-approved metal safety cans, painted red with a yellow stripe, that have self-closing lids and flame arrestors must be used to store small quantities of flammable liquids.* *6. Hot work is prohibited in areas where flammable materials, equipment containing flammable materials, and air emissions from contaminated soil may be present.* *7. Use hot work safety procedures, hot work permit and fire watch for hot work.* *1. Overhead utilities will be present.* *2. Survey for overhead utilities before bringing equipment with*	**L** **L** **L**

		striping when working near traffic areas. *3. Advise workers to look carefully where they walk to avoid vehicles and moving equipment.* *4. Use traffic control devices as needed.*	
	4. Physical Hazards: Material handling	*4d. Material handling involving lifting and carrying will be required.* *4e. Wear work gloves when handling materials.* *4d. Watch for items that can cut, puncture, pinch, or crush. Use proper lifting technique.* *4e. Size up load, get help for heavy or awkward items, get good grasp on object to be lifted, keep load close to body, keep back straight, lift with legs not with back, and do not twist when lifting.* *4f. Review material handling procedures during safety meetings.*	**L**
	5. Physical Hazards: Tools, machinery, and equipment use	*5g. Hand and power tools may be used.* *5h. Use the proper tool for the job.* *5i. Use GFCIs for power tool operation.* *5j. Use safety glasses.* *5b. Do not use damaged tools. Inspect tools including electrical cords*. *5k. Properly secure materials when working on them.* *5l. Make sure area is adequately clear when using equipment.*	**M**
	6. Physical Hazards: Electrical equipment and lockout/tagout	*6e. Generators may be used to provide electrical power.* *6f. Use GFCIs for portable electrical equipment.* *6g. Inspect electrical extension cords for damage and ground plugs.* *6b. Keep electrical equipment/cords away from water and fuel materials.* *6h. Follow lockout/tagout procedures.*	**M**
	7. Physical Hazards: Noise Exposure	*7d. Noise exposure above 85 dBA is expected when working near or operating machinery and equipment.* *7e. Monitor for noise levels.* *7f. Wear earplugs for protection*	**L**
	8. Physical Hazards: Heat/cold stress	*8b. Heat stress may occur when elevated ambient temperatures, moderate to heavy workloads, and/or use of impermeable protective clothing occur.* *8f. Adjust work-rest schedules as needed.* *8g. Work at a steady pace.* *8h. Drink fluids.* *8i. Take rest breaks and use shaded rest area.* *Know the signs and symptoms of heat exposure and emergency treatment.* *8j. Cold stress may occur during the winter/fall/spring months.*	**L**

		8i. Minimize exposures to cold temperatures below 45ºF. *8j. Wear insulated clothing.*	

Job Steps	Hazards	Controls	RAC
	9. Physical Hazards: Inclement weather and adverse environmental conditions	*9c. Inclement weather conditions such as strong winds, heavy rain or lightning, and snow may occur during outdoor operations.* *9d. Suspend outdoor operations during inclement weather or when other adverse environmental conditions exist.*	**L**
	Physical Hazards: Slips, trips, and falls and other miscellaneous physical hazards.	*10a. General safety hazards will be present during all site tasks.* *10b. Use PPE for head, eye, hand, foot, and body protection as needed.* *10g. Follow safe work practices.* ***10d. Watch for slip, trip, and fall hazards from uneven, wet, slippery ground surfaces.*** ***10e. Keep ground areas clear of tripping hazards such as hoses, cords, boxes, and debris.*** *10h. Maintain good housekeeping.* *10i. Look where walking.* *10j. Maintain three-point contact when stepping off equipment.* *10f. Maintain balance. Use short steps when walking on slippery surfaces.* *10g. Communicate general safety information during safety meetings.*	**L**
	11. Physical Hazards: Overhead / Underground Utilities	*11a. Overhead and underground utilities shall be identified prior to any ground intrusive activities. Manual digging or an air knife shall be employed to clear shaft locations down to eight feet.*	**L**
	12. Site Emergencies	*12a. Preparation for site emergencies is always a requirement for site work.* *12b. Set-up emergency communications.* *Prepare emergency supplies.* *12c. Post emergency contact and hospital route information.* *12d. Maintain emergency phone list/hospital location/route map on site.* *12e. Have first-aid kit, fire extinguisher, and safety supplies available.*	

		12d. Have cell phones available. *12e. Designate evacuation location and emergency signals.* *12f. See the “Emergency Response Plan” section of HASP*	

Equipment to be Used	Training Requirements/Competent or Qualified Personnel name(s)	Inspection Requirements
Hand Tools Power Tools Sampling Equipment 5 Gallon Buckets 55 Gallon Drum Sample bottles with chemical preservatives Spill Kit Portable Generator First Aid Kit Safety Shoes Vehicles	Competent/Qualified Personnel: **Diane Champagne** – SSHO Training Requirements: OSHA 4 Hour HAZWOPER First Aid/CPR Training Project Indoctrination Training Daily/Monthly safety toolbox meetings Heat or Cold Hazards Use of Power Tools and Equipment Electric Fire Extinguishers	Daily site safety inspections by SSHO. Daily Housekeeping of work areas. Inspect power cord sets prior to use. Inspect temporary power panel box, circuit breakers, grounding, etc. at least monthly. Inspect first aid kit at least monthly. Inspect heavy equipment daily in accordance with operation manual and operator experience Inspect equipment prior to use to ensure equipment is operational, the electrical connections are not damaged and all guards and equipment are in place. Ensure equipment is properly grounded and maintained in accordance with manufacturers recommendations GFCI - visual inspection before each day’s use and a scheduled inspection of grounding and continuity connections every 6 months. Grounding and continuity testing is also required before first use, after any repairs or when damage is suspected. Inspect fall protection equipment daily in accordance with manufacturer’s specifications

Activity Hazard Analysis (AHA)

ACTIVITY/WORK TASK:	**Field Guidance Pertaining to COVID-19**	Overall Risk Assessment Code (RAC) (Use highest code)	**E**
DATE:	May 2021	Activity # 8 AHA #	**5**
LOCATION:	Devens BRAC Legacy Sites		
CONTRACT NUMBER:	W912WJ19D0014		
PRIME CONTRACTOR:	SERES-Arcadis SB JV, LLC		
SUBCONTRACTOR:	Subcontractors : To Be Determined (TBD)		
PROJECT MANAGER	Andy Vitolins		
SITE SAFETY AND HEALTH OFFICER	Diane Champagne		

Risk Assessment Code (RAC) Matrix

Severity	**Probability**				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	**E**	**E**	**H**	**H**	**M**
Critical	**E**	**H**	**H**	**M**	**L**
Marginal	**H**	**M**	**M**	**L**	**L**
Negligible	**M**	**L**	**L**	**L**	**L**

Review each **"Hazard"** with identified safety **"Controls"** and determine (RAC)

E = EXTREMELY HIGH (PWO/OICC/ROICC)	🟥	Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard". Place the highest RAC at the top of AHA. This is the overall risk assessment code for this activity
H = HIGH RISK (FEAD DIRECTOR)	🟧	**"Severity"** is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible after controls are in place
M = MODERATE RISK (CM or ET or PAR)	🟨	
L = LOW RISK (ET or PAR)	🟩	**"Probability"** is the likelihood to cause an incident, near miss, or accident did occur and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely after controls are put in place.

Job Steps	Hazards	Controls	RAC
General Safety Requirements - all Steps	Exposure to COVID-19	**Practice Good Hygiene:** The best way to prevent illness is to avoid exposure to the virus. CDC and Health Canada recommend common flu and cold season preventative measures, including: • Get a flu vaccine. • Wash hands often with soap and water for at least 20 seconds. If soap and water are not readily available, use a hand sanitizer with at least 60% alcohol. • Clean and disinfect frequently touched surfaces and work areas both before start and after completion of work. • Avoid touching your eyes, nose and mouth. • Cover your nose and mouth with a tissue when sneezing or coughing. • Do not share Personal Protective Equipment (PPE). • Maintain and thoroughly clean PPE in accordance with manufacturer's instructions.	**H**

Practice Social Distancing	Exposure to COVID-19	• Remain out of congregate settings. • Do not shake hands. • Avoid mass gatherings. • Maintain distance (approximately 6 feet or 2 meters) from others when possible during field situations including tailgate and safety briefing meetings, work in field trailers or breaks. • If social distancing or other controls are not feasible discuss this with your supervisor and PM, discuss “Is the work necessary?” or “Can the work be rescheduled for a later date?”	**H**
Complete a Risk Assessment in Specific Work Situations	Exposure to COVID-19	• Complete a CDC a Risk Assessment and implement what is appropriate, outside of formal direction from federal, state or local directives based on the documented health risks. • If you are sick, stay home. • If feasible, prior to visiting the site, have a H&S check in to confirm all attendees are complying with CDC or Health Canada guidelines, including: o Confirm understanding that workers or clients should not go to the job site if they have personally tested positive for COVID-19 or have been in close contact to anyone else who has tested positive for COVID-19. o Out of respect for all, ask everyone to self-disclose if they are not feeling well (exhibiting flu-like symptoms), and request that they should go home. o Observe others and if they show flu-like symptoms, use Stop Work and contact Project Manager. o Determine if arrangements can be made to simplify our ability to social distance. o Set visual or physical barriers to keep the public away (caution tape and cones). o Consider if “split shifts” can be used to limit contact, or if work can be scheduled during hours of low to no facility operations. • If you are an embedded employee at a client facility: o Inquire whether working remotely is an option • If not, and we must work at the client facility: o Ask if arrangements can be made to practice social distancing (e.g. split shift, separate workstation, etc.) • Practice good hygiene, and if you do not feel the situation is safe, you can execute your Stop Work authority by having discussions with your Supervisor and Project Manager.	**M**

Field Vehicles and Transportation	Exposure to COVID-19	• When using shared vehicles (fleet, rental, ride sharing services) follow the cleaning guidance above for frequently touched surfaces. • Check with your rental agency before vehicle pick-up to understand their cleaning procedures, and supplement with your own as necessary. Note: if using wipes, make sure the wipe is compatible with the surface being cleaned. • If travelling with other employees, or other approved individuals in the same vehicle: o No more than 4 employees in a vehicle. o Maintain as much space between occupants, as practical, in the vehicle. If only two occupants, consider having one occupant in the back seat if vehicle is equipped with a back seat. o Do not share a vehicle with other employees or approved individuals if, after reviewing prevention and risk information described above, you are at risk of spreading COVID-19.	**M**
Lodging Considerations	Exposure to COVID-19	• Check with your hotel before check-in to understand their cleaning procedures. If there's still a concern, bring a surface cleaner and wipe down frequently touched surfaces such as doorknobs, tv remote, etc.	**H**

Rental Equipment and Sample Cooler Handling	Exposure to COVID-19	• Clean the exterior of rental equipment and sample coolers upon arrival at the job site using a cleaning product that will not impact data quality. • Wear gloves and safety glasses when handling sample coolers to prevent contact with acid preservation of the bottles in coolers.	
Client COVIS-19 Health Screening Forms	Exposure to COVID-19	• Some clients are requiring our employees to complete individual COVID-19 health screening forms. These forms may include questions pertaining to your travel to certain countries, your contact with people diagnosed with COVID-19, and whether you have experienced flu-like symptoms in the last 14 days. o You are not required to share personal medical information with clients; therefore, Arcadis is not requiring you to complete any form requesting medical information. Your disclosure of o personal medical information to clients is completely voluntary. o Please understand, if you do not complete the form, you will not be allowed on the client's sites and facilities, per the client's directive. o Also, if you complete the form, you have an ongoing duty to provide prompt notice of any changes to any of your responses. (Some clients may require periodically signing updated forms). o If you are restricted from a client site as a result of your answers to the COVID-19 health o screening form, or because you have chosen not to complete the form, Arcadis will attempt to find you alternative work that does not involve access to the client's site or facility; although, Arcadis cannot guarantee that other work will be available. o If your Project Manager is not already aware of the client COVID-19 health screening form, please alert them when you receive one from a client.	L
Reporting a COVID-19 Exposure	Exposure to COVID-19	• If you learn you have been in close contact with a worker, client or member of the public who is COVID-19 positive: o Stop work. o Notify your Supervisor and Project Manager o Self-isolate and contact your personal physician for additional direction.	L

COVID-19 Continuity Planning for Field Projects	Exposure to COVID-19	- If the project requires a COVID-19 continuity plan for the project or field portion of the project, any requirements in the Arcadis COVID-19 Continuity Plan template (or client approved equivalent) beyond the requirements of this guidance document must be followed.	L

Equipment to be Used	Training Requirements/Competent or Qualified Personnel name(s)	Inspection Requirements
PPE	Competent/Qualified Personnel: **Diane Champagne** – CP/SSHO and Fall **Diane Champagne** – QP/First Aid and CPR Training Requirements: OSHA 40 HAZWOPER First Aid/CPR Training Project Indoctrination Training Daily/Monthly safety toolbox meetings Heat or Cold Hazards Use of Power Tools and Equipment Electric Fire Extinguishers	Daily site safety inspections by SSHO. Daily Housekeeping of work areas. Inspect power cord sets prior to use. Inspect temporary power panel box, circuit breakers, grounding, etc. at least monthly. Inspect first aid kit at least monthly. Inspect heavy equipment daily in accordance with operation manual and operator experience Inspect equipment prior to use to ensure equipment is operational, the electrical connections are not damaged, and all guards and equipment are in place. Ensure equipment is properly grounded and maintained in accordance with manufacturers recommendations

Activity Hazard Analysis (AHA)

ACTIVITY/WORK TASK:	**Crystalline Silica**	Overall Risk Assessment Code (RAC) (Use highest code)	**M**
DATE:	May 2021	Activity # 8 AHA #	6
PWD/OICC/ROICC OFFICE NAME & DATE ACCEPTED BY	Devens BRAC Legacy Sites		
CONTRACT NUMBER:	W912WJ19D0014		
PRIME CONTRACTOR:	SERES-Arcadis SB JV, LLC		
SUBCONTRACTOR:	To Be Determined (TBD)		
PROJECT MANAGER:	Andy Vitolins		
SITE SAFETY and HEALTH	Diane Champagne		

Risk Assessment Code (RAC) Matrix

Severity	**Probability**				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	**E**	**E**	**H**	**H**	**M**
Critical	**E**	**H**	**H**	**M**	**L**
Marginal	**H**	**M**	**M**	**L**	**L**
Negligible	**M**	**L**	**L**	**L**	**L**

Review each **“Hazard”** with identified safety **“Controls”** and determine (RAC)

E = EXTREMELY HIGH (PWO/OICC/ROICC)	🟥	Identify the RAC (Probability/Severity) as E, H, M, or L for each “Hazard” .Place the highest RAC at the top of AHA. This is the overall risk assessment code for this activity
H = HIGH RISK (FEAD DIRECTOR)	🟧	**“Severity”** is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible after controls are in place
M = MODERATE RISK (CM or ET or PAR)	🟨	
L = LOW RISK (ET or PAR)	🟩	**“Probability”** is the likelihood to cause an incident, near miss, or accident did occur and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely after controls are put in

Job Steps	**Hazards**	**Controls**	**RAC**
General Safety Requirements - all Steps	Exposure to Cold or Heat Stress Weather	**<u>Minimum Personal Protective Equipment Dress:</u>** • Long Pants • High Visibility • Hardhat • Work Gloves • Covered Shoes • Safety Glasses • Hearing Protection (as required) **Weather**: • Wear appropriate • Sun block • Lip balm	**L**

Job Steps	Hazards	Controls	RAC
General Safety Requirements	Dehydration Eye Protection NOTE: The above hazards are not all inclusive. The SSHO and QAR shall review all AHAs daily and modify as necessary.	**Dehydration:** • Drink at least $^1/_2$ liter of water per hour. • Refer to APP/SSHP, SOPs, plan, etc. for specific details on heat stress signs and symptoms.	**L**
		Eye Protection: • Minimum eye protection is OSHA approved safety glasses with side shields. • Approved face shields must also be worn when flying particles or chemical splashes could contact the face.	**L**
• Drilling and Well Installation	The health effects of silica containing dust are based on the type of exposure encountered. Silicosis is a progressive lung disease resulting from prolonged and repeated exposure to silica-containing dusts, When inhaled, silica containing dust passes into the lungs, and scavenger cells such as macro phages engulf it. Enzymes released by the scavenger cells cause the lung tissue to scar. The onset and degree of the scarring is often dependent upon the duration and frequency of exposure.	When employee exposure is anticipated to be at or above OSHA Action Level (25 µg/m3) as an 8-hour time weighted average (TWA) under any foreseeable conditions: 1. Specified exposure control methods; or 2. Alternative exposure control methods. The specified exposure control option requires full compliance with OHSA's Table 1-Specified Exposure Control Method When Working With Materials Containing Crystalline Silica. When implementing the control measures specified, the following specified exposure control methods must be ensured by the Project Team: • For tasks performed indoors or in enclosed areas, provide a means of exhaust, as needed, to minimize the accumulation of visible airborne dust; • For tasks performed using wet methods, apply water at flow rates sufficient to minimize release of visible dust; • For measures implemented that include an enclosed cab or booth, ensure that the enclosed cab or booth: o Is maintained as free as practicable from settled dust; o Has door seals and closing mechanisms that work properly; o Has gaskets and seals that are in good condition and working properly;	**M**

		o Is under positive pressure maintained through continuous delivery of fresh air; o Has intake air that is filtered through a filter that is 95% efficient in the 0.3-10.0 µm range (e.g., MERV 16 or HEPA [MERV 17-20]); and o Has heating and cooling capabilities. Where an employee performs more than one task during the course of a shift, and the total duration of all tasks combined is more than four hours, the required respiratory protection for each task is the respiratory protection specified for more than four hours per shift. If the total duration of all tasks combined is less than four hours, the required respiratory protection for each task is the respiratory protection specified for less than four hours per shift. Project Teams who follow the specified exposure control methods must provide respiratory protection where required. Project Teams who follow alternative exposure control methods must provide respiratory protection: • Where exposures exceed the PEL during periods necessary to install or implement feasible engineering and work practice controls; • Where exposures exceed the PEL during tasks, such as some maintenance and repair tasks, for which engineering and work practice controls are not feasible; • During tasks in which the employer has implemented all feasible engineering and work practice controls but exposures remain above the PEL. When engineering controls, administrative controls and respiratory protection are not fully and properly implemented, alternative exposure control methods shall be implemented.	

		No employee will be exposed to an airborne concentration of silica-containing dust in excess of 50 μg/m^3, calculated as an 8-hour TWA. This is determined by assessing the exposure of each employee who is or may reasonably be expected to be exposed to silica-containing dust at or above the Action Level (25 μg/m^3 as an 8-hour TWA) in accordance with either the performance option or the scheduled monitoring option Project Teams who follow alternative exposure control methods must: 1. Determine the levels of silica-containing dust that employees are exposed to over an 8hr TWA. 2. Limit employee exposures to a PEL of 50 μg/m^3 as an 8-hour TWA; 0. Use engineering and administrative controls, to the extent feasible, to limit employee exposures to the PEL, and supplement the controls with respiratory protection when necessary. If exposure controls are not sufficient in reducing worker exposure to at or below the PEL, the controls must still be implemented and supplemented with respiratory protection (Approved Protection Factor [APF] of 10 or greater). 1. Keep records of employee exposure to silica-containing dust in accordance with the Arcadis Industrial Hygiene HSS (ARCHSI H009). Project Teams following alternative exposure control methods must assess the 8-hour TWA exposure for each employee who is or may reasonably be expected to be exposed to silica-containing dust at or above the Action Level.	

Equipment to be Used	**Training Requirements/Competent or Qualified Personnel name(s)**	**Inspection Requirements**
Potential Use of the following: - Rig-mounted core saws or drills; - Vehicle-mounted drilling rigs; - Stationary masonry saws	Competent/Qualified Personnel: **Diane Champagne** – SSHO Training Requirements: OSHA 40 HAZWOPER OSHA 30 Construction Safety First Aid/CPR Training Project Indoctrination Training Daily/Monthly safety toolbox meetings Heat or Cold Hazards Use of Power Tools and Equipment Electric Fire Extinguishers	A written Exposure Control Plan (written plan) is required when exposure to silica-containing dust is or can reasonably be expected to exceed 25 µg/m^3 of silica- containing dust in air averaged over an 8-hour period. - A description of the tasks in the workplace that involve exposure to silica- containing dust; - A description of the engineering controls, controls, and respiratory protection used to limit employee exposure to silica-containing dust for each task; - A description of the housekeeping measures used to employee exposure to silica-containing dust; - A description of the procedures used to restrict access to work areas, when necessary, to minimize the number of employees exposed to silica-containing dust and their level of exposure, including exposures generated by other employers or sole proprietors; - Designation of the Competent Person who is responsible for implementing the written plan and making frequent and regular inspection of job site material, and equipment - A copy of or location of the safety data sheet (SDS) for crystalline silica products in accordance with the Arcadis Hazard Communication HSS (ARCHSGE007).

ACTIVITY/WORK TASK:	**Boating**	Overall Risk Assessment Code (RAC) (Use highest code)	**M**
DATE:	May 2021	Activity # 3 AHA #	**7**
PWD/OICC/ROICC OFFICE NAME & DATE ACCEPTED BY GDA:	Devens BRAC Legacy Sites		
CONTRACT NUMBER:	W912WJ19D0014		
PRIME CONTRACTOR:	SERES-Arcadis 8(a) JV2, LLC		
SUBCONTRACTOR:	To Be Determined (TBD)		
PROJECT MANAGER:	Andy Vitolins		
SITE SAFETY and HEALTH OFFICER	Diane Champagne		

Risk Assessment Code (RAC) Matrix

Severity	**Probability**				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	**E**	**E**	**H**	**H**	**M**
Critical	**E**	**H**	**H**	**M**	**L**
Marginal	**H**	**M**	**M**	**L**	**L**
Negligible	**M**	**L**	**L**	**L**	**L**

Review each **"Hazard"** with identified safety **"Controls"** and determine (RAC)

E = EXTREMELY HIGH (PWO/OICC/ROICC)	Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" .Place the highest RAC at the top of AHA. This is the overall risk assessment code for this activity
H = HIGH RISK (FEAD DIRECTOR)	**"Severity"** is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible after controls are in place
M = MODERATE RISK (CM or ET or PAR)	
L = LOW RISK (ET or PAR)	**"Probability"** is the likelihood to cause an incident, near miss, or accident did occur and identified as: Frequent, Likely, Occasional, Seldom, or Unlikely after controls are put in place.

Job Steps	**Hazards**	**Controls**	**RAC**
Evaluate slip condition/don appropriate PPE	Weather: caught in flash flood, struck by lightning, heat or cold stress	Check forecast and monitor weather to avoid being caught unprepared for rain, thunder storms, or extreme high or low temperatures. Review section 3-I of the Arcadis Employee Field Health & Safety Handbook.	**M**

	Environmental hazards (sun, heat, cold), biological hazards (insects and plants - especially bees, ticks and the American Dagger Moth Caterpillar in the summer), temperature-related illnesses (sun exposure, heat, cold), weather (extreme weather, wind, lightning, may apply), working near water.	Check local weather forecasts daily prior to commencement of work. Avoid work in extreme weather conditions, stop work if extreme weather is imminent, and inspect area for hazardous plants and insects. Wear appropriate clothes for the area: long sleeves and gloves in overgrown areas, use sunscreen and hat. Apply insect repellant containing DEET during insect season. Monitor for heat and cold stress. Take breaks and consume fluids as necessary. Wear PFD.	**M**
Boat Operations	Drowning/falls overboard	- Wear personal flotation device (PFD). Know location and proper use of lifesaving devices (throw ring, throw bag, reach poles, cargo net, ladder).	**M**
	Vehicular traffic	- Follow safe boat handling procedures as listed below. - Use caution when approaching shoreline. - Be aware of shallow regions along the shore.	**L**

	Capsizing housekeeping	- Do not fill boat beyond stated capacity.	**L**
	Slips/trips/falls	- Maintain good housekeeping, and keep deck clear of core tubing, vessel tie-off, and miscellaneous tooling.	**L**
	Temperature-related illness	Wear appropriate clothes for the weather including rain suits, hat, and use sunscreen as necessary. - Monitor for heat and cold stress. - Employees should dress for the weather and potential weather changes (e.g., dress in layers so that clothes can be removed/added as needed for heat, cold, or moisture). - Take breaks and consume fluids as necessary.	**M**
	Disembarking	Plan route to ramp or shore and use lookouts to spot objects in water that may damage boat.	**L**

	Falls from boat accessing dock, ramp or shore.	Do not hurry through task, plan route and use TRACK. Step , not jump, off boats. Wear shoes with anti-slip soles. Secure boat to pier before off loading personnel or equipment.	**L**
	Media collection	- Refer to Surface Water and Sediment Sampling Activity Hazards Analysis. - Do not lean over boat edge to collect sample. - Maintain stability within the boat.	**M**

Equipment to be Used	**Training Requirements/Competent or Qualified Personnel name(s)**	**Inspection Requirements**
Safety glasses Steel-toe boots Chemical-resistant gloves Hard hat Ear plugs PFD Mobile phone Marine radio First aid kit Fire extinguisher Safety kit and spill kit Boat paddles Boat	Competent/Qualified Personnel: **Diane Champagne** – SSHO Training Requirements: OSHA 4 Hour HAZWOPER First Aid/CPR Training Hazmat DOT USCG Boat Safety	Boat Safety Checklist Vehicle Inspection Checklist

Appendix D

Site Control Log

SITE CONTROL LOG

Date/Day/Time: ______________________________

Project Name: ______________________________

Project Location: ______________________________

Time		Name	Organization
In	Out		

Appendix E

Incident Reporting Form

POST AT JOB SITE

Incident Reporting and Investigation Procedures Posting

(Injury/Property Damage/Liability Exposure/Spills/Fires/Serious Near Miss Incidents)

Notify the Site Supervisor or Site Safety and Health Officer (SSHO) immediately of injuries, property damage, liability exposure, spills, fires, and serious near miss incidents. The Site Supervisor or his/her representative shall:

- Take care of injured personnel immediately
- Secure remaining dangerous conditions to prevent accidents and additional damage
- Secure the incident scene to preserve information
- Identify employees involved in the incident and witnesses and obtain initial information

- Notify the Project Manager (PM) Safety and Health Manager (SHM) about the incident and receive further instructions. **Notify as soon as possible and no later than 2 hours of the incident**

- Initiate fact finding. Investigate the site, interview witnesses, and document circumstances and facts. Complete preliminary documentation forms. Depending upon incident severity and complexity, fact finding may involve other investigators determined by the SHM
- Complete required JV forms: Incident Statement by Employee, Incident Statement by Witness, Incident Report by Supervisor, Injury and Illness Report, Vehicle Accident Report, and/or Property Damage, Loss and General Liability Report. Submit all forms (if a form is not applicable write N/A on the form.)
- **Submit completed forms to the SHM and PM within 24 hours of an incident and immediately forward additional information as it becomes available**.

NOTE: Accidents resulting in a fatality or multiple hospitalizations require reporting to the nearest OSHA office within 8 hours (1-800-321-OSHA). This report shall be made by the SHM. A written report shall follow that provides OSHA with all details of the accident required by 29 CFR 1904.8. Any equipment, material, or related evidence that might help in an investigation must not be moved except to prevent further accidents. The SHM will record injuries on the OSHA 300 log.

INCIDENT REPORTING CONTACT INFORMATION:

SHM: Grey Coppi, CIH – Office (732) 225 5061 SSHO: Diane Champagne – Office (978)-937-9999 – Cell (978)-505-1120

FAILURE OF A JV EMPLOYEE TO PROMPTLY REPORT A SAFETY INCIDENT OR FAILURE TO PRESERVE AN ACCIDENT SCENE UNTIL AN INVESTIGATION IS COMPLETED, IS GROUNDS FOR DISCIPLINARY ACTION.

INCIDENT REPORT BY SUPERVISOR

Date/Time of Incident:

Project Name/Project No.:

Client Name/Location:

Specific Location of Incident:

Employees Involved in Incident (if applicable):

Detailed Description of Incident:

Primary Cause of Incident:

Contributing Cause(s) of Incident:

Recommendation for Preventing Such Incident in the Future:

Supervisor Name (print):

Signature:

Date:

INCIDENT STATEMENT BY EMPLOYEE

Employee Name:

Date/Time of Incident:
Project Name/Project No.:
Client Name/Location:
Specific Location of Incident:
Describe What You Were Doing Just Before the Incident:
Detailed Description of How the Incident Occurred:
Names of Witnesses:
Other Relevant Information:
How Can the Likelihood if This Happening Again Be Reduced?
Employee Name (print): Signature: Date:

INCIDENT STATEMENT BY WITNESS

Witness Name/Address/Telephone:

Employer/Telephone:

Date/Time of Incident:

Project Name/Project No.:

Client/Location:

Specific Location of Incident:

DETAILED DESCRIPTION OF INCIDENT BASED ON PERSONAL OBSERVATION

Describe where you were and what you were doing just before the incident:

Describe any injuries:

Describe any property damaged:

Describe what was the apparent nature of the injury and/or damage:

Describe what personnel and/or equipment were involved:

Describe what caused the injury and/or damage:

Describe the sequence of events:

List any observed unsafe acts or conditions:

Names of other witnesses:

Other relevant information:

Witness Name (print):

Signature:

Date:

Appendix F

JV Health & Safety Meeting Sign-In Sheet

SAFETY MEETING ATTENDANCE ROSTER

Project Name: ______________________________

Project Location: ______________________________

Date: ______________________________

Topic: ______________________________

Date	Signature	Company

Conducted By:

Signature: ______________________________

Date: ______________________________

Appendix G

JV Safety Inspection Report

SAFETY INSPECTION REPORT

Date/Day:

Project Name:

Project Location:

Work Description:

Comments:

OBSERVATIONS

Safety Conditions Requiring Corrective Action	Corrective Action, Assignment, and Completion Date

Project Manager:

Safety Inspector:

Distribution:

Appendix H

Tailgate Meeting Safety Record

TAILGATE SAFETY MEETING RECORD

Date / Day:	**Time:**
Project Name:	**Project No.:**
Client:	**Location:**

Specific Location:

Work Description:

Comments:

Protective Clothing / Equipment: Hard Hats, Personal Floatation Devices (while over water), Safety Shoes, Long Pants, Sleeved Shirts. Safety Glasses and Hearing Protection when required.

Chemical Hazards: Hydraulic Fluids, Oil, Grease, Gasoline, Diesel Fuel

Physical Hazards: Heavy Equipment Operations (Crane), Heavy Loads, Small Tool Operations, Overhead Power Lines (electrical), Water Hazards (Use PFDs, Watch for Boat Traffic), Slips, Trips, & Falls (Keep Good Housekeeping).

Emergency Procedures:

Emergency Hospital:

Hospital Telephone:

Hospital Directions:

Special Equipment: Fire Extinguishers / First Aid Kits / Spill Kits

Other:

Name Printed / Initial	Name Printed / Initial
1.	6.
2.	7.
3.	8.
4.	9.
5.	10.

Meeting conducted by (print name / signature):

Appendix I

JV Respiratory Protection Program

Respiratory Protection Program

1. INTRODUCTION

1.1. Purpose

The purpose of this Respiratory Protection Program (RPP) is to establish the procedures and requirements necessary to ensure that all affected employees are effectively protected against airborne contaminants that may be present in the workplace or at customer sites. The following sections provide generalized procedures and requirements for respiratory protection. For a project specific respiratory program, **please refer to the project specific Respiratory Protection Plan and associated AHAs which can be found in the project APP or SSHP**.

All activities involving the use of respiratory protective equipment shall be conducted in compliance with the requirements of OSHA 1910.134 and 1926.103.

2. POLICY

It is the policy of SERES to maintain work environments that not will adversely affect the health, safety, and well-being of its employees. This document focuses on the implementation of the Respiratory Protection Program for employees, contractors and visitors who might potentially be exposed to contaminated air.

Where possible, hazards will be reduced or eliminated through engineering controls, including Elimination, substitution, general or local ventilation, and isolation.

Respiratory protection is used for control of hazards only after all feasible engineering and administrative controls have been applied, or while engineering controls are being implemented.

3. DEFINITIONS

Air-purifying respirator means a respirator with an air-purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element.

Assigned protection factor (APF) means the workplace level of respiratory puprotection that a respirator or class of respirators is expected to provide to employees when the employer implements a continuing, effective respiratory protection program as specified by this section.

Atmosphere-supplying respirator means a respirator that supplies the respirator user with breathing air from a source independent of the ambient atmosphere, and includes supplied-air respirators (SARs) and self-contained breathing apparatus (SCBA) units.

Canister or cartridge means a container with a filter, sorbent, or catalyst, or combination of these items, which removes specific contaminants from the air passed through the container.

Demand respirator means an atmosphere-supplying respirator that admits breathing air to the face piece only when a negative pressure is created inside the face piece by inhalation.

Emergency situation means any occurrence such as, but not limited to, equipment failure, rupture of containers, or failure of control equipment that may or does result in an uncontrolled significant release of an airborne contaminant.

Employee exposure means exposure to a concentration of an airborne contaminant that would occur if the employee were not using respiratory protection.

End-of-service-life indicator (ESLI) means a system that warns the respirator user of the approach of the end of adequate respiratory protection, for example, that the sorbent is approaching saturation or is no longer effective.

Escape-only respirator means a respirator intended to be used only for emergency exit.

Filter or air purifying element means a component used in respirators to remove solid or liquid aerosols from the inspired air.

Filtering face piece (dust mask) means a negative pressure particulate respirator with a filter as an integral part of the face piece or with the entire face piece composed of the filtering medium.

Fit factor means a quantitative estimate of the fit of a particular respirator to a specific individual, and typically estimates the ratio of the concentration of a substance in ambient air to its concentration inside the respirator when worn.

Fit test means the use of a protocol to qualitatively or quantitatively evaluate the fit of a respirator on an individual. (See also Qualitative fit test QLFT and Quantitative fit test QNFT.)

Helmet means a rigid respiratory inlet covering that also provides head protection against impact and penetration.

High efficiency particulate air (HEPA) filter means a filter that is at least 99.97% efficient in removing monodisperse particles of 0.3 micrometers in diameter. The equivalent NIOSH 42 CFR 84 particulate filters are the N100, R100, and P100 filters.

Hood means a respiratory inlet covering that completely covers the head and neck and may also cover portions of the shoulders and torso.

Immediately dangerous to life or health (IDLH) means an atmosphere that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere.

Interior structural firefighting means the physical activity of fire suppression, rescue or both, inside of buildings or enclosed structures which are involved in a fire situation beyond the incipient stage. (See 29 CFR 1910.155)

Loose-fitting face piece means a respiratory inlet covering that is designed to form a partial seal with the face.

Maximum use concentration (MUC) means the maximum atmospheric concentration of a hazardous substance from which an employee can be expected to be protected when wearing a respirator, and is determined by the assigned protection factor of the respirator or class of respirators and the exposure limit of the hazardous substance. The MUC can be determined mathematically by multiplying the assigned protection factor specified for a respirator by the required OSHA permissible exposure limit, short-term exposure limit, or ceiling limit.

When no OSHA exposure limit is available for a hazardous substance, an employer must determine an MUC on the basis of relevant available information and informed professional judgment.

Negative pressure respirator (tight fitting) means a respirator in which the air pressure inside the face piece is negative during inhalation with respect to the ambient air pressure outside the respirator.

Oxygen deficient atmosphere means an atmosphere with an oxygen content below 19.5% by volume.

Physician or other licensed health care professional (PLHCP) means an individual whose legally permitted scope of practice (i.e., license, registration, or certification) allows him or her to independently provide, or be delegated the responsibility to provide, some or all of the health care services required by paragraph (e) of this section.

Positive pressure respirator means a respirator in which the pressure inside the respiratory inlet covering exceeds the ambient air pressure outside the respirator.

Powered air-purifying respirator (PAPR) means an air-purifying respirator that uses a blower to force the ambient air through air-purifying elements to the inlet covering.

Pressure demand respirator means a positive pressure atmosphere-supplying respirator that admits breathing air to the face piece when the positive pressure is reduced inside the face piece by inhalation.

Qualitative fit test (QLFT) means a pass/fail fit test to assess the adequacy of respirator fit that relies on the individual's response to the test agent.

Quantitative fit test (QNFT) means an assessment of the adequacy of respirator fit by numerically measuring the amount of leakage into the respirator.

Respiratory inlet covering means that portion of a respirator that forms the protective barrier between the user's respiratory tract and an air-purifying device or breathing air source, or both. It may be a facepiece, helmet, hood, suit, or a mouthpiece respirator with nose clamp.

Self-contained breathing apparatus (SCBA) means an atmosphere-supplying respirator for which the breathing air source is designed to be carried by the user.

Service life means the period of time that a respirator, filter or sorbent, or other respiratory equipment provides adequate protection to the wearer.

Supplied-air respirator (SAR) or airline respirator means an atmosphere-supplying respirator for which the source of breathing air is not designed to be carried by the user.

This section means this respiratory protection standard.

Tight-fitting face piece means a respiratory inlet covering that forms a complete seal with the face.

User seal check means an action conducted by the respirator user to determine if the respirator is properly seated to the face.

4. RESPONSIBILITIES

While it is the responsibility of all workers to understand their obligations under the law, the following section summarizes some key areas of responsibility for employers and workers:

4.1. Senior Management

Senior management is responsible for:

- Implementing a written Respiratory Protection Program.
- Designating a Respiratory Protection Program Administrator.
- Supporting training needs financially for all levels of employment at SERES that may potentially be exposed to contaminated air.

4.2. Project Managers

Project managers are responsible for:

- Identifying breathing hazards associated with the project.
- Eliminating or minimizing all breathing hazards.
- Providing and maintaining respirators needed for any airborne hazard present at the worksite, and ensuring that workers use the equipment when required.
- Providing materials for workers to clean their respirators.
- Providing supervisors with the education and training necessary to ensure that workers use respirators safely.
- Providing workers with the education, training, and supervision necessary for safe use of respirators.
- Developing emergency evacuation procedures and ensuring that supervisors and workers receive appropriate training in any workplace where workers may need to be rescued or evacuated due to breathing hazards.
- Ensuring that all illnesses or injuries resulting from breathing hazards and requiring medical aid are reported and recorded.
- Requiring a medical assessment if there is a concern about a worker’s ability to wear a respirator.

4.3. Plan Administrator

The Plan Administrator is responsible for:

- Assessing the type and amount of exposure.
- Selecting the appropriate respirators.
- Implementing training and instruction programs.
- Administering the overall program, including the maintenance of records.

- Reviewing the RPP on an annual basis.

4.4. Site Safety and Health Officer (SSHO)

The SSHO is responsible for:

- Communication breathing hazards to site personnel and establish safety control measures.
- Ensuring site personnel are adequately trained prior to initiating work activities.
- Reviewing AHAs with site personnel and prepare new AHAs for activities not previously covered or anticipated by existing AHAs.
- Ensuring respirators are available when required.
- Ensuring workers use respirators correctly as required.
- Ensuring workers are clean-shaven.
- Ensuring respirators are properly cleaned, inspected, maintained, and stored.
- Making workers are aware of any equipment or clothing that may interfere with respirator use.
- Monitoring working conditions in order to alert supervisors of exposure to higher concentrations of a contaminant or a new contaminant.
- Report and investigate accidents and incidents regarding employee and subcontractor exposure to breathing hazards.
- Making workers are aware of potential issues that may develop during respirator use, such as discomfort, skin irritation, or breathing difficulty.
- Notifying the Program Administrator or Project Manager of concerns or conditions that might affect workers' respiratory protection.

4.5. Workers

Workers responsible for:

- Understanding and following safe work procedures.
- Using their respirators as instructed.
- Understanding the limitations of their respirators and following the manufacturers' instructions.
- Inspecting their respirators before use.
- Immediately reporting any equipment problems to their supervisor or designate.
- Properly cleaning and storing their respirators.

5. PLAN ADMINISTRATOR

SERES has designated Ms. Carron Smoak as the plan administrator. Ms. Smoak is qualified by appropriate training or experience that is commensurate with the complexity of the plan to administer or oversee the RPP and conduct the required evaluations of plan effectiveness.

6. VOLUNTARY USE OF RESPIRATORS

The Occupational Safety and Health Administration (OSHA) requires that the voluntary use of respirators (i.e., when respirators are not required by SERES), be controlled as strictly as if their use were required. Any employee wearing a respirator voluntarily shall fall under this RPP, be issued a copy of Appendix D of 1910.134, and fill out a medical questionnaire and have it evaluated by a physician or licensed health care professional. Training will be conducted on the proper storage, cleaning, and maintenance of the respirator. The Plan Administrator, with the assistance of the SSHO, will ensure that the respirator does not pose a health risk to the person donning it. Exception: Employees whose only use of respirators involves the voluntary use of filtering (non-sealing) face pieces (dust masks, with one OR two straps) do not fall under this program.

7. PLAN EVALUATION

Evaluations of the workplace are necessary to ensure that the written RPP is being properly implemented. This includes consulting with employees to ensure that they are using the respirators properly. Evaluations shall be conducted as necessary to ensure that the provisions of the current written plan are being effectively implemented and that it continues to be effective.

Plan evaluation will include discussions with employees required to use respirators to assess the employees' views on plan effectiveness and to identify any problems. Any problems that are identified during this assessment shall be corrected. Factors to be assessed include, but are not limited to:

- Respirator fit (including the ability to use the respirator without interfering with effective workplace performance)
- Appropriate respirator selection for the hazards to which the employee is exposed
- Proper respirator use under the workplace conditions the employee encounters
- Proper respirator maintenance.

8. RECORD KEEPING

SERES will retain written information regarding medical evaluations, fit testing, and the respirator program. This information will facilitate employee involvement in the respirator program, assist SERES in auditing the adequacy of the program, and provide a record for compliance determinations by OSHA.

9. TRAINING

Effective training for employees who are required to use respirators is essential. The training must be comprehensive, understandable, and recur annually and more often if necessary. Training will be provided prior to requiring the employee to use a respirator in the workplace. The training shall ensure that each employee can demonstrate knowledge of at least the following:

- Why the respirator is necessary and how improper fit, usage, or maintenance can compromise the protective effect of the respirator
- Limitations and capabilities of the respirator

- How to use the respirator effectively in emergency situations, including situations in which the respirator malfunctions
- How to inspect, put on and remove, use, and check the seals of the respirator
- What the procedures are for maintenance and storage of the respirator
- How to recognize medical signs and symptoms that may limit or prevent the effective use of respirators
- The general requirements of this program.

9.1. Training Requirements

Training will be conducted by instructors who have adequate knowledge of OSHA training requirements. Training is divided into the following sections.

Classroom Instruction

1. Overview of SERES' RPP and OSHA Standard.
2. Respiratory Protection Safety Procedures.
3. Respirator selection.
4. Respirator operation and use.
5. Why the respirator is necessary.
6. How improper fit, usage, or maintenance can compromise the protective effect.
7. Limitations and capabilities of the respirator.
8. How to use the respirator effectively in emergency situations, including respirator malfunctions.
9. How to inspect, put on and remove, use, and check the seals of the respirator.
10. What the procedures are for maintenance and storage of the respirator.
11. How to recognize medical signs and symptoms that may limit or prevent the effective use of respirators.
12. Change out schedule and procedure for Air Purifying Respirators (APR).

Fit Testing

For each type of respirator used.

Hands-On Respirator Training

1. Respirator inspection.
2. Respirator cleaning and sanitizing.
3. Record keeping.
4. Respirator storage.
5. Respirator fit check.
6. Emergencies.

9.2. Retraining

Retraining will be conducted annually and when required.

- Changes in the workplace or the type of respirator render previous training obsolete.
- Inadequacies in the employee's knowledge or use of the respirator indicate that the employee has not retained the requisite understanding or skill.
- Other situation arises in which retraining appears necessary to ensure safe respirator use.

10. BASIC RESPIRATORY PROTECTION SAFETY PROCEDURES

- Only authorized and trained employees may use respirators. Those employees may use only the respirator that they have been trained on and properly fitted to use.
- Only physically qualified employees may be trained and authorized to use respirators. A pre-authorization and annual certification by a qualified physician will be required and maintained. Any changes in an employee's health or physical characteristics will be reported to the plan administrator and will be evaluated by a qualified physician.
- Only the proper prescribed respirator or Self-Contained Breathing Apparatus (SCBA) may be used for the job or work environment. APRs may be worn in work environments when oxygen levels are 19.5 percent to 23.5 percent and when the appropriate cartridge, (as determined by the manufacturer and approved by National Institute for Occupational Safety and Health (NIOSH)), for the known hazardous substance is used. SCBAs will be worn in oxygen deficient and oxygen rich environments (below 19.5 percent or above 23.5 percent oxygen).
- Employees working in environments where a sudden release of a hazardous substance is likely will wear an appropriate respirator for that hazardous substance (example: Employees working in an ammonia compressor room will have an ammonia APR respirator on their person).
- Only SCBAs will be used in oxygen deficient environments, environments with an unknown hazardous substance or unknown quantity of a known hazardous substance, or any environment that is determined Immediately Dangerous to Life or Health (IDLH).
- Employees with respirators loaned on "permanent check out" will be responsible for the sanitation, proper storage, and security. Respirators damaged by normal wear will be repaired or replaced by SERES when returned.
- The last employee using a respirator and/or SCBA that is available for general use will be responsible for proper storage and sanitation. Monthly and after each use, all respirators will be inspected with **documentation** to assure its availability for use.
- All respirators will be located in a clean, convenient, and sanitary location.
- In the event that employees must enter a confined space work in environments with hazardous substances that would be dangerous to life or health should an Respiratory Protection Equipment (RPE) fail (a SCBA is required in this environment)/or conduct a Hazardous Materials (HAZMAT) entry, a "buddy system" detail will be used with a Safety Watchman with constant voice, visual or signal line

communication. Employees will follow the established Emergency Response Plan (ERP) and/or Confined Space Entry Program (CSEP) when applicable. These documents are included in the project specific APP or SSHP.

- Management will establish and maintain surveillance of jobs and work place conditions and degree of employee exposure or stress to maintain the proper procedures and to provide the necessary RPE.
- Management will establish and maintain safe operation procedures for the safe use of RPE with strict enforcement and disciplinary action for failure to follow all general and specific safety rules. Standard Operating Procedures for General RPE use and emergency use will be maintained as attachments to the project specific APP or SSHP, as applicable.

11. SELECTION OF RESPIRATORS

Prior to initiating work, the SERES PM, Site Supervisor, and SSHO will identify and evaluated the respiratory hazard(s) in each workplace, and user factors. This information will be utilized to select the appropriate respirator for use. Also included are estimates of employee exposures to respiratory hazard(s) and an identification of the contaminant's chemical state and physical form. This selection should include appropriate protective respirators for use in IDLH atmospheres, where applicable. For non-IDLH atmospheres, SERES will apply OSHA assigned respiratory factors to select a respirator that meets or exceeds the required level of employee protection. Figure 003-1 below presents OSHA assigned protection factors for each respirator type. All selected respirators will be NIOSH certified.

Table 7-1: OSHA Assigned Protection Factors

Type of Respirator	Quarter Mask	Half Mask	Full Facepiece	Helmet/ Hood	Loose-Fitting Facepiece
1. Air Purifying Respirator	5	10	50	–	–
2. Powered Air Purifying Respirator (PAPR)	–	50	1,000	25/1,000	25
3. Supplied Air Respirator (SAR) or Airline Respirator					
• Demand Mode	–	10	50	–	–
• Continuous Flow Mode	–	50	1,000	25/1,000	25
• Pressure Demand or other positive pressure mode	–	50	1,000	–	–

Type of Respirator	Quarter Mask	Half Mask	Full Facepiece	Helmet/ Hood	Loose-Fitting Facepiece
4. Self-Contained Breathing Apparatus (SCBA)					
• Demand Mode	–	10	50	50	–
• Pressure Demand or other positive pressure mode (e.g., open/closed circuit)	–	–	10,000	10,000	–

11.1. Filter Classifications

These classifications are marked on the filter or filter package.

N-Series: Not Oil Resistant

- Approved for non-oil particulate contaminants
- Examples: dust, fumes, mists not containing oil.

R-Series: Oil Resistant

- Approved for all particulate contaminants, including those containing oil
- Examples: dusts, mists, fumes
- Time restriction of 8 hours when oils are present.

P-Series: Oil Proof

- Approved for all particulate contaminants including those containing oil
- Examples: dust, fumes, mists
- See Manufacturer's time use restrictions on packaging

Respirators for IDLH Atmospheres

- A full face piece pressure demand SCBA certified by NIOSH for a minimum service life of thirty minutes, or
- A combination full face piece pressure demand Supplied-Air Respirator (SAR) with auxiliary self-contained air supply.
- Respirators provided only for escape from IDLH atmospheres shall be NIOSH-certified for escape from the atmosphere in which they will be used.

Respirators for Atmospheres that are Not IDLH

- The respirators selected shall be adequate to protect the health of the employee and ensure compliance with all other OSHA statutory and regulatory requirements, under routine and reasonably foreseeable emergency situations. The respirator selected shall be appropriate for the chemical state and physical form of the contaminant.

12. IDENTIFICATIONOF FILTERS AND CARTRIGES

All filters and cartridges shall be labeled and color coded with the NIOSH approval label. The user shall ensure that the label is not removed and remains legible. A change out schedule for filters and cartridge has been developed to ensure these elements of the respirators remain effective.

13. RESPIRATOR FILTER AND CARTRIDGE REPLACEMENT

An important part of the RPP includes identifying the useful life of cartridges and filters used on APRs. Each filter and cartridge shall be equipped with an End-Of-Service-Life Indicator (ESLI) certified by NIOSH for the contaminant or if there is no ESLI appropriate for the conditions, a change schedule for canisters and cartridges based on objective information or data that will ensure that canisters and cartridges are changed before the end of their service life shall be implemented.

Cartridges shall be changed based on the most limiting factor below:

- Prior to expiration date.
- Manufactures recommendations for the specific use and environment.
- After each use.
- When requested by employee.
- When contaminant odor is detected.
- When restriction to air flow has occurred as evidenced by increase effort by user to breathe normally.

Cartridges shall remain in their original sealed packages until needed for immediate use.

Filters shall be changed on the most limiting factor below:

- Prior to expiration date
- Manufactures recommendations for the specific use and environment
- When requested by employee
- When contaminant odor is detected
- When restriction to air flow has occurred as evidenced by increase effort by user to breathe normally
- When discoloring of the filter media is evident.

Filters shall remain in their original sealed package until needed for immediate use.

14. RESPIRATORY PROTECTION SCHEDULE BY JOB AND WORKING CONDITION

SERES maintains a Respiratory Protection Schedule by Job and Working Condition. This schedule is provided to each authorized and trained employee. The schedule provides the following information:

- Job/Working Conditions
- Work Location
- Hazards Present
- Type of Respirator or SCBA Required
- Type of Filter/Canister Required
- Location of Respirator or SCBA
- Filter/Cartridge change out schedule.

The schedule will be reviewed and updated at least annually and whenever any changes are made in the work environments, machinery, equipment, or processes or if respirator different respirator models are introduced or existing models are removed.

15. PHYSICAL AND MEDICAL QUALIFICATIONS

Records of medical evaluations must be retained and made available in accordance with 29 CFR 1910.1020.

15.1. Medical Evaluation Required

Using a respirator may place a physiological burden on employees that varies with the type of respirator worn, the job and workplace conditions in which the respirator is used, and the medical status of the employee. SERES provides a medical evaluation to determine the employee's ability to use a respirator, before the employee is fit tested or required to use the respirator in the workplace.

15.2. Medical Evaluation Procedures

SERES employees will be provided a medical questionnaire by the designated Occupational Health Care Provider (OHCP).

15.3. Follow-Up Medical Examination

SERES shall ensure that a follow-up medical examination is provided for any employee who gives a positive response to any question among questions in Part B of the questionnaire or whose initial medical examination demonstrates the need for a follow-up medical examination. The follow-up medical examination shall include any medical tests, consultations, or diagnostic procedures that the physician deems necessary to make a final determination.

15.4. Administrator of the Medical Questionnaire and Examination

The medical questionnaire and examination shall be administered confidentially during the employee's normal working hours or at a time and place convenient to the employee. The medical questionnaire shall be administered in a manner that ensures that the employee understands its content. SERES shall provide the employee with an opportunity to discuss the questionnaire and examination results with the physician.

15.5. Supplemental Information for the Physician

The following information must be provided to the physician before the physician makes a recommendation concerning an employee's ability to use a respirator

- The type and weight of the respirator to be used by the employee
- The duration and frequency of respirator use (including use for rescue and escape)
- The expected physical work effort
- Additional protective clothing and equipment to be worn
- Temperature and humidity extremes that may be encountered
- Any supplemental information provided previously to the physician regarding an employee need not be provided for a subsequent medical evaluation if the information and the physician remain the same.

SERES has provided the physician with a copy of the written RPP and a copy of the OSHA Standard 29 CFR1910.134.

15.6. Medical Determination

In determining the employee's ability to use a respirator, SERES shall obtain a written recommendation regarding the employee's ability to use the respirator from the physician. The recommendation shall provide only the following information:

- Any limitations on respirator use related to the medical condition of the employee, or relating to the workplace conditions in which the respirator will be used, including whether or not the employee is medically able to use the respirator.
- The need, if any, for follow-up medical evaluations.

A statement that the physician has provided the employee with a copy of the physician's written recommendation

If the respirator is a negative pressure respirator and the physician finds a medical condition that may place the employee's health at increased risk if the respirator is used, SERES shall provide an APR if the physician's medical evaluation finds that the employee can use such a respirator. If a subsequent medical evaluation finds that the employee is medically able to use a negative pressure respirator, then SERES is no longer required to provide an APR

15.7. Additional Medical Evaluations

At a minimum, SERES shall provide additional medical evaluations that comply with the requirements of this section if:

- An employee reports medical signs or symptoms that are related to ability to use a respirator.
- A physician, supervisor, or the respirator plan administrator informs SERES that an employee needs to be reevaluated.
- Information from the RPP, including observations made during fit testing and plan evaluation, indicates a need for employee reevaluation.
- A change occurs in workplace conditions (physical work effort, protective clothing, temperature, etc.) that may result in a substantial increase in the physiological burden placed on an employee.

15.8. Respirator Fit Testing

Before an employee is required to use any respirator with a negative or positive pressure tight-fitting face piece, the employee must be fit tested with the same make, model, style, and size of respirator that will be used. SERES shall ensure that an employee using a tight-fitting face piece respirator is fit tested prior to initial use of the respirator, whenever a different respirator face piece (size, style, model, or make) is used, and at least annually thereafter.

SERES has established a record of the qualitative and quantitative fit tests administered to employees including:

- The name or identification of the employee tested
- Type of fit test performed
- Specific make, model, style, and size of respirator tested
- Date of test
- The pass/fail results for Qualitative Fit Tests (QLFT) or the fit factor and strip chart recording or other recording of the test results for Quantitative Fit Tests (QNFTs).

Additional fit tests will be conducted whenever the employee reports, or SERES, physician, supervisor, or plan administrator makes visual observations of, changes in the employee's physical condition that could affect respirator fit. Such conditions include, but are not limited to, facial scarring, dental changes, cosmetic surgery, or an obvious change in body weight.

If after passing a QLFT or QNFT, the employee notifies SERES, plan administrator, supervisor, or physician that the fit of the respirator is unacceptable, the employee shall be given a reasonable opportunity to select a different respirator face piece and to be retested.

The fit test shall be administered using an OSHA-accepted QLFT or QNFT protocol. The OSHA-accepted QLFT and QNFT protocols and procedures are contained in Appendix A of OSHA Standard 29 CFR 1910.134.

- QLFT may only be used to fit test negative pressure air-purifying respirators that must achieve a fit factor of 100 or less.

- If the fit factor, as determined through an OSHA-accepted QNFT protocol, is equal to or greater than 100 for tight-fitting half face pieces, or equal to or greater than 500 for tight-fitting full face pieces, the QNFT has been passed with that respirator.
- Fit testing of tight-fitting atmosphere-supplying respirators and tight-fitting powered APR shall be accomplished by performing quantitative or qualitative fit testing in the negative pressure mode, regardless of the mode of operation (negative or positive pressure) that is used for respiratory protection.
- Qualitative fit testing of these respirators shall be accomplished by temporarily converting the respirator user's actual face piece into a negative pressure respirator with appropriate filters, or by using an identical negative pressure APR face piece with the same sealing surfaces as a surrogate for the atmosphere-supplying or powered APR face piece.
- Quantitative fit testing of these respirators shall be accomplished by modifying the face piece to allow sampling inside the face piece in the breathing zone of the user, midway between the nose and mouth. This requirement shall be accomplished by installing a permanent sampling probe onto a surrogate face piece, or by using a sampling adapter designed to temporarily provide a means of sampling air from inside the face piece.
- Any modifications to the respirator face piece for fit testing shall be completely removed, and the face piece restored to NIOSH approved configuration, before that face piece can be used in the workplace.

Fit test records shall be retained for respirator users until the next fit test is administered. Written materials required to be retained shall be made available upon request to affected employees.

16. RESPIRATOR OPERATION AND USE

Respirators will only be used following the respiratory protection safety procedures established in this program. The Operations and User Manuals for each type of respirator will be maintained by the Plan Administrator and be available to all qualified users.

Surveillance by the site supervisor shall be maintained of work area conditions and degree of employee exposure or stress. When there is a change in work area conditions or degree of employee exposure or stress that may affect respirator effectiveness, the site supervisor shall reevaluate the continued effectiveness of the respirator.

For continued protection of respirator users, the following general use rules apply:

- Users shall not remove respirators while in a hazardous environment.
- Respirators are to be stored in sealed containers out of harmful atmospheres.
- Store respirators away from heat and moisture.
- Store respirators such that the sealing area does not become distorted or warped.
- Store respirator such that the face piece is protected.

16.1. Face Piece Seal Protection

SERES does not permit respirators with tight-fitting face pieces to be worn by employees who have:

- Facial hair that comes between the sealing surface of the face piece and the face or that interferes with valve function

  or

- Any condition that interferes with the face-to-face piece seal or valve function.

If an employee wears corrective glasses or goggles or other personal protective equipment, SERES shall ensure that such equipment is worn in a manner that does not interfere with the seal of the face piece to the face of the user.

16.2. Continuing Effectiveness of Respirators

SERES shall ensure that employees leave the respirator use area:

- To wash their faces and respirator face pieces as necessary to prevent eye or skin irritation associated with respirator use
- If they detect vapor or gas breakthrough, changes in breathing resistance, or leakage of the face piece
- To replace the respirator or the filter, cartridge, or canister elements.

If the employee detects vapor or gas breakthrough, changes in breathing resistance, or leakage of the face piece, SERES will replace or repair the respirator before allowing the employee to return to the work area.

17. PROCEDURES FOR IDLH ATMOSPHERES

For all IDLH atmospheres, SERES shall ensure that:

- One employee or, when needed, more than one employee is located outside the IDLH atmosphere
- Visual, voice, or signal line communication is maintained between the employee(s) in the IDLH atmosphere and the employee(s) located outside the IDLH atmosphere
- The employee(s) located outside the IDLH atmosphere are trained and equipped to provide effective emergency rescue
- SERES or designee is notified before the employee(s) located outside the IDLH atmosphere enter the IDLH atmosphere to provide emergency rescue
- SERES or authorized designee, once notified, provides necessary assistance appropriate to the situation.

Employee(s) located outside the IDLH atmospheres will be equipped with:

- Pressure demand or other positive pressure SCBAs, or a pressure demand or other positive pressure SAR with auxiliary SCBA.

- Appropriate retrieval equipment for removing the employee(s) who enter(s) these hazardous atmospheres where retrieval equipment would contribute to the rescue of the employee(s) and would not increase the overall risk resulting from entry or
- Equivalent means for rescue where retrieval equipment is not required.

18. CLEANING AND DISINFECTING

SERES shall provide each respirator user with a respirator that is clean, sanitary, and in good working order. SERES shall ensure that respirators are cleaned and disinfected using the Standard Operating Procedure (SOP) - Cleaning and Disinfecting.

The respirators shall be cleaned and disinfected when:

- Respirators issued for the exclusive use of an employee shall be cleaned and disinfected as often as necessary to be maintained in a sanitary condition
- Respirators issued to more than one employee shall be cleaned and disinfected before being worn by different individuals
- Respirators maintained for emergency use shall be cleaned and disinfected after each use
- Respirators used in fit testing and training shall be cleaned and disinfected after each use.
- Cleaning and Storage of respirators assigned to specific employees is the responsibility of that Employee.

19. RESPIRATOR INSPECTION

All respirators/SCBAs, both available for "General Use" and those on "Permanent Check-Out", will be inspected after each use and at least monthly. Should any defects be noted, the respirator/SCBA will be taken to the Plan Administrator. Damaged respirators will be repaired or replaced. The inspection of respirators loaned on "Permanent Check-Out" is the responsibility of that trained Employee.

Respirators shall be inspected as follows:

- All respirators used in routine situations shall be inspected before each use and during cleaning
- All respirators maintained for use in emergency situations shall be inspected at least monthly and in accordance with the manufacturer's recommendations, and shall be checked for proper function before and after each use
- Emergency escape-only respirators shall be inspected before being carried into the workplace for use.

Respirator inspections include the following:

- A check of respirator function, tightness of connections, and the condition of the various parts including, but not limited to, the face piece, head straps, valves, connecting tube, and cartridges, canisters, or filters.
- Check of elastomeric parts for pliability and signs of deterioration.

- Self-contained breathing apparatus shall be inspected monthly. Air and oxygen cylinders shall be maintained in a fully charged state and shall be recharged when the pressure falls to 90% of the manufacturer's recommended pressure level. SERES shall determine that the regulator and warning devices function properly.

For Emergency Use Respirators the additional requirements apply:

- Certify the respirator by documenting the date the inspection was performed, the name (or signature) of the person who made the inspection, the findings, required remedial action, and a serial number or other means of identifying the inspected respirator.
- Provide this information on a tag or label that is attached to the storage compartment for the respirator, is kept with the respirator, or is included in inspection reports stored as paper or electronic files. This information shall be maintained until replaced following a subsequent certification.

20. RESPIRATOR STORAGE

Respirators are to be stored as follows:

- All respirators shall be stored to protect them from damage, contamination, dust, sunlight, extreme temperatures, excessive moisture, and damaging chemicals, and they shall be packed or stored to prevent deformation of the face piece and exhalation valve.
- Emergency Respirators shall be:
    - Kept accessible to the work area
    - Stored in compartments or in covers that are clearly marked as containing emergency respirators
    - Stored in accordance with any applicable manufacturer instructions.

20.1. Repair of Respirators

Respirators that fail an inspection or are otherwise found to be defective will be removed from service to be discarded, repaired, or adjusted in accordance with the following procedures:

- Repairs or adjustments to respirators are to be made only by persons appropriately trained to perform such operations and shall use only the respirator manufacturer's NIOSH-approved parts designed for the respirator.
- Repairs shall be made according to the manufacturer's recommendations and specifications for the type and extent of repairs to be performed.
- Reducing and admission valves, regulators, and alarms shall be adjusted or repaired only by the manufacturer or a technician trained by the manufacturer.

21. BREATHING AIR QUALITY AND USE

SERES shall ensure that compressed air, compressed oxygen, liquid air, and liquid oxygen used for respiration accords with the following specifications:

- Compressed and liquid oxygen shall meet the United States Pharmacopoeia requirements for medical or breathing oxygen
- Compressed breathing air shall meet at least the requirements for Grade D breathing air described in American National Standards Institute (ANSI)/Compressed Gas Association (CGA) Commodity Specification for Air, G-7.1-1989, to include:
    - Oxygen content (v/v) of 19.5-23.5%
    - Hydrocarbon (condensed) content of 5 milligrams per cubic meter of air or less
    - Carbon monoxide (CO) content of 10 ppm or less
    - Carbon dioxide content of 1,000 ppm or less
    - Lack of noticeable odor.
- Compressed oxygen will not be used in atmosphere-supplying respirators that have previously used compressed air
- Oxygen concentrations greater than 23.5% are used only in equipment designed for oxygen service or distribution
- Cylinders used to supply breathing air to respirators meet the following requirements:
    - Cylinders are tested and maintained as prescribed in the Shipping Container Specification Regulations of the Department of Transportation (DOT) (49 CFR part 173 and part 178)
    - Cylinders of purchased breathing air have a certificate of analysis from the supplier that the breathing air meets the requirements for Grade D breathing air
    - Moisture content in breathing air cylinders does not exceed a dew point of -50 ºF (-45.6 ºC) at 1 atmosphere pressure
    - Breathing air couplings are incompatible with outlets for non-respirable worksite air or other gas systems. No asphyxiating substance shall be introduced into breathing air lines
    - Breathing gas containers shall be marked in accordance with the NIOSH respirator certification standard, 42 CFR part 84.

Appendix J

Air Monitoring Logs

Date: ________________________________

SERES-Arcadis 8(a) JV2, LLC

Field Crew:

Weather:

Field Equipment

Notes:

Make Model Serial #

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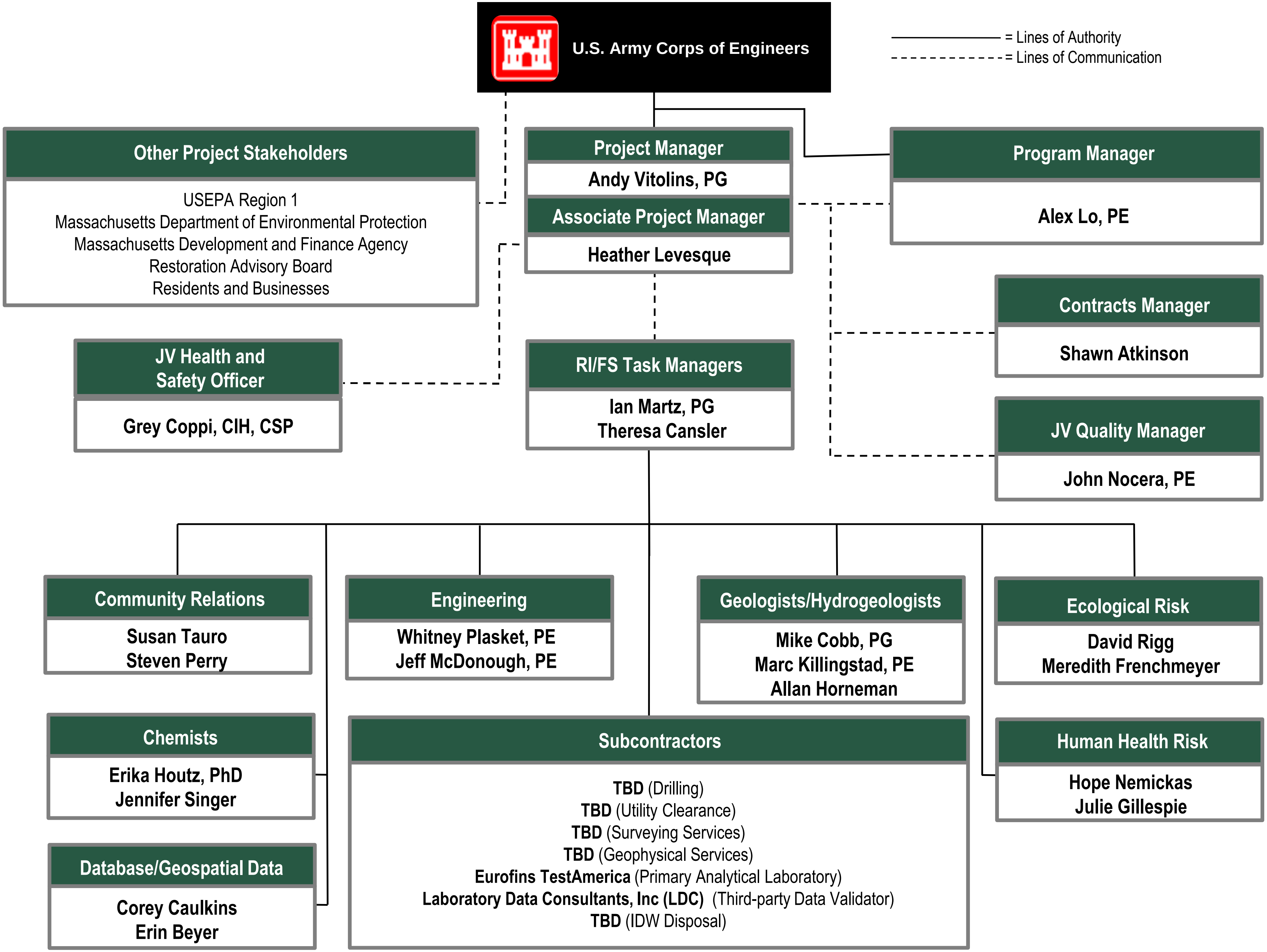
Location Identifier	**Time**	**Barometric Pressure (mm Hg)**	**Flow (ft^3/min)**	**Temperature (^{0}C)**	**02 (%)**	**C02 (%)**	**H2S (ppm)**	**CH4 (%)**	**CH4/LEL (%)**

Signature:____Date: _____________________________________

Attachment B Organizational Chart



U.S. Army Corps of Engineers

——— = Lines of Authority
- - - - - = Lines of Communication

Project Manager
Andy Vitolins, PG

Associate Project Manager
Heather Levesque

Program Manager
Alex Lo, PE

Other Project Stakeholders
USEPA Region 1
Massachusetts Department of Environmental Protection
Massachusetts Development and Finance Agency
Restoration Advisory Board
Residents and Businesses

JV Health and Safety Officer
Grey Coppi, CIH, CSP

RI/FS Task Managers
Ian Martz, PG
Theresa Cansler

Contracts Manager
Shawn Atkinson

JV Quality Manager
John Nocera, PE

Community Relations
Susan Tauro
Steven Perry

Engineering
Whitney Plasket, PE
Jeff McDonough, PE

Geologists/Hydrogeologists
Mike Cobb, PG
Marc Killingstad, PE
Allan Horneman

Ecological Risk
David Rigg
Meredith Frenchmeyer

Chemists
Erika Houtz, PhD
Jennifer Singer

Database/Geospatial Data
Corey Caulkins
Erin Beyer

Subcontractors
TBD (Drilling)
TBD (Utility Clearance)
TBD (Surveying Services)
TBD (Geophysical Services)
Eurofins TestAmerica (Primary Analytical Laboratory)
Laboratory Data Consultants, Inc (LDC) (Third-party Data Validator)
TBD (IDW Disposal)

Human Health Risk
Hope Nemickas
Julie Gillespie

Attachment C Health and Safety Acknowledgement

ACCIDENT PREVENTION PLAN REVIEW

Project Name: ______________________________

Project Location: ______________________________

Date: ______________________________

Conducted By: ______________________________

I have reviewed the JV Accident Prevention Plan for the above indicated site and understand the hazards and control measures required on this project.

I agree to follow the procedures outlined in this plan and to inform the JV Project Manager, Project Superintendent, and/or Site Safety and Health Officer should any unsafe condition be noted.

I understand that failure to follow safety regulations can be reason for removal from this project.

Date	Name	Signature	Company

Attachment D Resumes and Qualifications

PLACEHOLDER

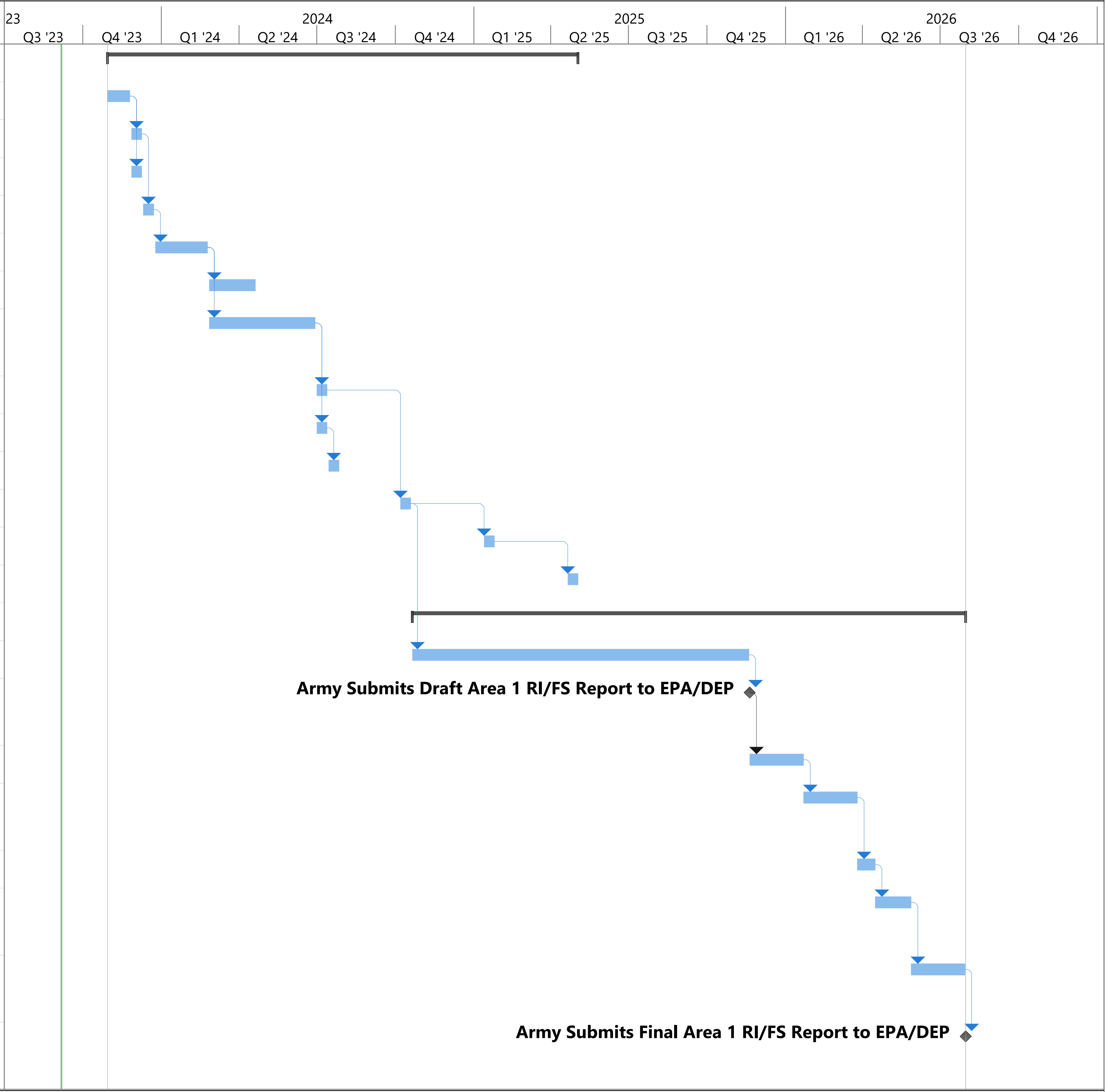
Resumes and qualifications for field personnel will be inserted when the Area 1- Phase 2 Remedial Investigation Work Plan is submitted for regulatory review.

QAPP Attachment B

Project Schedule

Anticipated Project Schedule
Area 1 Phase 2 PFAS RI/FS
Former Fort Devens, Massachusetts

ID	Task Name	Duration	Start	Finish
1	**Area 1 Phase 2 Remedial Investigation**	**395 days**	**Mon 10/30/23**	**Fri 5/2/25**
2	Right of Entry Agreements	20 days	Mon 10/30/23	Fri 11/24/23
3	Utility Clearance	10 days	Mon 11/27/23	Fri 12/8/23
4	Seismic Survey	10 days	Mon 11/27/23	Fri 12/8/23
5	Soil Borings	10 days	Mon 12/11/23	Fri 12/22/23
6	VAP Sampling	45 days	Mon 12/25/23	Fri 2/23/24
7	Overburden GW Monitoring Well Installation	40 days	Mon 2/26/24	Fri 4/19/24
8	Bedrock GW Monitoring Well Installation and Testing	90 days	Mon 2/26/24	Fri 6/28/24
9	Groundwater Sampling Event 1	10 days	Mon 7/1/24	Fri 7/12/24
10	Surface Water and Sediment Sampling	10 days	Mon 7/1/24	Fri 7/12/24
11	Fish Tissue Sampling	10 days	Mon 7/15/24	Fri 7/26/24
12	Groundwater Sampling Event 2	10 days	Mon 10/7/24	Fri 10/18/24
13	Groundwater Sampling Event 3	10 days	Mon 1/13/25	Fri 1/24/25
14	Groundwater Sampling Event 4	10 days	Mon 4/21/25	Fri 5/2/25
15	**Area 1 RI/FS Report (incl. BHRA)**	**464 days**	**Mon 10/21/24**	**Thu 7/30/26**
16	Preparation of Draft Area 1 RI/FS Report	282 days	Mon 10/21/24	Tue 11/18/25
17	Army Submits Draft Area 1 RI/FS Report to EPA/DEP	1 day	Wed 11/19/25	Wed 11/19/25
18	EPA/DEP Review of Draft Area 1 RI/FS Report	45 days	Thu 11/20/25	Wed 1/21/26
19	Army Issues Response Letter to Comments on Draft Area 1 RI/FS Report	45 days	Thu 1/22/26	Wed 3/25/26
20	EPA/DEP Review of Response Letter	15 days	Thu 3/26/26	Wed 4/15/26
21	Army Submits Draft Final Area 1 RI/FS Report to EPA/DEP	30 days	Thu 4/16/26	Wed 5/27/26
22	EPA/DEP Review of Draft Final Area 1 RI/FS Report	45 days	Thu 5/28/26	Wed 7/29/26
23	Army Submits Final Area 1 RI/FS Report to EPA/DEP	1 day	Thu 7/30/26	Thu 7/30/26



QAPP Attachment C

Field Standard Operating Procedures

ARCADIS Design & Consultancy for natural and built assets

PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS) FIELD SAMPLING GUIDANCE

Rev: 7

Rev Date: April 18, 2021

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	April 27, 2017	All	Initial Release	Erica Kalve Erika Houtz Sue Tauro
1	June 19, 2018	1 through 4 and 17	Updated Information on Sampling Materials	Erica Kalve Erika Houtz
2	October 15, 2018	6 to 16	Minor updates on laboratory elements, updates to decontamination procedures, and clarification on equipment and reagent blank collection	Erika Houtz Erica Kalve
3	December 17, 2018	4, 6, 17	Removed Sharpies from acceptable field writing implements; Changed language in Section 3.2 and Section 10.5 to provide stricter guidance for DoD projects.	Erika Houtz, Erica Kalve
4	March 26, 2019	4,5	Removed Citranox from acceptable Decon solutions in Table 1a, added all fluoropolymer containing materials to prohibited items in Table 1b. Made a correction that Liquinox contains trace levels of 1,4 Dioxane, not Alconox.	Erika Houtz
5	October 16, 2020	14	Added Air Force preference to sample surface water at surface for Air Force investigations.	Erika Houtz
6	March 23, 2021	4, 5, 7, 12, 13, 14, 15, 16, 17	Made clarifications that fine/ultra-fine point Sharpies are allowed. Referenced 2018 MDEQ sampling guidance. Made updates to ‘After Sample Collection’ in Section 7.	Kevin Engle
7	April 18, 2021	All	Changed title from Poly- and Perfluoroalkyl Substances to **“Per- and Polyfluoroalkyl Substances”** and changed PFASs to PFAS.	Rosario Varrella, Erika Houtz

APPROVAL SIGNATURES

Prepared by:

4/1/2021

Kevin Engle, PG
Geologist

Date:

Reviewed by:

Erika F. Houtz

4/18/2021

Erika F. Houtz, PhD, PE
Environmental Engineer and PFAS Analytical Lead

Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM’s responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project’s scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

The purpose of this Technical Guidance Instructions (TGI) is to provide guidance on field sampling to be used for **Per- and Polyfluoroalkyl Substances** (PFAS). This protocol was adapted from various sources including Arcadis Australia, Transport Canada, and the U.S Army Corp of Engineers (USACE) Omaha. In general, sampling techniques used for PFAS site characterization are consistent with conventional sampling techniques used in the environmental industry, but special consideration is made regarding PFAS-containing materials and cross-contamination potential. **Table 1a** provides a summary of materials that have been approved for site investigation; this list is expected to grow longer as industry experience increases. **Table 1b** provides a summary of field equipment and materials that have available testing information and/or industry knowledge regarding PFAS cross-contamination potential and it is recommended that these materials be prohibited for sample collection; for materials that are suspected of containing PFAS and/or to retain PFAS, these recommendations are considered preliminary and subject to change.

Table 1a: Summary of Acceptable Sampling Equipment and Materials for PFAS Site Investigations

Sampling Materials	Additional Considerations	References
Water Sampling Materials		
High density polyethylene (HDPE) or silicone tubing materials	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
HDPE HydraSleeves™	Low density polyethylene (LDPE) HydraSleeves™ are not recommended	USACE 2016; MassDEP 2017
Drilling and Soil Sampling Materials		
PFAS-free drilling fluids	--	DER 2016
PFAS-free makeup water	Confirm PFAS-free water source via laboratory analysis prior to investigation	--
Acetate liners	For use in soil sampling	USACE 2016
Sample Containers and Storage		
HDPE sample containers with HDPE lined lids for soil and water samples	Laboratory should provide; whole bottle analysis of aqueous samples combined with a solvent rinse of bottle is recommended	DER 2016, MassDEP 2017
Ice contained in plastic (polyethylene) bags (double bagged)	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Field Documentation		
Ball point pens	--	MassDEP 2017
Standard paper and paper labels	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Fine/Ultra-Fine point Sharpies®	Larger point Sharpies® should be avoided.	MDEQ 2018
Decontamination		
Water-only decontamination	Confirm PFAS-free water source via laboratory analysis prior to investigation	DER 2016
Alconox® or Liquinox® followed by deionized water or PFAS-free water rinse	Liquinox® known to contain trace levels of 1,4-dioxane	NHDES 2016; USACE 2016; MassDEP 2017
Methanol, isopropanol, or acetone	Special health and safety precautions are necessary	UNEP 2015; USACE 2016

Note: This list is considered preliminary and additional materials may be added as additional information becomes available. Project teams are expected to follow a methodical evaluation process of materials to be used and confirm acceptance prior to implementation of field activities.

Table 1b: Summary of Sampling Equipment and Materials Not Recommended for PFAS Site Investigations.

Sampling Materials	Known PFAS-Containing Materials	Suspected PFAS-Containing Materials	Materials with Potential to Retain PFAS	References
Water Sampling Materials				
Teflon®, PTFE-containing or other fluoropolymer coated or containing field equipment (e.g., tubing, bailers, liners, tape, plumbing paste, pump parts)	x			DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Passive diffusion bags			x	MassDEP 2017
LDPE HydraSleeves ™			x	USACE 2016; MassDEP 2017
Water particle filters			x	MassDEP 2017
Drilling and Soil Sampling Materials				
Aluminum foil			x	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Drilling fluid containing PFAS	x	x		DER 2016
Sample Containers and Storage				
Glass sample containers with lined lids			x	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
LDPE containers and lined lids			x	USACE 2016
Teflon® or PTFE- lined lids on containers (e.g., sample containers, rinsate water storage containers)	x			DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Reusable chemical or gel ice packs (e.g., BlueIce®)		x		DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Field Documentation				
Self-sticking notes and similar office products (e.g., 3M Post-it-notes)		x		DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Waterproof paper, notebooks, and labels	x			DER 2016, MassDEP 2017
Markers		x		NHDES 2016

Sampling Materials	Known PFAS-Containing Materials	Suspected PFAS-Containing Materials	Materials with Potential to Retain PFAS	References
Decontamination				
[Some] detergents and decontamination solutions (e.g., Decon 90® Decontamination Solution)	x	x		DER 2016; NHDES 2016; MassDEP 2017

Note: For materials that are suspected of containing PFAS, or have the potential to retain PFAS, project specific considerations may provide adequate justification for use during the field event. For example, further evaluation may be conducted in the form of pre-field equipment blank sample analysis.

Given the extremely low detection limits associated with PFAS analysis and the many potential sources of trace levels of PFAS, field personnel are advised to err on the side of caution by strictly following these protocols, frequently replacing nitrile gloves, and rinsing field equipment to help mitigate the potential for false detections of PFAS. A summary of other specific items related to field sampling for PFAS are discussed in the sections below.

This TGI applies to all Arcadis and subcontractor personnel involved in field sampling for PFAS.

3 PERSONNEL QUALIFICATIONS

3.1 Sampling Personnel

Field personnel must have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, and site-specific training, as needed. In addition, field personnel will be versed in the other relevant SOPs (e.g., low flow sampling) and will possess the skills and experience necessary to successfully complete the desired field work. The site Health and Safety Plan (HASP) and other documents will identify any other training requirements such as site-specific safety training or access control requirements.

3.2 Laboratories

These laboratories are example laboratories that could be used to analyze environmental media for PFAS, pending project approval:

- United States: TestAmerica, SGS, Vista, ALS, and Eurofins
- Canada: Axys-SGS and Maxxam Laboratories

Other laboratories may be used if they are appropriately accredited for PFAS analysis according to any project requirements. It is recommended that a laboratory is Environmental Laboratory Accreditation Program (ELAP)-accredited for PFAS analysis in accordance with the Department of Defense (DoD) Quality Systems Manual (QSM) 5.1 Table B-15 or any subsequent updates. **For all data collection efforts at DoD sites, PFAS data must be obtained using a method that is DoD ELAP-accredited under QSM 5.1 or later.**

4 EQUIPMENT LIST

The following equipment and materials must be available for sampling:

- Site plan of sampling locations, relevant work plan (or equivalent), and this TGI;
- Appropriate health and safety equipment, as specified in the site HASP;
- Dedicated plastic sheeting (preferably high-density polyethylene [HDPE]) or other clean surface to prevent sample contact with the ground;
- Conductivity/temperature/pH meter;
- Dissolved oxygen meter, oxidation reduction potential meter, and turbidity meter;
- Depth to water meter;
- If using low-flow groundwater sampling techniques, peristaltic pump (groundwater sampling)/bladder pump (with PFAS free bladder/ HDPE bladder), flow through cell, and accompanying HDPE and silicone tubing;
- Hydrasleeves, if using Hydrasleeves for groundwater sampling;
- Metal trowel for soil samples; specialized soil/sediment sampling equipment as required;
- Brushes for scrubbing sampling equipment;
- Pens, pencils, and/or fine/ultra-fine point Sharpies® for writing;
- Clipboards, field binders, and field note pages that are not waterproof;
- Labeled sample bottles:
  - Water: HDPE bottles fitted with polypropylene screw cap only; some types of PFAS samples (primarily drinking water) may require preservative, which will be indicated by the laboratory conducting the analysis. The laboratory will specify the sample bottle volume.
  - Soil and sediment: HDPE bottles fitted with polypropylene screw cap only; no preservatives. The laboratory will specify the sample bottle volume.
- If high concentrations of PFAS related to class B firefighting foams are expected, bring additional small vials to conduct field-based shaker tests for foaming;
- Ziploc® bags to hold ice and samples;
- Bottles containing “PFAS-free” water used for reagent blanks;
- Labeled coolers for samples with ice; Blue ice is not permitted;
- Deionized or distilled water for initial decontamination rinsing;
- “PFAS-free” water provided by the laboratory for final decontamination rinsing;
- Methanol, isopropanol, or acetone if able to be brought safely to field site; especially important for decontamination during soil sampling;
- Alconox or Liquinox®;

- Packing and shipping materials;
- Groundwater Sampling Log; and
- Chain-of-Custody (COC) Forms.

5 CAUTIONS

5.1 Food Packaging

Some food packaging may be treated with PFAS-containing chemicals to prevent permeation of oil and water in the food outside of the packaging. To avoid potential food packaging-related PFAS contact:

- Do not bring any food outside of the field vehicles onsite and eat snacks and meals offsite.
- Wash hands after eating.
- Remove any field garments or outer layers prior to eating. Do not put them back on until done eating and hands are washed.

5.2 Field Gear

5.2.1 Clothing

Many types of clothing are treated with PFAS for stain and water resistance, in particular outdoor performance wear under brand names such as Gore-Tex®. To avoid potential clothing-related PFAS contact:

- Do not wear any outdoor performance wear that is water or stain resistant, or appears to be. Err on the side of caution.
- Wear pre-laundered (multiple washings, i.e., 6+) clothing that is not stain resistant or water proof.
- Natural fabrics such as cotton are preferred. Synthetic fabrics may also be acceptable if there is no indication on the label that the fabric is water and stain resistant.
- Most importantly, avoid contacting your clothing with sampling equipment, bottles, and samples.

5.2.2 Personal Protective Equipment

Safety Footwear

Some safety footwear has been treated to provide a degree of waterproofing and increased durability and may represent a source of trace PFAS. For the health and safety of field personnel, footwear must be protected at all times to avoid potential PFAS contamination. To do this:

- Do not contact your footwear with equipment, bottles, or samples in any way.
- Do not allow gloves used for sampling to come in contact with safety footwear.

Nitrile Gloves

Wear disposable nitrile gloves at all times. Don a new pair of nitrile gloves **before** the following activities at each sample location:

- Decontamination of re-usable sampling equipment;
- Contact with sample bottles or "PFAS-free" water bottles;
- Insertion of anything into the sample ports (e.g., HDPE tubing); and
- Handling of any quality assurance/quality control (QA/QC) samples including field blanks and equipment blanks.

Don a new pair of nitrile gloves **after** the following activities:

- Handling of any non-dedicated sampling equipment;
- Contact with contaminated surfaces; or
- When judged necessary by field personnel.

5.3 Personal Hygiene

- Shower at night.
- Do not use personal care products after showering such as lotions, makeup, and perfumes, UNLESS medically necessary.
- Use sunscreen and insect repellent ONLY if necessary for health and safety. If they are necessary, apply sunscreen and repellant prior to initiating field sampling. If sunscreen and/or repellant need to be reapplied, ensure a safe distance away from the sampling locations and equipment (i.e., more than 10 meters (m) away). Wash hands after application.

5.4 Visitors

Visitors to the site are asked to remain at least 10 m from sampling areas.

5.5 Rain Events

Special care should be taken when rain is falling at the project site:

- Do not perform field sampling when rain fall is persistent at a consistent rate that saturates the ground (i.e., formation of puddles) because rain gear is not permitted while sampling. Intermittent showers or fog are acceptable conditions to proceed. If rain showers occur; field gear must be removed from the monitoring well location until the rain subsides.
- If project timelines are tight, consider the use of a gazebo tent that can be erected over the top of the monitoring well to provide shelter from the rain. The canopy material is possibly a PFAS-treated surface and should be managed as such; therefore, wear gloves when moving the tent, change them immediately after moving the tent, and avoid further contact with the tent until all sampling activities have been finished and the team is ready to move on to the next site.

6 HEALTH AND SAFETY CONSIDERATIONS

- The ability to safely access the surface water sampling locations must be verified before sampling.
- Field activities must be performed in accordance with the site HASP, a copy of which will be present onsite during such activities.
- Safety hazards associated with sampling surface water include fast-moving water, deep water, and steep slopes close to sampling sites. Use extreme caution when approaching sampling sites.
- If thunder or lighting is present, discontinue sampling and take cover until 30 minutes have passed after the last occurrence of thunder or lighting.
- Use caution when removing well caps as well may be under pressure, cap can dislodge forcefully and cause injury.

7 PROCEDURE

7.1 Field Equipment Cleaning

Reusable field sampling equipment will require cleaning between uses. For groundwater sampling, between uses, decontaminate the flow-through cell and any non-dedicated equipment (i.e., interface probe of depth to water meter) that comes into contact with well water. Trowels and other materials used to sample soil samples will also require decontamination, although dedicated, single use equipment such as liners should be used where possible.

After donning a new pair of nitrile gloves:

- Rinse sampling equipment with Alconox or Liquinox® cleaning solution; Scrub equipment with a plastic brush if needed;
- Rinse two times with distilled water or deionized water;
- Rinse one time with “PFAS-free” water or once with methanol/isopropanol/acetone, if it is available, and once with “PFAS-free” water; organic solvents are especially useful for decontaminating soil sampling equipment. If organic cleaning solvents cannot be brought to site, scrub equipment a second time after a single distilled or deionized water rinse, then rinse two times with distilled or deionized water and once with “PFAS-free” water (i.e., two scrubbings and four water rinsings total).
- Collect all rinsate in a sealed pail for disposal. Do not reuse decontamination solutions between sampling locations.

7.2 Borehole/Monitoring Well Development

If a drill rig is being used to drill for soil cores or to install monitoring wells, wear clean nitrile gloves before collecting each continuous soil sample. Additional requirements include the following:

- Verify in writing with the manufacturer that single-use liners used to collect each sample are made of a material that does not contain PFAS;

- Collect soil samples in laboratory-supplied HDPE bottles.
- Store the sample bottles in coolers and keep at a temperature of 0 to 6ºC until transported to the laboratory.

7.2.1 Well Condition Survey/ Water Level Monitoring

Using equipment that has been thoroughly decontaminated according to the procedures in Section 7.1, conduct the well condition surveys and water level monitoring:

- Conduct monitoring well inspections and record water levels.
- Use an interface probe to evaluate presence/absence of non-aqueous phase liquid (NAPL).
- Measure the depth to water from the top of the polyvinyl chloride (PVC) riser and the total depth of the well.
- Record information in the field notes.

7.2.2 Monitoring Well Development and Purging

Follow these requirements for monitoring well development and purging:

- Do not use Teflon™ tubing for purging or sample collection. HDPE tubing is acceptable.
- Do not re-use materials between wells. Upon completion of use, remove all disposable materials (such as HDPE and/or silicone tubing) and place in heavy duty garbage bags for disposal.
- During development of the well, create sufficient energy to agitate the water column and create flow reversals in the well screen, filter pack and formation to loosen fine-grained materials and draw them into the well. The pumping or bailing action should then draw all drilling fluids and fine-grained material out of the borehole and adjacent formation and then out of the well. Review the Arcadis Monitoring Well Development guidance (Arcadis 2010) for more detailed information.
- Follow the low-flow purge and sampling techniques per the U.S. Protection Agency's (EPA's) guidance document titled *Low Stress (Low Flow) purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells* (2010) and ASTM's standard titled *Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations* (2002). Also available for review is the Arcadis Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells (Arcadis 2011).
- To purge the well, if using HDPE tubing and a peristaltic pump, insert the end of the tubing to the approximate depth of the midpoint of the screened section of the monitoring wells. Measure the length of HDPE tubing to be inserted into each monitoring well and pre-cut it to approximate lengths (such as the previously measured arm span of a field technician) to avoid contact with any materials other than the monitoring well and peristaltic pump. Flow rates should be as low as can be reasonably achieved. Collect and appropriately dispose of purge water.
- Silicone tubing should direct the purge water through a flow-through cell for field parameter measurements of pH, conductivity, temperature, dissolved oxygen, and turbidity. Calibrate the

instrument in the field prior to use. Decontaminate the instrument and flow-through cell at each monitoring well location before purging.

- Record field parameters in intervals (generally of 3-minute duration) to ensure purge water has cycled through the flow-through cell. Sample the wells after field parameter measurements indicate stabilization, which allows collection of representative formation water (generally acceptable standards are three consecutive pH readings to within ±0.1 units, and three consecutive conductivity, temperature and dissolved oxygen measurements to within 3%). Turbidity must be monitored, but does not need to be used as a stabilization indicator of purge completion. Record field parameter measurements at each well. Drawdown should be monitored throughout the purge.
- If wells are suspected to be dewatering throughout the purge (i.e., reduced flow rate/difficulty pumping water or bubbles begin to come through the flow through cell), turn off the pump and allow the water level to recover for ½ hour, followed by sample collection. Document these activities in the field notes.

7.3 Sample Collection

Different laboratories may supply sample collection bottles of varying sizes depending on the type of media to be sampled.

7.3.1 Sample Containers

- Collect samples in HDPE bottles fitted with an unlined (no Teflon™), polypropylene screw cap.
- Complete bottle labels after the caps have been placed back on each bottle.
- Do not use glass bottles due to potential loss of analyte through adsorption. This is particularly important for aqueous samples.
- Review with analytical lab the sample size, sample container, etc. depending upon the type of PFAS analysis that is being requested.

7.3.2 Soil Sampling

Before Sample Collection

- Place plastic sheeting adjacent to the sample port for use as a clean work area, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
- Trowels or drilling equipment that will come into contact with a sample should be decontaminated prior to sample collection, preferably with methanol/isopropanol/acetone;
- Don a new set of nitrile gloves. Do not use gloved hands to subsequently handle papers, pens, clothes, etc., before collecting samples.
- Use the HDPE bottles that are supplied by the laboratory. Make sure that the caps remain on the bottle until immediately prior to sample collection.

During Sample Collection

- Collect soil samples using a clean stainless steel trowel or with single-use PFAS-free liners;

- Place soil samples in labeled HDPE bottles supplied by the laboratory.
- Note the time on the sample label.
- Collect any necessary duplicates/co-located samples and matrix spikes – verify with laboratory whether they need to be collected in separate sample bottles.
- Collect any necessary equipment blanks. The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFAS, after the sampling equipment has been appropriately decontaminated.
- Collect any necessary field reagent blanks. This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel.

After Sample Collection

- Place each sample bottle in two sealed Ziploc® bags. Another brand of LDPE bag is acceptable.
- Record the label information and time of sampling in the field notes.
- Place soil sample bottles in coolers that are durable in transportation and keep the temperature between 0 and 6ºC until transported to the laboratory. Do not use blue ice.

7.3.3 Groundwater Sampling

Before Sample Collection

- Place plastic sheeting adjacent to the sample port for use as a clean work area, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
- Don a new set of nitrile gloves. Do not use gloved hands to subsequently handle papers, pens, clothes, etc., before collecting samples.
- Use the labeled HDPE bottles that are supplied by the laboratory. Make sure that the caps remain on the bottle until immediately prior to sample collection.
- Measure depth to water and field parameters. Turbidity and the physical appearance of the purged water should be noted on the Groundwater Sampling Log.

During Sample Collection

- Start groundwater sample collection upon stabilization of field parameters.
- If low-flow groundwater sampling techniques are being used, disconnect the silicone tubing from the flow-through cell, enabling collection of groundwater samples prior to passing through the cell.
- Hydrasleeves are also considered acceptable for sampling of PFAS in groundwater – consult the project manager to determine which technique should be used. In general, low flow sampling is preferable.
- Collect groundwater samples (to the neck of the bottle, some headspace is acceptable) from the dedicated sampling ports at the center of the well screen. While collecting the sample, make sure the bottle cap remains in the other hand of the sampler, until replaced on the bottle.

- To mitigate cross contamination, collect groundwater samples in a pre-determined order from least impacted to greater impacted based on previous analytical data or knowledge about past activities at the site. If no analytical data are available, samples are to be collected in the following order:
    1. First sample the upgradient well(s).
    2. Next, sample the well located furthest downgradient of the interpreted or known source.
    3. The remaining wells should be progressively sampled in order from downgradient to upgradient, such that the wells closest to the interpreted or known source are sampled last.
- NOTE: If high concentrations of PFAS related to class B firefighting foams are expected in a groundwater sample, conduct a Shaker test by collecting and shaking a small portion of the sample (~10 to 25 mL) on site in a small disposable vial. If foaming is noted within the sample, document the foaming when samples are submitted for analysis; the 'shaker test' vial can then be disposed. This shaker test provides information about how each of the samples should be handled analytically.
- After collecting the sample, tightly screw on the polypropylene cap (snug, but not too tight). This will minimize leaking or cross contamination of the sample. Most PFAS, including all analytes measured by USEPA Method 537, are not volatile at environmental pH.
- Note the time on the sample label.
- Collect any necessary duplicates and matrix spikes. As the laboratory should be analyzing the entire aqueous sample rather than sub-sampling, separate bottles will be required for these samples.
- Collect any necessary equipment blanks. The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFAS, after the sampling equipment has been appropriately decontaminated.
- Collect any necessary field reagent blanks. This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel.
- Do not rinse PFAS sample bottles during sampling. Do not filter samples.

After Sample Collection

- Place each sample bottle in two sealed Ziploc® bags. Another brand of LDPE bag is acceptable.
- Record the label information and time of sampling in the field notes and COC. Note ‘shake test’ results if appropriate.
- Place groundwater samples in coolers that are durable in transportation and keep the temperature between 0 and 6ºC until transported to the laboratory. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**

  Treat all disposable sampling materials as single use and dispose of them appropriately after sampling at each monitoring well.

7.3.4 Sediment Sampling

Before Sample Collection

- Place plastic sheeting (preferably HDPE) adjacent to the sample port for use as a clean work area, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
- Don a new set of nitrile gloves. Do not use gloved hands to subsequently handle papers, pens, clothes, etc., before collecting samples.
- Use the HDPE bottles that are supplied by the laboratory. Make sure that the caps remain on the bottle until immediately prior to sample collection.

During Sample Collection

- Where surface water samples and sediment samples are collected at the same location, collect surface water samples first to minimize siltation.
- Collect sediment samples either manually using a stainless steel trowel or using a petite ponar grab sampler, depending on field conditions at each sampling location during sampling program.
- Collect sediment samples from the upper 10 cm of sediment.
- For a sample to be acceptable overlying, low turbidity water must be present.
- Decant the overlying water and use a stainless steel trowel to collect only the upper 5 centimeters (cm) of sediment.
- Collect sediment samples directly into laboratory-supplied bottles that are suitable in both material and size.
- Do not overfill the sample bottle.
- Make sure that the sample does not contain vegetation, that the sediment is undisturbed, and that the sampler shows no signs of winnowing or leaking.
- Make sure bottle caps remain in the gloved hand of the sampler until sampling is complete and caps are replaced on the bottle.
- Note the time on the sample label.
- Collect any necessary duplicates and matrix spikes.
- Collect any necessary equipment blanks. The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFAS, after the sampling equipment has been appropriately decontaminated.
- Collect any necessary field reagent blanks. This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel.

After Sample Collection

- Place each sample bottle in two sealed Ziploc® bags. Another brand of LDPE bag is acceptable.
- Record the label information and time of sampling in the field notes.

- Place samples in coolers that are durable in transportation and keep the temperature between 0 and 6ºC until transported to the laboratory. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**
- Measure surface water pH, conductivity, temperature, and total dissolved solids (TDS) at each location **after** both surface water and sediment sampling is completed.

7.3.5 Surface Water Sampling

Before Sample Collection

- Place plastic sheeting (preferably HDPE) adjacent to the sample port for use as a clean work area, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
- Don a new set of nitrile gloves. Do not use gloved hands to subsequently handle papers, pens, clothes, etc., before collecting samples.
- Use the HDPE bottles that are supplied by the laboratory. Make sure that the caps remain on the bottle until immediately prior to sample collection.

During Sample Collection

- Avoid sampling the surface, in general.
- However, for Air Force investigations, collect samples from the water surface.
- Where surface water samples and sediment samples are collected at the same location, collect surface water samples first to minimize siltation.
- Collect surface water samples directly into laboratory-supplied bottles; wide-mouth bottles may be preferable to narrow mouth bottles for ease of surface water collection.
- Make sure bottle caps remain in the gloved hand of the sampler until sampling is complete and caps are replaced on the bottle.
- Note the time on the sample bottle.
- Collect any necessary duplicates and matrix spikes. As the laboratory should be analyzing the entire aqueous sample rather than sub-sampling, separate bottles will be required for these samples.
- Collect any necessary equipment blanks. The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFAS, after the sampling equipment has been appropriately decontaminated.
- Collect any necessary field reagent blanks. This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel.

After Sample Collection

- Place each sample bottle in two sealed Ziploc® bags. Another brand of LDPE bag is acceptable.
- Record the label information and time of sampling in the field notes.

- Place samples in coolers that are durable in transportation and keep the temperature between 0 and 6ºC until transported to the laboratory. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**
- Measure surface water pH, conductivity, temperature, and TDS at each location **after** both surface water and sediment sampling.

7.4 Shipping

- If samples cannot be shipped the same day as collected, arrange an appropriate means of keeping the samples cool overnight and maintain the temperature between 0 and 10°C for the first 48 hours after collection, and then between 0 and 6°C thereafter.
- Store samples in appropriate transport bottles (coolers) with ice (Ziploc© bags for use as ice containers) with appropriate labeling. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**
- Complete the appropriate procedures for COC, handling, packing, and shipping.
- Fill out and check COC Forms against the labels on the sample bottles progressively after each sample is collected.
- Place all disposable sampling materials (such as plastic sheeting, and health and safety equipment) in appropriate containers.
- Ship samples via courier service with priority overnight delivery. Tracking numbers for all shipments should be provided and recorded after they have been sent out to ensure their timely delivery.
- Do not ship samples via Fed Ex for Saturday delivery.

8 WASTE MANAGEMENT

All rinsate should be collected in a sealed pail for disposal. Drill cuttings and purge water will be managed as specified in the Field Sampling Plan (FSP) or Work Plan, and according to state and/or federal requirements. PPE and decontaminated fluids will be contained separately and staged at the sampling location. Containers must be labeled at the time of collection. Labels will include date, location(s), site name, city, state, and description of matrix contained (e.g., soil, groundwater, PPE). General guidelines for investigation derived waste (IDW) handling and storage are set forth in a separate IDW guidance document (Arcadis 2009).

Typical waste characterization procedures include collection of a composite sample of the drill cutting material and a composite sample of the purge water for laboratory analysis. Samples are typically analyzed for disposal toxicity characteristic leaching procedure (TCLP) analysis for metals and VOCs. For PFAS, a simple leach test with neutral pH water may be more indicative of actual risk. Additionally, generators of waste are required to include analysis of other constituents that are reasonably believed to be present including (in this case) PFAS.

Emerging contaminants pose a unique challenge for disposal because acceptance of such waste will be based on the local facility and their permit restrictions. Project teams will be required to identify appropriate facilities based on the facility’s legal ability to accept the waste and the team should confirm that the facility is meeting the regulatory requirements for accepting waste containing PFAS. In general, facilities that provide solidification and/or incineration will be likely to meet the necessary requirements to accept PFAS-containing waste. The facility will then provide the definitive laboratory analysis requirements needed to meet their permit requirements for waste classification.

9 DATA RECORDING AND MANAGEMENT

9.1 Field Notes

Waterproof field books must not be used for field notes. Instead, field notes should be on loose paper on Masonite, plastic, or aluminum clip boards. Other requirements for field notes include:

- Pens, pencils, and fine/ultra-fine point Sharpies® may be used.
- Keep field notes and writing implements away from samples and sampling materials.
- One person should conduct sampling while another records field notes.
- Do not write on sampling bottles unless they are closed.

9.2 Other Project Documentation

- Complete Groundwater Sampling Logs.
- Make sure COC Forms are properly completed. Verify which PFAS analytes (e.g., just PFOS and PFOA, some or all of the 537 list, etc.) are required for analysis and note on the COC.

10 QUALITY CONTROL

Refer to quality control requirements for the project to ensure that appropriate quality assurance and quality control (QA/QC) samples are collected. When collecting QA/QC samples, the same guidelines apply as when collecting regular samples – specifically that:

- Samples should be collected in laboratory-supplied HDPE bottles;
- Bottle caps must remain in the hand of the sampler until replaced on the bottle;
- Labels must be completed after the caps have been placed back on each bottle; and
- Samples must be stored in appropriate transport bottles (coolers) with ice (Ziploc© bags for use as ice containers) with appropriate labeling. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**

10.1 Equipment Blanks (if relevant)

QA/QC sampling typically includes daily collection of equipment blanks using the laboratory-supplied “PFAS-free” water. For peristaltic pump tubing, laboratory supplied “PFAS-free” water should be poured into a clean HDPE sample bottle and then pumped through new HDPE tubing using the peristaltic pump (with new silicone tubing). The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFAS, after the sampling equipment has been appropriately decontaminated.

10.2 Field Duplicates

QA/QC sampling typically includes the collection of one field duplicate for every 10 or 20 samples collected. Each duplicate sample will be collected immediately after the initial sample of which it is a duplicate into a separate laboratory-provided sample bottle. Do not indicate to the laboratory which sample the duplicate replicates, i.e. it should be given a blind reference on the COC and sample name such as “duplicate”.

10.3 Field Reagent Blanks

QA/QC sampling for PFAS typically includes the submission of one laboratory supplied field reagent blank per day. The field reagent blank sample is brought to the site in a laboratory-supplied sample bottle. Field staff transfer the laboratory-supplied reagent blank to an empty sample bottle. This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel and should be placed in the same cooler as the other PFAS samples.

10.4 Matrix Spikes (optional in some cases)

QA/QC sampling includes submitting a sample to be used as a matrix spike if the project requires it. If a separate sample bottle is required, an additional sample will be collected immediately after the initial sample of which it is a duplicate into a separate laboratory-supplied sample bottle.

10.5 Laboratory Analytical QA/QC

- Arcadis recommends that any request for PFAS analysis in groundwater or soil should be conducted by an ELAP-accredited method compliant with QSM 5.1 Table B-15. Requirements laid out in Table B-15 strictly govern acceptable laboratory data quality for PFAS analysis in environmental samples. **For all data collection efforts at DoD sites, PFAS data must be obtained using a method that is DoD ELAP-accredited under QSM 5.1 or later.**
- Laboratory QA/QC should consist of one laboratory blank and one laboratory control sample (or blank spike) per batch of samples, and additional QA/QCs as indicated by the laboratory QA/QC procedures.
- Isotope dilution should be used for quantification with isotope-labeled surrogate standards, as available, according to the guidelines of QSM 5.1 Table B-15. USEPA Method 537 does not allow for isotope dilution in their PFAS drinking water method.
- For drinking water, groundwater, and surface water samples, laboratories must extract the entire sample and include a solvent rinse of the bottle for analysis. Aqueous samples should generally not be sub-sampled prior to analysis, unless they are high concentration and require serial dilution (US DoD 2017).
- Soil samples should be analyzed in their entirety or thoroughly homogenized before extraction and analysis.

- As part of the internal QA/QC of laboratory results, relative percent difference (RPD) should be calculated between samples and corresponding field or laboratory duplicates. The laboratory quality assurance portion of the laboratory certificates should be reviewed to verify that all calculations/recoveries were within acceptable limits as established by the laboratory method and guidelines in Table B-15 of QSM 5.1 or later (USDoD 2017).

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ARCADIS Design & Consultancy for natural and built assets

PFAS SAMPLING PROCEDURES AND LOW-FLOW GROUNDWATER PURGING FOR MONITORING WELLS

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PFAS SAMPLING PROCEDURES AND LOW-FLOW GROUNDWATER PURGING FOR MONITORING WELLS

REV. # 0

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CONTENTS

1 SCOPE AND APPLICATION

The protocol presented in this methods and procedures document describes the procedures recommended to purge monitoring wells and collect groundwater samples for per- and polyfluoroalkyl substances (PFASs) using low flow sampling with a peristaltic pump. Samples will be analyzed for a specified list of PFASs using a modified version of United States (U.S.) Environmental Protection Agency (USEPA) method 537 following the U.S. Department of Defense and U.S. Department of Energy Quality Systems Manual 5.1 methods and procedures set forth in Table B-15.

This protocol has been developed in accordance with the USEPA Region I Low Stress (Low-Flow) Purging and Sampling Procedures for the Collection of Groundwater Samples from Monitoring Wells (EQASOP-GW4; September 19, 2017). PFAS sampling guidelines are incorporated from various guidance documents including the United States Army Corps of Engineers (2016), Department of Environment Regulation, Western Australia (2016), New Hampshire Department of Environmental Services (2016), and Massachusetts Department of Environmental Protection (2017). Staff should also review the Arcadis Technical Guidance Instruction (TGI) titled, Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018).

The project team should determine the last time the wells were developed and if additional development is necessary prior to sample collection. Groundwater samples should not be collected within one week following well development.

2 PERSONNEL QUALIFICATIONS

Arcadis personnel providing assistance to groundwater sample collection and associated activities should have a minimum of six months of related experience or an advanced degree in environmental sciences, engineering, hydrogeology, or geology. The supervisor of the groundwater sampling team should have at least one year of previous supervised groundwater sampling experience, preferably with PFAS related experience. Prior to mobilizing to the field, the groundwater sampling team should review and be thoroughly familiar with relevant site-specific documents including but not limited to the site work plan, field sampling plan, Health and Safety Plan (HASP), historical information, and site relevant documents. Additionally, the groundwater sampling team should review and be thoroughly familiar with documentation provided by equipment manufacturers for all equipment that will be used in the field prior to mobilization, in particular to confirm the sample materials that will be in contact with the water sample are compatibile with PFAS sample collection.

3 EQUIPMENT LIST

Specific to this activity, the following materials (or equivalent) should be available:

- Health and safety documents and equipment (as identified in the Programmatic Accident Prevention Plan and Site Safety and Health Plan)
- Site Plan, well construction records, prior groundwater sampling records (if available)

- Peristaltic pump (e.g., ISCO Model 150) or bladder pump (e.g., Geotech PFC-Free Portable Bladder Pumps)
- A power supply for the peristaltic pump; peristaltic pumps require electric power from either a generator or a deep cell battery.
- High Density Polyethylene (HDPE) tubing and/or silicon tubing of an appropriate size for the pump being used. When collecting samples for PFASs, Teflon® or polytetrafluoroethylene-containing or coated components or tubing are prohibited.
- HDPE bailers (if necessary)
- Water-level probe with fluorine-free materials (e.g., Geotech ET 3/8" with Delrin tip and Buna-N O-ring)
- Water-quality (temperature/pH/specific conductivity/oxidation reduction potential [ORP]/turbidity/dissolved oxygen [DO]) meter, flow-through measurement cell, and appropriate calibration standards. Several brands may be used, including:
  - YSI 6-Series Multi-Parameter Instrument
  - Horiba U-22 Multi-Parameter Instrument
  - Hydrolab Series 3 or Series 4a Multiprobe and Display
- Supplemental turbidity meter (e.g., Horiba U-10, Hach 2100P, LaMotte 2020). Turbidity measurements collected with multi-parameter meters have sometimes been shown to be unreliable due to fouling of the optic lens of the turbidity meter within the flow-through cell. A supplemental turbidity meter should be used to verify turbidity data during purging if such fouling is suspected. An in-line tee and valve should allow for collection of water for turbidity measurements before the pump discharge enters the flow-through cell. Note that industry improvements may eliminate the need for these supplemental measurements in the future.
- HDPE water sample containers (supplied by the laboratory) fitted with an unlined (no Teflon™), polypropylene screw cap. Sample bottles for standard groundwater sampling should not contain Trizma® preservative. If sample bottles with Trizma® are provided by the laboratory, request new sample bottles prior to sample collection.
- Appropriate blanks (field reagent blanks supplied by the laboratory)
- Fluorine-free cleaning equipment
- Groundwater sampling log
- Dedicated plastic sheeting (preferably HDPE) or other clean surface to prevent sample contact with the ground
- Clipboards, field binders, and field note pages that are not waterproof and are fluorine-free
- If high concentrations of PFAS related to class B firefighting foams are expected, bring 'shaker test' vials
- Ziploc® bags to hold ice and samples

- Appropriate blanks (field reagent blanks supplied by the laboratory)
- Appropriate transport containers (coolers) with ice and appropriate labeling, no blue ice should be used
- "PFAS-free" water provided by the laboratory for decontamination rinsing
- Alconox® or Liquinox®; note that Alconox® is known to contain trace levels of 1,4-dioxane
- Packing and shipping materials
- Chain-of-Custody (COC) Forms

Note the specific make/model of the equipment used during each sampling event on the groundwater sampling log. The maintenance requirements for the above equipment generally involve decontamination or periodic cleaning, battery charging, calibration, and proper storage, as specified by the manufacturer. For operational difficulties, the equipment should be serviced by a qualified technician.

4 CAUTIONS

- Do not perform field sampling when rain fall is persistent at a consistent rate that saturates the ground (i.e., formation of puddles) because rain gear is not permitted while sampling. Intermittent showers or fog are acceptable conditions to proceed. If rain showers occur; field gear must be removed from the monitoring well location until the rain subsides. If project timelines are tight, consider the use of a gazebo tent that can be erected over the top of the monitoring well to provide shelter from the rain. The canopy material is possibly a PFAS-treated surface and should be managed as such; therefore, wear gloves when moving the tent, change them immediately after moving the tent, and avoid further contact with the tent until all sampling activities have been finished and the team is ready to move on to the next sample location. Ensure that the canopy will not leak into the sampling area prior to use.
- Do not wear any outdoor performance wear that is water or stain resistant or appears to be. Performance wear such as Gore-Tex® or eVent™ are examples of clothing brands to avoid. Natural fabrics such as cotton are preferred. Synthetic fabrics may also be acceptable if there is no indication on the label that the fabric is water and stain resistant. Avoid contacting clothing with sampling equipment, bottles, and samples.
- Waterproof field books must not be used for field notes. Use loose paper on Masonite, plastic, or aluminum clip boards. Pens, pencils, and Sharpies may be used but should be kept away from sampling materials. One person should conduct the sampling while another records the field notes.
- To avoid potential food packaging-related PFAS contact, do not bring any food outside of the field vehicles onsite. Wash your hands after eating and remove any field garments or outer layers prior to eating.
- Safety footwear is often treated to provide a degree of waterproofing and increased durability and may represent a source of trace PFAS. For the health and safety of field personnel, footwear must be protected at all times to avoid potential PFAS contamination. To do this, do not touch your safety footwear in the immediate vicinity of the sampling location and do not allow gloves used for sampling to come in contact with safety footwear.

- Wear disposable nitrile gloves at all times.
    - Don a new pair of nitrile gloves before the following activities at each sample location:
        - Decontamination of re-usable sampling equipment;
        - Contact with sample bottles or “PFAS-free” water bottles;
        - Insertion of anything into the sample ports (e.g., HDPE tubing); and
        - Handling of any quality assurance/quality control samples including field blanks and equipment blanks.
    - Don a new pair of nitrile gloves after the following activities:
        - Handling of any non-dedicated sampling equipment;
        - Contact with contaminated surfaces; or
        - When judged necessary by field personnel.
- Shower at night. Do not use personal care products after showering such as lotions, makeup, and perfumes, UNLESS medically necessary.
- Use sunscreen and insect repellent ONLY if necessary for health and safety. If they are necessary, apply sunscreen and repellant prior to initiating field sampling. If sunscreen and/or repellant need to be reapplied, ensure a safe distance away from the sampling locations and equipment (i.e., more than 10 meters away). Wash hands after application. Don a new pair of gloves as noted above.
- Visitors are asked to remain at least 30 feet from sampling areas.

5 HEALTH AND SAFETY CONSIDERATIONS

Review all site-specific and procedural hazards as they are provided in the HASP, and review Job Safety Analysis (JSA) documents in the field each day prior to beginning work. The HASP and JSA documents should be present onsite during all field activities. Generators and cord and plug equipment should employ an overcurrent protection device such as an integrated ground fault circuit interrupter cord. If thunder or lighting is present, discontinue sampling and take cover until 30 minutes have passed after the last occurrence of thunder or lighting. Use caution when removing well caps as the well may be under pressure and the cap can dislodge forcefully and cause injury.

6 PROCEDURE

If a round of water level measurements for all site monitoring wells are planned as part of the project scope, the site-wide water level measurements should be collected in such a manner to avoid potential cross-contamination between the wells. Follow appropriate decontamination procedures for collection of water level measurements.

Peristaltic pumps are preferred when sampling for PFASs to minimize potential cross-contamination. If the depth to water is below the sampling range of a peristaltic pump (approximately 25 feet), a PFAS-free bladder pump is acceptable. Purge water should be collected and containerized according to the direction of the project team.

1. Calibrate field instruments according to manufacturer procedures for calibration and document.
2. Place plastic sheeting (preferably HDPE) adjacent to the sample port for use as a clean work area, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
3. If required in the HASP, use a photoionization detector (PID) to measure the headspace before sampling. Open the well cover while standing upwind of the well. Remove the well cap and place it on the plastic sheeting. Insert the PID probe approximately 4 to 6 inches into the casing or the well headspace and cover it with a gloved hand. Record the PID reading in the field log. Perform air monitoring in the breathing zone according to the HASP and/or JSA.
4. Measure the initial depth to groundwater prior to placing the HDPE tubing.
5. Prepare and install the pump in the well: when using a peristaltic pump, slowly lower the HDPE sampling tubing into the well to a depth corresponding to the approximate center of the saturated screen section of the well. Any dedicated tubing in the well should be replaced with new HDPE tubing. The sampling tube must be kept at least 2 feet above the bottom of the well to prevent mobilization of any sediment present in the bottom of the well. If using a weight on the tubing ensure the material is PFAS free and has been deconned according to the procedures described in this document.
6. Measure the water level again with the pump in the well before starting the pump to ensure that it has stabilized. Start pumping the well at 200 to 500 milliliters (mL) per minute (or at a lower site-specific rate if specified). Adjust the pump rate to cause little or no water level drawdown in the well (less than 0.3 foot below the initial static depth to water measurement), and the water level should stabilize; however, this is not always possible. If the recovery rate is less than 50 mL per minute, or the well is being essentially dewatered during purging, the well should be sampled as soon as the water level has recovered sufficiently to collect the volume needed for all anticipated samples. Contact the project manager or other appropriate personnel to discuss.

   The water level should be monitored every 3 to 5 minutes (or as appropriate, lower flow rates may require longer time between readings) during pumping if the well diameter is of sufficient size to allow such monitoring. Do not break pump suction or cause entrainment of air in the sample. Record pumping rate adjustments and depths to water. If necessary, reduce pumping rates to the minimum capabilities of the pump to avoid pumping the well dry and/or to stabilize indicator parameters. Maintain a steady flow rate to the extent practicable. Review groundwater sampling records from previous sampling events (if available) prior to mobilization to estimate the optimum pumping rate and anticipated drawdown for the well in order to more efficiently reach a stabilized pumping condition.

   If the recharge rate of the well is very low, use approved alternative purging techniques, which will vary based on the well construction and screen position. For wells screened across the water table, the well may be pumped dry and sampling can commence as soon as the volume in the well has recovered sufficiently to permit collection of samples. For wells screened entirely below the water table, the well can be pumped until a stabilized level (which may be greater than the maximum displacement goal of 0.3 foot) is maintained and monitoring for stabilization of field indicator parameters can commence. If a lower stabilization level cannot be maintained, the well may be pumped until the drawdown is at a level slightly higher than top of the well screen. Sampling may commence after one well volume has been removed and the well has recovered sufficiently to permit collection of samples.

During purging, monitor the field indicator parameters (e.g., turbidity, temperature, specific conductance, pH, ORP, and DO) every 3 to 5 minutes (or after each volume of the flow-through cell has been purged). Measure field indicator parameters using a flow-through analytical cell or a clean container such as a glass beaker. Record field indicator parameters on the groundwater sampling log. The well is considered stabilized and ready for sample collection when turbidity values remain within 10% (or within 1 nephelometric turbidity unit [NTU] if the turbidity reading is less than 5 NTU), the specific conductance and temperature values remain within 3%, ORP readings remain within ± 10 mV, DO values remain within 10%, and pH remains within 0.1 unit for three consecutive readings collected at 3- to 5-minute intervals (or other appropriate interval, alternate stabilization goals may exist in different geographic regions, consult the site-specific Work Plan for stabilization criteria). If the field indicator parameters do not stabilize within 1 hour of the start of purging, but the groundwater turbidity is below the goal of 10 NTU and the values for all other parameters are within 10%, the well can be sampled. If the parameters have stabilized but the turbidity is not in the range of the 5 NTU goal, the pump flow rate may be decreased to a minimum rate of 100 mL/min to reduce turbidity levels as low as possible.

DO is extremely susceptible to various external influences (including temperature or the presence of bubbles on the DO meter); care should be taken to minimize the agitation or other disturbance of water within the flow-through cell while collecting these measurements. If air bubbles are present on the DO probe or in the discharge tubing, remove them before taking a measurement. If DO values are not within acceptable range for the temperature of groundwater then again check for and remove air bubbles on the probe before re-measuring. If the DO value is 0.00 or less, then the meter should be serviced and re-calibrated. If the DO values are above possible results, then the meter should be serviced and re-calibrated.

During extreme weather conditions, stabilization of field indicator parameters may be difficult to attain. Modifications to the sampling procedures to alleviate these conditions (e.g., measuring the water temperature in the well adjacent to the pump intake) should be documented in the field notes. If other field conditions preclude stabilization of certain parameters, an explanation of why the parameters did not stabilize should also be documented on the groundwater sampling log.

7. After the indicator parameters have stabilized, collect groundwater samples by diverting flow out of the unfiltered discharge tubing into the appropriate labeled sample container. If a flow-through analytical cell is being used to measure field parameters, the flow-through cell should be disconnected after stabilization of the field indicator parameters and prior to groundwater sample collection. Under no circumstances should analytical samples be collected from the discharge of the flow-through cell.

8. Make sure the sample bottle caps have remained on the bottle until immediately prior to sample collection.

9. Don a new set of nitrile gloves prior to sample collection. While collecting the sample, make sure the bottle cap remains in the other hand of the sampler until replaced on the bottle. When the container is full (fill to the neck of the bottle, some headspace is acceptable), firmly screw on the cap (snug but

not too tight so that the screw cap is stripped). Do not use gloved hands to subsequently handle papers, pens, clothes, etc. before collecting the sample.

10. Collect any necessary duplicates and matrix spikes. As the laboratory should be analyzing the entire aqueous sample rather than sub-sampling, separate bottles will be required for these samples.
11. Do not rinse PFAS sample bottles during sampling. Do not filter samples.
12. Complete and attach the sample label(s) after sample collection and after the caps have been placed back on each container. Pre-printed labels are preferred, but pens and Sharpies® may be used.
13. Place sample bottles in a sealed Ziploc® bag. Place samples in coolers that are durable in transportation and keep the temperature between 0 and 4ºC until transported to the laboratory.
14. Record the sample name and time of sampling on the sample bottle label, in the field notes and note observations (e.g., physical appearance and the presence or lack of odors or sheens), and record on the COC form.
15. NOTE: If high concentrations of PFAS related to class B firefighting foams are expected in a groundwater sample, collect and shake a small portion of the sample (~10 to 25 mL) on site. If foaming is noted within the sample, document the foaming when samples are submitted for analysis; the 'shaker test' vial can then be disposed. This shaker test provides information about how each of the samples should be handled analytically. Therefore, note ‘shake test’ results on the COC form if appropriate.
16. Turn off the pump. Slowly remove the tubing from the well. If the tubing will be dedicated, store the tubing in an appropriate storage container. Do not allow the tubing or lines to touch the ground or any other surfaces which could contaminate them.
17. Complete the procedures for packaging, shipping, and handling with the associated COC.
18. Between uses, complete decontamination procedures for flow-through analytical cell and water level meter, and any equipment that comes into contact with well water (see decontamination procedures described in Section 9 below).
19. At the end of the day, perform a calibration check of field instruments.
20. The general procedures listed in this document can be used for collection of samples from groundwater treatment systems or other similar sampling of water. In order to collect samples from a sampling port on a groundwater treatment system or for a similar situation follow the safety and quality procedures listed in this document. As a general note on sampling ports, ensure that there is no indication of Teflon™ tape or other Teflon™ containing material.

7 WASTE MANAGEMENT

Materials generated during groundwater sampling activities, including disposable equipment, should be placed in appropriate containers. PFAS containing waste requires special considerations and containerized waste will be stored onsite for future management by the responsible party.

8 DATA RECORDING AND MANAGEMENT

Initial field logs and COC records should be transmitted to the Arcadis Project Manager at the end of each day unless otherwise directed. The groundwater team leader retains copies of the groundwater sampling logs until they are relinquished to the project file.

9 QUALITY ASSURANCE

In addition to the quality control samples to be collected in accordance with these methods and procedures, the following quality control procedures should be observed in the field:

- Collect samples from monitoring wells, in order of increasing concentration, to the extent known based on review of historical site information if available. If no analytical data are available, collect samples in order of upgradient, then furthest downgradient to source area locations.
- Bottle caps must remain in the hand of the sampler until replaced on the bottle.
- Labels must be completed after the caps have been placed back on each bottle.
- Equipment blanks should be collected from various sampling equipment including the pump, water level meter (following decontamination procedures), disposable tubing, and nitrile gloves.
- Collect equipment blanks using laboratory supplied “PFAS-free” water after wells with higher concentrations (if known) have been sampled.
- Field duplicates, matrix spike, and matrix spike duplicates will be collected at a frequency in accordance with the QAPP and applicable QAPP Addenda.
- Samples must be stored in appropriate transport containers (coolers) with ice (Ziploc© bags for use as ice containers) with appropriate labeling. Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples. Samples should be maintained at temperatures between 0 and 4ºC until transported to the laboratory.
- Operate all monitoring instrumentation in accordance with manufacturer’s instructions and calibration procedures. Calibrate instruments at the beginning of each day and verify the calibration at the end of each day. Record all calibration activities on calibration log sheets.
- Clean all groundwater sampling equipment prior to use in the first well and after each subsequent well following the procedure for PFAS equipment decontamination noted below. Clean all field equipment used at locations that are suspected of containing class B firefighting foam (i.e., those that foam during shaking or are known to be near a class B firefighting foam source zone) using each of the below steps repeated twice.
- The steps for PFAS equipment decontamination are as follows:
    - Donning a new pair of nitrile gloves;
    - Rinse sampling equipment with Alconox or Liquinox® cleaning solution; Scrub equipment with a plastic brush if needed;
    - Rinse two times with distilled water or deionized water;

- Rinse one time with “PFAS-free” water; and
- Collect all rinsate in a sealed pail for disposal. Do not reuse decontamination solutions between sampling locations

10 REFERENCES

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U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUNDWATER SAMPLES FROM MONITORING WELLS

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Revision Page

Date	Rev #	Summary of changes	Sections
7/30/96	1	Finalized	
01/19/10	2	Updated	All sections
3/23/17	3	Updated	All sections
9/20/17	4	Updated	Section 7.0

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1.0 USE OF TERMS

Equipment blank: The equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank needs only to include the pump in subsequent sampling rounds. If the pump and tubing are dedicated to the well, the equipment blank is collected prior to its placement in the well. If the pump and tubing will be used to sample multiple wells, the equipment blank is normally collected after sampling from contaminated wells and not after background wells.

Field duplicates: Field duplicates are collected to determine precision of the sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

Indicator field parameters: This SOP uses field measurements of turbidity, dissolved oxygen, specific conductance, temperature, pH, and oxidation/reduction potential (ORP) as indicators of when purging operations are sufficient and sample collection may begin.

Matrix Spike/Matrix Spike Duplicates: Used by the laboratory in its quality assurance program. Consult the laboratory for the sample volume to be collected.

Potentiometric Surface: The level to which water rises in a tightly cased well constructed in a confined aquifer. In an unconfined aquifer, the potentiometric surface is the water table.

QAPP: Quality Assurance Project Plan

SAP: Sampling and Analysis Plan

SOP: Standard operating procedure

Stabilization: A condition that is achieved when all indicator field parameter measurements are sufficiently stable (as described in the “Monitoring Indicator Field Parameters” section) to allow sample collection to begin.

Temperature blank: A temperature blank is added to each sample cooler. The blank is measured upon receipt at the laboratory to assess whether the samples were properly cooled during transit.

Trip blank (VOCs): Trip blank is a sample of analyte-free water taken to the sampling site and returned to the laboratory. The trip blanks (one pair) are added to each sample cooler that contains VOC samples.

2.0 SCOPE & APPLICATION

The goal of this groundwater sampling procedure is to collect water samples that reflect the total mobile organic and inorganic loads (dissolved and colloidal sized fractions) transported through the subsurface under ambient flow conditions, with minimal physical and chemical alterations from sampling operations. This standard operating procedure (SOP) for collecting groundwater samples will help ensure that the project's data quality objectives (DQOs) are met under certain low-flow conditions.

The SOP emphasizes the need to minimize hydraulic stress at the well-aquifer interface by maintaining low water-level drawdowns, and by using low pumping rates during purging and sampling operations. Indicator field parameters (e.g., dissolved oxygen, pH, etc.) are monitored during purging in order to determine when sample collection may begin. Samples properly collected using this SOP are suitable for analysis of groundwater contaminants (volatile and semi-volatile organic analytes, dissolved gases, pesticides, PCBs, metals and other inorganics), or naturally occurring analytes. This SOP is based on Puls, and Barcelona (1996).

This procedure is designed for monitoring wells with an inside diameter (1.5-inches or greater) that can accommodate a positive lift pump with a screen length or open interval ten feet or less and with a water level above the top of the screen or open interval (Hereafter, the "screen or open interval" will be referred to only as "screen interval"). This SOP is not applicable to other well-sampling conditions.

While the use of dedicated sampling equipment is not mandatory, dedicated pumps and tubing can reduce sampling costs significantly by streamlining sampling activities and thereby reducing the overall field costs.

The goal of this procedure is to emphasize the need for consistency in deploying and operating equipment while purging and sampling monitoring wells during each sampling event. This will help to minimize sampling variability.

This procedure describes a general framework for groundwater sampling. Other site specific information (hydrogeological context, conceptual site model (CSM), DQOs, etc.) coupled with systematic planning must be added to the procedure in order to develop an appropriate site specific SAP/QAPP. In addition, the site specific SAP/QAPP must identify the specific equipment that will be used to collect the groundwater samples.

This procedure does not address the collection of water or free product samples from wells containing free phase LNAPLs and/or DNAPLs (light or dense non-aqueous phase liquids). For this type of situation, the reader may wish to check: Cohen, and Mercer (1993) or other pertinent documents.

This SOP is to be used when collecting groundwater samples from monitoring wells at all Superfund, Federal Facility and RCRA sites in Region 1 under the conditions described herein. Request for modification of this SOP, in order to better address specific situations at individual wells, must include adequate technical justification for proposed changes. All changes and modifications must be approved and included in a revised SAP/QAPP before implementation in field.

3.0 BACKGROUND FOR IMPLEMENTATION

It is expected that the monitoring well screen has been properly located (both laterally and vertically) to intercept existing contaminant plume(s) or along flow paths of potential contaminant migration. Problems with inappropriate monitoring well placement or faulty/improper well installation cannot be overcome by even the best water sampling procedures. This SOP presumes that the analytes of interest are moving (or will potentially move) primarily through the more permeable zones intercepted by the screen interval.

Proper well construction, development, and operation and maintenance cannot be overemphasized. The use of installation techniques that are appropriate to the hydrogeologic setting of the site often prevent "problem well" situations from occurring. During well development, or redevelopment, tests should be conducted to determine the hydraulic characteristics of the monitoring well. The data can then be used to set the purging/sampling rate, and provide a baseline for evaluating changes in well performance and the potential need for well rehabilitation. Note: if this installation data or well history (construction and sampling) is not available or discoverable, for all wells to be sampled, efforts to build a sampling history should commence with the next sampling event.

The pump intake should be located within the screen interval and at a depth that will remain under water at all times. It is recommended that the intake depth and pumping rate remain the same for all sampling events. The mid-point or the lowest historical midpoint of the saturated screen length is often used as the location of the pump intake. For new wells, or for wells without pump intake depth information, the site’s SAP/QAPP must provide clear reasons and instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected. If the depths to top and bottom of the well screen are not known, the SAP/QAPP will need to describe how the sampling depth will be determined and how the data can be used.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU, and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection may still take place provided the indicator field parameter criteria in this procedure are met. If after 2 hours of purging indicator field parameters have not stabilized, one of three optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization), c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may reflect a sampling bias and therefore, the data may not meet the data quality objectives of the sampling event).

It is recommended that low-flow sampling be conducted when the air temperature is above 32°F (0°C). If the procedure is used below 32°F, special precautions will need to be taken to prevent the groundwater from freezing in the equipment. Because sampling during freezing temperatures may adversely impact the data quality objectives, the need for water sample collection during months when these conditions are likely to occur should be evaluated during site planning and special sampling measures may need to be developed. Ice formation in the flow-through-cell will cause the monitoring probes to act erratically. A transparent flow-through-cell needs to be used to observe if ice is forming in the cell. If ice starts to form on the other pieces of the sampling equipment, additional problems may occur.

4.0 HEALTH & SAFETY

When working on-site, comply with all applicable OSHA requirements and the site's health/safety procedures. All proper personal protection clothing and equipment are to be worn. Some samples may contain biological and chemical hazards. These samples should be handled with suitable protection to skin, eyes, etc.

5.0 CAUTIONS

The following cautions need to be considered when planning to collect groundwater samples when the below conditions occur.

If the groundwater degasses during purging of the monitoring well, dissolved gases and VOCs will be lost. When this happens, the groundwater data for dissolved gases (e.g., methane, ethene, ethane, dissolved oxygen, etc.) and VOCs will need to be qualified. Some conditions that can promote degassing are the use of a vacuum pump (e.g., peristaltic pumps), changes in aperture along the sampling tubing, and squeezing/pinching the pump's tubing which results in a pressure change.

When collecting the samples for dissolved gases and VOCs analyses, avoid aerating the groundwater in the pump's tubing. This can cause loss of the dissolved gases and VOCs in the groundwater. Having the pump's tubing completely filled prior to sampling will avoid this problem when using a centrifugal pump or peristaltic pump.

Direct sun light and hot ambient air temperatures may cause the groundwater in the tubing and flow-through-cell to heat up. This may cause the groundwater to degas which will result in loss of VOCs and dissolved gases. When sampling under these conditions, the sampler will need to shade the equipment from the sunlight (e.g., umbrella, tent, etc.). If possible, sampling on hot days, or during the hottest time of the day, should be avoided. The tubing exiting the monitoring well should be kept as short as possible to avoid the sun light or ambient air from heating up the groundwater.

Thermal currents in the monitoring well may cause vertical mixing of water in the well bore. When the air temperature is colder than the groundwater temperature, it can cool the top of the water column. Colder water which is denser than warm water sinks to the bottom of the well and the warmer water at the bottom of the well rises, setting up a convection cell. "During low-flow sampling, the pumped water may be a mixture of convecting water from within the well casing and aquifer water moving inward through the screen. This mixing of water during low-flow sampling can substantially increase equilibration times, can cause false stabilization of indicator parameters, can give false indication of redox state, and can provide biological data that are not representative of the aquifer conditions" (Vroblesky 2007).

Failure to calibrate or perform proper maintenance on the sampling equipment and measurement instruments (e.g., dissolved oxygen meter, etc.) can result in faulty data being collected.

Interferences may result from using contaminated equipment, cleaning materials, sample containers, or uncontrolled ambient/surrounding air conditions (e.g., truck/vehicle exhaust nearby).

Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment and/or proper planning to avoid ambient air interferences. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

Clean and decontaminate all sampling equipment prior to use. All sampling equipment needs to be routinely checked to be free from contaminants and equipment blanks collected to ensure that the equipment is free of contaminants. Check the previous equipment blank data for the site (if they exist) to determine if the previous cleaning procedure removed the contaminants. If contaminants were detected and they are a concern, then a more vigorous cleaning procedure will be needed.

6.0 PERSONNEL QUALIFICATIONS

All field samplers working at sites containing hazardous waste must meet the requirements of the OSHA regulations. OSHA regulations may require the sampler to take the 40 hour OSHA health and safety training course and a refresher course prior to engaging in any field activities, depending upon the site and field conditions.

The field samplers must be trained prior to the use of the sampling equipment, field instruments, and procedures. Training is to be conducted by an experienced sampler before initiating any sampling procedure.

The entire sampling team needs to read, and be familiar with, the site Health and Safety Plan, all relevant SOPs, and SAP/QAPP (and the most recent amendments) before going onsite for the sampling event. It is recommended that the field sampling leader attest to the understanding of these site documents and that it is recorded.

7.0 EQUIPMENT AND SUPPLIES

A. Informational materials for sampling event

A copy of the current Health and Safety Plan, SAP/QAPP, monitoring well construction data, location map(s), field data from last sampling event, manuals for sampling, and the monitoring instruments' operation, maintenance, and calibration manuals should be brought to the site.

B. Well keys.

C. Extraction device

Adjustable rate, submersible pumps (e.g., centrifugal, bladder, etc.) which are constructed of stainless steel or polytetrafluoroethylene (PTFE, i.e. Teflon®) are preferred. PTFE, however, should not be used when sampling for per- and polyfluoroalkyl substances (PFAS) as it is likely to contain these substances.

Note: If extraction devices constructed of other materials are to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

If bladder pumps are selected for the collection of VOCs and dissolved gases, the pump setting should be set so that one pulse will deliver a water volume that is sufficient to fill a 40 mL VOC vial. This is not mandatory, but is considered a “best practice”. For the proper operation, the bladder pump will need a minimum amount of water above the pump; consult the manufacturer for the recommended submergence. The pump’s recommended submergence value should be determined during the planning stage, since it may influence well construction and placement of dedicated pumps where water-level fluctuations are significant.

Adjustable rate, peristaltic pumps (suction) are to be used with caution when collecting samples for VOCs and dissolved gases (e.g., methane, carbon dioxide, etc.) analyses. Additional information on the use of peristaltic pumps can be found in Appendix A.
If peristaltic pumps are used, the inside diameter of the rotor head tubing needs to match the inside diameter of the tubing installed in the monitoring well.

Inertial pumping devices (motor driven or manual) are not recommended. These devices frequently cause greater disturbance during purging and sampling, and are less easily controlled than submersible pumps (potentially increasing turbidity and sampling variability, etc.). This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

D. Tubing

PTFE (Teflon®) or PTFE-lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics. As discussed in the previous section, PTFE tubing should not be used when sampling for PFAS. In this case, a suitable alternative such as high-density polyethylene tubing should be used.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for metal and other inorganics analyses.

Note: If tubing constructed of other materials is to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

The use of 1/4 inch or 3/8 inch (inside diameter) tubing is recommended. This will help ensure that the tubing remains liquid filled when operating at very low pumping rates when using centrifugal and peristaltic pumps.

Silastic tubing should be used for the section around the rotor head of a peristaltic pump. It should be less than a foot in length. The inside diameter of the tubing used at the pump rotor head must be the same as the inside diameter of tubing placed in the well. A tubing connector is used to connect the pump rotor head tubing to the well tubing. Alternatively, the two pieces of tubing can be connected to each other by placing the one end of the tubing inside the end of the other tubing. The tubing must not be reused.

E. The water level measuring device

Electronic ”tape”, pressure transducer, water level sounder/level indicator, etc. should be capable of measuring to 0.01 foot accuracy. Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level “tape” at the start and end of each sampling event.

F. Flow measurement supplies

Graduated cylinder (size according to flow rate) and stopwatch usually will suffice.

Large graduated bucket used to record total water purged from the well.

G. Interface probe

To be used to check on the presence of free phase liquids (LNAPL, or DNAPL) before purging begins (as needed).

H. Power source (generator, nitrogen tank, battery, etc.)

When a gasoline generator is used, locate it downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate samples.

I. Indicator field parameter monitoring instruments

Use of a multi-parameter instrument capable of measuring pH, oxidation/reduction potential (ORP), dissolved oxygen (DO), specific conductance, temperature, and coupled with a flow-through-cell is required when measuring all indicator field parameters, except turbidity. Turbidity is collected using a separate instrument. Record equipment/instrument identification (manufacturer, and model number).

Transparent, small volume flow-through-cells (e.g., 250 mLs or less) are preferred. This allows observation of air bubbles and sediment buildup in the cell, which can interfere with the operation of the monitoring instrument probes, to be easily detected. A small volume cell facilitates rapid turnover of water in the cell between measurements of the indicator field parameters.

It is recommended to use a flow-through-cell and monitoring probes from the same manufacturer and model to avoid incompatibility between the probes and flow-through-cell.

Turbidity samples are collected before the flow-through-cell. A “T” connector coupled with a valve is connected between the pump’s tubing and flow-through-cell. When a turbidity measurement is required, the valve is opened to allow the groundwater to flow into a container. The valve is closed and the container sample is then placed in the turbidimeter.

Standards are necessary to perform field calibration of instruments. A minimum of two standards are needed to bracket the instrument measurement range for all parameters except ORP which use a Zobell solution as a standard. For dissolved oxygen, a wet sponge used for the 100% saturation and a zero dissolved oxygen solution are used for the calibration.

Barometer (used in the calibration of the Dissolved Oxygen probe) and the conversion formula to convert the barometric pressure into the units of measure used by the Dissolved Oxygen meter are needed.

J. Decontamination supplies

Includes (for example) non-phosphate detergent, distilled/deionized water, isopropyl alcohol, etc.

K. Record keeping supplies

Logbook(s), well purging forms, chain-of-custody forms, field instrument calibration forms, etc.

L. Sample bottles

M. Sample preservation supplies (as required by the analytical methods)

N. Sample tags or labels

O. PID or FID instrument

If appropriate, to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

P. Miscellaneous Equipment

Equipment to keep the sampling apparatus shaded in the summer (e.g., umbrella) and from freezing in the winter. If the pump's tubing is allowed to heat up in the warm weather, the cold groundwater may degas as it is warmed in the tubing.

8.0 EQUIPMENT/INSTRUMENT CALIBRATION

Prior to the sampling event, perform maintenance checks on the equipment and instruments according to the manufacturer's manual and/or applicable SOP. This will ensure that the equipment/instruments are working properly before they are used in the field.

Prior to sampling, the monitoring instruments must be calibrated and the calibration documented. The instruments are calibrated using U.S Environmental Protection Agency Region 1 *Calibration of Field Instruments (temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction [ORP], and turbidity),* March 23, 2017, or latest version or from one of the methods listed in 40CFR136, 40CFR141 and SW-846.

The instruments shall be calibrated at the beginning of each day. If the field measurement falls outside the calibration range, the instrument must be re-calibrated so that all measurements fall within the calibration range. At the end of each day, a calibration check is performed to verify that instruments remained in calibration throughout the day. This check is performed while the instrument is in measurement mode, not calibration mode. If the field instruments are being used to monitor the natural attenuation parameters, then a calibration check at mid-day is highly recommended to ensure that the instruments did not drift out of calibration. Note: during the day if the instrument reads zero or a negative number for dissolved oxygen, pH, specific conductance, or turbidity (negative value only), this indicates that the instrument drifted out of calibration or the instrument is malfunctioning. If this situation occurs the data from this instrument will need to be qualified or rejected.

9.0 PRELIMINARY SITE ACTIVITIES (as applicable)

Check the well for security (damage, evidence of tampering, missing lock, etc.) and record pertinent observations (include photograph as warranted).

If needed, lay out a sheet of clean polyethylene for monitoring and sampling equipment, unless equipment is elevated above the ground (e.g., on a table, etc.).

Remove well cap and if appropriate measure VOCs at the rim of the well with a PID or FID instrument and record reading in field logbook or on the well purge form.

If the well casing does not have an established reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook (consider a photographic record as well). All water level measurements must be recorded relative to this reference point (and the altitude of this point should be determined using techniques that are appropriate to site's DQOs.

If water-table or potentiometric surface map(s) are to be constructed for the sampling event, perform synoptic water level measurement round (in the shortest possible time) before any purging and sampling activities begin. If possible, measure water level depth (to 0.01 ft.) and total well depth (to 0.1 ft.) the day before sampling begins, in order to allow for re-settlement of any particulates in the water column. This is especially important for those wells that have not been recently sampled because sediment buildup in the well may require the well to be redeveloped. If measurement of total well depth is not made the day before, it should be measured after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe may not be necessary unless analytical data or field analysis signal a worsening situation. This SOP cannot be used in the presence of LNAPLs or DNAPLs. If NAPLs are present, the project team must decide upon an alternate sampling method. All project modifications must be approved and documented prior to implementation.

If available check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). If changes are made in the intake depth or extraction rate(s) used during previous sampling event(s), for either portable or dedicated extraction devices, record new values, and explain reasons for the changes in the field logbook.

10.0 PURGING AND SAMPLING PROCEDURE

Purging and sampling wells in order of increasing chemical concentrations (known or anticipated) are preferred.

The use of dedicated pumps is recommended to minimize artificial mobilization and entrainment of particulates each time the well is sampled. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

A. Initial Water Level

Measure the water level in the well before installing the pump if a non-dedicated pump is being used. The initial water level is recorded on the purge form or in the field logbook.

B. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the appropriate depth (may not be the mid-point of the screen/open interval). The Sampling and Analysis Plan/Quality Assurance Project Plan should specify the sampling depth (used previously), or provide criteria for selection of intake depth for each new well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well.

Pump tubing lengths, above the top of well casing should be kept as short as possible to minimize heating the groundwater in the tubing by exposure to sun light and ambient air temperatures. Heating may cause the groundwater to degas, which is unacceptable for the collection of samples for VOC and dissolved gases analyses.

C. Measure Water Level

Before starting pump, measure water level. Install recording pressure transducer, if used to track drawdowns, to initialize starting condition.

D. Purge Well

From the time the pump starts purging and until the time the samples are collected, the purged water is discharged into a graduated bucket to determine the total volume of groundwater purged. This information is recorded on the purge form or in the field logbook.

Start the pump at low speed and slowly increase the speed until discharge occurs. Check water level. Check equipment for water leaks and if present fix or replace the affected equipment. Try to match pumping rate used during previous sampling event(s). Otherwise, adjust pump speed until there is little or no water level drawdown. If the minimal drawdown that can be achieved exceeds 0.3 feet, but remains stable, continue purging.

Monitor and record the water level and pumping rate every five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump to ensure stabilization of the water level. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" somewhat as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. If the initial water level is above the top of the screen do not allow the water level to fall into the well screen. The final purge volume must be greater than the stabilized drawdown volume plus the pump's tubing volume. If the drawdown has exceeded 0.3 feet and stabilizes, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are collected.

Avoid the use of constriction devices on the tubing to decrease the flow rate because the constrictor will cause a pressure difference in the water column. This will cause the groundwater to degas and result in a loss of VOCs and dissolved gasses in the groundwater samples.

Note: the flow rate used to achieve a stable pumping level should remain constant while monitoring the indicator parameters for stabilization and while collecting the samples.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (e.g., bladder, peristaltic), and/or the use of dedicated equipment. For new monitoring wells, or wells where the following situation has not occurred before, if the recovery rate to the well is less than 50 mL/min., or the well is being essentially dewatered during purging, the well should be sampled as soon as the water level has recovered sufficiently to collect the volume needed for all anticipated samples. The project manager or field team leader will need to make the decision when samples should be collected, how the sample is to be collected, and the reasons recorded on the purge form or in the field logbook. A water level measurement needs to be performed and recorded before samples are collected. If the project manager decides to collect the samples using the pump, it is best during this recovery period that the pump intake tubing not be removed, since this will aggravate any turbidity problems. Samples in this specific situation may be collected without stabilization of indicator field parameters. Note that field conditions and efforts to overcome problematic situations must be recorded in order to support field decisions to deviate from normal procedures described in this SOP. If this type of problematic situation persists in a well, then water sample collection should be changed to a passive or no-purge method, if consistent with the site's DQOs, or have a new well installed.

E. Monitor Indicator Field Parameters

After the water level has stabilized, connect the "T" connector with a valve and the flow-through-cell to monitor the indicator field parameters. If excessive turbidity is anticipated or encountered with the pump startup, the well may be purged for a while without connecting up the flow-through-cell, in order to minimize particulate buildup in the cell (This is a judgment call made by the sampler). Water level drawdown measurements should be made as usual. If possible, the pump may be installed the day before purging to allow particulates that were disturbed during pump insertion to settle.

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, ORP, DO) at a frequency of five minute intervals or greater. The pump's flow rate must be able to "turn over" at least one flow-through-cell volume between measurements (for a 250 mL flow-through-cell with a flow rate of 50 mLs/min., the monitoring frequency would be every five minutes; for a 500 mL flow-through-cell it would be every ten minutes). If the cell volume cannot be replaced in the five minute interval, then the time between measurements must be increased accordingly. <u>Note: during the early phase of purging, emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments followed by stabilization of indicator parameters. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings are within the following limits:</u>

Turbidity (10% for values greater than 5 NTU; if three Turbidity values are less than 5 NTU, consider the values as stabilized),
Dissolved Oxygen (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),
Specific Conductance (3%),
Temperature (3%),
pH (± 0.1 unit),
Oxidation/Reduction Potential (±10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Samples for turbidity measurements are obtained before water enters the flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values measured within the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities. Record start and stop times and give a brief description of cleaning activities.

The flow-through-cell must be designed in a way that prevents gas bubble entrapment in the cell. Placing the flow-through-cell at a 45 degree angle with the port facing upward can help remove bubbles from the flow-through-cell (see Appendix B Low-Flow Setup Diagram). Throughout the measurement process, the flow-through-cell must remain free of any gas bubbles. Otherwise, the monitoring probes may act erratically. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must remain submerged in water at all times.

F. Collect Water Samples

When samples are collected for laboratory analyses, the pump's tubing is disconnected from the "T" connector with a valve and the flow-through-cell. The samples are collected directly from the pump's tubing. Samples must not be collected from the flow-through-cell or from the "T" connector with a valve.

VOC samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the pump's flow rate is too high to collect the VOC/dissolved gases samples, collect the other samples first. Lower the pump's flow rate to a reasonable rate and collect the VOC/dissolved gases samples and record the new flow rate.

During purging and sampling, the centrifugal/peristaltic pump tubing must remain filled with water to avoid aeration of the groundwater. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help ensure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use the following procedure to collect samples: collect non-VOC/dissolved gases samples first, then increase flow rate slightly until the water completely fills the tubing, collect the VOC/dissolved gases samples, and record new drawdown depth and flow rate.

For bladder pumps that will be used to collect VOC or dissolved gas samples, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 mL VOC vial.

Use pre-preserved sample containers or add preservative, as required by analytical methods, to the samples immediately after they are collected. Check the analytical methods (e.g. EPA SW-846, 40 CFR 136, water supply, etc.) for additional information on preservation.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter (transparent housing preferred) is required, and the filter size (0.45 µm is commonly used) should be based on the sampling objective. Pre-rinse the filter with groundwater prior to sample collection. Make sure the filter is free of air bubbles before samples are collected. Preserve the filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in groundwater for human health or ecological risk calculations.

Label each sample as collected. Samples requiring cooling will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

G. Post Sampling Activities

If a recording pressure transducer is used to track drawdown, re-measure water level with tape.

After collection of samples, the pump tubing may be dedicated to the well for re-sampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth annually is usually sufficient after the initial low stress sampling event. However, a greater frequency may be needed if the well has a “silting” problem or if confirmation of well identity is needed.

Secure the well.

11.0 DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well, and then following sampling of each subsequent well. Pumps should not be removed between purging and sampling operations. The pump, tubing, support cable and electrical wires which were in contact with the well should be decontaminated by one of the procedures listed below.

The use of dedicated pumps and tubing will reduce the amount of time spent on decontamination of the equipment. If dedicated pumps and tubing are used, only the initial sampling event will require decontamination of the pump and tubing.

Note if the previous equipment blank data showed that contaminant(s) were present after using the below procedure or the one described in the SAP/QAPP, a more vigorous procedure may be needed.

Procedure 1

Decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump and tubing. The pump may be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Optional - flush with isopropyl alcohol (pesticide grade; must be free of ketones {e.g., acetone}) or with methanol. This step may be required if the well is highly contaminated or if the equipment blank data from the previous sampling event show that the level of contaminants is significant.

Flush with distilled/deionized water. This step must remove all traces of alcohol (if used) from the equipment. The final water rinse must not be recycled.

Procedure 2

Steam clean the outside of the submersible pump.

Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

12.0 FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the groundwater samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. Quality control samples include field duplicates, equipment blanks, matrix spike/matrix spike duplicates, trip blanks (VOCs), and temperature blanks.

13.0 FIELD LOGBOOK

A field log shall be kept to document all groundwater field monitoring activities (see Appendix C, example table), and record the following for each well:

Site name, municipality, state.

Well identifier, latitude-longitude or state grid coordinates.

Measuring point description (e.g., north side of PVC pipe).

Well depth, and measurement technique.

Well screen length.

Pump depth.

Static water level depth, date, time and measurement technique.

Presence and thickness of immiscible liquid (NAPL) layers and detection method.

Pumping rate, drawdown, indicator parameters values, calculated or measured total volume pumped, and clock time of each set of measurements.

Type of tubing used and its length.

Type of pump used.

Clock time of start and end of purging and sampling activity.

Types of sample bottles used and sample identification numbers.

Preservatives used.

Parameters requested for analyses.

Field observations during sampling event.

Name of sample collector(s).

Weather conditions, including approximate ambient air temperature.

QA/QC data for field instruments.

Any problems encountered should be highlighted.

Description of all sampling/monitoring equipment used, including trade names, model number, instrument identification number, diameters, material composition, etc.

14.0 DATA REPORT

Data reports are to include laboratory analytical results, QA/QC information, field indicator parameters measured during purging, field instrument calibration information, and whatever other field logbook information is needed to allow for a full evaluation of data usability.

Note: the use of trade, product, or firm names in this sampling procedure is for descriptive purposes only and does not constitute endorsement by the U.S. EPA.

15.0 REFERENCES

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U.S Environmental Protection Agency, 40 CFR 141.

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APPENDIX A

PERISTALTIC PUMPS

Before selecting a peristaltic pump to collect groundwater samples for VOCs and/or dissolved gases, (e.g., methane, carbon dioxide, etc.) consideration should be given to the following:

- The decision of whether or not to use a peristaltic pump is dependent on the intended use of the data.
- If the additional sampling error that may be introduced by this device is NOT of concern for the VOC/dissolved gases data's intended use, then this device may be acceptable.
- If minor differences in the groundwater concentrations could affect the decision, such as to continue or terminate groundwater cleanup or whether the cleanup goals have been reached, then this device should NOT be used for VOC/dissolved gases sampling. In these cases, centrifugal or bladder pumps are a better choice for more accurate results.

EPA and USGS have documented their concerns with the use of the peristaltic pumps to collect water sample in the below documents.

- "Suction Pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001, December 1987.
- "The agency does not recommend the use of peristaltic pumps to sample ground water particularly for volatile organic analytes" *RCRA Ground-Water Monitoring Draft Technical Guidance*, EPA Office of Solid Waste, November 1992.
- "The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and volatiles loss", *Low-flow (Minimal drawdown) Ground-Water Sampling Procedures*, by Robert Puls & Michael Barcelona, April 1996, EPA/540/S-95/504.
- "Suction-lift pumps, such as peristaltic pumps, can operate at a very low pumping rate; however, using negative pressure to lift the sample can result in the loss of volatile analytes", USGS Book 9 Techniques of Water-Resources Investigation, Chapter A4. (Version 2.0, 9/2006).

APPENDIX B

SUMMARY OF SAMPLING INSTRUCTIONS

These instructions are for using an adjustable rate, submersible pump or a peristaltic pump with the pump's intake placed at the midpoint of a 10 foot or less well screen or an open interval. The water level in the monitoring well is above the top of the well screen or open interval, the ambient temperature is above 32°F, and the equipment is not dedicated. Field instruments are already calibrated. The equipment is setup according to the diagram at the end of these instructions.

1. Review well installation information. Record well depth, length of screen or open interval, and depth to top of the well screen. Determine the pump's intake depth (e.g., mid-point of screen/open interval).

2. On the day of sampling, check security of the well casing, perform any safety checks needed for the site, lay out a sheet of polyethylene around the well (if necessary), and setup the equipment. If necessary a canopy or an equivalent item can be setup to shade the pump's tubing and flow-through-cell from the sun light to prevent the sun light from heating the groundwater.

3. Check well casing for a reference mark. If missing, make a reference mark. Measure the water level (initial) to 0.01 ft. and record this information.

4. Install the pump's intake to the appropriate depth (e.g., midpoint) of the well screen or open interval. Do not turn-on the pump at this time.

5. Measure water level and record this information.

6. Turn-on the pump and discharge the groundwater into a graduated waste bucket. Slowly increase the flow rate until the water level starts to drop. Reduce the flow rate slightly so the water level stabilizes. Record the pump's settings. Calculate the flow rate using a graduated container and a stop watch. Record the flow rate. Do not let the water level drop below the top of the well screen.

If the groundwater is highly turbid or discolored, continue to discharge the water into the bucket until the water clears (visual observation); this usually takes a few minutes. The turbid or discolored water is usually from the well-being disturbed during the pump installation. If the water does not clear, then you need to make a choice whether to continue purging the well (hoping that it will clear after a reasonable time) or continue to the next step. Note, it is sometimes helpful to install the pump the day before the sampling event so that the disturbed materials in the well can settle out.

If the water level drops to the top of the well screen during the purging of the well, stop purging the well, and do the following:

> Wait for the well to recharge to a sufficient volume so samples can be collected. This may take a while (pump may be removed from well, if turbidity is not a problem). The project manager will need to make the decision when samples should be collected and the reasons recorded in the site's log book. A water level measurement needs to be performed and recorded before samples are collected. When samples are being collected, the water level must not drop below the top of the screen or open interval. Collect the samples from the pump's tubing. Always collect the VOCs and dissolved gases samples first. Normally, the samples requiring a small volume are collected before the large volume samples are collected just in case there is not sufficient water in the well to fill all the sample containers. All samples must be collected, preserved, and stored according to the analytical method. Remove the pump from the well and decontaminate the sampling equipment.

If the water level has dropped 0.3 feet or less from the initial water level (water level measure before the pump was installed); proceed to Step 7. If the water level has dropped more than 0.3 feet, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are be collected.

7. Attach the pump's tubing to the "T" connector with a valve (or a three-way stop cock). The pump's tubing from the well casing to the "T" connector must be as short as possible to prevent the groundwater in the tubing from heating up from the sun light or from the ambient air. Attach a short piece of tubing to the other end of the end of the "T" connector to serve as a sampling port for the turbidity samples. Attach the remaining end of the "T" connector to a short piece of tubing and connect the tubing to the flow-through-cell bottom port. To the top port, attach a small piece of tubing to direct the water into a calibrated waste bucket. Fill the cell with the groundwater and remove all gas bubbles from the cell. Position the flow-through-cell in such a way that if gas bubbles enter the cell they can easily exit the cell. If the ports are on the same side of the cell and the cell is cylindrical shape, the cell can be placed at a 45-degree angle with the ports facing upwards; this position should keep any gas bubbles entering the cell away from the monitoring probes and allow the gas bubbles to exit the cell easily (see Low-Flow Setup Diagram). Note:

make sure there are no gas bubbles caught in the probes' protective guard; you may need to shake the cell to remove these bubbles.

8. Turn-on the monitoring probes and turbidity meter.

9. Record the temperature, pH, dissolved oxygen, specific conductance, and oxidation/reduction potential measurements. Open the valve on the "T" connector to collect a sample for the turbidity measurement, close the valve, do the measurement, and record this measurement. Calculate the pump's flow rate from the water exiting the flow-through-cell using a graduated container and a stop watch, and record the measurement. Measure and record the water level. Check flow-through-cell for gas bubbles and sediment; if present, remove them.

10. Repeat Step 9 every 5 minutes or as appropriate until monitoring parameters stabilized. Note: at least one flow-through-cell volume must be exchanged between readings. If not, the time interval between readings will need to be increased. Stabilization is achieved when three consecutive measurements are within the following limits:

> **Turbidity** (10% for values greater than 5 NTUs; if three Turbidity values are less than 5 NTUs, consider the values as stabilized),
> **Dissolved Oxygen** (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),
> **Specific Conductance** (3%),
> **Temperature** (3%),
> **pH** (± 0.1 unit),
> **Oxidation/Reduction Potential** (±10 millivolts).

If these stabilization requirements do not stabilize in a reasonable time, the probes may have been coated from the materials in the groundwater, from a buildup of sediment in the flow-through-cell, or a gas bubble is lodged in the probe. The cell and the probes will need to be cleaned. Turn-off the probes (not the pump), disconnect the cell from the "T" connector and continue to purge the well. Disassemble the cell, remove the sediment, and clean the probes according to the manufacturer's instructions. Reassemble the cell and connect the cell to the "T" connector. Remove all gas bubbles from the cell, turn-on the probes, and continue the measurements. Record the time the cell was cleaned.

11. When it is time to collect the groundwater samples, turn-off the monitoring probes, and disconnect the pump's tubing from the "T" connector. If you are using a centrifugal or peristaltic pump check the pump's tubing to determine if the tubing is completely filled with water (no air space).

All samples must be collected and preserved according to the analytical method. VOCs and dissolved gases samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

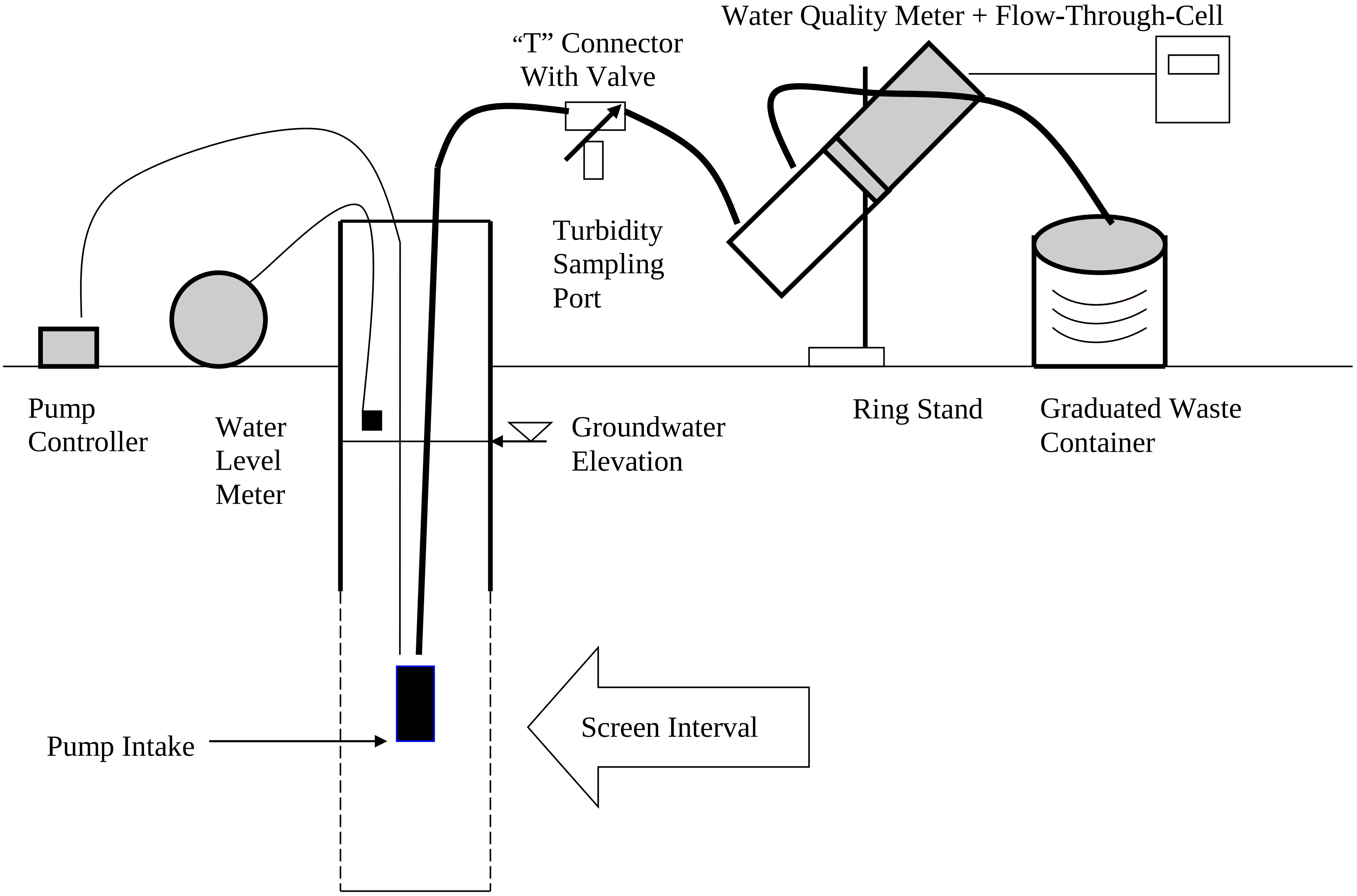
If the pump's tubing is not completely filled with water and the samples are being collected for VOCs and/or dissolved gases analyses using a centrifugal or peristaltic pump, do the following:

> All samples must be collected and preserved according to the analytical method. The VOCs and the dissolved gases (e.g., methane, ethane, ethene, and carbon dioxide) samples are collected last. When it becomes time to collect these samples increase the pump's flow rate until the tubing is completely filled. Collect the samples and record the new flow rate.

12. Store the samples according to the analytical method.

13. Record the total purged volume (graduated waste bucket). Remove the pump from the well and decontaminate the sampling equipment.

Low-Flow Setup Diagram



APPENDIX C

EXAMPLE (Minimum Requirements)

WELL PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Location (Site/Facility Name)________________________________
Well Number_________________ Date________________________
Field Personnel____
Sampling Organization______________________________________
Identify MP____

Depth to _______/________ of screen
(below MP) top bottom
Pump Intake at (ft. below MP)_________
Purging Device; (pump type)__________
Total Volume Purged _______________

Clock Time 24 HR	Water Depth below MP ft	Pump Dial[1]	Purge Rate ml/min	Cum. Volume Purged liters	Temp. "C	Spec. Cond.[2] µS/cm	pH	ORP[3] mv	DO mg/L	Tur-bidity NTU	Comments
Stabilization Criteria					3%	3%	±0.1	±10 mv	10%	10%	

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. µSiemens per cm(same as µmhos/cm)at 25°C.
3. Oxidation reduction potential (ORP)

TECHNICAL GUIDANCE INSTRUCTION - EQUIPMENT AND REAGENT BLANK SAMPLE COLLECTION FOR PFAS ANALYSIS

USAEC PFAS PA/SI

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1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

Equipment and reagent blanks will be collected in the field during sampling activities and submitted for laboratory analysis. These samples are primarily intended to verify that sampling and decontamination practices are effectively preventing cross-contamination caused by reusable sample equipment or other per- and polyfluoroalkyl substances (PFAS)-containing materials.

The intent of this Technical Guidance Instruction (TGI) is to provide instructions for collection of equipment and reagent blanks during United States Army Environmental Command (USAEC) PFAS Preliminary Assessment and Site Inspection (PA/SI) at various installations More detailed instructions related to general PFAS sampling considerations is provided in the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018).

3 PERSONNEL QUALIFICATIONS

Equipment and reagent samples will be collected by persons who have been trained in proper sampling procedures under the guidance of an experienced field geologist, engineer, or technician. Blank sampling should be completed with a two-person sampling team.

4 EQUIPMENT LIST

The following equipment and materials must be available for equipment and reagent blank sampling:

- Site plan which specifies frequency/quantity of blank sampling;
- Relevant work plan (e.g., PQAPP);
- Site Safety and Health Plan (SSHP);
- Appropriate health and safety equipment, as specified in the SSHP;
- Laboratory-provided “PFAS-free” water;
- Nitrile gloves;
- Dedicated plastic sheeting (preferably low-density polyethylene) or other clean surface to prevent sample contact with the ground;
- Pail or bucket with closable lid for excess rinse water;
- Garbage bags;
- Appropriate sample containers and labels;
  - Labeled high density polypropylene (HDPE) sample bottles: see the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018) for PFAS-specific considerations;
  - Ziploc®-style bags to hold ice and samples;
  - Packing and shipping materials;
  - Chain-of-Custody (COC) Forms; see the Sample Chain of Custody Standard Operating Procedure (SOP) for reference (Arcadis 2017a);
  - Appropriate transport containers (coolers) with ice and appropriate labeling; no blue ice is to be used.
- Decontamination:
  - Equipment cleaning materials: see the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018) or the Groundwater and Soil Sampling Equipment Decontamination TGI (Arcadis 2017b) as applicable;
  - An organic solvent such as isopropanol, methanol, or acetone should be used to decontaminate reusable equipment if it can be brought to the site safely. While strongly recommended, the use

  - of solvents may be excluded for project-specific health and safety concerns. Refer to Section 7.1.1 for more details.
  - Drum labels as required for investigation-derived waste handling: see the Investigation-Derived Waste Handling and Storage TGI for details (Arcadis 2017c);
- Field Notes:
  - Pens, pencils, and/or Sharpies® for writing;
  - Appropriate field forms;
  - Clipboards, field binders, field notebook, and field note pages that are not waterproof.

5 CAUTIONS

In general, sampling techniques used for PFAS sample collection are consistent with conventional sampling techniques used in the environmental industry, but special consideration is made regarding PFAS-containing materials and cross-contamination potential. The most important consideration during PFAS-related sampling is to prevent contact between sample media and suspect PFAS sources. During collection of equipment and reagent blanks, the sampled media (i.e., PFAS-free water) should not contact anything but the sample container. New nitrile gloves should be donned after handling of any non-dedicated sampling equipment; contact with contaminated surfaces; and whenever judged necessary by field personnel. **When in doubt change your gloves.** More detailed instructions related to general PFAS sampling considerations is provided in the TGI - Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018).

6 HEALTH AND SAFETY CONSIDERATIONS

Field activities associated with equipment and reagent blank sampling will be performed in accordance with the SSHP, a copy of which will be present on site during such activities.

7 PROCEDURE

The specific procedure for equipment and reagent blank sampling was developed after careful review and consideration of project data quality objectives. Procedures for equipment blank sampling and reagent blank sampling are further described in this section. **Note: the laboratory has to analyze the entire sample bottle for aqueous solutions of PFASs. When collecting each blank, fill two sample bottles and instruct the lab to hold one of them in reserve. If an unacceptable detection occurs in a blank, the second bottle of sample may be analyzed.**

7.1 Equipment Blank Sampling

7.1.1 Decontamination

Prior to collecting blank samples, the applicable piece of equipment should be properly decontaminated following these steps:

- Hand Tools and Sampling Devices (including hand augers and bladder pumps)
    1. Don new pair of nitrile gloves prior to decontamination
    2. Remove o-rings and bladder (applies only to bladder pump)
    3. Scrub using a plastic brush and a non-phosphate soap free of volatile organic compounds (VOCs) (e.g., Liquinox, Alconox);
    4. Double-rinse in deionized or distilled water;
    5. Rinse once with the site-approved organic rinsing solvent (e.g., isopropanol, methanol, acetone);
    6. Rinse once with PFAS-free water;
    7. Collect all rinsate in a sealed pail for disposal;
    8. Allowed time to air dry prior to re-use.
    9. Insert new o-rings and bladder (applies only to bladder pump)

See additional specifics in P-04, TGI - Groundwater and Soil Sampling Equipment Decontamination in the PQAPP Appendix A.

While strongly recommended, the use of solvents may be excluded for project-specific health and safety concerns. If solvents are prohibited, then additional procedures should be evaluated by the project team. Contingencies could include the use of dedicated sampling equipment at each sampling location or amending laboratory procedures to mitigate the increased risk of cross-contamination.

The following decontamination procedure could be utilized when organic solvent use is not possible:

1. Don new pair of nitrile gloves prior to decontamination
2. Remove o-rings and bladder (applies only to bladder pump)
3. Scrub using a plastic brush and a non-phosphate soap free of VOCs (e.g., Liquinox, Alconox);
4. Single-rinse in deionized or distilled water;
5. Scrub using a plastic brush and a non-phosphate soap free of VOCs (e.g., Liquinox, Alconox);
6. Rinse twice with deionized water and once with PFAS-free water;
7. Collect all rinsate in a sealed pail for disposal;
8. Allowed time to air dry prior to re-use.
9. Insert new o-rings and bladder (applies only to bladder pump)

- Drilling Rods
    - Drive casings and other drilling equipment will be steam cleaned or replaced with new equipment between boreholes.
    - The drilling equipment will be cleaned in an area designated by the supervising engineer or geologist that is located outside of the work zone.

After verifying the piece of equipment is properly decontaminated, and after determining an equipment blank is warranted per the sampling quality assurance / quality control (QA/QC) plan, follow the specific procedures for the relevant type of equipment found in the following sections.

7.1.2 Drilling Equipment (Hand Auger or Cutting Shoe/Drill Rod)

- Two field personnel should participate in the collection of the equipment blank. One person (“Field Personnel #1”) should hold the sampling bottle and collect the sample, and the second person (“Field Personnel #2”) should pour the rinse water.
- The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.

1. Label the laboratory-provided HDPE bottles with applicable information (e.g., sample ID, date, time, analysis required). Keep bottle lid on until immediately prior to sample collection.
2. Lay down dedicated plastic sheeting or other clean surface to prevent sample contact with the ground.
3. Place the sealable bucket or pail on top of plastic sheeting.
4. Don a new pair of nitrile gloves prior to blank collection (Field Personnel #1 and #2). Do not use gloved hands to handle other objects (e.g., papers, pens, clothes, equipment) before collecting samples.
5. Open the sample container and position the piece of clean, decontaminated sample equipment (i.e., hand auger or drilling rod/cutting shoe) above the container (Field Personnel #1). Keep the sample cap in the hand of the sampler (Field Personnel #1) until it is replaced on the bottle.
    - The bucket of the hand auger can be removed from the rods/handle and held manually.
    - The drillers should assist the field staff with removing the cutting shoe from the drill string and positioning it for sampling.
6. Slowly pour laboratory-provided “PFAS-free” water over any surface of the decontaminated sampling device that previously contacted sampled material (Field Personnel #2).
    - Pour water through the inside of the hand auger bucket while manually rotating the bucket so that “PFAS-free” water contacts all sides of the sampling device. Collect runoff in the sample container (Field Personnel #1), making sure that any excess “PFAS-free” water is contained in the sealable bucket or pail.
    - Pour water through the inside of cutting shoe while drilling contractor holds and manually rotates the shoe so that “PFAS-free” water contacts all sides of the shoe (Field Personnel #2). Collect runoff in the sample container, making sure that any excess “PFAS-free” water is contained in the sealable bucket or pail.
7. After collecting the necessary sample volume, place cap back on the sample bottle (Field Personnel #1). The bottle should be filled approximately full, but some headspace in the bottle is acceptable.
8. Collect the second bottle with the same procedure (Steps 5 to 7), if collecting a backup.
9. Record any label information that was not pre-filled out, if necessary (e.g., sample time), and place filled sample bottles in sealed Ziploc® bags. Record the label information and time of sampling in the field notes.
10. Add sample to the laboratory COC. Double check that the sample labels and COC agree. Note on the COC that one bottle should be held in reserve, if a backup bottle is collected.
11. Place sealed Ziploc® bag into the sample cooler. **Store PFAS samples in separate cooler from any other types of samples**.
12. Place dedicated plastic sheeting and nitrile gloves in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

7.1.3 Reusable Sediment Sampling Equipment (Stainless-Steel Hand Tools, Petite Ponar Grab Sampler)

- Two field personnel should participate in the collection of the equipment blank. One person (“Field Personnel #1”) should hold the sampling bottle and collect the sample, and the second person (“Field Personnel #2”) should pour the rinse water.
- The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.

1. Label the laboratory-provided HDPE bottles with applicable information (e.g., sample ID, date, time, analysis required). Keep bottle lid on until immediately prior to sample collection.
2. Lay down dedicated plastic sheeting or other clean surface to prevent sample contact with the ground.
3. Place sealable bucket or pail on top of plastic sheeting.
4. Don new pair of nitrile gloves prior to blank collection (both field personnel). Do not use gloved hands to handle other objects (e.g., papers, pens, clothes, equipment) before collecting samples.
5. Open sample container and position the clean, decontaminated piece of sample equipment (i.e., hand tool, grab sampler) above the container (Field Personnel #1). Keep the sample cap in the hand of the sampler (Field Personnel #1) until it is replaced on the bottle.
6. Slowly pour the laboratory-provided “PFAS-free” water over any surface of the sampling device that contacted sampled material (Field Personnel #2).
    - Pour water over front and back of all decontaminated hand tools such as spoons, spatulas, and trowels so that “PFAS-free” water touches all sides of the sampling device. Collect runoff in the sample container, making sure that any excess “PFAS-free” water is contained in the sealable bucket or pail (Field Personnel #1).
    - Pour water through inside of the decontaminated Petite Ponar Grab Sampler while rotating the sampler (or the “PFAS-free” water container) so that “PFAS-free” water contacts all interior sides of the sampler (Field Personnel #2). Collect runoff in the sample container, making sure that any excess “PFAS-free” water is contained in the sealable bucket or pail.
7. After collecting the necessary sample volume, place cap back on the sample bottle (Field Personnel #1). The bottle should be filled approximately full, but some headspace in the bottle is acceptable.
8. Collect the second bottle with the same procedure (Steps 5 to 7), if collecting a backup.
9. Record any label information that was not pre-filled out, if necessary (e.g., sample time), and place filled sample bottles in sealed Ziploc® bags. Record the label information and time of sampling in the field notes.
10. Add the sample to the laboratory COC. Double check that the sample labels and COC agree. Note on the COC that one bottle should be held in reserve, if a backup bottle is collected.
11. Place sealed Ziploc® bag into the sample cooler. **Store PFAS samples in separate cooler from any other types of samples**.
12. Place dedicated plastic sheeting and nitrile gloves in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

7.1.4 Disposable Sediment Sampling Equipment (Lexan ™ Liner Sleeve)

- Two field personnel should participate in the collection of the equipment blank. One person (“Field Personnel #1”) should hold the sampling bottle and collect the sample, and the second person (“Field Personnel #2”) should pour the rinse water.

- The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.

1. Label the laboratory-provided HDPE bottles with applicable information (e.g., sample ID, date, time, analysis required). Keep the bottle lid on until immediately prior to sample collection.
2. Lay down dedicated plastic sheeting or other clean surface to prevent sample contact with the ground.
3. Place sealable bucket or pail on top of plastic sheeting.
4. Don new pair of nitrile gloves prior to blank collection (both field personnel). Do not use gloved hands to handle other objects (e.g., papers, pens, clothes, equipment) before collecting samples.
5. Open sample container and position a clean, new, and unused section of Lexan™ liner above the container (Field Personnel #1). Keep the sample cap in the hand of the sampler (Field Personnel #1) until it is replaced on the bottle.
6. Slowly pour laboratory-provided “PFAS-free” water over any surface of the sampling device that contacted sampled material (Field Personnel #2).
   - Pour water through inside of Lexan ™ liner while rotating the liner so that “PFAS-free” water contacts all interior sides of the liner. Collect runoff in the sample container, making sure that any excess “PFAS-free” water is contained in the sealable bucket or pail.
7. After collecting the necessary sample volume, place cap back on the sample bottle (Field Personnel #1). The bottle should be filled approximately full, but some headspace in the bottle is acceptable.
8. Collect the second bottle with the same procedure (Steps 5 to 7), if collecting a backup.
9. Record any label information that was not pre-filled out, if necessary (e.g., sample time), and place filled sample bottles in sealed Ziploc® bags. Record the label information and time of sampling in the field notes.
10. Add sample to the laboratory COC. Double check that the sample labels and COC agree. Note on the COC that one bottle should be held in reserve, if a backup bottle is collected.
11. Place sealed Ziploc® bag into the sample cooler. **Store PFAS samples in separate cooler from any other types of samples**.
12. Place dedicated plastic sheeting and nitrile gloves in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

7.1.5 Reusable Water Sampling Equipment (Peristaltic Pump, Bladder Pump, Stainless-Steel Bailer)

7.1.5.1 Peristaltic Pump

- Two field personnel should participate in the collection of the equipment blank. One person (“Field Personnel #1”) should hold the sampling bottle and collect the sample, and the second person (“Field Personnel #2”) should set up the pump and pour/ transfer the blank water.
- The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.

1. Label the laboratory-provided HDPE bottles with applicable information (e.g., sample ID, date, time, analysis required). Keep bottle lid on until immediately prior to sample collection.
2. Lay down dedicated plastic sheeting other clean surface to prevent sample contact with the ground.

3. Don new pair of nitrile gloved prior to blank collection (both field personnel). Do not use gloved hands to handle other objects (e.g., papers, pens, clothes, equipment) before collecting samples.
4. Pour laboratory-supplied “PFAS-free” water into a clean HDPE sample bottle (Field Personnel #2).
5. Insert new HDPE tubing into the HDPE bottle containing “PFAS-free” water and connect tubing to peristaltic pump (with new silicone tubing) (Field Personnel #2).
6. Open sample container, keeping the sample cap in the hand of the sampler until it is replaced on the bottle (Field Personnel #1).
7. Turn the peristaltic pump on and slowly pump the “PFAS-free” water into the labeled sample container (Field Personnel #2).
8. After collecting the necessary sample volume, place cap back on the sample bottle (Field Personnel #1). The bottle should be filled approximately full, but some headspace in the bottle is acceptable.
9. Collect the second bottle with the same procedure (Steps 6 to 8), if collecting a backup.
10. Record any label information that was not pre-filled out, if necessary (e.g., sample time), and place filled sample bottles in sealed Ziploc® bags. Record the label information and time of sampling in the field notes.
11. Add the sample to the laboratory COC. Double check that the sample labels and COC agree. Note on the COC that one bottle should be held in reserve, if a backup bottle is collected.
12. Place sealed Ziploc® bag into the sample cooler. **Store PFAS samples in separate cooler from any other types of samples**.
13. Place dedicated plastic sheeting and nitrile gloves in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

7.1.5.2 Bladder Pump

- Two field personnel should participate in the collection of the equipment blank. One person (“Field Personnel #1”) should hold the sampling bottle and collect the sample, and the second person (“Field Personnel #2”) should set up the pump and pour/ transfer the blank water.
- The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.

1. Label the laboratory-provided HDPE bottles with applicable information (e.g., sample ID, date, time, analysis required). Keep the bottle lid on until immediately prior to sample collection.
2. Lay down dedicated plastic sheeting or other clean surface to prevent sample contact with the ground.
3. Don new pair of nitrile gloved prior to blank collection (both field personnel). Do not use gloved hands to handle papers, pens, clothes, equipment, etc., before collecting samples.
4. Pour laboratory-supplied “PFAS-free” water into an approved container (to avoid PFAS cross-contamination) large enough to submerge the bladder pump.
5. After properly decontaminating the bladder pump and replacing the bladder, attach a new section of HDPE tubing to the bladder pump, long enough to hold and direct flow into the labeled sample container. Submerge the bladder pump into the approved container of “PFAS-free” water (Field Personnel #2).
6. Open sample container, keeping the sample cap in the hand of the sampler until it is replaced on the bottle (Field Personnel #1).
7. Turn the bladder pump on and slowly pump the “PFAS-free” water into the labeled sample container (Field Personnel #2).

8. After collecting the necessary sample volume, place cap back on the sample bottle. The bottle should be filled approximately full, but some headspace in the bottle is acceptable.
9. Collect the second bottle with the same procedure (Steps 6 to 8), if collecting a backup.
10. Record any label information that was not pre-filled out, if necessary (e.g., sample time), and place filled sample bottles in sealed Ziploc® bags. Record the label information and time of sampling in the field notes.
11. Add sample to laboratory COC. Double check that the sample labels and COC agree. Note on the COC that one bottle should be held in reserve, if a backup bottle is collected.
12. Place sealed Ziploc® bag into the sample cooler. **Store PFAS samples in separate cooler from any other types of samples**.
13. Place dedicated plastic sheeting and nitrile gloves in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

7.1.5.3 Stainless-Steel Bailer

- Two field personnel should participate in the collection of the equipment blank. One person ("Field Personnel #1") should hold the sampling bottle and collect the sample, and the second person ("Field Personnel #2") should pour the rinse water.
- The best timing to collect equipment blanks is immediately after the collection of a sample likely to contain high concentrations of PFASs, after the sampling equipment has been appropriately decontaminated.

1. Label the laboratory-provided HDPE bottles with applicable information (e.g., sample ID, date, time, analysis required). Keep bottle lid on until immediately prior to sample collection.
2. Lay down dedicated plastic sheeting or other clean surface to prevent sample contact with the ground.
3. Place sealable bucket or pail on top of plastic sheeting.
4. Don new pair of nitrile gloves prior to blank collection (both field personnel). Do not use gloved hands to handle other objects (e.g., papers, pens, clothes, equipment) before collecting samples.
5. Open sample container (Field Personnel #1) and position the bailer above the container (Field Personnel #2). Keep the sample cap in the hand of the sampler (Field Personnel #1) until it is replaced on the bottle.
6. Fill the stainless-steel bailer with enough laboratory-provided "PFAS-free" water to collect the necessary sample volume (Field Personnel #2).
7. Slowly pour laboratory-provided "PFAS-free" water from the stainless-steel bailer into the sample container (Field Personnel #2).
8. After collecting the necessary sample volume, place cap back on the sample bottle. The bottle should be filled approximately full, but some headspace in the bottle is acceptable.
9. Collect the second bottle with the same procedure (Steps 5 to 8), if collecting a backup.
10. Place filled sample bottles in sealed Ziploc® bags, record any label information that was not pre-filled out, if necessary (e.g., sample time). Record the label information and time of sampling in the field notes and sampling forms.
11. Fill out the laboratory COC and check against the labels on the Equipment Blank sample bottle(s) progressively after each Equipment Blank is collected. Note on the COC that one bottle should be held in reserve, if a backup bottle is collected.
12. Place sealed Ziploc® bag into the sample cooler. **Store PFAS samples in a separate cooler from any other types of samples**.
13. Place dedicated plastic sheeting and nitrile gloves in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

7.2 Field Reagent Blank Sampling

- Two field personnel should participate in the collection of the reagent blank. One person ("Field Personnel #1") should hold the sampling bottle and collect the sample, and the second person ("Field Personnel #2") should pour the blank water.
- This sample should be collected after field staff return from an offsite break (e.g., lunch) to capture any potential cross-contamination from field personnel.

1. Label the laboratory-provided HDPE bottles with applicable information (e.g., sample ID, date, time, analysis required). Keep the bottle lid on until immediately prior to sample collection.
2. Don new pair of nitrile gloves prior to blank collection (both field personnel). Do not use gloved hands to handle other objects (e.g., papers, pens, clothes, equipment) before collecting samples.
3. Open sample container, keeping the sample cap in the hand of the sampler (Field Personnel #1) until it is replaced on the bottle (Field Personnel #1).
4. Slowly pour laboratory-provided "PFAS-free" water from the laboratory-provided container into the sample container ("Field Personnel #2").
5. After collecting the necessary sample volume, place cap back on the sample bottle. The bottle should be filled approximately full, but some headspace in the bottle is acceptable.
6. Collect the second bottle with the same procedure (Steps 3 to 5) if collecting a backup.
7. Record any label information that was not pre-filled out, if necessary (e.g., sample time), and place filled sample bottles in sealed Ziploc® bags. Record the label information and time of sampling in the field notes.
8. Add sample to the laboratory COC. Double check that the sample labels and COC agree. Note on the COC that one bottle should be held in reserve, if a backup bottle is collected.
9. Place sealed Ziploc® bag into the sample cooler. **Store PFAS samples in separate cooler from any other types of samples**.
10. Place dedicated plastic sheeting and nitrile gloves in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

8 WASTE MANAGEMENT

Excess water generated during equipment and reagent blank collection procedures will be collected and contained on site in appropriate containers, (see the Investigation-Derived Waste Handling and Storage TGI for details [Arcadis 2017c]). All investigation-derived waste (IDW) generated will be placed in Department of Transportation approved containers, sealed, and labeled. Containerized IDW will be stored on site until it is profiled and subsequently transported to an approved facility for disposal or recycling. Waste manifests for all IDW suspected to have come into contact with PFAS should clearly note the presence of PFAS. Additional IDW sampling and management details will be provided in the site-specific Work Plan (QAPP addendum) and will be consistent with applicable Army policies and Army post requirements. Disposable personal protective equipment (e.g., gloves, disposable clothing, disposable equipment) will be placed in plastic bags. These bags will be transferred into appropriately labeled containers for appropriate disposal.

9 DATA RECORDING AND MANAGEMENT

The supervising field lead will be responsible for documenting equipment and reagent blank collection to record all relevant information in a clear and concise format. The record should include:

- Project name and location;
- Project number, client, and site location;
- Date and time of sample collection;
- Weather conditions.

Field staff should ensure COC Forms are properly completed, and verify which PFAS analytes (e.g., just PFOS and PFOA, some or all of the 537 list) are required for analysis and note on the COC. Any samples collected as backup and not intended to be immediately analyzed should be clearly documented.

9.1 Field Notes

Waterproof field books must not be used for field notes. Instead, field notes should be on loose paper on masonite, plastic, or aluminum clip boards. Other requirements for field notes include:

- Keep field notes, writing implements, and electronic data collection tablets away from samples and sampling materials; and,
- Do not write on sampling bottles unless they are closed.

10 QUALITY ASSURANCE

Refer to quality control requirements for the project to ensure that appropriate QA/QC samples are collected. When collecting QA/QC samples, the same guidelines apply as when collecting regular samples – specifically:

- **Duplicate samples of each equipment blank and reagent blank should be collected and submitted to the laboratory with instructions to hold for analysis. The purpose of this sample is to provide analytical back-up in case there are any issues with the original blank sample.**
- Samples should be collected in laboratory-supplied HDPE bottles;
- Bottle caps must remain in the hand of the sampler until replaced on the bottle;
- Labels must be completed after the caps have been placed back on each bottle; and,
- Samples must be stored in appropriate transport containers (coolers) with ice (Ziploc®-type bags for use as ice containers) with appropriate labeling. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**

11 REFERENCES

Arcadis. 2018. TGI – Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance. Rev. 2. October 15.

Arcadis. 2017a. SOP – Sample Chain of Custody, Rev. #1. May 23.

Arcadis. 2017b. TGI – Groundwater and Soil Sampling Equipment Decontamination, Rev. #0. February 23.

Arcadis. 2017c. TGI – Investigation-Derived Waste Handling and Storage, Rev. #0. February 23.

TECHNICAL GUIDANCE INSTRUCTION

Ground Penetrating Radar

MAY 2020

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Revision/ Signatures	004	May 11, 2020	All	Update of Technical Guidance	Brent Barker, Greg Byer

CONTENTS

I. SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) document outlines the applications, limitations, and methodology for acquiring and interpreting subsurface data using ground penetrating radar (GPR). GPR is a non-invasive and non-destructive tool that transmits high frequency (generally between 100 and 1000 Megahertz [MHz]) electromagnetic waves into the ground and detects and records the energy reflected back to the surface with a frequency-matched receiver. The GPR unit is generally pulled or pushed across the ground surface and data collection should be done in a methodical manner either in a series of parallel lines or a grid of lines crossing at right angles to allow subsequent computer processing and analysis. Energy is reflected from boundaries that possess contrasting dielectric constants or electrical conductivities. Reflections typically occur at lithologic contacts where there may be changes in water content and/or mineral composition. Where subsurface materials have extremely high electrical conductivity and magnetic susceptibility including metal objects such as underground storage tanks (USTs), steel drums, and metallic utility pipes extremely high amplitude reflections are generally observed. Non-metallic pipes and utilities often produce weaker GPR reflections due to a lower contrast in dielectric constant between non-metallics and soil. The two most common requirements of GPR investigations are the depth of penetration and required horizontal and vertical resolution. Both depth of penetration and vertical resolution are inversely related to the transmitter center frequency. Higher frequency will potentially yield better resolution, but a loss of total depth of penetration may result. Conversely, a lower frequency will yield less vertical resolution while offering deeper penetration. A key variable in signal loss is the degree of attenuation of the transmitted signal. As a rule, environments that are electrically conductive such as soils or rocks with high clay content or groundwater high in total dissolved solids tend to offer the greatest signal attention and may be so severe as to limit the success of the GPR survey, regardless of frequency chosen. Environments with little or no clay minerals or soil moisture, frozen ground, or massive non-conductive rock offer the greatest success to GPR surveys.

Choice of transmitter frequency can generally be matched with project objectives and limitations posed by geologic conditions and/or infrastructure. The following are examples of applications by frequency range:

Antenna Center Frequency (MHz)	Typical Applications
1000 or greater	Concrete studies (delaminations, condition of rebar, rebar dimensions, etc.), shallow void surveys (beneath pavement), bridge decking analysis, Subfloor utility investigations (floor drains, conduits, etc.)
500 to 1000	Ice and snow thickness mapping, forensics, search and rescue applications, shallow utility mapping
250 to 500	Search for underground storage tanks or other buried metals such as drums, utility mapping surveys, characterization of fill materials, search for excavations such as graves, roadway mapping, boring clearance work
100 to 250	Shallow geologic investigations, fracture mapping in rock quarries, stratigraphic analysis, fill and waste mapping
100 or less	Deep geologic investigations, permafrost investigations, glacial studies, mining applications

II. PERSONNEL QUALIFICATIONS

GPR investigations should be conducted by qualified and experienced operators, such as an experienced field technician and/or geophysicist. The GPR operator should be experienced in evaluating data quality in the field and be able to adjust data acquisition procedures in response to variable site conditions in order to identify anomalies and resolve target features. Inexperienced Arcadis personnel directing or supervising GPR data acquisition or interpreting processed GPR data should seek appropriate guidance and technical peer review from qualified and experienced personnel available from the Geophysics Practice Area.

III. EQUIPMENT LIST

The following equipment will be available, as required, during GPR surveys.

- Personal protective equipment (PPE), as required in the site Health and Safety Plan (HASP).
- Appropriate forms, Site plans, field notebook, spray paint and camera.
- Specific GPR systems matched to project objectives and site conditions. Each manufacturer has their range of products, many of which are designed with specific applications in mind. In general, Arcadis will require that GPR data be stored and downloaded in digital format for later processing. Not all manufacturers offer data storage. The most common acceptable GPR system manufactures include:
    - GSSI – https://www.geophysical.com
    - Sensors & Software – https://www.sensoft.ca
    - Mala - https://www.guidelinegeo.com/products/category/mala-ground-penetrating-radar-gpr/
- A primary and, preferably, a secondary antennae of appropriate signal frequency1 to match anticipated dimension and depth of objective(s).
- Non-conductive measuring tape or measuring wheel; and
- Optionally a GPS unit which can be mounted to the GPR system for integration of GPS position into GPR data files.
- Optionally data processing software. Arcadis has licenses to Radan (GSSI), Ekko_Project (Sensors & Software), and Reflex (a general seismic and GPR processing program capable of converting most manufacturer-specific formats to industry standard formats).

IV. CAUTIONS

The effectiveness of GPR is site-specific and subject to the skill level of the operator. Reliability and efficiency are enhanced when used in conjunction with other geophysical methods. Soils with higher electrical conductivity rapidly attenuate the radar energy, reducing the penetration depth and resolution. Clayey soils and saturated soils, particularly when high in soluble salts, limit the usefulness of GPR. Other potential interference sources include subsurface debris, rebar reinforced concrete, above ground reflective objects (cars, surface water, transmission lines), and electromagnetic generating apparatus (electrical generators, radio transmitters).

Both metallic and non-metallic utilities may be imaged by GPR. However, it should be noted that due to differences in the properties of materials, locating a non-metallic utility (plastic, vitrified clay tile, etc.) may be more difficult than a metallic pipe because of a lesser contrast in dielectric constant between non-metallics and soil. A guideline for effective locating depth for utilities is 1-inch (2.5 cm) diameter of utility can be discerned for each foot (0.3 m) of depth to a depth of 12 feet (3.7 m). For instance, one may expect to resolve a utility 10 inches (25 cm) in diameter at a depth of 10 feet (3 m). This is a general rule of thumb that can be applied to both metallic and non-metallic utilities but should be used cautiously as the type of material can affect the resolution.

Also, the presence of reinforcing bar (rebar) in concrete can limit the resolution of pipes present below the concrete. The resolution of smaller diameter pipes found within or just below the concrete may be completed masked by the high response caused by the rebar.

Working inside of buildings can be especially challenging due the multiple surfaces (walls and ceilings) and fixtures above ground. The operator must know how to account for unwanted data artifacts. Generally, the GPR velocity in air is about 3 to 4 times faster than the subsurface. As a result, a metallic ceiling located 12 feet above the floor will appear in the GPR data at a “depth” of about 3 to 4 feet.

Standing water is problematic. Typically, if a GPR unit is passed through a puddle of standing water a strong ringing response will be recorded, often obscuring subsurface information entirely.

V. HEALTH AND SAFETY CONSIDERATIONS

Minimize physical hazard exposure through use of proper PPE as prescribed in the HASP. Maintain awareness of other potential hazards associated with the physical location where the GPR investigation is being conducted and any ingress or egress conditions.

VI. PROCEDURE

1. Become familiar with the details of the applicability and limitations of GPR.
2. Evaluate site-specific soil information to determine suitability of soils (clay content, saturation) for GPR. In general, soils with greater than 35% clay content are considered restrictive, and soils with less than 10% clay content are considered favourable for deep penetration with GPR.
3. Evaluate meteorological information regarding recent or forecasted precipitation that could impact soil moisture content and GPR effectiveness. Schedule GPR surveys appropriately.
4. Perform site reconnaissance in advance to identify potential sources of surface interference such as reinforced concrete, large metal objects, or electrical generators).
5. Consider complimentary technologies to supplement GPR and provide multiple lines of evidence. Technologies may include radio frequency, magnetic, electromagnetic surveys, or electrical resistivity surveys.
6. Employ only qualified and experienced GPR operators. For utility locating and mapping applications, the GPR operator should be specifically experienced in evaluating data quality and identifying anomalies in the field requiring variations in data acquisition procedures to positively interpret and locate targets of concern.

7. Consider the depth and size of subsurface features that GPR will be used for identification. Attempt to match the signal frequency to the expected depth and size of the subsurface feature. Change antennae as necessary for variable depths and sizes of target objects. Consider the selection of a primary and secondary choice of antennae and use multiple antennae as necessary. Evaluate GPR for known utility locations and/or relative to EM results, as an indication of potential effectiveness. A guideline for effective locating depths for utilities is 1-inch (2.5 cm) diameter of utility can be discerned for each foot (0.3 m) of depth to a depth of 12 feet (3.7 m). Expect a much coarser resolution below 12 feet.
8. Establish a reference grid over the area to be investigated and identify traverse locations in the field notebook or on a site plan map.
9. Most GPR systems are equipped with an odometer to keep track of the distance moved. It is important to confirm the accuracy of the odometer calibration and adjust if necessary.
10. Select and input a dielectric constant or average velocity into the GPR unit based on knowledge of the type of subsurface materials. Bear in mind that the dielectric constant or velocity is an approximation based on assumed subsurface materials and may vary based on the variability of the subsurface materials. The dielectric constant or velocity is necessary to estimate the depth of a target but should be considered an approximation not an absolute. Multiple passes over a known utility may be necessary using different dielectric constants before an accurate depth to a target can be estimated. Some manufacturers include the ability to perform hyperbola fitting to estimate dielectric constant or velocity from data collected in the field.
11. Depending on the system and antenna frequency, the pace at which the GPR unit is moved along a traverse may affect the target resolution. It is recommended that an initial starting pace should be approximately 1.5 feet (0.5m) per second and modified if necessary, during field operations. Appropriate pacing can be determined in advance if the size of the smallest target is known.
12. Record GPR data while slowly pushing or pulling the antenna along each survey traverse. It is good practice to annotate periodic grid crossings using the system’s ability to create fiducial markers. This is especially important for long traverses or locations where the ground surface is rough.
13. The data collection and storage approach is generally one of two types. One approach is to walk in a systematic pattern and mark out targets as they are found using paint or some other means. Once the area of interest is marked out, complete the survey by going back and storing key transects in the system memory for final reporting. The locations of the final stored traverses should be surveyed with GPR or taped to known locations via triangulation. This first approach is most appropriate for marking out USTs relatively simple utility patterns. The second approach is applicable to mapping large areas, complex utility layouts, fill mapping, or other geologic objectives. In such circumstances the best practice is to layout a control grid and using GPR mounted to the GPR system. The grid can either be a series of parallel lines at right angles to a known fabric, or if conditions are unknown, a grid of lines at orthogonal orientations. In this second approach it is important to start and end the GPR unit at marked out grid points and to keep good notes about the data collection process. Long lines should also be supplemented with fiducial marks at intermediate grid crossings. It is anticipated in this approach that data will be stored in memory and processed using appropriate GPR processing software.
14. For projects where a complete grid of data is stored, the results may be interpreted either as a series of horizontal slice maps or 3-dimensional data sets. Most contemporary software has the capability of digitizing discrete objects or horizons on a line by line basis, after which the interpretations can be exported to a vector drawing format such as DXF or SHP files in the form of 3D points and polylines.

VII. WASTE MANAGEMENT

GPR is a non-invasive procedure and should not result in the generation of derived wastes. Any trash or rubbish generated during the course of field activities should be disposed of in a proper trash receptacle.

VIII. DATA RECORDING AND MANAGEMENT

Conduct data processing and analysis in accordance with the manufacturer’s recommendations and industry practice. Processed data is available in electronic form. A copy of the PDF files for each individual GPR traverse should be included in the project directory along with scans of the field notes. Electronic data (raw and processed) should be maintained in accordance with data management procedures as outlined in the project sampling analysis plan (SAP), quality assurance project plan (QAPP), data quality objectives plan, or other applicable plan or guidance document.

IX. QUALITY ASSURANCE

The following quality control procedures should be observed:

- Seek appropriate input prior to conducting a GPR survey to identify site-specific features (soil conditions/sources of interference) that may impact data acquisition.
- Operate all equipment in accordance with manufacturer’s instructions and recommended procedures. Record all system components (Unit, antennae frequency, etc.) information in the field book or a pre-made field form.
- Regardless of which data collection approach is taken, data quality should always be checked in the field to identify factors that may require adjustment to the data acquisition procedures. Make appropriate adjustments to data acquisition methods to achieve survey objectives, as feasible.
- It is recommended that the operation and performance of the GPR equipment is field checked (if possible) by locating existing underground utilities or structures of known depth, size, and construction. These characteristics should be similar to that of unidentified target objects.
- Data interpretation should undergo peer review by appropriate qualified and experienced personnel.

X. REFERENCES

US Army Corps of Engineers, 1995. Geophysical Exploration for Engineering and Environmental Investigations, Engineering Manual (EM) 1110-1-1802.

TGI – MANUAL WATER-LEVEL AND NAPL MONITORING

Rev: #1

Rev Date: May 8, 2020

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0	October 11, 2018	All	Updated and re-written as TGI	Marc Killingstad Everett H. Fortner III
1	May 8, 2020	All	Updated and added NAPL gauging	Marc Killingstad Everett H. Fortner III Andy Pennington

APPROVAL SIGNATURES

Prepared by:		05/08/2020
	Everett H. Fortner III, PG	Date:
Technical Expert Reviewed by:		05/08/2020
	Marc Killingstad (Technical Expert)	Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM’s responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project’s scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

The objective of this Technical Guidance Instruction (TGI) is to describe procedures to measure and record water-levels (groundwater and surface-water) using manual water-level meters. Water levels may be measured using an electronic water-level probe or an oil-water level indicator from established reference points (e.g. top of casing). Reference points must be surveyed to evaluate fluid level elevations relative to a vertical datum (e.g. North America Vertical Datum of 1988 [NAVD88] relative to sea level). This TGI describes the equipment, field procedures, materials, and documentation procedures to measure and record water-levels using the aforementioned equipment. This TGI also describes procedures for measuring in-well thicknesses of non-aqueous phase liquid (NAPL), both light and/or dense (LNAPLs and DNAPLs, respectively).

Surface water-levels can be measured from stilling wells or fixed points (bridges, walls, etc.) and measuring from an established point of reference using a water-level meter. In some cases, surface water water-levels may be determined from a graduated stream gauge, attached to a pole located in open water with known elevation, without the use of a water-level meter.

The use of pressure transducers or other automated devices for the collection of groundwater elevation data will be subject of *TGI – Water-Level Monitoring using Pressure Transducers and TGI – Water-Level Measurements using Sonic Meters*.

3 PERSONNEL QUALIFICATIONS

Arcadis field sampling personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or regulations, such as 40-hour HAZWOPER training and/or OSHA HAZWOPER site supervisor training. Arcadis personnel will also have current training as specified in the Health and Safety Plan (HASP) which may include first aid, cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed. In addition, Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and TGIs and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. The HASP and other documents will identify other training requirements or access control requirements.

4 EQUIPMENT LIST

The following field equipment is suggested for water-level measurements:

- Site-specific Health and Safety Plan (HASP)
- Appropriate personal protective equipment (PPE) as specified in the HASP
- Electronic water-level indicator graduated in 0.01 ft. increments
- Electronic oil-water (interface) level indicator graduated in 0.01 ft. increments, if necessary
- Non-phosphate laboratory soap (Alconox or equivalent), brushes, clean buckets or clean wash tubs.
- Distilled or de-ionized (required for some sites) water for equipment decontamination
- Photoionization detector (PID) and/or organic vapor analyzer (optional)
- 150-foot measuring tape (or sufficient length for the maximum site depth requirement) – if required for total depth measurements of deeper wells
- Solvent (methanol/acetone/isopropyl alcohol) rinse – optional
- Spray bottle for solvent - optional
- Plastic drop cloth (e.g. Weatherall Visqueen) to place beneath the buckets or tubs to reduce potential for contamination of the tape or probe
- Tools and/or keys required for opening wells
- Well construction summary table and/or well construction logs
- Summary table of previous water-level measurements
- Field notebook and/or smart device (phone or tablet) or appropriate field forms (see **Attachment 1**).

- Indelible ink pen

5 CAUTIONS

Electronic water-level indicators and oil-water interface probes may sometimes produce false-positive readings. For example, if the inside casing surface of the well or stilling tube has condensation above the water level, then an electronic water-level probe may produce a signal by contacting the sidewall of the well, rather than the true water-level surface. For accuracy, the electronic water-level probe and/or interface probe should be raised and lowered several times at the approximate depth where the instrument produces a tone indicating a fluid interface to verify consistent, repeatable results (three or more times). Additionally, some wells may be constructed with a sump. If local/regional groundwater levels have declined such that the water-level is below the base of the well screen, a sump may still contain water and provide an erroneous measurement. Therefore, possessing and comparing measurements with a well construction summary table or well construction log is recommended for proper reporting.

If the presence of a NAPL is known or suspected within specific wells, *do not use* an electronic water-level indicator. Use an oil-water interface probe instead. If NAPL presents ignition or explosion hazards, an intrinsically safe oil-water interface probe is required to be used with grounding and following the manufacturer’s instructions.

If the NAPL is known to be very viscous or problematic to gauge, the data quality will require additional consideration prior to measuring. Staff will consider the data quality objectives for the gauging activity – e.g., if quantifying NAPL thickness is necessary, or if assessing the presence/absence is sufficient. Alternate NAPL measurement methods (such as using drop pipes or temporary coatings for down-well equipment) may be considered.

When measuring total well depths with an electronic water-level indicator, the measurement must have a correction factor applied for post processing or completed at the time of measurement that is equal to the length of the probe beneath the circuit closing electrodes (if applicable to the instrument). This is necessary because the tape distance markings are referenced to the electrode, rather than the end of the probe. Some newer instruments do not have an offset electrode and this correction factor is needed. In addition, total depth measurements are difficult with wells that have large water columns due to buoyancy issues. In addition, the total depth measurement will include notes that indicate a soft or hard bottom if recognized during the measurement.

Ensure that the type of electronic water-level indicator is compatible with the depth and diameter of the wells to be measured. Some smaller piezometers or larger diameter well stilling tubes will accommodate only smaller diameter probes.

6 HEALTH AND SAFETY CONSIDERATIONS

The HASP will be followed, as appropriate, to ensure the safety of field personnel. Access to wells may expose field personnel to hazardous materials such as contaminated groundwater or oil. Other potential hazards include pressurized wells, stinging insects that may inhabit well heads, other biologic hazards (e.g. ticks in long grass/weeds around well head), and potentially the use of sharp cutting tools (scissors, knife). Appropriate personal protective equipment (PPE) will be worn during these activities. Only use non-toxic peppermint oil spray for stinging insect nests. Open well caps slowly and keep face and body away to allow to vent any built-up pressure. Field personnel will thoroughly review client-specific health and safety requirements, which may preclude the use of fixed/folding-blade knives.

Obtaining measurements from active pumping wells requires knowledge of the construction and design, as the indicator probe and tape can become intertwined within down-well equipment (such as pump impellers) causing a serious health and safety hazard and equipment damage. Ensure that stilling wells have a perforated end and capped bottom to inhibit tape from extending into the downhole pump depth. If a stilling tube is not present or the still tube construction is not known, determine a conservative “not to exceed” measurement depth based on the top of pump depth with an added safety factor. If all information is not known, a water-level will not be taken from the pumping well until clarification on depths are available.

7 PROCEDURE

Calibration procedures and groundwater level measurement procedures for electronic water-level indicators and oil-water indicators are described in the sections below. Calibration documentation can be requested from the rental or manufacturer.

Calibration Procedures

If the indicator requires length and markings verification is required by project data quality plan or other reasons, then the following steps may be used:

- Measure the lengths between each increment marker on the indicator with a measuring tape. The appropriate length of indicator measuring tape, suitable to cover the depth range for the wells of interest, will be checked for accuracy.
- If the indicator measuring tape is inaccurate, the probe will require to be sent back to the manufacturer or rental company. If a replacement can’t immediately be available, then an offset can be measured to correct the measurements.
- If multiple water-level indicators and/or oil-water interface probes are being used for an event, calibration of the multiple devices will be required by measuring a water-level at a single well contemporaneously with all indicators to be used and calculated correction factors provided for data processing (typical corrections are small and range from 0.01 to 0.03 foot).
- Equipment calibration will be recorded in the field logbook and/or smart device.

Water-Level Measurement Procedures

The general procedures to be followed for the collection of fluid level measurements and well depths from the monitoring wells are as follows:

- Check that the water-level/oil-water level indicator battery is functional, before mobilization and prior to each work day (e.g. turn power on and check that meter sounds when probe is lowered into a bucket of water – note that water-level meters will not work with low-electrical-conductivity liquids such as distilled water).

- Record instrument make, model, serial number and (if present) Arcadis ID number in the field form or electronic field form.
- Don disposable nitrile gloves. Decontaminate the water-level/oil-water indicator, any attached tape and the spool with laboratory-grade soap and distilled water (see *Initial Decontamination Procedures* below). The spool requires caution with cleaning as it is not water-proof and can be damaged during cleaning.
- The top of the monitoring well will be cleaned with a clean rag to prevent loose particulate matter from falling into the well.
- Perform a well inspection (note that a well inspection form may be required to be filled out along with a photo to document the conditions).
- Place clean plastic sheeting on the ground next to the well.
- Unlock and/or open the monitoring well cover while standing upwind from the well (note that some wells may be under pressure and precaution should be taken with opening well caps – see Section 6).
- Measure the volatile organics present in the monitoring well head space with a PID and record the PID reading (if applicable and requirement for the site).
- Allow the water-level in the well to equilibrate with atmospheric pressure for a few minutes (check previous field forms or field books for equilibration time, if noted).
- Locate the measuring reference point that correlates to the survey point on the well casing. If one is not found, make a reference point by notching the highest and/or north point on the inner casing (or outer if an inner casing is not present) or mark with a permanent mark. All downhole measurements will be taken from the reference point. Document any changes or new reference point addition.
- Measure to the nearest 0.01 foot and record the height of the inner well casing and outer protective casing to ground level (note that some well pads are raised and are not at true ground surface).
- Lower the indicator probe into the center of the well until contact with the water surface is indicated by either an audible alarm or light. The sensitivity of the probe may need adjustment if the alarm or light is not strong signal. Use and install a tape guide (available from some manufacturers) to help with accuracy and provide protection with damaging the measurement tape. If a tape guide is not available, make sure that the tape does rub on the inner or outer casing which could fray and damage the tape.
- If an oil-water interface probe is being used to measure depth and thickness of NAPL, lower the interface probe into the center of the well until a contact with the NAPL surface is indicated by either audible alarm or light. The sensitivity of the probe may need adjustment if the alarm or light is not strong signal. To gauge the water level in a well which contains LNAPL (LNAPL-water interface), advance the interface probe past the LNAPL-water interface until the probe produces a solid audible alarm indicating water. While slowly retrieving the probe upward, the equipment will produce a different tone when the LNAPL-water interface is reached (typically this is a multiple alarm sound or flashing light). This level should represent the depth to water. The depth indicating the bottom of the

water column and top of DNAPL layer, if any, is indicated by the multiple alarm signal or flashing light emitted by the interface probe.

- Hold the tape at the measuring point and repeat the measurement two more times.
- Read and record measurement to the nearest 0.01 foot. Check the measurement with previous measurements, if available, and note any anomalies/discrepancies; if significant, contact the project staff.
- Measure and record total depth of well (see *Total Depth Measurement Procedures* below); note that measurement of total depth is not always performed at wells containing LNAPL or DNAPL, in order to reduce decontamination of the instrument and reduce potential exposure to NAPL.
- Record all measurements (**with date and time collected to the nearest minute**) and note any inconsistencies/anomalies and relevant observations in the field notebook and/or smart device or appropriate field forms.
- Follow decontamination procedure outlined below before measuring subsequent wells (see *Decontamination after Water Level and Total Depth Measurements* below).
- Replace cap and lock the well when all activities are completed.

Total Depth Measurement Procedures

- Weighted tape or electronic water-level indicator can be used to measure the total well depth.
- Follow initial procedures noted above in *Water-Level Measurements* above.
- Lower indicator probe (or tape) until weighted end is resting on the bottom of the well. Raise indicator slowly until there is no slack in the tape. Gently estimate the bottom of the well by slowly raising and lowering the indicator: great care should be taken to avoid damaging the sensor on the probe. The operator may find it easier to allow the weight to touch bottom and then detect the ‘tug’ on the tape while lifting the weight off the well bottom.
- Because of tape buoyancy and weight effects encountered in deep wells with long water columns, it may be difficult to determine when the probe is in contact the bottom of the well and sediment in the bottom of the well can also make it difficult to determine total depth. Care must be taken in these situations to ensure accurate measurements.
- If total depth measurements are to be collected during low-flow sampling events, the measurement will be made only after low-flow sampling has been completed or at least 12 hours prior to initiating sample collection from the well, in order to minimize: 1) mixing of the stagnant water at the top of the well column with potential formation water underneath; and/or 2) agitation and subsequent entrainment of possible sediment collected at the well bottom).
- Read and record measurement to the nearest 0.1 foot. Please refer to the note regarding total depth measurements described in *Section 5 Cautions* above.
- Follow decontamination procedure outlined below before gauging the next well (see Decontamination after *Water Level, NAPL Level, and Total Depth Measurements* below).

Initial Decontamination

- Note that there may be project specific decontamination procedure documents that will be followed in lieu of the below procedures.
- Set up a decontamination station consisting of three **clean** buckets (e.g. 5-gallon buckets). The buckets should not be used to containerize purge water; they will be used for decontamination purposes only.
- Fill the first bucket with one gallon of distilled water (use deionized water if metals are a contaminant at the site) and add non-phosphate laboratory-grade soap. Fill the second bucket with distilled water (use deionized water if metals are a contaminant at the site) and leave the third bucket empty. Place the drop cloth underneath.
- Unwind the entire tape from the spool into a bucket with non-phosphate laboratory-grade soap and distilled water; Brush the tape carefully to remove dirt and possible contamination, using a brush dedicated to the wash bucket.
- Carefully brush all dirt of the spool and wipe down with a soapy cloth or paper towel.
- Transfer the tape into the second bucket containing rinse water. Carefully brush the tape using a second brush, dedicated to the rinse bucket. Lift the tape out of the bucket and allow rinse water to drip off the tape.
- Transfer the tape to the third bucket. Wind the tape onto the spool while wiping excess water off the tape using a paper towel.

Decontamination after Water Level, NAPL Level, and Total Depth Measurements

- Set up a decontamination station consisting of three **clean** buckets, fill according to the initial decon procedure.
- Unwind the only the length of tape used for gauging from the spool into a bucket with laboratory-grade soap and distilled water. Brush the tape carefully to remove dirt and possible contamination, using a brush dedicated to the wash bucket.
- Continue as described above.
- Extra care should be taken to clean the probe after a total depth measurement. All sediment or dirt needs to be removed during decontamination.
- If an oil-water interface probe is used to gauge NAPL, a solvent may be necessary to remove all NAPL residue. After decontaminations steps above, use a spray bottle filled with chosen solvent (ex. isopropyl alcohol) and spray across all surfaces of the tape. Use paper towels to wipe off solvent and/or residue. This step may be repeated if necessary.

Notes:

- Collect equipment blanks if required by the work plan (minimum 1 per 20 samples or 1 per sampling event)

- Prepare new wash solution and rinse water when necessary (e.g., every 10 to 20 wells). The spent wash and rinse solution should be discharged according to site practices.
- The decontamination station may be expanded by adding extra rinse and/or detergent stations (i.e. solvent wash station) to the set up. The addition of more stations depends on the requirements of the work plan or the site-specific Field Sampling and Quality Assurance Plan and outlined in the project field plan or kick-off meeting.
- Small crates or washtubs are a possible substitute for the buckets. In any case, it is recommended to use containers with a lid.

8 WASTE MANAGEMENT

Decontamination fluids, PPE, and other disposable equipment will be properly stored on site in labeled containers and disposed of properly. Be certain that waste containers are properly labeled and documented in the field log book. Review *TGI – Investigation Derived Waste Handling and Storage*, for additional information and state- or client-specific requirements.

9 DATA RECORDING AND MANAGEMENT

Fluid level measurements as well as all relevant observations should be documented in the field logbook, field forms and/or PDA as appropriate. The following information must be documented:

- Well or location identification;
- Measurement time;
- Total well depth or depth of the water body at the location;
- Depth to water and, where necessary, depth to NAPL.

Once all the data has been collected and recorded, all notes/forms/data must be uploaded to the appropriate project directory on the Arcadis server, and an email should be sent to the Task Manager and/or Technical Lead for notification. A summary of the work completed that day and any relevant observations noted (such as well inspections) during the daily activities as well as copies of the data mentioned above should be included with the email. The appropriate team member will review the data for accuracy and provide feedback.

10 QUALITY ASSURANCE

Suggested quality control measures are below; project teams may implement some or all of these at their discretion and based on project data quality needs.

- As described in the detailed procedure, the electronic water-level meter and/or oil-water interface probe can be calibrated prior to use versus an engineer’s rule to ensure accurate length demarcations on the tape or cable. The results will be recorded.
- Measurements will be completed three times, with the final measurement recorded.

- Fluid interface measurements will be verified by gently raising and lowering the instrument through each interface to confirm repeatable results.
- Field notes will be reviewed by the project team once the field data has been delivered.

11 REFERENCES

Cunningham, W.L., and Schalk, C.W., comps., 2011. *Groundwater technical procedures of the U.S. Geological Survey: U.S. Geological Survey Techniques and Methods 1–A1, 151 pp*.

U.S. Environmental Protection Agency, 2013. *SESD Operating Procedure, Groundwater level and Well Depth Measurement.* January 29.

ATTACHMENT A

Water-Level Measurement Form

ARCADIS

Water-Level Measurement Form

Project No.: ______________________
Site Location: ______________________
Instrument Model ______________________

Field Personnel: ______________________
Date: ______________________
Instrument Serial No.: ______________________

Well Number	Time	W.L. Measurements			Comments		
		TD (feet)	DTW (feet)	DTL (feet)	Well Locked	Lock Condition	Other Comments

W.L.	Water Level
TD	Total Depth
DTW	Depth To Water
DTL	Depth To NAPL

ARCADIS

Water-Level Measurement Form

Project No.: ____________________
Site Location: ____________________
Instrument Model ____________________
Field Personnel: ____________________
Date: ____________________
Instrument Serial No.: ____________________

		W.L. Measurements			Comments		
Well Number	Time	TD (feet)	DTW (feet)	DTL (feet)	Well Locked	Lock Condition	Other Comments

W.L.	Water Level
TD	Total Depth
DTW	Depth To Water
DTL	Depth To NAPL

TGI - IN-SITU AND EX-SITU WATER QUALITY PARAMETERS

Rev: 0

Rev Date: October 16, 2018

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	October 16, 2018	All	Updated and re-written as TGI (in-situ and ex-situ adaptation)	Marc Killingstad

APPROVAL SIGNATURES

Prepared by:	Chris Shepherd	10/16/2018
	Chris Shepherd	Date:
Technical Expert Reviewed by:		10/16/2018
	Marc Killingstad (Technical Expert)	Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

Water quality parameters (e.g., turbidity, specific conductivity, pH, and temperature) of natural waters are usually measured in the field. The temperature, pH, specific conductivity, dissolved oxygen (DO), and oxidation reduction potential (ORP) and turbidity of surface water will be measured in-situ or ex-situ with a multiparameter water quality meter (i.e., multimeter).

Conductivity is the ability of a solution to pass an electric current. This current is carried by inorganic dissolved solids. The measurement is useful to quantify the chemical purity of the water relative to the amount of dissolved solids in a solution. Generally, temperature-compensated conductivity, termed specific conductivity, is measured by a water quality meter. Specific conductivity can also be used to estimate total dissolved solids (TDS) in solution (grams per liter or g/L) by multiplying the specific conductivity (measured in millisiemens per centimeter or mS/cm) by 0.65, which assumes that sodium chloride is a reasonable surrogate for the dissolved solids in solution.

Measuring the concentration of DO in water is an important component in evaluating the quality of natural as well as contaminated waters. The effects of wastes on rivers/streams, the suitability of water for fish and other organisms, as well as the effects of remediation efforts, can often be ascertained from the DO content. Dissolved oxygen levels generally range from 5 to 9 milligrams per liter (mg/L) when measured in water that is in equilibrium with air, depending on the temperature and barometric pressure; however, levels may be lower in a ‘reducing’ environment where anoxic conditions exist in water (e.g., gasoline plume undergoing bioremediation).

The measurement from an ORP sensor represents the net status of all the oxidation and reduction reactions in the sample being measured. Positive results indicate an oxidizing environment while negative results indicate a reducing environment. ORP is determined by measuring the potential of a chemically-inert electrode which is immersed in the solution. The sensing electrode potential is read relative to the reference electrode of the pH probe and the value is presented in millivolts (mV).

ORP meter results can indicate possible contamination and can be particularly useful if it is known that one component of the sample is primarily responsible for the observed value. For example, excess chlorine in a sample will result in a large positive ORP value while the presence of hydrogen sulfide will result in a large negative ORP value. Together with pH, temperature, and knowledge of the dominant species in a sample, ORP results help predict the oxidation state of ions in solution and whether certain reactions may take place.

Temperature readings will be taken at each water sampling location to assist understanding the water quality as well as compensating measurements. A thermometer is typically part of the multimeter. If not, a temperature probe or thermometer will be used.

The measurement of turbidity is useful in that it expresses the relative amount of suspended particles in the water column. Turbidity cannot be measured in-situ.

Refer to the following documents for procedures of groundwater sample collection:

> *TGI – Standard Groundwater Sampling for Monitoring Wells* (describes the methods to be used to collect groundwater samples using traditional purging and sampling techniques)
>
> *TGI - Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells* (describes low-flow purging and sampling techniques)
>
> *TGI – Passive Diffusion Bag Sampling, TGI – Groundwater Sampling with HydraSleeves*™, and *TGI - Bailer-Grab Groundwater Sampling* (describes no-purge/passive sampling techniques)

3 PERSONNEL QUALIFICATIONS

Arcadis field sampling personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or regulations, such as 40-hour HAZWOPER training and/or OSHA HAZWOPER site supervisor training. Arcadis personnel will also have current training as identified in the site-specific Health and Safety Plan (HASP) which may include first aid, cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed. The HASP will also identify any access control requirements.

Prior to mobilizing to the field, the sampling team will review and be thoroughly familiar with relevant site-specific documents including but not limited to the task-specific work plan or field implementation plan

(FIP)/field sampling plan, Quality Assurance Project Plan (QAPP), HASP, historical information, and other relevant site documents.

Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and TGIs and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. Additionally, the field sampling team will review and be thoroughly familiar with documentation provided by equipment manufacturers and become familiar with the operation of (i.e., hands-on experience) all equipment that will be used in the field prior to mobilization.

4 EQUIPMENT LIST

The following materials, as required, will be available during field measurement of water quality parameters:

- Site-specific HASP and health and safety documents identified in the HASP (e.g., job safety assessments [JSAs])
- Field Implementation Plan (FIP) that includes site map with sampling locations, well construction records (table or logs), sampling plan, and prior groundwater sampling records (if available)
- Field notebook, pen(s) (indelible ink) and/or smart device (smart phone or tablet)
- Field laptop / data manager
- Water Quality Measurement Log (**Attachment 1**)
- Water Quality Meter Calibration Log (**Attachment 2**)
- Appropriate personal protective equipment (PPE) (e.g., latex or nitrile gloves, safety glasses, etc.) as specified in the HASP
- Traffic cones, delineators, and caution tape as appropriate for securing the work area as specified in the Traffic Safety Plan (TSP)
- Well key(s)
- Photoionization detector (PID), flame ionization detector (FID) or other air monitoring equipment, as needed, in accordance with the HASP
- Dedicated plastic sheeting (e.g., Weatherall Visqueen) or other clean surface to prevent sampling equipment from coming in contact with the ground
- Electronic water-level indicator (e.g., Solinist Model 101) or oil/water interface probe with 0.01-foot accuracy (oil/water as appropriate, note that sampling will not be performed when sheen or light non-aqueous phase liquid [LNAPL] is present)
- Multiparameter (temperature/pH/specific conductivity/ORP/turbidity/DO) water quality meter or sonde with flow-through cell (as appropriate) plus reader and protective housing; for example:
    - YSI Professional Plus Multiparameter Instrument
    - YSI EX01 or EX02 Multiparameter Sonde

  - Horiba W-22 XD Multiparameter Instrument
  - Hydrolab DS5 Multiprobe and Display
- Operation manual(s) for multiparameter meter
- Water quality meter extension cable (as needed for in-situ readings of deepest well)
- Standard solutions for calibration
- Multimeter maintenance kit and extra DO membranes if using amperometric DO probe
- Extra batteries for the various instruments
- Tape measure and/or masking tape for in-situ readings
- Decontamination equipment (buckets, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern, paper towels)

5 CAUTIONS

NOTE: *Proper operation and maintenance are very important for a functioning meter and accurate readings. Carefully follow manufacturer's instructions for operation (including down-hole use), maintenance, and calibration as each manufacturer's instructions will vary.*

Verify the meter is intended for in-situ measurements and that all necessary parts are available prior to field mobilization.

Check and record the expiration dates of calibration fluids. Verify that calibration readings are reasonable and correspond to previous calibration readings when available. Expired calibration fluids may result in erroneous results. If accurate measurements of TDS are required, site-specific calibration will be necessary in accordance with the manufacturer's specifications.

Turbidity meters will be stored and used in dry locations.

When taking measurements in the field, verify that readings make sense and compare to historical readings when possible.

6 HEALTH AND SAFETY CONSIDERATIONS

The HASP will be followed, as appropriate, to ensure the safety of field personnel.

Appropriate personal protective equipment (PPE) will be worn at all times in line with the task and the site-specific HASP. Also, at a minimum, wear latex gloves and safety glasses when working with calibration solutions.

Review all site-specific and procedural hazards as they are provided in the HASP, and review Job Safety Analysis (JSA) documents in the field each day prior to beginning work.

Access to wells may expose field personnel to hazardous materials such as contaminated groundwater or non-aqueous phase liquid (NAPL) (e.g., oil). Other potential hazards include pressurized wells, stinging insects that may inhabit well heads, other biologic hazards (e.g. ticks in long grass/weeds around well head), and potentially the use of sharp cutting tools (scissors, knife)—open well caps slowly and keep face and body away to allow to vent any built-up pressure; only use non-toxic peppermint oil spray for stinging insect nests; review client-specific health and safety requirements, which may preclude the use of fixed/folding-blade knives, and use appropriate hand protection.

If working at a site with hazardous levels of volatile organic compounds, headspace and/or breathing zone readings will be measured prior to working at/in the well, in accordance with the HASP.

7 PROCEDURE

The procedure is organized into the following sections:

A. Standard Procedures – calibration, operation, and maintenance procedures that apply to all methods and meters
B. Calibration – general calibration procedures for:
   a. Multimeter
   b. Turbidity meter
C. Operation – general measurement operations for:
   a. Ex-situ measurements
      i. Multimeter
      ii. Turbidity meter
   b. In-situ measurements (downhole multimeter only)
D. Maintenance
   a. Multimeter
   b. Turbidity meter

7.1 Standard Procedures

Calibration

- The meter will be calibrated following the manufacturer’s instructions as calibration steps vary by manufacturer.
- Calibration information will be recorded in the calibration log (Attachment 2) and the field notebook.
- Check batteries/power levels during calibration.
- More frequent calibration may be necessary in harsh conditions or per project plans.

Operation

- The meter will be operated following the manufacturer’s instructions.

- Mutimeters can be operated in-situ (down-hole, in water, etc.) or ex-situ (water is transferred to container for measurement).
- Two readings will be made after stabilization (minimum 2 minutes) and the average will be recorded in the field notebook or both measurements will be recorded in the water quality measurement log and/or logger.
- Additional details for pH, conductivity, temperature, dissolved oxygen, and turbidity operation are presented in section **7.3 Operation** below.

Maintenance

- The meter will be maintained according to the manufacturer’s instructions.
- Maintenance information will be recorded in the field notebook or instrument log.
- Manufacturer recalibration or replacement probes may be required on a routine basis.
- A replacement meter and probes will be available onsite or ready for overnight shipment, as necessary.
- Additional details for pH, conductivity, temperature, dissolved oxygen, and turbidity maintenance are presented in section **7.4 Maintenance** below.
- More frequent maintenance (probe replacement, sensor reconditioning, etc.) may be necessary in harsh conditions or per project plans.

7.2 Calibration

Multimeter Calibration

1) Connect cables from meter to reader
2) Check probes and ensure they are clean
3) Switch on instrument and allow to warm-up
4) Check battery life and replace, if needed
5) Adjust date/time, if needed
6) Soak all probes in distilled or de-ionized water for at least 5 minutes (some probes may require longer soak times, see below and manufacturer instructions) and then shake off excess liquid.
    i. NOTE: *If the probes are recently reconditioned or have slight build-up, allow for longer soaking period.*
7) Navigate to calibration display/mode
8) **pH Calibration** – when in use, the pH meter will be calibrated daily, at a minimum.
    i. Connect electrode (if applicable) or remove protective cap from electrode
    ii. Rinse end of electrode in distilled/deionized water and shake off excess water

   iii. Measure and record temperature of buffer solutions
   iv. Immerse pH electrode in pH buffer 7.00, set the temperature to that of the buffer 7.00, and allow sufficient time for the electrode to stabilize
   v. Adjust the calibration for the correct readout and temperature
   vi. Confirm/press the calibration button
   vii. Remove electrode from buffer and rinse with distilled/deionized water
   viii. Immerse pH electrode in buffer 4.00, set the temperature control to that of the buffer 4.00, and allow sufficient time for the electrode to stabilize
   ix. Adjust the calibration for the correct readout and temperature
   x. Confirm/press the calibration button
   xi. Rinse electrode with distilled/deionized water
   xii. A pH 10 calibration will also be performed if high pH is anticipated, following manufacturers procedures
   xiii. The pH meter is calibrated

9) **Conductivity Calibration** – when in use, the conductivity meter will be calibrated daily, at a minimum.
   i. Conductivity is generally measured in specific conductivity (temperature compensated), verify with the FIP/work plan
   ii. Soak the probe in distilled/deionized water for at least 30 minutes
   iii. Remove the probe from the water and fling out drops clinging inside
   iv. Immerse the probe to or beyond the vent holes in a beaker containing 1.413 mS/cm standard solution and gently agitate vertically to remove entrapped air
   v. Repeat Steps 3 and 4 at least once more
   vi. Press calibration button

10) **Temperature calibration** – temperature will be verified according to FIP/work plan, if applicable.

11) **Dissolved Oxygen (DO) calibration** – when in use, the DO meter will be calibrated daily using the air calibration method or less frequently if using an optical sensor (see below).
   i. Preparation
      1. Polarographic sensor – periodically recondition sensor, replace fluids, and Teflon® membrane, per manufacturer, and air bubbles should not be present
      2. Galvanic sensor – Periodically recondition sensor, replace fluids, and membrane, per manufacturer, and air bubbles should not be present

        3. Optical sensor – Per manufacturer, most will only require field checks and maintenance, however, weekly checks are recommended to verify the accuracy, at a minimum

    ii. Obtain a barometric pressure reading from a daily weather report or from the instrument, as required by instrument

    iii. Keep instrument upright and vent cap/cover while retaining a small amount of clean water (do not cover probes) for non-optical sensors only

    iv. Allow 5 to 15 minutes for optimum probe stabilization and polarization, for non-optical sensors (reading will range between 5 to 9 mg/L depending on temperature and barometric pressure)

    v. Press calibration button, if reading is more than 2% off of the standard

12) **Oxidation reduction potential (ORP) calibration** – when in use, the ORP meter will be calibrated daily, if required.

    i. Rinse the probe in distilled/deionized water

    ii. Remove the probe from the water and fling out drops clinging inside

    iii. Immerse the probe in the ORP solution. Gently agitate vertically to remove entrapped air

    iv. Repeat Steps 3 and 4 at least once more

    v. Press calibration button, if reading is more than 2% off of the standard

13) Adjust the instrument to READ or LOGGING mode, per instruction manual and project plans; the instrument is now ready for use

Turbidity Calibration (if required)

Turbidity meters are generally calibrated weekly, unless required otherwise. However, daily checks are recommended to verify the accuracy. The turbidity meter will be calibrated per steps below:

1) Switch on instrument and allow time to warm-up

2) Check battery life and replace, if needed

3) Turbidity sample tubes will always be washed prior to use, but not the calibration standard tubes, using a mild detergent to remove any dirt or finger prints

4) Dry the outside of the sample turbidity tubes with a clean, lint-free cloth or disposable wipe and allow the turbidity tubes to air-dry in an inverted position to prevent dust from entering the tube, as allowable (but, not the calibration standard tubes)—dirt or fingerprints can lead to inaccurate results

5) Wipe the 1 Nephelometric turbidity unit (NTU) standard and place in the chamber after aligning the arrows (manufacturer dependent)

6) Place the light shield over the turbidity standard and allow the meter to stabilize

7) Press the read and/or CAL button, per instructions

8) Repeat steps 3 thru 5 above

9) Adjust to READ mode and the instrument is now ready for use.

7.3 Operation

Water quality parameters can be measured ex-situ or in-situ in accordance with the FIP/work plan. The operating procedures for each method are described below. It is also possible to collect a depth-specific sample from a well or water body for ex-situ measurement.

Ex-situ Operation

Multimeter

1) Fill two 100-mL plastic disposable beakers or clean beakers with water from the sample
2) Insert the probe into the first beaker immersing all sensors and allow to stabilize (2 minutes at minimum)
3) Record readings
    i. Temperature – in degrees Celsius or Fahrenheit
    ii. pH – in standard units between 0 and 14, in 0.01 increments
    iii. Specific conductivity – in mS/cm or microsiemens per centimeter (uS/cm)
    iv. DO – in mg/L and percent (will typically read between 0 and 15 mg/L)
    v. ORP – in millivolts (mV; will typically read between -1,400 mV and + 1,400 mV), if required
4) Rinse probe off with distilled/deionized water
5) Repeat Steps 2 thru 4 for the other beaker
6) Log results on the water quality measurement log and/or in field notebook - the average will be the actual result
7) Rinse probe off with distilled/deionized water

NOTE: *If a flow through cell is used during low flow groundwater sampling, a single reading can be obtained from the multimeter during each step of the wells purging in accordance with TGI - Low Flow Groundwater Purging and Sampling.*

Turbidity Meter

1) Fill the two cleaned, manufacturer provided sample tubes with water from the sample
2) Wipe off and dry the outside of the sample turbidity tubes with a clean, lint-free cloth or disposable wipe
3) Insert the first sample tube and close the cover
4) Push the READ button
5) Record turbidity reading in NTUs (0 to 1,100 NTUs)

   i. If readings are over the instrument limit, a single 2X dilution can be run by mixing the sample with equal parts distilled or de-ionized water and gently mixing
   ii. The resulting value will need to be doubled (for example, if the diluted reading is 750 NTUs, the estimated turbidity would be 750 x 2 = 1,500 NTUs. Diluted samples will be qualified as estimated)

6) Repeat steps 2 thru 5 with the second sample tube
7) Log the results on the water quality measurement log and/or in field notebook - the average will be the actual result
8) Rinse sample tubes with distilled/deionized water

NOTE: *If a flow through cell is used during low flow groundwater sampling, a single reading can be obtained from the multimeter during each step of the wells purging in accordance with TGI - Low Flow Groundwater Purging and Sampling. The turbidity sample is recommended to be collected prior to passing through the flow through cell.*

In-situ Operation

1) Connect extension cable and protective housing to meter
2) Measure water level from reference point
3) Lay out plastic sheeting as needed to keep the multimeter clean
4) Clean multimeter and cable per decontamination procedures and instruction manual and rinse with distilled/deionized water using caution, as most meters can only handle light washing with a mild soap and warm water
5) Organize work area to prevent dirt or objects from falling in the well
6) Measure and mark extension cable at planned measurement intervals
7) Slowly lower the probe into the well or water body to the desired measurement interval using caution to prevent rubbing of cable on the well and minimize water and sediment disturbance
8) Allow readings to stabilize (typically 1 to 3 minutes)
   i. For many instruments, the instrument may need to be slowly oscillated up and down a few inches to circulate water around the probes
9) Record readings
   i. Temperature – in degrees Celsius or Fahrenheit
   ii. pH – in standard units between 0 and 14, in 0.01 increments
   iii. Specific conductivity – in mS/cm or uS/cm
   iv. DO – in mg/L and percent (will typically read between 0 and 15 mg/L)
   v. ORP – in mV (will typically read between -1,400 mV and +1,400 mV), if required
10) Repeat steps 4 through 9 to complete targeted in-situ measurements

11) Log results on the water quality measurement log and/or in field notebook
12) Slowly retrieve the multimeter
13) Clean multimeter and cable per decontamination procedures and instruction manual and rinse with distilled/deionized water using caution, as most meters can only handle light washing with a mild soap and warm water

7.4 Maintenance

Multimeter

1) After use, the meter will be inspected and maintained according to the manufacturer's specifications and the inspection/maintenance activities will be recorded in the field notebook
2) Keep records of usage, maintenance, calibration, problems, and repairs
3) Recharge/replace batteries on a regular basis
4) Store meters or electrodes in protective casing when not in use
5) DO membranes will be stored moist, unless specified otherwise by manufacturer
6) Focused robe cleaning may be necessary in accordance with the operation manual and may be needed more frequently in harsh conditions
7) A replacement meter will be available onsite or ready for rapid delivery/shipment
8) Periodic manufacturer calibration may be necessary per operation manual and/or field plans

Turbidity Meter

1) Recharge battery on a regular basis
2) Store in protective casing when not in use
3) Keep records of usage, maintenance, calibration, problems, and repairs
4) After use, the meter will be inspected with results recorded in the field notebook
5) Keep sample tubes clean inside and out replacing them when they become scratched or etched and avoid handling the tubes in the region where the light beam enters them.
6) Clean lens periodically per instruction manual
7) Turbidity meter will be sent back to the manufacturer for service when needed

8 WASTE MANAGEMENT

Investigative-Derived Waste (IDW), including rinse water, excess sample water, spent calibration solutions, and disposable materials (plastic sheeting, PPE, etc.) generated during the procedures outlined in this TGI will be collected and stored on site in appropriately labeled containers (disposable materials will be contained separately) and disposed of properly. Containers must be labeled at the time of collection and will include date, location(s), site name, city, state, and description of matrix contained (e.g., soil, PPE). Waste will be managed in accordance with the *TGI – Investigation-Derived Waste Handling and Storage,* the procedures identified in the FIP or QAPP as well as state-, federal- or client-specific requirements. Be certain that waste containers are properly labeled and documented in the field log book.

PPE (such as gloves, disposable clothing, and other disposable equipment) resulting from personnel cleaning procedures activities will be placed in plastic bags. These bags will be disposed of as general waste unless specified otherwise.

9 DATA RECORDING AND MANAGEMENT

Management of the original documents from the field will be completed in accordance with the site-specific QAPP. Records generated as a result of this TGI will be controlled and maintained in the project record files in accordance with project requirements.

In general, documentation of the following information is required:

- Calibration – calibration information will be recorded on a calibration form, field log, or electronic device per project plans
    - Meter manufacturer and model
    - Serial number
    - Calibration personnel
    - Calibration date/time
    - Standard value, initial and final reading
    - Observations, if applicable
- Readings - data will be recorded on a field log, sampling form, or electronic device per project plans
    - Instrument model
    - Measurement date/time
    - Field personnel
    - Weather
    - Measurement location and depth, if applicable
    - Value of readings and average reading, if applicable
    - Units of readings
    - In-situ vs ex-situ measurement method
    - Key observations

All records will be provided to the project manager and retained in the project files. Any maintenance needs will be communicated to the project manager promptly.

QUALITY ASSURANCE

Quality assurance procedures will be conducted in accordance with the Arcadis Quality Management System or the site-specific QAPP.

Refer to the QAPP or FIP/sampling plan/work plan for the frequency of calibrations.

10 REFERENCES

Not applicable.

11 ATTACHMENTS

Attachment 1 - Water Quality Measurement Log

Attachment 2 - Water Quality Meter Calibration Log

ATTACHMENT 1

Water Quality Measurement Log

Design & Consultancy
for natural and
built assets

WATER QUALITY MEASUREMENT LOG

Page______of _______

GENERAL INFORMATION

Date ______________________________ Weather ______________________________

Project No ______________________________ Sample Personnel ______________________________

Site Name ______________________________ Sample ID ______________________________

Site Location ______________________________ Start reading time ______________________________

Site/Well No. ______________________________ End reading time ______________________________

MEASUREMENT DATA

Measuring Point (MP) description ____

Depth to Water (ft)/Time __________________ Instrument model/serial no. ______________________________

Well Screen Interval (ft) __________________ Instrument model /serial no. 2 ______________________________

Casing Diameter (in) __________________ ☐ In-situ ☐ Ex-situ reading

Meters calibrated (Y/N) __________________ (see calibration log, if applicable)

Water Quality Parameters

Time	**Depth**	**pH**	**Spec. Cond.**	**Temp**	**DO**		**ORP**	**Turbidity**	**Observations**
	(ft)	**(S.U.)**	**(mS/cm or uS/cm)**	**(°C or °F)**	**(mg/L)**	**(%)**	**(mV)**	**(NTU)**	**(Odor, clarity, etc., if applicable)**

REMARKS

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ATTACHMENT 2

Water Quality Meter Calibration Log

ARCADIS Design & Consultancy for natural and built assets

WATER QUALITY METER CALIBRATION LOG

PROJECT NAME	
PROJECT NO.	
MODEL	
SERIAL #	
SAMPLER	
DATE	

TURBIDITY CALIBRATION

CAL. READING		CAL. READING		CAL. RANGE	TIME
(LOT #)		(LOT #)			
(EXP. DATE)		(EXP. DATE)			
PRE-CAL. / POST-CAL		PRE-CAL. / POST-CAL			
/		/		☐ WITHIN RANGE	
/		/		☐ WITHIN RANGE	
/		/		☐ WITHIN RANGE	
/		/		☐ WITHIN RANGE	

AUTOCALIBRATION

AUTOCAL SOLUTION		CAL. READING	CAL. RANGE	TIME	CALIBRATION RANGES [1]	
(LOT #)						
(EXP. DATE)						
CALIBRATED PARAMETERS		PRE-CAL. / POST-CAL				
☐	pH	/	☐ WITHIN RANGE		pH	± 0.2 S.U.
☐	CONDUCTIVITY	/	☐ WITHIN RANGE		COND	± 1% OF CAL. STANDARD
☐	ORP	/	☐ WITHIN RANGE		ORP	± 25 mV
☐	DO	/	☐ WITHIN RANGE		DO	Atmospheric
☐	TURBIDITY	/	☐ WITHIN RANGE		TURB	± 5% OF CAL. STANDARD
☐		/	☐ WITHIN RANGE			
☐		/	☐ WITHIN RANGE			

(1) CALIBRATION RANGES ARE SPECIFIC TO THE MODEL OF THE WATER QUALITY METER

NOTES:

SIGNED DATE

CHECKED BY DATE

SOP - SAMPLE CHAIN OF CUSTODY

Rev: #2

Rev Date: April 29, 2020

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	April 19, 2017	All	Re-write to COC only	Richard Murphy
1	May 23, 2017	4 9 7	Add: Guidance on use of previous version of SOP. Add: Info on COCs for multiple shipping containers Modify: Move letter i. to letter m. and change to “when appropriate”	Peter Frederick
2	April 29, 2020	4 11	Remove obsolete link Remove obsolete link	Lyndi Mott

APPROVAL SIGNATURES

Prepared by:		05/23/2017
	Peter C. Frederick	Date:
Technical Expert Reviewed by:		05/29/2020
	Lyndi Mott (Technical Expert)	Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes the general Chain of Custody (COC) procedures and guidance instructions for samples collected from project sites that are relinquished from Arcadis' possession.

COC is defined as the maintenance of an unbroken record of possession of an item from the time of its collection through some analytical or testing procedure. COC is typically documented by a written record of the collection, possession, and handling of samples collected from a project location. Each sample will be tracked by a documented record that efficiently documents the individuals who were responsible for the sample during each successive transfer of that sample to various recipients beyond Arcadis' possession. This information can be used to legally establish the integrity of the samples and therefore the analytical results derived from the samples. This information can be used in addition to other records and documentation regarding the samples, such as field forms, field logs, and photographs.

A sample is considered under custody if:

- It is in your possession; or
- It is in your view, after being in your possession; or
- It was in your possession and then you then locked it up to prevent tampering; or
- It is in a designated secure area.

Continued use of previous version of SOP:

Although not recommended, Arcadis program-, project-, and client-teams may be able to use the previous version of this SOP provided that it meets all of the quality expectations of Arcadis and client, and meets applicable regulatory requirements. It is up to the program, project, and/or client-team leader to determine whether it is appropriate to adopt the current SOP or to continue using the previous version.

However, all new work not associated with the previous version of this SOP must be performed with the current version of the SOP.

When adopting this new SOP, users of the previous versions must be aware that specific handling, packing, and shipping procedures and guidance has been removed and that those should be addressed within program or project plans (e.g. QAPPs, Work Plans, SAPs, etc.) or in a more detailed SOP or TGI specific to that sampling activity, whether related to media, constituent/analyte, client, state, etc.

In addition, adopting this new SOP will require users to refer to the Arcadis DOT Safety Program for procedures and guidance on the determination and handling, packing, and shipping of samples that are or may be considered hazardous materials.

3 PERSONNEL QUALIFICATIONS

Arcadis personnel performing work under the purview of this SOP will have received appropriate training and have field experience regarding the collection of samples from project locations. Arcadis personnel will have all other applicable and appropriate training relevant to the sampling work and project site.

4 EQUIPMENT LIST

The following list provides materials that may be required for each COC. Project reporting and documentation requirements must be reviewed with the CPM prior to execution of work. Additional materials, tools, equipment, etc. may be required, and project staff are required to verify with the CPM and/or Technical Expert what specific equipment is required to complete the COC.

- Indelible ink pen (preferably either black or blue ink);
- COC form (**Appendix A**) from either Arcadis, laboratory receiving and analyzing the samples, or other applicable and appropriate entity for the work performed;
- When appropriate, such as for litigation or expert testimony work, custody seals or tape.

5 CAUTIONS

One way in which the law tries to ensure the integrity of evidence is by requiring proof of the chain of custody by the party who is seeking to introduce a particular piece of evidence.

A proper chain of custody requires three types of affirmations: (1) affirmation that a sample is what it purports to be (for example, soil collected from a specified location and depth); (2) affirmation of continuous possession by each individual who has had possession of the sample from the time it is collected until the time it is analyzed or held by a laboratory; and (3) affirmation by each person who has had possession that sample remained in substantially the same condition and not contaminated or affected by outside influences from the moment one person took possession until the moment that person released the evidence into the custody of another (for example, affirmation that the sample was stored in a secure location where no one but the person in custody had access to it).

Proving chain of custody is necessary to "lay a foundation" for the samples in question, by showing the absence of alteration, substitution, or change of condition.

Ensure that appropriate sample containers with applicable preservatives, coolers, and packing material are planned for and provided at the site at the time of sample collection.

Understand the offsite transfer requirements of the samples for the facility at which samples are collected.

If overnight courier service is required schedule pick-up or know where the drop-off service center is located and the hours of operation.

An Arcadis employee appropriately trained at the correct level of internal hazardous materials/DOT (Department of Transportation) shipping must complete an Arcadis shipping determination to address applicable DOT and IATA (International Air Transport Association) shipping requirements. Review the applicable Arcadis procedures and guidance instructions for sample packaging, and labeling. Prior to using air transportation, confirm air shipment is acceptable under DOT and IATA regulations.

The person relinquishing possession of the samples or other member of the project team should contact the final recipient of the samples to confirm receipt and review any special provisions on the COC or questions that they may have.

6 HEALTH AND SAFETY CONSIDERATIONS

Follow the health and safety procedures outlined in the project/site Health and Safety Plan (HASP) as well as other applicable H&S requirements, such as:

- Arcadis Hazardous Material/DOT handling, packaging, and shipping training
- Project site-specific H&S training
- Client-specific H&S training
- Constituent-specific H&S training
- Media-specific H&S training

7 PROCEDURE

Collected samples must be uniquely identified, and properly documented, containerized, labeled with unique identifier, possessed in a secure manner during remainder of sampling event, packaged, and shipped to recipient laboratory.

Sample Identification

The method of sample identification depends on the type of measurement or analyses performed. In some cases, in-situ measurements of existing conditions and/or sample location must be made during sample collection. These data will be recorded directly on field forms, logbooks, or other project record data sheets used to permanently retain this information for the project file. Examples of location identification information includes: latitude/longitudinal measurements, compass directions, well number, building number, floor number, room name, or proximity to a site feature unique to the site. Examples of in-situ measurements are pH, temperature, conductivity, flow measurement, or physical condition of the media being sampled. Physical samples collected are identified by a unique identifying number or code on a sample tag or label. These physical samples are removed from the sample location and transported to a laboratory for analyses.

In some cases, before samples are placed into individual containers and labeled as individual samples, samples may be separated into portions depending upon the analytical methods and required duplicate or triplicate analyses to be performed.

When completing a COC for samples, personnel must complete the following:

1. Written COCs must be completed with indelible ink (preferably either black or blue colored ink).
2. Written COCs must be completed using legible printed writing, and not cursive writing.
3. All entry fields on the COC form must be completed. If information is not applicable for a specific entry field, personnel will either put “N/A” or use a strike-out line or dash like “-----------“ to indicate no applicable information is needed for that field.
4. Use of quotation marks or lines/down arrows to represent repetitive/duplicative text in similar fields.
5. Regardless of the type or specific COC form, the following pertinent information must be provided on the COC form:
    a. Arcadis project number
    b. Arcadis project name
    c. Project location, including street address, city, state, building number, providing as much detail as appropriate
    d. Recipient laboratory contact and sample receiving shipping location information
    e. Entities’/persons’ contact information for who will be receiving analytical results
    f. Name of sampler, i.e. person collecting sample and relinquishing possession of samples to the next entity in the chain of custody
    g. Date of sample collection

  h. If appropriate for the sample media, contaminant/constituent of concern, or analytical method, document time of sample collection using standard military time

  i. Sample analytical method(s)

  j. Turnaround time required for analyses and/or reporting

  k. Instructions to laboratory regarding handling, timing, analyses, etc. as applicable and appropriate

  l. Printed name and signature of the individual person who collected the samples and relinquishing possession of the samples

  m. If appropriate or when documentation of the specific sample collection method will influence how the laboratory handles, prepares, or analyzes the samples, document the sample collection methodology used for collecting the samples (e.g. ASTM D5755)

6. The following additional specific information will be entered on the COC form, regardless of what type of COC is being used:

   a. <u>Unique Sample Identifier</u> – The sample identifier (ID) must be unique to the individual sample it is applied to. The information in which the sample ID conveys is determined by the CPM, Technical Expert, and/or other project team members in advance of sample collection so that sample identification is consistently applied for the project. The sample nomenclature may be dictated by a specific client, program, or project database and require unique identification for each sample collected for the project. Consult with the CPM and/or Technical Expert for additional information regarding sample identification.

      The sample ID could convey specific information regarding the sample to aid personnel in recognizing what the sample represents, or they may be arbitrary so as to facilitate the anonymity of the sample location, media, constituent of concern, project site, etc.

      Examples of unique identifiers include:

      1. Well locations, grid points, or soil boring identification numbers (e.g., MW-3, X-20, SB-30). When the depth interval is included, the complete sample ID would be “SB-30 (0.5-1.0) where the depth interval is in feet. Please note it is very important that the use of hyphens in sample names and depth units (i.e., feet or inches) remain consistent for all samples entered on the chain of custody form. DO NOT use the apostrophe or quotes in the sample ID.

      2. Sample names may also use the abbreviations “FB,” “TB,” and “DUP” as prefixes or suffixes to indicate that the sample is a field blank, trip blank, or field duplicate, respectively.

   b. List the date of sample collection. All indicated dates must be formatted using either mm/dd/yy (e.g., 03/07/09) or mm/dd/yyyy (e.g. 03/07/2009).

   c. When appropriate for the analytical procedure used, list the local time that the sample was collected. The time value should be presented using military format. For example, 3:15 P.M. should be entered as 15:15.

d. Samples should be indicated to be either “Grab” or “Composite”. Grab samples are collected from only one unique location at one specific point in time.

e. Composite samples are a group of individual samples that are combined for analysis in their totality. Composite samples need to be documented if they are either collected from a number of different locations over a broader area to be representative of the entire area being sampled, or if they are representative of a single location over an extended period of time.

f. If used, preservatives for the individual sample will be noted.

g. The requested analytical method(s) that the samples are being analyzed for must be indicated. As much detail, as necessary, should be presented to allow the analytical laboratory to properly analyze the samples. For example, polychlorinated biphenyl (PCB) analyses may be represented by entering “EPA Method 8082 – PCBs” or “EPA PLM 600-R93-116.” In cases where multiple analytical methods and/or analytical parameters are required for an individual sample, each method should be indicated for the sample (e.g., EPA 8082/8260/8270 or EPA PLM/400-point count).

h. If there are project-specific sample analytes to be reported, they should be specifically listed for each individual sample (e.g., 40 CFR 264 Appendix IX).

i. The total number of containers for each analytical method requested should be documented. This information may be included under the parameter or as a total for the sample.

j. When necessary, note which samples should be used for site specific matrix spikes.

k. Indicate special project-specific requirements pertinent to the handling, shipping, or analyses. These requirements may be on a per sample basis such as “extract and hold sample until notified,” or may be used to inform the laboratory of special reporting requirements for the entire sample delivery group (SDG).

l. Indicate turnaround time (TAT) required for samples on COC. If individual samples have differing TATs, the different TATs for each sample or groups of samples must be clearly indicated.

m. Provide contact name and phone number in the event that problems are encountered when samples are received at the laboratory. The person relinquishing possession of the samples or other member of the project team should contact the final recipient of the samples to confirm receipt and review any special provisions on the COC or questions that they may have.

n. If available, attach the Laboratory Task Order or Work Authorization forms.

o. The “Relinquished By” field must contain the signature of the Arcadis person who relinquished custody of the samples to the next entity in the chain of custody, which may be another person, the shipping courier, or the analytical laboratory.

p. Dates and times must be indicated using the following format:

    1) Date: either mm/dd/yy e.g., 01/01/17 OR mm/dd/yyyy e.g., 01/01/2017

    2) Time: use military format, e.g. 9:30 a.m. is 0930 and 9:30 p.m. is 2130

   q. The “Received By” section is signed by sample courier or laboratory representative who received the samples from the sampler or it is signed upon laboratory receipt from the overnight courier service.

4. When more than one page of the COC form is required to complete the total number of samples, use as many sheets as necessary to accurately and clearly document the samples and information. Some COCs may have a standard first page/cover page, and subsequent pages may not contain all the detailed fields as the first page/cover page. Ensure that any subsequent pages convey all of the necessary and pertinent information for each individual sample as required in this procedure document.
5. Pages of the COC must retain a page count of the total number of pages; e.g., Page 1 of 3, Page 2 of 3, Page 3 of 3.
6. Upon completing the COC forms, forward the original signed COC with the sample package. Ensure that the original COC form is secured with the sample package so that it remains with the physical samples for the duration of transport and handling to its final destination and ensure that the COC form will not be become damaged or rendered unreadable due to sample breakage/leakage if stored inside the sample shipping container or outside influences if COC is stored in an outside plastic pouch to the container.
7. If you’ve collected enough samples that would require more than one container to ship them all to the same laboratory or location, then each separate/individual container that contains any number of samples must have a separate COC representing only those samples contained within that specific container. For example, if you have 3 total shipping containers for all of your samples, you must have a total of 3 separate, individual COCs for each of the 3 containers representing only those samples in their representative container. Thus, every container holding samples must have its own, individual COC.
8. If electronic chain of custody (eCOC) forms are utilized, ensure that the requirements of this procedure and guidance instructions are followed to the extent possible. Verify that proper signature and COC procedures are maintained with the CPM and/or Technical Expert when using eCOC.

8 WASTE MANAGEMENT

Not Applicable.

9 DATA RECORDING AND MANAGEMENT

The original signed COC shall be submitted with the samples. Copies of COC records will be transmitted to the CPM or designee at the end of each day unless otherwise directed by the CPM. The sampling team leader retains copies of the chain of custody forms for filing in the project file. Record retention shall be in accordance with client- and project-specific requirements and Arcadis policies, the most stringent will apply.

10 QUALITY ASSURANCE

COC forms will be legibly completed in accordance with this procedure and guidance instruction document, as well as other applicable and appropriate project documents such as Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), Work Plan, or other project guidance documents.

COC records will be reviewed by the CPM or their appropriate designee for completeness and accuracy to the applicable requirements. Non-conformances will be noted and corrected in a timely manner on the copies retained by Arcadis as well as contacting the ultimate receiving entity for correction to the originally signed COC in their possession.

11 REFERENCES

Arcadis Client Document Retention Guide

Arcadis Transportation Safety Program requirements, procedures, and guidance instructions

EPA Samplers' Guide – Contract Laboratory Program Guidance for Field Samplers, EPA document EPA-540-R014-013 October 2014

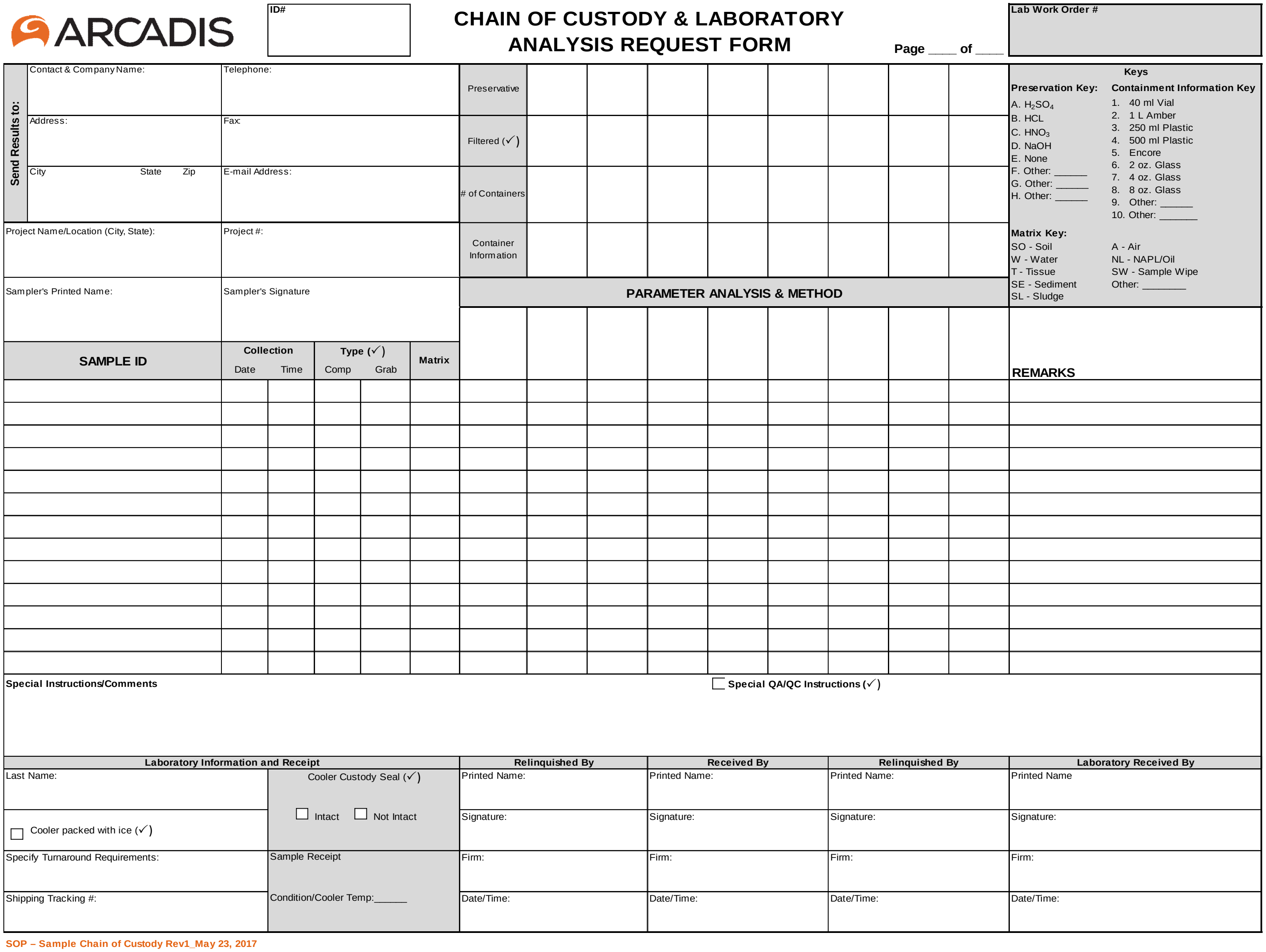
EPA Region III – *Sample Submission Procedures for the Office of Analytical Services and Quality Assurance (OASQA) Laboratory Branch* revision 13.0 January 29, 2014

EPA Region I Office Environmental Measurement and Evaluation – *Standard Operating Procedures for Chain of Custody of Samples* revision 1 March 25, 2002

EPA Region IV Science and Ecosystem Support Division *Operating Procedure for Sample and Evidence Management* January 29, 2013

APPENDIX A

Chain of Custody Form



ARCADIS

ID#

CHAIN OF CUSTODY & LABORATORY ANALYSIS REQUEST FORM

Page ____ of ____

Lab Work Order #

Send Results to:

Contact & Company Name:
Telephone:
Address:
Fax:
City State Zip
E-mail Address:
Project Name/Location (City, State):
Project #:
Sampler's Printed Name:
Sampler's Signature

Preservative									
Filtered (✓)									
# of Containers									
Container Information									

Keys

Preservation Key:
A. H_2SO_4
B. HCL
C. HNO_3
D. NaOH
E. None
F. Other: ______
G. Other: ______
H. Other: ______

Containment Information Key
1. 40 ml Vial
2. 1 L Amber
3. 250 ml Plastic
4. 500 ml Plastic
5. Encore
6. 2 oz. Glass
7. 4 oz. Glass
8. 8 oz. Glass
9. Other: ______
10. Other: _______

Matrix Key:

SO - Soil	A - Air
W - Water	NL - NAPL/Oil
T - Tissue	SW - Sample Wipe
SE - Sediment	Other: ________
SL - Sludge	

PARAMETER ANALYSIS & METHOD

SAMPLE ID	**Collection**		**Type (✓)**		**Matrix**										**REMARKS**
	Date	Time	Comp	Grab											

Special Instructions/Comments

☐ **Special QA/QC Instructions (✓)**

Laboratory Information and Receipt		**Relinquished By**	**Received By**	**Relinquished By**	**Laboratory Received By**
Last Name:	Cooler Custody Seal (✓)	Printed Name:	Printed Name:	Printed Name:	Printed Name
☐ Cooler packed with ice (✓)	☐ Intact ☐ Not Intact	Signature:	Signature:	Signature:	Signature:
Specify Turnaround Requirements:	Sample Receipt	Firm:	Firm:	Firm:	Firm:
Shipping Tracking #:	Condition/Cooler Temp:______	Date/Time:	Date/Time:	Date/Time:	Date/Time:

SOP – Sample Chain of Custody Rev1_May 23, 2017

ARCADIS Design & Consultancy for natural and built assets

TGI - INVESTIGATION-DERIVED WASTE HANDLING AND STORAGE

Rev #: 1

Rev Date: May 15, 2020

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	February 23, 2017	ALL	Conversion from SOP to TGI	Ryan Mattson / Peter Frederick
1	May 15, 2020	ALL	Updated to reflect regulatory changes	

APPROVAL SIGNATURES

Prepared by: Derrick Maurer 02/23/2017

Derrick Maurer Date:

Technical Expert Reviewed by: 05/15/2020

Ryan Mattson (Technical Expert) Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

The objective of this Technical Guidance Instruction (TGI) is to describe the procedures to manage investigation-derived wastes (IDW), both hazardous and nonhazardous, generated during site activities, which may include, but are not limited to: drilling, trenching/excavation, construction, demolition, monitoring well sampling, soil sampling, decontamination and remediation. For the purposes of this TGI, IDW is considered to be discarded materials which are defined as solid waste by United States Environmental Protection Agency (EPA) standard 40 CFR § 261.2 (which may include liquids, solids, or sludges). IDW may include soil, groundwater, drilling fluids, decontamination liquids, as well as contaminated personal protective equipment (PPE), sorbent materials, construction and demolition debris, and disposable sampling materials. Hazardous or uncharacterized IDW will be collected and staged at the point of generation. Quantities small enough to be containerized in 55-gallon drums will be taken to a designated temporary onsite storage area (discussed in further detail under Drum Storage) pending characterization and disposal. IDW materials will be characterized using process knowledge and appropriate laboratory analyses to determine the waste classification and evaluate proper safe handling and disposal methods.

This TGI describes the necessary equipment, field procedures, materials, regulatory references, and documentation procedures necessary for proper handling and storage of IDW up to the time it is properly transported from the project site and disposed. The procedures included in this TGI for handling and temporary storage of IDW are based on the EPA's guidance document *Guide to Management of Investigation Derived Wastes* (USEPA, 1992). IDW is assumed to be contaminated with the site constituents of concern (COCs) until analytical evidence indicates otherwise. IDW will be managed to ensure the protection of human health and the environment and will comply with all applicable or relevant and appropriate requirements (ARAR). Although not comprehensive, the following laws and regulations on Hazardous Waste Management should be considered as potential ARAR. It is the Arcadis Certified Project Manager (CPM) and/or designated Technical Expert to determine which laws and regulations, at all levels of government, are applicable to each project site and activity falling under this TGI.

Federal Laws and Regulations

- Resource Conservation and Recovery Act (RCRA) 42 USC § 6901-6987.
- Federal Hazardous Waste Regulations 40 CFR § 260-265

Department of Transportation (DOT) Hazardous Materials Transportation 49 CFR

Occupational Safety and Health Administration (OSHA) Regulations 29 CFR

State Laws and Regulations

- To be determined based on location of site and location of treatment, storage, and/or disposal facility (TSDF) to be utilized.

Regional, County, Municipal, and Local Regulations

- To be determined based on location of site and location of treatment, storage, and/or disposal facility (TSDF) to be utilized.

Initial Storage

Pending characterization, IDW will be temporarily stored appropriately within each area of contamination (AOC). Under RCRA, "storage" is defined as the "holding of hazardous waste for a temporary period, at the end of which the hazardous waste is treated, disposed of, or stored elsewhere" (40 CFR § 260.10). The onsite waste staging area will be in a secure and controlled area. Uncharacterized wastes are considered potentially hazardous wastes and must be stored in DOT approved packaging. Liquid wastes must be stored in DOT approved closed head drums or other approved containers (e.g., portable tank containers) that are compatible with the type of material stored therein. Solid materials must be stored in DOT approved open head drums where practicable. Larger quantities of solid IDW can be containerized in bulk containers (such as in a roll-off box). Soil from large excavation projects may be managed in stockpiles with within the AOC and does not need to be containerized until exiting the AOC.

Characterization

Waste characterization can either be based on generator knowledge, such as using historical process knowledge and safety data sheets (SDS), or can be based upon characterization sampling analytical results. IDW typically is not characterized using SDS as it is a mixture of aged chemicals and environmental media. Historical process knowledge should be used to determine if the IDW is a listed hazardous waste (40 CFR § 261.31-33). If the IDW is not a listed hazardous waste, waste characterization can be completed by laboratory analysis of representative samples of the IDW. The laboratory used for waste characterization analysis must have the appropriate state and federal accreditations and may be required to be pre-approved by the Client. IDW will be classified as RCRA hazardous or non-regulated under RCRA based on the waste characterization determination.

If IDW is characterized as RCRA hazardous waste, RCRA and DOT requirements must be followed for packaging, labeling, transporting, storing, and record keeping as described in 40 CFR § 262 and 49 CFR § 171-178. Waste material classified as RCRA nonhazardous may be handled and disposed of as nonhazardous waste in accordance with applicable federal, state, and local regulations.

Storage Time Limitations

Containerized hazardous wastes can be temporarily stored for a maximum of 90 calendar days from the accumulation start date for a large quantity generator or a maximum of 180 calendar days from the accumulation start date for a small quantity generator. Wastes classified as nonhazardous may be handled and disposed of as nonhazardous waste and are not subject to storage time limitations.

This is TGI may be modified by the CPM and/or Technical Expert for a specific project or client program, as required, dependent upon client requirements, site conditions, equipment limitations, or limitations imposed by the procedure. The resulting procedure employed to execute the work will be documented in the project work plans or reports. If changes to the sampling procedures are required due to unanticipated field conditions, the changes will be discussed with the CPM and/or Technical Expert as soon as practicable, and if approved to be performed, be documented.

3 PERSONNEL QUALIFICATIONS

Arcadis field sampling personnel will have current regulatory- and Arcadis-required health and safety training including 40-hour HAZWOPER training, site supervisor training, site-specific training, first aid, and cardiopulmonary resuscitation (CPR), as needed. Personnel handling and packaging hazardous waste and performing hazardous waste characterizations must have RCRA hazardous waste management training per 40 CFR § 264.16. Additional state-specific hazardous waste management training is required in certain states (i.e., California).

Although not common practice, in certain situations Arcadis personnel may sign waste profiles and/or waste manifests on a case by case basis for clients, provided the appropriate agreement is in place between Arcadis and the client documenting that Arcadis is not the generator, but is acting as an authorized representative of the generator. Arcadis personnel who sign waste profiles and/or waste manifests will have both current RCRA hazardous waste management training per 40 CFR § 264.16 and current DOT hazardous materials transportation training per 49 CFR § 172.704. Arcadis field personnel will also comply with client-specific training. In addition, Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and Technical Guidance Instructions (TGIs) and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. The project health and safety plan (HASP) and other documents will identify other training requirements or access control requirements.

4 EQUIPMENT LIST

The Following Materials, as required, will be available for IDW handling and Storage:

- Appropriate personal protective equipment as specified in the Site Health and Safety Plan (HASP)
- DOT approved containers
- Hammer
- Leather gloves
- Drum dolly
- Appropriate drum labels (outdoor waterproof self-adhesive)
- Portable tank container
- Appropriate labeling, packing, chain-of-custody forms, and shipping materials as determined by the CPM and/or Technical Expert.
- Indelible ink and/or permanent marking pens
- Plastic sheeting
- Appropriate sample containers, labels, and forms
- Stainless-steel bucket auger
- Stainless steel spatula or knife
- Stainless steel hand spade
- Stainless steel scoop
- Digital camera
- Field logbook

5 CAUTIONS

Filled drums can be very heavy, become unbalanced, or spill its contents. Therefore, use appropriate moving techniques and equipment for safe handling. Similar media (e.g. soils with other soils; or liquids with other liquids) will be stored in the same drums to aid in sample analysis and disposal. Drum lids must be secured to prevent rainwater from entering the drums and leakage during movement. Drums containing solid material may not contain any free liquids. Waste containers stored for extended periods of time may be subject to deterioration. Drum Over Packs may be used as secondary containment. All drums must be visually inspected for condition to ensure that they are in good condition without visible evidence of rusting, holes, breakage, etc., to prevent potential leakage and facilitate subsequent disposal. All drum lids must be verified as having a properly functioning secured lid prior to use.

6 HEALTH AND SAFETY CONSIDERATIONS

As determined by the site's known and suspected hazards, appropriate PPE must be worn by all field personnel within the designated work area. Exposure air monitoring may be required during certain field activities as required in the Site Health and Safety Plan. If soil excavation in areas with potentially hazardous contaminants is possible, contingency plans will be developed to address the potential for encountering gross contamination or non-aqueous phase liquids. All excavation activities shall be in compliance with OSHA standard 29 CFR 1926.651 Excavations, and any other applicable regulations.

Arcadis field personnel and subcontractors will be trained in and perform their work in compliance with all applicable federal, state, and local health and safety regulations as well as Arcadis' HASP and applicable Client health and safety requirements.

7 PROCEDURE

Specific waste temporary storage and handling procedures to be used are dependent upon the type of generated waste, including type of media (e.g. soils or free liquids) and constituents of concern. For this reason, IDW can be stored in a secure location onsite in separate 55-gallon storage drums, where solids can be stockpiled onsite (if nonhazardous) and purge water may be stored in portable tank containers. Waste materials such as broken sample bottles or equipment containers and wrappings will be stored in 55-gallon drums unless they were not in contact with sample media.

Management of IDW

Minimization of IDW should be considered by the project team during all phases of the project. Site managers may want to consider techniques such as replacing solvent based cleaners with aqueous-based cleaners for decontamination of equipment, reuse of equipment (where it can be properly decontaminated), limitation of traffic between exclusion and support zones, and drilling methods and sampling techniques that minimize the generation of waste. Alternative drilling and subsurface sampling methods may include the use of small diameter boreholes, as well as borehole testing methods such as a core penetrometer or direct push technique instead of coring.

Drum Storage

Drums containing hazardous waste will be stored in accordance with the requirements of 40 CFR 265 Subpart I (for containers) and 265 Subpart DD (for containment buildings). All 55-gallon drums will be stored at a secure, centralized onsite location that is readily accessible for vehicular pick-up. Drums confirmed as, or assumed to contain hazardous waste will be stored over an impervious surface provided with secondary spill containment. The storage location will, for drums containing liquid, have a containment system that can contain at least the larger of 10% of the aggregate volume of staged materials or 100% of the volume of the largest container. Drums will be closed during storage and be in good condition in accordance with the Guide to Management of Investigation-Derived Wastes (USEPA, 1992).

Hazardous Waste Determination

Waste material must be characterized to determine if it meets any of the federal definitions of hazardous waste as required by 40 CFR § 262.11. If the waste does not meet any of the federal definitions, it must then be established if any state-specific or local-specific hazardous waste criteria exist/apply.

Generator Status

Once hazardous waste determination has been made, the generator status will be determined. Large quantity generators (LQG) are generators who generate more than 1,000 kilograms of hazardous waste in a calendar month. Small quantity generators (SQG) of hazardous waste are generators who generate greater than 100 kilograms but less than 1,000 kilograms of hazardous waste in a calendar month. Very small quantity generators (VSQG) are generators who generate less than 100 kilograms of hazardous waste per month. Please note that a generator status may change from month to month and that a notice of this change is usually required by the generator's state agency.

Accumulation Time for Hazardous Waste

A LQG may accumulate hazardous waste on site for 90 calendar days or less without a permit and without having interim status, provided that such accumulation is in compliance with requirements in 40 CFR § 262.17. A SQG may accumulate hazardous waste on site for 180 calendar days or less without a permit or without having interim status, subject to the requirements of 40 CFR § 262.16. VSQG requirements are found in 40 CFR § 262.14. NOTE: The federal VSQG and SQG provisions may not be recognized by some states (e.g., California and Rhode Island). State-specific and local-specific regulations must be reviewed and understood prior to the generation of hazardous waste.

Satellite Accumulation of Hazardous Waste Satellite accumulation (SAA) will mean the accumulation of as much as fifty-five (55) gallons of hazardous waste, or the accumulation of as much as one quart of acutely hazardous waste, in containers at or near any point of generation where the waste initially accumulates, which is under the control of the operator of the process generating the waste, without a permit or interim status and without complying with the requirements of 40 CFR § 262.15 and without any storage time limit, provided that the generator complies with 40 CFR § 262.15.

Once more than 55 gallons of hazardous waste accumulates in SAA, the generator has three days to move this waste into storage.

Storage recommendations for hazardous waste include:

- Ignitable or reactive hazardous wastes must be >50 feet from the property line per 40 CFR § 265.176 (LQG generators only).
- Hazardous waste should be stored on a concrete slab (asphalt is acceptable if there are no free liquids in the waste).
- Drainage must be directed away from the accumulation area.
- Area must be properly vented.
- Area must be secure.

Drum/Container Labeling

Drums will be labeled on both the side and lid of the drum using a permanent marking pen. Old drum labels must be removed to the extent possible, descriptions crossed out should any information remain, and new labels affixed on top of the old labels. Other containers used to store various types of waste (e.g., polyethylene tanks, roll-off boxes, end-dump trailers, etc.) will be labeled with an appropriate "Waste Container" or “Testing in Progress” label pending characterization. Drums and containers will be labeled as follows:

- Appropriate waste characterization label (Pending Analysis, Hazardous, or Nonhazardous)
- Waste generator's name (e.g., client name)
- Project Name
- Name and telephone number of Arcadis project manager
- Composition of contents (e.g., used oil, acetone 40%, toluene 60%)
- Media (e.g., solid, liquid)
- Accumulation start date

- Drum number of total drums as reconciled with the Drum Inventory maintained in the field log book.

IDW containers will remain closed except when adding or removing waste. Immediately upon beginning to place waste into the drum/container, a “Waste Container” or “Pending Analysis” label will be filled out to include the information specified above, and affixed to the container. Once the contents of the container are identified as either non-hazardous or hazardous, the following additional labels will be applied.

- Containers with waste determined to be non-hazardous will be labeled with a green and white "Nonhazardous Waste" label over the "Waste Container" label.
- Containers with waste determined to be hazardous will be stored in an onsite storage area and will be labeled with the "Hazardous Waste" label and affixed over the "Waste Container" label.

The ACCUMULATION DATE for the hazardous waste is the date the waste is first placed in the container and is the same date as the date on the "Waste Container" label. DOT hazardous class labels must be applied to all hazardous waste containers for shipment offsite to an approved disposal or recycling facility. In addition, a DOT proper shipping name will be included on the hazardous waste label. The transporter should be equipped with the appropriate DOT placards. However, placarding or offering placards to the initial transporter is the responsibility of the generator per 40 CFR § 262.33.

Inspections and Documentation

All IDW will be documented as generated on a Drum Inventory Log maintained in the field log book. The Drum Inventory will record the generation date, type, quantity, matrix and origin (e.g., Boring-1, Test Pit 3, etc.) of materials in every drum, as well as a unique identification number for each drum. The drum inventory will be used during drum pickup to assist with labeling of drums. The drum storage area and any other areas of temporarily staged waste, such as soil/debris piles, will be inspected weekly. The weekly inspections will be recorded in the field notebook or on a Weekly Inspection Log. Digital photographs will be taken upon the initial generation and drumming/staging of waste, and final labeling after characterization to document compliance with labeling and storage protocols, and condition of the container. Evidence of damage, tampering or other discrepancy should be documented photographically.

Emergency Response and Notifications

Specific procedures for responding to site emergencies will be detailed in the HASP. If the generator is designated as a LQG, a Contingency Plan will need to be prepared to include emergency response and notification procedures per 40 CFR § 265 Subpart D. In the event of a fire, explosion, or other release which could threaten human health outside of the site or when Client or Arcadis has knowledge of a spill that has reached surface water, Client or Arcadis must immediately notify the National Response Center (800-424-8802) in accordance with 40 CFR § 262.265. Other notifications to state and/or other local regulatory agencies may also be necessary.

Drilling Soil Cuttings and Muds

Soil cuttings are solid to semi-solid soils generated during trenching activities, subsurface soil sampling, or installation of monitoring wells. Depending on the drilling method, drilling fluids known as "muds" may be used to remove soil cuttings. Drilling fluids flushed from the borehole must be directed into a settling section of a mud pit. This allows reuse of the decanted fluids after removal of the settled sediments. Soil cuttings will be labeled and stored in 55-gallon drums with bolt-sealed lids.

Excavated Solids

Excavated solids may include, but are not limited to: soil, fill, and construction and demolition debris. Prior to permitted treatment or offsite disposal, potentially hazardous excavated solids may be temporarily stockpiled onsite as long as the stockpile remains in the same AOC from where it was excavated. Potentially hazardous excavated solids removed from the AOC must be immediately containerized in labeled drums or closable top roll-offs lined with 9-mil polyvinyl chloride (PVC) sheeting and are subject to LQG storage time limits. Nonhazardous excavated solids can be stockpiled either inside or outside of the AOC, do not have to be containerized and are not subject to hazardous waste regulations. Potentially hazardous excavated solids must not be mixed with nonhazardous excavated solids. All classes of excavated solid stockpiles should be maintained in a secure area onsite. At a minimum, the floor of the stockpile area will be covered with a 20-mil high density polyethylene liner that is supported by a foundation or at least a 60-mil high density polyethylene liner that is not supported by a foundation. The excavated material will not contain free liquids. The owner/operator will provide controls for windblown dispersion, run-on control, and precipitation runoff. The run-on control system will prevent flow onto the active portion of the pile during peak discharge from at least a 25-year storm and the run-off management system will collect and control at least the water volume resulting from a 24-hour, 25-year storm (USEPA, 1992). Additionally, the stockpile area will be inspected on a weekly basis and after storm events. Individual states may require that the stockpile be inspected/certified by a licensed professional engineer. Stockpiled material will be covered with a 6-mil polyvinyl chloride (PVC) liner or sprayed dust control product. The stockpile cover will be secured in place with appropriate material (concrete blocks, weights, etc.) to prevent the movement of the cover.

Decontamination Solutions

Decontamination solutions are generated during the decontamination of personal protective equipment and sampling equipment. Decontamination solutions may range from detergents, organic solvents and acids used to decontaminate small field sampling equipment to steam cleaning rinsate used to wash heavy field equipment. These solutions are to be labeled and stored in closed head drums compatible with the decontamination solution. Decontamination procedures, including personnel and field sampling equipment, must comply with applicable Arcadis procedural documents.

Disposable Equipment

Disposable equipment includes personal protective equipment (e.g., tyvek coveralls, gloves, booties and APR cartridges) and disposable sampling equipment such as trowels or disposable bailers. If the media sampled exhibits hazardous characteristics per results of waste characterization sampling, contaminated disposable equipment will also be disposed of as a hazardous waste. If compatible with the original IDW waste stream (i.e., the IDW is a solid and the disposal equipment is a solid), the disposable equipment can be combined with the IDW. If these materials are not compatible (i.e., the IDW is a liquid and the disposal equipment is a solid), the disposable equipment will be stored onsite in separate labeled 55-gallon drums. Uncontaminated or decontaminated disposable equipment can be considered nonhazardous waste.

Purge Water

Purge water includes groundwater generated during well development, groundwater sampling, or aquifer testing. The volume of groundwater generated will dictate the appropriate storage procedure. Monitoring well development and groundwater sampling may generate three well volumes of groundwater or more. This volume will be stored in labeled 55-gallon drums. Aquifer tests may generate significantly greater volumes of groundwater depending on the well yield and the duration of the test. Therefore, large-volume portable polyethylene tanks will be considered for temporary storage pending groundwater-waste characterization.

Purged Water Storage Tank Decontamination and Removal

The following procedures will be used for inspection, cleaning, and offsite removal of storage tanks used for temporary storage of purge water. These procedures are intended to be used for rented portable tanks such as Baker Tanks or Rain for Rent containers. Storage tanks will be made of inert plastic materials. The major steps for preparing a rented tank for return to a vendor include characterizing the purge water, disposing of the purge water, decontaminating the tank, final tank inspection, and mobilization. Decontamination and inspection procedures are described in further detail below.

- Tank Cleaning: Most vendors require that tanks be free of any visible sediment and water before returning, a professional cleaning service may be required. Each specific vendor should be consulted concerning specific requirements for returning tanks.
- Tank Inspection: After emptying the tank, purged water storage tanks should be inspected for debris, chemical staining, and physical damage. The vendors require that tanks be returned in the original condition (i.e., free of sediment, staining and no physical damage).

8 WASTE MANAGEMENT

Soil/Solids Characterization

Waste characterization will be conducted in accordance with waste hauler, waste handling facility, and local/state/federal requirements. In general, RCRA hazardous wastes are those solid wastes determined by a Toxicity Characteristic Leaching Procedure (TCLP) test or to contain levels of certain toxic metals, pesticides, or other organic chemicals above specific applicable regulatory agency thresholds. If the one or more of 40 toxic compounds listed in Table I of 40 CFR § 261.24 are detected in the sample at levels above the maximum unregulated concentrations, the waste must be characterized as a toxic hazardous waste. Wastes can also be considered “listed” hazardous waste depending on site-specific processes.

Composite soil samples will be collected at a frequency of one sample per 250 cubic yard basis for stockpiled soil or one per 55-gallon drum per different waste stream for containerized. A four-point composite sample will be collected per 250 cubic yards of stockpiled material and for each drum waste stream. Sample and composite frequencies may be adjusted in accordance with the waste handling facility’s requirements and may be reduced for large volumes of waste with consistent properties. Waste characterization samples will be considered valid for consistent waste streams for a period of 1 year. Waste characterization samples may be analyzed for the TCLP volatile organic compounds (VOCs), TCLP semi-volatile organic compounds (SVOCs), TCLP RCRA metals, and polychlorinated biphenyls (PCBs), as well as reactivity and flammability (flashpoint). Additional samples may be collected and analyzed by the laboratory on a contingency basis. Site-specific constituents of concern including pesticides may require additional sampling. Please note that state- or local-specific regulations may require a different or additional sampling approaches.

Wastewater Characterization

Waste characterization will be conducted in accordance with the requirements of the waste hauler, waste handling facility, and local/state/federal governments. In general, purge water should be analyzed by methods appropriate for the known contaminants, if any, that have been historically detected in the monitoring wells. Samples will be collected and analyzed in accordance with the requirements of the waste disposal facility. Wastewater characterization samples may be analyzed for TCLP volatile organic compounds (VOCs), TCLP semi-volatile organic compounds (SVOCs), TCLP RCRA metals, and polychlorinated biphenyls, as well as corrosivity (pH), reactivity and flammability (flashpoint). Additional samples may be collected and analyzed by the laboratory on a contingency basis. Site-specific constituents of concern including pesticides may require additional sampling. Please note that state- and/or local-specific regulations may require different or additional sampling approaches.

Sample Handling and Shipping

All samples will be appropriately labeled, packed, and shipped, and the chain-of-custody will be filled out in accordance with current Arcadis sample chain of custody, handling, packing, and shipping procedures and guidance instructions.

It should be noted that additional training is required for packaging and shipping of hazardous and/or dangerous materials. Please refer to the current Arcadis training requirements related to handling and shipping of samples, shipping determinations, and hazardous materials.

Preparing Waste Shipment Documentation (Hazardous and Nonhazardous)

Waste profiles will be prepared by the Arcadis CPM and forwarded, along with laboratory analytical data to the Client for approval/signature. The Client will then return the profile to Arcadis who will then forward to the waste removal contractor for preparation of a manifest. The manifest will be reviewed by Arcadis prior to forwarding to the Client for approval. Upon approval of the manifest, the Client will return the original signed manifest directly to the waste contractor or to the Arcadis CPM for forwarding to the waste contractor. Arcadis personnel may sign waste profiles and/or waste manifests on a case by case basis for clients, provided the appropriate agreement is in place between Arcadis and the client documenting that Arcadis is not the generator, but is acting as an authorized representative of the generator.

Final drum labeling and pickup will be supervised by an Arcadis representative who is trained and experienced with applicable waste labeling procedures. The Arcadis representative will have a copy of the drum inventory maintained in the field book and will reconcile the drum inventory with the profile numbers on the labels and on the manifest. Different profile numbers will be generated for different matrices or materials in the drums. For example, the profile number for drill cuttings will be different than the profile number for purge water. When there are multiple profiles it is critical that the proper label, with the profile number appropriate to a specific material be affixed to the proper drums. A copy of the Arcadis drum inventory will be provided to the waste transporter during drum pickup and to the facility receiving the waste.

9 DATA RECORDING AND MANAGEMENT

Waste characterization sample handling, packing, and shipping procedures will be documented in accordance with relevant Arcadis procedures and guidance instructions as well as applicable client and/or project requirements, such as a Quality Assurance Project Plan or Sampling and Analysis Plan. Copies of the chain-of-custody forms will be maintained in the project file. Arcadis should photograph or maintain a copy of any hazardous waste manifest signed on behalf of Client in the corresponding office DOT record file.

10 QUALITY ASSURANCE

The CPM or APM will review all field documentation once per week for errors or omissions as compared to applicable project requirements including but not limited to: the proposal/scope of work, QAPP, SAP, HASP, etc. Deficiencies will be noted, tracked, and resolved. Upon correction, they will be noted for project documentation.

11 REFERENCES

United States Environmental Protection Agency (USEPA). 1992. Guide to Management of Investigation-Derived Wastes. Office of Remedial and Emergency Response. Hazardous Site Control Division. January 1992.

ARCADIS Design & Consultancy for natural and built assets

TGI – GROUNDWATER AND SOIL SAMPLING EQUIPMENT DECONTAMINATION

Rev: 1

Rev Date: May 8, 2020

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	February 23, 2017	ALL	Conversion from SOP to TGI	Cassandra McCloud / Pete Frederick
1	May 8, 2020	4-5	Added note regarding use of Liquinox and 1,4-Dioxane	Marc Killingstad

APPROVAL SIGNATURES

Prepared by: Derrick Maurer Date: 02/23/2017

Derrick Maurer

Technical Expert Reviewed by: Date: May 8, 2020

Marc Killingstad (Technical Expert)

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2 SCOPE AND APPLICATION

Decontamination is performed on sampling equipment prior to sample collection to ensure that the sampling equipment that contacts a sample, or monitoring equipment that is brought into contact with environmental media to be sampled, is free from analytes of interest and/or constituents that could interfere with laboratory analysis for analytes of interest. Sampling equipment must be appropriately cleaned prior to use for sampling or coming into contact with environmental media to be sampled, and following completion of the sampling event prior to shipment or storage. The effectiveness of the decontamination procedure should be verified by collecting and analyzing equipment blank samples.

The sampling equipment cleaning procedures described herein includes pre-field, in the field, and post-field cleaning of sampling equipment which may be conducted at an established equipment decontamination area (EDA) on site, as appropriate and necessary. Sampling equipment that may require decontamination at a given site includes: soil sampling tools; groundwater, sediment, and surface-water sampling devices; water testing instruments; down-hole instruments; and other activity-specific sampling equipment. Non-disposable equipment will be cleaned before collecting each sample, between each sample collected, and prior to placing sampling equipment in protective cases, or containers for transport. Cleaning procedures for sampling equipment should be monitored by collecting equipment blank samples as required in project work plans, field sampling plans, quality assurance project plans (QAPP), or other pertinent project documents. Dedicated and/or single-use (i.e., not to be re-used) sampling equipment will not require decontamination.

3 PERSONNEL QUALIFICATIONS

Arcadis field sampling personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or regulations, such as 40-hour HAZWOPER training and/or OSHA HAZWOPER site supervisor training. Arcadis personnel will also have current training as specified in the Health and Safety Plan (HASP) which may include first aid, cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed. In addition, Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and Technical Guidance Instructions (TGIs) and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. The project health and safety plan (HASP) and other documents will identify other training requirements or access control requirements.

4 EQUIPMENT LIST

The equipment required for equipment decontamination is presented below:

- Health and safety equipment, including appropriate PPE, as required in the site Health and Safety Plan (HASP)
- Deionized water that meets that analytical criteria for deionized water with no detectable constituents above the reporting limits for the methods to be used and analytes being analyzed for. Deionized water is used for inorganics, and organic-free water for VOCs, SVOCs, pesticides, etc.
- Non-phosphate detergent such as Alconox or, if sampling for phosphorus or phosphorus-containing compounds, Liquinox (or equivalent). NOTE: *Liquinox has shown to provide false positives for 1,4-Dioxane and should not be used at sites where that may be a constituent of concern (COC).*
- Tap water
- Rinsate collection plastic containers
- DOT-approved waste shipping container(s), as specified in the work plan, field sampling plan, or regulatory requirements if decontamination waste is to be shipped for disposal
- Brushes
- Large heavy-duty garbage bags
- Spray bottles

- (Optional) – Isopropyl alcohol (free of ketones) or methanol. These can be wipes or diluted with water (usually 1part isopropyl/methanol to 10 parts water) if a spray is needed.
- Airtight, sealable plastic baggies, such as Ziploc-type
- Plastic sheeting

5 CAUTIONS

Rinse equipment thoroughly and allow the equipment to dry before re-use or storage to prevent introducing solvent into sample medium. If manual drying of equipment is required, use clean lint-free material to wipe the equipment dry. Ensure all rinsate materials do not adversely affect sample collection efficiency or analytical results.

Store decontaminated equipment in a clean, dry environment. Do not store near combustion engine exhausts. Properly containerize equipment to ensure cross-contamination doesn't happen from other uncontaminated surfaces or equipment.

If equipment is damaged to the extent that decontamination is uncertain due to cracks, gouges, crevices, or dents, the equipment should not be used and should be discarded or submitted for repair prior to use for sample collection.

A proper shipping determination regarding hazardous materials will be performed by a DOT-trained individual for cleaning materials shipped by Arcadis.

Caution should be exercised to avoid contact with the pump casing and water in the container while the pump is running (do not use metal drums or garbage cans) to avoid electric shock.

6 HEALTH AND SAFETY CONSIDERATIONS

Review the safety data sheets (SDS) for the cleaning agents and materials used in decontamination. If solvent is used during decontamination, use appropriate PPE and work in a well-ventilated area and stand upwind while applying solvent to equipment. Apply solvent in a manner that minimizes potential for exposure to workers and bystanders. Follow health and safety procedures outlined in the HASP.

7 PROCEDURE

A designated area will be established to clean sampling equipment in the field prior to and following sample collection. Equipment cleaning areas will be set up within or adjacent to the specific work area, but not at a location that expose equipment to contamination (i.e. exposed to combustion engine exhaust). Detergent solutions will be prepared in clean containers for use in equipment decontamination. Decontaminated equipment should be handled by workers wearing clean gloves, properly changed to prevent cross-contamination.

Cleaning Sampling Equipment

1. Wash the equipment/pump with potable water.

2. Wash with detergent solution (Alconox, Liquinox or equivalent) to remove all visible particulate matter and any residual oils or grease. NOTE: *Liquinox has shown to provide false positives for 1,4-Dioxane and should not be used at sites where that may be a constituent of concern (COC).*

3. If equipment is very dirty, precleaning gross debris with a brush and tap water may be necessary.

4. If non-aqueous phase liquids are present, the use of isopropyl alcohol (free of ketones) or methanol is recommended. Cloth wipes or diluted solution can be used to remove the non-aqueous phase liquids that are hard to remove with detergent solution in step 2. Consult with project manager if non-aqueous phase liquids are present onsite and design an appropriate decontamination procedure that includes step 4.

5. Rinse with deionized water.

Decontaminating Submersible Pumps

Submersible pumps may be used during well development, groundwater sampling, or other investigative activities. The pumps must be cleaned and flushed before and between uses. This cleaning process will consist of an external detergent solution wash and tap water rinse, a flush of detergent solution through the pump, followed by a flush of potable water through the pump. Flushing will be accomplished by using an appropriate container filled with detergent solution and another container filled with potable water. The pump should be flushed with deionized water as the last step prior to use. The pump will run long enough to effectively flush the pump housing and hose (unless new, disposable hose is used). Disconnect the pump from the power source before handling. The pump and hose should be placed on or in clean polyethylene sheeting to avoid contact with the ground surface.

8 WASTE MANAGEMENT

Equipment decontamination rinsate will be managed in conjunction with all other waste produced during the field sampling effort. Waste management procedures are outlined in the work plan or Waste Management Plan (WMP).

9 DATA RECORDING AND MANAGEMENT

Equipment cleaning and decontamination will be noted in the field notebook for project documentation. Information will include the type of equipment cleaned, the decontamination location, specific procedures utilized, solvents and/or cleaning agents used, source of water, and deviations or omissions from this TGI.

Unusual field conditions should be noted if there is potential to impact the efficacy of the decontamination or subsequent sample collection.

An inventory of the solvents brought on site and used and removed from the site will be maintained in the project documentation. Records will be maintained for solvents used in decontamination, including lot number and expiration date.

Containers with decontamination fluids will be labeled.

10 QUALITY ASSURANCE

Equipment blanks should be collected to verify that the decontamination procedures are effective in minimizing potential for cross contamination. The equipment blank is prepared by pouring deionized water (or organic-free water, for organic analyses) over the clean and dry tools and collecting the water into appropriate sample containers. Equipment blanks should be analyzed for the same set of parameters that are performed on the field samples collected with the equipment that was cleaned as specified in the sampling and analysis plan. Equipment blanks are collected per equipment set, which represents all of the tools needed to collect a specific sample.

11 REFERENCES

USEPA Region 9 - Field Sampling Guidance #1230, Sampling Equipment Decontamination.

USEPA Region 1 - Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells.

TECHNICAL GUIDANCE INSTRUCTION - MONITORING WELL DEVELOPMENT

Rev: #0

Rev Date: April 24, 2017

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	4/24/2017	All	Re-written as TGI	Marc Killingstad

APPROVAL SIGNATURES

Prepared by: Jay Erickson — Date: 4/24/2017

Technical Expert Reviewed by: Marc Killingstad — Date: 4/24/2017

1 INTRODUCTION

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2 SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) covers the development of screened wells used for obtaining representative groundwater information and samples from granular aquifers (i.e., monitoring wells). Note that this TGI only applies to monitoring well development and not remediation (injection/extraction) well development.

The purposes of Monitoring Well Development are:

1. Repair damage to the borehole wall from drilling that can include clogging, smearing or compaction of aquifer materials;
2. Remove fine grained sediment from the formation and filter pack that may result in high turbidity levels in groundwater samples;
3. To re-sort formation and filter pack material adjacent to the well screen;

4. To recover any drilling fluids (if used) that may affect the permeability of the formation and filter pack or alter the water quality around the well; and
5. To optimize the well efficiency and hydraulic communication between the well screen and the formation.

Successful monitoring well development is dependent on the following:

1. Hydrostratigraphy – Permeable formations containing primarily sand and gravel are more easily developed due to lower percentages of silt and clay material. Water in permeable formations can be moved in and out of the screen and/or through the formation easier than in less permeable deposits
2. Well Diameter – Development tooling including brushes, surge blocks, pumps and jetting tools are more readily available for wells 4 inches in diameter and greater.
3. Well Design – Wells with filter packs and screens designed to match the formation through the analysis of formation sieve samples are easier to develop. An important aspect to well design is to minimize the size of the annular space between the formation and well screen. Adequate room must be allowed for the proper installation of well materials, but not too large as to prevent/reduce communication with the surrounding formation.
4. Drilling Methods – Different drilling methods result in varying amount of borehole damage and, therefore, impact the degree to which development will be successful.

Well development methods for monitoring wells include the following:

1. Bailing – use of a bailer to remove water and sediment from the well casing. This technique does little to remove fines from the filter pack and may lead to bridging of sediment since the flow in only in one direction, toward the well screen.
2. Pumping/overpumping – use of a pump to remove water and sediment from the well casing, overpumping involves pumping the well at a rate that exceeds the design capacity of the well. Similar to bailing, this technique does little to remove fines from the filter pack and may lead to bridging of sediment since the flow in only in one direction, toward the well screen. Small diameter monitoring wells have the additional constraint on pump size and flow rates.
3. Backwashing (rawhiding) – consists of starting and stopping a pump intermittently to produce rapid pressure changes in a well. This method can produce better results than pumping alone since the procedure involves movement of the water in and out of the screen and formation. However, in many cases the surging action is not rigorous enough to fully develop the well.
4. Surging/swabbing – use of a mechanical surge block or swabbing tool to operate like a piston with an up and down motion. The downstroke causes a backwash action that breaks up bridged sediment and the upstroke pulls the dislodged sediment into the well. This method works well for small and large diameter wells. Care should be taken on the downstroke so as not to force fines back into the formation, frequent pumping/purging during surging help to keep fines out of the well. Double surge blocks are recommended.
5. Jetting – use of a tool fitted with nozzles that direct streams of water horizontally into well screens at high velocity. Due to the size of the tooling, this method is better suited for wells 4 inch in diameter and larger. The method is also more effective with wire-wrapped/continuous slot screens due to the

increased open area. Jetting requires specialized equipment and concurrent pumping to prevent reintroducing fines into the filter pack. Additionally, jetting requires subsequent surging to remove fines dislodged in the filter pack and formation.

For most situations, gentle surging coupled with bailing or pumping to remove dislodged materials is recommended.

Well development for properly designed and constructed monitoring wells may begin after the annular seal materials have been installed and allowed to cure, since these wells are designed to retain 90-99% of the filter pack material. This cure time is typically at least 24 to 48 hours after the sealing materials have been installed.

This TGI is meant to provide a general guide for proper monitoring well development. A site-specific field implementation plan for well installation and development detailing the specific methods and tools should be developed to provide site-specific instruction and guidance.

3 PERSONNEL QUALIFICATIONS

Monitoring well development activities will be performed by persons who have been trained in proper well development procedures under the guidance of an experienced field geologist, engineer, or technician.

4 EQUIPMENT LIST

Required equipment depends on the selected method and should be detailed in the site-specific field implementation plan. However, the following are typically required.

- Health and safety equipment, as required by the site Health and Safety Plan (HASP):
- Cleaning equipment
- Field notebook and/or personal digital assistant (PDA)
- Monitoring well keys
- Water level indicator
- Field parameter meter (YSI)
- Well Development Logs
- Well construction logs/diagrams
- Weighted tape (measure depth)
- Turbidity meter
- Camera
- Watch/timing device.

5 CAUTIONS

Where surging is performed to assist in removing fine-grained material from the sand pack, surging must be performed in a gentle manner. Excessive suction could promote fine-grained sediment entry into the outside of the sand pack from the formation.

Avoid using development fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

In some cases, it may be necessary to add potable water to a well to allow surging and development, especially for new monitoring wells installed in low permeability formations. Before adding potable water to a well, the Certified Project Manager (CPM) and/or Project Hydrogeologist must be notified and the CPM shall make the decision regarding the appropriateness and applicability of adding potable water to a well during well development procedures. If potable water is to be added to a well as part of development, the potable water source should be sampled and analyzed for constituents of concern, and the results evaluated by the CPM prior to adding the potable water to the well. If potable water is added to a well for development purposes, at the end of development the well will be purged dry to remove the potable water, or if the well no longer goes dry then the well will be purged to remove at least three times the volume of potable water that was added.

6 HEALTH AND SAFETY CONSIDERATIONS

Field activities associated with monitoring well development will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

7 PROCEDURE

As indicated above, for most monitoring wells, gentle surging coupled with bailing or pumping to remove dislodged sediment is recommended.

1 Ensure sufficient time has passed to allow for proper curing of the well seal.

2 Don appropriate PPE (as required by the site-specific HASP).

3 Place plastic sheeting around the well.

4 Clean all equipment entering each monitoring well, except for new, disposable materials that have not been previously used.

5 Open the well cover while standing upwind of the well, remove well cap. Insert PID probe approximately 4 to 6 inches into the casing or the well headspace and cover with gloved hand. Record the PID reading in the field notebook. If the well headspace reading is less than 5 PID units, proceed; if the headspace reading is greater than 5 PID units, screen the air within the breathing zone. If the PID reading in the breathing zone is below 5 PID units, proceed. If the PID reading is above 5 PID units, move upwind from well for 5 minutes to allow the volatiles to dissipate. Repeat the breathing zone test. If the reading is still above 5 PID units, don the appropriate respiratory protection in accordance with the requirements of the HASP. Record all PID readings.

6 Obtain an initial measurement of the depth to water and the total well depth from the reference point at the top of the well casing. Record these measurements in the field log book. It is recommended to use a weighted tape for the total well depth measurement.

7 The depth to the bottom of the well should be sounded and then compared to the completion form or construction diagram for the well. Any discrepancies should be reported immediately to the CPM and/or Project Hydrogeologist. If sand or sediment is present inside the well, it should first be removed by bailing. Do not insert bailers, pumps, or surge blocks into the well if obstructions, parting of the casing, or other damage to the well is suspected. Instead report the conditions to the CPM and/or Project Hydrogeologist and obtain approval to continue or cease well development activities.

8 Lower a double surge block into the screened portion of the well. Starting from the bottom of the screen using 2 foot throws, gently raise and lower the surge block to force water in and out of the screen slots and sand pack. Continue surging for 15 to 30 minutes.

9 Lower a bottom-loading bailer, submersible pump, or inertia pump tubing with check valve to the bottom of the well and gently bounce on the bottom of the well to collect/remove accumulated sediment, if any. Remove and empty the bailer, if used. Repeat until the bailed/pumped water is free of excessive sediment and contact at the bottom of the well feels solid. Alternatively, measurement of the well depth with a weighted tape can be used to verify that sediment and/or silt has been removed to the extent practicable, based on a comparison with the well installation log or previous measurement of total well depth.

10 After surging the well for a minimum of two cycles and removing excess accumulated sediment from the bottom of the well, re-measure the depth-to-water and the total well depth from the reference point at the top of the well casing. Record these measurements in the field log book.

11 Remove formation water by pumping/bailing. Where pumping is used, measure and record the pre-pumping water level. Operate the pump at a relatively constant rate. Measure the pumping rate using a calibrated container and stop watch, and record the pumping rate in the field log book. Measure and record the water level in the well at least once every 5 minutes during pumping. Note any relevant observations in terms of water color, visual level of turbidity, sheen, odors, etc. Pump or bail until termination criteria specified in the Site-Specific Field Implementation plan are reached. Note: the project-specific field implementation plan may also specify a maximum turbidity requirement for completion of development. Unless otherwise specified the maximum turbidity should be 50 NTUs or less. Record the total volume of water purged from the well.

12 While developing, take periodic water level measurements (at least one every five minutes) to determine if drawdown is occurring and record the measurements on the Well Development Log.

13 While developing, calculate the rate at which water is being removed from the well. Record the volume on the Well Development Log.

14 While developing, water is also periodically collected directly from the well or bailer discharge and readings taken of the indicator parameters: pH, specific conductance, and temperature. Development is considered complete when the indicator parameters have stabilized (i.e., three consecutive pH, specific conductance, and temperature readings are within tolerances specified in the project work plans or within 10% if not otherwise specified), the extracted water is clear and free

of fine sediment and most importantly, when acceptable volume of water has been removed and/or a sufficient amount of surging has been performed.

15 In certain instances, for slow recharging wells, the parameters may not stabilize. In this case, well development is considered complete when minimal amounts of fine-grained sediments are recovered and acceptable volume of water has been removed.

16 If the well goes dry, stop pumping or bailing. Note the time that the well went dry. After allowing the well to recover, note the time and depth to water. Resume pumping or bailing when sufficient water has recharged the well.

17 Contain all development water in appropriate containers.

18 When complete, secure the lid back on the well.

19 Place disposable materials in plastic bags for appropriate disposal and decontaminate reusable, downhole pump components and/or bailer

8 WASTE MANAGEMENT

Materials generated during monitoring well installation and development will be placed in appropriate labeled containers and disposed of as described in the Work Plan/Field Implementation Plan or Field Sampling Plan.

9 DATA RECORDING AND MANAGEMENT

All well development activities should be documented on appropriate log forms as well as in a proper field notebook and/or PDA. Additionally, all documents (and photographs) should be scanned and electronically filed in the appropriate project directory for easy access. Pertinent information will include personnel present on site; times of arrival and departure; significant weather conditions; timing of well development activities; development method(s); observations of purge water color, turbidity, odor, sheen, etc.; purge rate; and water levels before, during, and after pumping.

10 QUALITY ASSURANCE

All reused, non-disposable, downhole well development equipment should be cleaned in accordance with the procedures outlined in the project documents.

11 REFERENCES

American Society for Testing Materials (ASTM), Designation D5521-05. *Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers*. American Society for Testing Materials. West Conshohocken, Pennsylvania.

PFAS-SPECIFIC DRILLING AND MONITORING WELL INSTALLATION TECHNICAL GUIDANCE INSTRUCTION

Rev: #0

Rev Date: 10/12/2018

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	10/12/2018	All	Generated from generic Well Installation TGI (Rev 0, April 24, 2017). Revised to be PFAS-specific, provide more instruction on soil sample collection, and only include DPT and Sonic methods	Ankit Gupta

APPROVAL SIGNATURES

Prepared by:

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10/12/2018

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Smart Characterization Practice Area Leader

Senior Environmental Engineer

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2 SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) describes methods used to advance soil borings via direct push technology (DPT) or rotosonic drilling techniques, collect single or multiple depth-discrete dry and/or saturated soil samples, and install groundwater monitoring wells in unconsolidated aquifers (as necessary) at sites impacted by per- and polyfluoroalkyl substances (PFASs). It covers specific considerations relevant for PFASs due to their unique chemical and physical properties, low detection limits, and low regulatory standards. A more detailed discussion of general PFAS sampling procedures is provided in PFAS Field Sampling Guidance TGI (Arcadis 2018a).

If monitoring wells are to be installed upon completion of borehole drilling and soil sampling, it is assumed that the monitoring well has been designed consistent with the approach and methods presented in the American Society of Testing and Materials (ASTM) D5092 – *Standard Practice for Design and Installation of Groundwater Monitoring Wells* (ASTM D5092). This includes sizing of the filter pack and screen slot size, the length of the screen, total depth of the well, material strength and compatibility and surface completion. Typical monitoring wells are constructed of manufactured screen and engineered filter pack and are generally suitable for formations with granular materials having a grain size distribution with up to 50% passing a #200 sieve and up to 20% clay-sized material. Monitoring wells installed in formations finer than this may not be able to produce turbidity free water.

The procedures set out herein are designed to produce standard groundwater monitoring wells suitable for: (1) groundwater sampling; (2) water level measurement; and (3) hydraulic conductivity testing of formation sediments immediately adjacent to the open interval of the well (e.g., slug testing).

This TGI will focus specifically on two drilling methods most likely to be utilized during drilling and soil sampling activities: DPT and rotosonic techniques. The drilling method to be used at a given site will be selected based on site-specific consideration of anticipated drilling depths, site or regional geologic knowledge, type of sampling to be conducted, project objectives, and cost.

No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools). No polyvinyl chloride (PVC) glue/cement will be used in constructing or retrofitting monitoring wells that will be used for water-quality monitoring. No coated bentonite pellets will be used in the well drilling or construction process. Specifications of materials to be installed in the borehole will be obtained prior to mobilizing onsite; these materials generally include:

- Well casing (length, material, and diameter);
- Well screen (length, material, diameter, and slot size);
- Bentonite (type, as applicable, chips, non-coated and granular bentonite are acceptable);
- Filter pack (filter pack type and fine sand seal type, as applicable); and
- Grout (type, as applicable).

Well materials will be inspected and, if needed, cleaned or replaced prior to installation.

3 PERSONNEL QUALIFICATIONS

Drilling and soil sampling activities will be performed by persons who have been trained in proper procedures under the guidance of an experienced field geologist, engineer, or technician, with particular emphasis on PFAS sampling procedures outlined in PFAS Field Sampling Guidance TGI (Arcadis 2018a). Field personnel will have undergone in-field training in soil description methods, as described in Soil Description TGI (Arcadis 2018b).

4 EQUIPMENT LIST

The following materials will be available during soil boring and monitoring well installation activities, as required:

- Site Plan with proposed soil boring/well locations;
- Work Plan (or equivalent) and Site Safety and Health Plan (SSHP);

- Personal protective equipment (PPE), as required by the SSHP;

- Traffic cones, delineators, caution tape, and/or fencing as appropriate for securing the work area, if not provided by drillers;

- Drilling/Sampling

    - Stainless-steel spatulas, spoons, and trowels
    - Stainless-steel hand auger with at least 10-ft of extension rods
    - PVC piping of larger diameter than hand auger, if necessary, to keep hand auger borings open
    - Soil logging equipment as specified in the appropriate project documents;
    - Dedicated low-density polyethylene (LDPE) plastic sheeting to prevent sample contact with the ground.
    - Photoionization detector (PID) or flame ionization detector (FID) with calibration gas;
    - 4-gas meter with calibration gas
    - Water level meter with fluorine-free materials (Geotech ET 3/8" with Delrin tip and Buna-N O-ring);
    - Laboratory provided PFAS-free water for field and equipment blank QC samples

- Appropriate sample containers and labels:

    - Laboratory-supplied sample bottles: see the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018a) for PFAS-specific considerations;
    - 1-qt and 1-gal polyethylene bags (Ziploc® brand only) to hold ice and samples;
    - Appropriate blanks (field reagent blanks supplied by the laboratory);
    - Packing and shipping materials;
    - Chain-of-Custody (COC) Forms; see the Sample Chain of Custody Standard Operating Procedure (SOP) for reference (Arcadis 2017a);
    - Appropriate transport containers (coolers) with ice and appropriate labeling, no blue ice;

- Decontamination/Waste Management:

    - PFAS-free decontamination fluids and equipment
        - HDPE or PVC brushes and squirt bottles, stainless steel bowl
        - HDPE buckets to hold decontamination fluids
        - Alconox or Liquinox (other detergents prohibited)
        - Methanol or isopropyl alcohol, if necessary
        - Distilled or laboratory-supplied deionized water
        - Laboratory provided PFAS-free water

  - See the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018a) or the Groundwater and Soil Sampling Equipment Decontamination TGI (Arcadis 2017b) for additional guidance;
  - Portable field hand washing setup;
  - Non-hazardous drum labels as required for investigation-derived waste handling: see the Investigation-Derived Waste Handling and Storage TGI for details (Arcadis 2017c).
- Field Notes:
  - Pens, pencils, and/or Sharpies® for writing;
  - Appropriate field forms; consider including a photo of the well head and a Google Earth map showing the well location.
  - Clipboards, field binders, field notebook, and field note pages that are not waterproof;
  - Digital camera.
- Other:
  - Field clothing made of cotton or other natural fibers that is well laundered (i.e., washed at least 6 times)
  - Well laundered cotton blankets for covering field vehicle seats
  - PFAS-free sunscreen and insect repellant
  - Garbage bags;
  - Paper towels;
- Locks and keys for securing the well after installation;
- Engineer's tape/measuring wheel;

Prior to mobilizing to the site, ARCADIS personnel will contact the drilling subcontractor or in-house driller (as appropriate) to confirm that appropriate sampling and well installation equipment will be provided. Specifications of the sampling and well installation equipment are expected to vary by project, and so communication with the driller is necessary to ensure that the materials provided will meet the project objectives. Equipment/materials typically provided by the driller could include:

- Disposable acetate (or Lexan ™) liners (when drilling with direct-push equipment);
- Drums for investigation derived waste;
- Drilling and sampling equipment decontamination materials;
- Decontamination pad materials;
- Well construction materials.

5 CAUTIONS

5.1 Utility Clearance

The appropriate drilling authorities will be contacted and a site visit for public utility line clearance at the proposed boring locations will be conducted at least 72 hours prior to work commencing. As applicable, utility maps will be reviewed during field reconnaissance of the proposed inspection locations to determine if any are co-located with public utility lines. Arcadis will also contract an independent geophysical survey company to verify that proposed boring locations are not co-located with existing underground utility/substructure features, as necessary. Arcadis will clear locations with soft dig methods to assess the presence of underground utilities as necessary. See the Utility Location and Clearance Arcadis Health and Safety Standard (Arcadis 2017d) for reference.

5.2 General Drilling and Well Construction Considerations

Prior to beginning field work, contact the project technical team to ensure that all field logistics (e.g., access issues, health and safety issues, communication network, schedules, etc.) and task objectives are clearly understood by all team members.

Some regulatory agencies require a minimum annular space between the well or permanent casing and the borehole wall. When specified, the minimum clearance is typically 2 inches on all sides (e.g., a 2-inch diameter well requires a 6-inch diameter borehole). In addition, some regulatory agencies have specific requirements regarding grout mixtures. Determine whether the oversight agency has any such requirements prior to finalizing the drilling and well installation plan.

If dense non-aqueous phase liquids (DNAPL) are known or expected to exist at the site, refer to the project specific documents for additional details regarding drilling and well installation to reduce the potential for inadvertent DNAPL remobilization.

Similarly, if light non-aqueous phase liquids (LNAPLs) are known or expected to be present as “perched” layers above the water table, refer to the DNAPL Contingency Plan. Follow the general provisions and concepts in the DNAPL contingency plan during drilling above the water table at known or expected LNAPL sites.

Consider the compatibility between the well materials and the surrounding environment. For example, PVC well materials are not preferred when DNAPL is present. In addition, some groundwater conditions leach metals from stainless steel or are corrosive to metal well materials. If questions arise, contact the CPM and/or project technical lead to discuss.

Specifications of materials used for backfilling the borehole will be obtained, reviewed and approved to meet project quality objectives. Bentonite is not recommended where DNAPLs are likely to be present or in groundwater with high salinity. In these situations, neat cement grout is preferred.

As noted above, coated bentonite pellets will not be used in monitoring well construction, as the coating could impact the water quality in the completed well.

Heat of hydration during neat cement grout curing must be considered to avoid damage to PVC well materials. The annular space for a typical monitoring well is small enough that heat of hydration should not create excessive temperature increases which may damage PVC well material. However, washouts in the borehole can lead to thick accumulations of grout which can produce enough heat during curing to weaken and potentially damage PVC casing. If heat of hydration is a concern, contact the project technical lead to address the issue.

5.3 PFAS-Specific General Sampling Considerations

This section provides a summary of methods and procedures applicable to the collection of environmental samples for field screening or laboratory analysis during PFAS site characterization activities. In general, sampling techniques used for PFAS site characterization are consistent with conventional sampling techniques used in the environmental industry, but special consideration is made regarding PFAS-containing materials and cross-contamination potential. For example, Teflon™ and other fluoropolymer containing materials are found in pumps, tubing, and sample storage containers and therefore should be avoided (Department of Environment Regulation [DER], Western Australia 2016; New Hampshire Department of Environmental Services [NHDES] 2016). Certain field documentation materials such as waterproof paper or field books, adhesive paper products, and some writing utensils (grouped as non-Sharpie® markers) are also prohibited items during PFAS sampling (DER 2016; NHDES 2016).

New nitrile gloves should be donned before any of the following activities:

- Decontamination of re-usable sampling equipment;
- Contact with sample bottles or PFAS-free water bottles;
- Handling clean sample tubing/down-well equipment or connecting tubing;
- Handling QC samples including field blanks and equipment blanks.

Additionally, new nitrile gloves should also be donned after handling of any non-dedicated sampling equipment; contact with contaminated surfaces; and whenever judged necessary by field personnel. **When in doubt change your gloves.**

Prior to initiating field activities, water sources to be used during drilling activities (e.g., rotosonic drilling, should be sampled to verify those sources are PFAS-free. While not part of the PQAPP, this is considered best practice and should be completed to the extent possible.

Waterproof field books must not be used for field notes. Instead, field notes should be on loose paper on Masonite, plastic, or aluminum clip boards. Other requirements for field notes include:

- Keep field notes, writing implements, and electronic data collection tablets away from samples and sampling materials; and,
- Do not write on sampling bottles unless they are closed.

Tables 1 and **2** in **Attachment 1** provide recommendations for PFAS Site Inspection equipment. **Table 1** provides a summary of materials that have been approved for site inspection; this list is expected to grow longer as industry experience increases. **Table 2** provides a summary of field equipment and materials that have available testing information and/or industry knowledge regarding PFAS cross-contamination potential and it is recommended that these materials be prohibited for sample collection. For materials that are suspected of containing PFASs and/or retaining PFASs, these recommendations are considered preliminary and subject to change.

Given the extremely low detection limits associated with PFAS analysis and the many potential sources of trace levels of PFASs, field personnel are typically advised to err on the side of caution by strictly following field wear guidelines and decontamination procedures as specified in the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018a). **The most important consideration during PFAS related drilling and soil sampling is to prevent contact between sample media and suspect PFAS sources.**

5.4 PFAS-Specific Soil Sampling

Equipment that contacts soil cuttings during sampling activities should be carefully considered and selected. PFAS-containing materials are potentially present in some of the equipment typically used for soil sampling. This includes any lubricants, connections, fittings, etc. used on the cutting shoe on the head of a direct push drill string. Additionally, no materials that pose a cross-contamination risk should be introduced to the bucket of a hand auger. **To minimize the risk of cross-contamination, all hand augering activities (i.e. augering, sample collection, decontamination) should be performed by Arcadis personnel (as opposed to drilling subcontractor) when surface soil samples will be collected**. Each piece of reusable drilling/sampling equipment that comes into direct contact with soil cuttings or groundwater must be inspected before use to confirm that PFAS-containing materials are not present, which could be a source of cross-contamination and cause false positives, and that PFASs will not adhere to the material, which has the potential to cause low bias sample results. If equipment cannot be verified as being PFAS-free and there is a concern that it could potentially introduce contamination, a conservative number of equipment blanks should be collected to confirm that materials in the sample equipment do not cause false positives by introducing PFASs. Other quality assurance methods may be implemented to avoid materials that could result in potential losses associated with PFASs adhering to surfaces. For example, collecting soil samples for laboratory analysis from an “undisturbed” portion of a large diameter soil core is a good practice.

The following additional notes are provided regarding soil sampling materials:

- Where drilling or decontamination water is needed, a sample of the source water must be collected and analyzed for PFAS before drilling begins to ensure that background PFASs will not be introduced. Some water systems may be constructed with PFAS-containing thread and gasket sealants; therefore, an inspection of the source water distribution system may provide an additional level of assurance for identifying a source of PFAS-free water for site inspections.
- It is often standard practice to cover the ends of sample sleeves and protect the sample from potential cross-contamination from the plastic end caps with Teflon™ or other PTFE tape (Geotechnical Services, Inc. 2018); this practice is prohibited for PFAS sample collection (DER 2016).
- Lexan™ liner sleeves are made of polycarbonate and they are not expected to contain PFASs based on review of the Safety Data Sheet (Sabic 2016).
- Acetate (i.e., cellulose acetate butyrate) liners are commonly used as sleeves and are not expected to contain PFASs.

- Studies evaluating the use of stainless steel indicate that PFASs do not strongly sorb to stainless-steel (Obal et al. 2012). Therefore, stainless-steel sleeves and equipment should be acceptable for collection of soil samples for PFAS analysis.

6 HEALTH AND SAFETY CONSIDERATIONS

Field activities associated with drilling, soil sampling, and monitoring well installation will be performed in accordance with the SSHP, a copy of which will be present on site during such activities.

7 PROCEDURE

The procedures for drilling, soil sampling, and installing groundwater monitoring wells (if necessary), are presented below. All field sampling should be completed by a two-person team, with one collecting the samples, and the other handling documentation and providing support. This will help to limit the potential for accidental cross-contamination of the sample media.

7.1 Direct Push Technology (DPT) Method

Direct-push drilling may be used to complete soil borings and install monitoring wells. Examples of this technique include the Diedrich ESP vibratory probe system, GeoProbe®, or AMS Power Probe® dual-tube system. Environmental probe systems typically use a hydraulically operated percussion hammer. Depending on the equipment used, the hammer delivers 140- to 350-foot pounds of energy with each blow. The hammer provides the force needed to penetrate very stiff to medium dense soil formations. The hammer simultaneously advances an outer steel casing that contains a dual-tube liner for sampling soil. The outside diameter (OD) of the outer casing ranges from 1.75 to 2.4 inches and the OD of the inner sampling tube ranges from 1.1 to 1.8 inches. The outer casing isolates shallow layers and permits the unit to continue to probe at depth. The double-rod system provides a borehole that may be tremie-grouted from the bottom up. Alternatively, the inside diameter (ID) of the steel casing provides clearance for the installation of small-diameter (e.g., 0.75- to 1-inch ID) micro-wells. The procedures for drilling, soil sampling, and installing monitoring wells (if necessary) in soil using the direct-push method are described below.

1. Place LDPE plastic sheeting over core/sampling processing area to create a clean working surface, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
2. Clear the ground surface of brush, root mat, grass, leaves, or other debris prior to sampling.
3. Decontaminate all non-disposable sampling equipment/tooling that will or may to come into direct contact with soil prior to first use. Disposable sampling equipment must be kept in sealed PFAS-free packaging until it is used.
4. Use stainless-steel hand auger to collect samples from 0 - 5 ft bgs surface interval, if applicable. All hand auguring to collect soil samples will be completed by Arcadis personnel, not the drilling subcontractor. These samples can be collected either during other Utility Clearance activities (e.g., third party clearance) or immediately prior to drilling.
    a. The sample should be collected manually directly from the hand auger bucket (using stainless steel scoop, spatula, or trowel as necessary) and placed directly into the sample

    jar, following Steps 7 – 15 below. The sample should not contact the ground or LDPE sheeting.
    b. If collecting multiple samples from the same boring, after collecting sample from the surface or shallowest depth interval examine the stability of the soil in the boring sidewalls. If sidewalls appear to be at risk of collapsing into the borehole insert a length of polyvinyl chloride (PVC) pipe into the boring to maintain the opening and prevent collapse prior to augering to the next deeper sampling interval.

5. If using direct push drilling method, use dual tube rod system and collect soil cores in acetate or Lexan ™ liners. The cutting shoe and core extractor must be stainless steel with no PFAS-containing materials present (e.g., gaskets, coatings).
6. After each drilling run, drillers extract and cut open liners and provide to Arcadis personnel for characterization and sampling. Drillers must not touch soil inside of liners during this process. Arcadis personnel decontaminate cutter between uses (see below).
7. Don a new set of nitrile gloves prior to handling sample core, then characterize soils in accordance with P-04 TGI - Soil Description (Arcadis 2018b). Record descriptions in the field notes, boring logs, and/or personal digital assistant (PDA). It is also beneficial to photo document the samples. It should be noted that PDA logs must be electronically backed up and transferred to a location accessible to other project team members as soon as feasible to retain and protect the field data.
8. Don a new set of nitrile gloves prior collecting soil samples for analysis. Do not use gloved hands to handle papers, pens, clothes, etc., before collecting samples. Do not touch outside of sample liner with gloved hands.
9. Collect field samples and any required QC samples from recovered soil cores using a clean stainless-steel trowel and place in clean, labeled bottles supplied by the laboratory for the required analyses. If collecting samples for multiple analyses, collect PFAS samples first. Make sure caps remain on PFAS sample bottles until immediately prior to filling. Caps must remain in the hand of the sampler until replacing on the bottle.
10. Once the sample has been placed in the bottle, and the bottle cap has been completely tightened, label the sample with sample identification number, date, and time of collection. Labels must be completed only after the caps have been placed back on each bottle. (See P-01 QP#3.06 Field Activities documentation for sample label information).
11. Place soil sample bottles in a sealed Ziploc© bag, and then into sample coolers. Store PFAS samples in separate cooler from other samples.
12. Record the label information and time of sampling in the field notes and sampling forms.
13. Fill out laboratory COC and check against the labels on the sample bottles progressively after each sample is collected.
14. Decontaminate all reusable sampling equipment between sample intervals and borings as described in Section 10.
15. Repeat Steps 7 – 14 until all samples have been collected from the boring location.
16. Abandon soil boring to grade in accordance with the site-specific work plan upon completion and before moving to the next boring location. **If well is to be installed, see Section 7.1.1 for well construction procedure**.
17. Mark boring location with wooden stake that identifies boring ID for subsequent surveying, as necessary.

18. Manage investigation-derived-waste (IDW) as specified in Section 8 and in accordance with the site-specific work plan.
19. If samples are not shipped the same day as collected, add fresh ice to sample coolers at the end of the day to maintain the temperature between 0 and 6°C. Place ice in sealed Ziplock® bags. Do not use blue ice. Sample coolers must remain in the possession of the sampling team at all times or secured under lock and key until shipment to the laboratory.

7.1.1 DPT Monitoring-Well Construction

1. Upon advancing the borehole to the desired depth, install the well through the inner drill casing. The well will consist of 2-inch ID PVC or stainless-steel slotted screen and blank riser. Screen length and construction will be specified in the Work Plan or discussed with the Arcadis PM.

2. When the monitoring well assembly has been set in place, place a washed silica filter pack in the annular space from the bottom of the boring to a height of 1 to 2 feet above the top of the well screen (following specifications in the Work Plan) using a tremie pipe. The filter pack is placed, and drilling equipment (i.e., rods) extracted in increments until the top of the sand pack is at the appropriate depth. Verify that the expected volume of filter pack matches with the actual amount installed. There can be differences due to irregularities in the borehole. Washout of the borehole will result in the need for greater than calculated well materials. If a difference of more than 10% is noted, consult with the project technical team. The filter pack will be consistent with the screen slot size and the soil particle size in the screened interval, as specified in the Work Plan. The well should be gently surged to prevent filter pack material bridging and to settle the filter pack prior to well seal installation.

   a. Alternately, a monitoring well assembly with a pre-packed screen can be installed. The monitoring well assembly (i.e., regular PVC or pre-packed) should be discussed and decided prior to beginning field work and specified in the QAPP addendum. Pre-packed filters should be verified as PFAS-free prior to use.

3. A hydrated bentonite seal (a minimum of 2 feet thick) will then be placed in the annular space above the sand pack (alternatively, in some cases a fine sand seal may be installed instead of bentonite—follow the specifications in the Work Plan). Use of a tremie pipe is not required for placement of the bentonite seal (though may be required if a well is very deep and borehole bridging is reasonably anticipated). However, bentonite should be poured into the annular space slowly enough to ensure borehole bridging does not occur. If non-hydrated bentonite is used, the bentonite should be permitted to hydrate in place for a minimum of 30 minutes before proceeding. *No coated bentonite pellets will be used in monitoring well drilling or construction*. PFAS-free water (verified by laboratory analysis of source water) should be added to hydrate the bentonite if the seal is above the water table. Continuously monitor the placement of the sand pack and bentonite with a weighted tape measure.

4. During the extraction of the augers or casing, a cement/bentonite or neat cement grout will be placed in the annular space from the bentonite seal to a depth approximately 2 ft bgs or as

specified in the Work Plan. As with the filter pack, it is recommended that seal material be placed with a tremie pipe. Ensure that seal materials are mixed at the proper ratios with PFAS-free water (verified by laboratory analysis of source water) following manufacturer's recommendations.

5. Install the monitoring well completion as specified in the Work Plan. Typical completions are a locking, steel protective casing (extended at least 1.5 feet below grade and 2 feet above grade) over the riser casing set within a neat cement pad at grade. Alternatively, for flush-mount completions, place a steel curb box with a bolt-down lid over the riser casing set within a neat cement pad. In either case, the cement pad will extend approximately 1.5 to 2.0 feet below grade and laterally at least 1 foot in all directions from the protective casing and should slope gently away to promote drainage away from the well.

6. During well installation, record construction details and tabulate materials used in field notebook as well as appropriate field forms.

7. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section 8 below.

7.2 Rotosonic Drilling Methods

Rotosonic drilling produces soil cores that, for the most part, are relatively undisturbed, but note that when drilling in consolidated or finer-grained sediment the vibratory action during core barrel advancement may create secondary fractures or breaks.

1. Place LDPE plastic sheeting over core/sampling processing area to create a clean working surface, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.
2. Clear the ground surface of brush, root mat, grass, leaves, or other debris prior to sampling.
3. Decontaminate all non-disposable sampling equipment/tooling that will or may to come into direct contact with soil prior to first use. Disposable sampling equipment must be kept in sealed PFAS-free packaging until it is used.
4. Use stainless-steel hand auger to collect samples from 0 - 5 ft bgs surface interval, if applicable. All hand augering to collect soil samples will be completed by Arcadis personnel, not the drilling subcontractor. These samples can be collected either during other Utility Clearance activities (e.g., third party clearance) or immediately prior to drilling.
    a. Hand auger soil sample should be collected manually from the hand auger bucket (using stainless steel scoop, spatula, or trowel as necessary) and placed directly into the sample jar. The sample should not contact the ground or LDPE sheeting.
    b. If sampling by hand auger, after collecting sample from the surface or shallowest depth interval examine the stability of the soil in the boring sidewalls. If sidewalls appear to be at risk of collapsing into the borehole insert a length of polyvinyl chloride (PVC) pipe into the boring to maintain the opening and prevent collapse prior to augering to the next deeper sampling interval.

5. During rotosonic drilling, drillers extract soil core bags after each drilling run, place the core bag onto LDPE sheeting, and cut open bags so Arcadis personnel can perform characterization and sampling. Arcadis personnel should confirm with drilling subcontractor that core bags are constructed of PFAS-free material. Drillers must not touch soil inside of bags during this process. Arcadis personnel decontaminate cutter between uses (see below).
6. Don a new set of nitrile gloves prior to collecting each sample. Do not use gloved hands to handle papers, pens, clothes, etc., before collecting samples. Do not touch outside of sample bag with gloved hands.
7. During sampling, characterize soils in accordance with P-04 TGI - Soil Description (Arcadis 2018b). Record descriptions in the field notes, boring logs, and/or personal digital assistant (PDA). It is also beneficial to photo document the samples. It should be noted that PDA logs must be electronically backed up and transferred to a location accessible to other project team members as soon as feasible to retain and protect the field data.
8. Collect sample volumes from recovered soil cores using a clean stainless-steel trowel and place in clean, labeled bottles supplied by the laboratory for the required analyses (see sample container list in PQAPP Worksheets #19&30). Make sure caps remain on PFAS sample bottles until immediately prior to filling. Caps must remain in the hand of the sampler until replacing on the bottle.
9. Once the sample has been placed in the bottle, and the bottle cap has been completely tightened, label the sample with sample identification number, date, and time of collection. Labels must be completed only after the caps have been placed back on each bottle. (See P-01 QP#3.06 Field Activities documentation for sample label information).
10. Collect QC samples at frequency specified in PQAPP Worksheet #20. QC sample locations to be selected based on consultation with Arcadis RL.
11. Place soil sample bottles in a sealed Ziploc© bag, and then into sample coolers. Store PFAS samples in separate cooler from other samples.
12. Record the label information and time of sampling in the field notes and sampling forms.
13. Fill out laboratory COC and check against the labels on the sample bottles progressively after each sample is collected.
14. Abandon all soil borings to grade as specified in the QAPP Addendum upon completion and before moving to the next boring location. **If well is to be installed, see Section 7.2.1 for well construction procedure**.
15. Mark boring location with wooden stake that identifies boring ID for subsequent surveying, as necessary.
16. Manage investigation-derived-waste (IDW) as specified in site-specific work plan.
17. If samples are not shipped the same day as collected, add fresh ice to sample coolers at the end of the day to maintain the temperature between 0 and 6°C. Place ice in sealed polyethylene bags (Ziplock). Do not use blue ice. See QAPP worksheet #19 and 30 for sample containers, preservation and hold times. Sample coolers must remain in the possession of the sampling team at all times or secured under lock and key until shipment to the laboratory.

7.2.1 Monitoring Well Construction

1. If it is necessary to install a monitor well into a permeable zone below a confining layer, particularly if the deeper zone is believed to have water quality that differs significantly from the zone above the confining layer, then a telescopic well construction will be considered. In this case, the borehole is advanced approximately 3 to 5 feet into the top of the confining layer, and a permanent casing (typically PVC, black steel or stainless steel) is installed into the socket drilled into the top of the confining layer. The casing is then grouted in place. Grout should be mixed with PFAS-free water (verified by laboratory analysis of source water). The preferred methods of grouting telescoping casings include: pressure-injection grouting using an inflatable packer installed temporarily into the base of the casing, such that grout is injected out the bottom of the casing until it is observed at ground surface outside the casing; displacement-method grouting (also known as the Halliburton method), which entails filling the casing with grout and displacing the grout out the bottom of the casing by pushing a drillable plug, typically made of wood to the bottom of the casing, following by tremie grouting the remainder of the annulus outside the casing; or tremie grouting the annulus surrounding the casing using a tremie pipe installed to the base of the borehole. In all three cases, the casing is grouted to the ground surface, and the grout is allowed to set prior to drilling deeper through the casing. Site-specific criteria and work plans should be created for the completion of non-standard monitoring wells, including telescopic wells.

2. Before installing a screened well, it is important to confirm that the borehole has been advanced into the targeted saturated zone. This is particularly important for wells installed to monitor the water table and/or the shallow saturated zone, as the capillary fringe may cause soils above the water table to appear saturated. If one or more previously installed monitoring wells exist nearby, use the depth to water at such well(s) to estimate the water-table depth at the new borehole location.

   To verify that the borehole has been advanced into the saturated zone, it is necessary to measure the water level in the borehole. For boreholes drilled using water (e.g., Rotosonic), monitor the water level in the borehole as it re-equilibrates to the static level. In low-permeability units like clay, fine-grained glacial tills, shale and other bedrock formations, it may be necessary to wait overnight to allow the water level to equilibrate. Document depth to water in the borehole on the appropriate field forms and field notebook. If there are questions concerning the depth of the well/screen interval, consult with the project technical lead or PM prior to finalizing well depth/screen interval. To the extent practicable, ensure that the depth of the well below the apparent water table is deep enough so that the installed well can monitor groundwater year-round, accounting for seasonal water-table fluctuations. When in doubt, err on the side of slightly deeper well installation.

3. Upon completing the borehole to the desired depth, if a screened well construction is desired, install the monitoring well by lowering the screen and solid PVC risers through the augers or casing. Monitoring wells typically will be constructed of 2-inch-diameter (although sometimes 4-inch), flush-threaded PVC or stainless steel slotted or wire wrapped well screen and blank riser

casing. Smaller diameters may be used if multiple wells are to be installed in a single borehole. The screen length will be specified in the Work Plan (or equivalent) based on regulatory requirements and specific monitoring objectives. Monitoring well screens should be limited to 5 to 10 feet long. The screen length will depend on the purpose for the well and the objectives of the groundwater investigation and will (in most cases) be determined prior to the field mobilization.

The slot size and filter pack gradation should be predetermined in the Work Plan (or equivalent) based on site-specific grain-size analysis (sieve analysis) or other geologic considerations or monitoring objectives. Typically, slot sizes for monitoring wells will range from 0.010 inches to 0.020 inches while the filter pack will be 20-40, Morie No. 0, or equivalent. In very fine-grained formations where sample turbidity needs to be minimized, it may be preferred to use a 0.006-inch slot size and 30-65, Morie No. 00, or equivalent filter pack. Alternatively, where monitoring wells are installed in coarse-grained deposits and higher well yield is required, a 0.020-inch slot size and 10-20, Morie No. 1, or equivalent filter pack may be preferred. If the screen slot size and filter pack have not been based on site-specific grain-size analysis, consider collecting soil samples during well installation so future wells can be properly designed.

Alternately, a monitoring well assembly with a pre-packed screen can be installed. The monitoring well assembly (i.e., regular PVC or pre-packed) should be discussed and decided prior to beginning field work and specified in the QAPP addendum. Pre-packed filters should be verified as PFAS-free prior to use.

A blank riser will extend from the top of the screen to approximately 2.5 feet above grade or, if necessary, just below grade where conditions warrant a flush-mounted monitoring well. For wells greater than 50 feet deep, centralizers may be desired to assist in centering the monitoring well in the borehole during construction.

4. When the monitoring well assembly has been set in place, place a washed silica filter pack in the annular space from the bottom of the boring to a height of 1 to 2 feet above the top of the well screen (following specifications in the Work Plan) using a tremie. The filter pack is placed, and drilling equipment extracted in increments until the top of the sand pack is at the appropriate depth. Verify that the expected volume of filter pack matches with the actual amount installed. There can be differences due to irregularities in the borehole. Washout of the borehole will result in the need for greater than calculated well materials. If a difference of more than 10% is noted, consult with the project technical team. The filter pack will be consistent with the screen slot size and the soil particle size in the screened interval, as specified in the Work Plan (or equivalent). The well should be gently surged to prevent filter pack material bridging and to settle the filter pack prior to well seal installation.

5. A hydrated bentonite seal (a minimum of 2 feet thick) will then be placed in the annular space above the sand pack (alternatively, in some cases a fine sand seal may be installed instead of bentonite—follow the specifications in the Work Plan). Use of a tremie pipe is not required for placement of the bentonite seal (though may be required if a well is very deep and borehole

bridging is reasonably anticipated). However, bentonite should be poured into the annular space slowly enough to ensure borehole bridging does not occur. If non-hydrated bentonite is used, the bentonite should be permitted to hydrate in place for a minimum of 30 minutes before proceeding. *No coated bentonite pellets will be used in monitoring well drilling or construction*. PFAS-free water (verified by laboratory analysis of source water) should be added to hydrate the bentonite if the seal is above the water table. Continuously monitor the placement of the sand pack and bentonite with a weighted tape measure.

6. During the extraction of the augers or casing, a cement/bentonite or neat cement grout will be placed in the annular space from the bentonite seal to a depth approximately 2 ft bgs or as specified in the Work Plan (or equivalent). As with the filter pack, it is recommended that seal material be placed with a tremie pipe. Ensure that seal materials are mixed at the proper ratios with PFAS-free water (verified by laboratory analysis of source water) following manufacturer's recommendations.

7. Install the monitoring well completion as specified Work Plan (or equivalent). Typical completions are a locking, steel protective casing (extended at least 1.5 feet below grade and 2 feet above grade) over the riser casing and secure with a neat cement seal. Alternatively, for flush-mount completions, place a steel curb box with a bolt-down lid over the riser casing and secure with a neat cement seal. In either case, the cement seal will extend approximately 1.5 to 2.0 feet below grade and laterally at least 1 foot in all directions from the protective casing and should slope gently away to promote drainage away from the well.

8. Monitoring wells should be labeled using indelible ink or paint with the appropriate designation on both the inner and outer well casings or inside of the curb box lid. Use caution when labeling the well as paint or indelible ink could potentially contain PFAS materials.

9. When an above-grade completion is used, the riser will be sealed using an expandable locking plug and the top of the well will be vented by drilling a small-diameter (1/8 inch) hole near the top of the well casing or through the locking plug, or by cutting a vertical slot in the top of the well casing. When a flush-mount installation is used, the riser will be sealed using an unvented, expandable locking plug.

10. During well installation, record construction details and actual measurements relayed by the drilling contractor and tabulate materials used (e.g., screen and riser footages; bags of bentonite, cement, and sand) in the field notebook as well as appropriate field forms.

11. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section 8 below.

8 WASTE MANAGEMENT

Investigation-derived waste (IDW) including soil cuttings, purge water, and decontamination water generated during cleaning procedures will be collected and placed in Department of Transportation approved containers, segregated by waste streams: see the Investigation-Derived Waste Handling and Storage TGI for details (Arcadis 2017c). All containers will be labeled as non-hazardous unless otherwise instructed by the project manager. Containerized IDW will be stored on site until it is profiled and subsequently transported to an approved facility for disposal or recycling. Waste manifests for all IDW suspected to have come into contact with PFAS should clearly note the presence of PFAS. Additional IDW sampling and management details will be provided in the site-specific Work Plan (QAPP addendum) and will be consistent with applicable Army policies and Army post requirements. Personal protective equipment (e.g., gloves, disposable clothing, disposable equipment) resulting from personnel cleaning procedures and soil sampling activities will be placed in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

9 DATA RECORDING AND MANAGEMENT

The supervising field lead will be responsible for documenting drilling events to record all relevant information in a clear and concise format. The record of drilling events should include:

- Start and finish drilling dates;
- Project name and location;
- Project number, client, and site location;
- Boring number and depths;
- Soil descriptions;
- Depth to water;
- Well construction specifications, if applicable (screen and riser material and diameter, sump length, screen length and slot size, riser length, sand pack type);
- Quantities of materials used (e.g., bentonite, grout);
- Type of drilling tools used (e.g., rig type);
- Core barrel size;
- Names of contractor’s drillers, inspectors, or other people onsite; and,
- Weather conditions.

Field staff should ensure COC Forms are properly completed, and verify which PFAS analytes (e.g., just PFOS and PFOA, some or all of the modified method 537 target analyte list) are required for analysis and note on the COC.

All documents (and photographs) should be scanned and electronically filed in the appropriate project directory for easy access. In addition, the locations of newly-installed wells will be documented photographically or in a site sketch. If appropriate, a measuring wheel or engineer's tape will be used to determine approximate distances between important site features.

The well location, ground surface elevation, and inner and outer casing elevations will be surveyed using the method specified in the site Work Plan. Generally, a local baseline control will be set up. This local baseline control can then be tied into the appropriate vertical and horizontal datum, such as the National Geodetic Vertical Datum of 1929 or 1988 and the State Plane Coordinate System. At a minimum, the elevation of the top of the inner casing used for water-level measurements should be measured to the nearest 0.01 foot. Elevations will be established in relation to the National Geodetic Vertical Datum of 1929. A permanent mark will be placed on top of the inner casing to mark the point for water-level measurements.

10 DECONTAMINATION

To avoid cross-contamination during drilling and sampling, all reusable groundwater sampling equipment that has or is suspected to have come into contact with groundwater or soil will be decontaminated between each sample using the following steps. If Class B firefighting foam is a suspected PFAS source at any sampling location, then these steps should be performed twice.

- Don new pair of Nitrile gloves prior to decontamination
- Scrub using a plastic brush and a non-phosphate soap free of VOCs (e.g., Liquinox, Alconox) and plastic brush;
- Double-rinse in potable deionized or distilled water;
- Rinse once with methanol or isopropyl alcohol;
- Rinse once with laboratory-certified PFAS-free water;
- Collect all rinsate in a sealed pail for disposal
- Allow time for equipment to air dry prior to re-use.

While strongly recommended, the use of solvents may be excluded for project-specific H&S concerns. If solvents are prohibited after DQO development, then additional procedures should be evaluated by the project team. Contingencies could include the use of dedicated sampling equipment at each sampling location or amending laboratory procedures to mitigate the increased risk of cross-contamination.

Additionally, the following decontamination procedure could be utilized when organic solvent use is not possible.

- Don new pair of Nitrile gloves prior to decontamination
- Scrub using a plastic brush and a non-phosphate soap free of VOCs (e.g., Liquinox, Alconox) and plastic brush;
- Single-rinse in potable deionized or distilled water;
- Scrub using a plastic brush and a non-phosphate soap free of VOCs (e.g., Liquinox, Alconox) and plastic brush;

- Rinse twice with deionized water and once with PFAS-free water;
- Collect all rinsate in a sealed pail for disposal
- Allow time for equipment to air dry prior to re-use.

Drive casings and other drilling tooling will be steam cleaned or replaced with new equipment between boreholes. Steam cleaning will be performed by the drillers within a temporary decontamination or other containment area designated by the supervising engineer or geologist that is located outside of the work zone. All decontamination water will be collected and containerized for disposal.

See additional specifics in P-04, TGI - Groundwater and Soil Sampling Equipment Decontamination in PQAPP Appendix A.

11QUALITY ASSURANCE

In general, the following quality assurance and quality control (QA/QC) samples should be collected:

- Equipment blanks
- Field (i.e., reagent) blanks
- Field duplicates
- Matrix spike/matrix spike duplicate

Details on QC sampling requirements (e.g., frequency of collection, types of QA/QC samples) are provided in the PQAPP and will be outlined in various Site-specific sampling scopes of work in the QAPP Addendum. Additionally, detailed procedures related to equipment and field (i.e., reagent) blank sample collection are outlined in the Equipment and Reagent Blank Sample Collection TGI (Arcadis 2018c). In general, equipment blanks should be collected from every piece of downhole equipment that could come in contact with soil or groundwater during sample collection. This includes all downhole tooling (e.g., drill bits, drill rods).

Prior to initiating field activities, water sources to be used during drilling and well construction activities should be sampled to verify those sources are PFAS-free. While not part of the PQAPP, this is considered best practice and should be completed to the extent possible.

Refer to quality control requirements for the project to ensure that appropriate quality assurance and quality control (QA/QC) samples are collected. When collecting QA/QC samples, the same guidelines apply as when collecting regular samples – specifically that:

- Samples should be collected in laboratory-supplied HDPE bottles;
- Bottle caps must remain in the hand of the sampler until replaced on the bottle;
- Labels must be completed after the caps have been placed back on each bottle; and,
- Samples must be stored in appropriate transport containers (coolers) with ice (Ziploc®-type bags for use as ice containers) with appropriate labeling. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**

12 REFERENCES

American Society for Testing Materials (ASTM), Designation D5092-04. *Standard Practice for Design and Installation of Ground Water Monitoring Wells*. American Society for Testing Materials. West Conshohocken, Pennsylvania.

American Society of Testing and Materials (ASTM) D 1586 - *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*. American Society for Testing Materials. West Conshohocken, Pennsylvania.

Arcadis. 2018a. TGI – Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance. Rev. 2. October 15.

Arcadis. 2018b. TGI – Soil Description. Rev. #2. February 16.

Arcadis. 2018c. TGI – Equipment and Reagent Blank Sample Collection for PFAS Analysis. Rev. #0. October 2.

Arcadis. 2017a. SOP – Sample Chain of Custody, Rev. #1. May 23.

Arcadis. 2017b. TGI – Groundwater and Soil Sampling Equipment Decontamination, Rev. #0. February 23.

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Arcadis. 2017d. Utility Location and Clearance, Rev. #16. March 17.

Arcadis. 2016. Arcadis ENV Quality Procedure QP#: 3.06 Field Activities Documentation, Revision Letter: C. November.

Department of Environment Regulation (DER). Government of Western Australia. 2016. Interim Guideline on the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS). Contaminated Sites Guidelines. February.

Massachusetts Department of Environmental Protection (MassDEP). 2017. DRAFT Fact Sheet, Guidance on Sampling and Analysis for PFAS at Disposal Sites Regulated under the Massachusetts Contingency Plan. January.

New Hampshire Department of Environmental Services (NHDES). 2016. Perfluorinated Compound (PFC) Sample Collection Guidance. November.

ATTACHMENT 1

Table 1 and Table 2: PFAS Inspection Material Recommendations

Table 1: Summary of Acceptable Sampling Equipment and Materials for PFAS Site Inspections

Sampling Materials	Additional Considerations	References
Water Sampling Materials		
High density polyethylene (HDPE) or silicone tubing materials	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
HDPE HydraSleeves^{TM}	Low density polyethylene (LDPE) HydraSleeves^{TM} are not recommended	USACE 2016; MassDEP 2017
Drilling and Soil Sampling Materials		
PFAS-free drilling fluids	--	DER 2016
PFAS-free makeup water	Confirm PFAS-free water source via laboratory analysis prior to inspections	--
Acetate liners	For use in soil sampling	USACE 2016
Sample Containers and Storage		
HDPE sample containers with HDPE lined lids for soil and water samples	Laboratory should provide; whole bottle analysis of aqueous samples combined with a solvent rinse of bottle is recommended	DER 2016, MassDEP 2017
Ice contained in plastic (polyethylene) bags (double bagged)	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Field Documentation		
Sharpie®	--	NHDES 2016; USACE 2016; MassDEP 2017
Ball point pens	--	MassDEP 2017
Standard paper and paper labels	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Decontamination		
Water-only decontamination	Confirm PFAS-free water source via laboratory analysis prior to inspections	DER 2016
Alconox®, Liquinox® or Citranox® followed by deionized water or PFAS-free water rinse	Alconox® known to contain trace levels of 1,4-dioxane	NHDES 2016; USACE 2016; MassDEP 2017
Methanol, isopropanol, or acetone	Special health and safety precautions are necessary	UNEP 2015; USACE 2016

Note: This list is considered preliminary and additional materials may be added as additional information becomes available. Project teams are expected to follow a methodical evaluation process of materials to be used and confirm acceptance prior to implementation of field activities.

Table 2: Summary of Equipment and Materials Not Recommended for PFAS Site Inspections

Sampling Materials	Known PFAS-Containing Materials	Suspected PFAS-Containing Materials	Materials with Potential to Retain PFASs	References
Water Sampling Materials				
Teflon® or polytetrafluoroethylene (PTFE)-containing or coated field equipment (e.g., tubing, bailers, tape, plumbing paste)	x			DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Passive diffusion bags			x	MassDEP 2017
LDPE HydraSleeves ™			x	USACE 2016; MassDEP 2017
Water particle filters			x	MassDEP 2017
Drilling and Soil Sampling Materials				
Aluminum foil			x	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Drilling fluid containing PFASs	x	x		DER 2016
Sample Containers and Storage				
Glass sample containers with lined lids			x	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
LDPE containers and lined lids			x	USACE 2016
Teflon® or PTFE- lined lids on containers (e.g., sample containers, rinsate water storage containers)	x			DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Reusable chemical or gel ice packs (e.g., BlueIce®)		x		DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Field Documentation				
Self-sticking notes and similar office products (e.g., 3M Post-it-notes)		x		DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Waterproof paper, notebooks, and labels	x			DER 2016, MassDEP 2017
Non-Sharpie® markers		x		NHDES 2016
Decontamination				
Some detergents and decontamination solutions (e.g., Decon 90® Decontamination Solution)	x	x		DER 2016; NHDES 2016; MassDEP 2017

Note: For materials that are suspected of containing PFASs, or have the potential to retain PFASs, project specific considerations may provide adequate justification for use during the field event. For example, further evaluation may be conducted in the form of pre-field equipment blank sample analysis.

ARCADIS Design & Consultancy for natural and built assets

TGI - SOIL DESCRIPTION

Rev: #2

Rev Date: February 16, 2018

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	May 20, 2008	17	Original SOP	Joe Quinnan Joel Hunt
1	September 2016	15	Updated to TGI	Nick Welty Patrick Curry
2	February 16, 2018	15	Updated descriptions, attachments and references in text	Nick Welty Patrick Curry

APPROVAL SIGNATURES

Prepared by: June 30, 2017

Patrick Curry, PG

Date:

Technical Expert Reviewed by: Niklaus R.H. Welt June 30, 2017

Nicklaus Welty, PG

Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

This Arcadis Technical Guidance Instruction (TGI) describes proper soil description procedures. This TGI should be followed for unconsolidated material unless there is an established client-required specific procedure or regulatory-required specific procedure. In cases where there is a required specific procedure, it should be followed and should be referenced and/or provided as an appendix to reports that include soil classifications and/or boring logs. When following a required non-Arcadis procedure, additional information required by this TGI should be included in field notes with client approval.

This TGI has been developed to emphasize field observation and documentation of details required to:

- make hydrostratigraphic interpretations guided by depositional environment/geologic settings;
- provide information needed to understand the distribution of constituents of concern; properly design wells, piezometers, and/or additional field investigations; and develop appropriate remedial strategies.

This TGI incorporates elements from various standard systems such as ASTM D2488-06, Unified Soil Classification System, Burmister and Wentworth. However, none of these standard systems focus specifically on contaminant hydrogeology and remedial design. Therefore, although each of these systems contain valuable guidance and information related to correct descriptions, strict application of these systems can omit information critical to our clients and the projects that we perform.

This TGI does not address details of health and safety; drilling method selection; boring log preparation; sample collection; or laboratory analysis. Refer to other Arcadis procedure, guidance, and instructional documents, the project work plans including the quality assurance project plan, sampling plan, and health and safety plan (HASP), as appropriate.

3 PERSONNEL QUALIFICATIONS

Soil descriptions should only be performed by Arcadis personnel or authorized sub-contractors with a degree in geology or a geology-related discipline. Field personnel will complete training on the Arcadis soil description TGI in the office and/or in the field under the guidance of an experienced field geologist with at least 2 years of prior experience applying the Arcadis soil description method.

4 EQUIPMENT LIST

The following equipment should be taken to the field to facilitate soil descriptions:

- field book, field forms or PDA to record soil descriptions;
- field book for supplemental notes;
- this TGI for Soil Descriptions and any project-specific procedure, guidance, and/or instructional documents (if required);
- field card showing Wentworth scale;
- Munsell® soil color chart;
- tape measure divided into tenths of a foot;
- stainless steel knife or spatula;
- hand lens;
- water squirt bottle;
- jar with lid;
- personal protective equipment (PPE), as required by the HASP; and
- digital camera

5 CAUTIONS

Drilling and drilling-related hazards including subsurface utilities are discussed in other procedure documents and site-specific HASPs and are not discussed herein.

Soil samples may contain hazardous substances that can result in exposure to persons describing soils. Routes for exposure may include dermal contact, inhalation and ingestion. Refer to the project specific HASP for guidance in these situations.

6 HEALTH AND SAFETY CONSIDERATIONS

Field activities associated with soil sampling and description will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities. Know what hazardous substances may be present in the soil and understand their hazards. Always avoid the temptation to touch soils with bare hands, detect odors by placing soils close to your nose, or tasting soils.

7 PROCEDURE

1. Select the appropriate sampling method to obtain representative samples in accordance with the selected sub-surface exploration method, e.g. split-spoon or Shelby sample for hollow-stem drilling, acetate sleeves for direct push, bagged core for sonic drilling, etc.
2. Proceed with field activities in required sequence. Although completion of soil descriptions is often not the first activity after opening sampler, identification of stratigraphic changes is often necessary to select appropriate intervals for field screening and/or selection of laboratory samples.
3. Set up boring log field sheet.
    - Drillers in both the US and Canada generally work in feet due to equipment specifications. Use the Arcadis standard boring log form (**Attachment A**).
    - The preferred boring log includes a graphic log of the principal soil component to support quick visual evaluation of grain size. The purpose of the graphic log is to quickly assess relative soil permeability. Note, for poorly sorted soils (e.g. glacial till), the principal component may not correlate to permeability of the sample. In this case, the geologist should use best judgement to graph overall soil type consistent with relative soil permeability. For example, for a dense sand/silt/clay till, the graphic log would reflect the silt/clay, rather than sand.
    - Record depths along the left-hand side at a standard scale to aid in the use of this tool. See an example completed boring log (**Attachment B**).
4. Examine each soil core (this is different than examining each sample selected for laboratory analysis), and record the following for each stratum:
    - depth interval;
    - principal component with descriptors, as appropriate;
    - amount and identification of minor component(s) with descriptors as appropriate;
    - moisture;
    - consistency/density;
    - color; and
    - additional description or comments (recorded as notes).
5. At the end of the boring, record the amount of drilling fluid used (if applicable) and the total depth logged.

The above is described more fully below.

DEPTH

To measure and record the depth below ground surface (bgs) of top and bottom of each stratum, the following information should be recorded.

1. Measured depth to the top and bottom of sampled interval. Use starting depth of sample based upon measured tool length information and the length of sample interval.
2. Length of sample recovered, not including slough (material that has fallen into hole from previous interval), expressed as fraction with length of recovered sample as numerator over length of sampled interval as denominator (e.g. 14/24 for 14 inches recovered from 24-inch sampling interval that had 2 inches of slough discarded).
3. Thickness of each stratum measured sequentially from the top of recovery to the bottom of recovery.
4. Any observations of sample condition or drilling activity that would help identify whether there was loss from the top of the sampling interval, loss from the bottom of the sampling interval, or compression of the sampling interval. Examples: 14/24, gravel in nose of spoon; or 10/18 bottom 6 inches of spoon empty.

DETERMINATION OF COMPONENTS

Obtain a representative sample of soil from a single stratum. If multiple strata are present in a single sample interval, each stratum should be described separately. More specifically, if the sample is from a 2-foot long split-spoon where strata of coarse sand, fine sand and clay are present, then the resultant description should be of the three individual strata unless a combined description can clearly describe the interbedded nature of the three strata. Example: Fine Sand with interbedded lenses of Silt and Clay, ranging between 1 and 3 inches thick.

Identify principal component and express volume estimates for minor components on logs using the following standard modifiers.

Modifier	Percent of Total Sample (by volume)
and	36 - 50
some	21 - 35
little	10 - 20
trace	<10

Determination of components is based on using the Udden-Wentworth particle size classification (see below) and measurement of the average grain size diameter. Each size grade or class differs from the next larger grade or class by a constant ratio of ½. Due to visual limitations, the finer classifications of Wentworth’s scale cannot be distinguished in the field and the subgroups are not included. Visual determinations in the field should be made carefully by comparing the sample to the Soil Description Field Guide (**Attachment C**) that shows Udden-Wentworth scale or by measuring with a ruler. Use of field sieves is encouraged to assist in estimating percentage of coarse grain sizes. Settling test or wash method (Appendix X4 of ASTM D2488) is encouraged for determining presence and estimating percentage of clay and silt. Note that “gravel” is not an Udden-Wentworth size class.

Udden-Wenworth Scale
Modified Arcadis, 2008

Size Class	Millimeters	Inches	Standard Sieve #
Boulder	256 – 4096	10.08+	
Large cobble	128 - 256	5.04 -10.08	
Small cobble	64 - 128	2.52 – 5.04	
Very large pebble	32 – 64	0.16 - 2.52	
Large pebble	16 – 32	0.63 – 1.26	
Medium pebble	8 – 16	0.31 – 0.63	
Small pebble	4 – 8	0.16 – 0.31	No. 5 +
Granule	2 – 4	0.08 – 0.16	No.5 – No.10
Very coarse sand	1 -2	0.04 – 0.08	No.10 – No.18
Coarse sand	½ - 1	0.02 – 0.04	No.18 - No.35
Medium sand	¼ - ½	0.01 – 0.02	No.35 - No.60
Fine sand	1/8 -¼	0.005 – 0.1	No.60 - No.120
Very fine sand	1/16 – 1/8	0.002 – 0.005	No. 120 – No. 230
Silt (subgroups not included)	1/256 – 1/16	0.0002 – 0.002	Not applicable (analyze by pipette or hydrometer)
Clay (subgroups not included	1/2048 – 1/256	.00002 – 0.0002	

Identify components as follows. Remove particles greater than very large pebbles (64-mm diameter) from the soil sample. Record the volume estimate of the greater than very large pebbles. Examine the sample fraction of very large pebbles and smaller particles and estimate the volume percentage of the pebbles, granules, sand, silt and clay. Use the jar method, visual method, and/or wash method (Appendix X4 of ASTM D2488) to estimate the volume percentages of each category.

Determination of actual dry weight of each Udden-Wentworth fraction requires laboratory grain-size analysis using sieve sizes corresponding to Udden-Wentworth fractions and is highly recommended to determine grain-size distributions for each hydrostratigraphic unit.

Lab or field sieve analysis is advisable to characterize the variability and facies trends within each hydrostratigraphic unit. Field sieve-analysis can be performed on selected samples to estimate dry weight fraction of each category using ASTM D2488 Standard Practice for Classification of Soils for Engineering Purposes as guidance, but replace required sieve sizes with the following Udden-Wentworth set: U.S. Standard sieve mesh sizes 6; 12; 20; 40; 70; 140; and 270 to retain pebbles; granules; very coarse sand; coarse sand; medium sand; fine sand; and very fine sand, respectively.

PRINCIPAL COMPONENT

The principal component is the size fraction or range of size fractions containing the majority of the volume. Examples: the principal component in a sample that contained 55% pebbles would be “Pebbles”; or the principal component in a sample that was 20% fine sand, 30% medium sand and 25% coarse sand would be “Sand, fine to coarse” or for a sample that was 40% silt and 45% clay the principal component would be “Clay and Silt”. Shade the boxes on the graphic log (**Attachment A**) up to and including the box with the principal component. The purpose of the graphical log is to provide a relative estimate of permeability. As noted above, for poorly sorted soils such as glacial till, the principal component may not correlate to permeability of the sample. In this case, the geologist should use best judgement to graph overall soil type consistent with relative soil permeability.

Include appropriate descriptors with the principal component. These descriptors vary for different particle sizes as follows.

Angularity – Describe the angularity for very coarse sand and larger particles in accordance with the table below (ASTM D-2488-06). Figures showing examples of angularity are available in ASTM D-2488-06 and the Arcadis Soil Description Field Guide.

Description	**Criteria**
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Sub-angular	Particles are similar to angular description but have rounded edges.
Sub-rounded	Particles have nearly plane sides but have well-rounded corners and edges.
Rounded	Particles have smoothly curved sides and no edges.

Plasticity – Describe the plasticity for silt and clay based on observations made during the following test method (ASTM D-2488-06).

- As in the dilatancy test below, select enough material to mold into a ball about ½ inch (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.
- Shape the test specimen into an elongated pat and roll by hand on a smooth surface or between the palms into a thread about 1/8 inch (3 mm) in diameter. If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation. Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1/8 inch. The thread will crumble when the soil is near the plastic limit.

Description	Criteria
Non-plastic	A 1/8-inch (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled, and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Dilatancy – Describe the dilatancy for silt and silt-sand mixtures using the following field test method (ASTM D-2488-06).

- From the specimen select enough material to mold into a ball about ½ inch (12 mm) in diameter. Mold the material adding water if necessary, until it has a soft, but not sticky, consistency.
- Smooth the ball in the palm of one hand with a small spatula.
- Shake horizontally, striking the side of the hand vigorously with the other hand several times.
- Note the reaction of water appearing on the surface of the soil.
- Squeeze the sample by closing the hand or pinching the soil between the fingers, and not the reaction as none, slow, or rapid in accordance with the table below. The reaction is the speed with which water appears while shaking and disappears while squeezing.

Description	Criteria
None	No visible change in the specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

Note that silt and silt-sand mixtures will be non-plastic and display dilatancy. Clay mixtures will have some degree of plasticity but do not typically react to dilatancy testing. Therefore, the tests outlined above can be used to differentiate between silt dominated and clay dominated soils.

MINOR COMPONENT(S)

The minor component(s) are the size fraction(s) containing less than 50% volume. Example: the identified components are estimated to be 60% medium sand to granules, 25% silt and clay; 15 % pebbles – there are two identified minor components: silt and clay; and pebbles.

Include a standard modifier to indicate percentage of minor components (see Table on Page 6) and the same descriptors that would be used for a principal component. Plasticity should be provided as a descriptor for clay and clay mixtures. Dilatancy should be provided for silt and silt mixtures. Angularity should be provided as a descriptor for pebbles and coarse sand. For the example above, the minor constituents with modifiers could be: some silt and clay, low plasticity; little medium to large pebbles, sub-round.

SORTING

Sorting is the opposite of grading, which is a commonly used term in the USCS or ASTM methods to describe the uniformity of the particle size distribution in a sample. Well-sorted samples are poorly graded and poorly sorted samples are well graded. Arcadis prefers the use of sorting for particle size distributions and grading to describe particle size distribution trends in the vertical profile of a sample or hydrostratigraphic unit because of the relationship between sorting and the energy of the depositional process. For soils with sand-sized or larger particles, sorting should be determined as follows:

Well sorted – the range of particle sizes is limited (e.g. the sample is comprised of predominantly one or two grain sizes).

Poorly sorted – a wide range of particle sizes are present.

You can also use sieve analysis to estimate sorting from a sedimentological perspective; sorting is the statistical equivalent of standard deviation. Smaller standard deviations correspond to higher degree of sorting (see Remediation Hydraulics, 2008).

MOISTURE

Moisture content should be described for every sample since increases or decreases in water content is critical information. Moisture should be described in accordance with the table below (percentages should not be used unless determined in the laboratory).

Description	Criteria
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet (Saturated)	Visible free water, soil is usually below the water table.

CONSISTENCY or DENSITY

This can be determined by standard penetration test (SPT) blow counts (ASTM D-1586) or field tests in accordance with the tables below. When drilling with hollow-stem augers and split-spoon sampling, the SPT blow counts and N-value is used to estimate density. The N-value is the blows per foot for the 6" to 18" interval. Example: for 24-inch spoon, recorded blows per 6-inch interval are: 4/6/9/22. Since the second interval is 6" to12", the third interval is 12" to 18", the N value is 6+9, or 15. Fifty blow counts for less than 6 inches is considered refusal. In recent years, more common drilling methods include rotary-sonic or direct push. When blow counts are not available, density is determined using a thumb test. Note however, the thumb test only applies to fine-grained soils.

Fine-grained soil – Consistency

Description	Criteria
Very soft	N-value < 2 or easily penetrated several inches by thumb.
Soft	N-value 2-4 or easily penetrated one inch by thumb.
Medium stiff	N-value 9-15 or indented about ¼ inch by thumb with great effort.
Very stiff	N-value 16-30 or readily indented by thumb nail.
Hard	N-value > than 30 or indented by thumbnail with difficulty

Coarse-grained soil – Density

Description	Criteria
Very loose	N-value 1- 4
Loose	N-value 5-10
Medium dense	N-value 11-30
Dense	N-value 31- 50
Very dense	N-value >50

COLOR

Color should be described using simple basic terminology and modifiers based on the Munsell system. Munsell alpha-numeric codes are required for all samples. If the sample contains layers or patches of varying colors this should be noted and all representative colors should be described. The colors should be described for moist samples. If the sample is dry it should be wetted prior to comparing the sample to the Munsell chart.

ADDITIONAL COMMENTS (NOTES)

Additional comments should be made where observed and should be presented as notes with reference to a specific depth interval(s) to which they apply. Some of the significant information that may be observed includes the following.

- Odor - You should not make an effort to smell samples by placing near your nose since this can result in unnecessary exposure to hazardous materials. However, odors should be noted if they are detected during the normal sampling procedures. Odors should be based upon descriptors such as those used in NIOSH "Pocket Guide to Chemical Hazards", e.g. "pungent" or "sweet" and should not indicate specific chemicals such as "phenol-like" odor or "BTEX" odor.
- Structure
- Bedding planes (laminated, banded, geologic contacts).
- Presence of roots, root holes, organic material, man-made materials, minerals, etc.
- Mineralogy
- Cementation
- NAPL presence/characteristics, including sheen (based on client-specific guidance).
- Reaction with HCl - typically only used for special soil conditions, such as caliche environments.
- Origin, if known (Lacustrine; Fill; etc.).

EXAMPLE DESCRIPTIONS

51.4 to 54.0' CLAY, some silt, medium to high plasticity; trace small to large pebbles, sub-round to sub-angular up to 2" diameter; moist, stiff, dark grayish brown (10 YR 4/2) NOTE: Lacustrine; laminated 0.1 to 0.2" thick, laminations brownish yellow (10 YR 4/3).

32.5 to 38.0’ SAND, medium to very coarse, sub-round to sub-angular; little granule and pebble, trace silt; poorly sorted, wet, grayish brown (10 YR 5/2).

Unlike the first example where a density of cohesive soils could be estimated, this rotary-sonic sand and pebble sample was disturbed during drilling (due to vibrations in a loose sand and pebble matrix) so no density description could be provided. Neither sample had noticeable odor so odor comments were not included.

The standard generic description order is presented below.

- Depth
- Principal Components
    - Angularity for very coarse sand and larger particles
    - Plasticity for silt and clay
    - Dilatancy for silt and silt-sand mixtures
- Minor Components
- Sorting
- Moisture
- Consistency or Density
- Color
- Additional Comments

8 WASTE MANAGEMENT

Project-specific requirements should be identified and followed. The following procedures, or similar waste management procedures are generally required.

Water generated during cleaning procedures will be collected and contained onsite in appropriate containers for future analysis and appropriate disposal. PPE (such as gloves, disposable clothing, and other disposable equipment) resulting from personnel cleaning procedures and soil sampling/handling activities will be placed in plastic bags. These bags will be transferred into appropriately labeled 55-gallon drums or a covered roll-off box for appropriate disposal.

Soil materials will be placed in sealed 55-gallon steel drums or covered roll-off boxes and stored in a secured area. Once full, the material will be analyzed to determine the appropriate disposal method.

9 DATA RECORDING AND MANAGEMENT

Upon collection of soil samples, the soil sample should be logged on a standard boring log and/or in the field log book depending on Data Quality Objectives (DQOs) for the task/project. The preferred standard boring log is presented below and is included as **Attachment A**.

The general scheme for soil logging entries is presented above; however, depending on task/project DQOs, specific logging entries that are not applicable to task/project goals may be omitted at the project manager's discretion. In any case, use of a consistent logging procedure is required.

Completed logs and/or logbook will be maintained in the task/project field records file. Digital photographs of typical soil types observed at the site and any unusual features should be obtained whenever possible. All photographs should include a ruler or common object for scale. Photo location, depth and orientation must be recorded in the daily log or log book and a label showing this information in the photo is useful.

10 QUALITY ASSURANCE

Soil descriptions should be completed only by appropriately trained personnel. Descriptions should be reviewed by an experienced field geologist for content, format and consistency. Edited boring logs should be reviewed by the original author to assure that content has not changed.

11 REFERENCES

Arcadis Soil Description Field Guide, 2008.

Munsell® Color Chart – available from Forestry Suppliers, Inc.- Item 77341 "Munsell® Color Soil Color Charts.

Field Gauge Card that Shows Udden-Wentworth scale – available from Forestry Suppliers, Inc. – Item 77332 "Sand Grain Sizing Folder."

ASTM D-1586, Test Method for Penetration Test and Split-Barrel Sampling of Soils.

ASTM D-2488-00, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

United States Bureau of Reclamation. Engineering Geology Field Manual. United States Department of Interior, Bureau of Reclamation. http://www.usbr.gov/pmts/geology/fieldmap.htm.

Petrology of Sedimentary Rocks, Robert L. Folk, 1980, p. 1-48.

NIOSH Pocket Guide to Chemical Hazards.

Remediation Hydraulics, Fred C. Payne, Joseph A. Quinnan, and Scott T. Potter, 2008, p 59-63.

ATTACHMENT A

Arcadis Standard Soil Boring Log Form

ARCADIS Design & Consultancy for natural and built assets

SOIL BORING LOG

Boring/Well ____________ Project ______________________________ Page ___ of ___

Site Location ____ Drilling Started ____________________

Total Depth Drilled _____ Feet Hole Diameter ______ inches Drilling Completed ____________________

Type of Sample or Coring Device __________ Length and Diameter of Coring Device ____________________ Sampling Interval _________ feet

Drilling Method __________ Drilling Fluid Used ______________

Drilling Contractor ____________________________ Driller ________________________

Prepared By ____________________________ Helper ________________________

Core Recovery (feet)	PID Reading (ppm)	Sample Depth (ft bgs)	MUD		SAND					GRAVEL				**Udden-Wentworth Description:** principal components, (angularity, plasticity, dilatency); minor components, (angularity, plasticity, dilatency); sorting, moisture content, consistency/density, color, additional comments
			clay	silt	very fine	fine	medium	coarse	very coarse	granular	pebble	cobble	boulder	

ARCADIS Design & Consultancy for natural and built assets

SOIL BORING LOG (CONT'D)

Boring/Well ____________________ Prepared By ____________________ Page ____ of ____

Core Recovery (feet)	PID Reading (ppm)	Sample Depth (ft bgs)	MUD		SAND					GRAVEL				Udden-Wentworth Description: principal components, (angularity, plasticity, dilatency); minor components, (angularity, plasticity, dilatency); sorting, moisture content, consistency/density, color, addtl. Comments
			clay	silt	very fine	fine	medium	coarse	very coarse	granular	pebble	cobble	boulder	

ATTACHMENT B

Example of Completed Arcadis Soil Boring Log

ARCADIS Design & Consultancy for natural and built assets

SOIL BORING LOG

Boring/Well SB-01 Project Example Page 1 of 1
Site Location Anytown, North America
Drilling Started 6/26/17
Total Depth Drilled 20 Feet
Hole Diameter 4.5 inches
Drilling Completed 6/26/17
Type of Sample or Coring Device Continuous
Length and Diameter of Coring Device 5', 2.25" macrocore
Sampling Interval 5 feet
Drilling Method Geoprobe
Drilling Fluid Used NA
Drilling Contractor Fibertec
Driller Ryan Brown
Prepared By A. DeGrandis
Helper Grant Berger

Core Recovery (feet)	PID Reading (ppm)	Sample Depth (ft bgs)	MUD clay	silt	SAND very fine	fine	medium	coarse	very coarse	GRAVEL granular	pebble	cobble	boulder	Udden-Wentworth Description: principal components, (angularity, plasticity, dilatency); minor components, (angularity, plasticity, dilatency); sorting, moisture content, consistency/density, color, additional comments
	0.3	1	X	X	X	X	X							(0.0-4.0) SAND, fine to medium, sub-rounded;
	0.1	2	X	X	X	X	X							little granules to small pebbles, sub-rounded
60"	0.0	3	X	X	X	X	X							to sub-angular; trace silt; poorly sorted, dry
(HA)	0.0	4	X	X	X	X	X							to moist, dark grayish brown (10YR 4/2).
	1.4	5	X	X										NOTE: Ablation till.
	1.7	6	X	X										
	0.9	7	X	X										(4.0-10.0) SILT, non-plastic, rapid dilatancy;
52"	1.2	8	X	X										dry to moist, soft to medium stiff,
	0.6	9	X	X										gray (10YR 5/1).
	0.2	10	X	X										
	0.0	11	X	X	X	X								(10.0-15.5) SAND, fine, sub-rounded; trace
	0.0	12	X	X	X	X								silt; well sorted, moist to wet, pale
60"	0.1	13	X	X	X	X								brown (10YR 6/3).
	0.0	14	X	X	X	X								
	0.0	15	X	X	X	X								NOTE: Wet at 12.0'
	0.2	16	X	X	X	X								
	0.0	17	X											(15.5-20.0) CLAY, high plasticity, no dilatancy;
58"	0.0	18	X											little silt; moist, soft to medium stiff,
	0.0	19	X											light gray (10YR 7/1) to dark gray (10YR 4/1).
	0.0	20	X											NOTE: Lacustrine, minor 0.1-0.25" lamination.
														End of boring - 20.0'

ATTACHMENT C

Arcadis Soil Description Field Guide

ON THE ORIGINAL DRAWING.
USE TO VERIFY FIGURE
REPRODUCTION SCALE

SOIL DESCRIPTION FIELD GUIDE (JUNE 30, 2017; REV. 2.0)

ARCADIS Design & Consultancy for natural and built assets

FINE-GRAINED SOILS

Description	Criteria
	Descriptor - Plasticity
Nonplastic	A 1/8-inch (3mm) thread cannot be rolled at any moisture content.
Low	Thread can barely be rolled, and lump cannot be formed when drier than plastic limit.
Medium	Takes considerable time and rolling to reach plastic limit. Thread cannot be rolled after reaching plastic limit. Lump crumbles when drier than plastic limit.
High	Thread is easy to roll and quickly reaches plastic limit. Thread can be rerolled several times after reaching plastic limit. Lump can be formed without crumbling when drier than plastic limit.
	Descriptor - Dilatancy
No Dilatancy	No visible change when shaken or squeezed.
Slow	Water appears slowly on the surface of soil during shaking and does not disappear or disappears slowly when squeezed.
Rapid	Water appears quickly on surface of soil during shaking and disappears quickly when squeezed.
Minor Components with Descriptors	
	Moisture
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet	Visible free water; soil is usually below the water table. (Saturated)
	Consistency
Very soft	N-value < 2 or easily penetrated several inches by thumb.
Soft	N-value 2-4 or easily penetrated 1 inch by thumb.
Medium stiff	N-value 5-8 or indented about 1/2 inch by thumb with great effort.
Stiff	N-value 9-15 or indented about 1/4 inch by thumb with great effort.
Very stiff	N-value 16-30 or readily indented by thumb nail.
Hard	N-value > than 30 or indented by thumbnail with difficulty.
Color using Munsell	
Geologic Origin (if known)	
Other	

EXAMPLE OF SOIL DESCRIPTION AND PHOTO

10-15 feet CLAY, medium to high plasticity; trace silt; trace small to very large pebbles, subround to subangular up to 2" diameter; moist, stiff, dark grayish brown (10YR 4/2). NOTE: Lacustrine; laminated 0.1 to 0.2" thick, laminations brownish yellow (10YR 4/3).

DESCRIPTION ORDER

Depth Interval
Principal Components with Descriptors
Minor Components with Descriptors
Sorting
Field Moisture Condition
Density/Consistency
Color using Munsell
Geologic Origin (if known)
Other descriptions as NOTES:
- Odor
- Stratigraphy
- Structure
- Sphericity
- Cementation
- Reaction to acid

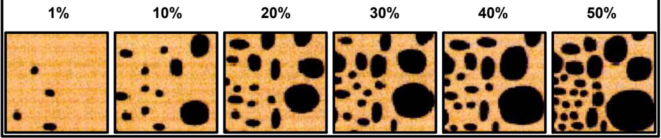
MINOR COMPONENTS % MODIFIERS

Modifier	Percent of Total Sample (by volume)
and	36 - 50
some	21 - 35
little	10 - 20
trace	<10

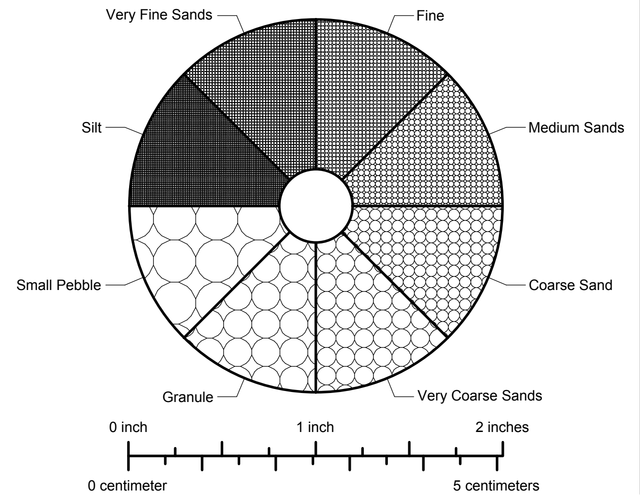
UDDEN-WENTWORTH SCALE

Fraction	Sieve Size	Grain Size	Approximate Scale
Boulder		256 - 4096 mm	Larger than volleyball
Large Cobble		128 - 256 mm	Softball to volleyball
Small Cobble		64 - 128 mm	Pool ball to softball
Very Large Pebble		32 - 64 mm	Pinball to pool ball
Large Pebble		16 - 32 mm	Dime size to pinball
Medium Pebble		8 - 16 mm	Pencil eraser to dime size
Small Pebble	No. 5+	4 - 8 mm	Pea size to pencil eraser
Granule	No. 10 - 5	2 - 4 mm	Rock salt to pea size
Very Coarse Sand	No. 18 - 10	1 - 2 mm	See field gauge card
Coarse Sand	No. 35 -18	0.5 - 1 mm	See field gauge card
Medium Sand	No. 60 - 35	0.25 - 0.5 mm	See field gauge card
Fine Sand	No. 120 - 60	0.125 - 0.25 mm	See field gauge card
Very Fine Sand	No. 230 - 120	0.0625 - 0.125 mm	See field gauge card
Silt and Clay. See SOP for description of fines	Not Applicable	<0.0625 mm	Analyze by pipette or hydrometer

PARTICLE PERCENT COMPOSITION ESTIMATION



GRAPH FOR DETERMINING SIZE OF PARTICLES



FOR COARSE-GRAINED SOILS

Description	Criteria
	Descriptor - Angularity
Angular	Particles have sharp edges and relatively planar sides withunpolished surfaces.
Subangular	Particles are similar to angular but have rounded edges.
Subround	Particles have nearly planar sides but have well-roundedcorners and edges.
Round	Particles have smoothly curved sides and no edges.
Minor Components with Descriptors	
	Sorting **Cu= d60/d10**
Well Sorted	Near uniform grain-size distribution Cu= 1 to 3.
Poorly Sorted	Wide range of grain size Cu= 4 to 6.
	Moisture
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet	Visible free water; soil is usually below the water table. (Saturated)
	Density
Very loose	N-value 1 - 4
Loose	N-value 5 - 10
Medium Dense	N-value 11 - 30
Dense	N-value 31 - 50
Very dense	N-value >50
Color using Munsell	
Geologic Origin (if known)	
Other	
	Cementation
Weak Cementation	Crumbles or breaks with handling or little finger pressure.
Moderate Cementation	Crumbles or breaks with considerable finger pressure.
Strong Cementation	Will not crumble with finger pressure.
	Reaction with Dilute HCl Solution (10%)
No Reaction	No visible reaction.
Weak Reaction	Some reaction, with bubbles forming slowly.
Strong Reaction	Violent reaction, with bubbles forming immediately.

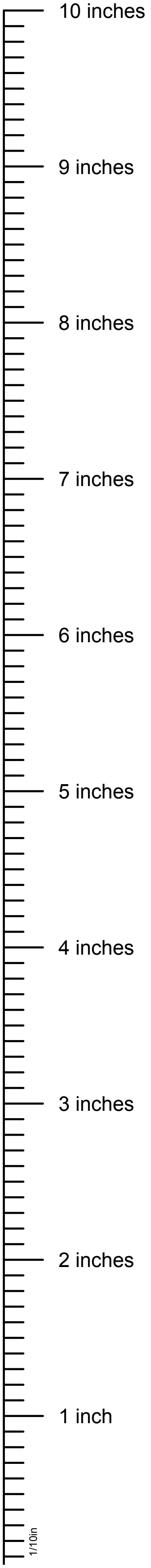
EXAMPLE OF SOIL DESCRIPTION AND PHOTO

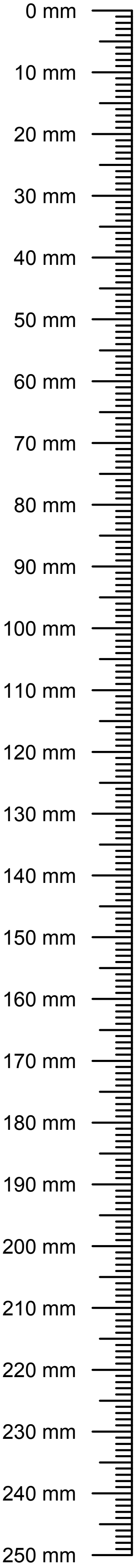
10 -15 feet SAND, medium to very coarse; little granules to medium pebbles, subround to subangular; trace silt; poorly sorted, wet, grayish brown (10YR5/2).

ON THE ORIGINAL DRAWING.
USE TO VERIFY FIGURE
REPRODUCTION SCALE

SOIL DESCRIPTION FIELD GUIDE (JUNE 30, 2017; REV. 2.0)

ARCADIS Design & Consultancy for natural and built assets





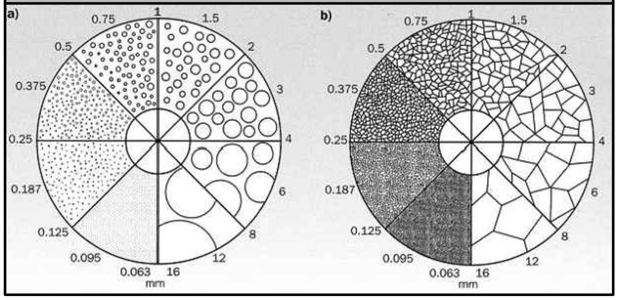
VARIATIONS IN SOIL STRATIGRAPHY

Term	Thickness of Configuration
Parting	0 - to 1/16-inch thickness.
Seam	1/16 - to 1/2-inch thickness.
Layer	1/2 - to 12-inch thickness.
Stratum	> 12-inch thickness.
Pocket	Small erratic deposit, usually less than 1 foot in size.
Varved Clay	Alternating seams or layers of sand, silt, and clay (laminated).
Occasional	≤ 1 foot thick.
Frequent	> 1 foot thick.

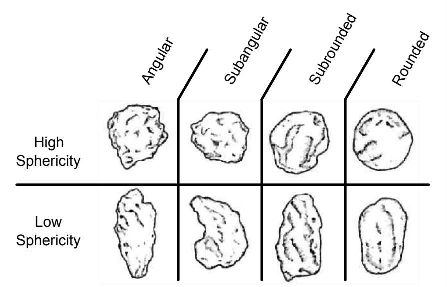
SOIL STRUCTURE DESCRIPTIONS

Term	Description
Homogeneous	Same color and appearance throughout.
Laminated	Alternating layers < 1/4 inch thick.
Stratified	Alternating layers ≥ 1/4 inch thick.
Lensed	Inclusions of small pockets of different materials, such as lenses of sand scattered through a mass of clay; note thickness.
Blocky	Cohesive soil can be broken down into small angular lumps, which resist further breakdown.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear to be polished or glossy, sometimes striated.

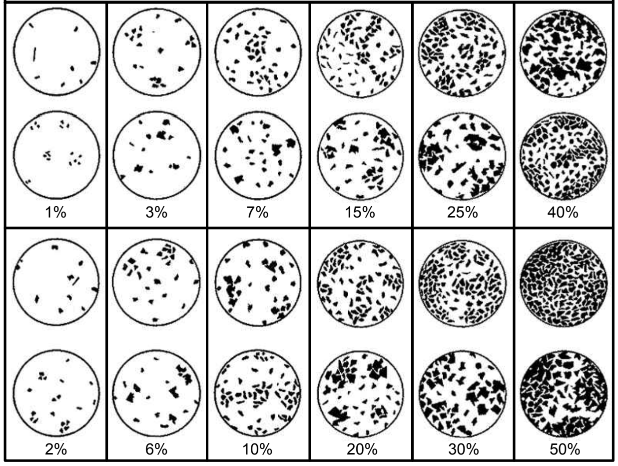
GRAPH FOR DETERMINING SIZE OF PARTICLES



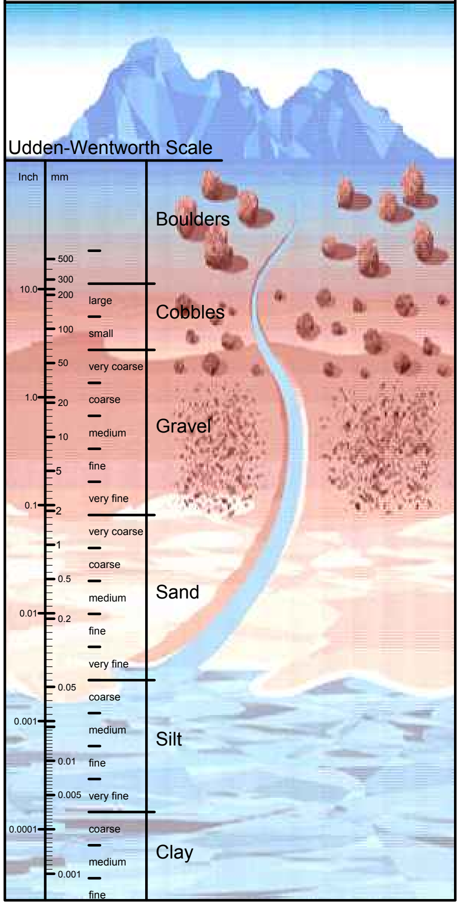
ANGULARITY CHART



PARTICLE PERCENT COMPOSITION ESTIMATION



SORTING



SETTLING TABLE (SILT/CLAY)

Diameter of Particle (mm)	<0.625	<0.031	<0.016	<0.008	<0.004	<0.002	<0.0005
Depth of Withdrawal (cm)	10	10	10	10	5	5	3
Time of Withdrawal	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec
Temperature (Celsius)							
20	00:00:29	00:01:55	00:07:40	00:30:40	00:61:19	04:05:00	37:21:00
21	00:00:28	00:01:52	00:07:29	00:29:58	00:59:50	04:00:00	
22	00:00:27	00:01:50	00:07:18	00:29:13	00:58:22	03:54:00	
23	00:00:27	00:01:47	00:07:08	00:28:34	00:57:05	03:48:00	
24	00:00:26	00:01:45	00:06:58	00:27:52	00:55:41	03:43:00	33:56:00
25	00:00:25	00:01:42	00:06:48	00:27:14	00:54:25	03:38:00	
26	00:00:25	00:01:40	00:06:39	00:26:38	00:53:12	03:33:00	
27	00:00:24	00:01:38	00:06:31	00:26:02	00:52:02	03:28:00	
28	00:00:24	00:01:35	00:06:22	00:25:28	00:50:52	03:24:00	31:00:00
29	00:00:23	00:01:33	00:06:13	00:24:53	00:49:42	03:10:00	
30	00:00:23	00:01:31	00:06:06	00:24:22	00:48:42	03:05:00	

TGI – SEDIMENT, SURFACE WATER, AND STORMWATER SAMPLE COLLECTION FOR PFAS ANALYSIS

Rev: 2

Rev Date: October 15, 2020

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	October 5, 2018	All	Combined aspects of generic Sediment Sample Collection TGI (Rev 0, June 18, 2018) and Stormwater Sampling TGI (Rev 0, August 29, 2018). Added surface water collection guidance and made this TGI PFAS-specific. Added stormwater and surface water sections; made PFAS-specific	Shannon Dunn
1	March 27, 2020	15, 16	Revised the depth criteria to 0.5 to 1 feet for shallow surface water and >1 for deeper surface water	Shannon Dunn
2	October 15, 2020	15, 16	Added Air Force preference to sample surface water at surface for Air Force investigations.	Erika Houtz

APPROVAL SIGNATURES

Prepared by:

10/5/2018

Josh Roberts
Staff Geologist, PG (TN)

Date:

Technical Expert Reviewed by:

Shannon Dunn

10/19/2020

Shannon Dunn
Assistant Vice President

Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) describes the collection of sediment, surface water, and stormwater samples, including field screening and logging of sediment samples. Sediment samples will be collected using a hand-held dredge, push cores, and/or stainless-steel scoop or trowel (the proper technique will be selected in the field depending on site conditions) for the laboratory analysis of sediment chemistry samples. Surface water and stormwater samples will be collected using direct-fill methods or peristaltic pumps. The general procedures to be utilized in obtaining sediment, surface water, and stormwater samples are outlined below. The intent of this TGI is to provide instructions for sampling during United States Army Environmental Command (USAEC) per- and polyfluoroalkyl substances (PFASs) Preliminary Assessment and Site Inspection (PA/SI) at various installations. It also covers specific considerations for PFASs due to their unique chemical and physical properties, low detection limits, and regulatory standards.

This TGI may change depending upon field conditions, equipment limitations, or limitations imposed by the procedure. Substantive modification to this TGI will be approved in advance by the Project Manager.

3 PERSONNEL QUALIFICATIONS

All field personnel must have the appropriate training required by Arcadis as described in the project Site Safety and Health Plan (SSHP). Arcadis field sampling personnel will be trained in proper sampling procedures under the guidance of an experienced field geologist, engineer, or technician. Arcadis field sampling personnel will also be versed in the relevant TGIs and standard operating procedures (SOPs) necessary to successfully complete the desired field work.

4 EQUIPMENT LIST

The following materials will be available, as required, during sampling. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, pending field conditions.

Site plan with proposed sampling locations;

Relevant work plan (e.g., Programmatic Quality Assurance Project Plan [PQAPP]);

SSHP;

Health and Safety equipment, as required by the site SSHP and task-specific Job Safety Analysis;

Sediment Sampling Equipment:

- Boat with outboard motor and associated equipment (as necessary);
- Global Positioning System (GPS) unit;
- Navigation chart(s) for on-water activities (if available and as applicable);
- Stainless-steel hand-held dredge (6-inch x 6-inch Ekman or Petite Ponar);
- Lexan^{TM} tubes (4-inch) and PFAS-free plastic caps;
- Stainless-steel bowl;
- Stainless-steel spatula, scoop, bent spoon, or trowel;
- Steel core driver (i.e., slide hammer);
- YSI 6-Series Multi-Parameter Instrument water quality meter with flow-through cell for monitoring temperature, conductivity, oxidation reduction potential (ORP), and dissolved oxygen (DO);
- Supplemental turbidity meter;
- Stainless-steel probe rod – for evaluating bottom softness when wading to sampling locations
- Polypropylene twine/rope
- Hacksaw with stainless steel blade;
- Tape measure;
- Stainless steel, polyvinyl chloride (PVC) or high-density polyethylene (HDPE) yard stick for measuring water depth.
- Stainless-steel extension rod (if necessary to extend reach of scoop or trowel);

- Rubber boots or rubber waders (only non-coated rubber, other more high-tech waterproof material is not permitted);
- Life jacket or other personal flotation device (PFD) as necessary based on water depth (note, these will likely have PFAS-containing materials so need to be careful to avoid cross-contamination when using).

Surface Water Sampling Equipment:

- If not using direct-fill method:
  - ISCO Model 150 peristaltic pump;
  - Rechargeable marine or car battery (for peristaltic pump);
  - Dedicated HDPE and silicon tubing (Teflon® or polytetrafluoroethylene [PTFE] tubing is prohibited);
  - Stainless steel rod (1/4-inch diameter x 4-feet long or similar) to support HDPE sampling tubing;
  - HDPE zip ties (nylon zip ties are not allowed) to attach tubing to rod;
  - YSI 6-Series Multi-Parameter Instrument water quality meter with flow-through cell for monitoring temperature, conductivity, ORP, and DO;
  - Supplemental turbidity meter;
  - Pail or bucket with closable lid for pump discharge;
- Rubber boots or rubber waders (only non-coated rubber, other more high-tech waterproof material is not permitted);
- Life jacket or other PFD as necessary based on water depth (note, these will likely have PFAS-containing materials so need to be careful to avoid cross-contamination when using).

Stormwater Sampling Equipment:

- Wrench, socket, manhole cover hook or magnetic manhole cover remover for access;
- Approximately 1-inch outer diameter Lexan™ pipe long enough to extend from bottom of storm drain to at least 2 feet above the manhole;
- HDPE zip ties (nylon zip ties are not allowed) to attach tubing to the Lexan™ pipe;
- Tape measure;
- ISCO Model 150 peristaltic pump;
- Rechargeable marine or car battery (for peristaltic pump);
- Dedicated HDPE and silicon tubing (Teflon® or PTFE tubing is prohibited);
- YSI 6-Series Multi-Parameter Instrument water quality meter with flow-through cell for monitoring temperature, conductivity, ORP, and DO;
- Supplemental turbidity meter;

- Pail or bucket with closable lid for pump discharge.

Appropriate sample containers and labels:

- Labeled sample bottles: see the TGI - Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018a) for PFAS-specific considerations;
- 1-quart and 1-gallon polyethylene bags (Ziploc® brand only) to hold ice and samples;
- Appropriate blanks (field reagent blanks supplied by the laboratory);
- Packing and shipping materials;
- Chain-of-Custody (COC) Forms; see the Sample Chain of Custody Standard Operating Procedure (SOP) for reference (Arcadis 2017a);
- Appropriate transport containers (coolers) with ice and appropriate labeling, no blue ice;

Decontamination/Water Management:

- PFAS-free decontamination fluids and equipment
  - HDPE or PVC brushes and squirt bottles
  - Stainless steel bowl
  - HPDE buckets to hold decontamination fluids
  - Alconox® or Liquinox® (other detergents are prohibited)
  - Methanol or isopropyl alcohol (for sediment sampling equipment decontamination only)
  - Distilled or laboratory-supplied deionized water
  - Laboratory-provided PFAS-free water
- See the TGI - Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018a) or the TGI - Groundwater and Soil Sampling Equipment Decontamination (Arcadis 2017b) for additional guidance;
- Portable field hand washing setup;
- Non-hazardous drum labels as required for investigation-derived waste handling: see the TGI - Investigation-Derived Waste Handling and Storage for details (Arcadis 2017c);

Field Notes:

- Pens, pencils, and/or Sharpies® for writing;
- Appropriate field forms;
- Clipboards, field binders, field notebook, and field note pages that are not waterproof;
- Digital camera.

Other

- Garbage bags;
- Paper towels;
- Duct and packing tape;
- Dedicated low-density polyethylene (LDPE) plastic sheeting to prevent sample contact with the ground;
- Field clothing made of cotton or other natural fibers that is well laundered (i.e., washed at least 5 times);
- PFAS-free sunscreen and insect repellant.

5 CAUTIONS

5.1 Utility Clearance

Sediment sampling requires a minimum of three reliable lines of evidence for utility clearance to demonstrate that sample locations are clear of subsurface utilities. A site visit for public utility line clearance at the proposed boring locations will be conducted at least 72 hours prior to work commencing. As applicable, utility maps will be reviewed during field reconnaissance of the proposed inspection locations to determine if any are co-located with public utility lines. Arcadis will also contract an independent geophysical survey company to verify, if possible, that proposed boring locations are not co-located with existing underground utility/substructure features. See the Utility Location and Clearance Arcadis Health and Safety Standard (Arcadis 2017d), including Supplement 6 Utility Location Procedures for Aquatic Work Activities, for reference.

5.2 PFAS-Specific General Sampling Considerations

This section provides a summary of methods and procedures applicable to the collection of environmental samples for field screening or laboratory analysis during PFAS site characterization activities. In general, sampling techniques used for PFAS site characterization are consistent with conventional sampling techniques used in the environmental industry, but special consideration is made regarding PFAS-containing materials and cross-contamination potential. For example, Teflon™ and other fluoropolymer containing materials are found in pumps, tubing, and sample storage containers and therefore should be avoided if possible (Department of Environment Regulation [DER], Western Australia 2016; New Hampshire Department of Environmental Services [NHDES] 2016). Certain field documentation materials such as waterproof paper or field books, adhesive paper products, and some writing utensils (grouped as non-Sharpie® markers) are also prohibited items during PFAS sampling (DER 2016; NHDES 2016).

New nitrile gloves should be donned before any of the following activities:

- Decontamination of re-usable sampling equipment;
- Contact with sample bottles or PFAS-free water bottles;
- Handling clean sample tubing or connecting tubing;
- Handling QC samples including field blanks and equipment blanks.

Additionally, new nitrile gloves should also be donned after handling of any non-dedicated sampling equipment; contact with contaminated surfaces; and whenever judged necessary by field personnel. **When in doubt change your gloves.**

Waterproof field books must not be used for field notes. Instead, field notes should be on loose paper on Masonite, plastic, or aluminum clip boards. Other requirements for field notes include:

- Keep field notes, writing implements, and electronic data collection tablets away from samples and sampling materials; and
- Do not write on sampling bottles unless they are closed.

Tables 1 and **2** in **Attachment 1** provides recommendations for PFAS Site Inspection equipment. **Table 1** provides a summary of materials that have been approved for site inspection; this list is expected to grow longer as industry experience increases. **Table 2** provides a summary of field equipment and materials that have available testing information and/or industry knowledge regarding PFAS cross-contamination potential and it is recommended that these materials be prohibited for sample collection. For materials that are suspected of containing PFASs and/or retaining PFASs, these recommendations are considered preliminary and subject to change.

Given the extremely low detection limits associated with PFAS analysis and the many potential sources of trace levels of PFASs, field personnel are typically advised to err on the side of caution by strictly following field wear guidelines and decontamination procedures as specified in the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018a).**The most important consideration during PFAS-related sampling is to prevent contact between sample media and suspect PFAS sources.**

5.3 PFAS-Specific Sediment Sampling

Because of the potential presence of PFASs in equipment typically used to collect samples, consideration for other sampling materials that contact sediment through the sampling process is necessary. Each piece of equipment that comes into direct contact with the sediment needs to be evaluated to determine if there are either PFAS-containing materials present, which could be a source of cross-contamination and cause false positives, or if PFASs adhere to the material, which has the potential to cause low bias sample results. For each additional piece of equipment that may introduce contamination, an equipment blank should be collected to confirm that materials in the sample equipment do not cause false positives by introducing PFASs. Equipment blanks are particularly important for any device/component where PFASs may be present or cannot be verified as being a non-PFAS containing material. Other quality assurance methods may be implemented to avoid materials that could result in potential losses associated with PFASs adhering to surfaces.

The following additional notes are provided regarding sediment sampling materials:

- Lexan™ liner sleeves are made of polycarbonate and they are not expected to contain PFASs based on review of the Safety Data Sheet (Sabic 2016).
- Studies evaluating the use of stainless steel indicate that PFASs do not strongly sorb to stainless-steel (Obal et al. 2012). Therefore, stainless-steel sleeves and equipment should be acceptable for collection of sediment samples for PFAS analysis.

5.4 PFAS-Specific Surface Water and Stormwater Sampling

As described for sediment sampling, the potential presence of PFASs in equipment that may come in contact with the target water sample must be evaluated as part of the sample planning process to maintain sample integrity.

Note that if high concentrations of PFASs related to Class B firefighting foams are expected in a surface water sample, it has been recommended to collect and shake a small portion of the sample at the time of sample collection (USACE 2016; Arcadis 2018a). If foaming is noted within the sample, it indicates elevated concentrations of PFASs may be present and the sample should be proactively diluted at the laboratory prior to analysis. The foaming should be noted on the sample COC form. It is recommended to collect sampling equipment blanks following foam observation to confirm the effectiveness of decontamination procedures.

While permissible during fog or intermittent showers, surface water samples should not be collected during steady, prolonged rainfall. Avoid entraining sediment in surface water samples. If accessing the sample location from water, approach slowly from downstream to avoid disturbing the bottom.

6 HEALTH AND SAFETY CONSIDERATIONS

Field activities associated with sediment, surface water, and stormwater sampling and description will be performed in accordance with a site-specific SSHP, a copy of which will be present on site during such activities. Additional health and safety discussions are specifically discussed below.

6.1 Sediment Sampling

- Walk established paths whenever possible to avoid slip/trip hazards. Take your time and watch your footing.
- A PFD may be required to complete sediment sampling. Review the Arcadis Water Operations Health and Safety Standard and the SSHP to determine if a PFD is required.
- To the extent possible, maintain three points of physical contact (i.e., two feet and one hand, or one foot and two hands) when entering and exiting a stream channel.
- Ensure the state One Call has been completed and the Arcadis Utilities and Structures Checklist is completed before sampling.
- Take breaks as needed to avoid repetitive use injury or muscle strain and take turns with co-workers as needed.
- Do not touch sediments with bare hands or detect odors by placing sediments close to your nose.
- STOP WORK when conditions change or become unsafe and discuss if/how to proceed safely before resuming work.
- If boats are required for sampling, the following considerations should be made:
  - Good housekeeping and three-points of physical contact should be maintained when entering/exiting the boat to prevent falls or trips
  - Boat operator will be properly trained
  - To avoid impact with other water traffic, ensure navigational lighting is functional (if applicable). Be vigilant and maintain situational awareness of other water traffic.

6.2 Surface Water Sampling

- A PFD may be required to complete surface water sampling. Review the Arcadis Water Operations Health and Safety Standard and the SSHP to determine if a PFD is required.
- Always have three points of contact when entering and exiting a stream channel, if necessary.
- If boats are required for sampling, the following considerations should be made:
    - Good housekeeping and three-points of physical contact should be maintained when entering/exiting the boat to prevent falls or trips
    - Boat operator will be properly trained
    - To avoid impact with other water traffic, ensure navigational lighting is functional (if applicable). Be vigilant and maintain situational awareness of other water traffic.

6.3 Stormwater Sampling

- The ability to safely access the stormwater sampling vaults or manholes should be verified prior to sampling. Confined space entry is not allowed.

7 PROCEDURE

7.1 Sediment Sampling

Sediment samples will be collected by one of the following methods considered most appropriate for the site conditions.

- Hand-held scoop or trowel – for shallow water depths (e.g., < 2 feet) that are nearshore and that sediment conditions preclude sampling by push core or grab sampler
- Push core – for sampling in deeper water (e.g., > 2 feet) or offshore
- Petite Ponar Grab Sampler – for sampling in deeper water offshore with coarse sediment or hard bottom.

Sampling Mobilization/Prep

- Don personal protective equipment (PPE) as discussed in Section 5.2 and the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018a).
- Mobilize to sampling location.
    - If accessing by wading, approach slowly from a downstream direction to limit disturbance of the bottom and resulting suspension of sediment into the surface water at sampling location.
    - If accessing by boat, maneuver to the target sample location using GPS and secure the vessel in place.
- Identify the proposed sample location in the field notebook along with other appropriate information (e.g., location, date, time, personnel, weather).

- Verify all dedicated sample gear has been properly decontaminated as discussed in Section 10.
- Measure and record water depth at the sampling location.

Sample Collection by Stainless Steel Scoop or Trowel

- Attach stainless steel scoop, bent spoon, or trowel to a stainless-steel extension rod (if needed) and lower vertically downward through the water column until it reaches the bottom. Collect sediment from the top 2 inches (5 centimeters [cm]) of the bottom surface.
- Retrieve the scoop, bent spoon, or trowel. Slowly decant overlying water and take care to prevent fine sediment from being poured out with the water. Inspect recovered sediment to confirm it does not contain vegetation (e.g., grass, leaves, sticks or similar undecomposed organic material). Use the stainless-steel trowel to remove any vegetation prior to filling sample bottles. If the sample contains too much vegetation to be removed effectively, collect another sediment sample from the bottom.
- Place the sediment in a decontaminated stainless-steel bowl.
- Photograph the grab sample to provide reference for post-processing questions regarding descriptions of color/staining, general texture, recovery, and other characteristics. Photos of the sample will include the grab sample ID, date, and time, written on loose paper with a Sharpie® marker. The photo will also include a view of a tape measure for scale.
- Describe lithology of recovered sediment in accordance with Arcadis TGI for Soil Descriptions (Arcadis 2018b).
- Homogenize the sediment with a stainless-steel mixing spoon until the sediment is of uniform color.
- Collect sediment samples. If additional sediment is needed to fill the bottles, collect additional sample volume approximately 1-2 feet upstream from the first to minimize disturbance.
- Measure surface water pH, conductivity, temperature, and turbidity at the sampling location and record on sampling forms.
    - Use YSI 6-Series Multi-Parameter Instrument water quality meter with flow-through cell for monitoring temperature, conductivity, ORP, and DO.
    - Use the supplemental turbidity meter to measure turbidity.

Sample Collection by Push Core

- Lower section of clean Lexan^{TM} tube (at least as long as the target sediment penetration depth plus the water depth) until it contacts the top of the sediment.
- Push Lexan^{TM} tube with a straight vertical entry into the sediment to a depth of approximately 4 inches (10 cm) below the sediment surface. If necessary, drive the tube a few more inches down into the sediment either by hand or using a steel core driver to obtain a plug at the bottom of the core

that will prevent the sediment from falling out during core retrieval. Note that only the top 2 inches (5 cm) of soil will be used for laboratory sampling.

- Place a cap made of PFAS-free materials (e.g., HDPE, silicon) on the top of the sediment tube and slowly pull the tube from the sediment, twisting it slightly as it is removed (if necessary)
- Before the tube is fully removed from the water, place a PFAS-free cap on the bottom end of the tube while it is still submerged. Ensure that the bottom end cap fits tightly and will not inadvertently slip off. Remove the tube from the water.
- Keeping the tube upright, wipe the bottom end dry and double check that the bottom cap is tight. If necessary (e.g., walking away from the sampling area to a more secure area to fill sample jars), keep one hand beneath the bottom cap to prevent the cap from falling off. Measure the length of sediment recovered and evaluate the integrity of the core.
- While keeping the core upright, use a hacksaw to make a horizontal cut in the tube approximately 2 - 3 inches above the sediment and carefully drain water from the core to prepare it for inspection and sampling.
  - Note: If possible, use a section of Lexan ™ tubing short enough to allow for sampling without cutting the core. This is only possible in shallow water conditions, as the Lexan ™ tubing should be at least long enough to keep the top of the tube above water.
- Slowly decant overlying water and take care to prevent fine sediment from being poured out with the water. Inspect recovered sediment to confirm it does not contain vegetation (e.g., grass, leaves, sticks or similar undecomposed organic material). Use the stainless-steel trowel to remove any vegetation prior to filling sample bottles. If the sample contains too much vegetation to be removed effectively, collect another sediment sample from the bottom.
- Using a stainless-steel bent spoon, scoop, or trowel, place the top 2 inches (5 cm) of sediment in a decontaminated stainless-steel bowl.
- Photograph the grab sample to provide reference for post-processing questions regarding descriptions of color/staining, general texture, recovery, and other characteristics. Photos of the sample will include the grab sample ID, date, and time written on loose paper with a Sharpie® marker. The photo will also include a view of a tape measure for scale.
- Describe the lithology of recovered sediment in accordance with Arcadis TGI for Soil Descriptions (Arcadis 2018b).
- Homogenize the sediment with a stainless-steel mixing spoon until the sediment is of uniform color.
- Collect sediment samples. If additional sediment is needed to fill the bottles, collect additional sample volume approximately 1-2 feet upstream from the first to minimize disturbance
- Measure surface water pH, conductivity, temperature, and turbidity at the sampling location and record on sampling forms.
  - Use YSI 6-Series Multi-Parameter Instrument water quality meter with flow-through cell for monitoring temperature, conductivity, ORP, and DO.

  - Use supplemental turbidity meter to measure turbidity.

Sample Collection by Petite Ponar Grab Sampler

- Use polypropylene twine/rope with the dredge or similar PFAS-free approved material.
- Set the stainless-steel Petite Ponar grab sampler dredge and slowly lower the open dredge from the side of the boat until it is just above the top of the sediment surface. Then drop the open dredge into the sediment.
- Once the dredge has been allowed to settle into the bottom sediment, pull hard on the rope, or send the messenger to trigger the dredge and close the sediment inside.
- Retrieve the dredge onto the boat.
- Inspect the sample for acceptability in accordance with the following criteria:
  - Sampler is not overfilled with sample such that the sediment surface presses against the top of the sampler or is extruding through the top of the sampler.
  - Overlying water is present above the sediment (indicates minimal leakage)
  - At least 4 inches (10 cm) of sediment penetration depth has been achieved.
- Tilt the dredge over slightly to drain the overlying water to prepare the sediment for inspection and sampling, being careful not to disturb the recovered sediment. Also take care to prevent fine sediment from being poured out with the water.
- Inspect recovered sediment to confirm it does not contain vegetation (e.g., grass, leaves, sticks or similar undecomposed organic material). Use the stainless-steel trowel to remove any vegetation prior to filling sample bottles if possible to do so with minimum disturbance of the recovered sediment. If the sample contains too much vegetation to be removed effectively without disturbing sediment, collect another sediment sample from the bottom.
- Using a stainless-steel bent spoon, scoop, or trowel, place the top 2 inches (5 cm) of sediment in a decontaminated stainless-steel bowl.
- Photograph the grab sample to provide reference for post-processing questions regarding descriptions of color/staining, general texture, recovery, and other characteristics. Photos of the sample will include the grab sample ID, date, and time written on loose paper with a Sharpie® marker. The photo will also include a view of a tape measure for scale.
- Describe the lithology of recovered sediment in accordance with Arcadis TGI for Soil Descriptions (Arcadis 2018b).
- Homogenize the sediment with a stainless-steel mixing spoon until the sediment is of uniform color.
- If additional sediment volume is needed to fill sample bottles, redeploy the dredge 1 – 2 feet upstream from the previous sampling location.

- Measure surface water pH, conductivity, temperature, and turbidity at the sampling location and record on sampling forms.
    - Use YSI 6-Series Multi-Parameter Instrument water quality meter with flow-through cell for monitoring temperature, conductivity, ORP, and DO.
    - Use supplemental turbidity meter to measure turbidity.

Laboratory Sample Collection/Management, Post-Sampling

- Fill the sample bottle for PFAS analysis first, then fill bottles for any remaining analyses.
- Don clean nitrile gloves and use a stainless-steel trowel to fill clean labeled bottles supplied by the laboratory for the required analyses with sediment. Collect lab samples from the top 5 cm of the recovered 10 cm interval only. Do not overfill bottles.
- Make sure caps remain on PFAS sample bottles until immediately prior to filling. Caps must remain in the hand of the sampler until replaced on the bottle.
- Once the PFAS sample has been placed in the bottle, and the bottle cap has been completely tightened, label the sample with sample identification number, date, and time of collection. Labels must be completed only after the caps have been placed back on each bottle. (See P-01 QP#3.06 Field Activities documentation for sample label information).
- Collect QC samples at the frequency specified in Quality Assurance Project Plan (QAPP) Addendum Worksheet #20. QC sample locations are to be selected based on consultation with the Arcadis Regional Lead (RL). **Note, if using waders to access sampling locations, collect equipment blank off of the waders.**
- Record the label information and time of sampling in the field notes and sampling forms.
- Fill out the laboratory COC and check against the labels on the sample bottles progressively after each sample is collected.
- Place the sample bottles in a sealed Ziploc© bag, and then into sample coolers. Store PFAS samples in separate cooler from other samples.

7.2 Surface Water Sampling

Sampling Mobilization/Prep

- Don PPE as discussed in Section 5.2 and the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2018a).
- Mobilize to sampling location.
    - If accessing by wading, approach slowly from downstream direction to limit disturbance of bottom and resulting suspension of sediment into the surface water at the sampling location.

  - If accessing by boat, maneuver to the target sample location using GPS and secure the vessel in place.
- Identify the proposed sample location in the field notebook along with other appropriate information (e.g., location, date, time, personnel, weather).
- Verify all dedicated sample gear has been properly decontaminated as discussed in Section 10.
- Measure and record water depth at the sampling location.
- Do not sample surface water when it is raining. Fog or intermittent showers are okay, but not steady rainfall. Avoid entraining sediment in surface water samples.

Shallow Surface Water (0.5 – 1 feet)

- Cut a length of new HDPE tubing to the appropriate size for desired sampling depth and pump location and attach to stainless steel rod using HDPE zip ties. Insert a new length of silicon tubing into the peristaltic pump and connect HDPE tubing on intake side and a shorter length of new HDPE tubing on discharge side.
- Direct pump discharge into pail/bucket during sampling.
- For general PFAS investigation, lower the HPDE tubing on intake side of pump to the desired depth in the water column. For water depths < 1 ft, place tubing intake at approximately mid-depth of the water column.
- For Air Force investigations, place the HDPE tubing on intake at the surface. Collect samples from the water surface.
- Do not disturb sediment at bottom of water body with sampling equipment, as this could cause suspension of sediment into the surface water that could introduce cross contamination into the sample.
- Verify pump flow direction and turn on pump.
- Once water fills the tubing and begins flowing out of the discharge end turn off pump and prepare to sample.
- Don fresh set of nitrile gloves. Disconnect HDPE tubing from silicon tubing on discharge end. Keep silicon tubing in clean gloved hand and do not allow it to contact any surfaces or equipment. Turn on pump and fill sample bottle to the neck directly from silicon tubing, headspace is acceptable. Do not rinse PFAS sample bottles during sampling.
- Only use labelled HDPE bottles that are supplied by the laboratory. Make sure the cap remains on the bottle until immediately prior to sample collection and gets placed back on the bottle immediately after sample collection. Do not place the cap on any surface, and keep cap in gloved hand opposite of sample collection, do not touch the inside of the cap.
- Measure surface water pH, conductivity, temperature, and turbidity at the sampling location and record on the sampling forms.
  - Use YSI 6-Series Multi-Parameter Instrument water quality meter with flow-through cell for monitoring temperature, conductivity, ORP, and DO.
  - Use supplemental turbidity meter to measure turbidity.

Deeper Surface Water (>1 feet)

- Don fresh set of nitrile gloves immediately prior to collecting samples. Use nitrile glove with long cuff that covers the forearm, as this will help avoid submerging clothing or skin during sampling.
- Only use labelled HDPE bottles that are supplied by the laboratory. Do not rinse PFAS sample bottles prior to collecting sample. Do not remove cap prior to or after sample collection. Do not place the cap on any surface, and keep cap in gloved hand opposite of sample collection, do not touch the inside of the cap.
- Facing the upstream direction (if the surface water body is flowing), place sample container in freshly gloved hand and gently submerge the sample container beneath the water surface with the cap on. For Air Force investigations, the bottle should be submerged at the water surface.
- Tilt the container so the mouth is angled slightly upward, then with the other gloved hand gently unscrew the cap, open it a crack and allow water to flow slowly down the inner wall of the container filling it. For Air Force investigations, the mouth should be at the surface.
- Do not submerge hands below top of gloves during sampling such that clothing or bare skin of sampling personnel comes into contact with the surface water.
- When the sample container is full, replace and tighten the cap while the container is still submerged, then remove it from the water.
- Measure surface water pH, conductivity, temperature, and turbidity at sampling location and record on sampling forms.
    - Use YSI 6-Series Multi-Parameter Instrument water quality meter with flow-through cell for monitoring temperature, conductivity, ORP, and DO.
    - Use supplemental turbidity meter to measure turbidity.

Laboratory Sample Management, Post-Sampling

- Once the PFAS sample has been placed in the bottle, and the bottle cap has been completely tightened, label the sample with sample identification number, date, and time of collection. Labels must be completed only after the caps have been placed back on each bottle. (See P-01 QP#3.06 Field Activities documentation for sample label information).
- Collect QC samples at the frequency specified in the QAPP Addendum Worksheet #20. QC sample locations are to be selected based on consultation with the Arcadis RL. **Note, if using waders to access sampling locations, collect equipment blank off of the waders.**
- Record the label information and time of sampling in the field notes and sampling forms.
- Fill out the laboratory COC and check against the labels on the sample bottles progressively after each sample is collected.
- Place sample bottles in a sealed Ziploc® bag, and then into sample coolers. Store PFAS samples in separate cooler from other samples.

7.3 Stormwater Sampling

The following general guidelines apply when sampling stormwater.

- Sampling should be started from the manhole farthest downstream and work upstream. This mitigates the impact of subsequent samples if anything on the bottom is disturbed and migrates downstream.
- Care should be taken not to disturb the bottom sediments in catch basin sumps or other storm water sampling locations.
- Stormwater samples should only be collected from active flow. Stormwater will not be collected from pools or standing water.

Use the following procedure to collect grab stormwater samples.

- Verify all dedicated sample gear has been properly decontaminated as discussed in Section 10.
- Mobilize to stormwater sampling location.
- Confirm that active flow is entering the sampling space.
- Measure the depths from the top of the manhole to the top of the stormwater surface and to the bottom of the stormwater system with a tape measure (do this downstream from the spot where the sample will be collected).
- Subtract the depth of the water surface from the depth of the stormwater system. This is the thickness of the stormwater column. Divide the thickness by two. Add the result to the depth of the stormwater surface. This is the sampling depth.
- Strap the HDPE sampling tubing to the Lexan ™ pipe using the HDPE zip ties.
- Place a HDPE zip tie on the Lexan ™ pipe that marks the sampling depth, as measured above. This HDPE zip tie will be used as a marker to guide how far to insert the pipe and tubing into the manhole. The HDPE zip tie marker will prevent over inserting the Lexan ™ pipe and tubing and thus prevent disturbing the deposited sediment in the stormwater system.
- Attach the other end of the tubing (the end that will not be placed into the stormwater for sampling) to the peristaltic pump.
- Collect active flow sample.
  - Slowly lower the Lexan ™ pipe and tubing into the stormwater system to the sample collection depth, using the marker HDPE zip tie as a guide.
- Verify pump flow direction and turn on pump.
- Once water fills the tubing and begins flowing out of the discharge end turn off pump and prepare to sample.
- Don fresh set of nitrile gloves. Disconnect HDPE tubing from silicon tubing on discharge end. Keep silicon tubing in clean gloved hand and do not allow it to contact any surfaces or equipment. Turn on pump and fill sample bottle to the neck directly from silicon tubing, headspace is acceptable. Do not rinse PFAS sample bottles during sampling.

- Only use labelled HDPE bottles that are supplied by laboratory. Make sure that the cap remains on the bottle until immediately prior to sample collection and gets placed back on the bottle immediately after sample collection. Do not place the cap on any surface, and keep cap in gloved hand opposite of sample collection, do not touch the inside of the cap.
- Measure surface water pH, conductivity, temperature, and turbidity at the sampling location and record on sampling forms.
  - Use YSI 6-Series Multi-Parameter Instrument water quality meter with flow-through cell for monitoring temperature, conductivity, ORP, and DO.

Use supplemental turbidity meter to measure turbidity.

Laboratory Sample Management, Post-Sampling

- Once the PFAS sample has been placed in the bottle, and the bottle cap has been completely tightened, label the sample with sample identification number, date, and time of collection. Labels must be completed only after the caps have been placed back on each bottle. (See P-01 QP#3.06 Field Activities documentation for sample label information).
- Collect QC samples at the frequency specified in the QAPP Addendum Worksheet #20. QC sample locations are to be selected based on consultation with the Arcadis RL. **Note, if using waders to access sampling locations, collect equipment blank off of the waders.**
- Record the label information and time of sampling in the field notes and sampling forms.
- Fill out the laboratory COC and check against the labels on the sample bottles progressively after each sample is collected.
- Place sample bottles in a sealed Ziploc® bag, and then into sample coolers. Store PFAS samples in separate cooler from other samples.

8 WASTE MANAGEMENT

Investigation-derived waste (IDW) including excess sediment, surface water, stormwater and decontamination fluids will be collected and placed in Department of Transportation approved containers, segregated by waste streams: see the Investigation-Derived Waste Handling and Storage TGI for details (Arcadis 2017c). All containers will be labeled as non-hazardous unless otherwise instructed by the Project Manager. Containerized IDW will be stored on site until it is profiled and subsequently transported to an approved facility for disposal or recycling. Waste manifests for all IDW suspected to have come into contact with PFAS should clearly note the presence of PFAS. Additional IDW sampling and management details will be provided in the site-specific QAPP Addendum and will be consistent with applicable Army policies and Army post requirements. Personal protective equipment (e.g., gloves, disposable clothing, disposable equipment) resulting from personnel cleaning procedures and soil sampling activities will be placed in plastic bags. These bags will be transferred into appropriately labeled waste containers for appropriate disposal.

9 DATA RECORDING AND MANAGEMENT

The supervising field lead will be responsible for documenting sampling events to record all relevant information in a clear and concise format. The record of sampling events should include:

- Sample dates
- Project name and location
- Project number, client, and site location
- Sampling details (e.g., field measured water quality parameters, standing water column depth)
- Sediment core log
- Type of tools used
- Weather conditions

Field staff should ensure COC Forms are properly completed, and verify which PFAS analytes (e.g., just PFOS and PFOA, some or all of the 537 list) are required for analysis and note on the COC.

10 DECONTAMINATION

To avoid cross-contamination during sampling, all reusable sampling equipment will be cleaned between sampling locations as follows. Repeat these steps twice at all locations suspected of containing a Class B firefighting foam source.

Sediment Sampling

With Organic Solvent Rinse (Preferred Method)

- Don new pair of nitrile gloves prior to decontamination
- Scrub using a plastic brush and non-phosphate soap (Liquinox® or Alconox® only)
- Double-rinse in deionized or distilled water
- Rinse once with methanol or isopropyl alcohol
- Rinse once with PFAS-free water
- Collect all rinsate in a sealed pail for disposal
- Allow time to air dry prior to re-use

Without Organic Solvent Rinse (Contingency Method)

- Don new pair of nitrile gloves prior to decontamination
- Scrub using a plastic brush and non-phosphate soap (Liquinox® or Alconox® only);
- Single-rinse in deionized or distilled water;
- Scrub using a plastic brush and non-phosphate soap (Liquinox® or Alconox® only);
- Double-rinse in deionized or distilled water and single-rinse with PFAS-free water;
- Collect all rinsate in a sealed pail for disposal;
- Allow time to air dry prior to re-use.

Surface Water/Stormwater Sampling

- Don new pair of nitrile gloves prior to decontamination
- Scrub using a plastic brush and non-phosphate soap (Liquinox® or Alconox® only);
- Double-rinse in deionized or distilled water;
- Collect all rinsate in a sealed pail for disposal;
- Allow time to air dry prior to re-use.

See additional specifics in P-04, TGI - Groundwater and Soil Sampling Equipment Decontamination in PQAPP Appendix A.

11 QUALITY ASSURANCE

In general, the following quality assurance and quality control (QA/QC) samples should be collected:

- Equipment blanks
- Field (i.e., reagent) blanks
- Field duplicates
- Matrix spike/matrix spike duplicate

Details on QC sampling requirements (e.g., frequency of collection, types of QA/QC samples) are provided in the PQAPP and will be outlined in various Site-specific sampling scopes of work in the QAPP Addendum. Additionally, detailed procedures related to equipment and field (i.e., reagent) blank sample collection are outlined in the Equipment and Reagent Blank Sample Collection TGI (Arcadis 2018c).

Refer to QC requirements for the project to ensure that appropriate QA/QC samples are collected. When collecting QA/QC samples, the same guidelines apply as when collecting regular samples – specifically that:

- Samples should be collected in laboratory-supplied HDPE bottles
- Bottle caps must remain in the hand of the sampler until replaced on the bottle
- Labels must be completed after the caps have been placed back on each bottle
- Samples must be stored in appropriate transport containers (coolers) with ice (Ziploc®-type bags for use as ice containers) with appropriate labeling. **Do not use blue ice. Store PFAS samples in a separate cooler from other types of samples.**

12 REFERENCES

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ATTACHMENT 1

Table 1 and Table 2: PFAS Inspection Material Recommendations

Table 1: Summary of Acceptable Sampling Equipment and Materials for PFAS Site Inspections

Sampling Materials	Additional Considerations	References
Water Sampling Materials		
High density polyethylene (HDPE) or silicone tubing materials	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
HDPE HydraSleeves^{TM}	Low density polyethylene (LDPE) HydraSleeves^{TM} are not recommended	USACE 2016; MassDEP 2017
Drilling and Soil Sampling Materials		
PFAS-free drilling fluids	--	DER 2016
PFAS-free makeup water	Confirm PFAS-free water source via laboratory analysis prior to inspections	--
Acetate liners	For use in soil sampling	USACE 2016
Sample Containers and Storage		
HDPE sample containers with HDPE lined lids for soil and water samples	Laboratory should provide; whole bottle analysis of aqueous samples combined with a solvent rinse of bottle is recommended	DER 2016, MassDEP 2017
Ice contained in plastic (polyethylene) bags (double bagged)	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Field Documentation		
Sharpie®	--	NHDES 2016; USACE 2016; MassDEP 2017
Ball point pens	--	MassDEP 2017
Standard paper and paper labels	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Decontamination		
Water-only decontamination	Confirm PFAS-free water source via laboratory analysis prior to inspections	DER 2016
Alconox®, Liquinox® or Citranox® followed by deionized water or PFAS-free water rinse	Alconox® known to contain trace levels of 1,4-dioxane	NHDES 2016; USACE 2016; MassDEP 2017
Methanol, isopropanol, or acetone	Special health and safety precautions are necessary	UNEP 2015; USACE 2016

Note: This list is considered preliminary and additional materials may be added as additional information becomes available. Project teams are expected to follow a methodical evaluation process of materials to be used and confirm acceptance prior to implementation of field activities.

Table 2: Summary of Equipment and Materials Not Recommended for PFAS Site Inspections

Sampling Materials	Known PFAS-Containing Materials	Suspected PFAS-Containing Materials	Materials with Potential to Retain PFASs	References
Water Sampling Materials				
Teflon® or polytetrafluoroethylene (PTFE)-containing or coated field equipment (e.g., tubing, bailers, tape, plumbing paste)	x			DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Passive diffusion bags			x	MassDEP 2017
LDPE HydraSleeves ™			x	USACE 2016; MassDEP 2017
Water particle filters			x	MassDEP 2017
Drilling and Soil Sampling Materials				
Aluminum foil			x	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Drilling fluid containing PFASs	x	x		DER 2016
Sample Containers and Storage				
Glass sample containers with lined lids			x	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
LDPE containers and lined lids			x	USACE 2016
Teflon® or PTFE- lined lids on containers (e.g., sample containers, rinsate water storage containers)	x			DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Reusable chemical or gel ice packs (e.g., BlueIce®)		x		DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Field Documentation				
Self-sticking notes and similar office products (e.g., 3M Post-it®-notes)		x		DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Waterproof paper, notebooks, and labels	x			DER 2016, MassDEP 2017
Non-Sharpie® markers		x		NHDES 2016
Decontamination				
Some detergents and decontamination solutions (e.g., Decon 90® Decontamination Solution)	x	x		DER 2016; NHDES 2016; MassDEP 2017

Note: For materials that are suspected of containing PFASs, or have the potential to retain PFASs, project specific considerations may provide adequate justification for use during the field event. For example, further evaluation may be conducted in the form of pre-field equipment blank sample analysis.

TECHNICAL GUIDANCE INSTRUCTIONS - VERTICAL AQUIFER PROFILING (VAP)

Rev: 1

Date: 05/11/2020

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
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APPROVAL SIGNATURES

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1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM’s responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project’s scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

Vertical aquifer profile (VAP) borings are advanced via direct push or rotosonic drilling techniques to collect single or multiple depth-discrete groundwater samples using low-flow or grab sampling methodologies. They can be combined with retrieval of continuous soil cores and lithologic logging, as well as collection of single or multiple depth-discrete dry and saturated soil samples. VAP groundwater sampling intervals should be co-located with or biased towards potential discrete transport zones (and target slow advection zones when feasible) as indicated by soil logging observations or permeability measurements (e.g., point slug tests, Geoprobe® hydraulic profiling tool [HPT] [preferred], Waterloo APS™ [alternate]). Permeability measurements coupled with contaminant concentration allows estimation of relative flux and mass discharge to evaluate potential risk to downgradient receptors. In the absence of permeability measurements, field soil lithological logging observations may be used to interpret hydrostratigraphy and select sampling intervals.

The intent of this Technical Guidance Instruction (TGI) is to provide VAP instructions. It also covers specific considerations for per- and polyfluoroalkyl substances (PFASs) due to their unique chemical and physical properties, low detection limits, and regulatory standards.

Multiple VAP samples can be collected through temporary wells, drilling rod tooling (e.g., Geoprobe® Screen Point 16 [SP-16]/Screen Point 22 [SP-22] Groundwater Samplers or SP-60 Sonic Groundwater Sampler or Cascade's Sonic Push-Ahead or Packer Isolation Groundwater Profilers) or via combined hydraulic profiling and sampling tools (e.g., Geoprobe® HPT-Groundwater Sampling System [HPT-GWS], Waterloo APS™). They can be analyzed quickly via on-site mobile lab or expedited off-site fixed lab analysis to provide adaptive high-resolution quantitative groundwater concentration data. The vertical frequency of groundwater sampling within a formation should be determined relative to the scale of variability demonstrated in site hydrostratigraphy. Thin aquifers with transport zones only tens of feet thick can be sampled at intervals as close as 3 to 5 feet. In aquifers with transport zones of substantial thickness (e.g., more than 50 feet), sample spacing of 5 to 20 feet is usually adequate. It is important to note that field data should be evaluated to verify that sampling intervals provide sufficient resolution to meet data quality objectives (DQOs) (See **Section 7**).

3 PERSONNEL QUALIFICATIONS

In general, VAP activities will be performed by persons who have been trained in proper drilling and sampling procedures under the guidance of an experienced field geologist, engineer, or technician. Drilling subcontractors will need current applicable drilling licenses.

Arcadis field personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or regulations, such as 40-hour HAZWOPER training and/or OSHA HAZWOPER site supervisor training. Arcadis personnel will also have current training as identified in the site-specific Health and Safety Plan (HASP) which may include first aid, cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed. The HASP will also identify any access control requirements.

Prior to mobilization, the field team will review and be thoroughly familiar with relevant site-specific documents including but not limited to the task-specific work plan or field implementation plan (FIP)/field sampling plan, Quality Assurance Project Plan (QAPP), HASP, historical information, and other relevant site documents.

Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and TGIs and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. Additionally, the field team will review and be thoroughly familiar with documentation provided by equipment manufacturers and become familiar with the operation of (i.e., hands-on experience) all equipment that will be used in the field prior to mobilization.

4 EQUIPMENT LIST

The following equipment and materials must be available for VAP sampling

- Site plan with proposed sampling locations
- Relevant work plan (or equivalent)
- Health and Safety Plan (HASP)
- Appropriate health and safety equipment, as specified in the site HASP
- Drilling Equipment
  - Drill rig (to be provided by drilling subcontractor). Type (e.g., rotosonic, direct push) to be determined based on site-specific details
  - Traffic cones, delineators, caution tape, and/or fencing as appropriate for securing the work area, if not provided by the drillers
  - NOTE: *Prior to mobilizing to the site, Arcadis personnel will contact the drilling subcontractor or in-house driller (as appropriate) to confirm that appropriate sampling equipment will be provided in quantities capable of achieving estimated target depths. Typical equipment/materials provided by the driller could include*
    - Acetate or plastic liners
    - Appropriate length of drilling rods and tooling
    - Drilling and sampling equipment decontamination materials,
    - Decontamination pad materials, if required. See **Section 5.3** below for more information
- Sampling Equipment
  - Appropriate groundwater sampling equipment (e.g., disposable bailers for volumetric sampling, peristaltic pump for shallow groundwater sampling, submersible bladder pump for deeper sampling). Refer to *the TGI – Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells* (Arcadis 2020a) for necessary equipment
  - Direct push groundwater samplers (e.g., Geprobe® SP-22) or rotosonic sampling devices (e.g., Cascade Push Ahead/Packer Isolation Groundwater Profiler or Geoprobe® SP-60 Sonic Groundwater Sampler) (to be provided by drilling subcontractor)
  - Appropriate soil sampling equipment (e.g., stainless steel spatulas, knife, metal trowel)
  - Dedicated plastic sheeting (preferably high-density polyethylene [HDPE]) or other clean surface to prevent sample contact with the ground
  - Multi-parameter water quality probe (e.g., conductivity, temperature, pH, dissolved oxygen, oxidation reduction potential, and turbidity meter)
  - Water level meter
  - Appropriate sample containers and labels

  - Labeled sample bottles: see the *TGI – Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance* (Arcadis 2017a) for PFAS-specific considerations
  - Ziplock-style bags to hold ice and samples
  - Appropriate blanks (field reagent blanks supplied by the laboratory)
  - Packing and shipping materials
  - Chain-of-Custody (COC) Forms; see the *Sample Chain of Custody* for reference (Arcadis 2017b)
  - Appropriate transport bottles (coolers) with ice and appropriate labeling, no blue ice

- Decontamination Equipment
  - Equipment cleaning materials: see the *TGI – Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance* (Arcadis 2017a) or the *TGI – Groundwater and Soil Sampling Equipment Decontamination* (Arcadis 2020b) as applicable
  - Drum labels as required for investigation derived waste handling: see the *TGI – Investigation-Derived Waste Handling and Storage* for details (Arcadis 2017c)
- Documentation/Field Notes
  - Electronic data collection device (smart phone or tablet) as applicable
  - Pens, pencils, and/or Sharpie® brand pens for writing
  - Appropriate field forms
  - Clipboards, field binders, field notebook, and field note pages that are not waterproof

5 CAUTIONS

5.1 Utility Clearance

The appropriate drilling authorities will be contacted and a site visit for public utility line clearance at the proposed boring locations will be conducted at least 72 hours prior to work commencing. As applicable, utility maps will be reviewed during field reconnaissance of the proposed investigation locations to determine if any are co-located with public utility lines. Arcadis will also contract an independent geophysical survey company to verify that proposed boring locations are not co-located with existing underground utility/substructure features, as necessary. Arcadis will clear locations with soft dig methods to assess the presence of underground utilities as necessary. See the *Utility Location and Clearance Arcadis Health and Safety Standard* (Arcadis 2017d) for reference.

5.2 PFAS-Specific General Sampling Considerations

This section provides a summary of methods and procedures applicable to the collection of environmental samples for field screening or laboratory analysis during PFAS site characterization activities. In general, sampling techniques used for PFAS site characterization are consistent with conventional sampling techniques used in the environmental industry, but special consideration is made regarding PFAS-containing materials and cross-contamination potential. For example, Teflon™ and other fluoropolymer containing materials are found in pumps, tubing, and sample storage containers and therefore should be avoided if possible (Department of Environment Regulation [DER], Western Australia 2016; New Hampshire Department of Environmental Services [NHDES] 2016). Certain field documentation materials such as waterproof paper or field books, adhesive paper products, and some writing utensils (grouped as non-Sharpie® markers) are also prohibited items during PFAS sampling (DER 2016; NHDES 2016).

Tables 1 and 2 in **Attachment 1** provides recommendations for PFAS Site Investigation equipment. Table 1 provides a summary of materials that have been approved for site investigation; this list is expected to grow longer as industry experience increases. Table 2 provides a summary of field equipment and materials that have available testing information and/or industry knowledge regarding PFAS cross-contamination potential and it is recommended that these materials be prohibited for sample collection. For materials that are suspected of containing PFASs and/or retaining PFASs, these recommendations are considered preliminary and subject to change.

Given the extremely low detection limits associated with PFAS analysis and the many potential sources of trace levels of PFASs, field personnel are typically advised to err on the side of caution by strictly following field wear guidelines and decontamination procedures as specified in the Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling Guidance (Arcadis 2017a).The most important consideration during PFAS related VAP sampling is to prevent contact between sample media and suspect PFAS sources.

5.3 PFAS-Specific Soil Sampling

Because of the potential presence of PFASs in equipment typically used to collect samples, consideration for other sampling materials that contact the soil cuttings through the sampling process is necessary. For example, a cutting shoe is used on the head of a direct push drill string and a bucket auger is used to collect samples from a test pit using a backhoe. Each piece of equipment that comes into direct contact with the soil cuttings needs to be evaluated to determine if there are either PFAS-containing materials present, which could be a source of cross-contamination and cause false positives, or if PFASs adhere to the material, which has the potential to cause low bias sample results. If there is concern that equipment may introduce contamination, a conservative number of equipment blanks should be collected to confirm that materials in the sample equipment do not cause false positives by introducing PFASs. Equipment blanks are particularly important for any device/component where PFASs may be present or cannot be verified as being a non-PFAS containing material. Other quality assurance methods may be implemented to avoid materials that could result in potential losses associated with PFASs adhering to surfaces. For example, collecting samples from an “undisturbed” portion of a large diameter soil core and transferring it to the laboratory supplied container may provide assurance that representative soil samples are collected for PFAS sample analysis.

The following additional notes are provided regarding soil sampling materials:

- Where drilling or decontamination water is needed, it is required to submit water samples of the source water for PFAS analysis prior to investigation activities to ensure that background PFASs will not be introduced. Some water systems may be constructed with PFAS-containing thread and gasket sealants; therefore, an inspection of the source water distribution system may provide an additional level of assurance for identifying a source of PFAS-free water for site investigation.

- It is often standard practice to cover the ends of sample sleeves and protect the sample from potential cross-contamination from the plastic end caps with Teflon™ or other PTFE tape (Geotechnical Services, Inc. 2018); this practice is prohibited for PFAS sample collection (DER 2016).
- Lexan™ liner sleeves are made of polycarbonate and they are not expected to contain PFASs based on review of the Safety Data Sheet (Sabic 2016).
- Acetate (i.e., cellulose acetate butyrate) liners are commonly used as sleeves and are not expected to contain PFASs.
- Studies evaluating the use of stainless steel indicate that PFASs do not strongly sorb to stainless-steel (Obal et al. 2012). Therefore, stainless-steel sleeves and equipment should be acceptable for collection of soil samples for PFAS analysis.

5.4 PFAS-Specific Groundwater Sampling

As described for soil sampling, the potential presence of PFASs in equipment that may come in contact with the target water sample must be evaluated as part of the sample planning process to maintain sample integrity. For example, low-flow sampling with a peristaltic pump should be conducted using silicone or HDPE tubing; Teflon™ tubing is prohibited (DER 2016). If a bladder pump is used to collect samples, the bladder and other internal parts (e.g., check balls, o-rings, compression fittings) should not be made of Teflon™ either, and bladder and O-rings should be changed between samples (DER 2016).

Note that if high concentrations of PFASs related to Class B firefighting foams are expected in a groundwater sample, it has been recommended to collect and shake a small portion of the sample at the time of sample collection (USACE 2016; Arcadis 2017a). If foaming is noted within the sample, it indicates elevated concentrations of PFASs may be present and the sample should be proactively diluted at the laboratory prior to analysis. The foaming should be noted on the sample chain of custody form. It is recommended to collect sampling equipment blanks following foam observation to confirm the effectiveness of decontamination procedures.

6 HEALTH AND SAFETY CONSIDERATIONS

To ensure the safety of the field personnel, field activities associated with VAP will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

Appropriate personal protective equipment (PPE) will be worn at all times in line with the task and the site-specific HASP.

Review all site-specific and procedural hazards as they are provided in the HASP, and review Job Safety Analysis (JSA) documents in the field each day prior to beginning work.

7 PROCEDURE

The specific procedure for advancing VAP borings should be developed after careful review and consideration of project DQOs. Typically, VAP borings are conducted in boreholes adjacent to prior HPT borings completed to develop stratigraphic and relative permeability profiles of the aquifer to determine sampling depth intervals targeting transport zones. The primary advantage of completing stratigraphic/permeability profiles in advance of sampling is to gain understanding of hydrofacies trends to ensure that the most appropriate intervals and sampling methods are used. In the absence of HPT data from a co-located boring, sampling depth intervals can be determined based upon lithologic logging of soil cores, either from a separate adjacent borehole or from the same borehole. Soil lithologic logging should be performed in accordance with *TGI – Soil Descriptions* (Arcadis 2018). Waterloo APS^{TM} can be utilized as an alternative to HPT to provide permeability profiles, but it is more time intensive than HPT; therefore, it is not considered the preferred tool for permeability profiling.

7.1 Direct Push Vertical Aquifer Profile Sampling

Direct push tooling is ideal for shallow unconsolidated aquifers and requires minimal water for drilling, reducing the potential for sample dilution. For sites with shallow groundwater in unconsolidated formations (e.g. at less than 100 feet bgs), the typical approach is to collect VAP groundwater samples nominally every 5 to 10 feet with a bias to the more permeable transport zones.

When a zone of interest is identified, either by using permeability measurements (preferred) or logging soil, a screen point sampling device such as Geoprobe® SP-16 or SP-22 (see **Attachment 2**) can be driven to the target interval and the screen opened to collect a groundwater sample. In poorly sorted aquifers with appreciable amounts of silt, VAP sampling from an adjacent borehole after completing initial permeability profiling (e.g., Geoprobe® HPT or point slug tests) is typically more efficient and cost effective. In the absence of permeability profiling tools, VAP sampling can be performed based on soil lithological observations alone, either from a separate borehole or in the same borehole. Combined permeability profiling and sampling tools such as the Geoprobe® HPT-GWS (or Waterloo APS™ as an alternate) can be used to collect groundwater samples based on permeability measurements from the same borehole at deeper depths where the process is more cost-effective; otherwise at shallower depths, separate permeability profiling prior to VAP sampling is preferred. This is most effective in well-sorted sand and gravel when small volumes are required for analysis, since these tools provide limited volumes for purging and sample collection. Use of these combined tools (Waterloo APS or HPT-GWS) for PFASs sites is not recommended because low detection and regulatory thresholds for PFASs require more extensive purging to decontaminate the sampling equipment. Insufficient data are available to confirm the volume of purging required to eliminate cross-contamination with PFASs.

Direct push drilling for VAP sampling should be completed using a dual-tube drilling approach. An outer casing is advanced with the screen point sampling device to limit the potential for cross-contamination between sampling intervals. Pre-calculated volume purging and monitoring for water quality parameter stabilization can be performed with low-flow sampling as part of sample collection process. There are two general methods for completing VAP sampling: bottom-up and top-down. With bottom-up sampling, a greater purge volume is required to ensure a representative groundwater sample; however, the overall time savings is significant relative to top-down sampling. With top-down sampling, more time is required per borehole to lower the tooling and retract it and decontaminate it between subsequent sampling intervals; however, it minimizes any potential for cross-contamination, and is the preferred approach for PFAS projects due to the low detection limits and regulatory levels associated with PFASs.

7.1.1 Bottom-Up VAP Sampling

Bottom-up VAP sampling involves advancing dual-tube direct push casing to target depth with either a solid drive tip (without collecting soil cores) or plastic liners (or acetate liners for PFASs as specified in Table 1 of **Attachment 1**) for collection of continuous soil cores to provide a lithological log for the entire boring. This is followed by lowering the groundwater sampling screen through the outer casing to the bottom of the borehole and collecting multiple VAP groundwater samples at different depths as the casing and screen is retracted back up. Under this approach, the external casing is retracted to allow borehole collapse around the sampling screen while isolating it from the section above that is still covered by the external casing. The advantages of this approach are: (a) when combined with soil cores collection, groundwater sampling depth intervals can be selected based on lithological log observations to target the transport zones, especially in the absence of any co-located permeability measurements and (b) the entire process is much more time-efficient per borehole.

The disadvantage is this doesn’t allow grouting of the borehole from bottom-up, since when the groundwater sampling device is pulled up to the next VAP sampling interval, the sidewalls of the open borehole below it collapse, thus closing off the borehole. Any potential for cross-contamination from adjacent sampling intervals due to the open borehole below is minimized by borehole collapse and can be further mitigated by adjustment of low-flow sampling rates. *Bottom-up VAP sampling should also generally be avoided when potential for dense non-aqueous phase liquid exists, or the borehole goes through multiple confining units, or the contamination is typically concentrated in the bottom portions of the aquifer. Bottom-up is not recommended for PFASs sampling due to potential cross contamination concerns associated with lack of decontamination between sample intervals.*

7.1.2 Top-Down VAP Sampling

Top-down VAP sampling involves advancing dual-tube direct push casing with either a solid drive tip (without collecting soil cores) or a plastic liner for soil core retrieval from target depth interval followed by lowering the screen point sampling screen to target depth and pulling up the outer casing to expose the screen. After purging and sample collection, the screen point sampling screen is pulled back up, and decontaminated. The solid drive tip or plastic liner is lowered back in and the entire assembly is then advanced to the next depth interval. Thus, top-down sampling requires pulling the tooling after each sample interval, decontaminating the tooling (if necessary), resetting the groundwater sampler, and advancing the tooling to the next planned interval. The advantages of this approach are that it allows grouting of the borehole from the bottom of the borehole and reduces the potential for cross contamination from adjacent sampling intervals.

The primary disadvantage is that the entire process is much less time-efficient per borehole, since the tooling has to be retracted and re-advanced every time. *Top-down is the preferred method for PFAS VAP sampling.*

7.2 Sonic Drilling Vertical Aquifer Profile Sampling

For sites with deep unconsolidated aquifers or challenging drilling conditions (e.g., presence of dense tills, caliche, cobbles), direct push drilling may not be feasible or cost effective due to limited production rates. In these cases, alternate drilling methods (e.g., rotosonic) are required. Like direct push, groundwater profilers can be used to collect multiple depth-discrete groundwater samples biased towards transport zones based on soil lithological cores. The configuration of individual samplers varies based on their manufacture by different drilling contractors (e.g., Cascade Push Ahead/Packer Isolation Groundwater Profiler or Geoprobe® SP-60). The overall strategy of sonic drilling VAP sampling is consistent with direct push VAP sampling; however, drilling with sonic or some rotary methods requires the introduction of drilling water that can potentially affect the integrity of the groundwater sample. If drilling water is used, it should be spiked with non-toxic fluorescence dyes per *SOP – Use of Visible Tracer in Drilling Fluid to Obtain Representative Groundwater Samples During Drilling* (Arcadis, 2010).

Sonic VAP sampling is typically performed in a top-down manner using dual-tube casing. Two types of VAP sampling can be conducted – (a) Push-Ahead and (b) Packer Isolation groundwater profilers.

7.2.1 Push-Ahead Groundwater Profiler

The Push-Ahead groundwater profiler is available by Cascade and is threaded to the base of the sonic drill rod and driven through and ahead of the sonic casing into the undisturbed formation to the prescribed sample depth interval. Once the point is at the specified interval, the threaded portion between the profiler and drill steel is partially unthreaded to expose the water ports to allow native formation water to enter the profiler. A groundwater sample is then obtained using either a stainless-steel bailer or pump with tubing depending on DQOs. The biggest disadvantage of this device is that groundwater samples are obtained from undisturbed native formation with unknown soil lithology, so a pre-existing lithological log from an adjacent borehole is needed to determine sampling depth intervals.

7.2.2 Packer Isolation Groundwater Profiler

Packer Isolation groundwater profilers (e.g., Packer Isolation groundwater profiler from Cascade, Geoprobe ® SP-60 Sonic Groundwater Profiler) work by retrieving the soil core and the sonic core barrel and inserting a stainless screen and packer assembly to the base of the sonic casing. The sonic outer casing is then extracted to expose the screen to the formation, and the packer is inflated to isolate the screened interval from any water that might be above the packer in the sonic casing. A groundwater sample can then be collected from the screen. The biggest advantage of this device is that groundwater sampling depth intervals can be determined based on lithological logs obtained from the same borehole.

7.3 Boring Abandonment

Upon completion, each top-down borehole is backfilled with bentonite grout from the terminal end of the boring upward. The top portion of each boring is sealed with asphalt or concrete to match the existing grade. Each bottom-up borehole is typically abandoned by the collapse as the rods are retraced. Borehole abandonment requirements in some geographies dictate top-down sampling; this should be verified in advance of work.

8 WASTE MANAGEMENT

Investigation derived waste (IDW) soil cuttings and decontamination water generated during cleaning procedures will be collected and contained on site in appropriate containers: see the *TGI – Investigation-Derived Waste Handling and Storage* for details (Arcadis 2017c). All IDW generated during field activities will be placed in Department of Transportation approved containers, sealed, and labeled. Containerized IDW will be stored on site until it is profiled and subsequently transported to an approved facility for disposal or recycling. Personal protective equipment (e.g., gloves, disposable clothing, disposable equipment) resulting from personnel cleaning procedures and soil sampling activities will be placed in plastic bags. These bags will be transferred into appropriately labeled containers for appropriate disposal.

9 DATA RECORDING AND MANAGEMENT

The supervising field lead will be responsible for documenting drilling events to record all relevant information in a clear and concise format. The record of drilling events should include:

- Start and finish drilling dates
- Project name and location
- Project number, client, and site location
- VAP boring number and depths
- Depth to water
- Type of VAP-special tools
- Core barrel size
- Names of contractor's drillers, inspectors, or other people onsite
- Weather conditions

Field staff should ensure COC Forms are properly completed, and verify which PFAS analytes (e.g., just PFOS and PFOA, some or all of the 537 list) are required for analysis and note on the COC.

9.1 Field Notes

Waterproof field books must not be used for field notes. Instead, field notes should be on loose paper on Masonite, plastic, or aluminum clip boards and/or electronic data collection tablets (as required). Other requirements for field notes include:

- Keep field notes, writing implements, and electronic data collection tablets away from samples and sampling materials; and,
- Do not write on sampling bottles unless they are closed.

10 QUALITY ASSURANCE

To avoid cross-contamination during drilling and sampling, reusable equipment such as hand tools will be cleaned using a non-phosphate soap free of VOCs, double-rinsed in potable water, and allowed to air dry prior to re-use. Drive casings and other drilling equipment will be steam cleaned or replaced with new equipment between boreholes. The drilling equipment will be cleaned in an area designated by the supervising engineer or geologist that is located outside of the work zone.

Refer to quality control requirements for the project to ensure that appropriate quality assurance and quality control (QA/QC) samples are collected. When collecting QA/QC samples, the same guidelines apply as when collecting regular samples – specifically that:

- Samples should be collected in laboratory-supplied HDPE bottles
- Bottle caps must remain in the hand of the sampler until replaced on the bottle
- Labels must be completed after the caps have been placed back on each bottle
- Samples must be stored in appropriate transport bottles (coolers) with ice (Ziplock-type bags for use as ice containers) with appropriate labeling
- **Do not use blue ice**
- **Store PFAS samples in a separate cooler from other types of samples**

10.1 Equipment Blanks (if relevant)

QA/QC sampling typically includes daily collection of equipment blanks using the laboratory-supplied “PFAS-free” water. For peristaltic pump tubing, laboratory supplied “PFAS-free” water should be poured into a clean HDPE sample bottle and then pumped through new HDPE tubing using the peristaltic pump (with new silicone tubing). Equipment blanks should also be collected from the water used by drillers, as well as any downhole tooling to ensure absence of any cross-contamination. Drilling water sources must be submitted for PFAS analysis before work commences for PFAS-related VAP as discussed in **Section 5.3** above.

10.2 Field Duplicates

QA/QC sampling typically includes the collection of one field duplicate for every 10 or 20 samples collected. Each duplicate sample will be collected immediately after the initial sample of which it is a duplicate into a separate laboratory-provided sample bottle. Do not indicate to the laboratory which sample the duplicate replicates, i.e. it should be given a blind reference on the COC and sample name such as “duplicate”.

10.3 Field Blanks

QA/QC sampling for PFAS typically includes the submission of one laboratory supplied reagent field blank per day. The reagent field blank sample is brought to the site in a laboratory-supplied sample bottle.

Field staff transfer the laboratory-supplied reagent blank to an empty sample bottle. This reagent field blank should be placed in the same cooler as the other PFAS samples.

10.4 Matrix Spikes (optional in some cases)

QA/QC sampling includes submitting a sample to be used as a matrix spike if the project requires it. If a separate sample bottle is required, an additional sample will be collected immediately after the initial sample of which it is a duplicate into a separate laboratory-supplied sample bottle.

10.5 Laboratory Analytical QA/QC

- Internal laboratory QA/QC should consist of one laboratory blank and one laboratory control sample (or blank spike) per batch of samples, and additional QA/QCs as indicated by the laboratory QA/QC procedures. Isotope dilution should be used for quantification with isotope-labeled surrogate standards, as available.
- For groundwater and surface water samples, extract the entire groundwater and surface water sample and at least two sampling bottle solvent rinsates for analysis to increase sample accuracy. Avoid sub-sampling an aliquot of the sample bottle.
- Soil samples should be analyzed in their entirety or thoroughly homogenized before extraction and analysis.
- As part of the internal QA/QC, relative percent difference should be calculated between samples and corresponding field or laboratory duplicates. The laboratory quality assurance portion of the laboratory certificates should be reviewed to verify that all calculations/recoveries were within acceptable limits as established by the laboratory method.
- In January 2017, the U.S. Department of Defense and U.S. Department of Energy Quality Systems Manual (QSM) 5.1 (U.S. Department of Defense 2017) was finalized and introduced laboratory guidance for the measurement of PFASs in matrices other than drinking water. This guidance is not a detailed procedural method such as an U.S. Environmental Protection Agency method, but it does recommend best practices around the analysis of PFASs. Laboratories are not required to comply with QSM 5.1 until 2019, although the recommendations around PFAS analysis are similar to what most laboratories are already implementing. Arcadis recommends that any request for PFAS analysis in groundwater or soil should specifically reference the need to comply with Table B-15 in the QSM 5.1 (i.e., Per- and Polyfluoroalkyl Substances (PFAS) Using Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS) With Isotope Dilution or Internal Standard Quantification in Matrices Other Than Drinking Water); however, this list can be modified to support project specific deliverables.

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ATTACHMENT 1

Table 1 and Table 2: PFAS Investigation Material Recommendations

Table 1: Summary of Acceptable Sampling Equipment and Materials for PFAS Site Investigations

Sampling Materials	Additional Considerations	References
Water Sampling Materials		
High density polyethylene (HDPE) or silicone tubing materials	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
HDPE HydraSleeves™	Low density polyethylene (LDPE) HydraSleeves™ are not recommended	USACE 2016; MassDEP 2017
Drilling and Soil Sampling Materials		
PFAS-free drilling fluids	--	DER 2016
PFAS-free makeup water	Confirm PFAS-free water source via laboratory analysis prior to investigation	--
Acetate liners	For use in soil sampling	USACE 2016
Sample Containers and Storage		
HDPE sample containers with HDPE lined lids for soil and water samples	Laboratory should provide; whole bottle analysis of aqueous samples combined with a solvent rinse of bottle is recommended	DER 2016, MassDEP 2017
Ice contained in plastic (polyethylene) bags (double bagged)	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Field Documentation		
Sharpie®	--	NHDES 2016; USACE 2016; MassDEP 2017
Ball point pens	--	MassDEP 2017
Standard paper and paper labels	--	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Decontamination		
Water-only decontamination	Confirm PFAS-free water source via laboratory analysis prior to investigation	DER 2016
Alconox®, Liquinox® or Citranox® followed by deionized water or PFAS-free water rinse	Alconox® known to contain trace levels of 1,4-dioxane	NHDES 2016; USACE 2016; MassDEP 2017
Methanol, isopropanol, or acetone	Special health and safety precautions are necessary	UNEP 2015; USACE 2016

Note: This list is considered preliminary and additional materials may be added as additional information becomes available. Project teams are expected to follow a methodical evaluation process of materials to be used and confirm acceptance prior to implementation of field activities.

Table 2: Summary of Equipment and Materials Not Recommended for PFAS Site Investigations.

Sampling Materials	Known PFAS-Containing Materials	Suspected PFAS-Containing Materials	Materials with Potential to Retain PFASs	References
Water Sampling Materials				
Teflon® or polytetrafluoroethylene (PTFE)-containing or coated field equipment (e.g., tubing, bailers, tape, plumbing paste)	x			DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Passive diffusion bags			x	MassDEP 2017
LDPE HydraSleeves ™			x	USACE 2016; MassDEP 2017
Water particle filters			x	MassDEP 2017
Drilling and Soil Sampling Materials				
Aluminum foil			x	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Drilling fluid containing PFASs	x	x		DER 2016
Sample Containers and Storage				
Glass sample containers with lined lids			x	DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
LDPE containers and lined lids			x	USACE 2016
Teflon® or PTFE- lined lids on containers (e.g., sample containers, rinsate water storage containers)	x			DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Reusable chemical or gel ice packs (e.g., BlueIce®)		x		DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Field Documentation				
Self-sticking notes and similar office products (e.g., 3M Post-it-notes)		x		DER 2016; USACE 2016; NHDES 2016; MassDEP 2017
Waterproof paper, notebooks, and labels	x			DER 2016, MassDEP 2017
Non-Sharpie® markers		x		NHDES 2016
Decontamination				
Some detergents and decontamination solutions (e.g., Decon 90® Decontamination Solution)	x	x		DER 2016; NHDES 2016; MassDEP 2017

Note: For materials that are suspected of containing PFASs, or have the potential to retain PFASs, project specific considerations may provide adequate justification for use during the field event. For example, further evaluation may be conducted in the form of pre-field equipment blank sample analysis.

ATTACHMENT 2

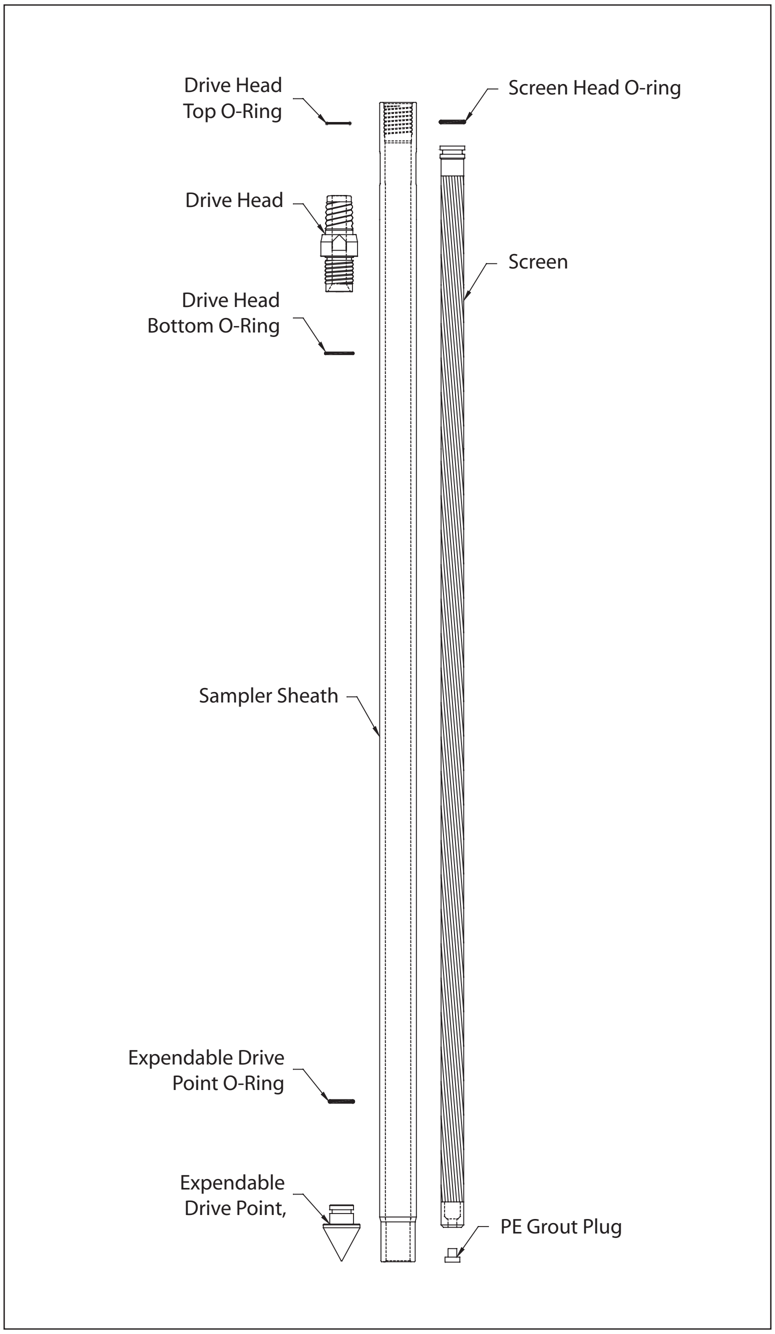
SOPs Geoprobe® Screen Point 16 and Screen Point 22 Groundwater Samplers

GEOPROBE® SCREEN POINT 16 GROUNDWATER SAMPLER

STANDARD OPERATING PROCEDURE

Technical Bulletin No. MK3142

PREPARED: November, 2006



GEOPROBE® SCREEN POINT 16 GROUNDWATER SAMPLER PARTS

Geoprobe® and Geoprobe Systems®, Macro-Core® and Direct Image® are Registered Trademarks of Kejr, Inc., Salina, Kansas

Screen Point 16 Groundwater Sampler is manufactured under U.S. Patent 5,612,498

1.0 OBJECTIVE

The objective of this procedure is to drive a sealed stainless steel or PVC screen to depth, deploy the screen, obtain a representative water sample from the screen interval, and grout the probe hole during abandonment. The Screen Point 16 Groundwater Sampler enables the operator to conduct abandonment grouting that meets American Society for Testing and Materials (ASTM) Method D 5299 requirements for decommissioning wells and borings for environmental activities (ASTM 1993).

2.0 BACKGROUND

2.1 Definitions

Geoprobe®: A brand name of high quality, hydraulically powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling and monitoring, soil conductivity and contaminant logging, grouting, and materials injection.

Screen Point 16 (SP16) Groundwater Sampler: A direct push device consisting of a PVC or stainless steel screen that is driven to depth within a sealed, steel sheath and then deployed for the collection of representative groundwater samples. The assembled SP16 Sampler is approximately 51.5 inches (1308 mm) long with an OD of 1.625 inches (41 mm). Upon deployment, up to 41 inches (1041 mm) of screen can be exposed to the formation. The Screen Point 16 Groundwater Sampler is designed for use with 1.5-inch probe rods and machines equipped with the more powerful GH60 Hydraulic Hammer. Operators with GH40 Series hammers may chose to use this sampler in soils where driving is difficult.

Rod Grip Pull System: An attachment mounted on the hydraulic hammer of a direct push machine which makes it possible to retract the tool string with extension rods or flexible tubing protruding from the top of the probe rods. The Rod Grip Pull System includes a pull block with rod grip jaws that are bolted directly to the machine. A removable handle assembly straddles the tool string while hooking onto the pull block to effectively grip the probe rods as the hammer is raised. A separate handle assembly is required for each probe rod diameter.

2.2 Discussion

In this procedure, the assembled Screen Point 16 Groundwater Sampler (Fig. 2.1A) is threaded onto the leading end of a Geoprobe® probe rod and advanced into the subsurface with a Geoprobe® direct push machine. Additional probe rods are added incrementally and advanced until the desired sampling interval is reached. While the sampler is advanced to depth, O-ring seals at each rod joint, the drive head, and the expendable drive point provide a watertight system. This system eliminates the threat of formation fluids entering the screen before deployment and assures sample integrity.

Once at the desired sampling interval, extension rods are sent downhole until the leading rod contacts the bottom of the sampler screen. The tool string is then retracted approximately 44 inches (1118 mm) while the screen is held in place with the extension rods (Fig. 2.1B). As the tool string is retracted, the expendable point is released from the sampler sheath. The tool string and sheath may be retracted the full length of the screen or as little as a few inches if a small sampling interval is desired.

There are three types of screens that can be used in the Screen Point 16 Groundwater Sampler. Two of the these, a stainless steel screen with a standard slot size of 0.004 inches (0.10 mm) and a PVC screen with a standard slot size of 0.010 inches (0.25 mm), are recovered with the tool string after sampling. The third screen is also manufactured from PVC with a standard slot size of 0.010 inches (0.25 mm), but is designed to be left downhole when sampling is complete. This disposable screen has an exposed screen length of approximately 43 inches (1092 mm). The two screens that are recovered with the sampler both have an exposed screen length of approximately 41 inches (1041 mm).

(continued on following page)

An O-ring on the head of the stainless steel screens maintains a seal at the top of the screen. As a result, any liquid entering the sampler during screen deployment must first pass through the screen. PVC screens do not require an O-ring because the tolerance between the screen head and sampler sheath is near that of the screen slot size.

The screens are constructed such that flexible tubing, a mini-bailer, or a small-diameter bladder pump can be inserted into the screen cavity. This makes direct sampling possible from anywhere within the saturated zone. A removable plug in the lower end of the screens allows the user to grout as the sampler is extracted for further use.

Groundwater samples can be obtained in a number of ways. A common method utilizes polyethylene (TB25L) or Teflon® (TB25T) tubing and a Check Valve Assembly (GW4210). The check valve (with check ball) is attached to one end of the tubing and inserted down the casing until it is immersed in groundwater. Water is pumped through the tubing and to the ground surface by oscillating the tubing up and down.

An alternative means of collecting groundwater samples is to attach a peristaltic or vacuum pump to the tubing. This method is limited in that water can be pumped to the surface from a maximum depth of approximately 26 feet (8 m). Another technique for groundwater sampling is to use a stainless steel Mini-Bailer Assembly (GW41). The mini-bailer is lowered down the inside of the casing below the water level where it fills with water and is then retrieved from the casing.

The latest option for collecting groundwater from the SP16 sampler is to utilize a Geoprobe® MB470 Series Mechanical Bladder Pump (MBP)*. The MBP may be used to meet requirements of the low-flow sampling protocol (Puls and Barcelona 1996, ASTM 2003). Through participation in a U.S. EPA Environmental Technology Verification study, it was confirmed that the MB470 can provide representative samples (EPA 2003).

**The Mechanical Bladder Pump is manufactured under U.S. Patent No. 6,877,965 issued April 12, 2005.*

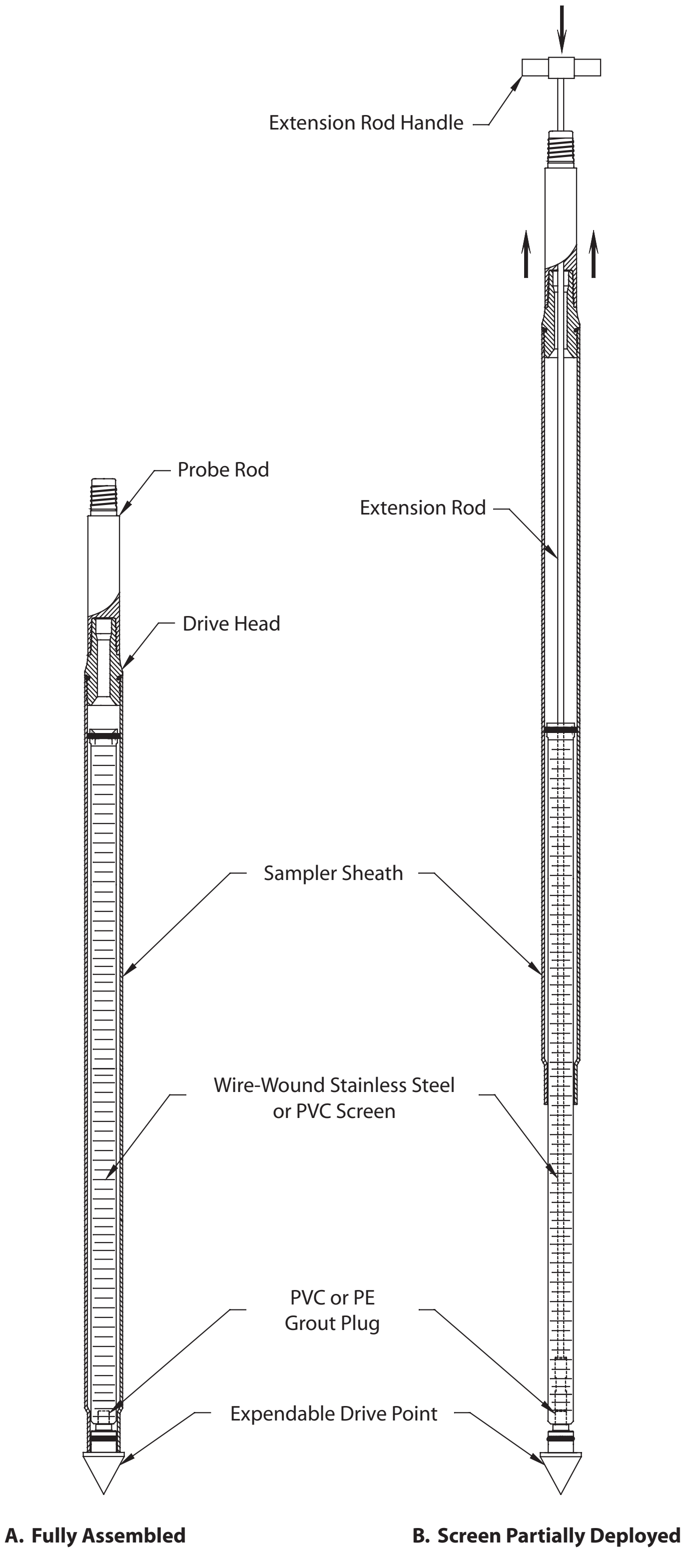


FIGURE 2.1
Screen Point 16 Groundwater Sampler

3.0 TOOLS AND EQUIPMENT

The following tools and equipment can be used to successfully recover representative groundwater samples with the Geoprobe® Screen Point 16 Groundwater Sampler. Refer to Figures 3.1 and 3.2 for identification of the specified parts. Tools are listed below for the most common SP16 / 1.5-inch probe rod configurations. Additional parts for optional rod sizes and accessories are listed in Appendix A.

SP16 Sampler Parts	**Part Number**
SP16 Sampler Sheath	15187
SP16 Drive Head, 0.5-inch bore, 1.5-inch rods*	18307
SP16 O-ring Service Kit, 1.5-inch rods *(includes 4 each of the O-ring packets below)*	15844
O-rings for Top of SP16 Drive Head, 1.5-inch rods only (Pkt. of 25)	*15389*
O-rings for Bottom of SP16 Drive Head (Pkt. of 25)	*13196*
O-rings for GW1520 Screen Head (Pkt. of 25)	*GW1520R*
O-rings for SP16 Expendable Drive Point (Pkt. of 25)	*GW1555R*
Screen, Wire-Wound Stainless Steel, 4-Slot*	GW1520
Grout Plugs, PE (Pkg. of 25)	GW1552K
Expendable Drive Points, steel, 1.625-inch OD (Pkg. of 25)*	GW1555K
Screen Point 16 Groundwater Sampler Kit, 1.5-inch Probe Rods *(includes 1 each of: 15187, 18307, 15844, GW1520, GW1535, GW1540, GW1555K, and GW1552K)*	15770

Probe Rods and Probe Rod Accessories	**Part Number**
Drive Cap, 1.5-inch probe rods, threadless, (for GH60 Hammer)	12787
Pull Cap, 1.5-inch probe rods	15090
Probe Rod, 1.5-inch x 60-inch*	11121

Extension Rods and Extension Rod Accessories	**Part Number**
Screen Push Adapter	GW1535
Grout Plug Push Adapter	GW1540
Extension Rod, 60-inch*	10073
Extension Rod Coupler	AT68
Extension Rod Handle	AT69
Extension Rod Jig	AT690
Extension Rod Quick Link Coupler, pin	AT695
Extension Rod Quick Link Coupler, box	AT696

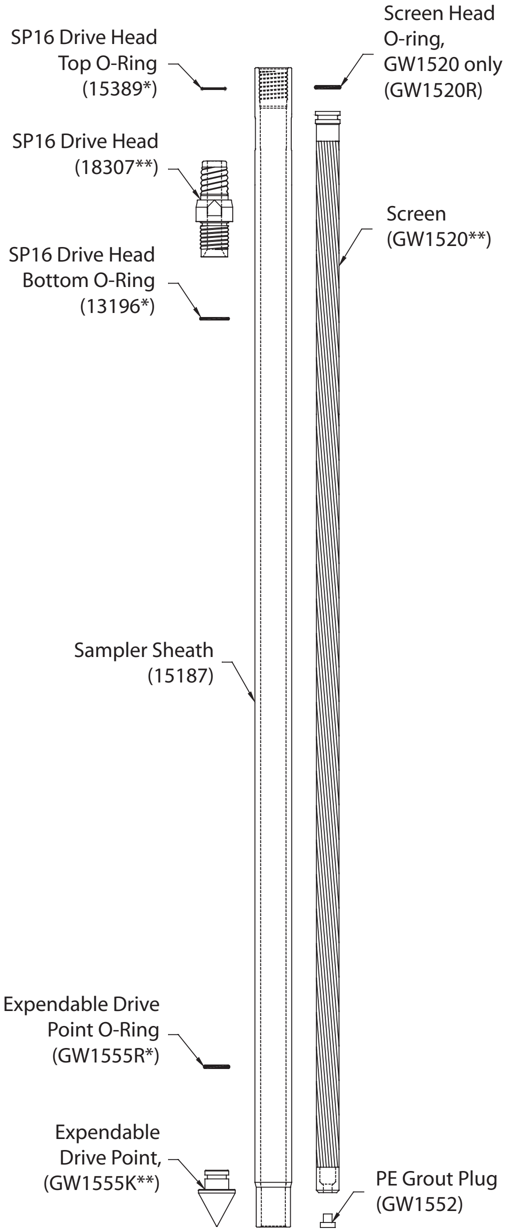
Grout Accessories	**Part Number**
Grout Nozzle, for 0.375-inch OD tubing	GW1545
High-Pressure Nylon Tubing, 0.375-inch OD / 0.25-inch ID, 100-ft. (30 m)	11633
Grout Machine, self-contained*	GS1000
Grout System Accessories Package, 1.5-inch rods	GS1015

Groundwater Purging and Sampling Accessories	**Part Number**
Polyethylene Tubing, 0.375-inch OD, 500 ft.*	TB25L
Check Valve Assembly, 0.375-inch OD Tubing*	GW4210
Water Level Meter, 0.438-inch OD Probe, 100 ft. cable*	GW2000
Mechanical Bladder Pump**	MB470
Mini Bailer Assembly, stainless steel	GW41

Additional Tools	**Part Number**
Adjustable Wrench, 6.0-inch	FA200
Adjustable Wrench, 10.0-inch	FA201
Pipe Wrenches	NA

* See Appendix A for additional tooling options.

** Refer to the Standard Operating Procedure (SOP) for the Mechanical Bladder Pump (Technical Bulletin No. MK3013) for additional tooling needs.



* Included in the SP16 O-ring Service Kit (15844)
** Part numbers show most common tool configuration. See Appendix A for alternative parts.

FIGURE 3.1
SP16 Sampler Parts

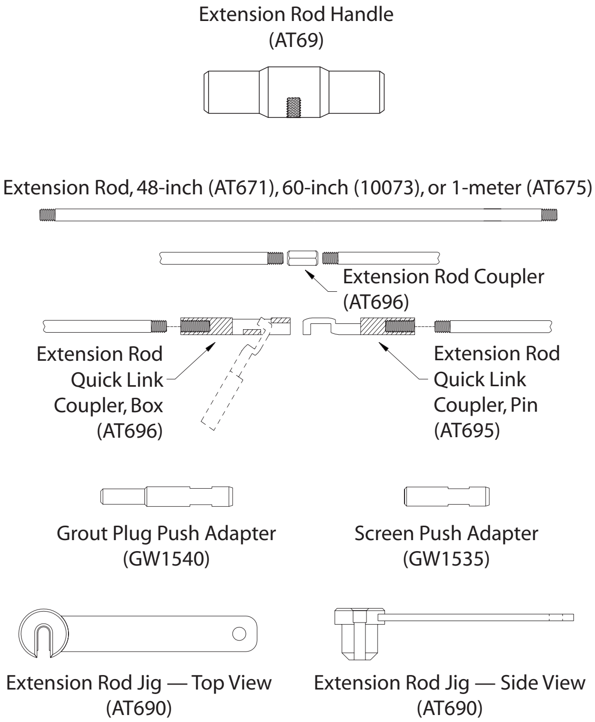


FIGURE 3.2
Geoprobe® Extension Rods and Accessories

4.0 OPERATION

4.1 Basic Operation

The SP16 sampler utilize a stainless steel or PVC screen which is encased in an alloy steel sampler sheath. An expendable drive point is placed in the lower end of the sheath while a drive head is attached to the top. O-rings on the drive head and expendable point provide a watertight sheath which keeps contaminants out of the system as the sampler is driven to depth.

Once the sampling interval is reached, extension rods equipped with a screen push adapter are inserted down the ID of the probe rods. The tool string is then retracted up to 44 inches (1118 mm) while the screen is held in place with the extension rods. The system is now ready for groundwater sampling. When sampling is complete, a removable plug in the bottom of the screen allows for grouting below the sampler as the tool string is retrieved.

4.2 Sampler Options

The Screen Point 15 and Screen Point 16 Groundwater Samplers are nearly identical. Subtle differences in the design of the SP16 sampler make it more durable than the earlier SP15 system. Operators of GH60-equipped machines should always utilize SP16 tooling. Operators of machines equipped with GH40 Series hammers may also choose SP16 tooling when sampling in difficult probing conditions.

A 1.75-inch OD Expendable Drive Point (17066K) and Disposable PVC Screen (16089) provide two useful options for the SP16 sampler. The 1.75-inch drive point may be used when soil conditions make it difficult to remove the sampler after driving to depth. The disposable PVC screen may be left downhole after sampling (when regulations permit) to eliminate the time required for screen decontamination.

4.3 Decontamination

In order to collect representative groundwater samples, all sampler parts must be thoroughly cleaned before and after each use. Scrub all metal parts using a stiff brush and a nonphosphate soap solution. Steam cleaning may be substituted for hand-washing if available. Rinse with distilled water and allow to air-dry before assembly.

4.4 SP16 Sampler Assembly (Figure 4.1)

Part numbers are listed for a standard SP16 sampler using 1.5-inch probe rods. Refer to Page 6 for screen and drive head alternatives.

1. Place an O-ring on a steel expendable drive point (GW1555K). Firmly seat the expendable point in the necked end of a sampler sheath (15187).

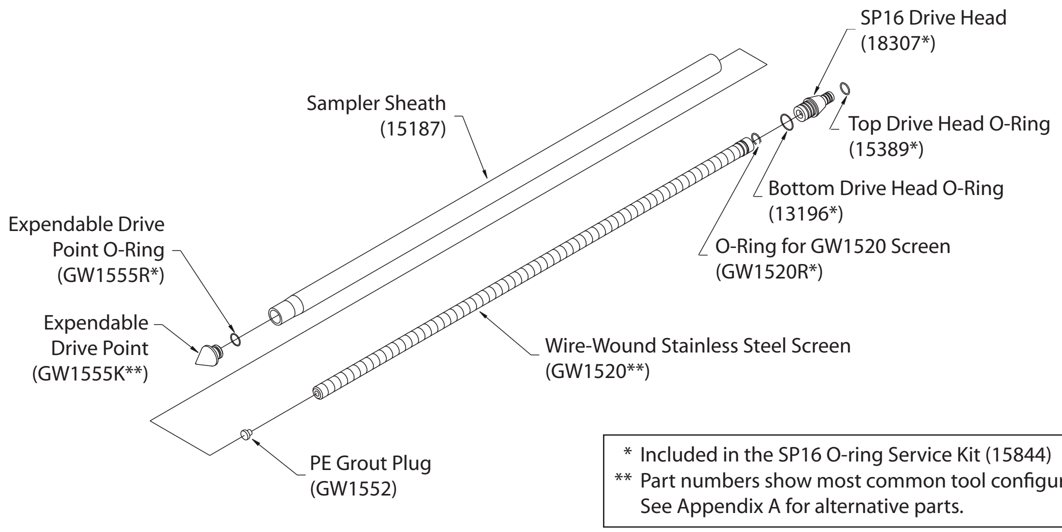
2. Install a PE Grout Plug (GW1552) in the bottom end of a Wire-wound Stainless Steel Screen (GW1520). Place a GW1520R O-ring in the groove on the top end of the screen.

3. Slide the screen inside of the sampler sheath with the grout plug toward the bottom of the sampler. Ensure that the expendable point was not displaced by the screen.

4. Install a bottom O-ring (13196) on a Drive Head (18307 or 15188). Thread the drive head into the sampler sheath using an adjustable wrench if necessary to ensure complete engagement of the threads. Attach a Drive Cap (12787 or 15590) to the top of the drive head.

   NOTE: The 18307 drive head should be used whenever possible as the smaller 0.5-inch ID provides a greater material cross-section for increased durability.

Sampler assembly is complete.



* Included in the SP16 O-ring Service Kit (15844)
** Part numbers show most common tool configuration.
See Appendix A for alternative parts.

FIGURE 4.1
Screen Point 16 Groundwater Sampler Assembly

4.5 Advancing the SP16 Sampler

To provide adequate room for screen deployment with the Rod Grip Pull System, the probe derrick should be extended a little over halfway out of the carrier vehicle when positioning for operation.

1. Begin by placing the assembled sampler (Fig. 2.1.A) in the driving position beneath the hydraulic hammer of the direct push machine as shown in Figure 4.2.

2. Advance the sampler with the throttle control at slow speed for the first few feet to ensure that the sampler is aligned properly. Switch to fast speed for the remainder of the probe stroke.

3. Completely raise the hammer assembly. Remove the drive cap and place an O-ring in the top groove of the drive head. Distilled water may be used to lubricate the O-ring if needed.

   Add a probe rod (length to be determined by operator) and reattach the drive cap to the rod string. Drive the sampler the entire length of the new rod with the throttle control at fast speed.

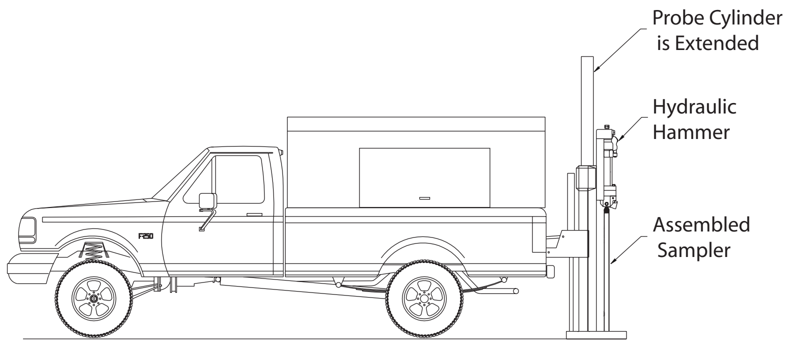


FIGURE 4.2
Screen Point 16 Groundwater Sampler in Driving Position

4. Repeat Step 3 until the desired sampling interval is reached. Approximately 12 inches (305 mm) of the last probe rod must extend above the ground surface to allow attachment of the puller assembly. A 12-inch (305 mm) rod may be added if the tool string is over-driven.

5. Remove the drive cap and retract the probe derrick away from the tool string.

4.6 Screen Deployment

1. Thread a screen push adapter (GW1535) on an extension rod of suitable length (AT671, 10073, or AT675). Attach a threaded coupler (AT68) to the other end of the extension rod. Lower the extension rod inside of the probe rod taking care not to drop it down the tool string. An extension rod jig (AT690) may be used to hold the rods.

2. Add extension rods until the adapter contacts the bottom of the screen. To speed up this step, it is recommended that Extension Rod Quick Links (AT695 and AT696) are used at every other rod joint.

3. Ensure that at least 48 inches (1219 mm) of extension rod protrudes from the probe rod. Thread an extension rod handle (AT69) on the top extension rod.

4. Maneuver the probe assembly into position for pulling.

5. Raise (pull) the tool string while physically holding the screen in place with the extension rods (Fig. 4.3.B). A slight knock with the extension rod string will help to dislodge the expendable point and start the screen moving inside the sheath.

   Raise the hammer and tool string about 44 inches (1118 cm) if using a GW1520 or GW1530 screen. At this point the screen head will contact the necked portion of the sampler sheath (Fig. 4.3.C.) and the extension rods will rise with the probe rods. Use care when deploying a PVC screen so as not to break the screen when it contacts the bottom of the sampler sheath.

   The Disposable Screen (16089) will extend completely out of the sheath if the tool string is raised more than 45 inches (1143 mm). Measure and mark this distance on the top extension rod to avoid losing the screen during deployment.

6. Remove the rod grip handle, lower the hammer assembly, and retract the probe derrick. Remove the top extension rod (with handle) and top probe rod. Finally, extract all extension rods.

7. Groundwater samples can now be collected with a mini-bailer, peristaltic or vacuum pump, tubing bottom check valve assembly, bladder pump, or other acceptable small diameter sampling device.

   When inserting tubing or a bladder pump down the rod string, ensure that it enters the screen interval. The leading end of the tubing or bladder pump will sometimes catch at the screen head giving the illusion that the bottom of the screen has been reached. An up-and-down motion combined with rotation helps move the tubing or bladder pump past the lip and into the screen.

4.7 Abandonment Grouting for GW1520 and GW1530 Screens

The SP16 Sampler can meet ASTM D 5299 requirements for abandoning environmental wells or borings when grouting is conducted properly. A removable grout plug makes it possible to deploy tubing through the bottom of GW1520 and GW1530 screens. A GS500 or GS1000 Grout Machine is then used to pump grout into the open probe hole as the sampler is withdrawn. The following procedure is presented as an example only and should be modified to satisfy local abandonment grouting regulations.

1. Maneuver the probe assembly into position for pulling. Attach the rod grip puller to the top probe rod. Raise the tool string approximately 4 to 6 inches (102 to 152 cm) to allow removal of the grout plug.

2. Thread the Grout Plug Push Adapter (GW1540) onto an extension rod. Insert the adapter and extension rod inside the probe rod string. Add extension rods until the adapter contacts the grout plug at the bottom of the screen. Attach the handle to the top extension rod. When the extension rods are slightly raised and lowered, a relatively soft rebound should be felt as the adapter contacts the grout plug. This is especially true when using a PVC screen.

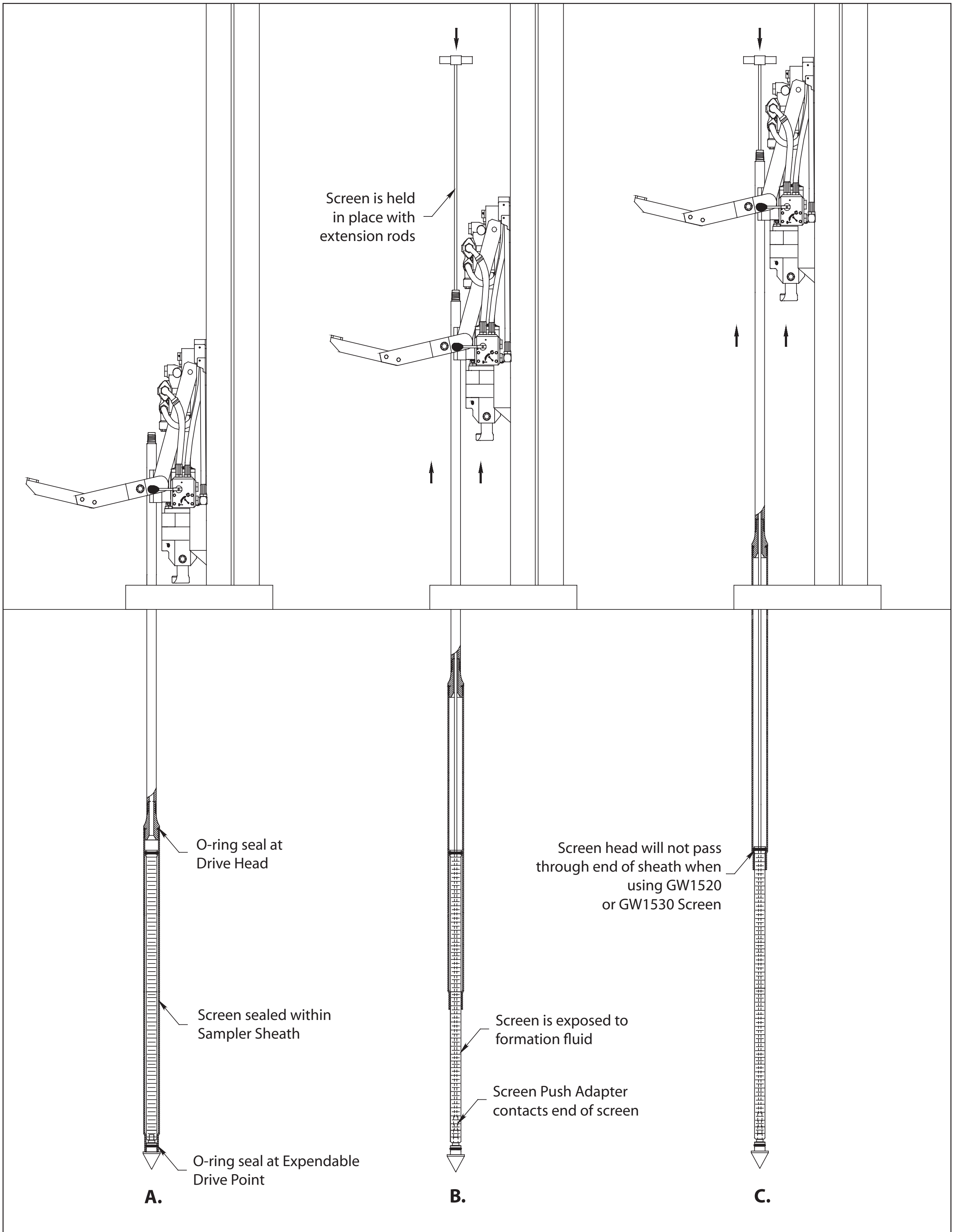
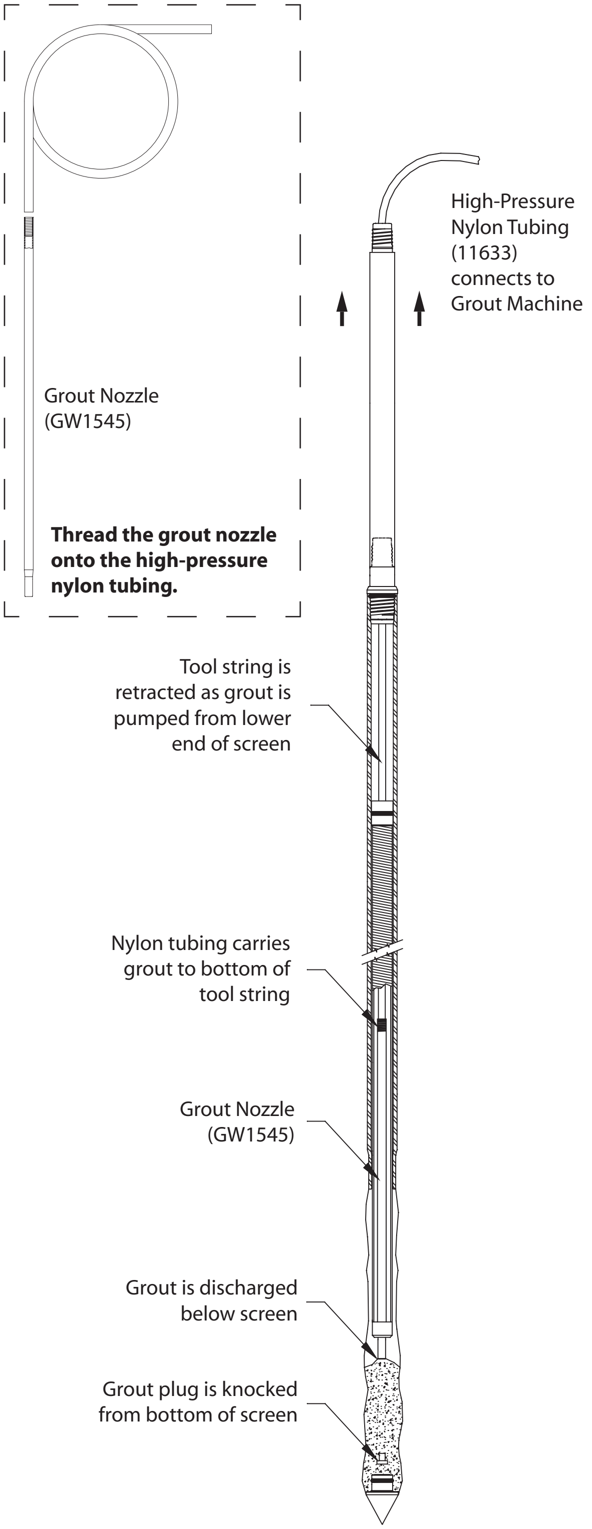


FIGURE 4.3
Screen Deployment for SP16 Sampler



Thread the grout nozzle onto the high-pressure nylon tubing.

FIGURE 4.4
Grouting the SP16 Sampler With a GW1520 or GW1530 Screen

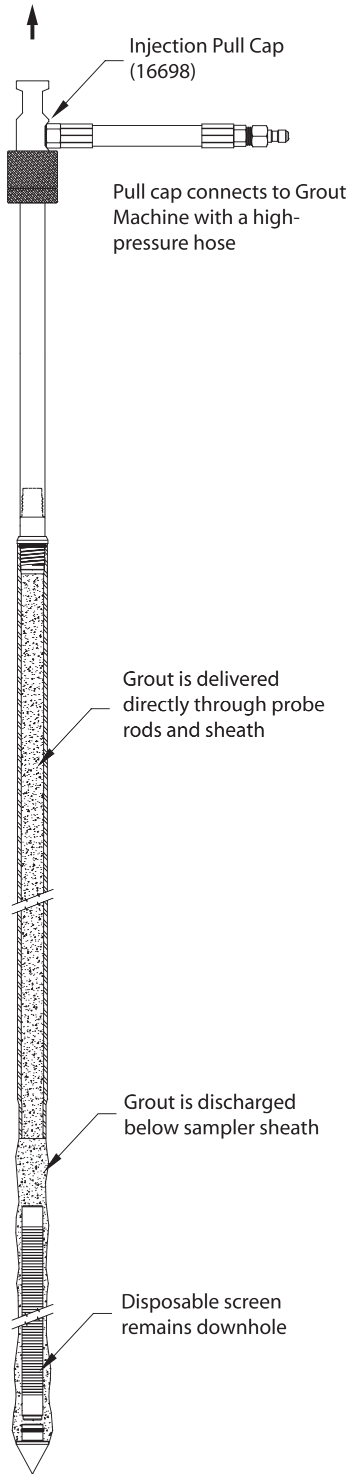


FIGURE 4.5
Grouting the SP16 Sampler With a 16089 Disposable Screen

3. Place a mark on the extension rod even with the top of the probe rod. Apply downward pressure on the extension rods and push the grout plug out of the screen. The mark placed on the extension rod should now be below the top of the probe rod. Remove all extension rods.

   Note: When working with a stainless steel screen, it may be necessary to raise and quickly lower the extension rods to jar the grout plug free. When the plug is successfully removed, a metal-on-metal sensation may be noted as the extension rods are gently "bounced" within the probe rods.

4. A Grout Nozzle (GW1545) is now connected to High-Pressure Nylon Tubing (11633) and inserted down through the probe rods to the bottom of the screen (Fig. 4.4). It may be necessary to pump a small amount of clean water through the tubing during deployment to jet out sediments that settled in the bottom of the screen. Resistance will sometimes be felt as the grout nozzle passes through the drive head. Rotate the tubing while moving it up-and-down to ensure that the nozzle has reached the bottom of the screen and is not hung up on the drive head.

   Note: *All probe rods remain strung on the tubing as the tool string is pulled. Provide extra tubing length to allow sufficient room to lay the rods on the ground as they are removed. An additional 20 feet is generally enough.*

5. Operate the grout pump while pulling the first rod with the rod grip pull system. Coordinate pumping and pulling rates so that grout fills the void left by the sampler. After pulling the first rod, release the rod grip handle, fully lower the hammer, and regrip the tool string. Unthread the top probe and slide it over the tubing placing it on the ground near the end of the tubing.

6. Repeat Step 5 until the sampler is retrieved. Do not bend or kink the tubing when pulling and laying out the probe rods. Sharp bends create weak spots in the tubing which may burst when pumping grout. Remember to operate the grout pump only when pulling the rod string. The probe hole is thus filled with grout from the bottom up as the rods are extracted.

7. Promptly clean all probe rods and sampler parts before the grout sets up and clogs the equipment.

4.8 Abandonment Grouting for the 16089 Disposable Screen

ASTM D 5299 requirements can also be met for the SP16 samplers when using the 16089 disposable screen. Because the screen remains downhole after sampling, the operator may choose either to deliver grout to the bottom of the tool string with nylon tubing or pump grout directly through the probe rods using an Injection Pull Cap (16698). A GS500 or GS1000 Grout Machine is needed to pump grout into the open probe hole as the sampler is withdrawn. The following procedure is presented as an example only and should be modified to satisfy local abandonment grouting regulations.

1. Maneuver the probe assembly into position for pulling with the rod grip puller.

2. Thread the screen push adapter onto an extension rod. Insert the adapter and extension rod inside the probe rod string. Add extension rods until the adapter contacts the bottom of the screen. Attach the handle to the top extension rod.

3. The disposable screen must be extended at least 46 inches (1168 mm) to clear the bottom of the sampler sheath. Considering the length of screen deployed in Section 4.7, determine the remaining distance required to fully extend the screen from the sheath. Mark this distance on the top extension rod.

4. Pull the tool string up to the mark on the top extension rod while holding the disposable screen in place.

   The screen is now fully deployed and the sampler is ready for abandonment grouting. Apply grout to the bottom of the tool string during retrieval using either flexible tubing (as described in Section 4.7) or an injection pull cap (Fig. 4.5). This section continues with a description of grouting with a pull cap.

5. Remove the rod grip handle and maneuver the probe assembly directly over the tool string. Thread an Injection Pull Cap (16698) onto the top probe rod and close the hammer pull latch over the top of the pull cap.

6. Connect the pull cap to a Geoprobe® grout machine using a high-pressure grout hose.

7. Operate the pump to fill the entire tool string with grout. When a sufficient volume has been pumped to fill the tool string, begin pulling the rods and sampler while continuing to operate the grout pump. Considering the known pump volume and sampler cross-section, time tooling withdrawal to slightly "overpump" grout into the subsurface. This will ensure that all voids are filled during sampler retrieval.

   The grouting process can lubricate the probe hole sufficiently to cause the tool string to slide back downhole when disconnected from the pull cap. Prevent this by withdrawing the tool string with the rod grip puller while maintaining a connection to the grout machine with the pull cap.

4.9 Retrieving the Screen Point 16 Sampler

If grouting is not required, the Screen Point 16 Sampler can be retrieved by pulling the probe rods as with most other Geoprobe® applications. The Rod Grip Pull System should be used for this process as it allows the operator to remove rods without completely releasing the tool string. This avoids having the probe rods fall back downhole when released during the pulling procedure. A standard Pull Cap (15164) may still be used if preferred. Refer to the Owner's Manual for your Geoprobe® direct push machine for specific instructions on pulling the tool string.

5.0 REFERENCES

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Appendix A
ALTERNATIVE PARTS

The following parts are available to meet unique soil conditions. See section 3.0 for a complete listing of the common tool configurations for the Geoprobe® Screen Point 16 Groundwater Sampler.

SP16 Sampler Parts and Accessories	**Part Number**
SP16 Drive Head, 0.625-inch bore, 1.5-inch rods	15188
Expendable Drive Points, aluminum, 1.625-inch OD (Pkg. of 25)	GW1555ALK
Expendable Drive Points, steel, 1.75-inch OD (Pkg. of 25)	17066K
Screen, PVC, 10-Slot	GW1530
Screen, Disposable, PVC, 10-Slot	16089

Groundwater Purging and Sampling Accessories	**Part Number**
Polyethylene Tubing, 0.25-inch OD, 500 ft.	TB17L
Polyethylene Tubing, 0.5-inch OD, 500 ft.	TB37L
Polyethylene Tubing, 0.625-inch OD, 50 ft.	TB50L
Check Valve Assembly, 0.25-inch OD Tubing	GW4240
Check Valve Assembly, 0.5-inch OD Tubing	GW4220
Check Valve Assembly, 0.625-inch OD Tubing	GW4230
Water Level Meter, 0.375-inch OD Probe, 100-ft. cable	GW2001
Water Level Meter, 0.438-inch OD Probe, 200-ft. cable	GW2002
Water Level Meter, 0.375-inch OD Probe, 200-ft. cable	GW2003
Water Level Meter, 0.438-inch OD Probe, 30-m cable	GW2005
Water Level Meter, 0.438-inch OD Probe, 60-m cable	GW2007
Water Level Meter, 0.375-inch OD Probe, 60-m cable	GE2008

Grouting Accessories	**Part Number**
Grout Machine, auxiliary-powered	GS500

Probe Rods, Extension Rods, and Accessories	**Part Number**
Probe Rod, 1.5-inch x 1-meter	17899
Probe Rod, 1.5-inch x 48-inch	13359
Drive Cap, 1.5-inch rods (for GH40 Series Hammer)	15590
Rod Grip Pull Handle, 1.5-inch Probe Rods (for GH40 Series Hammer)	GH1555
Extension Rod, 48-inch	AT671
Extension Rod, 1-meter	AT675

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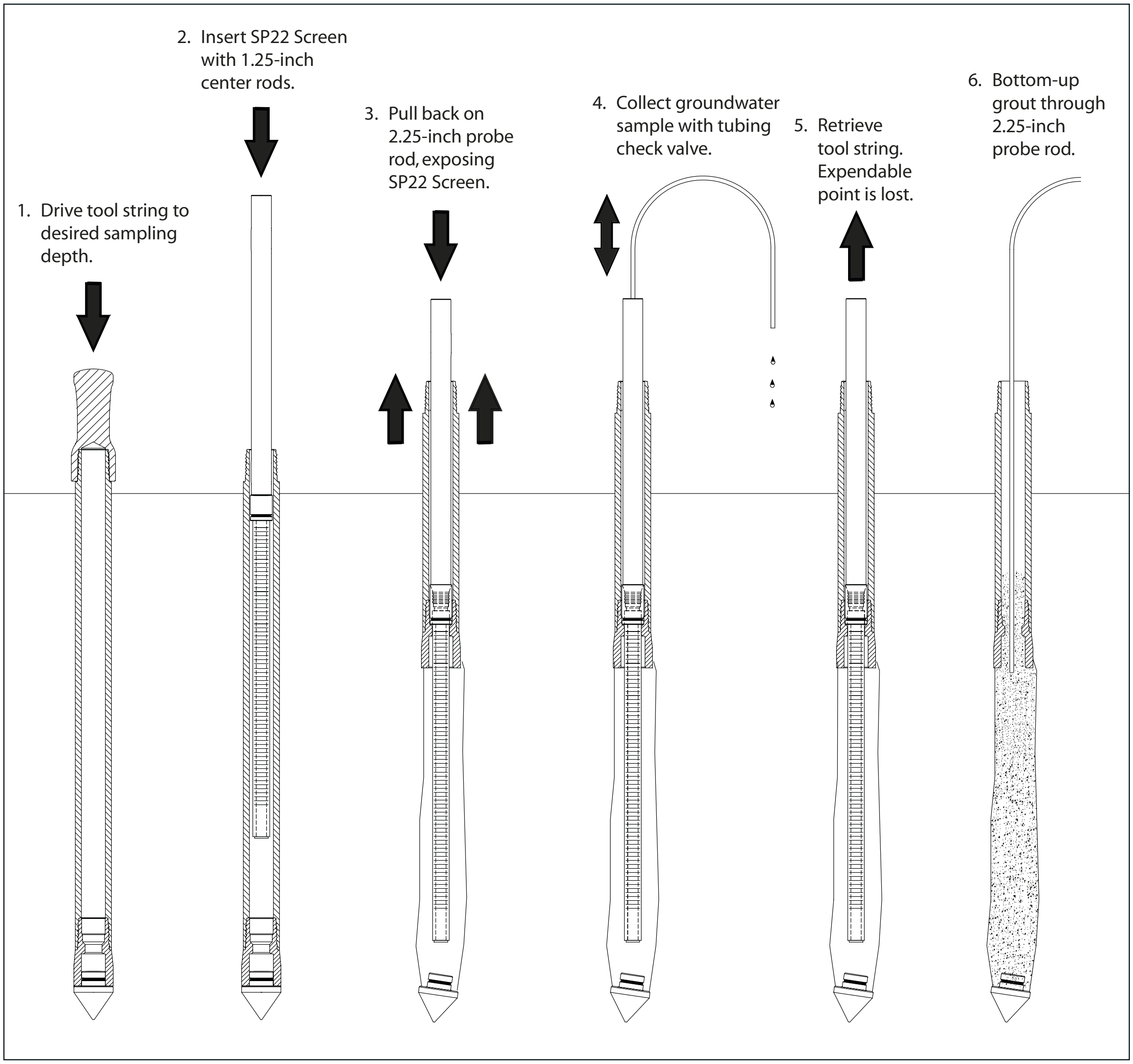
GEOPROBE® SCREEN POINT 22 GROUNDWATER SAMPLER

STANDARD OPERATING PROCEDURE

Technical Bulletin No. MK3173

PREPARED: April 2010



1. Drive tool string to desired sampling depth.
2. Insert SP22 Screen with 1.25-inch center rods.
3. Pull back on 2.25-inch probe rod, exposing SP22 Screen.
4. Collect groundwater sample with tubing check valve.
5. Retrieve tool string. Expendable point is lost.
6. Bottom-up grout through 2.25-inch probe rod.

OPERATION OF THE GEOPROBE® SCREEN POINT 22 GROUNDWATER SAMPLER

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Screen Point 22 Groundwater Sampler is manufactured under U.S. Patent 5,612,498

1.0 OBJECTIVE

The objective of this procedure is to deploy a stainless steel or PVC screen at depth, obtain a representative water sample from the screen interval, and grout the probe hole during abandonment. The Screen Point 22 Groundwater Sampler enables the operator to conduct abandonment grouting that meets American Society for Testing and Materials (ASTM) Method D 5299 requirements for decommissioning wells and borings for environmental activities (ASTM 1993).

2.0 BACKGROUND

2.1 Definitions

Geoprobe®: A brand name of high quality, hydraulically powered machines that utilize static force and percussion or rotation to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform activities such as soil core and soil gas sampling, groundwater sampling and monitoring, soil conductivity and contaminant logging, grouting, and materials injection.

Screen Point 22 (SP22) Groundwater Sampler: A direct push device consisting of a PVC or stainless steel screen that is lowered (post-run) to depth within a sealed string of steel probe rods and then deployed for the collection of representative groundwater samples. Upon deployment, up to 48 inches (1219 mm) of screen can be exposed to the formation. There is also an optional 12-inch screen that can be used. The Screen Point 22 Groundwater Sampler is designed for use with 2.25-inch probe rods and machines equipped with the more powerful GH60 and GH80 series hydraulic hammers. Operators with GH40 series hammers may choose to use this sampler in soils where driving is easier.

Rod Grip Pull System: An attachment mounted on the hydraulic hammer of a direct push machine which makes it possible to retract the tool string with probe rods or flexible tubing protruding from the top of the probe rods. The Rod Grip Pull System includes a pull block with rod grip jaws that are bolted directly to the machine. A removable handle assembly straddles the tool string while hooking onto the pull block to effectively grip the probe rods as the hammer is raised. A separate handle assembly is required for each probe rod diameter.

2.2 Discussion (Fig. 2.1)

In this procedure, 2.25-inch probe rods are advanced into the subsurface with a Geoprobe® subsurface machine (Fig. 2.1, Step 1). While the tool string is advanced to depth, O-ring seals at each rod joint, the expendable point holder, and the expendable drive point provide a watertight system. This eliminates the threat of formation fluids entering the screen before deployment and assures sample integrity.

Once the leading end of the 2.25-inch probe rods reaches the desired sampling interval, an SP22 screen is lowered to the bottom of the rods using a string of either 1.25-inch outside diameter (OD) light-weight center rods, 1.25-inch probe rods, or 0.75-inch schedule 40 flush-thread PVC riser (Fig. 2.1, Step 2). The 2.25-inch rods are then retracted while the SP22 screen is held in place with the 1.25-inch rods or PVC riser (Fig 2.1, Step 3). As the 2.25-inch tool string is retracted, the expendable point is released from the expendable point holder. The tool string and expendable point holder may be retracted the full length of the screen or as little as a few inches if a small sampling interval is desired.

The SP22 Sampler can also be used with the Geoprobe® DT22 system. (Fig. 2.2)

(continued on following page)

Expendable Drive Points

The SP22 system utilizes an SP22 Expendable Point Holder (33764) and standard 2.45-inch (62-mm) OD steel Expendable Drive Points for 2.25-inch probe rods (AT2015K). Extended Shank Expendable Drive Points (19442) are available for soft soil conditions where standard points may be advanced out of the point holder during percussion. A third option is to use a part number 43128 SP22 Expendable Point Holder along with 1.625-inch (41-mm) steel Expendable Drive Points (GW1555K). These smaller drive points are more economical to purchase and ship, but must not be used with GH80 Series Hydraulic Hammers as they may not stay seated during percussion.

Screens

Two types of screens have been developed for use in the Screen Point 22 Groundwater Sampler - a stainless steel screen with a standard slot size of 0.004 inches (0.10 mm) and a PVC screen with a standard slot size of 0.010 inches (0.25 mm). These screens are available in nominal 48- and 12-inch lengths. Effective screen lengths for the 48- and 12-inch PVC screens are 48 inches (1219 mm) and 12 inches (305 mm), while 48- and 12-inch stainless steel screens have effective screen lengths of 43 inches (1092 mm) and 14 inches (356 mm) respectively. Both types of screens are recovered with the tool string after sampling.

The SP22 PVC Screen Head Adapter (37871) provides yet another screen option for the SP22 sampler. Using this adapter, a section of slotted 0.75-inch Schedule 40 PVC pipe may be lowered through the 2.25-inch probe rods using a string of flush-threaded 0.75-inch Schedule 40 PVC Riser. An SP22 PVC Screen Plug (38968) is installed in the leading end of the slotted pipe prior to use. The slotted pipe may be cut and the screen plug installed to provide custom screen lengths .

An O-ring is located at the top of each stainless screen and on the screen adapters. When a screen is deployed, this O-ring maintains a seal between the top of the screen and the inner wall of the probe rods or expendable point holder as indicated in Figure 2.1. As a result, any liquid entering the tool string must first pass through the screen.

Screens are constructed such that equipment can be inserted into the screen cavity for sample collection as noted in the following section and illustrated in Figure 2.1, Step 4. This makes direct sampling possible from anywhere within the saturated zone.

The inner rod string and screen are generally removed prior to grouting through the 2.25-inch rod string as shown in Figure 2.1, Steps 5-6. However, a removable plug in the lower end of the screens allows for grouting through flexible tubing extending out the bottom of the screen as with the Geoprobe® SP15/16 Groundwater Samplers if desired.

Sample Collection

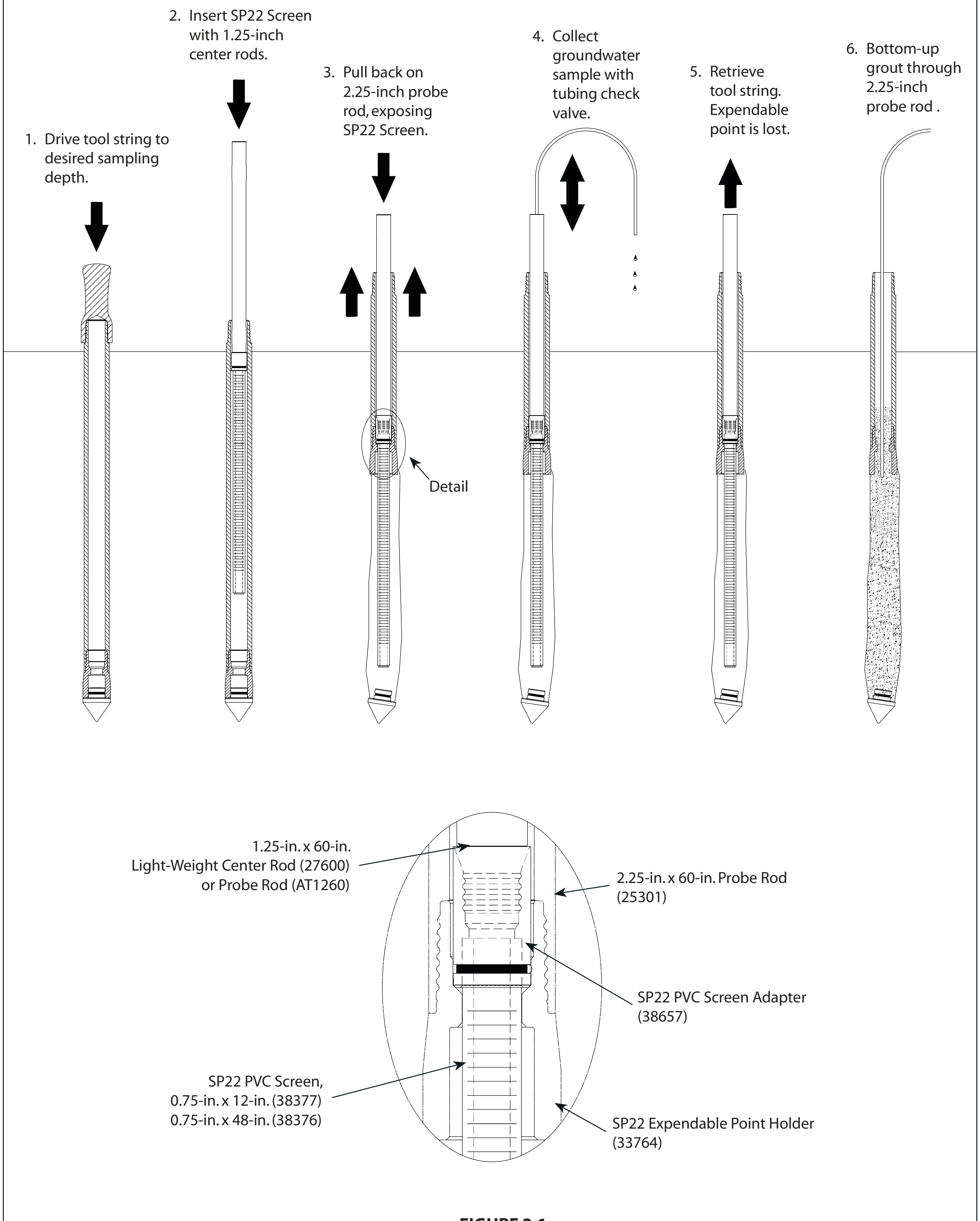
Groundwater samples can be obtained from the SP22 screen in a number of ways. A common method utilizes 0.375-inch OD polyethylene (TB25L) or Teflon® (TB25T) tubing and a check valve assembly. The check valve (with check ball) is attached to one end of the tubing and inserted down the casing until it is immersed in groundwater. Water is then pumped through the tubing and to the ground surface by oscillating the tubing up and down.

An SP22 Check Valve Assembly (37893) is recommended if sampling through 1.25-inch light-weight center rods. The SP22 Check Valve Assembly is approximately 20 inches long to enable it to pass through the stepped diameters at each rod joint that may cause problems for other, shorter check valves.

An alternative means of collecting groundwater samples is to attach a peristaltic or vacuum pump to tubing that is inserted through the inner rods to within the SP22 screen. This method is limited in that water can be pumped to the surface from a maximum depth of approximately 26 feet (8 m). Another technique for groundwater sampling is to use a stainless steel Mini-Bailer Assembly (GW41). The mini-bailer is lowered down the inside of the casing below the water level where it fills with water and is then retrieved from the casing.

The latest option for collecting groundwater from the SP22 Sampler is to utilize a Geoprobe® MB470 Series Mechanical Bladder Pump (MBP)*. The MBP may be used to meet requirements of the low-flow sampling protocol (Puls and Barcelona 1996, ASTM 2003). Through participation in a U.S. EPA Environmental Technology Verification study, it was confirmed that the MB470 can provide representative samples (EPA 2003).

**The Mechanical Bladder Pump is manufactured under U.S. Patent No. 6,877,965 issued April 12, 2005.*



1. Drive tool string to desired sampling depth.
2. Insert SP22 Screen with 1.25-inch center rods.
3. Pull back on 2.25-inch probe rod, exposing SP22 Screen.
4. Collect groundwater sample with tubing check valve.
5. Retrieve tool string. Expendable point is lost.
6. Bottom-up grout through 2.25-inch probe rod .

FIGURE 2.1

Screen Point 22 Groundwater Sampler - 0.75-inch PVC Screen Option

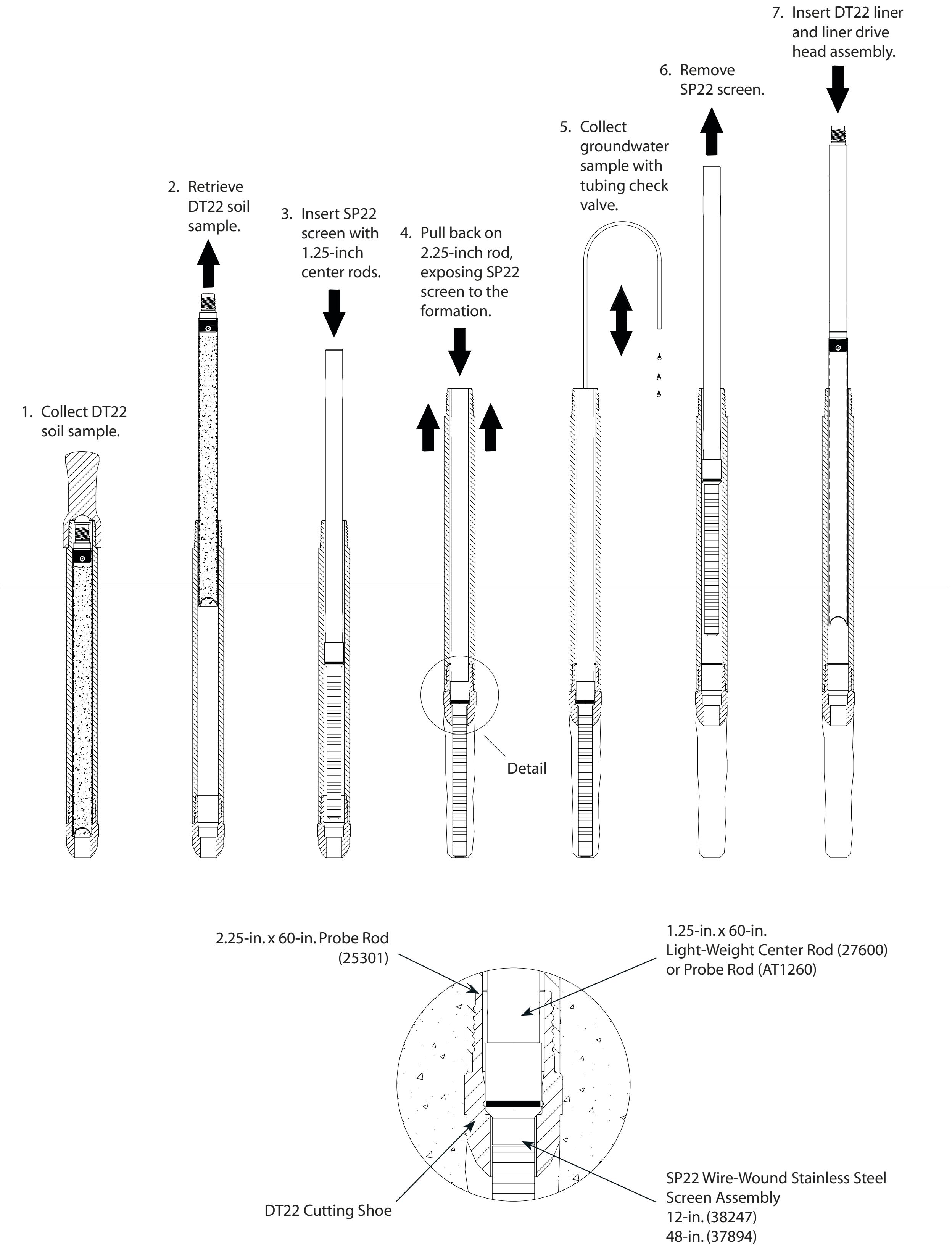


FIGURE 2.2

Screen Point 22 Groundwater Sampler Operation with DT22 Sampling System

3.0 TOOLS AND EQUIPMENT

The following tools and equipment can be used to successfully recover representative groundwater samples with the Geoprobe® Screen Point 22 Groundwater Sampler. Refer to Figures 3.1 and 3.2 for identification of the specified parts. Tools are listed below for the most common SP22 / 2.25-inch probe rod configurations. Additional rod sizes and accessories are available. Contact Geoprobe Systems® for information regarding tools and equipment options.

SP22 Sampler Parts	**Part Number**
SP22 Screen, Wire-Wound Stainless Steel, 4-Slot (48-in.)	37894
SP22 Screen, Wire-Wound Stainless Steel, 4-Slot (12-in.)	38247
Grout Plugs, PE (Pkg. of 25)	GW1552K
SP22 Screen, PVC, 10-Slot, 0.75-in. x 48-in.	38376
SP22 Screen, PVC, 10-Slot, 0.75-in. x 48-inch, Kit (includes 2 each of 38376 and 38429)	*38664*
SP22 Screen, PVC, 10-Slot, 0.75-in. x 12-in.	38377
SP22 Screen, PVC, 10-Slot 0.75-in. x 12-in., Kit (includes 2 each of 38377 and 38429)	*38667*
SP22 PVC Screen Plug	38968
SP22 PVC Screen Plug Kit (includes 10 of 38968)	*38530*
SP22 PVC Screen Adapter, 0.75-in. PVC x 1.25-in. Probe Rod Box	38657
SP22 PVC Screen Head Adapter, 0.75-in. (for flush-threaded 0.75-in. Schedule 40 PVC)	37871
SP22 O-ring Kit (Pkg. of 10 O-rings for SP22 PVC screen adapters and stainless steel screens)	37853
O-rings, 0.75-in. PVC Riser (Pkg. of 25)	GW4401R
SP22 Expendable Point Holder, 2.25-in. Probe Rods, AT2045K and 19442 Points	33764
SP22 Expendable Point Holder, 2.25-in. Probe Rods, GW1555 Points*	43128

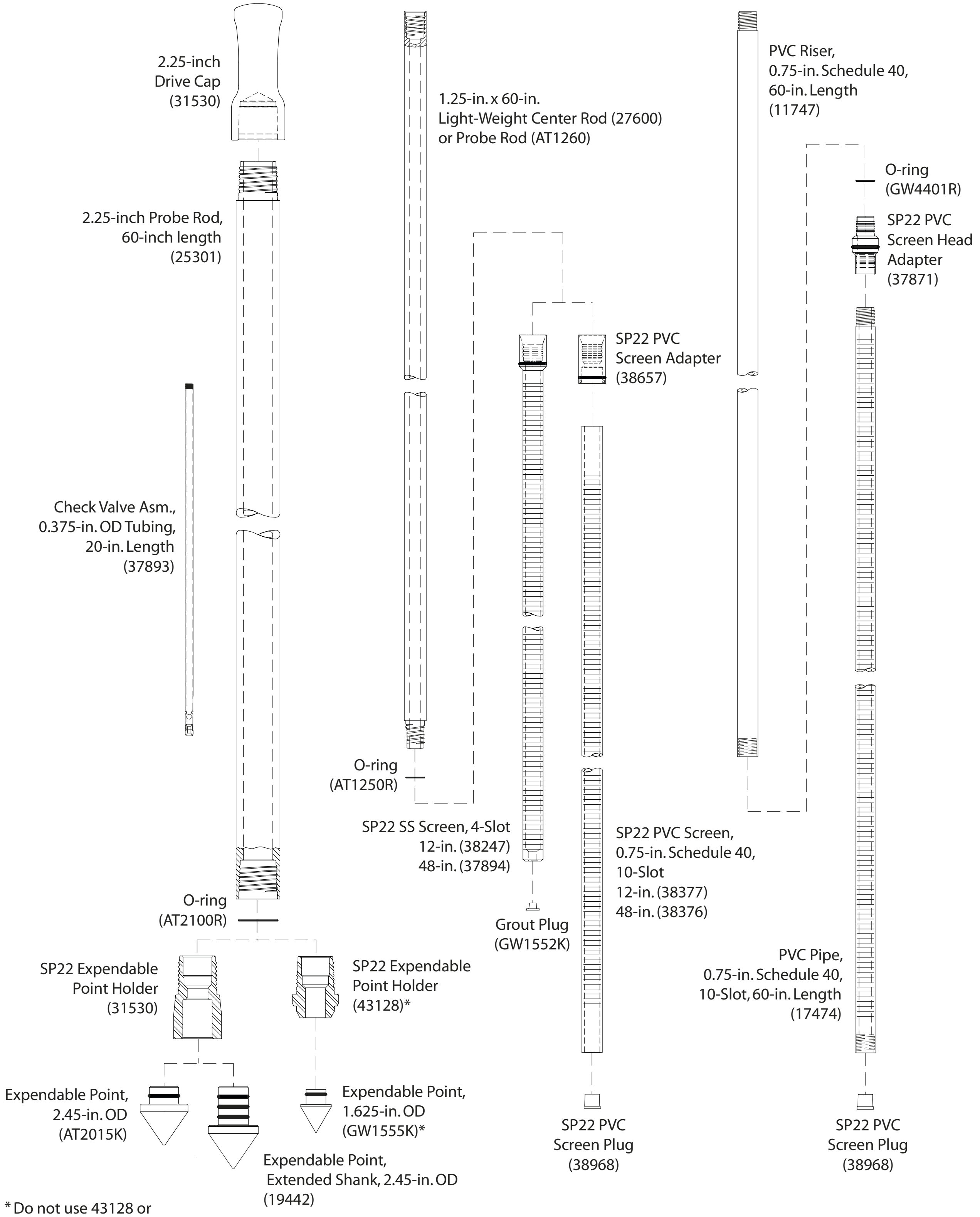
Outer Casing (2.125-inch Probe Rods) and Inner Rod String	**Part Number**
Probe Rod, 2.25-in. x 60-in.	25301
Expendable Drive Points, Steel, 2.45-in. OD (Pkg. of 25)	AT2015K
Expendable Drive Points, Steel, 2.45-in. OD, extended shank	19442
Expendable Points, steel, 1.625-in. OD (Pkg. of 25)*	GW1555K
Drive Cap, 2.25-in. Probe Rods, Threadless, (for GH60 and GH80 Series Hammers)	31530
O-Rings, 2.25-in. Probe Rods (Pkg. of 25)	AT2100R
Rod Grip Handle, 2.25-in. Probe Rods, (for GH60 and GH80 Series Hammers)	29385
Light-Weight Center Rod, 1.25-in. x 60-in.	27600
Probe Rod, 1.25-in. x 60-in.	AT1260
O-ring, 1.25-in. rods (Pkg. of 25)	AT1250R
Rod Grip Handle, 1.25/1.5-in. Rods, (for GH60 and GH80 Series Hammers)	15554
PVC Riser, 0.75-in. Schedule 40 x 60-inch	11747
PVC Pipe, 0.75-in. Schedule 40 x 60-inch, 10-Slot	17474

Grout Accessories	**Part Number**
High-Pressure Nylon Tubing, 0.375-in. OD / 0.25-in. ID, 100-ft. (30 m)	11633
Grout Machine, Auxiliary-Powered	GS2200
Grout System Accessories Package, 2.25-in. rods	GS1015

Groundwater Purging and Sampling Accessories	**Part Number**
Polyethylene Tubing, 0.375-in. OD, 500 ft.	TB25L
Check Valve Assembly, 0.375-in. OD Tubing x 20 in. Long	37893
Water Level Meter, 0.438-in. OD Probe, 100 ft. cable	GW2000
Mechanical Bladder Pump**	MB470
Mini Bailer Assembly, Stainless Steel	GW41

* Not for use with GH80 Series Hydraulic Hammers

** Refer to the Standard Operating Procedure (SOP) for the Mechanical Bladder Pump (Technical Bulletin No. MK3013) for additional tooling needs.



* Do not use 43128 or
GW1555K with GH80
series hammers

FIGURE 3.1
SP22 Sampler Parts

4.0 OPERATION

4.1 Basic Operation

The SP22 Sampler utilizes a stainless steel or PVC screen which is lowered (post-run) through an alloy steel 2.25-inch OD probe rod tool string. An expendable drive point is placed in an expendable point holder on the leading 2.25-inch probe rod prior to advancement (Fig. 4.1). This expendable point is removed and stays in the subsurface as the rods are pulled back to exposes the SP22 screen. O-rings on the probe rods ,the expendable point holder, and the expendable drive point provide a watertight tool string which keeps contaminants out of the system as the 2.25-inch rods are driven to depth in preparation for installation of the SP22 screen.

Once the sampling interval is reached with the 2.25-inch probe rods, the stainless steel or PVC screen is lowered through the rods using 1.25-inch probe rods, 1.25-inch light-weight center rods, or 0.75-inch PVC riser pipe. The 2.25-inch tool string is then retracted while the screen is held in place with the inner rods or riser. The system is now ready for groundwater sampling. When sampling is complete, the inner rods and screen are removed for grouting during retrieval or the 2.25-inch rods. Alternatively, a removable plug is located in the bottom of the screens to allow grouting directly through the inner tool string with high-pressure tubing during retrieval.

4.2 Decontamination

In order to collect representative groundwater samples, all sampler parts must be thoroughly cleaned before and after each use. Scrub all metal parts using a stiff brush and a nonphosphate soap solution. Steam cleaning may be substituted for hand-washing if available. Rinse with distilled water and allow to air-dry before assembly.

4.3 Lead Rod Assembly (Fig. 4.1)

1. Place an O-ring on the expendable point holder.
2. Thread expendable point holder into the 2.25-inch probe rod.
3. Place an O-ring on a steel expendable drive point.
4. Firmly seat the expendable point in the expendable point holder.
5. Place 2.25-inch Drive Cap (31530) on the top of the 2.25-inch probe rod. The lead rod assembly is now ready to be driven to depth.

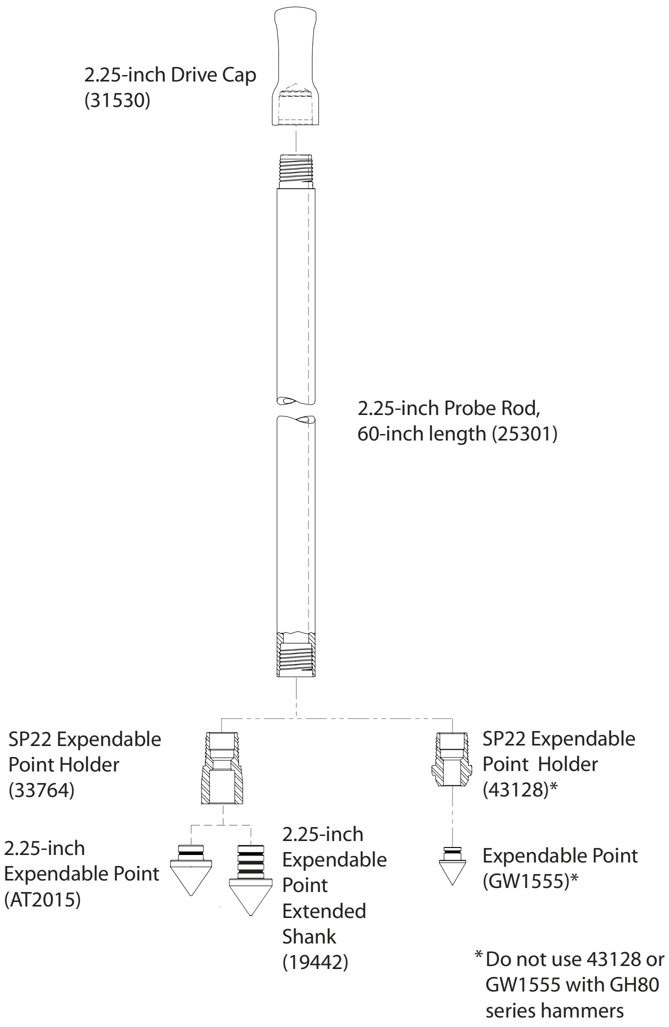


FIGURE 4.1
Lead Rod Assembly for the SP22 Groundwater Sampler

4.4 Advancing the Tool String (Fig. 4.2, step 1)

To provide adequate room for screen deployment with the Rod Grip Pull System, the probe derrick should be extended a little over halfway out of the carrier vehicle when positioning for operation.

1. Drive first 2.25-inch probe rod (as assembled in section 4.3).

2. Advance the tool string at a slow speed for the first few feet to ensure that the string is aligned properly.

3. Completely raise the hammer assembly. Remove the drive cap and place an O-ring in the top groove of the driven probe rod. Distilled water may be used to lubricate the O-ring if needed.

Add a probe rod (length to be determined by operator) and reattach the drive cap to the rod string. Drive the tool string the entire length of the new rod.

4. Repeat Step 3 until the desired sampling interval is reached. Approximately 12 inches (305 mm) of the last probe rod must extend above the ground surface to allow attachment of the puller assembly. A 12-inch (305 mm) rod may be added if the tool string is over-driven.

5. Remove the drive cap and retract the probe derrick away from the tool string.

4.5 Screen Deployment (Fig 4.2, step 2 - 4)

1. Attach an SP22 stainless steel or PVC screen to a 1.25-inch probe rod, 1.25-inch light-weight center rod, or 0.75-inch fiush-thread PVC riser using an SP22 PVC Screen Adapter (38657) or SP22 PVC Screen Head Adapter (37871) as shown in Figure 3.1. Note that the 38657 screen adapter is connected to the SP22 PVC screen using the setscrews provided with the adapter.

and lower it into the driven casing.

2. Lower the screen into the 2.25-inch probe rod casing and add rods or riser until the screen head contacts the bottom of the tool string.

3. Ensure that at least 48 inches (1219 mm) of rods or riser protrudes from the top 2.25-inch probe rod.

4. Maneuver the probe assembly into position for pulling.

5. Raise (pull) the outer 2.25-inch tool string while physically holding the screen in place with the inner 1.25-inch rods or 0.75-inch riser. A slight knock with the inner tool string will help to dislodge the expendable point and start the screen moving inside the probe rod.

Raise the hammer and outer tool string to expose the desired length of screen. The inner rods will begin raising with the outer rods when the screen adapter contacts the necked portion of the expendable point holder or DT22 Cutting Shoe. Use care when deploying a PVC screen so as not to break the screen when it contacts the expendable point.

6. Remove the rod grip handle, lower the hammer assembly, and retract the probe derrick. Remove the top 2.25-inch probe rod.

7. Groundwater samples can now be collected with a mini-bailer, peristaltic or vacuum pump, tubing bottom check valve assembly, bladder pump, or other acceptable small diameter sampling device.

When inserting tubing or a bladder pump down the rod string, ensure that it enters the screen interval. The leading end of the tubing or bladder pump will sometimes catch at the screen head giving the illusion that the bottom of the screen has been reached. An up-and-down motion combined with rotation helps move the tubing or bladder pump past the lip and into the screen.

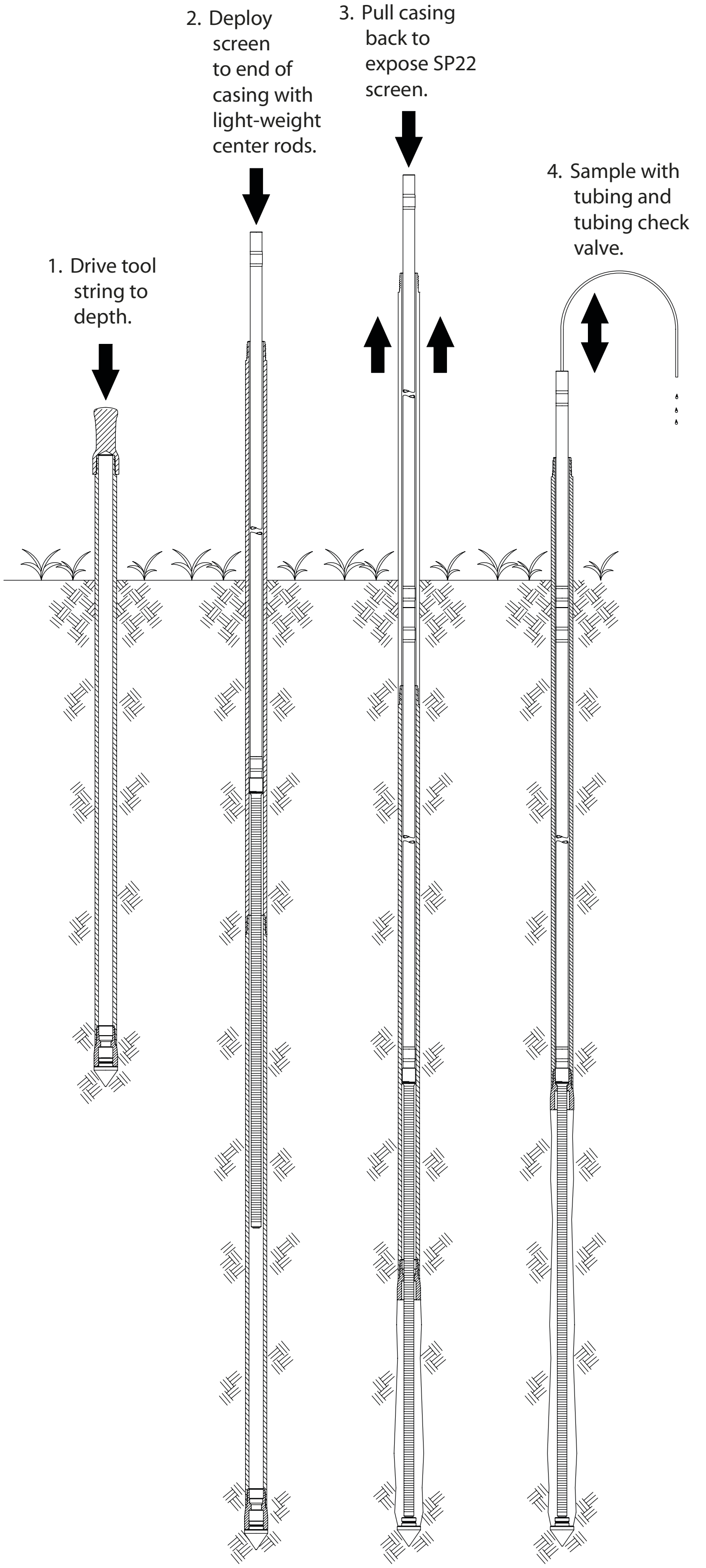


FIGURE 4.2
Screen Deployment for SP22 Sampler

4.6 Abandonment Grouting for SP22 Screens

The SP22 Sampler can meet ASTM D 5299 requirements for abandoning environmental wells or borings when grouting is conducted properly. A removable grout plug makes it possible to deploy tubing through the bottom of the SP22 screens, but the easiest method is to remove the inner string of rods; including the SP22 screen. A Grout Machine is then used to pump grout into the open probe hole as the outer casing is withdrawn. The following procedure is presented as an example only and should be modified to satisfy local abandonment grouting regulations. (Figure 4.3)

1. Maneuver the probe assembly into position for pulling.

2. High-Pressure Nylon Tubing (11633) is inserted down through the probe rods through the bottom of the expendable point holder (Fig. 4.3).

Note: *All probe rods remain strung on the tubing as the tool string is pulled. Provide extra tubing length to allow sufficient room to lay the rods on the ground as they are removed. An additional 20 feet is generally enough.*

3. Operate the grout pump while pulling the first rod with the rod grip pull system. Coordinate pumping and pulling rates so that grout fills the void left by the sampler. After pulling the first rod, release the rod grip handle, fully lower the hammer, and regrip the tool string. Unthread the top probe and slide it over the tubing placing it on the ground near the end of the tubing.

4. Repeat Step 5 until the tool string is retrieved. Do not bend or kink the tubing when pulling and laying out the probe rods. Sharp bends create weak spots in the tubing which may burst when pumping grout. Remember to operate the grout pump only when pulling the rod string. The probe hole is thus filled with grout from the bottom up as the rods are extracted.

5. Promptly clean all probe rods and sampler parts before the grout sets up and clogs the equipment.

4.7 Retrieving the Screen Point 22 Sampler

If grouting is not required, the Screen Point 22 Sampler can be retrieved by pulling the probe rods as with most other Geoprobe® applications. The Rod Grip Pull System should be used for this process as it allows the operator to remove rods without completely releasing the tool string. This avoids having the probe rods fall back downhole when released during the pulling procedure. A standard Pull Cap (33622) may still be used if preferred. Refer to the Owner's Manual for your Geoprobe® direct push machine for specific instructions on pulling the tool string.

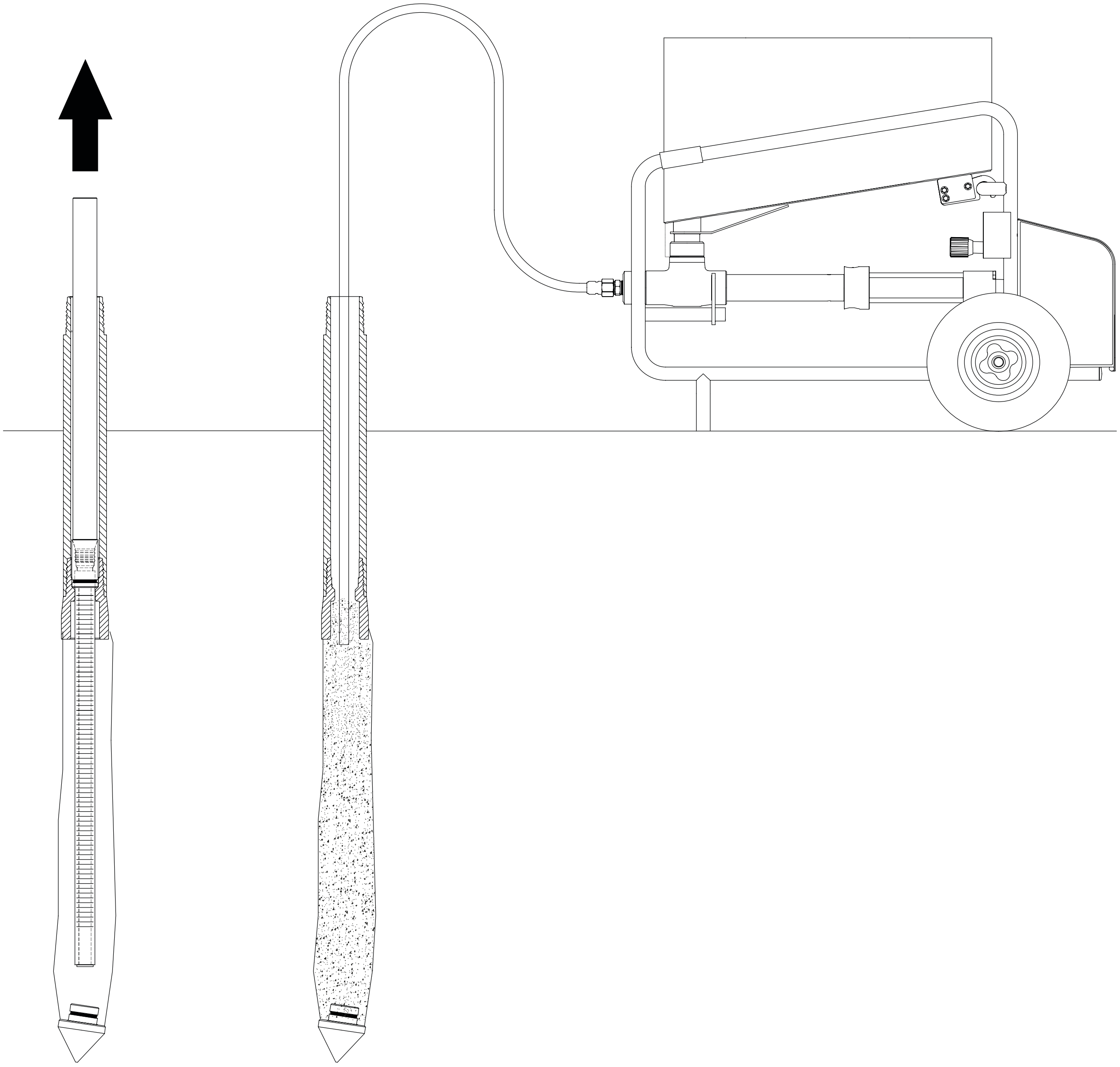


FIGURE 4.3
Abandonment Grouting for the SP22 Sampler

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TGI – FIELD PROCESSING FOR FISH SAMPLES PROCEDURES

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Revision No	Revision Date	Page No(s)	Description	Reviewed by

APPROVAL SGNATURES

Prepared by:	Nick Firman Environmental Scientists	Date:
Technical Expert Reviewed by:	David Rigg Senior Scientist	Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

The following procedures describe the general methodologies that will be used in the field to process, handle, pack, and ship fish tissue samples to the laboratory for tissue preparation and chemical analysis for PFAS.

3 EQUIPMENT

The following equipment and materials will be available, as required, to process whole fish samples:

- Work documents (e.g., field sampling plan, health and safety plan);
- Measuring board or ruler;
- Top-loading electronic and suspended-weight spring balances;
- Forceps or knife;

- Storage envelopes and glass vials;
- Heavy duty aluminum foil and freezer paper;
- Tape (e.g., duct, strapping, masking or freezer, and clear packing);
- Sealable plastic bags and indelible ink markers;
- Cleaning and decontamination materials;
- Potable water;
- Insulated coolers with ice;
- Forms (e.g., chain-of-custody, custody seal, address label, and air-bill);
- Camera; and
- Field notebook.

4 FIELD NOTES

Field notes will be recorded during processing of fish samples, and at a minimum, will include the following:

- Names of field processing crew and oversight personnel;
- Date and time of processing;
- Sample identification numbers that correspond to fish species, sampling date, and collection location;
- Body lengths and/or weights, and number of organisms per sample;
- Gross external abnormalities and visible parasites;
- Bony structures collected for aging (where applicable); and
- Photographs (if necessary).

5 PROCESSING, HANDLING, PACKING, AND SHIPPING

The following identifies the procedures that will be used to process, handle, pack, and ship fish samples:

5.1 Processing

1. All samples will be given a unique sample identification number that will be recorded in the field notebook, and that corresponds to the fish species, sampling date, and collection location.
2. Chain-of-custody forms, custody seals, address labels, and air-bill forms will be initiated. Chain-of-custody forms will identify the tissue sample preparation procedure and chemical analysis. A copy of the completed chain-of-custody form and air-bill form will be retained by the sampler.
3. To begin processing, sediments, soil, and other debris will be removed from the fish, as needed, by hand-picking or by rinsing with potable water.

4. Fish will be measured and/or weighed following project-specific requirements, but will generally include total length and weight measurements of each individual in a sample.
5. Individual and composite fish samples will have sufficient sample mass, as possible, to meet the minimum sample mass requirements for chemical analysis.
6. Photographs will be taken, as required, and any external abnormalities or visible parasites will be noted in the field notebook.
7. Hard body parts (scales, spines and/or otoliths) will be removed from fish, as needed, if it does not compromise the integrity of the sample. If sample integrity is compromised, the laboratory may instead be asked to remove the bony structure. The structure will be archived for possible aging at a later date.
8. Fish samples will be wrapped in heavy-duty aluminum foil (shiny side out) or placed in a sealable plastic bag and then wrapped in freezer paper and secured with masking/freezer tape to maintain sample integrity. The sample identification number will be written on each package with a waterproof marker.
9. Samples will be placed into large sealable plastic bags in preparation for packing.
10. All equipment will be cleaned with a laboratory grade detergent and a potable water rinse as required or immediately following processing.

5.2 Handling

1. Specify in the field notebook and on the chain-of-custody form the tissue sample preparation procedure (e.g., skin-on/scales-off fillets, whole body grinding) and chemical analysis (e.g., PFAS) the laboratory will follow.
2. Designate sampling personnel responsible for sample custody. Note: If the designated sampling person relinquishes the samples to other sampling or field personnel for packing or other purposes, the sampler will complete the chain-of-custody form to document the sample custody transfer.

5.3 Packing

1. Coolers used for transport will be duct-taped at the drain plug on the outside and inside of the cooler.
2. Ice will be packaged in sealable plastic bags (double-bagged with the outer seal duct-taped) and placed in the bottom of the cooler. The sealed fish samples will be placed inside the cooler with enough room for additional ice bags to be placed on top.
3. The completed chain-of-custody form will be placed into a plastic bag and duct-taped to the inside of the cooler lid.
4. The cooler will be closed and fastened with duct tape around the seam of the lid to prevent water leakage and with strapping or duct tape around the entire cooler to prevent it from opening during transport.

5. A completed custody seal will be placed across the seam of the cooler lid. A completed address label will be placed on top of the cooler. Both will be taped-over using clear packing tape.

5.4 Shipping

1. Samples with holding time requirements will be shipped to the laboratory by hand or by express carrier within the specified timeframe. The signed and dated chain-of-custody forms should be included in the cooler. The express carrier will not be required to sign the chain- of-custody forms. The sampler should retain the express carrier receipt or bill of lading.
2. The laboratory will be notified of the shipment and will be contacted following the arrival date to ensure that delivery has occurred. When the samples are received by the laboratory, the laboratory personnel shall complete the chain-of- custody forms by recording receipt of samples, and then check the sample identification numbers on the containers against the chain-of-custody forms.

5.5 Special Considerations for PFAS Sampling

The detection of PFAS compounds at very low concentrations can be influenced by common PFAS-containing materials that may be present during sample processing. Therefore, sample processing protocols are to be strictly followed by the sampling personnel. To minimize the potential for cross-contamination, attention will be given to sampling materials, decontamination procedures, as well as clothing and personal care products used by sampling personnel. Some examples of products to avoid and that are acceptable are provided below.

Products to Avoid

- Materials containing polytetrafluorethylene (PTFE or Teflon), polyvinylidene fluoride (PVDF), polyvinyl fluoride (PVF), fluorinated ethylene propylene (FEP) and perfluoropolyether (PFPE)
- Clothing or boots containing Gore-Tex
- Clothing washed with fabric softener containing PFAS
- PFAS chemically treated clothing or insect/stain resistance and ultraviolet (UV) protection
- Personal care products (cosmetics, shampoo, sunscreens, dental floss, etc.) containing PFAS
- PFAS treated paper towel
- Plastic clipboards or notebooks made with PFAS treated paper
- Pre-wrapped food or snacks, carry-out food, fast food

Note: When staff requires a break to eat, they should remove their gloves and move to the designated area for food and beverage consumption. When finished, staff should wash their hands and put on a fresh pair of powderless nitrile gloves before returning to the sample processing area.

Materials That are Acceptable

- High density polyethylene (HDPE) or polypropylene (PP) coolers and buckets

- Synthetic and natural fibers (preferably cotton)
- Any boots made of polyurethane and PVC
- Well-laundered clothes without fabric softener from time of purchase
- Powderless nitrile gloves
- Untreated wooden measuring board or stainless-steel meter stick
- Stainless steel processing table, tray, electronic balance boat, and/or fillet knife
- Alconox, Liquinox, or Citranox
- Polypropylene scrub brush
- PFAS-free DI water
- Low-density polyethylene (LDPE) plastic freezer bags (Ziploc) and aluminum foil
- Ballpoint pen, pencil or fine-point Sharpie marker
- Rite in the Rain notebooks
- Aluminum or Masonite clipboard with loose paper (non-waterproof, non-recycled)
- Bottled water and hydration drinks (Gatorade)
- Sunscreen (Banana Boat, Coppertone, Neutrogena), OFF Deep Woods, Sawyer Permethrin

Items That May Need Screening

- Municipal potable water (if used to rinse fish or cleaning)
- Aluminum foil

Powderless nitrile gloves should frequently be changed any time there is an opportunity for cross-contamination of the sampling including, but not limited to, the following activities:

- After handling any sample, including QA/QC samples such as field reagent blanks or equipment rinse blanks.
- After the handling of any non-dedicated sampling equipment, contact with non-decontaminated surfaces, or when judged necessary by field personnel.
- During and after decontamination of non-dedicated sampling equipment.

TGI – FISH SAMPLING PROCEDURES

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1 INTRODUCTION

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2 SCOPE AND APPLICATION

The following procedures describe the general methodologies that will be used in the field to collect fish for tissue analysis.

3 PRE-COLLECTION

Staff assigned the responsibility of collecting fish will be provided with the following information:

- Work documents (field sampling plan, health and safety plan, etc.);
- Water body name and site maps;
- Number and size of each species to be collected;
- Collection and sample processing procedures;
- Special instructions (if any);

- Appropriate fisheries office contact; and
- Sampling permits and licenses.

4 EQUIPMENT

The following collection equipment and materials will be available, as required, during fish sampling:

- Personal protective equipment (as required by the health and safety plan);
- Boat equipment;
- Electrofishing equipment;
- Dip nets with non-conductive handles;
- Non-conductive gloves and boots;
- Chest or hip waders;
- Polarized sunglasses;
- Fish nets or traps;
- Angling tackle and bait;
- Chest or hip waders;
- Live well, cooler, or 5-gallon bucket;
- Measuring board or ruler;
- Top-loading electronic and suspended-weight spring balances;
- Insulated coolers with ice;
- Aluminum foil;
- Plastic sealable bags and indelible ink markers;
- Camera;
- Global positioning system (GPS); and
- Field notebook.

5 FIELD NOTES

Field notes will be recorded during sampling activities, and at a minimum, will include the following:

- Names of field crew and oversight personnel;
- General weather conditions;
- Date, time, and capture location/area (GPS if specified);
- Capture technique;
- Sample duration;

- General observations of fish habitat, abundance, and diversity; and
- Sample reach approximate length and/or area;
- Site photographs

6 COLLECTION PROCEDURES

Fish will be collected using trained personnel and approved sampling techniques. State personnel (conservation officers) will be notified of the sampling activities prior to going into the field per the permit requirements. Only those target species identified in the work plan and scientific collectors permit will be retained. Collection of other species may occur when target species are absent, and as approved. Non-target species will be released back to the system. Fish sampling will begin at the central portion of the proposed sampling location, and will be conducted outward until the target number of fish have been collected, and the approximate length/area of the sampling reach will be recorded in the field notes.

The following procedures will be used, as necessary, to collect fish:

6.1 Electrofishing

This section describes the procedures associated with the use of boat-mounted, barge-mounted, and backpack electrofishing units. Electrofishing activities will be temporarily halted when any unauthorized persons, pets, or livestock are observed in the water or on the shore in close proximity to the electrofishing unit.

6.1.1 Boat-Mounted Electrofishing

The following procedures describe the use of an electrofishing boat to collect fish:

1. The field crew will don personal protective equipment (life jackets, non-conductive shoes and gloves, etc.), set up the electrofishing equipment, and test it upon arrival at the site.
2. The boat operator will be responsible for control of the boat, and operation of the control equipment and generator. The remaining field crew will operate from the front of the boat and will be responsible for control of the on-off floorboard switch, and capturing the fish.
3. Electricity will be applied to the water by actively maintaining the on-off switch in the closed position while the generator and control equipment are operative.
4. The electrical current will be set to stun the fish, but should not cause mortality.
5. Target species of appropriate size will be collected using non-conductive dip-nets and will be placed in a live-well with fresh water until they can be transferred to a cooler with ice.

6.1.2 Barge-Mounted Electrofishing

The following procedures describe the use of a barge-mounted electrofishing unit to collect fish:

1. The field crew will don personal protective equipment (life jackets, non-conductive waders and gloves, etc.), set up the electrofishing equipment, and test it upon arrival at the site.
2. The barge operator will be responsible for pushing the barge (six-foot in length), and operation of the control equipment and generator. The remaining field crew will walk in front of the barge with anodes and will be responsible for control of the on-off switch on the anode handles, and capturing the fish.

3. Electricity will be applied to the water by actively maintaining the on-off switch in the closed position while the generator and control equipment are operative.
4. The electrical current will be set to stun the fish, but should not cause mortality.
5. Target species of appropriate size will be collected using non-conductive dip-nets and will be placed in a cooler with fresh water until they can be transferred to a cooler with ice.

6.1.3 Backpack Electrofishing

The following procedures describe the use of a backpack electrofishing unit to collect fish:

1. The field crew will don personal protective equipment (non-conductive waders and gloves, etc.), set up the electrofishing equipment, and test it upon arrival at the site.
2. The backpack operator will be responsible for control of the on-off switch on the anode handle, operation of the control equipment, and for capturing fish. The remaining field crew will work alongside the backpack operator and will capture fish.
3. Electricity will be applied to the water by actively maintaining the on-off switch in the closed position while the control equipment is operative.
4. The electrical current will be set to stun the fish, but should not cause mortality.
5. Target species of appropriate size will be collected using non-conductive dip-nets and will be placed in a 5-gallon bucket with fresh-water until they can be transferred to a cooler with ice.
6. Backpack electrofishing batteries will be recharged as needed.

6.2 Fish Nets and Traps

This section describes the procedures for using fish nets (gill nets and seines) and traps (trap nets, minnow traps, and eel pots) to collect fish.

6.2.1 Gill Nets

The following procedures describe the use of gill nets to collect fish:

1. The field crew will ready the appropriate sized gill nets (length, depth, and mesh size) for site conditions prior to field sampling.
2. In large water bodies, the boat operator will be responsible for selecting the locations to place the gill nets, and for control of the boat. The remaining crew will be responsible for setting the buoys, and anchoring, playing out, and retrieving the gill nets.
3. In small water bodies, where boat use is impractical, one crew member will be responsible for tossing a lead line that is attached to the gill net across the water body. Another crew member will retrieve the lead line and pull the gill net into position.
4. Gill nets will be placed within or adjacent to aquatic habitats that contain the target fish species desired for collection, and will be set to intercept moving fish.

5. Gill nets will be checked a minimum of once per 24-hour period.
6. Target species of appropriate size will be removed from the gill nets and will be placed into sealable plastic bags, and then into a cooler with ice. Non-target species will be counted and noted in the field notebook.

6.2.2 Seines

The following procedures describe the use of seines to collect fish:

1. The field crew will ready the appropriate sized seines (length, depth, and mesh size) for site conditions prior to field sampling.
2. In large water bodies, one crew member will hold the end of a large seine secure at the shoreline. The other crew member will pull the seine away from shore in a semi-circle pattern, reconnecting with the shoreline a distance away. Both crew members will haul the net in, keeping the bottom of the seine in contact with the substrate and the top of the seine above the water, to collect fish.
3. In small water bodies, two crew members will use a small seine to guide fish to the shoreline or to scoop them up. When moving through the water, the bottom of the seine should remain in contact with the substrate.
4. Target species of appropriate size will be removed from the seines and will be placed into sealable plastic bags, and then into a cooler with ice. Non-target species will be counted and noted in the field notebook.

6.2.3 Trap Nets

The following procedures describe the use of trap nets to collect fish:

1. The field crew will ready the appropriate sized trap nets (hoop diameter and mesh size) for site conditions prior to field sampling. An assortment of lead-net and wing-net panels will be available to meet site-specific demands.
2. In large water bodies, the boat operator will be responsible for selecting the locations to place the trap nets, and for control of the boat. The remaining crew will be responsible for setting the buoys, and anchoring, playing out, and retrieving the trap nets.
3. In small water bodies, where boat use is impractical, one crew member will be responsible for tossing a lead line that is attached to the trap net across the water body. Another crew member will retrieve the lead line and pull the trap net into position.
4. Trap nets will be placed within or adjacent to aquatic habitats that contain the target fish species desired for collection, and will be set to intercept moving fish.
5. Trap nets will be checked a minimum of once per 24-hour period.
6. Target species of appropriate size will be removed from the trap nets and will be placed into sealable plastic bags, and then into a cooler with ice. Non-target species will be counted and noted in the field notebook.

6.2.4 Minnow Traps

The following procedures describe the use of minnow traps to collect small fish:

1. The field crew will ready the minnow traps prior to field sampling.
2. In large water bodies, the boat operator will be responsible for selecting the locations to place the minnow traps, and for control of the boat. The remaining crew will be responsible for setting the buoys, and baiting, anchoring, and retrieving the minnow traps.
3. Without a boat, minnow traps will be baited, tethered, and set just off the shoreline.
4. Minnow traps will be placed within or adjacent to aquatic habitats that contain the target fish species desired for collection.
5. Minnow traps will be checked a minimum of once per 24-hour period.
6. Target species of appropriate size will be removed from the minnow traps and will be placed into sealable plastic bags, and then into a cooler with ice. Non-target species will be counted and noted in the field notebook.

6.3 Angling Techniques

This section describes the procedures used to collect fish by angling (rod-and-reel) and trotline techniques (multiple hooks on an anchored line).

6.3.1 Rod-and-Reel

The following procedures describe the use of rods-and-reels to collect fish:

1. The field crew will ready the rods-and-reels and tackle (hooks, line, bait, and artificial lures) prior to field sampling.
2. Baited hooks or artificial lures will be cast into aquatic habitats that contain the target fish species desired for collection
3. Target species of appropriate size will be retained and will be placed on a stringer, in a live-well, or into sealable plastic bags, and then into a cooler with ice. Non-target species will be counted and noted in the field notebook.

6.4 Trotlines

The following procedures describe the use of trotlines to collect fish:

1. The field crew will ready the trotlines and clip-on hooks prior to field sampling.
2. In large water bodies, the boat operator will be responsible for selecting the locations to place the trotlines, and for control of the boat. The remaining crew will be responsible for setting the buoys, and anchoring, baiting, playing out, and retrieving the trotlines.

3. In small water bodies, where boat use is impractical, one crew member will be responsible for tossing a lead line that is attached to the trotline across the water body. Another crew member will retrieve the lead line and pull the trotline into position.
4. Trotlines will be placed within or adjacent to aquatic habitats that contain the target fish species desired for collection, and will be set to intercept moving fish.
5. Trotlines will be checked a minimum of once per 24-hour period.
6. Target species of appropriate size will be removed from the trotlines and will be placed into sealable plastic bags, and then into a cooler with ice. Non-target species will be counted and noted in the field notebook.

7 SAMPLE HANDLING

The following identifies the temporary storage procedures that will be used to preserve fish in the field prior to sample processing, handling, and shipment to the laboratory:

1. Measure or weigh each fish after collection, as necessary, to ensure that appropriate sized fish are taken and that minimum sample mass requirements are satisfied.
2. Count the number of fish to ensure that the correct amount is taken.
3. Transfer fish to aluminum foil to be wrapped and then placed in a sealable plastic bags (if not done previously) and label with sampling date and capture location, and place in coolers with ice until field processing can occur. Large fish that do not fit into plastic bags may be placed on ice in clean coolers that are clearly labeled.

8 SPECIAL CONSIDERATIONS FOR PFAS SAMPLING

The detection of PFAS compounds at very low concentrations can be influenced by common PFAS-containing materials that may be present during sampling. Therefore, sampling protocols are to be strictly followed by the sampling personnel. To minimize the potential for cross-contamination, attention will be given to sampling materials, decontamination procedures, as well as clothing and personal care products used by sampling personnel. Some examples of products to avoid and that are acceptable are provided below.

Products to Avoid

- Materials containing polytetrafluorethylene (PTFE or Teflon), polyvinylidene fluoride (PVDF), polyvinyl fluoride (PVF), fluorinated ethylene propylene (FEP) and perfluoropolyether (PFPE)
- Clothing or boots containing Gore-Tex
- Clothing washed with fabric softener containing PFAS
- PFAS chemically treated clothing or insect/stain resistance and ultraviolet (UV) protection
- Personal care products (cosmetics, shampoo, sunscreens, dental floss, etc.) containing PFAS
- PFAS treated paper towel
- Plastic clipboards or notebooks made with PFAS treated paper

- Pre-wrapped food or snacks, carry-out food, fast food
- Note: When staff requires a break to eat, they should remove their gloves and move to the designated area for food and beverage consumption. When finished, staff should wash their hands and put on a fresh pair of powderless nitrile gloves before returning to the sampling area.

Materials That are Acceptable

- Life jackets made of polyethylene foam and nylon shell fabric
- Natural rubber (electrofishing lineman's gloves)
- PFAS free dip-nets and seines, gill nets, trap nets and/or trotlines
- High density polyethylene (HDPE) or polypropylene (PP) coolers and buckets
- Waders made of polyvinyl chloride (PVC) or neoprene
- Synthetic and natural fibers (preferably cotton)
- Any boots made of polyurethane and PVC
- Well-laundered clothes without fabric softener from time of purchase
- Powderless nitrile gloves
- Untreated wooden measuring board or stainless-steel meter stick
- Stainless steel processing table, tray, electronic balance boat, and/or fillet knife
- Alconox, Liquinox, or Citranox
- Polypropylene scrub brush
- PFAS-free DI water
- Low-density polyethylene (LDPE) plastic freezer bags (Ziploc) and aluminum foil
- Ballpoint pen, pencil or fine-point Sharpie marker
- Rite in the Rain notebooks
- Aluminum or Masonite clipboard with loose paper (non-waterproof, non-recycled)
- Bottled water and hydration drinks (Gatorade)
- Sunscreen (Banana Boat, Coppertone, Neutrogena), OFF Deep Woods, Sawyer Permethrin

Items That May Need Screening

- Municipal potable water (if used to rinse fish or cleaning)
- Aluminum foil
- Any special gloves required by a HASP (electrofishing lineman's gloves)

Powderless nitrile gloves should frequently be changed any time there is an opportunity for cross-contamination of the sampling including, but not limited to, the following activities:

- Each time sampling equipment is handled.

- Prior to sample collection.
- After handling any sample, including QA/QC samples such as field reagent blanks or equipment rinse blanks.
- After the handling of any non-dedicated sampling equipment, contact with non-decontaminated surfaces, or when judged necessary by field personnel.
- During and after decontamination of non-dedicated sampling equipment.

QAPP Attachment D

Field Forms

Design & Consultancy
for natural and
built assets

Document Control Number:TGM - ______________________________
TGM + project number plus date as follows: xxxxxxxx.xxxx.xxxxx - dd/mm/year

TAILGATE HEALTH & SAFETY MEETING FORM

This form documents the tailgate meeting conducted in accordance with the Project HASP. Personnel who perform work operations on-site during the day are required to attend this meeting and to acknowledge their attendance, at least daily.

Project Name:			**Project Location:**
Date:	**Time:**	**Conducted by:**	**Signature/Title:**
Client:		**Client Contact:**	**Subcontractor companies:**

TRACKing the Tailgate Meeting

Think through the Tasks (list the tasks for the day):

1 ______________________________
2 ______________________________
3 ______________________________
4 ______________________________
5 ______________________________
6 ______________________________

Other Hazardous Activities - Check the box if there are any other Arcadis, Client or other party activities that may pose hazards to Arcadis operations ☐

If there are none, write "None" here: __________

If yes, describe them here: ______________________________

How will they be controlled? ______________________________

Prework Authorization - check activities to be conducted that require permit issuance or completion of a checklist or similar before work begins:

			Doc #		Doc #
☐ Not applicable	Doc #	☐ Working at Height	________	☐ Confined Space	________
☐ Energy Isolation (LOTO)	________	☐ Excavation/Trenching	________	☐ Hot Work	________
☐ Mechanical Lifting Ops	________	☐ Overhead & Buried Utilities	________	☐ Other permit	________

Discuss following questions **(for some review previous day's post activities)**. **Check if yes :**

☐ Incidents from day before to review?
☐ Any corrective actions from yesterday?
☐ JSAs or procedures are available?
☐ Staff has appropriate PPE?
☐ Lessons learned from the day before?
☐ Will any work deviate from plan?
☐ Field teams to "dirty" JSAs, as needed?
☐ Staff knows Emergency Plan (EAP)?
☐ Topics from Corp H&S to cover?
☐ Any Stop Work Interventions yesterday?
☐ If deviations, notify PM & client
☐ All equipment checked & OK?
☐ Staff knows gathering points?

Comments: ______________________________

Recognize the hazards (check all those that are discussed) (Examples are provided) and **Assess** the Risks (Low, Medium, High - circle risk level) - Provide an overall assessment of hazards to be encountered today and briefly list them under the hazard category.

☐ Gravity (i.e., ladder, scaffold, trips) (L M H)
____
☐ Electrical (i.e., utilities, lightning) (L M H)
____
☐ Chemical (i.e., fuel, acid, paint) (L M H)
____
☐ Sound (i.e., machinery, generators) (L M H)
____
☐ Motion (i.e., traffic, moving water) (L M H)
____
☐ Pressure (i.e. gas cylinders, wells) (L M H)
____
☐ Biological (i.e., ticks, poison ivy) (L M H)
____
☐ Personal (i.e. alone, night, not fit) (L M H)
____
☐ Mechanical (i.e., augers, motors) (L M H)
____
☐ Environment (i.e., heat, cold, ice) (L M H)
____
☐ Radiation (i.e., alpha, sun, laser) (L M H)
____
☐ Driving (i.e. car, ATV, boat, dozer) (L M H)
____

Continue TRACK Process on Page 2

TAILGATE HEALTH & SAFETY MEETING FORM - Pg. 2

Control the hazards (Check all and discuss those methods to control the hazards that will be implemented for the day): Review the HASP, applicable JSAs, and other control processes. Discuss and document any additional control processes.

☒ **STOP WORK AUTHORITY** (Must be addressed in every Tailgate meeting - (*See statements below*)

- ☐ Elimination
- ☐ Engineering controls
- ☐ General PPE Usage
- ☐ Personal Hygiene
- ☐ Emergency Action Plan (EAP)
- ☐ JSA to be developed/used ***specify***
- ☐ Substitution
- ☐ Administrative controls
- ☐ Hearing Conservation
- ☐ Exposure Guidelines
- ☐ Fall Protection
- ☐ TIP conducted ***(specify job/JSA)***
- ☐ Isolation
- ☐ Monitoring
- ☐ Respiratory Protection
- ☐ Decon Procedures
- ☐ Work Zones/Site Control
- ☐ Traffic Control
- ☐ Other ***(specify)***

Signature and Certification Section - Site Staff and Visitors

Name/Company/Signature	Initial & Sign in Time	Initial & Sign out Time	I have read and understand the HASP

Important Information and Numbers

All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns.

In the event of an injury, employees will call WorkCare at **1.888-449-7787** and then notify the field supervisor who will then notify the Project or Task Manager.

In the event of a motor vehicle accident, employees will notify the field supervisor who will then notify the Project or Task Manager.

In the event of a utility strike or other damage to property of a client or 3rd party, employees will immediately notify the field supervisor, who will then immediately notify the Project or Task Manager.

Visitor Name/Co - not involved in work

In Out

In Out

In Out

In Out

I will STOP the job any time anyone is concerned or uncertain about health & safety or if anyone identifies a hazard or additional mitigation not recorded in the site, project, job or task hazard assessment.

I will be alert to any changes in personnel, conditions at the work site or hazards not covered by the original hazard assessments.

If it is necessary to **STOP THE JOB,** I will perform **TRACK**; and then amend the hazard assessments or the HASP as needed.

I will not assist a subcontractor or other party with their work unless it is absolutely necessary and then only after I have done TRACK and I have thoroughly controlled the hazard.

Post Daily Activities Review - Review at end of day or before next day's work (Check those applicable and explain:)

- ☐ Lessons learned and best practices learned today: ______
- ☐ Incidents that occurred today: ______
- ☐ Any Stop Work interventions today? ______
- ☐ Corrective/Preventive Actions needed for future work: ______
- ☐ Any other H&S issues: ______

Keep H&S 1st in all things

WorkCare - 1.888.449.7787

DAILY LOG

Project No.: ______________________________ Page _____ of _____

Site Location: ______________________________

Prepared By: ______________________________

Date	Time	Description of Activities

ARCADIS Design & Consultancy for natural and built assets

GROUNDWATER SAMPLING LOG

Page _____ of _____

Project No. ______________________ Well ID ______________ Date ______________

Project Name/Location ______________________________________ Weather ______________

Measuring Pt. Description ______________ Screen Setting (ft-bmp) ______________ Casing Diameter (in.) ______________ Well Material _____ PVC _____ SS

Static Water Level (ft-bmp) ______________ Total Depth (ft-bmp) ______________ Water Column/ Gallons in Well ______________

MP Elevation ______________ Pump Intake (ft-bmp) ______________ Purge Method: ______________

Centrifugal ______________

Submersible ______________

Other ______________

Sample Method ______________

Pump On/Off ______________ Volumes Purged ______________

Sample Time: Label ________ Start ________ End ________

Replicate/ Code No. ______________

Sampled by ______________

Time	Minutes Elapsed	Rate (gpm) (mL/min)	Depth to Water (ft)	Gallons Purged	pH	Cond. (mMhos) (mS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Temp. (°C) (°F)	Redox (mV)	Appearance	
											Color	Odor

Constituents Sampled	**Container**	**Number**	**Preservative**

Well Casing Volumes

Gallons/Foot
1" = 0.04
1.25" = 0.06
1.5" = 0.09
2" = 0.16
2.5" = 0.26
3" = 0.37
3.5" = 0.50
4" = 0.65
6" = 1.47

Well Information

Well Location: ______________________ Well Locked at Arrival: Yes / No

Condition of Well: ______________________ Well Locked at Departure: Yes / No

Well Completion: Flush Mount / Stick Up Key Number To Well: ______________

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INSTRUMENT CALIBRATION LOG

Project Name: ______________________

Date: __________

Project Number: ______________________

Calibrating Personnel: ______________________

Time of Calibration: ______________________

Weather Conditions: ______________________

Barometric Pressure: ______________ mm Hg

Calibrant	Instrument	Initial Reading	Value Entered	Final Reading	Time	Temperature
pH 7.00						
pH 4.00						
Conductivity (_____________)						
Turbidity (1.0 NTU)						
Turbidity (10.0 NTU)						
DO (mg/L)						
DO%						
ORP (mV)						

Notes: ______________________

WATER LEVEL MEASUREMENT FORM

Page ______ of ______

Project Name: ______________________ Date: ______________________

Project Number: ______________________ Weather: ______________________

Field Personnel: ______________________

Well Casing Volumes

gallon/foot

1-¼" = 0.06	2" = 0.16	3" = 0.37	4" = 0.65
1-½" = 0.09	2-½" = 0.26	3-½" = 0.50	6" = 1.47

Well ID	Time	Measuring Point	TSD (ft)	DTP (ft)	DTW (ft)	Notes

Notes:

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INVESTIGATION DERIVED WASTE LOG

Page ______ of ______

Project Name/Location ______________________ Date ______________

Project/No. ______________________ Weather ______________

Technician ______________________ Project Manager ______________

Date	Container Number	Container Type (drum, rolloff, tank)	Container Capacity	Container Description (OT, CT, etc.)	Media (SO, GW)	Content Description	Source	Volume from Source	Storage Location

NOTES:

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PHOTOGRAPH LOG

Date: ____________________

Site Name: ____ Project No.: ____

Street: ____ City/State: ____

Photo #	Direction of View	Description

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WELL ABANDONMENT LOG

Site Name/Location

Recorded By

Project No.

Well ID

Date

Total Depth (ft)

Construction Material

Casing Diameter (in)

Start Time

End Time

Well Volume (gallon)

Method:
Overdrill (ft)

Grout/Chips

Bags of Material

Contractor

Driller

Helper

	Well Casing Volume Conversion Factor				
gallon/foot	1" = 0.04	1-¼" = 0.06	2" = 0.16	3" = 0.37	4" = 0.65
		1-½" = 0.09	2-½" = 0.26	3-½" = 0.50	6" = 1.47

Time	Notes

NR = Not Recorded

TSD = Total Sound Depth

bgs = below ground surface

PID = Photo Ionization Detector

ppm = part per million

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DELIVERY TRUCK LOG

Page ____________ of ____________

Project/No. ______________________________ Date ____________________

Location/Area ______________________________

Prepared by ______________________________

Time Onsite	Begin Pump Time	End Pump Time	Time Offsite	Truck Company	Driver	Grace Period (Hrs)	Overage (Hrs)

Comments: ____

____

____

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INDOOR AIR QUALITY SAMPLE LOG

Sample ID ____________________ Project/No. ____________________

Date ____________________ Sampling Personnel ____________________

Weather ____________________ ____________________

Precipitation w/in preceeding 12 hours? Y / N Amount: ________ in ____________________

Current Building Type: Residential Commercial Industrial

Building Construction Characteristics (e.g., rancher, apartment): ____________________

General Description of Building Materials (e.g., concrete, cinder block): ____________________

Characteristics of Basement:

	Floor:	**Foundation Walls:**	**Moisture:**
Finished			
Unfinished	Concrete	Concrete	Wet
	Dirt	Block	Damp
	Other: ________	Layered up stone	Dry

DESCRIPTION OF SAMPLE LOCATION:

Location: ____________________

Floor Level: Basement / 1st Floor

Room Size (ft x ft): ____________

SAMPLE COLLECTION:

Sample Time: ____________

Sample Rate: ____________

Sample Volume: ____________

CONTAINER DESCRIPTION:

________ L Summa Canister

ANALYTICAL METHOD:

____

Location Sketch:

INDOOR AIR QUALITY SURVEY

Project/No. ______________________

Date: ______________________

Personnel: ______________________

Address/Building No.: ______________________

Point of Contact: ______________________

Current Building Type: Residential Commercial Industrial

Building Construction Characteristics:

Ranch
Raised Ranch
Cape
Colonial
Split Level

Mobile Home
Duplex
Apartment
Condo
Other: ______________

General Description of Building Materials (e.g., concrete, cinder block):

Number of floors in building (including basement):

Has the building been weatherized with any of the following?

Insulation Energy-Efficient Windows Storm Windows Other: ______________________

Characteristics of basement:

Finished	Floor:	Foundation Walls:	Moisture:
Unfinished	Concrete	Concrete	Wet
	Dirt	Block	Damp
	Other: ______________	Layered up stone	Dry

Is a sump present? Y / N

Does the baement have any of the following characteristics?

Cracks Pipes Utility Conduits Slab drainage Sump pump
Other: ______________________________

Heating and Ventilation System(s) Present:

Types of heating system(s) used in building:

Hot Air Circulation
Hot Air Radiation

Heat Pump
Unwanted Kerosene

Steam Radiation
Electric Baseboard

Wood Stove
Other: ______________________

Types of Fuel:

Natural Gas
Fuel Oil

Electric
Wood

Coal
Solar

Mechanical ventilation system(s):

Central Air
Individual A/C

Mechanical Fans
Kitchen Range Hood

Bathroom Exhaust
Air-to-Air Heat XCHG

Open Windows
Other: ______________________

Sources of Indoor Chemicals:

Potential VOC Source	Locations of Source	Can be removed?
Paints or paint thinners		
Gas-powered equipment		
Gasoline storage cans		
Cleaning solvents		
Air fresheners		
Oven cleaners		
Carpet/upholstery cleaners		
Hairspray		
Nail polish/polish remover		
Bathroom cleaner		
Appliance cleaner		
Furniture polish		
Moth balls		
Fuel tank		
Wood stove		
Fireplace		
Perfume		
Hobby supplies:		
Scented trees/wreaths/potpourri		
Other:		

Do one or more smokers occupy this building? Y / N

Does the building have an attached garage? Y / N

If so, is a car or other gas-powered equipment stored in the garage? Y / N

Do occupants of the building have clothes dry-cleaned? Y / N

Any recent remodeling/painting/carpeting done? Y / N

Are there any pressed wood products in the building? (e.g., wall paneling, particle board, fiberboard) Y / N

Is there any new upholstery, drapes, or other textiles in the building? Y / N

Has the building been treated with insecticides or pesticides? Y / N

Outdoor Sources of Contamination:

Is there any stationary emission source in the vicinity of the building? Y / N

Are there any mobile emission sources (e.g., highway, bus-stopm high-traffic areas) in vicinity? Y / N

SAMPLE/CORE LOG

Boring/Well ____________ Project/No. ______________________ Page _____ of _____

Site Location ______________________ Drilling Started ____________ Drilling Completed ____________

Total Depth Drilled _____ feet Hole Diameter _____ inches Type of Sample / Coring Device ____________

Length and Diameter of Coring Device ______________________ Sampling Interval _____ feet

Land-Surface Elev. _____ feet ☐ Surveyed ☐ Estimated Datum ____________

Drilling Fluid Used ______________________ Drilling Method ____________

Drilling Contractor ______________________ Driller ________ Helper ________

Prepared by ______________________ Hammer Weight ________ Hammer Drop ________ ins.

Sample/Core Depth (ft below land surface)		Core Recovery (ft)	PID Reading (ppm)	Time/Hydraulic Pressure or Blows per 6 inches	Sample/Core Description
From	To				

SAMPLE/CORE LOG (CONT.D)

Boring/Well __________________________ Page _____ of _____

Prepared by __________________________

Sample/Core Depth (ft below land surface)		Core Recovery (ft)	PID Reading (ppm)	Time/Hydraulic Pressure or Blows per 6 inches	
From	To				

SAMPLE/CORE LOG

Boring/Well ____________ Project/No. ____________ Page ______ of ______

Site Location ____________ Drilling Started ____________ Drilling Completed ____________

Total Depth Drilled ________ feet Hole Diameter ________ inches Type of Sample / Coring Device ____________

Length and Diameter of Coring Device ____________ Sampling Interval ______ feet

Land-Surface Elev. ________ feet ☐ Surveyed ☐ Estimated Datum ____________

Drilling Fluid Used ____________ Drilling Method ____________

Drilling Contractor ____________ Driller ____________ Helper ____________

Prepared by ____________ Hammer Weight ____________ Hammer Drop ________ ins.

Sample/Core Depth (ft below land surface)		Core Recovery (ft)	PID Reading (ppm)	Time/Hydraulic Pressure or Blows per 6 inches	Sample/Core Description
From	To				

SAMPLE/CORE LOG (CONT.D)

Boring/Well ______________________ Page _____ of _____

Prepared by ______________________

Sample/Core Depth (ft below land surface)		Core Recovery (ft)	PID Reading (ppm)	Time/Hydraulic Pressure or Blows per 6 inches	Sample/Core Description
From	To				

SOIL/SEDIMENT SAMPLE LOG

Sample ID ____________________
Date ____________________
Time ____________________
Weather ____________________

Project/No. ____________________
Sampling Personnel ____________________
____
____

DESCRIPTION OF SAMPLE LOCATION:

____________ Soil
Location ____________________
Sample depth (ft) ____________________
Soil type ____________________
____

____________ Sediment
Name of Water Body ____________________
Location ____________________
Depth of water ____________________
Velocity of water ____________________
Substrate description ____________________
Description of vegetation ____________________
____

FIELD PARAMETERS:

Sample Method ____________________
Sample Description ____________________
____
Color ____________________
Odor ____________________
Salinity ____________________

CONTAINER DESCRIPTION: From ________ Lab ________

Number	Container	Analysis

TOTAL: ☐

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SOIL-VAPOR SAMPLE LOG

Sample ID ____________________
Date ____________________
Time ____________________
Weather ____________________

Project/No. ____________________
Sampling Personnel ____________________
____
____

DESCRIPTION OF SAMPLE LOCATION:

________ Outdoor
Location ____________________
Est. depth to water (ft): ____________________
Soil type: ____________________
____
Odor: ____________________
Color: ____________________

________ Indoor
Location ____________________
Basement: yes / no
Room size (ft x ft): ____________________
Floor material: cement / wood / dirt
Slab Thickness (ft): ____________________
Visible cracks?: yes / no
Sub-slab material: dirt / gravel

PROBE INSTALLATION:

Date: ____________________
Method: ____________________
Diameter: ____________________
Depth: ____________________
Packing material: ____________________

PURGE:

Date: ____________________
Time: ____________________
Rate: ____________________
Volume: ____________________

SAMPLE COLLECTION:

Sample Time: ____________________
Sample Rate: ____________________
Sample Volume: ____________________

Location Sketch:

CONTAINER DESCRIPTION:

________ L Summa Canister

SURFACE WATER SAMPLE LOG

Sample ID ______________ Project/No. ______________

Date ______________ Sampling Personnel ______________

Time ______________ ______________

Weather ______________ ______________

DESCRIPTION OF SAMPLE LOCATION:

Name of Water Body ______________ Velocity ______________

Depth of Water ______________

Other Comments ______________

Substrate Description ______________

Location ______________

____

Description of Nearby Vegetation ______________

FIELD PARAMETERS:

Sample Method ______________

Sample Description ______________

____

Temperature (°C/°F) ______________ pH ______________

Dissolved Oxygen ______________ SC ______________

Salinity ______________

CONTAINER DESCRIPTION: From ________ Lab ________ ARCADIS

Bottle Type	**Analysis**	**Preservative**

WELL CONSTRUCTION LOG

(Unconsolidated)

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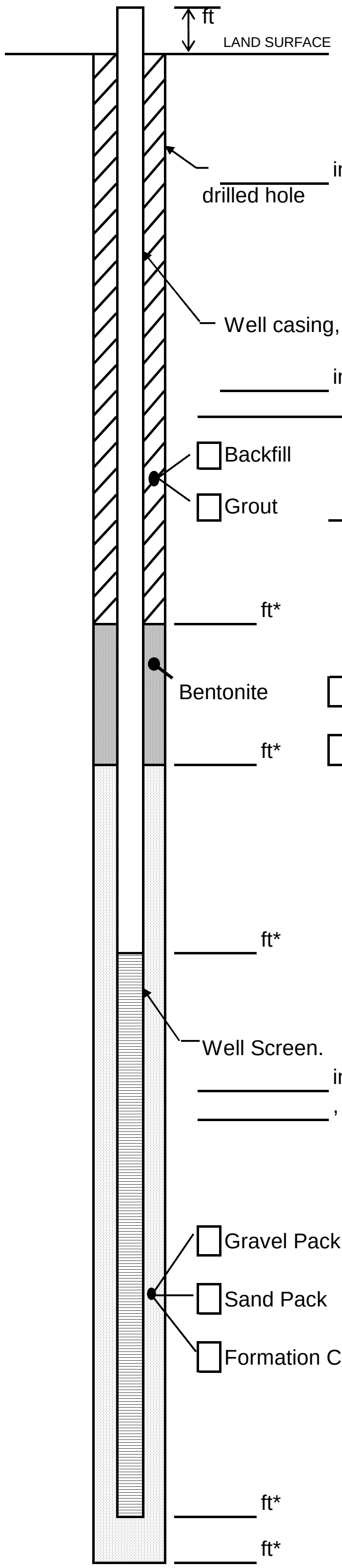

_____ inch diameter drilled hole

Well casing,
_____ inch diameter,
_____

☐ Backfill
☐ Grout _____

_____ ft*

Bentonite ☐ slurry
_____ ft* ☐ pellets

_____ ft*

Well Screen.
_____ inch diameter
_____ , _____ slot

☐ Gravel Pack
☐ Sand Pack
☐ Formation Collapse

_____ ft*

_____ ft*

Measuring Point is
Top of Well Casing
Unless Otherwise Noted.
* Depth Below Land Surface

Project _____ Well _____

Town/City _____

County _____ State _____

Permit No. _____

Land-Surface (LS) Elevation and Datum:

_____ feet ☐ Surveyed
☐ Estimated

Installation Date(s) _____

Drilling Method _____

Drilling Contractor _____

Drilling Fluid _____

_____

Development Technique(s) and Date(s)

_____

_____

_____

Fluid Loss During Drilling _____ gallons

Water Removed During Development _____ gallons

Static Depth to Water _____ feet below M.P.

Pumping Depth to Water _____ feet below M.P.

Pumping Duration _____ hours

Yield _____ gpm Date _____

Specific Capacity _____ gpm/ft

Well Purpose _____

_____

_____

Remarks _____

_____

_____

_____

Prepared by _____

ARCADIS Design & Consultancy for natural and built assets

WELL DEVELOPMENT LOG

Site/Well No. ____________

Project ____________ Project No. ____________ Page ____ of 1

Site Location ____________ Date ____________

Weather ____________ Development Time Begin ________ End ____________

Evacuation Data

Measuring Point ____________

MP Elevation (ft) ____________

Land Surface Elevation (ft) ____________

Sounded Well Depth (ft bmp) ____________

Depth to Water (ft bmp) ____________

Water-Level Elevation (ft) ____________

Water Column in Well (ft) ____________

Casing Diameter/Type ____________

Gallons in Well ____________

Sample Pump Intake Setting (ft bmp) ____________

Pumping Rate (gpm) ____________

Evacuation Method ____________

Field Parameters

Color ____________

Odor ____________

Appearance ____________

Well Volume	Total Gallons Removed	pH (s.u.)	Conductivity (mS/cm or umhos/cm)	Turbidity (NTU)	Temperature (°F/°C)	Remarks
Initial						
1st						
2nd						
3rd						
4th						
5th						
6th						
7th						
8th						
9th						
10th						

Development Personnel: ____________

Notes: ____________

Well Casing Volumes (gallon/feet)

1-¼" = 0.06
1-½" = 0.09
2" = 0.16
2-½" = 0.26
3" = 0.37
3-½" = 0.50
4" = 0.65
6" = 1.47

bmp	below measuring point	ml	mililiter	NTU	Nephelometric Turbidity Units
°C	Degrees Celsius	mS/cm	Milisiemens per centimeter	PVC	Polyvinyl chloride
ft	feet	msl	mean sea-level	s.u.	Standard units
gpm	Gallons per minute	N/A	Not Applicable	umhos/cm	Micromhos per centimeter
mg/L	Miligrams per liter	NM	Not Measured	VOC	Volatile Organic Compounds

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IN-SITU GROUNDWATER PARAMETER LOG

Client: ______________ Project #: ______________ Date: __________

Location: ______________ City: ______________ State: __________

Location #: ______________ Instrument: ______________

Technician: ______________ Project Mngr: ______________

Well	Time	DTW (ft bmp)	DO%	DO (mg/L)	DO (Charge*) (25-75)	Redox (ORP) (mV)	pH	SC (µS/cm)	Temp (°C)

Notes:

____

____

____

____

* DO CHARGE MUST BE 25 - 75 FOR PROPER OPERATION OF DO PROBE

QAPP Attachment E

Laboratory Standard Operating Procedures and Certificates

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

EUROFINS LANCASTER LABORATORIES ENVIRONMENT TESTING LLC
2425 New Holland Pike
Lancaster, PA 17601
Dorothy M. Love Phone: 717-556-7327

ENVIRONMENTAL

Valid To: November 30, 2022 Certificate Number: 0001.01

In recognition of the successful completion of the A2LA evaluation process (including an assessment of the laboratory's compliance with the 2009 TNI Environmental Testing Laboratory Standard, and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 5.4 of the DoD/DOE Quality Systems Manual for Environmental Laboratories, accreditation is granted to this laboratory to perform recognized EPA methods using the following testing technologies and in the analyte categories identified below:

Testing Technologies

Atomic Absorption/ICP-AES Spectrometry, ICP-MS Spectrometry, Gas Chromatography, Gas Chromatography/Mass Spectrometry, Gravimetry, High Performance Liquid Chromatography, Ion Chromatography, Misc.-Electronic Probes (pH, F$^-$, O_2), Oxygen Demand, Spectrophotometry (Visible), Spectrophotometry (Automated), Titrimetry, TCLP, Total Organic Carbon, Turbidity, Liquid Chromatography/Mass Spectrometry/Mass Spectrometry, High Resolution Gas Chromatography/Mass Spectrometry

Parameter/Analyte	**Drinking Water**	**Non-Potable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
Demands				
COD	---------------	EPA 410.4	---------------	---------------
Total Organic Carbon	---------------	EPA 9060A SM 5310C-2011	EPA 9060A SM 5310C-2011	EPA 9060A SM 5310 B-2011
Anions				
Ammonia	---------------	EPA 350.1	EPA 350.1	SM 4500-NH3 B/C-2011
Fluoride	---------------	EPA 300.0 EPA 9056A	EPA 9056A	EPA 9056A EPA 300.0
Nitrate (as N)	---------------	EPA 300.0 EPA 9056A	EPA 9056A	EPA 9056A EPA 300.0
Nitrite (as N)	---------------	EPA 300.0 EPA 9056A	EPA 9056A	EPA 9056A EPA 300.0

Parameter/Analyte	**Drinking Water**	**Non-Potable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
Bromide	------------------	EPA 300.0 EPA 9056A	EPA 9056A	EPA 9056A EPA 300.0
Chloride	------------------	EPA 300.0 EPA 9056A	EPA 9056A	EPA 9056A EPA 300.0
Sulfate	------------------	EPA 300.0 EPA 9056A	EPA 9056A	EPA 9056A EPA 300.0
Wet Chemistry				
Alkalinity	------------------	SM 2320B-2011	---------------	---------------
Corrosivity	------------------	---------------	SW-846 Chapter 7	SW-846 Chapter 7
Cyanide	------------------	EPA 9012B	EPA 9012B	EPA 9012B
Filterable Residue (TDS)	------------------	SM 2540C-2011	---------------	---------------
Flashpoint	------------------	---------------	EPA1010A	EPA 1010A
Grain Size	------------------	---------------	---------------	ASTM D422 MOD
Hexavalent Chromium Digestion	------------------	---------------	---------------	EPA 3060A
Hexavalent Chromium	------------------	EPA 7196A EPA 7199	EPA 7196A EPA 7199	EPA 7196A EPA 7199
Ignitability	------------------	---------------	40 CFR 261.21	40 CFR 261.21
Nitrate/Nitrite	------------------	---------------	EPA 353.2	---------------
Non-filterable Residue (TSS)	------------------	SM 2540D-2011	---------------	---------------
pH	------------------	SM 4500 H+B-2011 EPA 9040B EPA 9040C	EPA 9040B EPA 9040C	EPA 9045C EPA 9045D
Phenol	------------------	EPA 9066	EPA 9066	---------------
Reactivity	------------------	---------------	SW-846 Chapter 7.3	SW-846 Chapter 7.3
Sulfide	------------------	EPA 376.1 EPA 376.2 SM 4500 S2D-2011 SM 4500 S2F-2011	---------------	---------------
Total Residue	------------------	SM 2540B-2011	---------------	SM 2540G-2011
Metals				
Metals Digestion	------------------	EPA 3005A EPA 3010A EPA 3020A	EPA 3010A EPA 3020A	EPA 3050B
Aluminum	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Antimony	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Arsenic	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B

Parameter/Analyte	**Drinking Water**	**Non-Potable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
Barium	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Beryllium	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Boron	------------------	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D
Cadmium	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Calcium	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Chromium	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Cobalt	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Copper	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Iron	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Lead	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Lithium	------------------	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D
Molybdenum	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Magnesium	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B

Parameter/Analyte	Drinking Water	Non-Potable Water	Solid Hazardous Waste	
			Aqueous	Solid
Manganese	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Mercury	------------------	EPA 7470A	EPA 7470A	EPA 7471A EPA 7471B
Nickel	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Potassium	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Selenium	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Silicon	------------------	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D
Silver	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Sodium	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Strontium	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Sulfur	------------------	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D
Thallium	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Thorium	------------------	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D
Tin	------------------	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D
Titanium	------------------	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D
Tungsten	------------------	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D

Parameter/Analyte	**Drinking Water**	**Non-Potable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
Uranium	------------------	EPA 6020A EPA 6020B	EPA 6020A EPA 6020B	EPA 6020A EPA 6020B
Vanadium	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Zinc	------------------	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B	EPA 6010C EPA 6010D EPA 6020A EPA 6020B
Zirconium	------------------	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D	EPA 6010C EPA 6010D
Purgeable Organics (Volatiles)				
Volatile Preparation	------------------	EPA 5030C	EPA 5030C	EPA 5035A
Acetone	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Acetonitrile	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Acrolein	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Acrylonitrile	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Allyl chloride	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
tert-Amyl Alcohol	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
tert-Amyl Methyl Ether	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
tert-Butyl Alcohol	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
tert-Butyl Formate	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Benzene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Bromobenzene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Bromochloromethane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Bromodichloromethane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Bromoform	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Bromomethane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
2-Butanone	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
n-Butylbenzene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
sec-Butylbenzene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
tert-Butylbenzene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Carbon disulfide	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Carbon tetrachloride	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
2-Chloro-1,3-butadiene	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Chloroacetonitrile	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Chlorobenzene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1-Chlorobutane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Chlorodifluoromethane	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Chloroethane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
2-Chloroethyl Vinyl Ether	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Chloroform	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D

Parameter/Analyte	**Drinking Water**	**Non-Potable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
1-Chlorohexane	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Chloromethane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
2-Chlorotoluene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
4-Chlorotoluene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Cyclohexane	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Cyclohexanone	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Di-Isopropyl ether	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Dibromochloromethane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,2-Dibromo-3-chloropropane	EPA 524.2	EPA 8260C/D EPA 8011	EPA 8260C/D EPA 8011	EPA 8260C/D
Dibromomethane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,2-Dibromoethane (EDB)	------------------	EPA 8260C/D EPA 8011	EPA 8260C/D EPA 8011	EPA 8260C/D
1,2-Dichlorobenzene	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,3-Dichlorobenzene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,4-Dichlorobenzene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
trans-1,4-dichloro-2-butene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Dichlorodi-fluoromethane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,1-Dichloroethane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,2-Dichloroethane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,1-Dichloroethene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
cis-1,2-Dichloroethene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
trans-1,2-Dichloroethene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Dichlorofluoromethane	EPA 524.2	---------------	---------------	---------------
1,2-Dichloropropane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,3-Dichloropropane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
2,2-Dichloropropane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,1-Dichloropropene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
cis-1,3-Dichloropropene	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
trans-1,3-Dichloropropene	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,4-Dioxane	------------------	EPA 8260C/D EPA 8260C/D SIM	EPA 8260C/D EPA 8260C/D SIM	EPA 8260C/D EPA 8260C/D SIM
Ethanol	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Ethylbenzene	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Ethyl ether	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Ethyl Methacrylate	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Ethyl Tert-Butyl Ether	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Freon-113	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Gasoline Range Organics (GRO) [Volatile Petroleum Hydrocarbons (VPH)]	------------------	EPA 8015C EPA 8015D EPA 8260C/D NW TPH-Gx MA VPH AK101	EPA 8015C EPA 8015D EPA 8260C/D NW TPH-Gx MA VPH AK101	EPA 8015C EPA 8015D EPA 8260C/D NW TPH-Gx MA VPH AK101
Heptane	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Hexane	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
2-Hexanone	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D

Parameter/Analyte	**Potable Water**	**Non-Potable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
Hexachlorobutadiene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Hexachloroethane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Isobutyl Alcohol	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Isopropyl Alcohol	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Isopropylbenzene	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,4-Isopropyltoluene	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Methylacrylonitrile	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Methyl Acetate		EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Methyl Acrylate	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Methyl Iodide	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Methyl Ethyl ketone	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Methylene Chloride	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Methyl Isobutyl Ketone	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Methyl Methacrylate	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Methyl Tert-Butyl Ether	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
4-Methyl-2-pentanone	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Methylcyclohexane		EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
2-Nitropropane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Naphthalene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Pentachloroethane	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Propionitrile	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
n-Propylbenzene	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Styrene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Tert-Amyl Ethyl Ether		EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,1,1,2-Tetrachloroethane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,1,2,2-Tetrachloroethane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Tetrachloroethene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Tetrahydrofuran	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Toluene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,2,3-Trichlorobenzene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,2,4-Trichlorobenzene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,1,1-Trichloroethane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,1,2-Trichloroethane	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Trichloroethene	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Trichlorofluoromethane	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,2,3-Trichloropropane	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,2,4-Trimethylbenzene	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,3,5-Trimethylbenzene	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Vinyl Acetate	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Vinyl Chloride	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
Xylenes, Total	------------------	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,2-Xylene (o-Xylene)	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D
1,3+1,4-Xylene (m+p Xylene)	EPA 524.2	EPA 8260C/D	EPA 8260C/D	EPA 8260C/D

Parameter/Analyte	**Potable Water**	**Non-Potable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
Extractable Organics (Semivolatiles)				
Acenaphthene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Acenaphthylene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Acetophenone	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2-Acetylaminofluorene	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Alkylated PAHs	------------------	EPA 8270D/E SIM	EPA 8270D/E SIM	EPA 8270D/E SIM
4-Aminobiphenyl	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2-Amino-4,6-dinitrotoluene	------------------	EPA 8330B	EPA 8330B	EPA 8330B
4-Amino-2,6-dinitrotoluene	------------------	EPA 8330B	EPA 8330B	EPA 8330B
Aniline	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Anthracene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Atrazine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Benzaldehyde	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Benzidine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Benzoic acid	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Benzo (a) anthracene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Benzo (b) fluoranthene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Benzo (k) fluoranthene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Benzo (ghi) perylene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Benzo (a) pyrene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Benzo (e) pyrene	------------------	EPA 8270D/E SIM	EPA 8270D/E SIM	EPA 8270D/E SIM
Benzyl Alcohol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Biphenyl	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
bis (2-Chloroethoxy) Methane	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
bis (2-Chloroethyl) Ether	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
bis (2-Chloroisopropyl) Ether	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
bis (2-Ethylhexyl) Phthalate	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
4-Bromophenylphenyl Ether	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Butyl benzyl Phthalate	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM

Parameter/Analyte	**Potable Water**	**Non-Potable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
Caprolactam	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Carbazole	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Carbon Range Organics C8-C44 (including subsets of this range i.e. HRO, MRO, ORO, RRO)	------------------	EPA 8015C EPA 8015D	EPA 8015C EPA 8015D	EPA 8015C EPA 8015D
4-Chloroaniline	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
4-Chloro-3-methylphenol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Chlorobenzilate	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
1-Chloronaphthalene	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2-Chloronaphthalene	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2-Chlorophenol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
4-Chlorophenyl phenyl ether	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Chrysene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Cresols (Methyl phenols)	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
cis-/trans-Diallate	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2,4-Diamino-6-nitrotoluene	------------------	EPA 8330B	EPA 8330B	EPA 8330B
2,6-Diamino-4-nitrotoluene	------------------	EPA 8330B	EPA 8330B	EPA 8330B
Dibenzo (a,h) acridine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Dibenzo (a,h) anthracene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Dibenzofuran	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
1,2-Dichlorobenzene	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
1,3-Dichlorobenzene	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
1,4-Dichlorobenzene	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
3,3-Dichlorobenzidine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Diesel Range Organics (DRO) [Extractable Petroleum Hydrocarbons (EPH)]	------------------	EPA 8015C EPA 8015D NWTPH DX MA EPH TX1005/1006 AK102/103 AK102/103-SV	EPA 8015C EPA 8015D NWTPH DX MA EPH TX1005/1006 AK102/103 AK102/103-SV	EPA 8015C EPA 8015D NWTPH DX MA EPH TX1005/1006 AK102/103
2,4-Dichlorophenol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2,6-Dichlorophenol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Diethyl Phthalate	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Dimethoate	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
p-Dimethylaminoazobenze	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
7,12-Dimethylbenz (a) anthracene	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2,4-Dimethylphenol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Dimethyl Phthalate	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
3,3’-Dimethylbenzidine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E

Parameter/Analyte	**Potable Water**	**Non-Potable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
Di-n-butyl Phthalate	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Di-n-octyl phthalate	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
3,5-Dinitroaniline	------------------	EPA 8330B	EPA 8330B	EPA 8330B
1,3-Dinitrobenzene	------------------	EPA 8270D/E EPA 8330B	EPA 8270D/E EPA 8330B	EPA 8270D/E EPA 8330B
1,4-Dinitrobenzene	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2,4-Dinitrophenol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2,4-Dinitrotoluene	------------------	EPA 8270D/E EPA 8330B	EPA 8270D/E EPA 8330B	EPA 8270D/E EPA 8330B
2,6-Dinitrotoluene	------------------	EPA 8270D/E EPA 8330B	EPA 8270D/E EPA 8330B	EPA 8270D/E EPA 8330B
1,4-Dioxane	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Diphenylamine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Diphenyl ether	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
1,2-Diphenylhydrazine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Ethyl Methane Sulfonate	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Fluoroanthene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Fluorene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Hexachlorobenzene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Hexachlorobutadiene	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Hexachlorocyclo-pentadiene	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Hexachloroethane	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Hexachloropropene	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	------------------	EPA 8330B	EPA 8330B	EPA 8330B
Indeno (1,2,3-cd) Pyrene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Isodrin	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Isophorone	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E

Parameter/Analyte	**Potable Water**	**Non-Potable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
Isosafrole	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
3-Methycholanthrene	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2-Methyl-4,6-dinitrophenol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Methyl methane sulfonate	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
1-Methylnaphthalene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
2-Methylnaphthalene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
2-Methylphenol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
4-Methylphenol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Naphthalene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
1,4-Naphthoquinone	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
1-Naphthylamine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2-Naphthylamine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
4-Nitroquinoline-1-oxide	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2-Nitroaniline	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
3-Nitroaniline	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
4-Nitroaniline	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Nitrobenzene	------------------	EPA 8270D/E EPA 8330B	EPA 8270D/E EPA 8330B	EPA 8270D/E EPA 8330B
Nitroglycerin	------------------	EPA 8330B	EPA 8330B	EPA 8330B
2-Nitrophenol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
4-Nitrophenol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2-Nitrotoluene	------------------	EPA 8330B	EPA 8330B	EPA 8330B
3-Nitrotoluene	------------------	EPA 8330B	EPA 8330B	EPA 8330B
4-Nitrotoluene	------------------	EPA 8330B	EPA 8330B	EPA 8330B
5-Nitro-o-toluidine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
n-Nitroso-di-n-butylamine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
n-Nitrosodiethylamine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
n-Nitrosodimethylamine	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
n-Nitrosomethylethylamine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
n-Nitrosomorpholine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
n-Nitrosodi-n-propylamine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
n-Nitrosodiphenylamine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
n-Nitrosopiperidine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
n-Nitrosopyrrolidine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	------------------	EPA 8330B	EPA 8330B	EPA 8330B

Parameter/Analyte	**Potable Water**	**Non-Potable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
2,2-Oxybis (1-chloropropane)	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Pentachlorobenzene	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Pentachloronitrobenzene	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Pentachlorophenol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Pentaerythritol Tetranitrate (PETN)	------------------	EPA 8330B	EPA 8330B	EPA 8330B
Perylene	------------------	EPA 8270D/E SIM	EPA 8270D/E SIM	EPA 8270D/E SIM
Phenacetin	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Phenanthrene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Phenol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2-Picoline	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Pronamide	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Pyrene	------------------	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM	EPA 8270D/E EPA 8270D/E SIM
Pyridine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Safrole	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
1,2,4,5- Tetrachlorobenzene	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2,3,4,6-Tetrachlorophenol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Tetraethyl dithiopyrophosphate	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Tetraethy lead	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Tetryl	------------------	EPA 8330B	EPA 8330B	EPA 8330B
Thionazin	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
o-Toluidine	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
1,2,4-Trichlorobenzene	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
1,3,5-Trinitrobenzene	------------------	EPA 8330B	EPA 8330B	EPA 8330B
2,4,5-Trichlorophenol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2,4,6-Trichlorophenol	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
O,O,O-Tri-ethylphosphorothioate	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
2,4,6-Trinitrotoluene	------------------	EPA 8330B	EPA 8330B	EPA 8330B
Organochlorine Pesticides				
Aldrin	------------------	EPA 8081B	EPA 8081B	EPA 8081B
alpha-BHC	------------------	EPA 8081B	EPA 8081B	EPA 8081B
beta-BHC	------------------	EPA 8081B	EPA 8081B	EPA 8081B
delta-BHC	------------------	EPA 8081B	EPA 8081B	EPA 8081B
gamma-BHC (Lindane)	------------------	EPA 8081B	EPA 8081B	EPA 8081B

Parameter/Analyte	**Potable Water**	**Non-Potable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
alpha-Chlordane	------------------	EPA 8081B	EPA 8081B	EPA 8081B
Chlordane (Technical)	------------------	EPA 8081B	EPA 8081B	EPA 8081B
2,4’-DDD	------------------	EPA 8081B	EPA 8081B	EPA 8081B
2,4’-DDE	------------------	EPA 8081B	EPA 8081B	EPA 8081B
2,4’-DDT	------------------	EPA 8081B	EPA 8081B	EPA 8081B
4,4’-DDD	------------------	EPA 8081B	EPA 8081B	EPA 8081B
4,4’-DDE	------------------	EPA 8081B	EPA 8081B	EPA 8081B
4,4’-DDT	------------------	EPA 8081B	EPA 8081B	EPA 8081B
Dieldrin	------------------	EPA 8081B	EPA 8081B	EPA 8081B
Dinoseb	------------------	EPA 8270D/E	EPA 8270D/E	EPA 8270D/E
Endosulfan I (alpha)	------------------	EPA 8081B	EPA 8081B	EPA 8081B
Endosulfan II (beta)	------------------	EPA 8081B	EPA 8081B	EPA 8081B
Endosulfan Sulfate	------------------	EPA 8081B	EPA 8081B	EPA 8081B
Endrin	------------------	EPA 8081B	EPA 8081B	EPA 8081B
Endrin Aldehyde	------------------	EPA 8081B	EPA 8081B	EPA 8081B
Endrin Ketone	------------------	EPA 8081B	EPA 8081B	EPA 8081B
gamma-Chlordane	------------------	EPA 8081B	EPA 8081B	EPA 8081B
Heptachlor	------------------	EPA 8081B	EPA 8081B	EPA 8081B
Heptachlor Epoxide	------------------	EPA 8081B	EPA 8081B	EPA 8081B
Hexachlorobenzene	------------------	EPA 8081B	EPA 8081B	EPA 8081B
Hexachlorocyclopentadiene	------------------	EPA 8081B	EPA 8081B	EPA 8081B
Methoxychlor	------------------	EPA 8081B	EPA 8081B	EPA 8081B
Mirex	------------------	EPA 8081B	EPA 8081B	EPA 8081B
Toxaphene	------------------	EPA 8081B	EPA 8081B	EPA 8081B
PCBs (Aroclors)				
PCB-1016 (Arochlor)	------------------	EPA 8082A	EPA 8082A	EPA 8082A
PCB-1221	------------------	EPA 8082A	EPA 8082A	EPA 8082A
PCB-1232	------------------	EPA 8082A	EPA 8082A	EPA 8082A
PCB-1242	------------------	EPA 8082A	EPA 8082A	EPA 8082A
PCB-1248	------------------	EPA 8082A	EPA 8082A	EPA 8082A
PCB-1254	------------------	EPA 8082A	EPA 8082A	EPA 8082A
PCB-1260	------------------	EPA 8082A	EPA 8082A	EPA 8082A
PCB-1262	------------------	EPA 8082A	EPA 8082A	EPA 8082A
PCB-1268	------------------	EPA 8082A	EPA 8082A	EPA 8082A
PCB congeners (209)	------------------	EPA 1668A EPA 1668C	EPA 1668A EPA 1668C	EPA 1668A EPA 1668C

Parameter/Analyte	**Potable Water**	**Non-Potable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
Herbicides				
2,4,5-T	------------------	EPA 8151A	EPA 8151A	EPA 8151A
2,4,5-TP (Silvex)	------------------	EPA 8151A	EPA 8151A	EPA 8151A
2,4-D	------------------	EPA 8151A	EPA 8151A	EPA 8151A
2,4-DB	------------------	EPA 8151A	EPA 8151A	EPA 8151A
Dalapon	------------------	EPA 8151A	EPA 8151A	EPA 8151A
Dicamba	------------------	EPA 8151A	EPA 8151A	EPA 8151A
Dichlorprop	------------------	EPA 8151A	EPA 8151A	EPA 8151A
Dinoseb	------------------	EPA 8151A	EPA 8151A	EPA 8151A
MCPA	------------------	EPA 8151A	EPA 8151A	EPA 8151A
MCPP	------------------	EPA 8151A	EPA 8151A	EPA 8151A
Pentachlorophenol	------------------	EPA 8151A	EPA 8151A	EPA 8151A
PCB Homologues				
Monochlorobiphenyls	------------------	EPA 680	EPA 680	EPA 680
Dichlorobiphenyls	------------------	EPA 680	EPA 680	EPA 680
Trichlorobiphenyls	------------------	EPA 680	EPA 680	EPA 680
Tetrachlorobiphenyls	------------------	EPA 680	EPA 680	EPA 680
Pentachlorobiphenyls	------------------	EPA 680	EPA 680	EPA 680
Hexachlorobiphenyls	------------------	EPA 680	EPA 680	EPA 680
Heptachlorobiphenyls	------------------	EPA 680	EPA 680	EPA 680
Octachlorobiphenyls	------------------	EPA 680	EPA 680	EPA 680
Nonachlorobiphenyls	------------------	EPA 680	EPA 680	EPA 680
Decachlorobiphenyls	------------------	EPA 680	EPA 680	EPA 680
Dioxins/Furans				
2,3,7,8-TCDD	EPA 1613B	EPA 8290A	EPA 8290A	EPA 8290A
2,3,7,8-TCDF	------------------	EPA 8290A	EPA 8290A	EPA 8290A
1,2,3,7,8-PeCDF	------------------	EPA 8290A	EPA 8290A	EPA 8290A
2,3,4,7,8-PeCDF	------------------	EPA 8290A	EPA 8290A	EPA 8290A
1,2,3,7,8-PeCDD	------------------	EPA 8290A	EPA 8290A	EPA 8290A
1,2,3,4,7,8-HxCDF	------------------	EPA 8290A	EPA 8290A	EPA 8290A
1,2,3,6,7,8-HxCDF	------------------	EPA 8290A	EPA 8290A	EPA 8290A
2,3,4,6,7,8-HxCDF	------------------	EPA 8290A	EPA 8290A	EPA 8290A
1,2,3,7,8,9-HxCDF	------------------	EPA 8290A	EPA 8290A	EPA 8290A
1,2,3,4,7,8,-HxCDD	------------------	EPA 8290A	EPA 8290A	EPA 8290A
1,2,3,6,7,8-HxCDD	------------------	EPA 8290A	EPA 8290A	EPA 8290A
1,2,3,7,8,9-HxCDD	------------------	EPA 8290A	EPA 8290A	EPA 8290A
1,2,3,4,6,7,8-HpCDF	------------------	EPA 8290A	EPA 8290A	EPA 8290A
1,2,3,4,7,8,9-HpCDF	------------------	EPA 8290A	EPA 8290A	EPA 8290A
1,2,3,4,6,7,8-HpCDD	------------------	EPA 8290A	EPA 8290A	EPA 8290A
OCDF	------------------	EPA 8290A	EPA 8290A	EPA 8290A
OCDD	------------------	EPA 8290A	EPA 8290A	EPA 8290A
Total HpCDD	------------------	EPA 8290A	EPA 8290A	EPA 8290A
Total HpCDF	------------------	EPA 8290A	EPA 8290A	EPA 8290A
Total HxCDD	------------------	EPA 8290A	EPA 8290A	EPA 8290A
Total HxCDF	------------------	EPA 8290A	EPA 8290A	EPA 8290A
Total PeCDD	------------------	EPA 8290A	EPA 8290A	EPA 8290A

Parameter/Analyte	**Potable Water**	**Non-Potable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
Total PeCDF	------------------	EPA 8290A	EPA 8290A	EPA 8290A
Total TCDD	------------------	EPA 8290A	EPA 8290A	EPA 8290A
Total TCDF	------------------	EPA 8290A	EPA 8290A	EPA 8290A
Misc. Headspace Analysis				
Carbon dioxide	------------------	RSK-175	RSK-175	------------------
Ethane	------------------	RSK-175	RSK-175	------------------
Ethene	------------------	RSK-175	RSK-175	------------------
Methane	------------------	RSK-175	RSK-175	------------------
Hazardous Waste Characteristics				
Toxicity Characteristic Leaching Procedure	------------------	------------------	EPA 1311	EPA 1311
Synthetic Precipitation Leaching Procedure	------------------	------------------	EPA 1312	EPA 1312
ASTM Leaching Procedure	------------------	------------------	ASTM D3987-85	ASTM D3987-85
Other				
Perchlorate	------------------	EPA 6850	EPA 6850	EPA 6850
Hydrazine	------------------	EPA 8315A MOD	EPA 8315A MOD	EPA 8315A MOD
Formaldehyde	------------------	------------------	EPA 8315A	EPA 8315A
Methylhydrazine	------------------	EPA 8315A MOD	EPA 8315A MOD	EPA 8315A MOD
1,1-Dimethylhydrazine	------------------	EPA 8315A MOD	EPA 8315A MOD	EPA 8315A MOD
Volatile Preparation	------------------	EPA 5030A EPA 5030C	EPA 5030A EPA 5030C	EPA 5035 EPA 5035A
Organic Extraction/Cleanup	------------------	EPA 3510C EPA 3511 EPA 3660B, 3620C, 3665A	EPA 3510C EPA 3511 EPA 3660B, 3620C, 3665A	EPA 3546 EPA 3550C EPA 3660B, 3620C, 3665A, 3640A

Parameter/Analyte	**Drinking Water**	**Nonpotable Water**	**Solid Haz.Waste**
Per and Polyfluoroalkyl Substances (PFAS)			
N-ethyl Perfluorooctane-Sulfonamidoacetic Acid (NetFOSAA)	EPA 537 EPA 537.1	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15 EPA Draft Method 1633
N-methyl Perfluoroctane-Sulfonamidoacetic Acid (NMeFOSAA)	EPA 537 EPA 537.1	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3 Table B-15 EPA Draft Method 1633

Parameter/Analyte	Drinking Water	Nonpotable Water	Solid Haz.Waste
Perfluorobutanesulfonic Acid (PFBS)	EPA 537 EPA 537.1 EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluorodecanoic Acid (PFDA)	EPA 537 EPA 537.1 EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluorododecanoic Acid (PFDoDA)	EPA 537 EPA 537.1 EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluoroheptanoic Acid (PFHpA)	EPA 537 EPA 537.1 EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluorohexanesulfonic Acid (PFHxS)	EPA 537 EPA 537.1 EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluorohexanoic Acid (PFHxA)	EPA 537 EPA 537.1 EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluorononanoic Acid (PFNA)	EPA 537 EPA 537.1 EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluorooctanesulfonic Acid (PFOS)	EPA 537 EPA 537.1 EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633

Parameter/Analyte	**Drinking Water**	**Nonpotable Water**	**Solid Haz.Waste**
Perfluorooctanoic Acid (PFOA)	EPA 537 EPA 537.1 EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluorotetradecanoic Acid (PFTeDA)	EPA 537 EPA 537.1	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluorotridecanoic Acid (PFTrDA)	EPA 537 EPA 537.1	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluoroundecanoic Acid (PFUnDA)	EPA 537 EPA 537.1 EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoic acid (HFPODA)	EPA 537.1 EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
4,8-Dioxa-3H-perfluorononanoic acid (DONA)	EPA 537.1 EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	EPA 537.1 EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	EPA 537.1 EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633

Parameter/Analyte	Drinking Water	Nonpotable Water	Solid Haz.Waste
Perfluoro-n-butanoic Acid (PFBA)	EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluoro-n-pentanoic Acid (PFPeA)	EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
8:2 Fluorotelomersulfonic Acid (8:2FTS)	EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
4:2 Fluorotelomersulfonic Acid (4:2-FTS)	EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluoropentanesulfonic Acid (PFPeS)	EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
6:2 Fluorotelomersulfonic Acid (6:2-FTS)	EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluoroheptanesulfonic Acid (PFHpS)	EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluorononanesulfonic Acid (PFNS)	-------------	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633

Parameter/Analyte	**Drinking Water**	**Nonpotable Water**	**Solid Haz.Waste**
Perfluorodecanesulfonic Acid (PFDS)	-------------	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
10:2 Fluorotelomersulfonic Acid (10:2-FTS)	-------------	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluorododecanesulfonic Acid (PFDoDS)	-------------	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluorohexadecanoic Acid (PFHxDA)	-------------	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluorooctadecanoic Acid (PFODA)	-------------	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
Perfluorooctanesulfonamide (PFOSA)	-------------	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
2-(N-methylperfluoro-1-octanesulfonamido)-ethanol (NMePFOSAE)	-------------	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
N-methylperfluoro-1-octanesulfonamide (NMePFOSA)	-------------	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633

Parameter/Analyte	**Drinking Water**	**Nonpotable Water**	**Solid Haz.Waste**
(N-ethylperfluoro-1-octanesulfonamido)-ethanol (NEtPFOSAE)	-------------	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
N-ethylperfluoro-1-octanesulfonamide (NEtPFOSA)	------------	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
PFECA B	EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
PFECA F	EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
PFECA A	EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
PES	EPA 533	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
3-Perfluoropropylpropanoic acid (3:3 FTCA)	---	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633
3-Perfluoropentylpropanoic acid (5:3 FTCA)	---	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633

Parameter/Analyte	Drinking Water	Nonpotable Water	Solid Haz.Waste
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	---	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633	PFAS by LCMSMS Compliant with QSM 5.3/5.4 Table B-15 EPA Draft Method 1633

End of DoD ELAP section of scope

Start of KY, WY, and ISO 17025 section of scope

In addition, in recognition of the successful completion of the A2LA evaluation process (including an assessment of the laboratory's compliance with ISO IEC 17025:2017, the 2009 TNI Environmental Testing Laboratory Standard, and for the test methods applicable to Kentucky Statute KRS 224.60-130(2)(a), and for the test methods applicable to the Wyoming Storage Tank Remediation Laboratory Accreditation Program), accreditation is granted to this laboratory to perform recognized EPA methods using the following testing technologies and in the analyte categories identified below:

Testing Technologies

Atomic Absorption/ICP-AES Spectrometry, ICP-MS Spectrometry, Gas Chromatography, Gas Chromatography/Mass Spectrometry, Gravimetry, High Performance Liquid Chromatography, Ion Chromatography, Misc.-Electronic Probes (pH, F^-, O_2), Oxygen Demand, Spectrophotometry (Visible), Spectrophotometry (Automated), Titrimetry, TCLP, Total Organic Carbon, Turbidity, Liquid Chromatography/Mass Spectrometry/Mass Spectrometry, High Resolution Gas Chromatography/Mass Spectrometry

Parameter/Analyte	Tissue	Nonpotable Water	Solid Hazardous Waste	
			Aqueous	Solid
Other				
Perchlorate	Food & Food Products EPA 6850	EPA 6850	EPA 6850	EPA 6850
Hydrazine	--------------	EPA 8315A MOD	EPA 8315A MOD	EPA 8315A MOD
Methylhydrazine	--------------	EPA 8315A MOD	EPA 8315A MOD	EPA 8315A MOD
1,1-Dimethylhydrazine	--------------	EPA 8315A MOD	EPA 8315A MOD	EPA 8315A MOD
Volatile Preparation	--------------	EPA 5030A EPA 5030C	EPA 5030A EPA 5030C	EPA 5035 EPA 5035A

Parameter/Analyte	**Tissue**	**Nonpotable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
Organic Extraction/ Cleanup	EPA 3546 EPA 3550C EPA 3660B EPA 3620C EPA 3665A EPA 3640A	EPA 3510C EPA 3511 EPA 3660B EPA 3620C EPA 3665A	EPA 3510C EPA 3511 EPA 3660B EPA 3620C EPA 3665A	EPA 3546 EPA 3550C EPA 3660B EPA 3620C EPA 3665A EPA 3640A

Parameter/Analyte	**Tissue**	**Nonpotable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
Kentucky UST Program				
Metals				
Arsenic	--------------	------------------	EPA 6010B	EPA 6010B
Barium	--------------	------------------	EPA 6010B	EPA 6010B
Cadmium	--------------	------------------	EPA 6010B	EPA 6010B
Chromium	--------------	------------------	EPA 6010B	EPA 6010B
Lead	--------------	------------------	EPA 6010B	EPA 6010B
Mercury	--------------	------------------	EPA 7470A	EPA 7471A
Selenium	--------------	------------------	EPA 6010B	EPA 6010B
Silver	--------------	------------------	EPA 6010B	EPA 6010B
Purgeable Organics (Volatiles)				
Diesel Range Organics (DRO)	--------------	EPA 8015C EPA 8015D	EPA 8015C EPA 8015D	EPA 8015C EPA 8015D
Gasoline Range Organics (GRO)	--------------	EPA 8015C EPA 8015D	EPA 8015C EPA 8015D	EPA 8015C EPA 8015D
Wyoming Storage Tank Program				
Metals				
Cadmium	--------------	------------------	EPA 6010C	EPA 6010C
Chromium	--------------	------------------	EPA 6010C	EPA 6010C
Chromium (Total, hexavalent)	--------------	------------------	EPA 7196A	EPA 7196A
Lead	--------------	------------------	EPA 6010C	EPA 6010C
Purgeable Organics (Volatiles)				
Volatile Preparation	--------------	------------------	EPA 5030C EPA 5030C	EPA 5035 EPA 5035A
Benzene	--------------	------------------	EPA 5030C EPA 8260D	EPA 8260D
1,2-Dichloroethane	--------------	------------------	EPA 8260D	EPA 8260D
1,2-Dibromoethane	--------------	------------------	EPA 8011	EPA 8011
Diisopropyl Ether	--------------	------------------	EPA 5030C EPA 8260D	EPA 8260D
Ethyl Benzene	--------------	------------------	EPA 5030C EPA 8260D	EPA 8260D
Ethyl tert-butyl Ether	--------------	------------------	EPA 8260D	EPA 8260D

Parameter/Analyte	**Tissue**	**Nonpotable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
Methyl tert-butyl Ether	-------------	-----------------	EPA 5030C EPA 8260D	EPA 8260D
Naphthalene	-------------	-----------------	EPA 5030C EPA 8260D	EPA 8260D
Toluene	-------------	-----------------	EPA 5030C EPA 8260D	EPA 8260D
Tert-amyl Methyl Ether	-------------	-----------------	EPA 5030C EPA 8260D	EPA 8260D
Tert-butyl Alcohol	-------------	-----------------	EPA 5030C EPA 8260D	EPA 8260D
Xylenes, total	-------------	-----------------	EPA 5030C EPA 8260D	EPA 8260D
Gasoline Range Organics (GRO C6-C10)	-------------	-----------------	EPA 5030C EPA 8260D	EPA 8260D
Extractable Organics (Semivolatiles)				
Diesel Range Organics (DRO C10-C32)	-------------	-----------------	EPA 8015C w/ EPA 3630 cleanup	EPA 8015C w/ EPA 3630 cleanup

Food and Feed (WHO 29)	**Food/Feed**
2,3,7,8-TCDD	EPA 1613B
2,3,7,8-TCDF	EPA 1613B
1,2,3,7,8-PeCDF	EPA 1613B
2,3,4,7,8-PeCDF	EPA 1613B
1,2,3,7,8-PeCDD	EPA 1613B
1,2,3,4,7,8-HxCDF	EPA 1613B
1,2,3,6,7,8-HxCDF	EPA 1613B
2,3,4,6,7,8-HxCDF	EPA 1613B
1,2,3,7,8,9-HxCDF	EPA 1613B
1,2,3,4,7,8-HxCDD	EPA 1613B
1,2,3,6,7,8-HxCDD	EPA 1613B
1,2,3,7,8,9-HxCDD	EPA 1613B
1,2,3,4,6,7,8-HpCDF	EPA 1613B
1,2,3,4,7,8,9-HpCDF	EPA 1613B
1,2,3,4,6,7,8-HpCDD	EPA 1613B
OCDF	EPA 1613B
OCDD	EPA 1613B
Food and Feed (WHO 29)	**Food/Feed**
Total HpCDD	EPA 1613B
Total HpCDF	EPA 1613B
Total HxCDD	EPA 1613B
Total HxCDF	EPA 1613B
Total PeCDD	EPA 1613B
Total PeCDF	EPA 1613B

Total TCDD	EPA 1613B
Total TCDF	EPA 1613B
6 marker PCBs (PCB28, PCB52, PCB101, PCB138, PCB153, and PCB180)	EPA 1668A EPA 1668C

Parameter/Analyte	**Tissue**	**Nonpotable Water**	**Solid Hazardous Waste**	
			Aqueous	**Solid**
12 Dioxin-like PCBs (dl-PCBs)/coplanar PCBs (PCB77, PCB81, PCB105, PCB114, PCB118, PCB123, PCB126, PCB156, PCB157, PCB167, PCB169, and PCB189)	EPA 1668A EPA 1668C	------------------	---------------	---------------

Parameter/Analyte	**Drinking Water**	**Nonpotable Water**	**Solid Haz.Waste**
Per and Polyfluoroalkyl Substances (PFAS)			
N-ethyl perfluorooctane-sulfonamidoacetic acid (NetFOSAA)	EPA 537 Ver. 1.1 EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
N-methyl perfluoroctane-sulfonamidoacetic acid (NMeFOSAA)	EPA 537 Ver. 1.1 EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluorobutanesulfonic acid (PFBS)	EPA 537 Ver. 1.1 EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluorodecanoic acid (PFDA)	EPA 537 Ver. 1.1 EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluorododecanoic acid (PFDoDA)	EPA 537 Ver. 1.1 EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluoroheptanoic acid (PFHpA)	EPA 537 Ver. 1.1 EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluorohexanesulfonic acid (PFHxS)	EPA 537 Ver. 1.1 EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluorohexanoic acid (PFHxA)	EPA 537 Ver. 1.1 EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluorononanoic acid (PFNA)	EPA 537 Ver. 1.1 EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluorooctanesulfonic acid (PFOS)	EPA 537 Ver. 1.1 EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluorooctanoic acid (PFOA)	EPA 537 Ver. 1.1 EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluorotetradecanoic acid (PFTeDA)	EPA 537 Ver. 1.1 EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod

Perfluorotridecanoic acid (PFTrDA)	EPA 537 Ver. 1.1 EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluoroundecanoic acid (PFUnDA)	EPA 537 Ver. 1.1 EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoic acid (HFPODA)	EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod

Parameter/Analyte	**Drinking Water**	**Nonpotable Water**	**Solid Haz.Waste**
4,8-Dioxa-3H-perfluorononanoic acid (DONA)	EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	EPA 537.1	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluoro-n-butanoic acid (PFBA)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluoro-n-pentanoic acid (PFPeA)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
8:2 Fluorotelomersulfonic acid (8:2FTS)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
4:2 Fluorotelomersulfonic acid (4:2-FTS)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluoropentanesulfonic acid (PFPeS)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
6:2 Fluorotelomersulfonic acid (6:2-FTS)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluoroheptanesulfonic acid (PFHpS)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluorononanesulfonic acid (PFNS)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluorodecanesulfonic acid (PFDS)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
10:2 Fluorotelomersulfonic acid (10:2-FTS)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluorododecanesulfonic acid (PFDoDS)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluorohexadecanoic acid (PFHxDA)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluorooctadecanoic acid (PFODA)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
Perfluorooctanesulfonamide (PFOSA)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
2-(N-methylperfluoro-1-octanesulfonamido)-ethanol (NMePFOSAE)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
N-methylperfluoro-1-octanesulfonamide (NMePFOSA)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol (NEtPFOSAE)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod
N-ethylperfluoro-1-octanesulfonamide (NEtPFOSA)	---------------------	EPA 537 Ver.1.1 Mod	EPA 537 Ver.1.1 Mod

End of KY, WY, and ISO 17025 section of scope

Accredited Laboratory

A2LA has accredited

EUROFINS LANCASTER LABORATORIES ENVIRONMENTAL, LLC

Lancaster, PA

for technical competence in the field of

Environmental Testing

In recognition of the successful completion of the A2LA evaluation process that includes an assessment of the laboratory's compliance with ISO/IEC 17025:2017, the 2009 TNI Environmental Testing Laboratory Standard, and the requirements of the Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 5.4 of the DoD/DOE Quality System Manual for Environmental Laboratories (QSM), accreditation is granted to this laboratory to perform recognized EPA methods as defined on the associated A2LA Environmental Scope of Accreditation. This accreditation demonstrates technical competence for this defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated *April 2017*).

Presented this 28th day of January 2021.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 1.01
Valid to November 30, 2022

For the tests to which this accreditation applies, please refer to the laboratory's Environmental Scope of Accreditation.

eurofins	Always check on-line for validity. **Analysis of Per and Polyfluoroalkyl Substances (PFAS) in Solid Samples by LC-MS/MS Using Draft Method 1633/QSM5.4 Table B24**	Level: **Work Instruction**
Document number: **T-PFAS-WI48593**		
Old Reference:		
Version: **2**		Organisation level: **5-Sub-BU**
Approved by: **X6TJ** Effective Date: **05-OCT-2022**	Document users: **5_EUUSLA_PFAS_Manager, 6_EUUSLA_PFAS_Analyst, 6_EUUSLA_PFAS_Data_Reviewers, 6_EUUSLA_PFAS_Management_Team, 6_EUUSLA_PFAS_Sample_Prep**	Responsible: **5_EUUSLA_PFAS_Manager**

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Revision Log

Revision:	2	**Effective date:** This version
Section	**Justification**	**Changes**
Revision Log	Formatting Requirement	Revision logs up to the previous version
Reference	Enhancement	Updated to 2nd version of draft june 2022
Apparatus and Equipment	Enhancement	Add 15ml bottles used to store standards
Reagents and Standards	Reflect current practice	Remove NH4OH 5M. this is not used. reagent 5. Updated to 0.3% solution in Methanol B.standards-updated to standarized verbiage

Revision:	2	**Effective date:** This version
Section	**Justification**	**Changes**
Attachments	Enhancement	Updated attachments 5-20 for added clarity
Procedure	Clarification/reflect current practice	A: updated for clarity as needed B.8 add volume of 5ml for 1:1 0.1M formic acid:MeOH rinse C.6 updated example sequence B.16 Replace QC with bring to final volume 5ml

Revision:	1	**Effective date:** 26-MAY-2022
Section	**Justification**	**Changes**
Revision Log	NEW	NEW

Reference

1. Per- and Polyfluoroalkyl Substances (PFAS) Analysis by LC/MS/MS (EPA Draft method 1633), Department of Defense Quality System Manual Version 5.4, Table B-24.
2. US EPA Method 1633, *Analysis of Per and Polyfluoroalkyl Substances(PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS*, Version 2nd DRAFT, June 2022.
3. *Chemical Hygiene Plan*, current version.

Cross Reference

Document	Document Title
T-PFAS-WI21568	Manifold and N-EVAP Cleaning for PFAS Extractions
T-PEST-WI9847	Common Equations Used During Chromatographic Analyses
QA-SOP11178	Demonstrations of Capability
QA-SOP11892	Determining Method Detection Limits and Limits of Quantitation

Scope

This method is applicable for the determination of selected per- and polyfluorinated alkyl substances (PFAS) in solid samples. The compounds analyzed in this method are listed in the table below. The most current MDLs and LOQs are listed in the LIMS. Compounds other than those listed may be analyzed by client request.

Analyte	Acronym	CAS#
Perfluorobutanesulfonic acid	PFBS	375-73-5
Perfluorodecanoic acid	PFDA	335-76-2
Perfluorododecanoic acid	PFDoDA	307-55-1
Perfluoroheptanoic acid	PFHpA	375-85-9
Perfluorohexanesulfonic acid	PFHxS	355-46-4
Perfluorohexanoic acid	PFHxA	307-24-4
Perfluorononanoic acid	PFNA	375-95-1
Perfluorooctanesulfonic acid	PFOS	1763-23-1
Perfluorooctanoic acid	PFOA	335-67-1
Perfluorotetradecanoic acid	PFTeDA	376-06-7
Perfluorotridecanoic acid	PFTrDA	72629-94-8
Perfluoroundecanoic acid	PFUnDA	2058-94-8
Perfluoro-n-butanoic acid	PFBA	375-22-4
Perfluoro-n-pentanoic acid	PFPeA	2706-90-3
8:2 - Fluorotelomersulfonic acid	8:2FTS	39108-34-4
N-methylperfluoro-1-octanesulfonamidoacetic acid	NMeFOSAA	2355-31-9
N-ethylperfluoro-1-octanesulfonamidoacetic acid	NEtFOSAA	2991-50-6
4:2-Fluorotelomersulfonic acid	4:2-FTS	757124-72-4
Perfluoropentanesulfonic acid	PFPeS	2706-91-4
6:2-Fluorotelomersulfonic acid	6:2-FTS	27619-97-2

Analyte	Acronym	CAS#
Perfluoroheptanesulfonic acid	PFHpS	375-92-8
Perfluorononanesulfonic acid	PFNS	68259-12-1
Perfluorodecanesulfonic acid	PFDS	335-77-3
Perfluorododecanesulfonic acid	PFDoDS	79780-39-5
Perfluorooctanesulfonamide	PFOSA	754-91-6
2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	NMePFOSAE	24448-09-7
N-methylperfluoro-1-octanesulfonamide	NMePFOSA	31506-32-8
2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	NEtPFOSAE	1691-99-2
N-ethylperfluoro-1-octanesulfonamide	NEtPFOSA	4151-50-2
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoic acid; (Hexafluoropropylene oxide dimer acid)	HFPODA	13252-13-6
Ammonium 4,8-dioxa-3H-perfluorononanoic acid	DONA **	919005-14-4 *
Potassium 9-chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS, F53B major	756426-58-1 *
Potassium 11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS, F53B minor	763051-92-9 *
3-Perfluoropropylpropanoic acid	3:3 FTCA	356-02-5
3-Perfluoropentylpropanoic acid	5:3 FTCA	914637-49-3
3-Perfluoroheptylpropanoic acid	7:3 FTCA	812-70-4
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7

*CAS# for the free acid form of the analyte

**Acronym for the free acid form of the analyte

Basic Principles

A solid sample is fortified with isotopically-labeled extraction standards. The sample extract is shaken, centrifuged, and the supernatant decanted. Carbon cleanup is performed on each sample extract. Sample extract is diluted to volume and then concentrated. The sample is then passed through a solid phase extraction (SPE) cartridge to extract the analytes. The compounds are eluted from the solid phase with a combination of solvents. The extract is fortified with Isotopically-labeled injection internal standards and filtered. It is then analyzed by LC/MS/MS operated in negative electrospray ionization (ESI) mode for detection and quantification of the analytes. Quantitative analysis is performed using isotope dilution.

Interferences

Compounds which have similar structures to the compounds of interest and similar molecular weights would potentially interfere. Method interferences may be caused by contaminants in solvents, reagents (including reagent water), sample bottles and caps, and other sample processing hardware that lead to discrete artifacts and/or elevated baselines in the chromatograms. The analytes in this method can also be found in many common laboratory supplies and equipment, such as PTFE (polytetrafluoroethylene) products, LC solvent lines, methanol, aluminum foil, etc. A laboratory blank is performed with each batch of samples to demonstrate that the extraction system is free of contaminants.

Precaution to Minimize Method Interference

1. LC system components contain many of the target analytes. To minimize the background PFAS peaks, PTFE solvent frits and tubing are replaced by PEEK™ solvent frits and tubing where possible.

2. A precolumn, Phenomenex Luna, 30 x 2 mm, 5 µm C18 column, is installed before the injection valve to separate PFAS in standards/samples from those from the LC system and mobile phases.

3. All parts of the SPE manifold must be cleaned as per *T-PFAS-WI21568*.

Safety Precautions and Waste Handling

See *Chemical Hygiene Plan* for general information regarding employee safety, waste management, and pollution prevention.

The toxicity or carcinogenicity of each reagent used in this method has not been precisely defined. PFOA has been described as "likely to be carcinogenic to humans". Each chemical should be treated as a potential health hazard and exposure to these chemicals should be minimized.

Exposure to these chemicals must be reduced to the lowest possible level by whatever means available, such as fume hoods, lab coats, safety glasses, and gloves. Gloves, lab coats, and safety glasses should be worn when preparing standards and handling samples. Avoid inhaling solvents and chemicals and getting them on the skin. Wear gloves when handling neat materials. When working with acids and bases, take care not to come in contact and to wipe any spills. Always add acid to water when preparing reagents containing concentrated acids.

All laboratory waste is accumulated, managed, and disposed of in accordance with all Federal, State, and local laws and regulations. All solvent waste and extracts are collected in approved solvent waste containers in the laboratory and subsequently emptied by personnel trained in hazardous waste disposal into the lab-wide disposal facility. HPLC vials are disposed of in the lab container for waste vials, and subsequently lab packed. Any solid waste material (disposable pipettes and broken glassware, etc.) may be disposed of in the normal solid waste collection containers.

Personnel Training and Qualifications

All personnel performing this procedure must have documentation of reading, understanding, and agreeing to follow the current version of this SOP and an annual documented Demonstration of Capability (DOC).

Each chemist performing the extraction must work with an experienced employee for a period of time until they can independently perform the extraction. Also, several batches of sample extractions must be performed under the direct observation of another experienced chemist to assure the trainee is capable of independent preparation. Proficiency is measured through a documented Initial Demonstration of Capability (IDOC).

Each LC/MS/MS analyst must work with an experienced employee for a period of time until they can independently calibrate the LC/MS/MS, review and process data, and perform maintenance procedures. Proficiency is measured through a documented Initial Demonstration of Capability (IDOC).

The IDOC and DOC consist of four laboratory control samples (or alternatively, one blind sample for the DOC) that is carried through all steps of the extraction and meets the defined acceptance criteria. The criteria include the calculation of mean accuracy and standard deviation. IDOC trials are spiked at the OPR Level.

See *QA-SOP11178* for additional information on IDOC and DOC.

Sample Collection, Preservation, and Handling

A. Sample Collection

The samples are collected in 500 mL HDPE widemouth sample bottle or jar with linerless HDPE or polypropylene caps. Collect samples as grab samples using wide-mouth jar and fill no more than ¾ full. Keep the sample sealed from time of collection until extraction.

NOTE: PFAS contamination during sampling can occur from a number of common sources, such as food packaging and certain foods and beverages. Proper hand washing and wearing nitrile gloves will aid in minimizing this type of accidental contamination of the samples.

B. Sample Storage and Shipment

1. Solid and Biosolid samples must be chilled during shipment and must not exceed 6°C during the first 48 hours after collection. Sample temperature must be confirmed to be at 0° to 6°C when the samples are received at the laboratory.

2. Solid and Biosolid Samples stored in the lab must protected from light and held at a temperature of 0° to 6°C, or $\leq$ -20°C until extraction.

3. Solid and Biosolid samples must be extracted within 90 days. Extracts must be analyzed within 28 days after extraction. Extracts are stored at a temperature of 0° to 6°C.

Note: Biosolid samples stored under refrigeration may produce gases that may cause sample to be expelled from the container when opened. This may produce noxious odors. It is recommended to store frozen if extraction will not occur for a few days.

Apparatus and Equipment

A. Apparatus

1. 500-mL HDPE bottles: Scientific Specialties; # 334008-blk-1, or equivalent.

2. Centrifuge tubes – 15-mL conical polypropylene with polypropylene screw caps; Fisher Scientific, Cat. No. 05-539-5 or equivalent

3. 10-mL polypropylene volumetric flask, Class A – Fisher Scientific, Cat. No. S02288 or equivalent.

4. HDPE bottles for extraction fluid storage: L; Environmental Sampling Supply, Cat. No. 1000-1902-PC.

5. Analytical Balance – Capable of weighing to 0.0001 g

6. Top-Loading Balance – Capable of weighing to 0.01 g

7. Solid phase extraction (SPE) Weak Anion Exchange ("WAX") cartridge – Agilent; Sampli-Q WAX Polymer; 150mg/6mL; Cat. # 5982-3667.

8. Large-volume SPE Reservoir (25-mL) - Millipore-Sigma; Product # 54258-U.

9. SPE Tube Adapter - Millipore-Sigma; Product # 57020-U.

10. SPE vacuum extraction manifold –"Resprep" 24-port manifold; Restek Corp catalog # 26080, or equivalent.

11. Polypropylene SPE delivery needles – Agilent; Cat. No. 12234511.

12. Centrifuge – "Q-Sep 3000"; Restek Corp. Cat. No. 26230, or equivalent, capable of a minimum rotational speed of 3000 rpm.

13. Disposable polyethylene pipette – Fisher Scientific, Cat. No. S30467-1 or equivalent.

14. Auto Pipettes – Eppendorf; capable of accurately dispensing 10- to 1000-µL. FisherScientific cat # 14-287-150, or equivalent.

15. Polypropylene pipette tips: 0-200µl. Fisher; Cat. No. 02-681-135

16. Polypropylene pipette tips: 101-1000µl. Fisher, Cat. No. 02-707-508

17. Pipettes – Disposable transfer. FisherScientific, Cat. No. 13-711-7M

18. Vortex mixer, variable speed, Fisher Scientific or equivalent.

19. N-Evap sample extract concentrator with N_2 supply and water bath for temperature control. Organomation, Inc. Cat. #11250, or equivalent.

20. Reagent Water Purification System: Capable of producing ultrapure "Type 1/Milli-Q"-grade water from in-house deionized water system. Millipore SAS; Cat. No. FTPF08831.

21. Thermo Target PP Polyspring inserts, catalog number C4010-630P

22. Agilent 9mm vial kit pack, catalog number 5190-2278, or equivalent

23. Centrifuge tubes – 50-mL conical polypropylene with polypropylene screw caps; Fisher Scientific, Cat. No. 06-443-21 or equivalent

24. Polypropylene bottles for standard storage - 4 mL; Fisher Scientific, Cat. No. 2006-9125

25. Stainless steel spatula/scoop set. Bel-Art SP Scienceware; Product # 11-865-130.

26. pH paper, range 0-14, Whatman Panpeha or equivalent, 0.5 unit readability

27. Syringe filter - Acrodisc, Syringe Filter, GHP,13 mm, 0.2 µm, Aqueous, 100/pkg, Part # WAT097962.

28. Silanized glass wool (Sigma-Alrich, Cat #20411 or equivalent

29. Disposable syringe filter, 25-mm, 0.2um Nylon membrane, PALL/Acrodisc or equivalent

30. Glass fiber filter, 47 mm, 1 um, PALL A/E or equivalent

31. Variable speed mixing table (Fisherbrand^{TM} Nutating mixer or equivalent

32. Evaporation/concentrator tubes: 60 mL clear glass vial, 30x125 mm, without caps (Wheaton Cat # W226060 or eqvalent).

33. Wooden Tongue Depressors - Fisher; Cat. # 11-700-555, or equivalent.

34. Wheaton Bottle, 15ml, Narrow mouth, HDPE, Leak resistant; DWK Life Sciences, Cat. No. 209044SP, or equivalent

B. Equipment

1. AB Sciex Triple Quad 4500/5500/5500 Plus Turbo V Ion Source

   ExionLC Controller
   ExionLC AC Pump
   ExionLC AC Autosampler
   Exion AC Column Oven
   Data system –Analyst 1.6.3

2. HPLC columns

   a. Analytical column: Gemini 3µm C18, 50 x 3 mm, Phenomenex Cat# 00B-4439-YO or equivalent

   b. Pre-column: Luna, 5µm C18, 50 x 3 mm, Phenomenex Cat# 00B-4252-Y0, or equivalent

Reagents and Standards

All solvents, acids, and bases are stored in glass bottles in flammable proof cabinets or pressure resistant steel drums. Solvents, acids, and bases are stored at ambient temperature for up to 1 year. All non-solvents are stored according to manufacturer’s storage conditions.

A. Reagents:

1. Methanol (MeOH) – Honeywell Burdick and Jackson "Chromasolv LC-MS" grade Cat. No. BJ34966-4L or equivalent

2. Acetonitrile (ACN) – Fisher Scientific, Optima Cat. No. A955-4 or equivalent

3. Ammonium acetate – Fisher Scientific, Cat. No. A637-500 or equivalent

4. Ammonium hydroxide, 30% in water, certified ACS+ grade or equivalent, store at room temperature

5. Methanolic ammonium hydroxide (0.3%) – add ammonium hydroxide (10 mL, 30%) to methanol (990 mL), store at room temperature, replace after 1 month

6. Methanolic ammonium hydroxide (1%) - add ammonium hydroxide (3.3 mL, 30%) to methanol (97 mL), store at room temperature, replace after 1 month

7. Methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid - add ammonium hydroxide (3.3 mL, 30%), reagent water (1.7 mL) and acetic acid (0.625 mL) to methanol (92 mL), store at room temperature, replace after 1 month.

8. Acetic Acid – ACS grade or equivalent, store at room temperature

9. Acetic Acid (0.1%) – dissolve acetic acid (1 mL) in reagent water (1 L), store at room temperature, replace after 3 months.

10. Formic acid

    a. Formic acid (aqueous, 0.1 M) - dissolve formic acid (4.6 g) in reagent water (1 L), store at room temperature, replace after 2 years

    b. Formic acid (aqueous, 0.3 M) - dissolve formic acid (13.8 g) in reagent water (1 L), store at room temperature, replace after 2 years

    c. Formic acid (aqueous, 5% v/v) - mix 5 mL formic acid with 95 mL reagent water, store at room temperature, replace after 2 years

    d. Formic acid (aqueous, 50% v/v) - mix 50 mL formic acid with 50 mL reagent water, store at room temperature, replace after 2 years

    e. Formic acid (methanolic 1:1, 0.1 M formic acid/methanol) - mix equal volumes of methanol and 0.1 M formic acid, store at room temperature, replace after 2 years

11. "Superclean Envi-Carb"; bulk sorbent. Millipore-Sigma; 50g; Product # 57210-U.

12. Solids reference matrix – Ottawa or reagent-grade sand

13. 20 mM ammonium acetate solution in 95:5(v/v) Milli-Q water/acetonitrile-Weigh 3.08 ± 0.01g ammonium acetate into a 2-L glass mobile phase bottle. Add 1900 mL Milli-Q water and mix well to dissolve the ammonium acetate. Add 100 mL acetonitrile and mix well. Store at room temperature for up to 2 months. Different volumes can be prepared as long as final concentrations are equivalent.

14. 20 mM ammonium acetate solution in 90:10 acetonitrile/Milli-Q water – Weigh 3.08 ± 0.01g ammonium acetate into a 2-L glass mobile phase bottle. Add 200 mL of Milli-Q water and mix well to dissolve the Ammonium Acetate. Add 1800 mL of acetonitrile and mix well. Store at room temperature for up to 2 months. Different volumes can be prepared as long as final concentrations are equivalent.

B. Standards:

Standards are prepared using calibrated pipettes, polypropylene microcentrifuge tubes, polypropylene bottles, and 10 ml Class A PP volumetric flasks to create solutions at desired concentrations. The concentrated solution is injected below the surface of the diluting solvent. After preparation is completed, standards should be vortexed to ensure complete mixing. Measurement of volumes less than 5 µl should be avoided in routine production operations.

All stock, intermediate and spiking solutions are prepared using Methanol.

All initial calibration, initial calibration verification, and linear branched working standard solutions are prepared using Methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid.

All diluted solutions must be stored in HDPE containers that have been thoroughly rinsed with methanol.

Stock standard and intermediate standard solutions are stored in the refrigerator in labeled polypropylene screw-top vials, PP bottles, or PP centrifuge tubes.

Expiration dates are managed through LIMS Reagent. Solutions transferred from sealed glass ampules to screw-capped vials are given expiration dates of 1 year from the date opened or the expiration date provided by the vendor, whichever occurs sooner. Intermediate solutions are given an expiration date of 6 months from the preparation date, or the expiration date from the ampule provided by the vendor, whichever occurs sooner. The ampules and transferred solutions are stored in the refrigerator.

Working native and labeled (extraction surrogate and internal standard) compound spiking solutions are given an expiration date of 6 months, or the expiration date of the solutions used to prepare the working solution, whichever occurs sooner. The solutions are stored in labeled polypropylene screw-top vials in the refrigerator. When these solutions are prepared they must be tested prior to use in the PFAS extraction lab and verified monthly until they are consumed by operations or expire. Records of the standard verification are maintained by the laboratory. Prior to use, the working spiking solution should be evaluated against recovery windows of 85-115% for all compounds that will be analyzed using that solution. Should a standard fail to meet these criteria, the data must be reviewed by departmental management for acceptability and/or corrective action.

Working initial calibration solutions are given an expiration date of 6 months, or the expiration date of the solutions used to prepare the working initial calibration solution, whichever occurs sooner.

The primary/preferred standard vendor is Wellington Laboratories, Inc. Ontario, Canada. Listed catalog numbers are taken from Wellington product lists. Equivalent standards may be substituted, if the listed standards are unavailable.

The solution concentration listed is as presented on the certificate of analysis and includes adjustment for purity and the salt form of the compound used.

Note: The concentrations referenced for the sulfonate salts, (for example PFBS, PFHxS and PFOS) have already been corrected to the acid form by the standards supplier as noted in the example Certificate of analysis (CofA). See *Attachment 4*.
If the compound purity is assayed to be 96% or greater, weight can be used without correction to calculate concentrations.

Log purchased standards into LIMS Reagent. Select the solution category SOURCE for purchased mixes and/or single-compound ampules. LIMS Reagent system will assign formatted names to the purchased standard solutions. The automatically-generated name can be overwritten with a manually created name if desired. Use labels printed through the LIMS Reagent to identify and track standard solutions after transfer from original ampule to storage vial. The CofA for the ampulated stock standard is attached in LIMS Reagent for reference.

Standards are prepared by transferring a known quantity of Standard to a final volume of solvent. Standard Preparation is documented in LIMS Reagent. Solutions are stored by Type in LIMS Reagent, i.e., INTERMEDIATE=working solutions and intermediate standards and SOURCE=stocks (ampulated solutions). Each Standard is given a unique name.

The following attachments provide examples of standard preparation and purchasing information. Refer to the documentation in LIMS Reagent for standards preparation information.

Attachment 5 - Native PFAS Intermediate A
Attachment 6 - Native PFAS Intermediate B
Attachment 7 - Working Labeled Extraction Standard Spike
Attachment 8 - Internal Standard Spike
Attachment 9 - Native 1633 Mid-Level Spike
Attachment 10 - Native 1633 Low-Level Spike
Attachment 11 - 1633 Initial Calibration Standards Preparation
Attachment 12 - 1633 Initial calibration Standards Concentrations
Attachment 13 - TDCA Stock Solution
Attachment 14 - TDCA Working Solution A
Attachment 15 - TDCA Working Solution B
Attachment 16 - 1633 Linear/Branched TDCA Intermediate
Attachment 17 - 1633 Linear/Branched TDCA Solution

Attachment 18 - PFAS 1633 ICV Working Standard
Attachment 19 - 1633 Labeled Ampulated Standards
Attachment 20 - 1633 Native Ampulated Standards

Calibration

A. Initial Calibration

1. A minimum of six calibration standards are required when using an average or linear curve fit. A minimum of seven calibration standards are required for a second-order curve fit(quadratic). In general, Cal1, Cal2, Cal3, Cal4, Cal5, Cal6, and Cal7 are included in the initial calibration. The calibration standards contain the branched isomers for PFHxS, PFOS, NMeFOSAA, and NEtFOSAA. S/N ratio must be greater than or equal to 3:1 for all ions used for quantification.

2. Analyze a Cal4 level standard that contains TDCA retention time marker and linear and branch chained isomers of PFOA, PFNA, PFOSA, NMeFOSA, NEtFOSA, NMeFOSE, and NEtFOSE. The analysis of this standard is used to evaluate the interference from bile salts in tissue samples, as well as evaluate where the branch chained isomers elute and not included in the calibration curve. This will assist the chemist in identifying and properly integrating this compound in samples.

   Example Initial Calibration Sequence:
    1. Instrument Blank
    2. Instrument Blank
    3. Instrument Blank
    4. CAL 1
    5. CAL 2
    6. CAL 3
    7. CAL 4
    8. CAL 5
    9. CAL 6
    10. CAL 7
    11. ICB (Instrument Blank)
    12. ICV
    13. MDL
    14. WDM (Linear Branched/TDCA standard)

3. Isotopically-labeled compounds are not available for some compounds. See below for compounds and their referenced extraction standards. See *Attachment 2* for additional information about compound relationships.

4. Analyze a standard at a concentration of 100 ppb containing Taurodeoxycholic Acid (TDCA). The analysis of this standard is used to evaluate the chromatographic program relative to the risk of an interference from bile salts in tissue samples. The analytical conditions must be set to allow a separation of at least 1 minute between the bile salts and PFOS.

NOTE: For better accuracy, PFTrDA is quantitated using the average of the areas of labeled compounds 13C2-PFTeDA and 13C2-PFDoDA.

Compound	Extraction Standard
PFBA	13C4-PFBA
PFPeA	13C5-PFPeA
3:3FTCA	
PFMPA	
PFMBA	
PFHxA	13C5-PFHxA
NFDHA	
5:3FTCA	
7:3FTCA	
PFEESA	
PFHpA	13C4-PFHpA
PFOA	13C8-PFOA
PFNA	13C9-PFNA
PFDA	13C6-PFDA
PFUnA	13C7-PFUnA
PFDoA	13C2-PFDoA
PFTrDA	Avg 13C2-PFTeDA and 13C2-PFDoA
PFTeDA	13C2-PFTeDA
PFBS	13C3-PFBS
PFPeS	13C3-PFHxS
PFHxS	

PFHpS	13C8-PFOS
PFOS	
PFNS	
PFDS	
PFDoS	
4:2-FTS	13C2-4:2-FTS
6:2-FTS	13C2-6:2-FTS
8:2-FTS	13C2-8:2-FTS
PFOSA	13C8-PFOSA
NMeFOSA	D3-NMeFOSA
NEtFOSA	D5-NEtFOSA
NMeFOSAA	D3-NMeFOSAA
NEtFOSAA	D5-N-EtFOSAA
NMeFOSE	D7-NMeFOSE
NEtFOSE	D9-NEtFOSE
HFPO-DA	13C3-HFPO-DA
DONA	
9Cl-PF3ONS	
11Cl-PF3OUdS	

5. Fit the curve

   a. If the %RSD for the response factors is less than or equal to 20%, the average response factor (Ave RRF) can be used to quantitate the data.

   b. If the %RSD is greater than 20%, a linear regression with a concentratoin weighing factor of 1/x is tried for the compounds not meeting the criteria in 5.a. The RSE for all method analytes must be less than or equal to 20%

   c. For all curve fits, each calibration point is calculated back against the curve. The back calculated concentration for each calibration point should be within ±30% of its true value.

d. If the criteria are not met, the source of the problem must be determined and corrected. Situations may exist where the initial calibration can be used. In those cases, the data will be reported with a qualifying comment.

NOTE: The concentrations referenced for the sulfonate salts, (for example PFBS, PFHxS and PFOS) have already been corrected to the acid form by the standards supplier as noted in the example Certificate of Analysis (CofA). See *Attachment 4*.

6. Initial Calibration Verification (ICV)

A check standard prepared from a second source (ICV) is injected to confirm the validity of the calibration curve/standard. If a second source is not available, a separate preparation from the same stock by a second analyst may be used. The calculated amount for each analyte must be within ±30% of the true value. If this criteria is not met, re-inject or remake the standard. If the criteria is still not met, recalibration is necessary. Instrument maintenance may be needed prior to recalibrating.

B. Continuing calibration

1. Once the calibration curve has been established, the continuing accuracy must be verified by analysis of a continuing calibration verification (CCV) standard every ten samples and at the end of the analysis sequence. Subsequent CCV standards should use the Cal4 level standard.

2. Acceptance criteria

   a. The calculated amount for each compound (native and extraction standard) in the CCV standard must be within ±30% of the true value. Samples that are not bracketed by acceptable CCV analyses must be reanalyzed. The exception to this would be if the CCV recoveries are high, indicating increased sensitivity, and there are no positive detections in the associated samples, the data may be reported with a qualifying comment. If two consecutive CCVs fail criteria for target analytes, two passing CCVs must be analyzed or the source of the problem determined and the system recalibrated before continuing sample analysis.

   b. The absolute areas of the injection internal standards should be greater than 30% of the average areas measured during the initial calibration.

Procedure

A. Sample Preparation

NOTE: Prior to weighing out samples, thoroughly mix each sample using a wooden tongue depressor or stainless steel spoon to ensure a homogeneous sample matrix. Stir from the bottom to the top in a circular motion along the sides of the jar, breaking particles to less than 1 mm by pressing against the side of the container. Remove rocks, invertebrates, and foreign objects. Vegetation can either be removed or cut into smaller pieces based on project requirements.

1. On a calibrated, top-loading balance, accurately weigh 5.0g ± 0.10g (0.5 g for biosolids) of solid sample into a tared, labeled 15-mL centrifuge tube using a disposable polypropylene spatula. Record sample weight in the prep entry system.
2. For each batch - maximum 20 samples - include the following quality control samples:
   a. Method Blank: Weigh 5.0g ± 0.10g (0.5 g for biosolids) of sand wetted with 2.5 g (0.25 g for biosolids) of reagent water
   b. LCS: Fortify 5.0g ± 0.10g (0.5 g for biosolids) of sand wetted with 2.5 g (0.25 g for biosolids) reagent water and spiked with 200 µL of Native 1633 Mid-Level Spike Solution (PFC_1633_MID_XXXXX).
   c. LLCS: Fortify 5.0g ± 0.10g (0.5 g for biosolids) of sand wetted with 2.5 g (0.25 g for biosolids) reagent water and spiked with 400 µL of Native 1633 Low-Level Spike Solution (PFC_1633_LOW_XXXXX).
   d. Matrix Spike/Matrix Spike Duplicate (MS/MSD): Fortify 5.0g ± 0.10 g (0.5 g for biosolids) of sample as specified in sample preparation log with 200 µL of Native 1633 Mid-Level Spike Solution (PFC_1633_MID_XXXXX).
3. Add 25 µl working labeled extraction standard spike solution (PFC_1633_SS_XXXXX) to each sample/QC tube.
4. Cap and vortex for approximately 30 seconds.
5. Allow samples/QC to equilibrate for at least 30 minutes.
6. Add 10 mL of 0.3% methanolic ammonium hydroxide to each centrifuge tube.
7. Cap and vortex
8. Shake for 30 minutes on a variable speed mixing table
9. Centrifuge for 10 minutes and transfer supernatant to a clean 50 mL polypropylene centrifuge tube.
10. Add 15 mL of 0.3% methanolic ammonium hydroxide to the remaining solid sample in each centrifuge tube. Cap and vortex.
11. Shake for 30 minutes on a variable speed mixing table
12. Centrifuge for 10 minutes and decant the supernatant from the second extraction into the centrifuge tube with the supernatant from the first extraction.
13. Add another 5 mL of 0.3% methanolic ammonium hydroxide to the remaining sample in each centrifuge tube.
14. Shake by hand to disperse.
15. Immediately decant the supernatant from the third extraction into the centrifuge tube with the supernatant from the first and second extraction.
16. Using a 10 mg scoop, add 10 mg of Superclean Envi-Carb to the combined extract, mix by occasionally hand shaking for no more than 5 minutes.
17. Centrifuge for 10 minutes.
18. Immediately decant the extract into a new labeled 50ml PP centrifuge tube.
19. Concentrate the extracts at no more than 40°C with an N_2 flow of approximately 1.2 L/min to a final volume of approximately 3-5 mL.
20. Allow extracts to concentrate for 25 minutes, then vortex to mix thoroughly.
21. Continue concentrating and mixing every 10 minutes until the extract has been reduced to the required volume.

22. Add enough reagent water to the extract to reach the "40ml" mark on the centrifuge tube and vortex. Check that the pH is 6.5 ± 0.5 and adjust as necessary with 50% formic acid or 30% ammonium hydroxide (or with 5% formic acid and 4% aqueous ammonium hydroxide).

B. Solid Phase Extraction (SPE)

1. Pack clean silanized glass wool to half the height of the WAX SPE cartridge barrel.

2. Label each SPE cartridge to correspond with each associated sample/QC piece and attach to a rinsed SPE port. Record the SPE port # for each sample/QC piece on the batchlog.

3. Condition each SPE cartridge with the following reagents in the following order:

    a. 15 mL 1% methanolic ammonium hydroxide

    b. 5 mL 0.3M formic acid

    c. Discard conditioning eluent(s)

4. Label each sample bottle, cap and reservoir with the same number to insure samples are not inadvertently switched during the extraction procedure (i.e.; 1,1,1; 2,2,2; 3,3,3; etc.).

5. Attach a 25-mL SPE reservoir to each cartridge. Load the QC and samples to their respective cartridges. Allow full volume to pass through each cartridge by gravity, if possible. Apply light vacuum if necessary. The drip rate should be approximately 1-2 drops per second.

6. After full volume has passed through the cartridges, dry the cartridges with vacuum - no more than 15" of Hg - for approximately five minutes. After five minutes, visually inspect the cartridge to determine if the sorbent is dry. This done by comparing the cartridge to a visual standard (an unused SPE cartridge). If the sorbent is not dry, continue to check at one minute intervals until the cartridge is dry.

7. Discard the waste and rinse the waste reservoir with DI water. Wipe each needle with a Kim-wipe/methanol.

8. Rinse the walls of the reservoir with 5mL reagent water (twice) followed by 5ml of **1:1 0.1M formic acid/methanol** and pass the rinses through the cartridge using vacuum. Dry the cartridge by pulling air through for 15 seconds. Discard the rinse solution.

9. Place labeled 15-mL polypropylene centrifuge collection tubes under each respective SPE cartridge.

10. Rinse the inside of the evaporation/concentrator tube using 5mL of 1% methanolic ammonium hydroxide.

11. Using a glass pipette, transfer the rinse to the SPE reservoirs, washing the walls of the reservoirs.

12. Apply a slight vacuum to the manifold in order to reclaim as much solvent as possible from the SPE cartridges.

13. Disconnect the cartridge/adapter from the manifold. Remove the collection tubes.

14. Add 25 uL of concentrated acetic acid to each collection tube and vortex to mix thoroughly.

Note: The instrument lab chemist performs the next steps.

15. Add 25 uL of Intenal Standard Spike Solution (PFC_ST_XXXXX) to each sample extract.

16. Bring each sample extract to final volume 5mL with methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid solution.

17. Cap and vortex to mix.

18. Place a syringe filter (25-mm filter, 0.2-um nylon membrane) on a 3 mL polypropylene syringe. Take the plunger out and carefully decant ~1 mL the sample supernatant into the syringe barrel. Replace the plunger and filter ~1 mL of sample into the corresponding labeled auto-sampler vial. Cap the auto-sampler vial. Samples are now ready for analysis.

19. Cap the centrifuge tube. Store the remaining centrifuged extracts in the refrigerator for dilution or reinjection if needed.

C. LC/MS/MS Analysis

1. Mass Calibration and Tuning

   a. At instrument set up and installation, after the performance of major maintenance, or annually calibrate the mass scale of the MS with calibration compounds and procedures described by the manufacturer. The entire mass range must be calibrated.

   b. When masses fall outside of the ±0.5 amu of the true value, the instrument must be retuned using PPG according to the manufacturer's specifications. Mass assignments of the tuning standard must be within 0.5 amu of the true value. Refer to the instrument manufacturer’s instructions for tuning and conditions. These values are stored in the tune file for future reference.

2. The mass spectral acquisition rate must include a minimum of 10 spectra scans across each chromatographic peak. See the AB Sciex (4500/5500/5500 Plus) Acquisition, Quantitation, Gradient, and detector condition files for the most up to date chromatographic conditions.

Modifications to these conditions can be made at the discretion of the analyst to improve resolution or the chromatographic process.

3. Acquisition method: See *Attachment 3*. Mass Transitions: See *Attachment 1*.
4. Instrument Sensitivity Check (ISC) and Instrument Blanks
    a. Prior to sample analysis, an instrument sensitivity check (ISC) must be performed. The ISC standard concentration must be at the LOQ. The CAL1 standard's concentration is at the LOQ. The CAL1 standard will be analyzed. All analyte concentrations must be within ±30% of their true value. The signal-to-noise ratio must be greater than or equal to 3:1. If the criteria is not met, correct problem and rerun ISC. If problem persists, repeat the ICAL. No samples can be analyzed until the ISC meets acceptance criteria.
    b. Instrument blanks need to be analyzed immediately following the highest standard analyzed and daily or at the start of a sequence. The concentration of all analytes must be less than or equal to 1/2 the LOQ. If acceptance criteria are not met the calibration must be performed using a lower concentration standard for the high standard until the criteria are met.
5. Load sample vials containing standards, quality control samples, and sample extracts into autosampler tray. Allow the instrument adequate time to equilibrate to ensure the mass spec and LC have reached operating conditions (approximately 5 minutes) before the first injection. Analyze several solvent blanks clean the instrument prior to sample acquisition.

6. After the initial calibration and when analyzing samples within the same tune, inject an instrument blank, followed by the ICV, Linear branched (L/B) standard, instrument sensitivity check, CCV standard using the CAL4, qualitative identification standard (includes TDCA RT marker), Instrument blank, extraction batch QC, and samples. Bracket each set of ten samples with a CCV standard at the CAL4 level, followed by an instrument blank.

    Example Sample Sequence:
    1. Instrument blank
    2. Instrument blank
    3. Instrument blank
    4. Instrument Sensitivity Check (CCV0 _CAL1)
    5. CCV 2_CAL4
    6. Linear Branched/TDCA marker (WDM)
    7. Instrument Blank (ICB)
    8. Method Blank (MB)
    9. Low Level LCS (LLCS)
    10. LCS
    11. Sample (10 or less)
    12. CCV 3_CAL4
    13. Instrument Blank

7. After injections are completed, check all CCV recoveries and absolute areas to make sure they are within method control limits. See Calibration section B.2 for acceptance criteria. Process each chromatogram and closely evaluate all integrations, baseline anomalies, and

retention time differences. If manual integrations are performed, they must be documented and a reason given for the change in integrations. The manual integrations are documented during data processing and all original integrations are reported at the end of the sample PDF file with the reason for manual integration clearly listed.

8. Quantitate results for the extraction blank. No target analytes at or above the reporting limit, at or greater than one-third the regulatory compliance limit, at or greater than one-tenth the concentration in a sample in the extraction batch, whichever is greatest, may be found in the extraction blank for acceptable batch results. If this criteria is not met, the samples must be re-extracted.

9. Calculate the recoveries of spiked analytes for the LLCS, LCS, matrix spike and matrix spike duplicate (MS/MSD) by comparing concentrations observed to the true values.

    a. LLCS, LCS, MS, extraction standard recoveries and RPDs are calculated and compared to the limits stored on the LIMS.

    b. If LLCS and LCS recoveries are acceptable, proceed to sample quantitation.

    c. If the LCS and LLCS recoveries are above QC acceptance criteria and there are no detections for the compound(s) in the associated sample(s), the data can be reported with a qualifying comment. In all other cases, the samples associated with the LCS/LLCS must be reextracted.

    d. If MS/MSD recoveries are outside QC acceptance criteria, the associated data will be flagged or noted in the comments section of the report.

10. Isotopically-labeled extraction standards are added to all samples, extraction blank, LLCS/LCS, and MS/MSD prior to extraction. The recovery of the extraction standards should be within QC acceptance criteria. If the extraction standard recovery(ies) is(are) outside the QC limit(s), reextract using a reduced sample volume. If the extraction standard recovery(ies) is(are) again outside the QC limit(s), consult a supervisor to determine the appropriate course of action based on batch and sample results.

11. Isotopically-labeled injection standards are added to each QC and field sample extract prior to analysis. The absolute areas of the injection standards should be within 30-200% of the average areas measured during the initial calibration. If the internal standards are recovered outside 30-200%, consult a supervisor to determine the appropriate course of action based on batch and sample results.

12. Compare the retention times of all of the analytes, surrogates, and internals standards to the retention time from the initial calibration. The retention times should not vary from the expected retention time by more than

    a. 0.4 minutes for isotopically-labeled compounds

   b. 0.1 minutes from their analog for native compounds with an exact isotopically-labeled compound

   c. 0.4 minutes from their assigned analog for native compounds without an exact isotopically-labeled compound.

   If the retention time is outside of the criteria, the compound is considered a false positive unless it is a compound with branched isomers. Compounds with branched isomers can vary in intensity of the individual isomers that are used for reporting and must be reviewed and compared to the preceding CCV to determine if it should be reported.

13. Two ion transitions and the ion transition ratio per analyte shall be monitored and documented with the exception of 13C4-PFBA, 13C5-PFPeA, 13C4-PFHpA, 13C8-PFOA, 13C9-PFNA, 13C6-PFDA, 13C7-PFUnA, 13C2-PFDA,13C2-PFDoDA 13C2-PFTeDA, 13C8-PFOSA, D3-NMePFOSA, D5-NEtFOSAA, D3-NMeFOSAA, D5-NEtPFOSA, D7-NMePFOSAE, D9-NEtPFOSAE, 13C3-PFBA, 13C4-PFOA, 13C5-PFNA, 13C2-PFOA, 18O2-PFHxS, PFBA, PFECA F(PFMPA), PFECA A(PFMBA), NMePFOSAE, and NEtPFOSAE. The expected ion ratio for each compound is calculated by using the average of ion ratios of each compound from initial calibration standards. When an ion ratio for a compound differs from the expected ion ratio by more than 50%, a qualifier is placed on the raw data and on the sample report. No corrective action is required.

14. The linear/branch chain standard is used when assessing the correctness of the computer generated peak integrations for PFOA, PFNA, PFOSA, NMeFOSA, NEtFOSA, NMeFOSE, and NEtFOSE.

15. If the calculated concentration exceeds the calibration range of the system, determine the appropriate dilution required and dilute the extract using Methanol with 4% water, 1% ammonium hydfrtoxide and 0.625% acetic acid solution and adjust the amount of Intenal Standard Spike solution in the diluted extract. Select the dilution so that the expected EIS recoveries in the diluted extract are >5%. Extracts requiring greater than a 10x dilution should be reextracted using a reduced aliquot.

    Dilution Example 1/10: Mix 895 µl of Methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid solution with 100 µl of sample extract and 5 uL of Internal Standard Spike solution. Vortex to mix. Using an auto-pipette, transfer an aliquot of the mixed solution into a labeled auto-sampler vial. Cap and vortex thoroughly to mix.

Calculations

1. Peak Area Ratio

$$\text{Peak Area Ratio} = \frac{\text{Analyte Response}}{\text{Labeled Analyte Response}}$$

2. On-Column Analyte Concentration using average RRF

   On-column Concentration = peak area ratio ÷ AVE RRF

3. On-Column Analyte Concentration using linear curve

   On-column Concentration = (peak area ratio - intercept) ÷ slope

4. Sample Concentration

   Sample concentration (ng/g) = (On-column concentration x Final Sample Volume x DF) ÷ Initial Sample Volume

5. Ion Ratio

   ion ration = (peak area or height of quantifier)/(peak area or height of qualifier)

6. See *T-PEST-WI9847* for additional calculations used to evaluate the calibrations and quality control samples.

Statistical Information/Method Performance

The LCS should contain all compounds of interest. LCS, MS, and extraction standard recoveries are compared to the limits stored on the LIMS. These limits are statistically derived when sufficient data points are available. If sufficient data points are not available to generate statistical windows advisory limits will be used.

QC parameter	Lower acceptance limit	High acceptance limit
Extracted Internal standard (EIS)	20%	150%
Non-extracted Internal Standard (NIS)	>30% of the average NIS from the initial calibration	200%
Analyte recoveries	40%	150%

LCS/LLCS/MS/MSD		

Note: lower acceptance limit for EIS cannot not be <20%, lower acceptance limit for analyte recovery cannot be <40%.

Historical data for MS/Ds, LCSs, measurement of uncertainty, is reviewed at least annually. Reporting limits including method detection limits (MDLs) and limits of quantitation (LOQs) are set according to EPA method requirements and are evaluated annually. Refer to *QA-SOP11892* for specific guidelines and procedures. Updates to the LIMS are made as needed by the QA Department and only as directed by the supervisor.

Quality Assurance/Quality Control

For each batch of samples extracted, a method blank(sand) and an LCS/LLCS (sand spiked with all compounds to be determined carried through the entire procedure) must be extracted and analyzed. MS/MSD is extracted only if submitted by the client. A batch is defined as the samples to be extracted on any given day, but not to exceed 20 field samples. If more than 20 samples are prepared in a day, an additional batch must be prepared.

If any client, state, or agency has more stringent QC or batching requirements, these must be followed.

Attachment:
Attachment 1 - Mass Transitions (.doc)
Attachment 10 - Native Low Level Spike (.pdf)
Attachment 11 - 1633 Initial Calibration Standards Preparation (.pdf)
Attachment 12 - 1633 Initial Calibration Standard Concentrations (.pdf)
Attachment 13 - TDCA Stock Solution (.pdf)
Attachment 14 - TDCA working Solution A (.pdf)
Attachment 15 - TDCA Working Solution B (.pdf)
Attachment 16 - 1633 Linear Branched and TDCA Intermediate (.pdf)
Attachment 17 - 1633 Linear Branched and TDCA Solution (.pdf)
Attachment 18 - PFAS ICV Working Standard (.pdf)
Attachment 19 - 1633 Labeled Ampulated Standards (.pdf)
Attachment 2 - Standards relationships (.docx)
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Attachment 3 - Acquisition Parameters (.pdf)
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Attachment 5 - 1633 Native PFAS Intermediate A (.pdf)
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Attachment 7 - Working Labeled Extraction Standard Spike (.pdf)
Attachment 8 - Internal Standard Spike (.pdf)
Attachment 9 - Native Mid Level Spike (.pdf)

11178 Demonstrations of Capability
11892 Determining Method Detection Limits and Limits of Quantitation
21568 Manifold and N-EVAP Cleaning for PFAS Extractions
9847 Common Equations Used During Chromatographic Analyses
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Attachment: Attachment 7 - Working Labeled Extraction Standard Spike (pdf)
Attachment: Attachment 8 - Internal Standard Spike (pdf)
Attachment: Attachment 9 - Native Mid Level Spike (pdf)

End of document

Version history

Version	Approval	Revision information	
1	26.MAY.2022		
2	05.OCT.2022		

Attachment 1

Mass Transitions AB Sciex 4500/5500/5500+

Compound	Parent Ion	Daughter Ion
13C3-PFBA	216.0	172.0
13C4-PFBA	216.8	171.9
PFBA	212.8	168.9
13C5-PFPeA	268.3	223
PFPeA	263.0	219.0
PFPeA (2)	263.0	68.9
13C3-PFBS	302.1	79.9
13C3-PFBS (2)	302.1	98.9
PFBS	298.7	79.9
PFBS (2)	298.7	98.8
13C2-4:2-FTS	329.1	80.9
13C2-4:2-FTS (2)	329.1	309.0
4:2-FTS	327.1	307.0
4:2-FTS (2)	327.1	80.9
13C2-PFHxA	315.1	270.0
13C2-PFHxA (2)	315.1	119.4
13C5-PFHxA	318.0	273.0
13C5-PFHxA (2)	318.0	120.3
PFHxA	313.0	269.0
PFHxA (2)	313.0	118.9
PFPeS	349.1	79.9
PFPeS (2)	349.1	98.9
18O2-PFHxS	403.0	83.9
13C3-PFHxS	402.1	79.9
13C3-PFHxS (2)	402.1	98.8
PFHxS	398.7	79.9
PFHxS (2)	398.7	98.9
13C4-PFHpA	367.1	322.0
PFHpA	363.1	319.0
PFHpA (2)	363.1	169.0
13C2-6:2-FTS	429.1	80.9
13C2-6:2-FTS (2)	429.1	409.0
6:2-FTS	427.1	407.0
6:2-FTS (2)	427.1	80.9
PFHpS	449.0	79.9
PFHpS (2)	449.0	98.8
13C4-PFOA	417.1	172.0

Attachment 1

Compound	Parent Ion	Daughter Ion
13C8-PFOA	421.1	376.0
PFOA	413.0	369.0
PFOA (2)	413.0	169.0
13C4-PFOS	502.8	79.9
13C4-PFOS (2)	502.8	98.9
13C8-PFOS	507.1	79.9
13C8-PFOS (2)	507.1	98.9
PFOS	498.9	79.9
PFOS (2)	498.9	98.8
13C5-PFNA	468.0	423.0
13C9-PFNA	472.1	427.0
PFNA	463.0	419.0
PFNA (2)	463.0	219.0
13C8-PFOSA	506.1	77.8
PFOSA	498.1	77.9
PFOSA (2)	498.1	478.0
PFNS	548.8	79.9
PFNS (2)	548.8	98.8
13C2-PFDA	515.1	470.1
13C6-PFDA	519.1	474.1
PFDA	512.9	469.0
PFDA (2)	512.9	219.0
13C2-8:2-FTS	529.1	80.9
13C2-8:2-FTS (2)	529.1	509.0
8:2-FTS	527.1	507.0
8:2-FTS (2)	527.1	80.8
d7-NMePFOSAE	623.2	58.9
NMePFOSAE	616.1	58.9
d3-NMePFOSA	515.0	219.0
NMEPFOSA	511.9	219.0
NMEPFOSA (2)	511.9	169.0
d3-NMeFOSAA	573.2	419.0
NMeFOSAA	570.1	419.0
NMeFOSAA (2)	570.1	483.0
d9-NEtPFOSAE	639.2	58.9
NEtPFOSAE	630.0	58.9
d5-NETPFOSA	531.1	219.0
NEtPFOSA	526.0	219.0
NEtPFOSA (2)	526.0	169.0
PFDS	599.0	79.9

Attachment 1

Compound	Parent Ion	Daughter Ion
PFDS (2)	599.0	98.8
13C7-PFUnDA	570.0	525.1
PFUnDA	563.1	519.0
PFUnDA (2)	563.1	269.1
d5-NEtFOSAA	589.2	419.0
NEtFOSAA	584.2	419.1
NEtFOSAA (2)	584.2	526.0
13C2-PFDoDA	615.1	570.0
PFDoDA	613.1	569.0
PFDoDA (2)	613.1	319.0
PFDoS	699.1	79.9
PFDoS (2)	699.1	98.8
PFTrDA	663.0	619.0
PFTrDA (2)	663.0	168.9
13C2-PFTeDA	715.2	670.0
PFTeDA	713.1	669.0
PFTeDA (2)	713.1	168.9
13C3-HFPODA	286.9	168.9
13C3-HFPODA (2)	286.9	184.9
HFPODA	284.9	168.9
HFPODA (2)	284.9	184.9
DONA	376.9	250.9
DONA (2)	376.9	84.8
9Cl-PF3ONS	530.8	351.0
9Cl-PF3ONS (2)	532.8	353.0
11Cl-PF3OUdS	630.9	450.9
11Cl-PF3OUdS (2)	632.9	452.9
PFECA B (NFDHA)	295.0	201.0
PFECA B(NFDHA) (2)	295.0	84.9
PFECA F (PFMPA)	229.0	84.9
3:3 FTCA	241.0	177.0
3:3 FTCA (2)	241.0	117.0
PFECA A (PFMBA)	279.0	85.1
PFEESA (PES)	314.8	134.9
PFEESA (PES) (2)	314.8	82.9
5:3 FTCA	341.0	237.1
5:3 FTCA (2)	341.0	217.0
7:3 FTCA	441.0	316.9
7:3 FTCA (2)	441.0	336.9

Attachment 10

Native 1633 Low-Level Spike								
Vendor	**Catalog Number**	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/mL)**	**Aliquot (mL)**	**Final Volume**	**Final Conc. Native 1633 Low-Level Spike (ng/ml)**
Wellington	PFAC-MXF	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9	11Cl-PF3OUdS	1890	0.1	10mL Methanol	18.9
		9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1	9Cl-PF3ONS	1870			18.7
		4,8-dioxa-3H-Perfluorononanoic acid	919005-14-4	DONA	1890			18.9
		Perfluoro(2-propxypropanoic) acid	13252-13-6	HFPODA	2000			10
Wellington	PFAC-MXH	1H,1H,2H,2H perfluorodecanesulfonic acid	39108-34-4	8:2-FTS	3840	0.05		19.2
		1H,1H,2H,2H perfluorohexanesulfonic acid	757124-72-4	4:2-FTS	3750			18.75
		1H,1H,2H,2H perfluorooctanesulfonic acid	27619-97-2	6:2-FTS	3800			19
		N-ethylperfluorooctanesulfonamidoacetic acid	2991-50-6	NEtFOSAA	1000			5
		N-methylperfluorooctanesulfonamidoacetic acid	2355-31-9	NMeFOSAA	1000			5
		Perfluorobutanesulfonic acid	375-73-5	PFBS	887			4.435
		Perfluorobutanoic acid	375-22-4	PFBA	4000			20
		Perfluorodecanesulfonic acid	335-77-3	PFDS	965			4.825
		Perfluorodecanoic acid	335-76-2	PFDA	1000			5
		Perfluorododecanesulfonic acid	79780-39-5	PFDoDS	970			4.850
		Perfluorododecanoic acid	307-55-1	PFDoDA	1000			5
		Perfluoroheptanesulfonic acid	375-92-8	PFHpS	953			4.765
		Perfluoroheptanoic acid	375-85-9	PFHpA	1000			5
		Perfluorohexanesulfonic acid	355-46-4	PFHxS	914			4.57
		Perfluorohexanoic acid	307-24-4	PFHxA	1000			5
		Perfluorononanesulfonic acid	68259-12-1	PFNS	962			4.81
		Perfluorononanoic acid	375-95-1	PFNA	1000			5
		Perfluorooctanesulfonamide	754-91-6	PFOSA	1000			5
		Perfluorooctanesulfonic acid	1763-23-1	PFOS	928			4.64
		Perfluorooctanoic acid	335-67-1	PFOA	1000			5
		Perfluoropentanesulfonic acid	2706-91-4	PFPeS	941			4.705
		Perfluoropentanoic acid	2706-90-3	PFPeA	2000			10
		Perfluorotetradecanoic acid	376-06-7	PFTeDA	1000			5
		Perfluorotridecanoic acid	72629-94-8	PFTrDA	1000			5
		Perfluoroundecanoic acid	2058-94-8	PFUnDA	1000			5
Wellington	PFAC-MXG	Perfluoro-3-methoxypropanoic acid	377-73-1	PFMPA	2000	0.05		10
		Perfluoro-4-methoxybutanoic acid	863090-89-5	PFMBA	2000			10
		Nonafluoro-3,6-dioxaheptanoic acid	151722-58-6	NFDHA	2000			10
		Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	PFEESA	1780			8.9
Wellington	PFAC-MXI	2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	24448-09-7	NMePFOSAE	10000	0.05		50
		N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	1000			5
		2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	1691-99-2	NEtPFOSAE	10000			50
		N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	1000			5
Wellington	PFAC-MXJ	3-Perfluoropropylpropanoic acid	763051-92-9	3:3 FTCA	4000	0.0626		25.04
		3-Perfluoropentylpropanoic acid	756426-58-1	5:3 FTCA	20000			125.2
		3-Perfluoroheptylpropanoic acid	919005-14-4	7:3 FTCA	20000			125.2

1633 Initial Calibration Standards Preparation

Solution Name	MDL	CAL1	CAL2	CAL3	CAL4	CAL5	CAL6	CAL7
Native Replacement PFAS Solution/Mixture Aliquot (mL)	NA	NA	NA	NA	NA	0.020	0.050	0.250
Native Perfluoroalkyl Ether Carboxylic Acids and Sulfonate Solution/Mixture Aliquot (mL)	NA	NA	NA	NA	NA	0.010	0.025	0.125
Native PFAS Solution/Mixture Aliquot (mL)	NA	NA	NA	NA	NA	0.010	0.025	0.125
Native N-NMe/EtFOSA & N-Nme/EtFOSE Solution/Mixture Aliquot (mL)	NA	NA	NA	NA	NA	0.010	0.025	0.125
Native X:3 Flourotelomer Caroxylic Acid Solution/Mixture Aliquot (mL)	NA	NA	NA	NA	NA	0.0125	0.0312	0.156
Native PFAS Intermediate A Aliquot (mL)	0.008	0.016	0.040	0.100	0.200	NA	NA	NA
Native PFAS Intermediate B Aliquot (mL)	0.010	0.020	0.050	0.125	0.250	NA	NA	NA
Mass-Labelled PFAS Injection Standard Solution/Mixture - IS Aliquot (mL)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Mass-Labelled PFAS Extraction Standard Solution/Mixture - ES Aliquot (mL)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Final Volume (mL) (methanol with 4% water, 1% ammonium hydroxide, and 0.625% acetic acid)	**2**	2	2	2	2	2	2	2

1633 Initial Calibration Standards Concentrations

	MDL	CAL1	CAL2	CAL3	CAL4	CAL5	CAL6	CAL7
Compound Name	**Conc. (ng/ml)**	**Conc. (ng/ml)**	**Conc. (ng/ml)**	**Conc. (ng/ml)**	**Conc. (ng/ml)**	**Conc. (ng/ml)**	**Conc. (ng/ml)**	**Conc. (ng/ml)**
PFBA	0.4	0.8	2	5	10	20	50	250
PFPeA	0.2	0.4	1	2.5	5	10	25	125
PFHxA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFHpA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFOA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFNA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFDA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFUnA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFDoA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFTrDA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFTeDA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFBS	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFPeS	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFHxS	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFHpS	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFOS	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFNS	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFDS	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFDoS	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
8:2FTS	0.4	0.8	2	5	10	20	50	NA
4:2FTS	0.4	0.8	2	5	10	20	50	NA
6:2FTS	0.4	0.8	2	5	10	20	50	NA
PFOSA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
NMeFOSA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
NEtFOSA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
NMeFOSAA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
NEtFOSAA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
NMeFOSE	1	2	5	12.5	25	50	125	625
NEtFOSE	1	2	5	12.5	25	50	125	625
HFPO-DA	0.4	0.8	2	5	10	20	50	250
ADONA	0.4	0.8	2	5	10	20	50	250
PFMPA	0.2	0.4	1	2.5	5	10	25	125
PFMBA	0.2	0.4	1	2.5	5	10	25	125
NFDHA	0.2	0.4	1	2.5	5	10	25	125
9Cl-PF3ONS	0.4	0.8	2	5	10	20	50	250
11Cl-PF3OUdS	0.4	0.8	2	5	10	20	50	250
PFEESA	0.2	0.4	1	2.5	5	10	25	125
3:3FTCA	0.5	1	2.5	6.26	12.5	25	62.4	312
5:3FTCA	2.5	5	12.5	31.3	62.5	125	312	1560
7:3FTCA	2.5	5	12.5	31.3	62.5	125	312	1560
^{13}C4-PFBA	10	10	10	10	10	10	10	10
^{13}C5-PFPeA	5	5	5	5	5	5	5	5
^{13}C5-PFHxA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C4-PFHpA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C8-PFOA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C9-PFNA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C6-PFDA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C7-PFUnA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C2-PFDoA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C2-PFTeDA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C3-PFBS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C3-PFHxS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C8-PFOS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C2-4:2 FTS	5	5	5	5	5	5	5	5
^{13}C2-6:2 FTS	5	5	5	5	5	5	5	5
^{13}C2-8:2 FTS	5	5	5	5	5	5	5	5
^{13}C8-PFOSA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
D3-NMeFOSA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
D5-NEtFOSA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
D3-NMeFOSAA	5	5	5	5	5	5	5	5
D5-NEtFOSAA	5	5	5	5	5	5	5	5
D7-NMeFOSE	25	25	25	25	25	25	25	25
D9-NEtFOSE	25	25	25	25	25	25	25	25
^{13}C3-HFPO-DA	10	10	10	10	10	10	10	10
^{13}C3-PFBA	5	5	5	5	5	5	5	5
^{13}C2-PFHxA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C4-PFOA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C5-PFNA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C2-PFDA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{18}O2-PFHxS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C4-PFOS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5

TDCA Stock Solution								
Vendor	Catalog Number	Analyte	CAS#	Acronym	Conc. (mg)	Aliquot (g)	Final Volume (ml) Methanol	Final Conc. TDCA Stock Solution (ng/ml)
Sigma Alrich	T0557-500MG	Sodium Taurodeoxycholate hydrate	207737-97-1	TDCA	1000000	0.05	50	1000000

TDCA Working Solution A							
Solution Name	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/ml)**	**Aliquot (mL)**	**Final Volume (mL) Methanol**	**Final Conc. TDCA Working Solution A (ng/ml)**
TDCA Stock Solution	Sodium Taurodeoxycholate hydrate	207737-97-1	TDCA	1000000	1	4	250000

TDCA Working Solution B							
Solution Name	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/ml)**	**Aliquot (mL)**	**Final Volume (ml) Methanol**	**Final Conc. TDCA Working Solution B (ng/ml)**
TDCA Working Solution A	Sodium Taurodeoxycholate hydrate	207737-97-1	TDCA	250000	0.10	5	5000

1633 Linear/Branched TDCA Intermediate								
Vendor	**Catalog Number**	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/mL)**	**Aliquot (mL)**	**Final Volume (ml) Methanol**	**Final Conc. 1633 Linear/ Branched TDCA Intermediate (ng/ml)**
Wellington	T-PFOA	Technical Ammonium, Perfluorooctanoa te (Technical Grade)	95328-99-7	T-PFOA	50000	0.02	2mL	500
		Perfluoroctanoic acid	335-67-1	PFOA	50000			500
Cambridge Isotope Laboratories, Inc.	ULM-11036-S	2-(N-ethylperfluoro-1-octanesulfonamido) ethanol	1691-99-2	NEtPFOSAE	50000	0.02		500
Cambridge Isotope Laboratories, Inc.	ULM-11034-S	2-(N-methylperfluoro-1-octanesulfonamido) ethanol	24448-09-7	NMePFOSAE	50000	0.02		500
Cambridge Isotope Laboratories, Inc.	ULM-10780-S	N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	100000	0.01		500
Cambridge Isotope Laboratories, Inc.	ULM-10779-S	N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMeFOSA	100000	0.01		500
Cambridge Isotope Laboratories, Inc.	ULM-10977-S	Perfluorooctanesfulonamide	754-91-6	PFOSA	50000	0.02		500
Wellington	ipPFNA	Perfluoro-7-methyloctanoic acid	15899-31-7	PF7MOA	50000	0.02		500
Wellington	PFNA	Perfluorononanoic acid	375-95-1	PFNA	50000	0.02		500

1633 Linear/Branched TDCA Solution

Solution Name	Analyte	CAS#	Acronym	Conc. (ng/mL)	Aliquot (mL)	Final Volume* (ml)	Final Conc. 1633 Linear/ Branched TDCA Solution (ng/ml)
TDCA Working Solution B	Sodium Taurodeoxycholate hydrate	207737-97-1	TDCA	5000	0.01	2	25
1633 Linear/Branched TDCA Intermediate	2-(N-ethylperfluoro-1-octanesulfonamido) ethanol	1691-99-2	NEtPFOSAE	500	0.02		5
	2-(N-methylperfluoro-1-octanesulfonamido) ethanol	24448-09-7	NMePFOSAE	500			5
	N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	500			5
	N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMeFOSA	500			5
	Perfluorooctanesfulonamide	754-91-6	PFOSA	500			5
	Perfluoro-7-methyloctanoic acid	15899-31-7	PF7MOA	500			5
	Perfluorononanoic acid	375-95-1	PFNA	500			5
	Technical Ammonium, Perfluorooctanoa te (Technical Grade)	95328-99-7	T-PFOA	500			5
	Perfluoroctanoic acid	335-67-1	PFOA	500			5
Mass-Labelled PFAS Extraction Standard Solution/Mixture-ES	Perfluoro-n-[^{13}C4]butanoic acid	STL00992	^{13}C4-PFBA	2000	0.01		10
	Perfluoro-n-[^{13}C5]pentanoic acid	STL01893	^{13}C5-PFPeA	1000			5
	Perfluoro-n-[1,2,3,4,6-^{13}C5]hexanoic acid	STL02577	^{13}C5 -PFHxA	500			2.5
	Perfluoro-n-[1,2,3,4-^{13}C4]heptanoic acid	STL01892	^{13}C4-PFHpA	500			2.5
	Perfluoro-n-[^{13}C8]octanoic acid	STL01052	^{13}C8-PFOA	500			2.5
	Perfluoro-n-[^{13}C9]nonanoic acid	STL02578	^{13}C9-PFNA	250			1.25
	Perfluoro-n-[1,2,3,4,5,6-^{13}C6]decanoic acid	STL02579	^{13}C6-PFDA	250			1.25
	Perfluoro-n-[1,2,3,4,5,6,7-^{13}C7]undecanoic acid	STL02580	^{13}C7-PFUnA	250			1.25
	Perfluoro-n-[1,2-^{13}C2]dodecanoic acid	STL02703	^{13}C2-PFDoA	250			1.25
	Perfluoro-n-[1,2-^{13}C2]tetradecanoic acid	STL02116	^{13}C2-PFTeDA	250			1.25
	Perfluoro-1-[2,3,4-^{13}C3]butanesulfonic acid	STL02337	^{13}C3-PFBS	466			2.33
	Perfluoro-1-[1,2,3-^{13}C3]hexanesulfonic acid	STL02581	^{13}C3-PFHxS	474			2.37
	Perfluoro-1-[^{13}C8]octanesulfonic acid	STL01054	^{13}C8-PFOS	479			2.4
	Perfluoro-1-[^{13}C8]octanesulfonamide	STL01056	^{13}C8 -PFOSA	500			2.5
	N-methyl-d3-perfluoro-1-octanesulfonamidoacetic acid	STL02118	D3-NMeFOSAA	1000			5
	N-ethyl-d5-perfluoro-1-octanesulfonamidoacetic acid	STL02117	D5-NEtFOSAA	1000			5
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]hexan sulfonic acid	STL02395	^{13}C2-4:2FTS	938			4.69
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]octanesulfonic acid	STL02279	^{13}C2-6:2FTS	951			4.76
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]decanesulfonic acid	STL02280	^{13}C2-8:2FTS	960			4.8
	Tetrafluoro-2-heptafluoropropoxy-^{13}C3-propanoic acid	STL02255	^{13}C3-HFPO-DA	2000			10
	N-methyl-d7-perfluorooctanesulfonamidoethanol	STL02277	D7-NMeFOSE	5000			25
	N-ethyl-d9-perfluorooctanesulfonamidoethanol	STL02278	D9-NEtFOSE	5000			25
	N-ethyl-d5-perfluoro-1-octanesulfonamide	STL02704	D5-NEtFOSA	500			2.5
	N-methyl-d3-perfluoro-1-octanesulfonamide	STL02705	D3-NMeFOSA	500			2.5
Mass-Labelled PFAS Injection Standard Solution/Mixture	Perfluoro-n-[2,3,4-^{13}C3]butanoic acid	STL02680	^{13}C3-PFBA	1000	0.01		5
	Perfluoro-n-[1,2,3,4-^{13}C4]octanoic acid	STL00990	^{13}C4-PFOA	500			2.5
	Perfluoro-n-[1,2-^{13}C2]decanoic acid	STL00996	^{13}C2-PFDA	250			1.25
	Perfluoro-n-[1,2,3,4-^{13}C4]octanesulfonic acid	STL00991	^{13}C4-PFOS	479			2.4
	Perfluoro-n-[1,2,3,4,5-^{13}C5] nonanoic acid	STL00995	^{13}C5-PFNA	250			1.25
	Perfluoro-n-[1,2-^{13}C2]hexanoic acid	STL00993	^{13}C2-PFHxA	500			2.5
	Perfluoro-1-hexane[^{18}O2]sulfonic acid	STL00994	^{18}O2-PFHxS	474			2.37

* Bring to final volume using methanol with 4% water, 1% ammonium hydroxide, and 0.625% acetic acid

Attachment 18

PFAS 1633 ICV Working Standard

Solution Name	Analyte	CAS#	Acronym	Conc. (ng/ml)	Aliquot (ml)	Final Volume* (ml)	Final Conc. PFAS 1633 ICV Working Standard (ng/ml)
Native PFAS Intermediate A	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9	11Cl-PF3OUdS	94.5	0.5	5	9.45
	9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1	9Cl-PF3ONS	93.5			9.35
	4,8-dioxa-3H-Perfluorononanoic acid	919005-14-4	DONA	94.5			9.45
	Perfluoro(2-propxypropanoic) acid	13252-13-6	HFPODA	100			10
	1H,1H,2H,2H perfluorodecanesulfonic acid	39108-34-4	8:2-FTS	96			4.69
	1H,1H,2H,2H perfluorohexanesulfonic acid	757124-72-4	4:2-FTS	93.8			4.76
	1H,1H,2H,2H perfluorooctanesulfonic acid	27619-97-2	6:2-FTS	95			4.8
	N-ethylperfluorooctanesulfonamidoacetic acid	2991-50-6	NEtFOSAA	25			2.5
	N-methylperfluorooctanesulfonamidoacetic acid	2355-31-9	NMeFOSAA	25			2.5
	Perfluorobutanesulfonic acid	375-73-5	PFBS	22.2			2.22
	Perfluorobutanoic acid	375-22-4	PFBA	100			10
	Perfluorodecanesulfonic acid	335-77-3	PFDS	24.1			2.41
	Perfluorodecanoic acid	335-76-2	PFDA	25			2.5
	Perfluorododecanesulfonic acid	79780-39-5	PFDoDS	24.3			2.43
	Perfluorododecanoic acid	307-55-1	PFDoDA	25			2.5
	Perfluoroheptanesulfonic acid	375-92-8	PFHpS	23.8			2.38
	Perfluoroheptanoic acid	375-85-9	PFHpA	25			2.5
	Perfluorohexanesulfonic acid	355-46-4	PFHxS	22.9			2.29
	Perfluorohexanoic acid	307-24-4	PFHxA	25			2.5
	Perfluorononanesulfonic acid	68259-12-1	PFNS	24.1			2.41
	Perfluorononanoic acid	375-95-1	PFNA	25			2.5
	Perfluorooctanesulfonamide	754-91-6	PFOSA	25			2.5
	Perfluorooctanesulfonic acid	1763-23-1	PFOS	23.2			2.32
	Perfluorooctanoic acid	335-67-1	PFOA	25			2.5
	Perfluoropentanesulfonic acid	2706-91-4	PFPeS	23.5			2.35
	Perfluoropentanoic acid	2706-90-3	PFPeA	50			5
	Perfluorotetradecanoic acid	376-06-7	PFTeDA	25			2.5
	Perfluorotridecanoic acid	72629-94-8	PFTrDA	25			2.5
	Perfluoroundecanoic acid	2058-94-8	PFUnDA	25			2.5
	Perfluoro-3-methoxypropanoic acid	377-73-1	PFMPA	50			5
	Perfluoro-4-methoxybutanoic acid	863090-89-5	PFMBA	50			5
	Nonafluoro-3,6-dioxaheptanoic acid	151722-58-6	NFDHA	50			5
	Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	PFEESA	44.5			4.45
	2-(N-methylperfluoro-1-octanesulfonamido)- ethanol	24448-09-7	NMePFOSAE	250			25
	N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	25			2.5
	2-(N-ethylperfluoro-1-octanesulfonamido)- ethanol	1691-99-2	NEtPFOSAE	250			25
	N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	25			2.5
Native PFAS Intermediate B	3-Perfluoropropylpropanoic acid	763051-92-9	3:3 FTCA	100	0.625		12.5
	3-Perfluoropentylpropanoic acid	756426-58-1	5:3 FTCA	500			62.5
	3-Perfluoroheptylpropanoic acid	919005-14-4	7:3 FTCA	500			62.5
Mass-Labelled PFAS Extraction Standard Solution/ Mixture-ES	Perfluoro-n-[^{13}C4]butanoic acid	STL00992	^{13}C4-PFBA	2000	0.025		10
	Perfluoro-n-[^{13}C5]pentanoic acid	STL01893	^{13}C5-PFPeA	1000			5
	Perfluoro-n-[1,2,3,4,6-^{13}C5]hexanoic acid	STL02577	^{13}C5 -PFHxA	500			2.5
	Perfluoro-n-[1,2,3,4-^{13}C4]heptanoic acid	STL01892	^{13}C4-PFHpA	500			2.5
	Perfluoro-n-[^{13}C8]octanoic acid	STL01052	^{13}C8-PFOA	500			2.5
	Perfluoro-n-[^{13}C9]nonanoic acid	STL02578	^{13}C9-PFNA	250			1.25
	Perfluoro-n-[1,2,3,4,5,6-^{13}C6]decanoic acid	STL02579	^{13}C6-PFDA	250			1.25
	Perfluoro-n-[1,2,3,4,5,6,7-^{13}C7]undecanoic acid	STL02580	^{13}C7-PFUnA	250			1.25
	Perfluoro-n-[1,2-^{13}C2]dodecanoic acid	STL02703	^{13}C2-PFDoA	250			1.25
	Perfluoro-n-[1,2-^{13}C2]tetradecanoic acid	STL02116	^{13}C2-PFTeDA	250			1.25
	Perfluoro-1-[2,3,4-^{13}C3]butanesulfonic acid	STL02337	^{13}C3-PFBS	466			2.33
	Perfluoro-1-[1,2,3-^{13}C3]hexanesulfonic acid	STL02581	^{13}C3-PFHxS	474			2.37
	Perfluoro-1-[^{13}C8]octanesulfonic acid	STL01054	^{13}C8-PFOS	479			2.4
	Perfluoro-1-[^{13}C8]octanesulfonamide	STL01056	^{13}C8 -PFOSA	500			2.5
	N-methyl-d3-perfluoro-1-octanesulfonamidoacetic acid	STL02118	D3-NMeFOSAA	1000			5
	N-ethyl-d5-perfluoro-1-octanesulfonamidoacetic acid	STL02117	D5-NEtFOSAA	1000			5
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]hexan sulfonic acid	STL02395	^{13}C2-4:2FTS	938			4.69
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]octanesulfonic acid	STL02279	^{13}C2-6:2FTS	951			4.76
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]decanesulfonic acid	STL02280	^{13}C2-8:2FTS	960			4.8
	Tetrafluoro-2-heptafluoropropoxy-^{13}C3-propanoic acid	STL02255	^{13}C3-HFPO-DA	2000			10
	N-methyl-d7-perfluorooctanesulfonamidoethanol	STL02277	D7-NMeFOSE	5000			25
	N-ethyl-d9-perfluorooctanesulfonamidoethanol	STL02278	D9-NEtFOSE	5000			25
	N-ethyl-d5-perfluoro-1-octanesulfonamide	STL02704	D5-NEtFOSA	500			5
	N-methyl-d3-perfluoro-1-octanesulfonamide	STL02705	D3-NMeFOSA	500			5
Mass-Labelled PFAS Injection Standard Solution/ Mixture-IS	Perfluoro-n-[2,3,4-^{13}C3]butanoic acid	STL02680	^{13}C3-PFBA	1000	0.025		5
	Perfluoro-n-[1,2,3,4-^{13}C4]octanoic acid	STL00990	^{13}C4-PFOA	500			2.5
	Perfluoro-n-[1,2-^{13}C2]decanoic acid	STL00996	^{13}C2-PFDA	250			1.25
	Perfluoro-n-[1,2,3,4-^{13}C4]octanesulfonic acid	STL00991	^{13}C4-PFOS	479			2.4
	Perfluoro-n-[1,2,3,4,5-^{13}C5] nonanoic acid	STL00995	^{13}C5-PFNA	250			1.25
	Perfluoro-n-[1,2-^{13}C2]hexanoic acid	STL00993	^{13}C2-PFHxA	500			2.5
	Perfluoro-1-hexane[^{18}O2]sulfonic acid	STL00994	^{18}O2-PFHxS	474			2.37

* Bring to final volume using methanol with 4% water, 1% ammonium hydroxide, and 0.625% acetic acid

1633 Labeled Ampulated Standards						
Ampulated Solution Name	**Vendor**	**Catalog Number**	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/mL)**
Mass-Labelled PFAS Extraction Standard Solution/Mixture - ES	Wellington	MPFACHIFES	Perfluoro-n-[^{13}C4]butanoic acid	STL00992	^{13}C4-PFBA	2000
			Perfluoro-n-[^{13}C5]pentanoic acid	STL01893	^{13}C5-PFPeA	1000
			Perfluoro-n-[1,2,3,4,6-^{13}C5]hexanoic acid	STL02577	^{13}C5 -PFHxA	500
			Perfluoro-n-[1,2,3,4-^{13}C4]heptanoic acid	STL01892	^{13}C4-PFHpA	500
			Perfluoro-n-[^{13}C8]octanoic acid	STL01052	^{13}C8-PFOA	500
			Perfluoro-n-[^{13}C9]nonanoic acid	STL02578	^{13}C9-PFNA	250
			Perfluoro-n-[1,2,3,4,5,6-^{13}C6]decanoic acid	STL02579	^{13}C6-PFDA	250
			Perfluoro-n-[1,2,3,4,5,6,7-^{13}C7]undecanoic acid	STL02580	^{13}C7-PFUnA	250
			Perfluoro-n-[1,2-^{13}C2]dodecanoic acid	STL02703	^{13}C2-PFDoA	250
			Perfluoro-n-[1,2-^{13}C2]tetradecanoic acid	STL02116	^{13}C2-PFTeDA	250
			Perfluoro-1-[2,3,4-^{13}C3]butanesulfonic acid	STL02337	^{13}C3-PFBS	466
			Perfluoro-1-[1,2,3-^{13}C3]hexanesulfonic acid	STL02581	^{13}C3-PFHxS	474
			Perfluoro-1-[^{13}C8]octanesulfonic acid	STL01054	^{13}C8-PFOS	479
			Perfluoro-1-[^{13}C8]octanesulfonamide	STL01056	^{13}C8 -PFOSA	500
			N-methyl-d3-perfluoro-1-octanesulfonamidoacetic acid	STL02118	D3-NMeFOSAA	1000
			N-ethyl-d5-perfluoro-1-octanesulfonamidoacetic acid	STL02117	D5-NEtFOSAA	1000
			1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]hexan sulfonic acid	STL02395	^{13}C2-4:2FTS	938
			1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]octanesulfonic acid	STL02279	^{13}C2-6:2FTS	951
			1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]decanesulfonic acid	STL02280	^{13}C2-8:2FTS	960
			Tetrafluoro-2-heptafluoropropoxy-^{13}C3-propanoic acid	STL02255	^{13}C3-HFPO-DA	2000
			N-methyl-d7-perfluorooctanesulfonamidoethanol	STL02277	D7-NMeFOSE	5000
			N-ethyl-d9-perfluorooctanesulfonamidoethanol	STL02278	D9-NEtFOSE	5000
			N-ethyl-d5-perfluoro-1-octanesulfonamide	STL02704	D5-NEtFOSA	500
			N-methyl-d3-perfluoro-1-octanesulfonamide	STL02705	D3-NMeFOSA	500
Mass-Labelled PFAS Injection Standard Solution/Mixture - IS	Wellington	MPFACHIFIS	Perfluoro-n-[2,3,4-^{13}C3]butanoic acid	STL02680	^{13}C3-PFBA	1000
			Perfluoro-n-[1,2,3,4-^{13}C4]octanoic acid	STL00990	^{13}C4-PFOA	500
			Perfluoro-n-[1,2-^{13}C2]decanoic acid	STL00996	^{13}C2-PFDA	250
			Perfluoro-n-[1,2,3,4-^{13}C4]octanesulfonic acid	STL00991	^{13}C4-PFOS	479
			Perfluoro-n-[1,2,3,4,5-^{13}C5] nonanoic acid	STL00995	^{13}C5-PFNA	250
			Perfluoro-n-[1,2-^{13}C2]hexanoic acid	STL00993	^{13}C2-PFHxA	500
			Perfluoro-1-hexane[^{18}O2]sulfonic acid	STL00994	^{18}O2-PFHxS	474

Attachment 2

PFAS Injection Standards/Extraction Standards/Native Compounds

Injection Standards

Inj Std	Internal Standard/Injection Standard
I13C3-PFBA	13C3-PFBA
I13C2-PFHxA	13C2-PFHxA
I13C4-PFOA	13C4-PFOA
I13C5-PFNA	13C5-PFNA
I13C2-PFDA	13C2-PFDA
I18O2-PFHxS	18O2-PFHxS
I13C4-PFOS	13C4-PFOS

Extraction Standards

Extraction Standard	Internal Standard
E13C4-PFBA	13C3-PFBA
E13C5-PFPeA	13C2-PFHxA
E13C5-PFHxA	
E13C4-PFHpA	
E13C3-HFPO-DA	
E13C8-PFOA	13C4-PFOA
E13C9-PFNA	13C5-PFNA
E13C6-PFDA	13C2-PFDA
E13C7-PFUnA	
E13C2-PFDoA	
E13C2-PFTeDA	
E13C3-PFBS	18O2-PFHxS
E13C3-PFHxS	
E13C2-4:2-FTS	
E13C2-6:2-FTS	
E13C2-8:2-FTS	

Extraction Standard	Internal Standard
E13C8-PFOS	13C4-PFOS
E13C8-PFOSA	
Ed3-NMeFOSA	
Ed5-NEtFOSA	
Ed3-NMeFOSAA	
Ed7-NMeFOSE	
Ed9-NEtFOSE	

Native PFAS Compounds

Native	Extraction Standard
PFBA	13C4-PFBA
PFPeA	13C5-PFPeA
3:3FTCA	
PFMPA	
PFMBA	
PFHxA	13C5-PFHxA
NFDHA	
5:3FTCA	
7:3FTCA	
PFEESA	
PFHpA	13C4-PFHpA
PFOA	13C8-PFOA
PFNA	13C9-PFNA
PFDA	13C6-PFDA
PFUnA	13C7-PFUnA
PFDoA	13C2-PFDoA
PFTrDA	Avg 13C2-PFTeDA and 13C2-PFDoA
PFTeDA	13C2-PFTeDA
PFBS	13C3-PFBS
PFPeS	13C3-PFHxS
PFHxS	
PFHpS	13C8-PFOS
PFOS	
PFNS	
PFDS	
PFDoS	

Native	Extraction Standard
4:2-FTS	13C2-4:2-FTS
6:2-FTS	13C2-6:2-FTS
8:2-FTS	13C2-8:2-FTS
PFOSA	13C8-PFOSA
NMeFOSA	D3-NMeFOSA
NEtFOSA	D5-NEtFOSA
NMeFOSAA	D3-NMeFOSAA
NEtFOSAA	D5-N-EtFOSAA
NMeFOSE	D7-NMeFOSE
NEtFOSE	D9-NEtFOSE
HFPO-DA	13C3-HFPO-DA
DONA	
9Cl-PF3ONS	
11Cl-PF3OUdS	

Attachment 20

1633 Native Ampulated Standards

Ampulated Solution Name	Vendor	Catalog Number	Analyte	CAS#	Acronym	Conc. (ng/mL)
Native Replacement PFAS Solution/Mixture	Wellington	PFAC-MXF	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9	11Cl-PF3OUdS	1890
			9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1	9Cl-PF3ONS	1870
			4,8-dioxa-3H-Perfluorononanoic acid	919005-14-4	DONA	1890
			Perfluoro(2-propxypropanoic) acid	13252-13-6	HFPODA	2000
Native PFAS Solution/Mixture	Wellington	PFAC-MXH	1H,1H,2H,2H perfluorodecanesulfonic acid	39108-34-4	8:2-FTS	3840
			1H,1H,2H,2H perfluorohexanesulfonic acid	757124-72-4	4:2-FTS	3750
			1H,1H,2H,2H perfluorooctanesulfonic acid	27619-97-2	6:2-FTS	3800
			N-ethylperfluorooctanesulfonamidoacetic acid	2991-50-6	NEtFOSAA	1000
			N-methylperfluorooctanesulfonamidoacetic acid	2355-31-9	NMeFOSAA	1000
			Perfluorobutanesulfonic acid	375-73-5	PFBS	887
			Perfluorobutanoic acid	375-22-4	PFBA	4000
			Perfluorodecanesulfonic acid	335-77-3	PFDS	965
			Perfluorodecanoic acid	335-76-2	PFDA	1000
			Perfluorododecanesulfonic acid	79780-39-5	PFDoDS	970
			Perfluorododecanoic acid	307-55-1	PFDoDA	1000
			Perfluoroheptanesulfonic acid	375-92-8	PFHpS	953
			Perfluoroheptanoic acid	375-85-9	PFHpA	1000
			Perfluorohexanesulfonic acid	355-46-4	PFHxS	914
			Perfluorohexanoic acid	307-24-4	PFHxA	1000
			Perfluorononanesulfonic acid	68259-12-1	PFNS	962
			Perfluorononanoic acid	375-95-1	PFNA	1000
			Perfluorooctanesulfonamide	754-91-6	PFOSA	1000
			Perfluorooctanesulfonic acid	1763-23-1	PFOS	928
			Perfluorooctanoic acid	335-67-1	PFOA	1000
			Perfluoropentanesulfonic acid	2706-91-4	PFPeS	941
			Perfluoropentanoic acid	2706-90-3	PFPeA	2000
			Perfluorotetradecanoic acid	376-06-7	PFTeDA	1000
			Perfluorotridecanoic acid	72629-94-8	PFTrDA	1000
			Perfluoroundecanoic acid	2058-94-8	PFUnDA	1000
Native Perfluoroalkyl Ether Carboxylic Acids and Sulfonate Solution/Mixture	Wellington	PFAC-MXG	Perfluoro-3-methoxypropanoic acid	377-73-1	PFMPA	2000
			Perfluoro-4-methoxybutanoic acid	863090-89-5	PFMBA	2000
			Nonafluoro-3,6-dioxaheptanoic acid	151722-58-6	NFDHA	2000
			Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	PFEESA	1780
Native N-NMe/EtFOSA & N-Nme/EtFOSE Solution/Mixture	Wellington	PFAC-MXI	2-(N-methylperfluoro-1-octanesulfonamido)- ethanol	24448-09-7	NMePFOSAE	10000
			N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	1000
			2-(N-ethylperfluoro-1-octanesulfonamido)- ethanol	1691-99-2	NEtPFOSAE	10000
			N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	1000
Native X:3 Flourotelomer Caroxylic Acid Solution/Mixture	Wellington	PFAC-MXJ	3-Perfluoropropylpropanoic acid	763051-92-9	3:3 FTCA	4000
			3-Perfluoropentylpropanoic acid	756426-58-1	5:3 FTCA	20000
			3-Perfluoroheptylpropanoic acid	919005-14-4	7:3 FTCA	20000
	Wellington	T-PFOA	Technical Ammonium, Perfluorooctanoa te (Technical Grade)	95328-99-7	T-PFOA	50000
			Perfluoroctanoic acid	335-67-1	PFOA	50000
	Cambridge	ULM-11036-S	2-(N-ethylperfluoro-1-octanesulfonamido) ethanol	1691-99-2	NEtPFOSAE	50000
	Cambridge	ULM-11034-S	2-(N-methylperfluoro-1-octanesulfonamido) ethanol	24448-09-7	NMePFOSAE	50000
	Cambridge	ULM-10780-S	N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	100000
	Cambridge	ULM-10779-S	N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMeFOSA	100000
	Cambridge	ULM-10977-S	Perfluorooctanesfulonamide	754-91-6	PFOSA	50000
	Wellington	ipPFNA	Perfluoro-7-methyloctanoic acid	15899-31-7	PF7MOA	50000
	Wellington	PFNA	Perfluorononanoic acid	375-95-1	PFNA	50000

Attachment 3

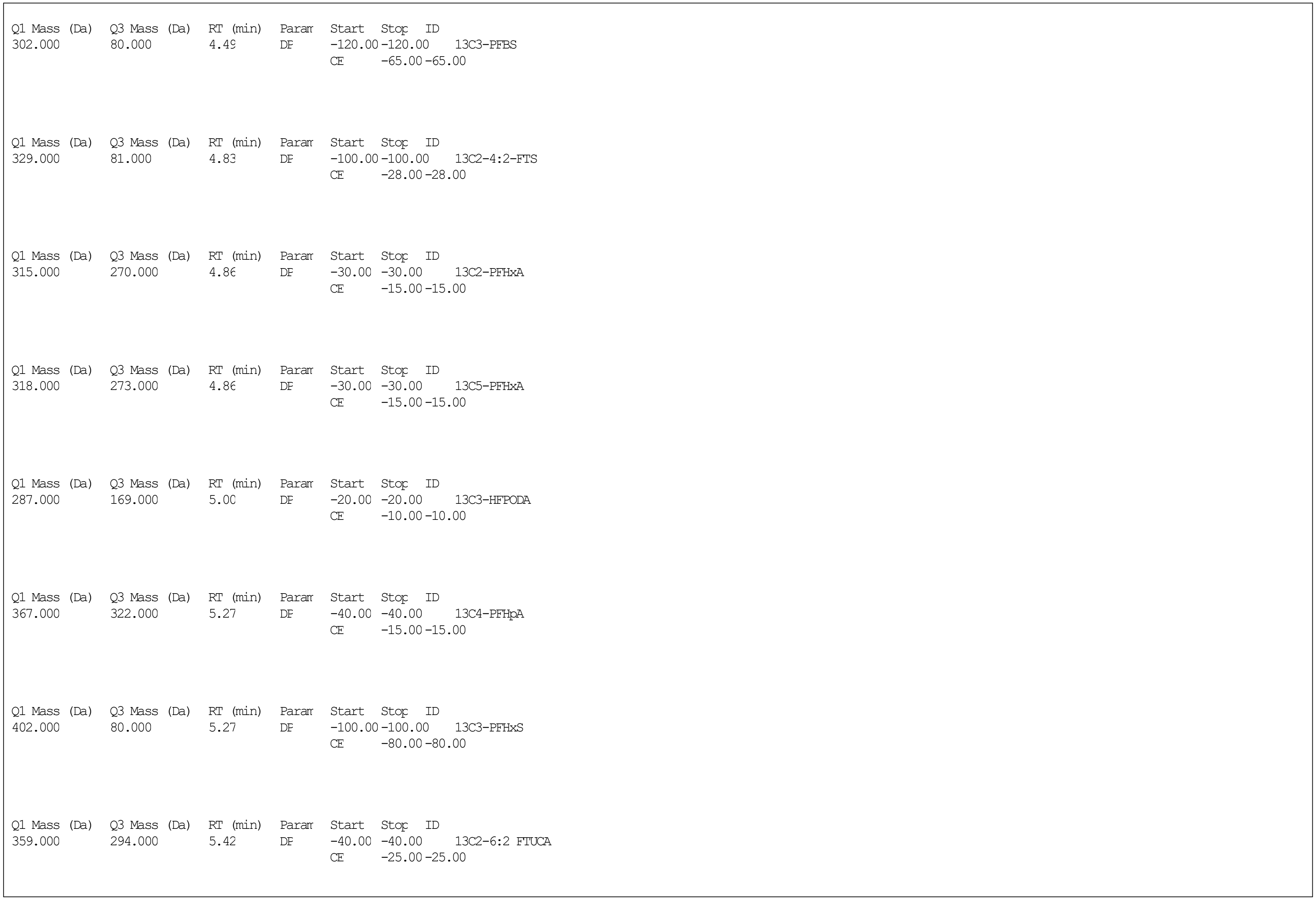
Acquisition Method

```
EPA1633_DOD

Mass Spec  10.500 min
   Period  10.500 min
      -MRM
Integrated Valve
Sciex LC System
   Equilibrate
   Injection
```

Mass Spectrometer Method Properties

```
Period 1:
--------------
Scans in Period:        1050
Min. Dwell Time:        3 ms
Max. Dwell Time:        250 ms
Relative Start Time:    0.00 msec
Scheduled Ionization:   Off
Experiments in Period:  1
Use target Cycle Time:  No
Target Cycle Time:      N/A

Period 1  Experiment   1:
----------------------------
Scan Type:              MRM (MRM)
Scheduled MRM:          Yes
Polarity:               Negative
Scan Mode:              N/A
Ion Source:             Turbo Spray
sMRM Q1Q3 Resolution:   No
MRM detection window:   60 sec
Target Scan Time:       0.6000 sec
Resolution Q1:          Unit
Resolution Q3:          Unit
Intensity Thres.:       0.00 cps
Settling Time:          0.0000 msec
MR Pause:               5.0070 msec
MCA:                    No
Step Size:              0.00 Da

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
216.000       172.000       3.88      DP     -40.00 -40.00    13C3-PFBA
                                      CE     -14.00 -14.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
217.000       172.000       3.88      DP     -40.00 -40.00    13C4-PFBA
                                      CE     -14.00 -14.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
268.000       223.000       4.44      DP     -40.00 -40.00    13C5-PFPeA
                                      CE     -14.00 -14.00
```

Attachment 3



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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
302.000       80.000        4.49      DP     -120.00-120.00    13C3-PFBS
                                             CE     -65.00-65.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
329.000       81.000        4.83      DP     -100.00-100.00    13C2-4:2-FTS
                                             CE     -28.00-28.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
315.000       270.000       4.86      DP     -30.00 -30.00     13C2-PFHxA
                                             CE     -15.00-15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
318.000       273.000       4.86      DP     -30.00 -30.00     13C5-PFHxA
                                             CE     -15.00-15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
287.000       169.000       5.00      DP     -20.00 -20.00     13C3-HFPODA
                                             CE     -10.00-10.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
367.000       322.000       5.27      DP     -40.00 -40.00     13C4-PFHpA
                                             CE     -15.00-15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
402.000       80.000        5.27      DP     -100.00-100.00    13C3-PFHxS
                                             CE     -80.00-80.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
359.000       294.000       5.42      DP     -40.00 -40.00     13C2-6:2 FTUCA
                                             CE     -25.00-25.00
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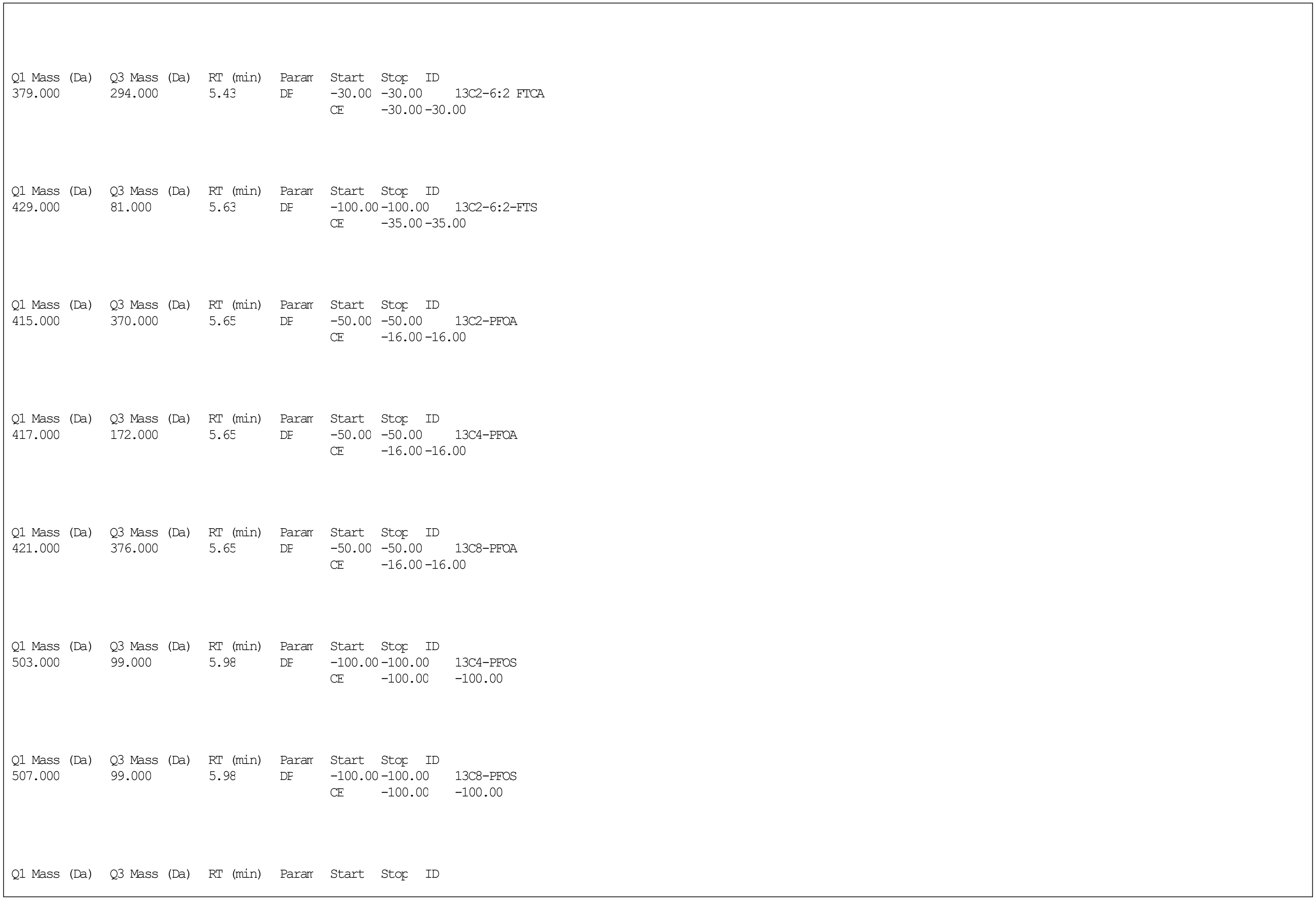

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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
379.000       294.000       5.43      DP     -30.00 -30.00     13C2-6:2 FTCA
                                             CE     -30.00 -30.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
429.000       81.000        5.63      DP     -100.00 -100.00   13C2-6:2-FTS
                                             CE     -35.00 -35.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
415.000       370.000       5.65      DP     -50.00 -50.00     13C2-PFOA
                                             CE     -16.00 -16.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
417.000       172.000       5.65      DP     -50.00 -50.00     13C4-PFOA
                                             CE     -16.00 -16.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
421.000       376.000       5.65      DP     -50.00 -50.00     13C8-PFOA
                                             CE     -16.00 -16.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
503.000       99.000        5.98      DP     -100.00 -100.00   13C4-PFOS
                                             CE     -100.00    -100.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
507.000       99.000        5.98      DP     -100.00 -100.00   13C8-PFOS
                                             CE     -100.00    -100.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
```

Attachment 3

```
472.000 427.000 5.99    DP      -50.00  -50.00  13C9-PFNA
                                CE      -18.00  -18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
459.000       394.000       6.13      DP     -50.00 -50.00     13C2-8:2 FTUCA
                                             CE     -25.00 -25.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
479.000       394.000       6.13      DP     -35.00 -35.00     13C2-8:2 FTCA
                                             CE     -25.00 -25.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
519.000       474.000       6.30      DP     -50.00 -50.00     13C6-PFDA
                                             CE     -18.00 -18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
515.000       470.000       6.30      DP     -50.00 -50.00     13C2-PFDA
                                             CE     -18.00 -18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
529.000       81.000        6.31      DP     -100.00 -100.00   13C2-8:2-FTS
                                             CE     -42.00 -42.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
506.000       78.000        6.40      DP     -100.00 -100.00   13C8-PFOSA
                                             CE     -80.00 -80.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
573.000       419.000       6.40      DP     -80.00 -80.00     d3-NMeFOSAA
                                             CE     -30.00 -30.00
```

Attachment 3

```
Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
565.000       520.000       6.58      DP     -70.00 -70.00    13C2-PFUnDA
                                      CE     -19.00 -19.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
570.000       525.000       6.58      DP     -70.00 -70.00    13C7-PFUnDA
                                      CE     -19.00 -19.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
589.000       419.000       6.50      DP     -90.00 -90.00    d5-NEtFOSAA
                                      CE     -30.00 -30.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
559.000       494.000       6.70      DP     -60.00 -60.00    13C2-10:2 FTUCA
                                      CE     -30.00 -30.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
579.000       494.000       6.72      DP     -50.00 -50.00    13C2-10:2 FTCA
                                      CE     -30.00 -30.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
615.000       570.000       6.81      DP     -60.00 -60.00    13C2-PFDoDA
                                      CE     -20.00 -20.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
623.000       59.000        6.85      DP     -50.00 -50.00    d7-NMePFOSAE
                                      CE     -70.00 -70.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
515.000       219.000       6.86      DP     -100.00 -100.00  d3-NMePFOSA
```

```
                             CE       -37.00  -37.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
639.000       59.000        7.01      DP     -45.00 -45.00    d9-NEtPFOSAE
                                             CE     -70.00-70.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
531.000       219.000       7.03      DP     -100.00-100.00   d5-NEtPFOSA
                                             CE     -38.00-38.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
715.000       670.000       7.21      DP     -60.00 -60.00    13C2-PFTeDA
                                             CE     -22.00-22.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
163.000       119.000       1.83      DP     -30.00 -30.00    PPF Acid
                                             CE     -15.00-15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
213.000       169.000       3.89      DP     -40.00 -40.00    PFBA
                                             CE     -14.00-14.00

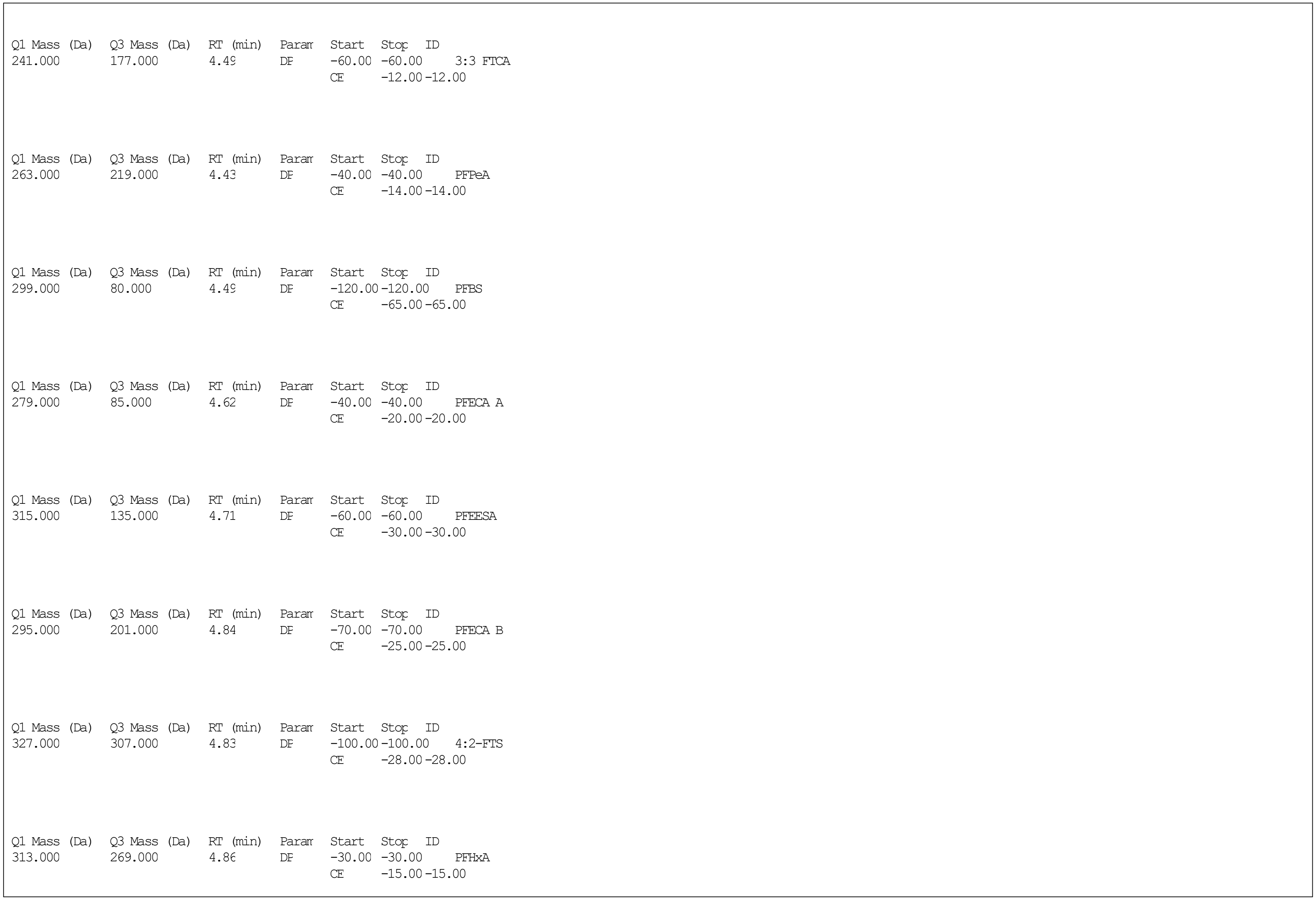


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
249.000       99.000        4.12      DP     -60.00 -60.00    PFPrS
                                             CE     -40.00-40.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
229.000       85.000        4.17      DP     -40.00 -40.00    PFECA F
                                             CE     -25.00-25.00
```

Attachment 3



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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
241.000       177.000       4.49      DP     -60.00  -60.00     3:3 FTCA
                                             CE      -12.00 -12.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
263.000       219.000       4.43      DP     -40.00  -40.00     PFPeA
                                             CE      -14.00 -14.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
299.000       80.000        4.49      DP     -120.00 -120.00    PFBS
                                             CE      -65.00 -65.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
279.000       85.000        4.62      DP     -40.00  -40.00     PFECA A
                                             CE      -20.00 -20.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
315.000       135.000       4.71      DP     -60.00  -60.00     PFEESA
                                             CE      -30.00 -30.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
295.000       201.000       4.84      DP     -70.00  -70.00     PFECA B
                                             CE      -25.00 -25.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
327.000       307.000       4.83      DP     -100.00 -100.00    4:2-FTS
                                             CE      -28.00 -28.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
313.000       269.000       4.86      DP     -30.00  -30.00     PFHxA
                                             CE      -15.00 -15.00
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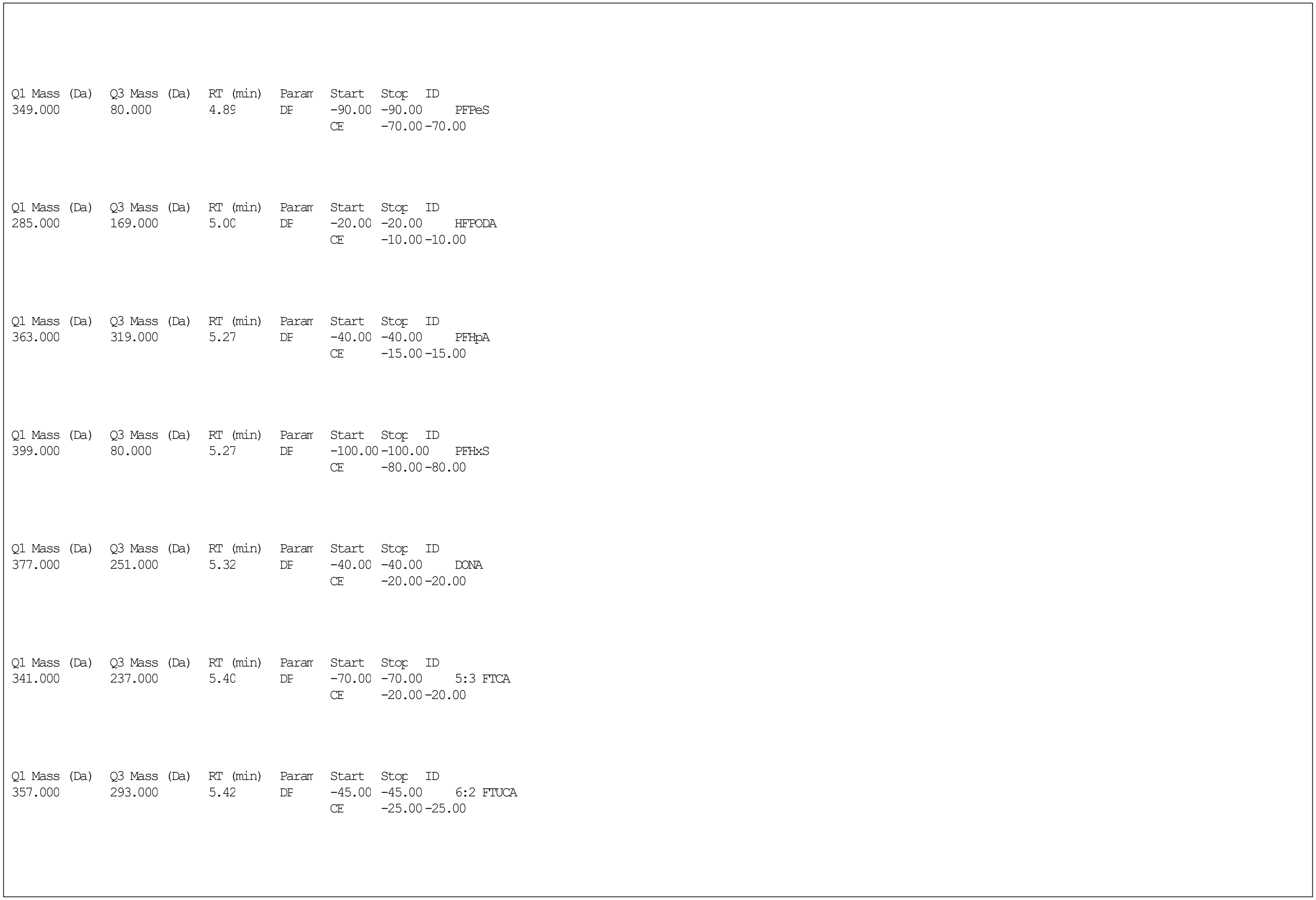

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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
349.000       80.000        4.89      DP     -90.00 -90.00     PFPeS
                                             CE     -70.00 -70.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
285.000       169.000       5.00      DP     -20.00 -20.00     HFPODA
                                             CE     -10.00 -10.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
363.000       319.000       5.27      DP     -40.00 -40.00     PFHpA
                                             CE     -15.00 -15.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
399.000       80.000        5.27      DP     -100.00 -100.00   PFHxS
                                             CE     -80.00 -80.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
377.000       251.000       5.32      DP     -40.00 -40.00     DONA
                                             CE     -20.00 -20.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
341.000       237.000       5.40      DP     -70.00 -70.00     5:3 FTCA
                                             CE     -20.00 -20.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
357.000       293.000       5.42      DP     -45.00 -45.00     6:2 FTUCA
                                             CE     -25.00 -25.00
```

Attachment 3

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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)   Param   Start   Stop  ID
377.000       293.000       5.44       DP      -45.00  -45.00     6:2 FTCA
                                               CE      -30.00 -30.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)   Param   Start   Stop  ID
461.000       381.000       5.63       DP      -70.00  -70.00     PFECHS
                                               CE      -40.00 -40.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)   Param   Start   Stop  ID
427.000       407.000       5.62       DP      -100.00 -100.00    6:2-FTS
                                               CE      -35.00 -35.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)   Param   Start   Stop  ID
449.000       80.000        5.63       DP      -100.00 -100.00    PFHpS
                                               CE      -90.00 -90.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)   Param   Start   Stop  ID
413.000       369.000       5.65       DP      -50.00  -50.00     PFOA
                                               CE      -16.00 -16.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)   Param   Start   Stop  ID
499.000       80.000        5.90       DP      -100.00 -100.00    PFOS
                                               CE      -100.00    -100.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)   Param   Start   Stop  ID
463.000       419.000       5.99       DP      -50.00  -50.00     PFNA
                                               CE      -18.00 -18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)   Param   Start   Stop  ID
441.000       317.000       6.13       DP      -80.00  -80.00     7:3 FTCA
                                               CE      -20.00 -20.00
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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)   Param   Start   Stop  ID
457.000       393.000       6.13       DP      -50.00  -50.00     8:2 FTUCA
                                               CE      -25.00 -25.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)   Param   Start   Stop  ID
477.000       393.000       6.15       DP      -45.00  -45.00     8:2 FTCA
                                               CE      -30.00 -30.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)   Param   Start   Stop  ID
531.000       351.000       6.12       DP      -100.00 -100.00    9Cl-PF3ONS
                                               CE      -38.00 -38.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)   Param   Start   Stop  ID
549.000       80.000        6.28       DP      -100.00 -100.00    PFNS
                                               CE      -110.00    -110.00

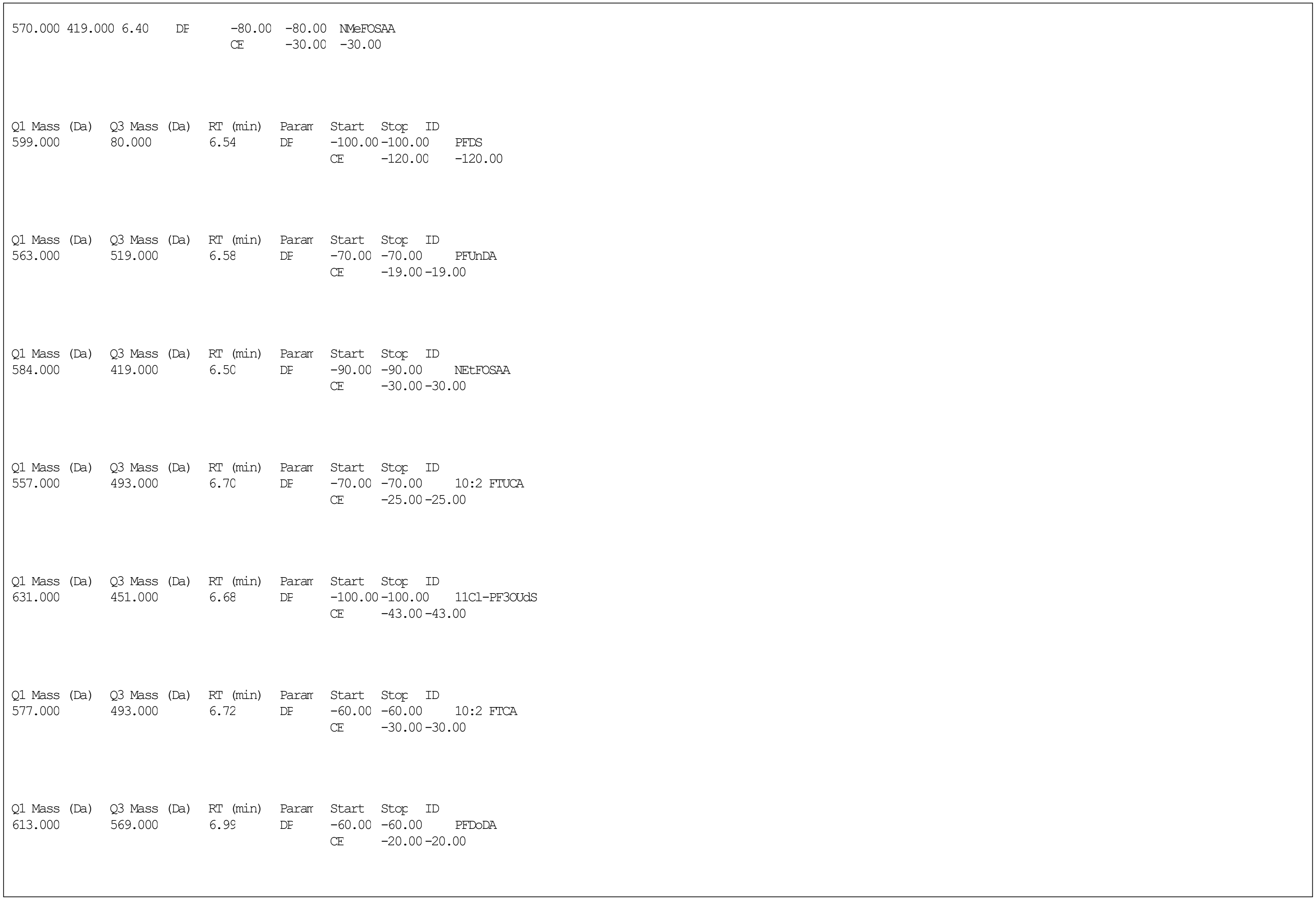
Q1 Mass (Da)  Q3 Mass (Da)  RT (min)   Param   Start   Stop  ID
513.000       469.000       6.30       DP      -50.00  -50.00     PFDA
                                               CE      -18.00 -18.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)   Param   Start   Stop  ID
527.000       507.000       6.30       DP      -100.00 -100.00    8:2-FTS
                                               CE      -42.00 -42.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)   Param   Start   Stop  ID
498.000       78.000        6.40       DP      -100.00 -100.00    PFOSA
                                               CE      -80.00 -80.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)   Param   Start   Stop  ID
```

Attachment 3



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570.000 419.000 6.40    DP      -80.00  -80.00  NMeFOSAA
                                CE      -30.00  -30.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
599.000       80.000        6.54      DP     -100.00 -100.00    PFDS
                                             CE     -120.00    -120.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
563.000       519.000       6.58      DP     -70.00 -70.00     PFUnDA
                                             CE     -19.00 -19.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
584.000       419.000       6.50      DP     -90.00 -90.00     NEtFOSAA
                                             CE     -30.00 -30.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
557.000       493.000       6.70      DP     -70.00 -70.00     10:2 FTUCA
                                             CE     -25.00 -25.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
631.000       451.000       6.68      DP     -100.00 -100.00    11Cl-PF3OUdS
                                             CE     -43.00 -43.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
577.000       493.000       6.72      DP     -60.00 -60.00     10:2 FTCA
                                             CE     -30.00 -30.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
613.000       569.000       6.99      DP     -60.00 -60.00     PFDoDA
                                             CE     -20.00 -20.00
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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
627.000       607.000       6.84      DP     -100.00-100.00    10:2-FTS
                                             CE     -47.00-47.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
616.000       59.000        6.85      DP     -50.00 -50.00     NMePFOSAE
                                             CE     -70.00-70.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
512.000       219.000       6.86      DP     -100.00-100.00    NMePFOSA
                                             CE     -37.00-37.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
699.000       80.000        6.99      DP     -100.00-100.00    PFDoS
                                             CE     -150.00    -150.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
630.000       59.000        7.01      DP     -45.00 -45.00     NEtPFOSAE
                                             CE     -70.00-70.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
526.000       219.000       7.03      DP     -100.00-100.00    NEtPFOSA
                                             CE     -38.00-38.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
663.000       619.000       7.03      DP     -60.00 -60.00     PFTrDA
                                             CE     -21.00-21.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
713.000       669.000       7.21      DP     -60.00 -60.00     PFTeDA
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                                 CE       -22.00  -22.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
813.000       769.000       7.51      DP     -100.00 -100.00    PFHxDA
                                             CE      -25.00 -25.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
913.000       869.000       7.74      DP     -100.00 -100.00    PFODA
                                             CE      -27.00 -27.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
299.000       99.000        4.50      DP     -100.00 -100.00    PFBS_2
                                             CE      -45.00 -45.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
295.000       85.000        4.45      DP     -25.00  -25.00     PFECA B_2
                                             CE      -15.00 -15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
327.000       81.000        4.83      DP     -100.00 -100.00    4:2 FTS_2
                                             CE      -50.00 -50.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
313.000       119.000       4.86      DP     -50.00  -50.00     PFHxA_2
                                             CE      -31.00 -31.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
349.000       99.000        4.89      DP     -100.00 -100.00    PFPeS_2
                                             CE      -50.00 -50.00
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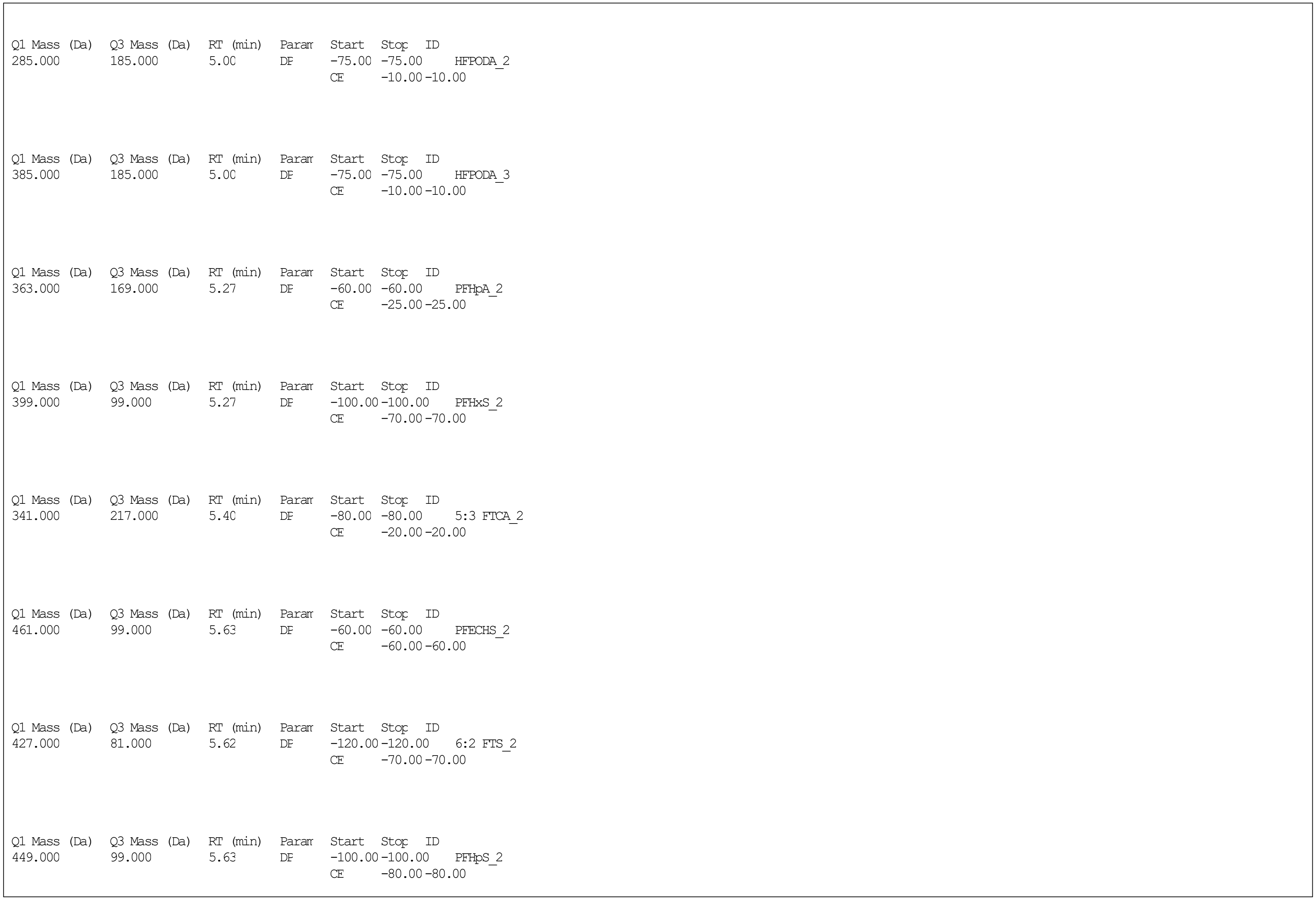
Attachment 3



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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
285.000       185.000       5.00      DP     -75.00  -75.00    HFPODA_2
                                      CE     -10.00 -10.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
385.000       185.000       5.00      DP     -75.00  -75.00    HFPODA_3
                                      CE     -10.00 -10.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
363.000       169.000       5.27      DP     -60.00  -60.00    PFHpA_2
                                      CE     -25.00 -25.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
399.000       99.000        5.27      DP     -100.00 -100.00   PFHxS_2
                                      CE     -70.00 -70.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
341.000       217.000       5.40      DP     -80.00  -80.00    5:3 FTCA_2
                                      CE     -20.00 -20.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
461.000       99.000        5.63      DP     -60.00  -60.00    PFECHS_2
                                      CE     -60.00 -60.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
427.000       81.000        5.62      DP     -120.00 -120.00   6:2 FTS_2
                                      CE     -70.00 -70.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
449.000       99.000        5.63      DP     -100.00 -100.00   PFHpS_2
                                      CE     -80.00 -80.00
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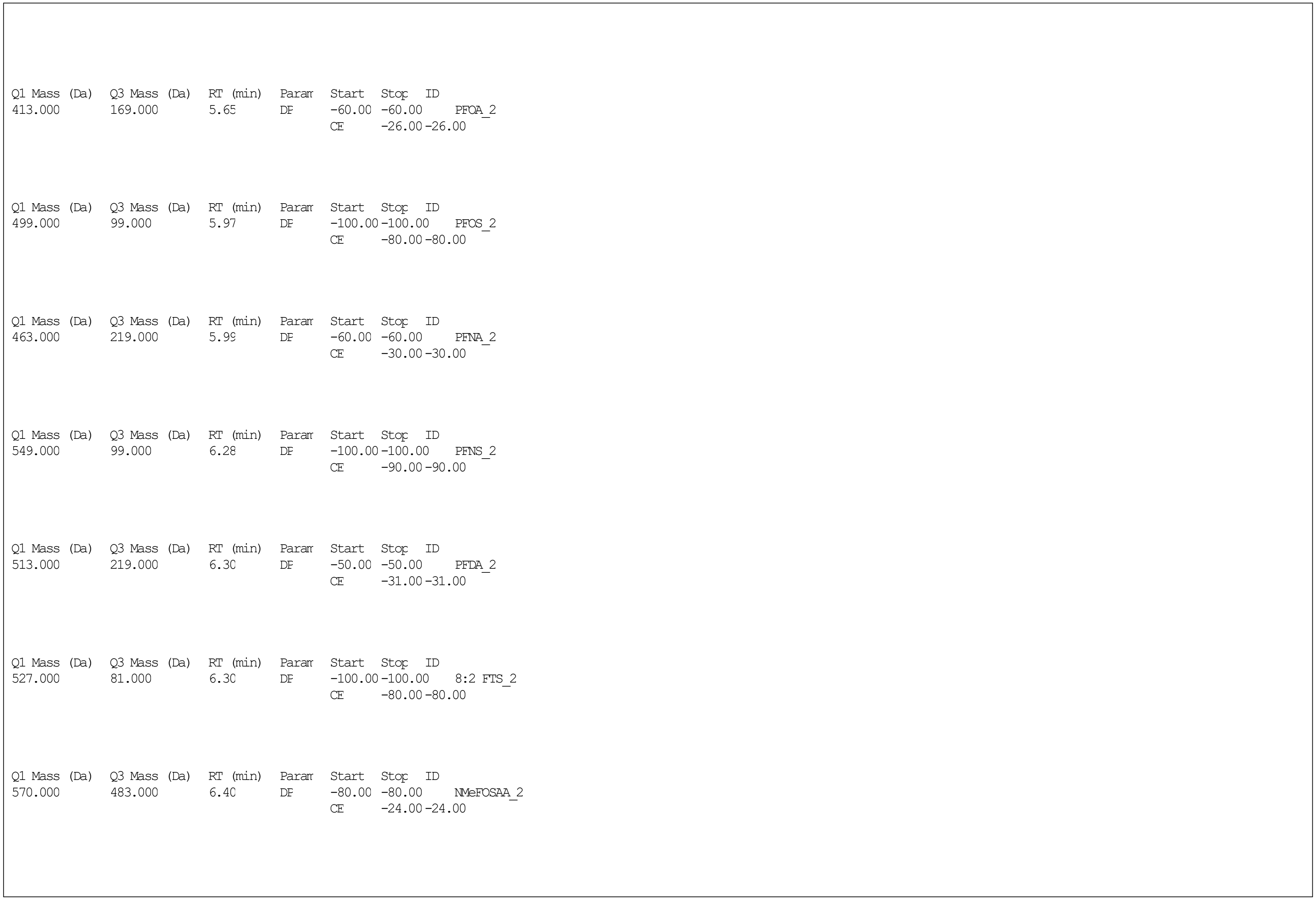
Attachment 3



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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
413.000       169.000       5.65      DP     -60.00  -60.00     PFOA_2
                                             CE      -26.00-26.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
499.000       99.000        5.97      DP     -100.00-100.00     PFOS_2
                                             CE      -80.00-80.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
463.000       219.000       5.99      DP     -60.00  -60.00     PFNA_2
                                             CE      -30.00-30.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
549.000       99.000        6.28      DP     -100.00-100.00     PFNS_2
                                             CE      -90.00-90.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
513.000       219.000       6.30      DP     -50.00  -50.00     PFDA_2
                                             CE      -31.00-31.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
527.000       81.000        6.30      DP     -100.00-100.00     8:2 FTS_2
                                             CE      -80.00-80.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
570.000       483.000       6.40      DP     -80.00  -80.00     NMeFOSAA_2
                                             CE      -24.00-24.00
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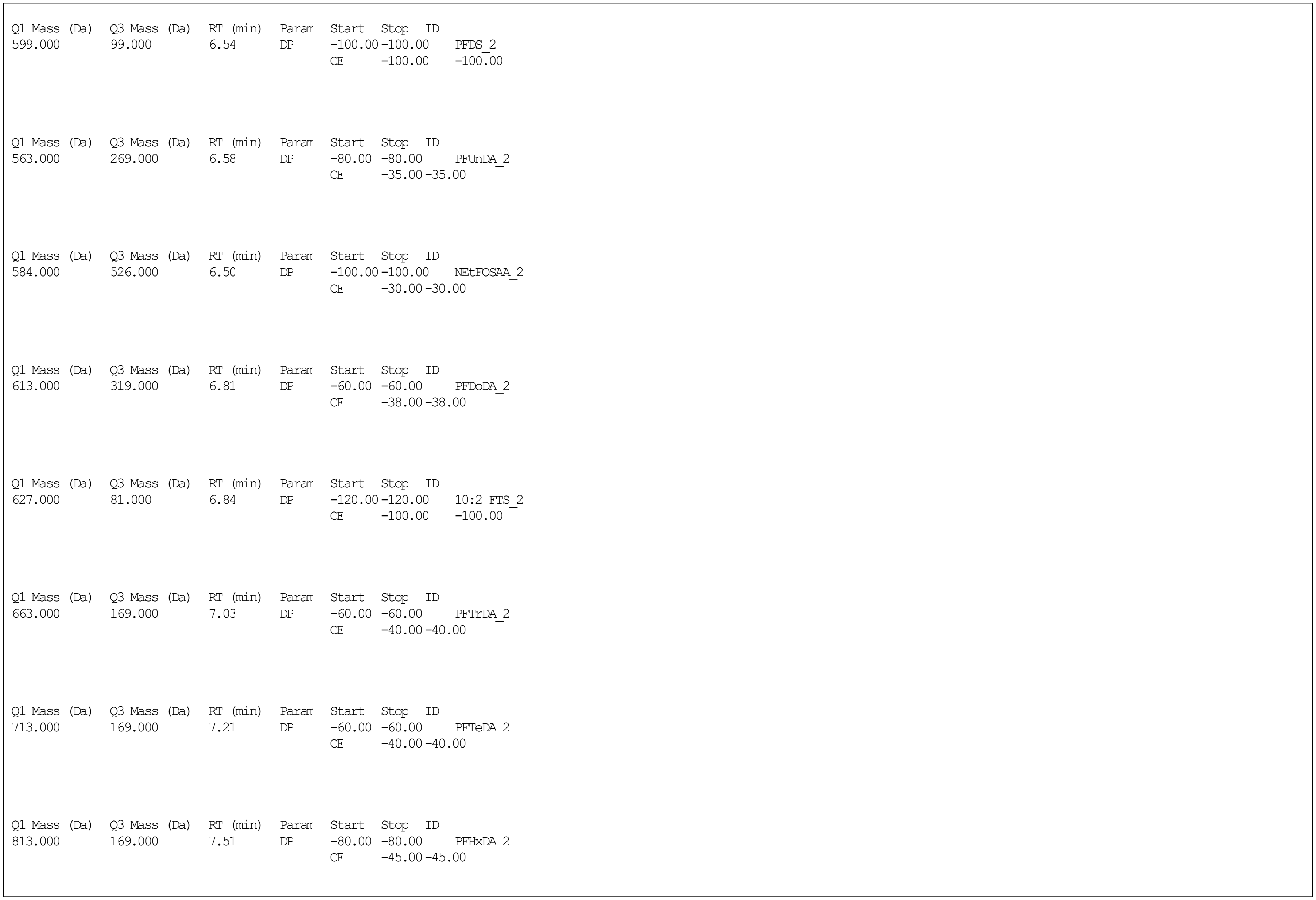
Attachment 3



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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
599.000       99.000        6.54      DP     -100.00-100.00    PFDS_2
                                             CE     -100.00    -100.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
563.000       269.000       6.58      DP     -80.00 -80.00     PFUnDA_2
                                             CE     -35.00-35.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
584.000       526.000       6.50      DP     -100.00-100.00    NEtFOSAA_2
                                             CE     -30.00-30.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
613.000       319.000       6.81      DP     -60.00 -60.00     PFDoDA_2
                                             CE     -38.00-38.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
627.000       81.000        6.84      DP     -120.00-120.00    10:2 FTS_2
                                             CE     -100.00    -100.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
663.000       169.000       7.03      DP     -60.00 -60.00     PFTrDA_2
                                             CE     -40.00-40.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
713.000       169.000       7.21      DP     -60.00 -60.00     PFTeDA_2
                                             CE     -40.00-40.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
813.000       169.000       7.51      DP     -80.00 -80.00     PFHxDA_2
                                             CE     -45.00-45.00
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Attachment 3

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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
913.000       169.000       7.74      DP     -80.00 -80.00    PFODA_2
                                             CE     -50.00 -50.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
179.000       85.000        2.90      DP     -15.00 -15.00    PFMOAA
                                             CE     -15.00 -15.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
441.000       241.000       3.92      DP     -80.00 -80.00    R-PSDA
                                             CE     -32.00 -32.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
405.000       217.000       3.92      DP     -60.00 -60.00    R-EVE
                                             CE     -25.00 -25.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
439.000       343.000       3.94      DP     -80.00 -80.00    Hydrolized PSDA
                                             CE     -35.00 -35.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
229.000       185.000       4.06      DP     -20.00 -20.00    PMPA
                                             CE     -12.00 -12.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
297.000       135.000       4.17      DP     -80.00 -80.00    NVHOS
                                             CE     -35.00 -35.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
```

Attachment 3

```
245.000 85.000  4.37    DP      -10.00  -10.00  PFO2HxA
                                CE      -15.00  -15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
279.000       235.000       4.59      DP     -10.00 -10.00    PEPA
                                             CE     -20.00-20.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
311.000       85.000        4.97      DP     -20.00 -20.00    PFO3OA
                                             CE     -15.00-15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
427.000       283.000       5.27      DP     -40.00 -40.00    Hydro-EVE Acid
                                             CE     -18.00-18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
397.000       217.000       5.27      DP     -80.00 -80.00    R-PSDCA
                                             CE     -35.00-35.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
463.000       263.000       5.26      DP     -80.00 -80.00    Hydro-PS Acid
                                             CE     -38.00-38.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
379.000       185.000       5.38      DP     -35.00 -35.00    PFECA-G
                                             CE     -20.00-20.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
377.000       84.000        5.48      DP     -20.00 -20.00    PFO4DA
                                             CE     -40.00-40.00
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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
443.000       147.000       5.53      DP     -70.00  -70.00    PS Acid
                                             CE      -32.00 -32.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
407.000       263.000       5.55      DP     -40.00  -40.00    EVE Acid
                                             CE      -14.00 -14.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
443.000       85.000        5.93      DP     -7.00   -7.00 PFO5DA
                                             CE      -37.00 -37.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
175.000       97.000        1.46      DP     -45.00  -45.00    MTP
                                             CE      -22.00 -22.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
468.000       423.000       5.99      DP     -50.00  -50.00    13C5-PFNA
                                             CE      -18.00 -18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
403.000       84.000        5.27      DP     -100.00 -100.00   18O2-PFHxS
                                             CE      -80.00 -80.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
263.000       69.000        4.43      DP     -40.00  -40.00    PFPeA_2
                                             CE      -14.00 -14.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
498.000       478.000       6.40      DP     -100.00 -100.00   PFOSA_2
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Attachment 3

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                                CE       -80.00  -80.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
512.000       169.000       6.86      DP     -100.00 -100.00   NMePFOSA_2
                                             CE      -37.00 -37.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
526.000       169.000       7.03      DP     -180.00 -180.00   NEtPFOSA_2
                                             CE      -40.00 -40.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
377.000       85.000        5.32      DP     -40.00  -40.00    DONA_2
                                             CE      -20.00 -20.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
533.000       353.000       6.12      DP     -100.00 -100.00   9Cl-PF3ONS_2
                                             CE      -38.00 -38.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
633.000       453.000       6.68      DP     -180.00 -180.00   11Cl-PF3OUdS_2
                                             CE      -40.00 -40.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
241.000       117.000       4.49      DP     -60.00  -60.00    3:3 FTCA_2
                                             CE      -12.00 -12.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
441.000       337.000       6.13      DP     -80.00  -80.00    7:3 FTCA_2
                                             CE      -20.00 -20.00
```
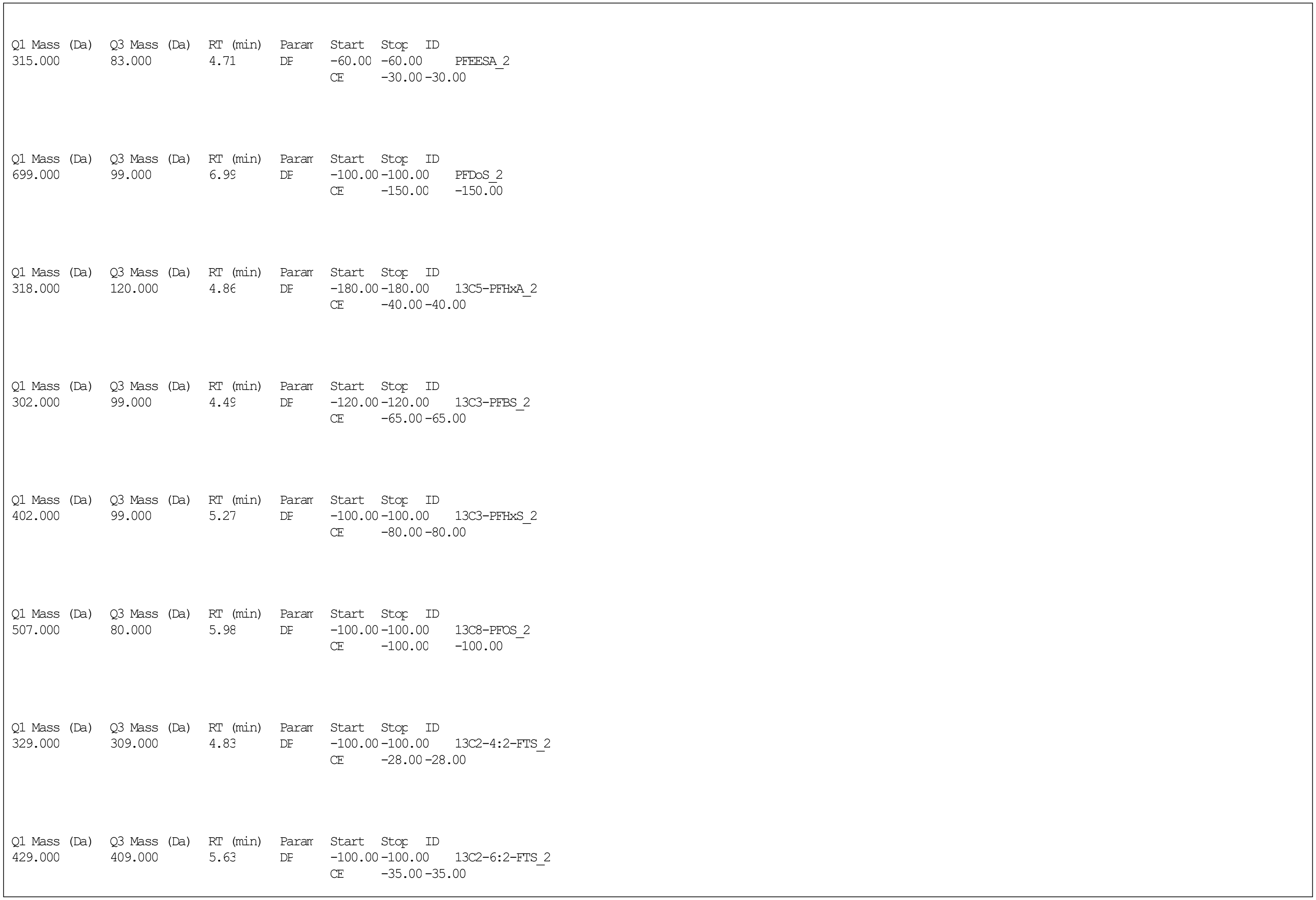

Attachment 3



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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
315.000       83.000        4.71      DP     -60.00  -60.00     PFEESA_2
                                      CE     -30.00 -30.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
699.000       99.000        6.99      DP     -100.00 -100.00    PFDoS_2
                                      CE     -150.00    -150.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
318.000       120.000       4.86      DP     -180.00 -180.00    13C5-PFHxA_2
                                      CE     -40.00 -40.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
302.000       99.000        4.49      DP     -120.00 -120.00    13C3-PFBS_2
                                      CE     -65.00 -65.00

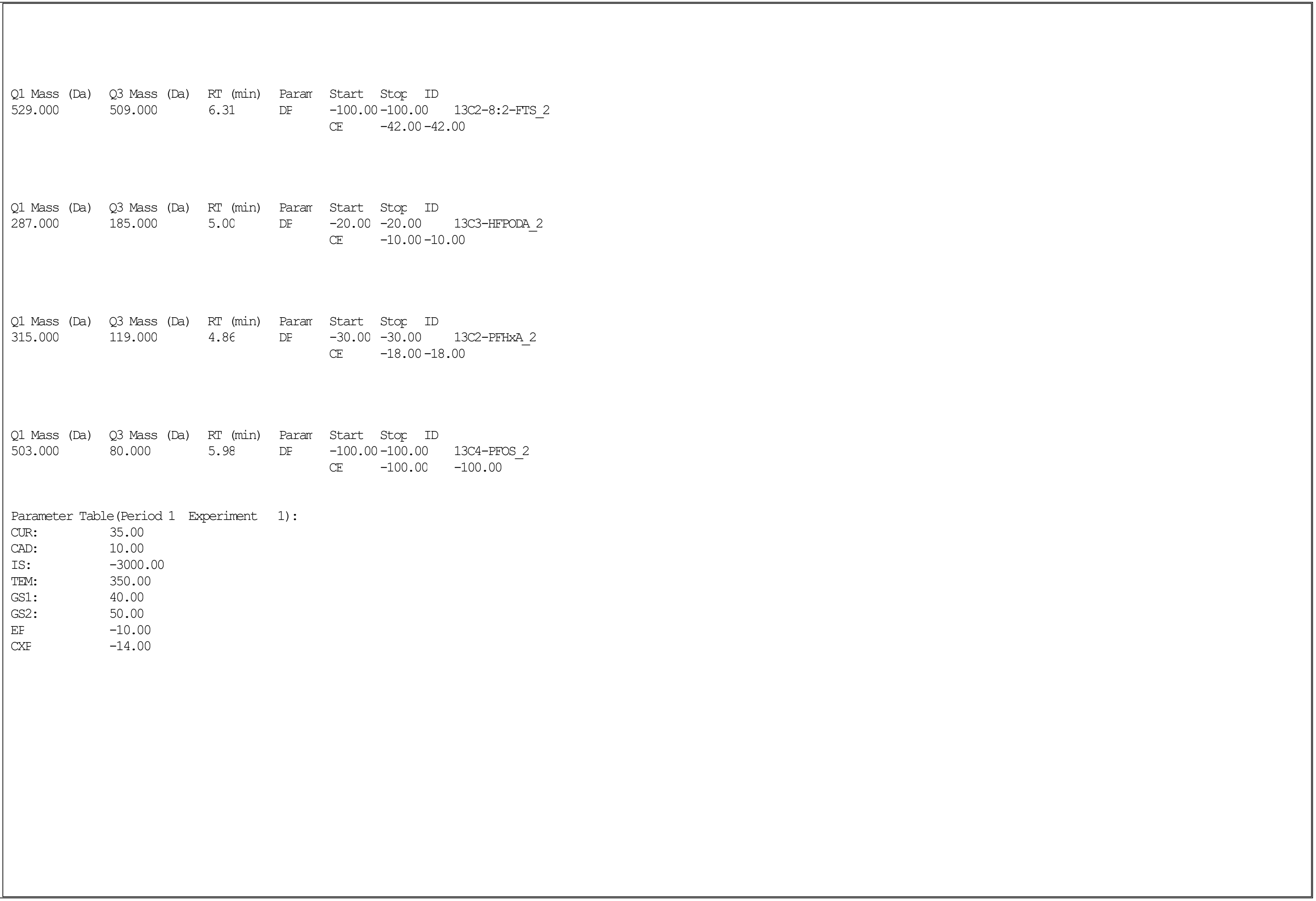
Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
402.000       99.000        5.27      DP     -100.00 -100.00    13C3-PFHxS_2
                                      CE     -80.00 -80.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
507.000       80.000        5.98      DP     -100.00 -100.00    13C8-PFOS_2
                                      CE     -100.00    -100.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
329.000       309.000       4.83      DP     -100.00 -100.00    13C2-4:2-FTS_2
                                      CE     -28.00 -28.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
429.000       409.000       5.63      DP     -100.00 -100.00    13C2-6:2-FTS_2
                                      CE     -35.00 -35.00
```

Attachment 3



```
Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
529.000       509.000       6.31      DP     -100.00-100.00   13C2-8:2-FTS_2
                                      CE     -42.00 -42.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
287.000       185.000       5.00      DP     -20.00 -20.00    13C3-HFPODA_2
                                      CE     -10.00 -10.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
315.000       119.000       4.86      DP     -30.00 -30.00    13C2-PFHxA_2
                                      CE     -18.00 -18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
503.000       80.000        5.98      DP     -100.00-100.00   13C4-PFOS_2
                                      CE     -100.00   -100.00

Parameter Table(Period 1  Experiment   1):
CUR:          35.00
CAD:          10.00
IS:           -3000.00
TEM:          350.00
GS1:          40.00
GS2:          50.00
EP            -10.00
CXP           -14.00
```

ATTACHMENT 4 ST1927333A

WELLINGTON LABORATORIES

CERTIFICATE OF ANALYSIS DOCUMENTATION

PFAC-MXC

Native Perfluorinated Compound Solution/Mixture

PRODUCT CODE:	PFAC-MXC
LOT NUMBER:	PFACMXC0617
SOLVENT(S):	Methanol / Water (<1%)
DATE PREPARED: (mm/dd/yyyy)	06/14/2017
LAST TESTED: (mm/dd/yyyy)	03/19/2019
EXPIRY DATE: (mm/dd/yyyy)	03/19/2024
RECOMMENDED STORAGE:	Store ampoule in a cool, dark place

DESCRIPTION:

PFAC-MXC is a solution/mixture of thirteen native perfluoroalkylcarboxylic acids (C_4-C_{14}, C_{16}, and C_{18}) and eight native perfluoroalkylsulfonates (C_4-C_{10} and C_{12}). The full name, abbreviation and concentration for each of the components are given in Table A.

The individual perfluoroalkylcarboxylic acids and perfluoroalkylsulfonates all have chemical purities of >98%.

DOCUMENTATION/ DATA ATTACHED:

Table A: Components and Concentrations of the Solution/Mixture
Figure 1: LC/MS Data (SIR)
Figure 2: LC/MS/MS Data (Selected MRM Transitions)

ADDITIONAL INFORMATION:

- See page 2 for further details.
- Contains 4 mole eq. of NaOH to prevent conversion of the carboxylic acids to their respective methyl esters.

FOR LABORATORY USE ONLY: NOT FOR HUMAN OR DRUG USE

INTENDED USE:

The products prepared by Wellington Laboratories Inc. are for laboratory use only. This certified reference material (CRM) was designed to be used as a standard for the identification and/or quantification of the specific chemical compounds it contains.

HANDLING:

This product should only be used by qualified personnel familiar with its potential hazards and trained in the handling of hazardous chemicals. Due care should be exercised to prevent unnecessary human contact or ingestion. All procedures should be carried out in a well-functioning fume hood and suitable gloves, eye protection, and clothing should be worn at all times. Waste should be disposed of according to national and regional regulations. Safety Data Sheets (SDSs) are available upon request.

SYNTHESIS / CHARACTERIZATION:

Our products are synthesized using single-product unambiguous routes whenever possible. They are then characterized, and their structures and purities confirmed, using a combination of the most relevant techniques, such as NMR, GC/MS, LC/MS/MS, SFC/UV/MS/MS, x-ray crystallography, and melting point. Isotopic purities of mass-labelled compounds are also confirmed using HRGC/HRMS and/or LC/MS/MS.

HOMOGENEITY:

Prior to solution preparation, crystalline material is tested for homogeneity using a variety of techniques (as stated above) and its solubility in a given diluent is taken into consideration. Duplicate solutions of a new product are prepared from the same crystalline lot and, after the addition of an appropriate internal standard, they are compared by GC/MS, LC/MS/MS, and/or SFC/UV/MS/MS. The relative response factors of the analyte of interest in each solution are required to be <5% RSD. New solution lots of existing products, as well as mixtures and calibration solutions, are compared to older lots in a similar manner. This further confirms the homogeneity of the crystalline material as well as the stability and homogeneity of the solutions in the storage containers. In order to maintain the integrity of the assigned value(s), and associated uncertainty, the dilution or injection of a subsample of this product should be performed using calibrated measuring equipment.

UNCERTAINTY:

The maximum combined relative standard uncertainty of our reference standard solutions is calculated using the following equation:

The combined relative standard uncertainty, $u_c(y)$, of a value y and the uncertainty of the independent parameters $x_1, x_2, \ldots x_n$ on which it depends is:

$$u_c(y(x_1, x_2, \ldots x_n)) = \sqrt{\sum_{i=1}^{n} u(y, x_i)^2}$$

where x is expressed as a relative standard uncertainty of the individual parameter.

The individual uncertainties taken into account include those associated with weights (calibration of the balance) and volumes (calibration of the volumetric glassware). An expanded maximum combined percent relative uncertainty of ±5% (calculated with a coverage factor of 2 and a level of confidence of 95%) is stated on the Certificate of Analysis for all of our products.

TRACEABILITY:

All reference standard solutions are traceable to specific crystalline lots. The microbalances used for solution preparation are regularly calibrated by an external ISO/IEC 17025 accredited laboratory. In addition, their calibration is verified prior to each weighing using calibrated external weights traceable to an ISO/IEC 17025 accredited laboratory. All volumetric glassware used is calibrated, of Class A tolerance, and traceable to an ISO/IEC 17025 accredited laboratory. For certain products, traceability to international interlaboratory studies has also been established.

EXPIRY DATE / PERIOD OF VALIDITY:

Ongoing stability studies of this product have demonstrated stability in its composition and concentration, until the specified expiry date, in the unopened ampoule. Monitoring for any degradation or change in concentration of the listed analyte(s) is performed on a routine basis.

LIMITED WARRANTY:

At the time of shipment, all products are warranted to be free of defects in material and workmanship and to conform to the stated technical and purity specifications.

QUALITY MANAGEMENT:

This product was produced using a Quality Management System registered to the latest versions of ISO 9001 by SAI Global, ISO/IEC 17025 by the Canadian Association for Laboratory Accreditation Inc. (CALA; A 1226), and ISO 17034 by ANSI-ASQ National Accreditation Board (ANAB; AR-1523).

CALA
Testing
Accreditation No. A 1226

ANAB
ACCREDITED
ISO 17034
REFERENCE MATERIAL PRODUCER

For additional information or assistance concerning this or any other products from Wellington Laboratories Inc., please visit our website at www.well-labs.com or contact us directly at info@well-labs.com

ATTACHMENT 4

Table A: **PFAC-MXC; Components and Concentrations (ng/ml, ± 5% in Methanol / Water (<1%))**

Compound	Abbreviation	Concentration (ng/ml)*	Peak Assignment in Figure 1
Perfluoro-n-butanoic acid	PFBA	2000	A
Perfluoro-n-pentanoic acid	PFPeA	2000	B
Perfluoro-n-hexanoic acid	PFHxA	2000	D
Perfluoro-n-heptanoic acid	PFHpA	2000	F
Perfluoro-n-octanoic acid	PFOA	2000	H
Perfluoro-n-nonanoic acid	PFNA	2000	J
Perfluoro-n-decanoic acid	PFDA	2000	L
Perfluoro-n-undecanoic acid	PFUdA	2000	N
Perfluoro-n-dodecanoic acid	PFDoA	2000	P
Perfluoro-n-tridecanoic acid	PFTrDA	2000	Q
Perfluoro-n-tetradecanoic acid	PFTeDA	2000	S
Perfluoro-n-hexadecanoic acid	PFHxDA	2000	T
Perfluoro-n-octadecanoic acid	PFODA	2000	U

Compound	Abbreviation	Concentration (ng/ml)*		Peak Assignment in Figure 1
		As the salt	As the anion	
Potassium perfluoro-1-butanesulfonate	L-PFBS	2000	1770	C
Sodium perfluoro-1-pentanesulfonate	L-PFPeS	2000	1880	E
Sodium perfluoro-1-hexanesulfonate	L-PFHxS	2000	1890	G
Sodium perfluoro-1-heptanesulfonate	L-PFHpS	2000	1900	I
Sodium perfluoro-1-octanesulfonate	L-PFOS	2000	1910	K
Sodium perfluoro-1-nonanesulfonate	L-PFNS	2000	1920	M
Sodium perfluoro-1-decanesulfonate	L-PFDS	2000	1930	O
Sodium perfluoro-1-dodecanesulfonate	L-PFDoS	2000	1940	R

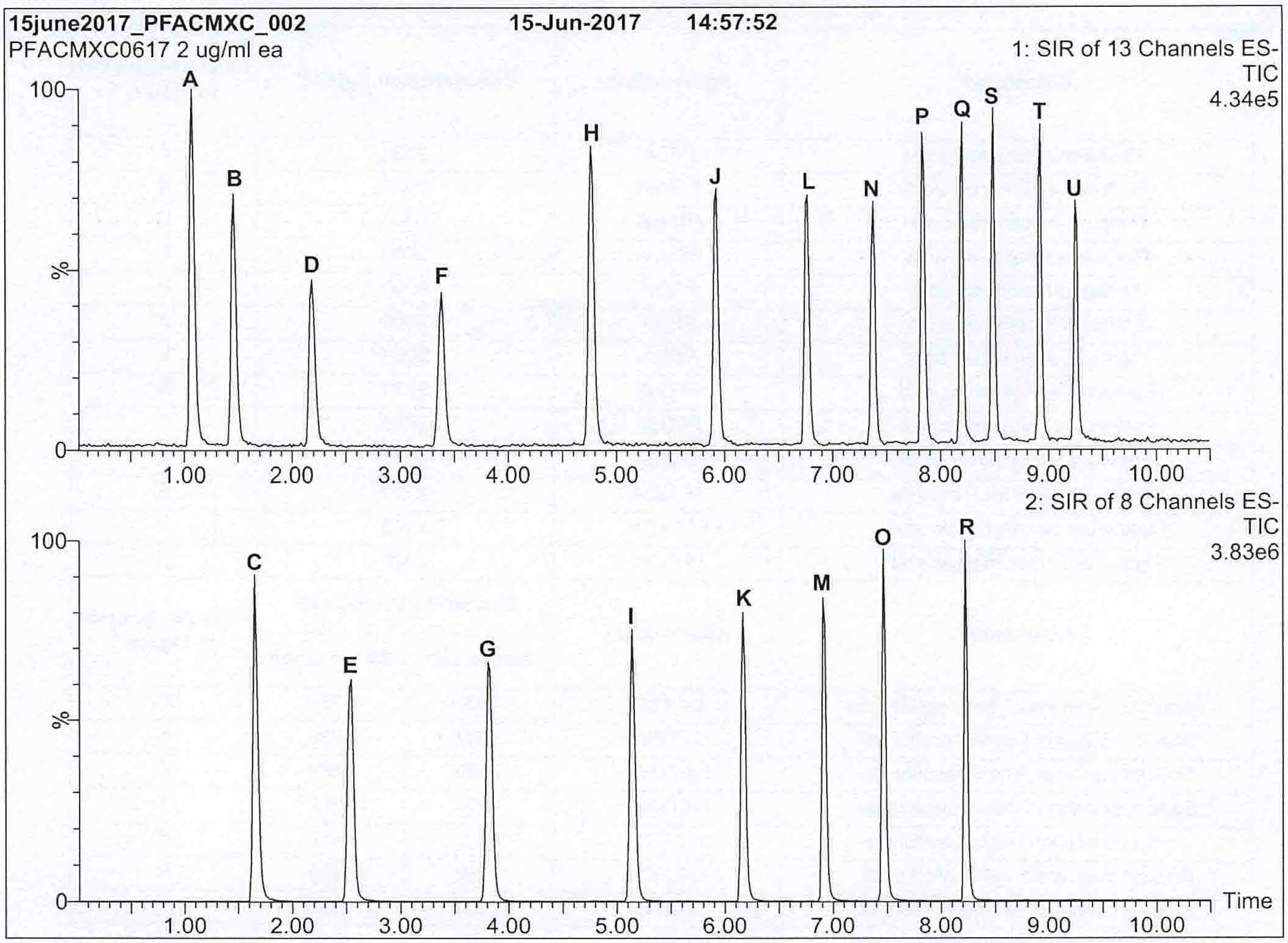
* Concentrations have been rounded to three significant figures.

Certified By: ____________________ **Date:** 06/06/2019
(mm/dd/yyyy)

B.G. Chittim, General Manager

ATTACHMENT 4

Figure 1: **PFAC-MXC; LC/MS Data (Total Ion Current Chromatogram; SIR)**



Conditions for Figure 1:

LC: **Waters Acquity Ultra Performance LC**
MS: **Micromass Quattro *micro* API MS**

Chromatographic Conditions

Column: Acquity UPLC BEH Shield RP_{18}
1.7 µm, 2.1 x 100 mm

Mobile phase: Gradient
Start: 50% H_2O / 50% (80:20 MeOH:ACN)
(both with 10 mM NH_4OAc buffer)
Ramp to 90% organic over 8 min and hold for 2 min
before returning to initial conditions in 1 min.

Time: 12 min

Flow: 300 µl/min

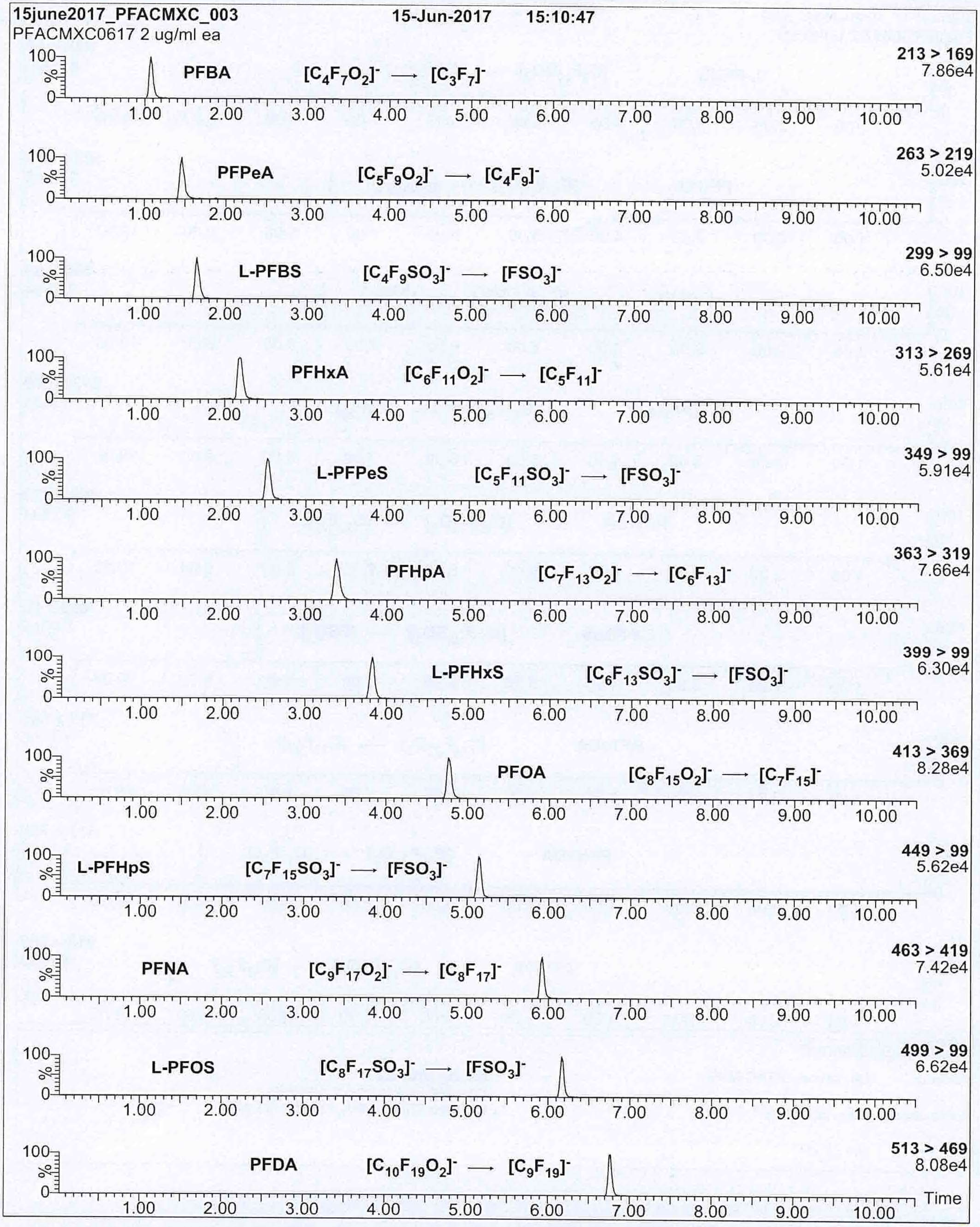
MS Parameters

Experiment: SIR of 21 Channels

Source: Electrospray (negative)
Capillary Voltage (kV) = 3.00
Cone Voltage (V) = variable (10-80)
Cone Gas Flow (l/hr) = 50
Desolvation Gas Flow (l/hr) = 750

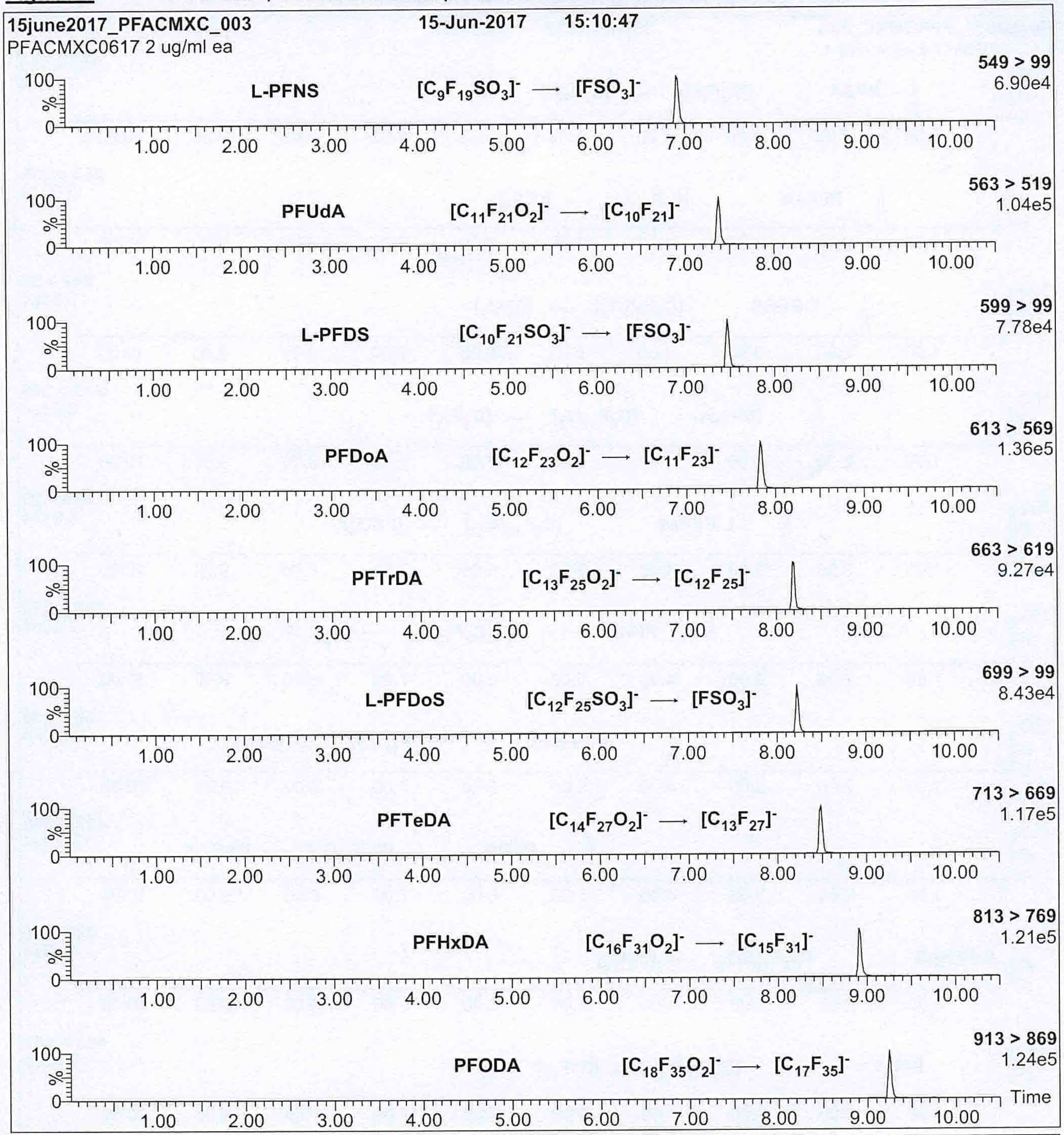
ATTACHMENT 4

Figure 2: PFAC-MXC; LC/MS/MS Data (Selected MRM Transitions)



ATTACHMENT 4

Figure 2: **PFAC-MXC; LC/MS/MS Data (Selected MRM Transitions)**



Conditions for Figure 2:

Injection: On-column (PFAC-MXC)

Mobile phase: Same as Figure 1

Flow: 300 µl/min

MS Parameters
Collision Gas (mbar) = 3.46e-3
Collision Energy (eV) = 8-50 (variable)

Native PFAS Intermediate A								
Vendor	Catalog Number	Analyte	CAS#	Acronym	Conc. (ng/mL)	Aliquot (mL)	Final Volume (ml) Methanol	Final Conc. Native PFAS Intermediate A (ng/ml)
Wellington	PFAC-MXF	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9	11Cl-PF3OUdS	1890	0.10	2	94.5
		9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1	9Cl-PF3ONS	1870			93.5
		4,8-dioxa-3H-Perfluorononanoic acid	919005-14-4	DONA	1890			94.5
		Perfluoro(2-propxypropanoic) acid	13252-13-6	HFPODA	2000			100
Wellington	PFAC-MXH	1H,1H,2H,2H perfluorodecanesulfonic acid	39108-34-4	8:2-FTS	3840	0.05		96
		1H,1H,2H,2H perfluorohexanesulfonic acid	757124-72-4	4:2-FTS	3750			93.8
		1H,1H,2H,2H perfluorooctanesulfonic acid	27619-97-2	6:2-FTS	3800			95
		N-ethylperfluorooctanesulfonamidoacetic acid	2991-50-6	NEtFOSAA	1000			25
		N-methylperfluorooctanesulfonamidoacetic acid	2355-31-9	NMeFOSAA	1000			25
		Perfluorobutanesulfonic acid	375-73-5	PFBS	887			22.2
		Perfluorobutanoic acid	375-22-4	PFBA	4000			100
		Perfluorodecanesulfonic acid	335-77-3	PFDS	965			24.1
		Perfluorodecanoic acid	335-76-2	PFDA	1000			25
		Perfluorododecanesulfonic acid	79780-39-5	PFDoDS	970			24.3
		Perfluorododecanoic acid	307-55-1	PFDoDA	1000			25
		Perfluoroheptanesulfonic acid	375-92-8	PFHpS	953			23.8
		Perfluoroheptanoic acid	375-85-9	PFHpA	1000			25
		Perfluorohexanesulfonic acid	355-46-4	PFHxS	914			22.9
		Perfluorohexanoic acid	307-24-4	PFHxA	1000			25
		Perfluorononanesulfonic acid	68259-12-1	PFNS	962			24.1
		Perfluorononanoic acid	375-95-1	PFNA	1000			25
		Perfluorooctanesulfonamide	754-91-6	PFOSA	1000			25
		Perfluorooctanesulfonic acid	1763-23-1	PFOS	928			23.2
		Perfluorooctanoic acid	335-67-1	PFOA	1000			25
		Perfluoropentanesulfonic acid	2706-91-4	PFPeS	941			23.5
		Perfluoropentanoic acid	2706-90-3	PFPeA	2000			50
		Perfluorotetradecanoic acid	376-06-7	PFTeDA	1000			25
		Perfluorotridecanoic acid	72629-94-8	PFTrDA	1000			25
		Perfluoroundecanoic acid	2058-94-8	PFUnDA	1000			25
Wellington	PFAC-MXG	Perfluoro-3-methoxypropanoic acid	377-73-1	PFMPA	2000	0.05		50
		Perfluoro-4-methoxybutanoic acid	863090-89-5	PFMBA	2000			50
		Nonafluoro-3,6-dioxaheptanoic acid	151722-58-6	NFDHA	2000			50
		Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	PFEESA	1780			44.5
Wellington	PFAC-MXI	2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	24448-09-7	NMePFOSAE	10000	0.05		250
		N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	1000			25
		2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	1691-99-2	NEtPFOSAE	10000			250
		N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	1000			25

Native PFAS Intermediate B								
Vendor	Catalog Number	Analyte	CAS#	Acronym	Conc. (ug/mL)	Aliquot (mL)	Final Volume (ml) Methanol	Final Conc. Native PFAS Intermediate B (ug/ml)
Wellington	PFAC-MXJ	3-Perfluoropropylpropanoic acid	763051-92-9	3:3 FTCA	4	0.125	5	100
		3-Perfluoropentylpropanoic acid	756426-58-1	5:3 FTCA	20			500
		3-Perfluoroheptylpropanoic acid	919005-14-4	7:3 FTCA	20			500

Working Labeled Extraction Standard Spike*							
Solution Name	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/mL)**	**Aliquot (mL)**	**Final Volume**	**Final Conc. Working Labeled Extraction Standard Spike (ng/ml)**
Mass-Labelled PFAS Extraction Standard Solution/Mixture-ES*	Perfluoro-n-[^{13}C4]butanoic acid	STL00992	^{13}C4-PFBA	2000	1	1	2000
	Perfluoro-n-[^{13}C5]pentanoic acid	STL01893	^{13}C5-PFPeA	1000			1000
	Perfluoro-n-[1,2,3,4,6-^{13}C5]hexanoic acid	STL02577	^{13}C5 -PFHxA	500			500
	Perfluoro-n-[1,2,3,4-^{13}C4]heptanoic acid	STL01892	^{13}C4-PFHpA	500			500
	Perfluoro-n-[^{13}C8]octanoic acid	STL01052	^{13}C8-PFOA	500			500
	Perfluoro-n-[^{13}C9]nonanoic acid	STL02578	^{13}C9-PFNA	250			250
	Perfluoro-n-[1,2,3,4,5,6-^{13}C6]decanoic acid	STL02579	^{13}C6-PFDA	250			250
	Perfluoro-n-[1,2,3,4,5,6,7-^{13}C7]undecanoic acid	STL02580	^{13}C7-PFUnA	250			250
	Perfluoro-n-[1,2-^{13}C2]dodecanoic acid	STL02703	^{13}C2-PFDoA	250			250
	Perfluoro-n-[1,2-^{13}C2]tetradecanoic acid	STL02116	^{13}C2-PFTeDA	250			250
	Perfluoro-1-[2,3,4-^{13}C3]butanesulfonic acid	STL02337	^{13}C3-PFBS	466			466
	Perfluoro-1-[1,2,3-^{13}C3]hexanesulfonic acid	STL02581	^{13}C3-PFHxS	474			474
	Perfluoro-1-[^{13}C8]octanesulfonic acid	STL01054	^{13}C8-PFOS	479			479
	Perfluoro-1-[^{13}C8]octanesulfonamide	STL01056	^{13}C8 -PFOSA	500			500
	N-methyl-d3-perfluoro-1-octanesulfonamido acetic acid	STL02118	D3-NMeFOSAA	1000			1000
	N-ethyl-d5-perfluoro-1-octanesulfonamido acetic acid	STL02117	D5-NEtFOSAA	1000			1000
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]hexan sulfonic acid	STL02395	^{13}C2-4:2FTS	938			938
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]octanesulfonic acid	STL02279	^{13}C2-6:2FTS	951			951
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]decanesulfonic acid	STL02280	^{13}C2-8:2FTS	960			960
	Tetrafluoro-2-heptafluoropropoxy-^{13}C3-propanoic acid	STL02255	^{13}C3-HFPO-DA	2000			2000
	N-methyl-d7-perfluorooctanesulfonamidoethanol	STL02277	D7-NMeFOSE	5000			5000
	N-ethyl-d9-perfluorooctanesulfonamidoethanol	STL02278	D9-NEtFOSE	5000			5000
	N-ethyl-d5-perfluoro-1-octanesulfonamide	STL02704	D5-NEtFOSA	500			500
	N-methyl-d3-perfluoro-1-octanesulfonamide	STL02705	D3-NMeFOSA	500			500

* Solution used without dilution for spiking. Entered into LIMS as a 1:1 dilution to utilize the standardized naming

Internal Standard Spike				
Solution Name	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/mL)**
Mass-Labelled PFAS Injection Standard Solution/Mixture	Perfluoro-n-[2,3,4-^{13}C3]butanoic acid	STL02680	^{13}C3-PFBA	1000
	Perfluoro-n-[1,2,3,4-^{13}C4]octanoic acid	STL00990	^{13}C4-PFOA	500
	Perfluoro-n-[1,2-^{13}C2]decanoic acid	STL00996	^{13}C2-PFDA	250
	Perfluoro-n-[1,2,3,4-^{13}C4]octanesulfonic acid	STL00991	^{13}C4-PFOS	479
	Perfluoro-n-[1,2,3,4,5-^{13}C5] nonanoic acid	STL00995	^{13}C5-PFNA	250
	Perfluoro-n-[1,2-^{13}C2]hexanoic acid	STL00993	^{13}C2-PFHxA	500
	Perfluoro-1-hexane[^{18}O2]sulfonic acid	STL00994	^{18}O2-PFHxS	474

Native 1633 Mid-Level Spike

Vendor	Catalog Number	Analyte	CAS#	Acronym	Conc. (ng/mL)	Aliquot (mL)	Final Volume	Final Conc. Native 1633 Mid-Level Spike (ng/ml)
Wellington	PFAC-MXF	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9	11Cl-PF3OUdS	1890	0.625	5mL Methanol	236.25
		9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1	9Cl-PF3ONS	1870			233.75
		4,8-dioxa-3H-Perfluorononanoic acid	919005-14-4	DONA	1890			236.25
		Perfluoro(2-propxypropanoic) acid	13252-13-6	HFPODA	2000			250
Wellington	PFAC-MXH	1H,1H,2H,2H perfluorodecanesulfonic acid	39108-34-4	8:2-FTS	3840	0.313		240.38
		1H,1H,2H,2H perfluorohexanesulfonic acid	757124-72-4	4:2-FTS	3750			234.75
		1H,1H,2H,2H perfluorooctanesulfonic acid	27619-97-2	6:2-FTS	3800			237.88
		N-ethylperfluorooctanesulfonamidoacetic acid	2991-50-6	NEtFOSAA	1000			62.6
		N-methylperfluorooctanesulfonamidoacetic acid	2355-31-9	NMeFOSAA	1000			62.6
		Perfluorobutanesulfonic acid	375-73-5	PFBS	887			55.53
		Perfluorobutanoic acid	375-22-4	PFBA	4000			250.4
		Perfluorodecanesulfonic acid	335-77-3	PFDS	965			60.41
		Perfluorodecanoic acid	335-76-2	PFDA	1000			62.6
		Perfluorododecanesulfonic acid	79780-39-5	PFDoDS	970			60.72
		Perfluorododecanoic acid	307-55-1	PFDoDA	1000			62.6
		Perfluoroheptanesulfonic acid	375-92-8	PFHpS	953			59.66
		Perfluoroheptanoic acid	375-85-9	PFHpA	1000			62.6
		Perfluorohexanesulfonic acid	355-46-4	PFHxS	914			57.22
		Perfluorohexanoic acid	307-24-4	PFHxA	1000			62.6
		Perfluorononanesulfonic acid	68259-12-1	PFNS	962			60.22
		Perfluorononanoic acid	375-95-1	PFNA	1000			62.6
		Perfluorooctanesulfonamide	754-91-6	PFOSA	1000			62.6
		Perfluorooctanesulfonic acid	1763-23-1	PFOS	928			58.09
		Perfluorooctanoic acid	335-67-1	PFOA	1000			62.6
		Perfluoropentanesulfonic acid	2706-91-4	PFPeS	941			58.91
		Perfluoropentanoic acid	2706-90-3	PFPeA	2000			125.2
		Perfluorotetradecanoic acid	376-06-7	PFTeDA	1000			62.6
		Perfluorotridecanoic acid	72629-94-8	PFTrDA	1000			62.6
		Perfluoroundecanoic acid	2058-94-8	PFUnDA	1000			62.6
Wellington	PFAC-MXG	Perfluoro-3-methoxypropanoic acid	377-73-1	PFMPA	2000	0.313		125.2
		Perfluoro-4-methoxybutanoic acid	863090-89-5	PFMBA	2000			125.2
		Nonafluoro-3,6-dioxaheptanoic acid	151722-58-6	NFDHA	2000			125.2
		Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	PFEESA	1780			111.4
Wellington	PFAC-MXI	2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	24448-09-7	NMePFOSAE	10000	0.313		626
		N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	1000			62.6
		2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	1691-99-2	NEtPFOSAE	10000			626
		N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	1000			62.6
Wellington	PFAC-MXJ	3-Perfluoropropylpropanoic acid	763051-92-9	3:3 FTCA	4000	0.391		312.8
		3-Perfluoropentylpropanoic acid	756426-58-1	5:3 FTCA	20000			1564
		3-Perfluoroheptylpropanoic acid	919005-14-4	7:3 FTCA	20000			1564

eurofins	Always check on-line for validity. **Analysis of Per and Polyfluoroalkyl Substances (PFAS) in Aqueous Samples by LC-MS/MS Using Draft Method 1633/QSM5.4 Table B24**	Level: **Work Instruction**
Document number: **T-PFAS-WI46412**		
Old Reference:		
Version: **2**		Organisation level: **5-Sub-BU**
Approved by: **XL3S** Effective Date: **31-AUG-2022**	Document users: **5_EUUSLA_PFAS_Manager, 6_EUUSLA_PFAS_Analyst, 6_EUUSLA_PFAS_Data_Reviewers, 6_EUUSLA_PFAS_Management_Team, 6_EUUSLA_PFAS_Sample_Prep**	Responsible: **5_EUUSLA_PFAS_Manager**

Revision Log

Revision:	2	**Effective date:** This version
Section	**Justification**	**Changes**
Revision Log	Formatting Requirement	Revision logs up to the previous version
Reference	Enhancement	Updated to 2nd version of draft june 2022
Cross Reference	Enhancement	Add T-WC-WI53304
Reagents and Standards	Reflect current practice	Remove NH4OH 5M. this is not used B.standards-updated to standarized verbiage
Attachments	Enhancement	Updated attachments 5-20 for added clarity

Revision:	2	**Effective date:** This version
Section	**Justification**	**Changes**
Procedure	Clarification/reflect current practice	B.6, change PFC_ST_XXXX to PFC_1633_SS_XXXX B.7 updated for clarity B.8 add volume of 5ml for 1:1 0.1M formic acid:MeOH rinse B.8 update drying instructions. C.6 updated example sequence Add verbiage about TSS

Revision:	1	**Effective date:** 03-JUN-2022
Section	**Justification**	**Changes**
Revision Log	NEW	NEW

Reference

1. Per- and Polyfluoroalkyl Substances (PFAS) Analysis by LC/MS/MS (EPA Draft method 1633), Department of Defense Quality System Manual Version 5.4, Table B-24.
2. US EPA Method 1633, *Analysis of Per and Polyfluoroalkyl Substances(PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS*, Version 2nd DRAFT, June 2022.
3. *Chemical Hygiene Plan*, current version.

Cross Reference

Document	Document Title
T-PFAS-WI21568	Manifold and N-EVAP Cleaning for PFAS Extractions
T-PEST-WI9847	Common Equations Used During Chromatographic Analyses

Document	Document Title
T-WC-WI53304	Total Suspended Solids (TSS Gravimetric) Prescreen by EPA Draft Method 1633 Revision 2 in Aqueous Samples
QA-SOP11178	Demonstrations of Capability
QA-SOP11892	Determining Method Detection Limits and Limits of Quantitation

Scope

This method is applicable for the determination of selected per- and polyfluorinated alkyl substances (PFAS) in aqueous samples to include non-potable waters and non-regulatory potable water when directed by the client. The compounds analyzed in this method are listed in the table below. The most current MDLs and LOQs are listed in the LIMS. Compounds other than those listed may be analyzed by client request.

Analyte	Acronym	CAS#
Perfluorobutanesulfonic acid	PFBS	375-73-5
Perfluorodecanoic acid	PFDA	335-76-2
Perfluorododecanoic acid	PFDoDA	307-55-1
Perfluoroheptanoic acid	PFHpA	375-85-9
Perfluorohexanesulfonic acid	PFHxS	355-46-4
Perfluorohexanoic acid	PFHxA	307-24-4
Perfluorononanoic acid	PFNA	375-95-1
Perfluorooctanesulfonic acid	PFOS	1763-23-1
Perfluorooctanoic acid	PFOA	335-67-1
Perfluorotetradecanoic acid	PFTeDA	376-06-7
Perfluorotridecanoic acid	PFTrDA	72629-94-8
Perfluoroundecanoic acid	PFUnDA	2058-94-8
Perfluoro-n-butanoic acid	PFBA	375-22-4
Perfluoro-n-pentanoic acid	PFPeA	2706-90-3
8:2 - Fluorotelomersulfonic acid	8:2FTS	39108-34-4

Analyte	Acronym	CAS#
N-methylperfluoro-1-octanesulfonamidoacetic acid	NMeFOSAA	2355-31-9
N-ethylperfluoro-1-octanesulfonamidoacetic acid	NEtFOSAA	2991-50-6
4:2-Fluorotelomersulfonic acid	4:2-FTS	757124-72-4
Perfluoropentanesulfonic acid	PFPeS	2706-91-4
6:2-Fluorotelomersulfonic acid	6:2-FTS	27619-97-2
Perfluoroheptanesulfonic acid	PFHpS	375-92-8
Perfluorononanesulfonic acid	PFNS	68259-12-1
Perfluorodecanesulfonic acid	PFDS	335-77-3
Perfluorododecanesulfonic acid	PFDoDS	79780-39-5
Perfluorooctanesulfonamide	PFOSA	754-91-6
2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	NMePFOSAE	24448-09-7
N-methylperfluoro-1-octanesulfonamide	NMePFOSA	31506-32-8
2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	NEtPFOSAE	1691-99-2
N-ethylperfluoro-1-octanesulfonamide	NEtPFOSA	4151-50-2
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoic acid; (Hexafluoropropylene oxide dimer acid)	HFPODA	13252-13-6
Ammonium 4,8-dioxa-3H-perfluorononanoic acid	DONA **	919005-14-4 *
Potassium 9-chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS, F53B major	756426-58-1 *
Potassium 11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS, F53B minor	763051-92-9 *
3-Perfluoropropylpropanoic acid	3:3 FTCA	356-02-5
3-Perfluoropentylpropanoic acid	5:3 FTCA	914637-49-3
3-Perfluoroheptylpropanoic acid	7:3 FTCA	812-70-4

Analyte	Acronym	CAS#
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7

*CAS# for the free acid form of the analyte

**Acronym for the free acid form of the analyte

Basic Principles

A 500-mL aqueous sample is fortified with isotopically-labeled extraction standards and is passed through a solid phase extraction (SPE) cartridge to extract the analytes. The compounds are eluted from the solid phase with a combination of solvents. Carbon cleanup is performed on each sample extract. The extract is filtered and fortified with Isotopically-labeled injection internal standards. It is then analyzed by LC/MS/MS operated in negative electrospray ionization (ESI) mode for detection and quantification of the analytes. Quantitative analysis is performed using isotope dilution.

Interferences

Compounds which have similar structures to the compounds of interest and similar molecular weights would potentially interfere. Method interferences may be caused by contaminants in solvents, reagents (including reagent water), sample bottles and caps, and other sample processing hardware that lead to discrete artifacts and/or elevated baselines in the chromatograms. The analytes in this method can also be found in many common laboratory supplies and equipment, such as PTFE (polytetrafluoroethylene) products, LC solvent lines, methanol, aluminum foil, etc. A laboratory blank is performed with each batch of samples to demonstrate that the extraction system is free of contaminants.

Precaution to Minimize Method Interference

1. LC system components contain many of the target analytes. To minimize the background PFAS peaks, PTFE solvent frits and tubing are replaced by PEEK™ solvent frits and tubing where possible.

2. A precolumn, Phenomenex Luna, 30 x 2 mm, 5 µm C18 column, is installed before the injection valve to separate PFAS in standards/samples from those from the LC system and mobile phases.

3. All part of the SPE manifold must be cleaned as per *T-PFAS-WI21568*.

Safety Precautions and Waste Handling

See *Chemical Hygiene Plan* for general information regarding employee safety, waste management, and pollution prevention.

The toxicity or carcinogenicity of each reagent used in this method has not been precisely defined. PFOA has been described as "likely to be carcinogenic to humans". Each chemical should be treated as a potential health hazard and exposure to these chemicals should be minimized.

Exposure to these chemicals must be reduced to the lowest possible level by whatever means available, such as fume hoods, lab coats, safety glasses, and gloves. Gloves, lab coats, and safety glasses should be worn when preparing standards and handling samples. Avoid inhaling solvents and chemicals and getting them on the skin. Wear gloves when handling neat materials. When working with acids and bases, take care not to come in contact and to wipe any spills. Always add acid to water when preparing reagents containing concentrated acids.

All laboratory waste is accumulated, managed, and disposed of in accordance with all Federal, State, and local laws and regulations. All solvent waste and extracts are collected in approved solvent waste containers in the laboratory and subsequently emptied by personnel trained in hazardous waste disposal into the lab-wide disposal facility. HPLC vials are disposed of in the lab container for waste vials, and subsequently lab packed. Any solid waste material (disposable pipettes and broken glassware, etc.) may be disposed of in the normal solid waste collection containers.

Personnel Training and Qualifications

All personnel performing this procedure must have documentation of reading, understanding, and agreeing to follow the current version of this SOP and an annual documented Demonstration of Capability (DOC).

Each chemist performing the extraction must work with an experienced employee for a period of time until they can independently perform the extraction. Also, several batches of sample extractions must be performed under the direct observation of another experienced chemist to assure the trainee is capable of independent preparation. Proficiency is measured through a documented Initial Demonstration of Capability (IDOC).

Each LC/MS/MS analyst must work with an experienced employee for a period of time until they can independently calibrate the LC/MS/MS, review and process data, and perform maintenance procedures. Proficiency is measured through a documented Initial Demonstration of Capability (IDOC).

The IDOC and DOC consist of four laboratory control samples (or alternatively, one blind sample for the DOC) that is carried through all steps of the extraction and meets the defined acceptance criteria. The criteria include the calculation of mean accuracy and standard deviation. IDOC trials are spiked at the OPR Level.

See *QA-SOP11178* for additional information on IDOC and DOC.

Sample Collection, Preservation, and Handling

A. Sample Collection

The samples are collected in 500-mL HDPE containers. The second aliquot may be collected in a smaller sample container (e.g. 250 mL or 125 mL). All sample containers must have linerless HDPE or polypropylene caps. Keep the sample sealed from time of collection until extraction.

NOTE: PFAS contamination during sampling can occur from a number of common sources, such as food packaging and certain foods and beverages. Proper hand washing and wearing nitrile gloves will aid in minimizing this type of accidental contamination of the samples.

B. Sample Storage and Shipment

1. Samples must be chilled during shipment and must not exceed 6°C during the first 48 hours after collection. Sample temperature must be confirmed to be at 0° to 6°C when the samples are received at the laboratory.

2. Samples stored in the lab must be held at a temperature of 0° to 6°C, not frozen, and protected from light until extraction. Alternatively, to meet project requirements, samples may be stored at $\leq$ -20°C and protected from light until extraction.

3. Water samples must be extracted within 28 days when stored at a temperature of 0° to 6°C, not frozen, and protected from light. Water samples must be extracted within 90 days when stored at a temperature $\leq$ -20°C and protected from light. Extracts must be analyzed within 28 days after extraction. Extracts are stored at a temperature of 0° to 6°C.

Apparatus and Equipment

A. Apparatus

1. 500 mL HDPE bottles: Scientific Specialties; #334008-blk-1, or equivalent.

2. Centrifuge tubes – 15-mL conical polypropylene with polypropylene screw caps; Fisher Scientific, Cat. No. 05-539-5 or equivalent

3. 10-mL polypropylene volumetric flask, Class A – Fisher Scientific, Cat. No. S02288 or equivalent.

4. HDPE bottles for extraction fluid storage: L; Environmental Sampling Supply, Cat. No. 1000-1902-PC.

5. Analytical Balance – Capable of weighing to 0.0001 g

6. Top-Loading Balance – Capable of weighing to 0.01 g

7. Solid phase extraction (SPE) Weak Anion Exchange ("WAX") cartridge – Agilent; Sampli-Q WAX Polymer; 150mg/6mL; Cat. # 5982-3667.

8. Large-volume SPE Reservoir (25-mL) - Millipore-Sigma; Product # 54258-U.

9. SPE Tube Adapter - Millipore-Sigma; Product # 57020-U.

10. SPE vacuum extraction manifold –"Resprep" 24-port manifold; Restek Corp catalog # 26080, or equivalent.

11. Polypropylene SPE delivery needles – Agilent; Cat. No. 12234511.

12. Centrifuge – "Q-Sep 3000"; Restek Corp. Cat. No. 26230, or equivalent, capable of a minimum rotational speed of 3000 rpm.

13. Disposable polyethylene pipette – Fisher Scientific, Cat. No. S30467-1 or equivalent.

14. Auto Pipettes – Eppendorf; capable of accurately dispensing 10- to 1000-µL. FisherScientific cat # 14-287-150, or equivalent.

15. Polypropylene pipette tips: 0-200µl. Fisher; Cat. No. 02-681-135

16. Polypropylene pipette tips: 101-1000µl. Fisher, Cat. No. 02-707-508

17. Pipettes – Disposable transfer. FisherScientific, Cat. No. 13-711-7M

18. Vortex mixer, variable speed, Fisher Scientific or equivalent.

19. N-Evap sample extract concentrator with N_2 supply and water bath for temperature control. Organomation, Inc. Cat. #11250, or equivalent.

20. Reagent Water Purification System: Capable of producing ultrapure "Type 1/Milli-Q"-grade water from in-house deionized water system. Millipore SAS; Cat. No. FTPF08831.

21. Thermo Target PP Polyspring inserts, catalog number C4010-630P

22. Agilent 9mm vial kit pack, catalog number 5190-2278, or equivalent

23. Centrifuge tubes – 50-mL conical polypropylene with polypropylene screw caps; Fisher Scientific, Cat. No. 06-443-21 or equivalent

24. Polypropylene bottles for standard storage - 4 mL; Fisher Scientific, Cat. No. 2006-9125

25. Stainless steel spatula/scoop set. Bel-Art SP Scienceware; Product # 11-865-130.

26. pH paper, range 0-14, Whatman Panpeha or equivalent, 0.5 unit readability

27. Syringe filter - Acrodisc, Syringe Filter, GHP,13 mm, 0.2 µm, Aqueous, 100/pkg, Part # WAT097962.

28. Silanized glass wool (Sigma-Alrich, Cat #20411 or equivalent

29. Disposable syringe filter, 25-mm, 0.2um Nylon membrane, PALL/Acrodisc or equivalent

30. Glass fiber filter, 47 mm, 1 um, PALL A/E or equivalent

B. Equipment

1. AB Sciex Triple Quad 4500/5500/5500 Plus Turbo V Ion Source

   ExionLC Controller
   ExionLC AC Pump
   ExionLC AC Autosampler
   Exion AC Column Oven
   Data system –Analyst 1.6.3

2. HPLC columns

   a. Analytical column: Gemini 3µm C18, 50 x 3 mm, Phenomenex Cat# 00B-4439-YO or equivalent

   b. Pre-column: Luna, 5µm C18, 50 x 3 mm, Phenomenex Cat# 00B-4252-Y0, or equivalent

Reagents and Standards

All solvents, acids, and bases are stored in glass bottles in flammable proof cabinets or pressure resistant steel drums. Solvents, acids, and bases are stored at ambient temperature for up to 1 year. All non-solvents are stored according to manufacturer's storage conditions.

A. Reagents:

1. Methanol (MeOH) – Honeywell Burdick and Jackson "Chromasolv LC-MS" grade Cat. No. BJ34966-4L or equivalent

2. Acetonitrile (ACN) – Fisher Scientific, Optima Cat. No. A955-4 or equivalent

3. Ammonium acetate – Fisher Scientific, Cat. No. A637-500 or equivalent

4. Ammonium hydroxide, 30% in water, certified ACS+ grade or equivalent, store at room temperature

5. Aqueous ammonium hydroxide (3%) – add ammonium hydroxide (10 mL, 30%) to reagent water (90 mL), store at room temperature, replace after 3 months

6. Methanolic ammonium hydroxide (1%) - add ammonium hydroxide (3.3 mL, 30%) to methanol (97 mL), store at room temperature, replace after 1 month

7. Methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid - add ammonium hydroxide (3.3 mL, 30%), reagent water (1.7 mL) and acetic acid (0.625 mL) to methanol (92 mL), store at room temperature, replace after 1 month.

8. Acetic Acid – ACS grade or equivalent, store at room temperature

9. Acetic Acid (0.1%) – dissolve acetic acid (1 mL) in reagent water (1 L), store at room temperature, replace after 3 months.

10. Formic acid

    a. Formic acid (aqueous, 0.1 M) - dissolve formic acid (4.6 g) in reagent water (1 L), store at room temperature, replace after 2 years

    b. Formic acid (aqueous, 0.3 M) - dissolve formic acid (13.8 g) in reagent water (1 L), store at room temperature, replace after 2 years

    c. Formic acid (aqueous, 5% v/v) - mix 5 mL formic acid with 95 mL reagent water, store at room temperature, replace after 2 years

    d. Formic acid (aqueous, 50% v/v) - mix 50 mL formic acid with 50 mL reagent water, store at room temperature, replace after 2 years

    e. Formic acid (methanolic 1:1, 0.1 M formic acid/methanol) - mix equal volumes of methanol and 0.1 M formic acid, store at room temperature, replace after 2 years

11. "Superclean Envi-Carb"; bulk sorbent. Millipore-Sigma; 50g; Product # 57210-U.

12. 20 mM ammonium acetate solution in 95:5(v/v) Milli-Q water/acetonitrile-Weigh 3.08 ± 0.01g ammonium acetate into a 2-L glass mobile phase bottle. Add 1900 mL Milli-Q water and mix well to dissolve the ammonium acetate. Add 100 mL acetonitrile and mix well. Store at room temperature for up to 2 months. Different volumes can be prepared as long as final concentrations are equivalent.

13. 20 mM ammonium acetate solution in 90:10 acetonitrile/Milli-Q water – Weigh 3.08 ± 0.01g ammonium acetate into a 2-L glass mobile phase bottle. Add 200 mL of Milli-Q water and mix well to dissolve the Ammonium Acetate. Add 1800 mL of acetonitrile and mix well. Store at room temperature for up to 2 months. Different volumes can be prepared as long as final concentrations are equivalent.

B. Standards:

Standards are prepared using calibrated pipettes, polypropylene microcentrifuge tubes, polypropylene bottles, and 10 ml Class A PP volumetric flasks to create solutions at desired concentrations. The concentrated solution is injected below the surface of the diluting solvent. After preparation is completed, standards should be vortexed to ensure complete mixing. Measurement of volumes less than 5 µl should be avoided in routine production operations.

All stock, intermediate and spiking solutions are prepared using Methanol.

All initial calibration, initial calibration verification, and linear branched working standard solutions are prepared using Methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid.

All diluted solutions must be stored in HDPE containers that have been thoroughly rinsed with methanol.

Stock standard and intermediate standard solutions are stored in the refrigerator in labeled polypropylene screw-top vials, PP bottles, or PP centrifuge tubes.

Expiration dates are managed through LIMS Reagent. Solutions transferred from sealed glass ampules to screw-capped vials are given expiration dates of 1 year from the date opened or the expiration date provided by the vendor, whichever occurs sooner. Intermediate solutions are given an expiration date of 6 months from the preparation date, or the expiration date from the ampule provided by the vendor, whichever occurs sooner. The ampules and transferred solutions are stored in the refrigerator.

Working native and labeled (extraction surrogate and internal standard) compound spiking solutions are given an expiration date of 6 months, or the expiration date of the solutions used to prepare the working solution, whichever occurs sooner. The solutions are stored in labeled polypropylene screw-top vials in the refrigerator. When these solutions are prepared they must be tested prior to use in the PFAS extraction lab and verified monthly until they are consumed by operations or expire. Records of the standard verification are maintained by the laboratory. Prior to use, the working spiking solution should be evaluated against recovery windows of 85-115% for all compounds that will be analyzed using that solution. Should a standard fail to meet these criteria, the data must be reviewed by departmental management for acceptability and/or corrective action.

Working initial calibration solutions are given an expiration date of 6 months, or the expiration date of the solutions used to prepare the working initial calibration solution, whichever occurs sooner.

The primary/preferred standard vendor is Wellington Laboratories, Inc. Ontario, Canada. Listed catalog numbers are taken from Wellington product lists. Equivalent standards may be substituted, if the listed standards are unavailable.

The solution concentration listed is as presented on the certificate of analysis and includes adjustment for purity and the salt form of the compound used.

Note: The concentrations referenced for the sulfonate salts, (for example PFBS, PFHxS and PFOS) have already been corrected to the acid form by the standards supplier as noted in the example Certificate of analysis (CofA). See *Attachment 4*.
If the compound purity is assayed to be 96% or greater, weight can be used without correction to calculate concentrations.

Log purchased standards into LIMS Reagent. Select the solution category SOURCE for purchased mixes and/or single-compound ampules. LIMS Reagent system will assign formatted names to the purchased standard solutions. The automatically-generated name can be overwritten with a manually created name if desired. Use labels printed through the LIMS Reagent to identify and track standard solutions after transfer from original ampule to storage vial. The CofA for the ampulated stock standard is attached in LIMS Reagent for reference.

Standards are prepared by transferring a known quantity of Standard to a final volume of solvent. Standard Preparation is documented in LIMS Reagent. Solutions are stored by Type in LIMS Reagent, i.e., INTERMEDIATE=working solutions and intermediate standards and SOURCE=stocks (ampulated solutions). Each Standard is given a unique name.

The following attachments provide examples of standard preparation and purchasing information. Refer to the documentation in LIMS Reagent for standards preparation information.

Attachment 5 - Native PFAS Intermediate A
Attachment 6 - Native PFAS Intermediate B
Attachment 7 - Working Labeled Extraction Standard Spike
Attachment 8 - Internal Standard Spike
Attachment 9 - Native 1633 Mid-Level Spike
Attachment 10 - Native 1633 Low-Level Spike
Attachment 11 - 1633 Initial Calibration Standards Preparation
Attachment 12 - 1633 Initial calibration Standards Concentrations

Attachment 13 - TDCA Stock Solution
Attachment 14 - TDCA Working Solution A
Attachment 15 - TDCA Working Solution B
Attachment 16 - 1633 Linear/Branched TDCA Intermediate
Attachment 17 - 1633 Linear/Branched TDCA Solution
Attachment 18 - PFAS 1633 ICV Working Standard
Attachment 19 - 1633 Labeled Ampulated Standards
Attachment 20 - 1633 Native Ampulated Standards

Calibration

A. Initial Calibration

1. A minimum of six calibration standards are required when using an average or linear curve fit. A minimum of seven calibration standards are required for a second-order curve fit. In general, Cal1, Cal2, Cal3, Cal4, Cal5, Cal6, and Cal7 are included in the initial calibration. The calibration standards contain the branched isomers for PFHxS, PFOS, NMeFOSAA, and NEtFOSAA. S/N ratio must be greater than or equal to 3:1 for all ions used for quantification.

2. Analyze a Cal4 level standard that contains TDCA retention time marker and linear and branch chained isomers of PFOA, PFNA, PFOSA, NMeFOSA, NEtFOSA, NMeFOSE, and NEtFOSE. The analysis of this standard is used to evaluate the interference from bile salts in tissue samples, as well as evaluate where the branch chained isomers elute and not included in the calibration curve. This will assist the chemist in identifying and properly integrating this compound in samples.

   Example Initial Calibration Sequence:
    1. Instrument Blank
    2. Instrument Blank
    3. Instrument Blank
    4. CAL 1
    5. CAL 2
    6. CAL 3
    7. CAL 4
    8. CAL 5
    9. CAL 6
    10. CAL 7
    11. ICB (Instrument Blank)
    12. ICV
    13. MDL
    14. WDM (Linear Branched/TDCA standard)

3. Isotopically-labeled compounds are not available for some compounds. See below for compounds and their referenced extraction standards. See *Attachment 2* for additional information about compound relationships.

4. Analyze a standard at a concentration of 100 ppb containing Taurodeoxycholic Acid (TDCA). The analysis of this standard is used to evaluate the chromatographic program relative to the risk of an interference from bile salts in tissue samples. The analytical conditions must be set to allow a separation of at least 1 minute between the bile salts and PFOS.

   NOTE: For better accuracy, PFTrDA is quantitated using the average of the areas of labeled compounds 13C2-PFTeDA and 13C2-PFDoDA.

Compound	Extraction Standard
PFBA	13C4-PFBA
PFPeA	13C5-PFPeA
3:3FTCA	
PFMPA	
PFMBA	
PFHxA	13C5-PFHxA
NFDHA	
5:3FTCA	
7:3FTCA	
PFEESA	
PFHpA	13C4-PFHpA
PFOA	13C8-PFOA
PFNA	13C9-PFNA
PFDA	13C6-PFDA
PFUnA	13C7-PFUnA
PFDoA	13C2-PFDoA
PFTrDA	Avg 13C2-PFTeDA and 13C2-PFDoA
PFTeDA	13C2-PFTeDA
PFBS	13C3-PFBS

PFPeS	13C3-PFHxS
PFHxS	
PFHpS	13C8-PFOS
PFOS	
PFNS	
PFDS	
PFDoS	
4:2-FTS	13C2-4:2-FTS
6:2-FTS	13C2-6:2-FTS
8:2-FTS	13C2-8:2-FTS
PFOSA	13C8-PFOSA
NMeFOSA	D3-NMeFOSA
NEtFOSA	D5-NEtFOSA
NMeFOSAA	D3-NMeFOSAA
NEtFOSAA	D5-N-EtFOSAA
NMeFOSE	D7-NMeFOSE
NEtFOSE	D9-NEtFOSE
HFPO-DA	13C3-HFPO-DA
DONA	
9Cl-PF3ONS	
11Cl-PF3OUdS	

5. Fit the curve

   a. If the %RSD for the response factors is less than or equal to 20%, the average response factor (Ave RRF) can be used to quantitate the data.

   b. If the %RSD is greater than 20%, a linear regression with a concentration weighing factor of 1/x is tried for the compounds not meeting the criteria in 5.a. The RSE for all method analytes must be less than or equal to 20%.

c. For all curve fits, each calibration point is calculated back against the curve. The back calculated concentration for each calibration point should be within ±30% of its true value.

d. If the criteria are not met, the source of the problem must be determined and corrected. Situations may exist where the initial calibration can be used. In those cases, the data will be reported with a qualifying comment.

NOTE: The concentrations referenced for the sulfonate salts, (for example PFBS, PFHxS and PFOS) have already been corrected to the acid form by the standards supplier as noted in the example Certificate of Analysis (CofA). See *Attachment 4*.

6. Initial Calibration Verification (ICV)

A check standard prepared from a second source (ICV) is injected to confirm the validity of the calibration curve/standard. If a second source is not available, a separate preparation from the same stock by a second analyst may be used. The calculated amount for each analyte must be within ±30% of the true value. If this criteria is not met, re-inject or remake the standard. If the criteria is still not met, recalibration is necessary. Instrument maintenance may be needed prior to recalibrating.

B. Continuing calibration

1. Once the calibration curve has been established, the continuing accuracy must be verified by analysis of a continuing calibration verification (CCV) standard every ten samples and at the end of the analysis sequence. Subsequent CCV standards should use the Cal4 level standard.

2. Acceptance criteria

a. The calculated amount for each compound (native and extraction standard) in the CCV standard must be within ±30% of the true value. Samples that are not bracketed by acceptable CCV analyses must be reanalyzed. The exception to this would be if the CCV recoveries are high, indicating increased sensitivity, and there are no positive detections in the associated samples, the data may be reported with a qualifying comment. If two consecutive CCVs fail criteria for target analytes, two passing CCVs must be analyzed or the source of the problem determined and the system recalibrated before continuing sample analysis.

b. The absolute areas of the injection internal standards should be greater than 30% of the average areas measured during the initial calibration.

Procedure

All water samples should be evaluated for Total Suspended Solids(TSS) as per T-WC-WI53304. Although the full container volume of sample should be extracted, this method is applicable to aqueous samples containing up to 100mg/L of suspended solids. For samples containing > 100mg/l of suspended solids, or when unavoidable due to high levels of PFAS, smaller samples volumes may be analyzed. However, ultimately, the TSS results, visual inspection, and analyst experience are all used to determine the volume to be used to extract the sample.

A. Sample Preparation

1. Weigh sample container with contents on a calibrated top loading balance, and record the first reading in the automated prep entry system.
    a. For all samples, the full bottle must be extracted. The sample must remain in the original sample container until after spiking solutions have been added.
    b. If limited sample is submitted, spike sample in original container, then add Milli-Q water to bring to final volume of 500 mL prior to SPE extraction (see B.6 for spiking details).
2. Use a 500 mL HDPE bottle for the method blank, the laboratory control sample (LCS), and the low level laboratory control sample (LLCS). Fill each bottle with 500 mL of Milli-Q water. Record 500 mL as the volume for the batch QC samples on the batchlog.
3. Check that the pH is 6.5±0.5. If necessary, adjust the pH with 50% formic acid or ammonium hydroxide (or with 5% formic acid and 3% aqueous ammonium hydroxide).

B. Solid Phase Extraction (SPE)

1. Pack clean silanized glass wool to half the height of the WAX SPE cartridge barrel.
2. Label each SPE cartridge to correspond with each associated sample/QC piece and attach to a rinsed SPE port. Record the SPE port # for each sample/QC piece on the batchlog.
3. Condition each SPE cartridge with the following reagents in the following order without allowing the cartridges to go dry:
    a. 15 mL 1% methanolic ammonium hydroxide
    b. 5 mL 0.3M formic acid
    c. Discard conditioning eluent(s)
4. Label each sample bottle, cap and reservoir with the same number to ensure samples are not inadvertently switched during the extraction procedure (i.e.; 1,1,1; 2,2,2; 3,3,3; etc.).
5. Vortex all spike solutions prior to use.
6. Spike QC and all samples with 25 µl of Working labeled extraction standard spike solution (PFC_1633_SS_XXXXX). Spike LCS/MS/MSD with 200 µl of native 1633 mid-level spike solution

(PFC_1633_MID_XXXXX). Spike LLCS with 400 µl of native 1633 low-level spike solution (PFC_1633_LOW_XXXXX). Vortex/Shake containers to mix thoroughly.

7. Attach a 25-mL SPE reservoir to each cartridge. Load the QC and samples to their respective cartridges.
8. Rinse the walls of the reservoir with 5mL reagent water (twice) followed by 5 mL 1:1 0.1M formic acid/methanol and pass the rinses through the cartridge using vacuum. Apply full vacuum (not exceeding 20" Hg) to the cartridges and dry until they are visually similar to an unused cartridge. This may take up to 15 minutes for some cartridges. Discard the rinse solution.

9. Place labeled 15-mL polypropylene centrifuge collection tubes under each respective SPE cartridge ensuring the delivery needles to do not touch the sides of the tubes.

10. Rinse the inside of each empty sample/QC bottle with 5mL of 1% methanolic ammonium hydroxide.

11. Using a glass pipette, transfer the rinse from the bottles to the SPE reservoirs, washing the walls of the reservoirs. Set empty bottles aside to air dry.

12. Apply a slight vacuum to the manifold in order to reclaim as much solvent as possible from the SPE cartridges.

13. Disconnect the cartridge/adapter from the manifold. Remove the collection tubes.

14. Add 25 uL of concentrated acetic acid to each collection tube and vortex to mix.

15. Place each empty sample bottle on the top-loading balance and weigh. Record the second reading in the automated prep entry system. The prep entry system will calculate the sample weight. Record the calculated weight as the sample volume on the batchlog.

Note: The instrument lab chemist performs the next steps.

16. Add 10 mg of Superclean Envi-Carb to each sample and batch QC extracts using a 10 mg scoop.

17. Handshake occasionally for no more than 5 minutes. Immediately vortex and centrifuge for 10 minutes.

18. Add 25 uL of Internal Standard Spike Solution (PFC_ST_XXXXX) to a clean 15-mL polypropylene centrifuge collection tube.

19. Place a syringe filter (25-mm filter, 0.2-um nylon membrane) on a 5 mL polypropylene syringe. Take the plunger out and carefully decant the sample supernatant into the syringe barrel. Replace the plunger and filter the entire extract into the new collection tube containing the internal standard.

20. QS each sample extract using methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid solution.

21. Cap and vortex to mix.

22. Transfer a portion of the final extract to the corresponding labeled auto-sampler vial. Cap the auto-sampler vial. Samples are now ready for analysis.

23. Cap the centrifuge tube. The remaining centrifuged extracts are stored in the refrigerator for dilution or reinjection if needed.

C. LC/MS/MS Analysis

1. Mass Calibration and Tuning

   a. At instrument set up and installation, after the performance of major maintenance, or annually calibrate the mass scale of the MS with calibration compounds and procedures described by the manufacturer. The entire mass range must be calibrated.

   b. When masses fall outside of the ±0.5 amu of the true value, the instrument must be retuned using PPG according to the manufacturer's specifications. Mass assignments of the tuning standard must be within 0.5 amu of the true value. Refer to the instrument manufacturer's instructions for tuning and conditions. These values are stored in the tune file for future reference.

2. The mass spectral acquisition rate must include a minimum of 10 spectra scans across each chromatographic peak. See the AB Sciex (4500/5500/5500 Plus) Acquisition, Quantitation, Gradient, and detector condition files for the most up to date chromatographic conditions. Modifications to these conditions can be made at the discretion of the analyst to improve resolution or the chromatographic process.

3. Acquisition method: See *Attachment 3*. Mass Transitions: See *Attachment 1*.

4. Instrument Sensitivity Check (ISC) and Instrument Blanks
   a. Prior to sample analysis, an instrument sensitivity check (ISC) must be performed. The ISC standard concentration must be at the LOQ. The CAL1 standard's concentration is at the LOQ. The CAL1 standard will be analyzed. All analyte concentrations must be within ±30% of their true values for 90% of the native and isotopically labeled compounds, with the other recoveries achieving 50-150%. The signal-to-noise ratio must be greater than or equal to 3:1. If the criteria is not met, correct problem and rerun ISC. If problem persists, repeat the ICAL. No samples can be analyzed until the ISC meets acceptance criteria.

   b. Instrument blanks need to be analyzed immediately following the highest standard analyzed and daily or at the start of a sequence. The concentration of all analytes must be less than or equal to 1/2 the LOQ. If acceptance criteria are not met the calibration must be performed using a lower concentration standard for the high standard until the criteria are met.

5. Load sample vials containing standards, quality control samples, and sample extracts into autosampler tray. Allow the instrument adequate time to equilibrate to ensure the mass spec and LC have reached operating conditions (approximately 5 minutes) before the first injection. Analyze several solvent blanks clean the instrument prior to sample acquisition.

6. After the initial calibration and when analyzing samples within the same tune, inject an instrument blank, followed by the ICV, Linear branched (L/B) standard, instrument sensitivity check, CCV standard using the CAL4, qualitative identification standard (includes TDCA RT marker), Instrument blank, extraction batch QC, and samples. Bracket each set of ten samples with a CCV standard at the CAL4 level, followed by an instrument blank.

   Example Sample Sequence:
   1. Instrument blank
   2. Instrument blank
   3. Instrument blank
   4. Instrument Sensitivity Check (CCV0 _CAL1)
   5. CCV 2_CAL4
   6. Linear Branched/TDCA marker (WDM)
   7. Instrument Blank (ICB)
   8. Method Blank (MB)
   9. Low Level LCS (LLCS)
   10. LCS
   11. Sample (10 or less)
   12. CCV 3_CAL4
   13. Instrument Blank

7. After injections are completed, check all CCV recoveries and absolute areas to make sure they are within method control limits. See Calibration section B.2 for acceptance criteria. Process each chromatogram and closely evaluate all integrations, baseline anomalies, and retention time differences. If manual integrations are performed, they must be documented and a reason given for the change in integrations. The manual integrations are documented during data processing and all original integrations are reported at the end of the sample PDF file with the reason for manual integration clearly listed.

8. Quantitate results for the extraction blank. No target analytes at or above the reporting limit, at or greater than one-third the regulatory compliance limit, at or greater than one-tenth the concentration in a sample in the extraction batch, whichever is greatest, may be found in the extraction blank for acceptable batch results. If this criteria is not met, the samples must be re-extracted.

9. Calculate the recoveries of spiked analytes for the LLCS, LCS, matrix spike and matrix spike duplicate (MS/MSD) by comparing concentrations observed to the true values.

    a. LLCS, LCS, MS, extraction standard recoveries and RPDs are calculated and compared to the limits stored on the LIMS.

    b. If LLCS and LCS recoveries are acceptable, proceed to sample quantitation.

    c. If the LCS and LLCS recoveries are above QC acceptance criteria and there are no detections for the compound(s) in the associated sample(s), the data can be reported with a qualifying comment. In all other cases, the samples associated with the LCS must be reextracted.

    d. If MS/MSD recoveries are outside QC acceptance criteria, the associated data will be flagged or noted in the comments section of the report.

10. Isotopically-labeled extraction standards are added to all samples, extraction blank, LLCS/LCS, and MS/MSD prior to extraction. The recovery of the extraction standards should be within QC acceptance criteria. If the extraction standard recovery(ies) is(are) outside the QC limit(s), reextract using a reduced sample volume. If the extraction standard recovery(ies) is(are) again outside the QC limit(s), consult a supervisor to determine the appropriate course of action based on batch and sample results.

11. Isotopically-labeled injection standards are added to each QC and field sample extract prior to analysis. The absolute areas of the injection standards should be within 30-200% of the average areas measured during the initial calibration. If the internal standards are recovered outside 30-200%, consult a supervisor to determine the appropriate course of action based on batch and sample results.

12. Compare the retention times of all of the analytes, surrogates, and internals standards to the retention time from the initial calibration. The retention times should not vary from the expected retention time by more than

    a. 0.4 minutes for isotopically-labeled compounds

    b. 0.1 minutes from their analog for native compounds with an exact isotopically-labeled compound

    c. 0.4 minutes from their assigned analog for native compounds without an exact isotopically-labeled compound.

    If the retention time is outside of the criteria, the compound is considered a false positive unless it is a compound with branched isomers. Compounds with branched isomers can vary in intensity of the individual isomers that are used for reporting and must be reviewed and compared to the preceding CCV to determine if it should be reported.

13. Two ion transitions and the ion transition ratio per analyte shall be monitored and documented with the exception of 13C4-PFBA, 13C5-PFPeA, 13C4-PFHpA, 13C8-PFOA, 13C9-PFNA, 13C6-PFDA, 13C7-PFUnA, 13C2-PFDA,13C2-PFDoDA 13C2-PFTeDA, 13C8-PFOSA, D3-NMePFOSA, D5-NEtFOSAA, D3-NMeFOSAA, D5-NEtPFOSA, D7-NMePFOSAE, D9-NEtPFOSAE, 13C3-PFBA, 13C4-PFOA, 13C5-PFNA, 13C2-PFOA, 18O2-PFHxS, PFBA, PFECA F(PFMPA), PFECA A(PFMBA), NMePFOSAE, and NEtPFOSAE. The expected ion ratio for each compound is calculated by using the average of ion ratios of each compound from initial calibration standards. When an ion ratio for a compound differs from the expected ion ratio by more than 50%, a qualifier is placed on the raw data and on the sample report. No corrective action is required.

14. The linear/branch chain standard is used when assessing the correctness of the computer generated peak integrations for PFOA, PFNA, PFOSA, NMeFOSA, NEtFOSA, NMeFOSE, and NEtFOSE.

15. If the calculated concentration exceeds the calibration range of the system, determine the appropriate dilution required and dilute the extract with Methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid solution and adjust the amount of internal standard spike solution in the diluted extract. Select the dilution so that the expected EIS recoveries in the diluted extract are >5%. Extracts requiring dilutions greater than 10X should be reextracted using a reduced aliquot.

    Dilution Example 1/10: Mix 895 µl of Methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid solution with 100 µl of sample extract and 5 uL of internal standard spike solution. Vortex to mix. Using an auto-pipette, transfer an aliquot of the mixed solution into a labeled auto-sampler vial. Cap and vortex thoroughly to mix.

Calculations

1. Peak Area Ratio

$$\text{Peak Area Ratio} = \frac{\text{Analyte Response}}{\text{Labeled Analyte Response}}$$

2. On-Column Analyte Concentration using average RRF

On-column Concentration = peak area ratio ÷ AVE RRF

3. On-Column Analyte Concentration using linear curve

On-column Concentration = (peak area ratio - intercept) ÷ slope

4. Sample Concentration

   Sample concentration (ng/l) = (On-column concentration x Final Sample Volume x DF) ÷ Initial Sample Volume

5. Ion Ratio

   ion ration = (peak area or height of quantifier)/(peak area or height of qualifier)

6. See *T-PEST-WI9847* for additional calculations used to evaluate the calibrations and quality control samples.

Statistical Information/Method Performance

The LCS should contain all compounds of interest. LCS, MS, and extraction standard recoveries are compared to the limits stored on the LIMS. These limits are statistically derived when sufficient data points are available. If sufficient data points are not available to generate statistical windows advisory limits will be used.

QC parameter	Lower acceptance limit	High acceptance limit
Extracted Internal standard (EIS)	20%	150%
Non-extracted Internal Standard (NIS)	>30% of the average NIS from the initial calibration	200%
Analyte recoveries LCS/LLCS/MS/MSD	40%	150%

Note: lower acceptance limit for EIS cannot not be <20%, lower acceptance limit for analyte recovery cannot be <40%.

Historical data for MS/Ds, LCSs, measurement of uncertainty, is reviewed at least annually. Reporting limits including method detection limits (MDLs) and limits of quantitation (LOQs) are set according to EPA method requirements and are evaluated annually. Refer to *QA-SOP11892* for specific guidelines and procedures. Updates to the LIMS are made as needed by the QA Department and only as directed by the supervisor.

Quality Assurance/Quality Control

For each batch of samples extracted, a method blank and an LCS/LLCS (Milli Q water spiked with all compounds to be determined carried through the entire procedure) must be extracted and analyzed. MS/MSD is extracted only if submitted by the client. A batch is defined as the samples to be extracted on any given day, but not to exceed 20 field samples. If more than 20 samples are prepared in a day, an additional batch must be prepared.

If any client, state, or agency has more stringent QC or batching requirements, these must be followed.

Attachment:
Attachment 1 - Mass Transitions (.doc)
Attachment 10 - Native Low Level Spike (.pdf)
Attachment 11 - 1633 Initial Calibration Standards Preparation (.pdf)
Attachment 12 - 1633 Initial Calibration Standard Concentrations (.pdf)
Attachment 13 - TDCA Stock Solution (.pdf)
Attachment 14 - TDCA Working Solution A (.pdf)
Attachment 15 - TDCA Working Solution B (.pdf)
Attachment 16 - 1633 Linear Branched and TDCA Intermediate (.pdf)
Attachment 17 - 1633 Linear Branched and TDCA Solution (.pdf)
Attachment 18 - PFAS ICV Working Standard (.pdf)
Attachment 19 - 1633 Labeled Ampulated Standards (.pdf)
Attachment 2 - Standard Relationships (.docx)
Attachment 20 - 1633 Native Ampulated Standards (.pdf)
Attachment 3 - Acquisition Parameters (.pdf)
Attachment 4 - Example Certificate of Analysis (.pdf)
Attachment 5 - 1633 Native PFAS Intermediate A (.pdf)
Attachment 6 - 1633 Native PFAS Intermediate B (.pdf)
Attachment 7 - Working Labeled Extraction Standard Spike (.pdf)
Attachment 8 - Internal Standard Spike (.pdf)
Attachment 9 - Native Mid Level Spike (.pdf)

11178 Demonstrations of Capability
11892 Determining Method Detection Limits and Limits of Quantitation
21568 Manifold and N-EVAP Cleaning for PFAS Extractions
9847 Common Equations Used During Chromatographic Analyses
Attachment: Attachment 1 - Mass Transitions (doc)
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Attachment: Attachment 13 - TDCA Stock Solution (pdf)
Attachment: Attachment 14 - TDCA Working Solution A (pdf)
Attachment: Attachment 15 - TDCA Working Solution B (pdf)
Attachment: Attachment 16 - 1633 Linear Branched and TDCA Intermediate (pdf)
Attachment: Attachment 17 - 1633 Linear Branched and TDCA Solution (pdf)
Attachment: Attachment 18 - PFAS ICV Working Standard (pdf)

eurofins	Always check on-line for validity. **Analysis of Per and Polyfluoroalkyl Substances (PFAS) in Aqueous Samples by LC-MS/MS Using Draft Method 1633/QSM5.4 Table B24**	Level: **Work Instruction**
Document number: **T-PFAS-WI46412**		
Old Reference:		
Version: **2**		Organisation level: **5-Sub-BU**
Approved by: **XL3S** Effective Date: **31-AUG-2022**	Document users: **5_EUUSLA_PFAS_Manager, 6_EUUSLA_PFAS_Analyst, 6_EUUSLA_PFAS_Data_Reviewers, 6_EUUSLA_PFAS_Management_Team, 6_EUUSLA_PFAS_Sample_Prep**	Responsible: **5_EUUSLA_PFAS_Manager**

Attachment: Attachment 19 - 1633 Labeled Ampulated Standards (pdf)
Attachment: Attachment 2 - Standard Relationships (docx)
Attachment: Attachment 20 - 1633 Native Ampulated Standards (pdf)
Attachment: Attachment 3 - Acquisition Parameters (pdf)
Attachment: Attachment 4 - Example Certificate of Analysis (pdf)
Attachment: Attachment 9 - Native Mid Level Spike (pdf)

End of document

Version history

Version	Approval	Revision information	
1	20.MAY.2022		
2	31.AUG.2022		

Attachment 1

Mass Transitions AB Sciex 4500/5500/5500+

Compound	Parent Ion	Daughter Ion
13C3-PFBA	216.0	172.0
13C4-PFBA	216.8	171.9
PFBA	212.8	168.9
13C5-PFPeA	268.3	223
PFPeA	263.0	219.0
PFPeA (2)	263.0	68.9
13C3-PFBS	302.1	79.9
13C3-PFBS (2)	302.1	98.9
PFBS	298.7	79.9
PFBS (2)	298.7	98.8
13C2-4:2-FTS	329.1	80.9
13C2-4:2-FTS (2)	329.1	309.0
4:2-FTS	327.1	307.0
4:2-FTS (2)	327.1	80.9
13C2-PFHxA	315.1	270.0
13C2-PFHxA (2)	315.1	119.4
13C5-PFHxA	318.0	273.0
13C5-PFHxA (2)	318.0	120.3
PFHxA	313.0	269.0
PFHxA (2)	313.0	118.9
PFPeS	349.1	79.9
PFPeS (2)	349.1	98.9
18O2-PFHxS	403.0	83.9
13C3-PFHxS	402.1	79.9
13C3-PFHxS (2)	402.1	98.8
PFHxS	398.7	79.9
PFHxS (2)	398.7	98.9
13C4-PFHpA	367.1	322.0
PFHpA	363.1	319.0
PFHpA (2)	363.1	169.0
13C2-6:2-FTS	429.1	80.9
13C2-6:2-FTS (2)	429.1	409.0
6:2-FTS	427.1	407.0
6:2-FTS (2)	427.1	80.9
PFHpS	449.0	79.9
PFHpS (2)	449.0	98.8
13C4-PFOA	417.1	172.0

Attachment 1

Compound	Parent Ion	Daughter Ion
13C8-PFOA	421.1	376.0
PFOA	413.0	369.0
PFOA (2)	413.0	169.0
13C4-PFOS	502.8	79.9
13C4-PFOS (2)	502.8	98.9
13C8-PFOS	507.1	79.9
13C8-PFOS (2)	507.1	98.9
PFOS	498.9	79.9
PFOS (2)	498.9	98.8
13C5-PFNA	468.0	423.0
13C9-PFNA	472.1	427.0
PFNA	463.0	419.0
PFNA (2)	463.0	219.0
13C8-PFOSA	506.1	77.8
PFOSA	498.1	77.9
PFOSA (2)	498.1	478.0
PFNS	548.8	79.9
PFNS (2)	548.8	98.8
13C2-PFDA	515.1	470.1
13C6-PFDA	519.1	474.1
PFDA	512.9	469.0
PFDA (2)	512.9	219.0
13C2-8:2-FTS	529.1	80.9
13C2-8:2-FTS (2)	529.1	509.0
8:2-FTS	527.1	507.0
8:2-FTS (2)	527.1	80.8
d7-NMePFOSAE	623.2	58.9
NMePFOSAE	616.1	58.9
d3-NMePFOSA	515.0	219.0
NMEPFOSA	511.9	219.0
NMEPFOSA (2)	511.9	169.0
d3-NMeFOSAA	573.2	419.0
NMeFOSAA	570.1	419.0
NMeFOSAA (2)	570.1	483.0
d9-NEtPFOSAE	639.2	58.9
NEtPFOSAE	630.0	58.9
d5-NETPFOSA	531.1	219.0
NEtPFOSA	526.0	219.0
NEtPFOSA (2)	526.0	169.0
PFDS	599.0	79.9

Attachment 1

Compound	Parent Ion	Daughter Ion
PFDS (2)	599.0	98.8
13C7-PFUnDA	570.0	525.1
PFUnDA	563.1	519.0
PFUnDA (2)	563.1	269.1
d5-NEtFOSAA	589.2	419.0
NEtFOSAA	584.2	419.1
NEtFOSAA (2)	584.2	526.0
13C2-PFDoDA	615.1	570.0
PFDoDA	613.1	569.0
PFDoDA (2)	613.1	319.0
PFDoS	699.1	79.9
PFDoS (2)	699.1	98.8
PFTrDA	663.0	619.0
PFTrDA (2)	663.0	168.9
13C2-PFTeDA	715.2	670.0
PFTeDA	713.1	669.0
PFTeDA (2)	713.1	168.9
13C3-HFPODA	286.9	168.9
13C3-HFPODA (2)	286.9	184.9
HFPODA	284.9	168.9
HFPODA (2)	284.9	184.9
DONA	376.9	250.9
DONA (2)	376.9	84.8
9Cl-PF3ONS	530.8	351.0
9Cl-PF3ONS (2)	532.8	353.0
11Cl-PF3OUdS	630.9	450.9
11Cl-PF3OUdS (2)	632.9	452.9
PFECA B (NFDHA)	295.0	201.0
PFECA B(NFDHA) (2)	295.0	84.9
PFECA F (PFMPA)	229.0	84.9
3:3 FTCA	241.0	177.0
3:3 FTCA (2)	241.0	117.0
PFECA A (PFMBA)	279.0	85.1
PFEESA (PES)	314.8	134.9
PFEESA (PES) (2)	314.8	82.9
5:3 FTCA	341.0	237.1
5:3 FTCA (2)	341.0	217.0
7:3 FTCA	441.0	316.9
7:3 FTCA (2)	441.0	336.9

Attachment 10

Native 1633 Low-Level Spike

Solution Name	Catalog Number	Analyte	CAS#	Acronym	Conc. (ng/mL)	Aliquot (mL)	Final Volume	Final Conc. Native 1633 Low-Level Spike (ppb)
Wellington	PFAC-MXF	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9	11Cl-PF3OUdS	1890	0.05	5mL	236.250
		9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1	9Cl-PF3ONS	1870			233.750
		4,8-dioxa-3H-Perfluorononanoic acid	919005-14-4	DONA	1890			236.250
		Perfluoro(2-propxypropanoic) acid	13252-13-6	HFPODA	2000			250.000
Wellington	PFAC-MXH	1H,1H,2H,2H perfluorotelomersulfonic acid	39108-34-4	4:2-FTS	3840	0.03		480.000
		1H,1H,2H,2H perfluorotelomersulfonic acid	757124-72-4	6:2-FTS	3750			468.750
		1H,1H,2H,2H perfluorotelomersulfonate acid	27619-97-2	8:2-FTS	3800			475.000
		N-ethylperfluorooctanesulfonamidoacetic acid	2991-50-6	NEtFOSAA	1000			125.000
		N-methylperfluorooctanesulfonamidoacetic acid	2355-31-9	NMeFOSAA	1000			125.000
		Perfluorobutanesulfonic acid	375-73-5	PFBS	887			110.875
		Perfluorobutanoic acid	375-22-4	PFBA	4000			500.000
		Perfluorodecanesulfonic acid	335-77-3	PFDS	965			120.625
		Perfluorodecanoic acid	335-76-2	PFDA	1000			125.000
		Perfluorododecanesulfonic acid	79780-39-5	PFDoDS	970			121.250
		Perfluorododecanoic acid	307-55-1	PFDoDA	1000			125.000
		Perfluoroheptanesulfonic acid	375-92-8	PFHpS	953			119.125
		Perfluoroheptanoic acid	375-85-9	PFHpA	1000			125.000
		Perfluorohexanesulfonic acid	355-46-4	PFHxS	914			114.250
		Perfluorohexanoic acid	307-24-4	PFHxA	1000			125.000
		Perfluorononanesulfonic acid	68259-12-1	PFNS	962			120.250
		Perfluorononanoic acid	375-95-1	PFNA	1000			125.000
		Perfluorooctanesulfonamide	754-91-6	PFOSA	1000			125.000
		Perfluorooctanesulfonic acid	1763-23-1	PFOS	928			116.000
		Perfluorooctanoic acid	335-67-1	PFOA	1000			125.000
		Perfluoropentanesulfonic acid	2706-91-4	PFPeS	941			117.625
		Perfluoropentanoic acid	2706-90-3	PFPeA	2000			250.000
		Perfluorotetradecanoic acid	376-06-7	PFTeDA	1000			125.000
		Perfluorotridecanoic acid	72629-94-8	PFTrDA	1000			125.000
		Perfluoroundecanoic acid	2058-94-8	PFUnDA	1000			125.000
Wellington	PFAC-MXG	Perfluoro-3-methoxypropanoic acid	377-73-1	PFMPA	2000	0.03		250.000
		Perfluoro-4-methoxybutanoic acid	863090-89-5	PFMBA	2000			250.000
		Nonafluoro-3,6-dioxaheptanoic acid	151722-58-6	NFDHA	2000			250.000
		Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	PFEESA	1780			222.500
Wellington	PFAC-MXI	2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	24448-09-7	NMePFOSAE	10000	0.03		1250.000
		N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	1000			125.000
		2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	1691-99-2	NEtPFOSAE	10000			1250.000
		N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	1000			125.000
Wellington	PFAC-MXJ	3-Perfluoropropylpropanoic acid	763051-92-9	3:3 FTCA	4000	0.03		25.000
		3-Perfluoropentylpropanoic acid	756426-58-1	5:3 FTCA	20000			125.000
		3-Perfluoroheptylpropanoic acid	919005-14-4	7:3 FTCA	20000			125.000

1633 Initial Calibration Standards Preparation

Solution Name	MDL	CAL1	CAL2	CAL3	CAL4	CAL5	CAL6	CAL7
Native Replacement PFAS Solution/Mixture Aliquot (mL)	NA	NA	NA	NA	NA	0.020	0.050	0.250
Native Perfluoroalkyl Ether Carboxylic Acids and Sulfonate Solution/Mixture Aliquot (mL)	NA	NA	NA	NA	NA	0.010	0.025	0.125
Native PFAS Solution/Mixture Aliquot (mL)	NA	NA	NA	NA	NA	0.010	0.025	0.125
Native N-NMe/EtFOSA & N-Nme/EtFOSE Solution/Mixture Aliquot (mL)	NA	NA	NA	NA	NA	0.010	0.025	0.125
Native X:3 Flourotelomer Caroxylic Acid Solution/Mixture Aliquot (mL)	NA	NA	NA	NA	NA	0.0125	0.0312	0.1560
Native PFAS Intermediate A Aliquot (mL)	0.008	0.016	0.040	0.100	0.200	NA	NA	NA
Native PFAS Intermediate B Aliquot (mL)	0.010	0.020	0.050	0.125	0.250	NA	NA	NA
Mass-Labelled PFAS Injection Standard Solution/Mixture - IS Aliquot (mL)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Mass-Labelled PFAS Extraction Standard Solution/Mixture - ES Aliquot (mL)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Final Volume (mL)	**2**	2	2	2	2	2	2	2

Attachment 12

1633 Initial Calibration Standards Concentrations

	1	2	3	4	5	6	7
Compound Name	**Conc. (ppb)**	**Conc. (ppb)**	**Conc. (ppb)**	**Conc. (ppb)**	**Conc. (ppb)**	**Conc. (ppb)**	**Conc. (ppb)**
PFBA	0.8	2	5	10	20	50	250
PFPeA	0.4	1	2.5	5	10	25	125
PFHxA	0.2	0.5	1.25	2.5	5	12.5	62.5
PFHpA	0.2	0.5	1.25	2.5	5	12.5	62.5
PFOA	0.2	0.5	1.25	2.5	5	12.5	62.5
PFNA	0.2	0.5	1.25	2.5	5	12.5	62.5
PFDA	0.2	0.5	1.25	2.5	5	12.5	62.5
PFUnA	0.2	0.5	1.25	2.5	5	12.5	62.5
PFDoA	0.2	0.5	1.25	2.5	5	12.5	62.5
PFTrDA	0.2	0.5	1.25	2.5	5	12.5	62.5
PFTeDA	0.2	0.5	1.25	2.5	5	12.5	62.5
PFBS	0.2	0.5	1.25	2.5	5	12.5	62.5
PFPeS	0.2	0.5	1.25	2.5	5	12.5	62.5
PFHxS	0.2	0.5	1.25	2.5	5	12.5	62.5
PFHpS	0.2	0.5	1.25	2.5	5	12.5	62.5
PFOS	0.2	0.5	1.25	2.5	5	12.5	62.5
PFNS	0.2	0.5	1.25	2.5	5	12.5	62.5
PFDS	0.2	0.5	1.25	2.5	5	12.5	62.5
PFDoS	0.2	0.5	1.25	2.5	5	12.5	62.5
4:2FTS	0.8	2	5	10	20	50	NA
6:2FTS	0.8	2	5	10	20	50	NA
8:2FTS	0.8	2	5	10	20	50	NA
PFOSA	0.2	0.5	1.25	2.5	5	12.5	62.5
NMeFOSA	0.2	0.5	1.25	2.5	5	12.5	62.5
NEtFOSA	0.2	0.5	1.25	2.5	5	12.5	62.5
NMeFOSAA	0.2	0.5	1.25	2.5	5	12.5	62.5
NEtFOSAA	0.2	0.5	1.25	2.5	5	12.5	62.5
NMeFOSE	2	5	12.5	25	50	125	625
NEtFOSE	2	5	12.5	25	50	125	625
HFPO-DA	0.8	2	5	10	20	50	250
ADONA	0.8	2	5	10	20	50	250
PFMPA	0.4	1	2.5	5	10	25	125
PFMBA	0.4	1	2.5	5	10	25	125
NFDHA	0.4	1	2.5	5	10	25	125
9Cl-PF3ONS	0.8	2	5	10	20	50	250
11Cl-PF3OUdS	0.8	2	5	10	20	50	250
PFEESA	0.4	1	2.5	5	10	25	125
3:3FTCA	1	2.5	6.26	12.5	25	62.4	312
5:3FTCA	5	12.5	31.3	62.5	125	312	1560
7:3FTCA	5	12.5	31.3	62.5	125	312	1560
^{13}C4-PFBA	10	10	10	10	10	10	10
^{13}C5-PFPeA	5	5	5	5	5	5	5
^{13}C5-PFHxA	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C4-PFHpA	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C8-PFOA	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C9-PFNA	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C6-PFDA	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C7-PFUnA	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C2-PFDoA	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C2-PFTeDA	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C3-PFBS	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C3-PFHxS	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C8-PFOS	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C2-4:2 FTS	5	5	5	5	5	5	5
^{13}C2-6:2 FTS	5	5	5	5	5	5	5
^{13}C2-8:2 FTS	5	5	5	5	5	5	5
^{13}C8-PFOSA	2.5	2.5	2.5	2.5	2.5	2.5	2.5
D3-NMeFOSA	2.5	2.5	2.5	2.5	2.5	2.5	2.5
D5-NEtFOSA	2.5	2.5	2.5	2.5	2.5	2.5	2.5
D3-NMeFOSAA	5	5	5	5	5	5	5
D5-NEtFOSAA	5	5	5	5	5	5	5
D7-NMeFOSE	25	25	25	25	25	25	25
D9-NEtFOSE	25	25	25	25	25	25	25
^{13}C3-HFPO-DA	10	10	10	10	10	10	10
^{13}C3-PFBA	5	5	5	5	5	5	5
^{13}C2-PFHxA	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C4-PFOA	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C5-PFNA	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C2-PFDA	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{18}O2-PFHxS	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C4-PFOS	2.5	2.5	2.5	2.5	2.5	2.5	2.5

TDCA Stock Solution								
Vendor	**Catalog Number**	**Analyte**	**CAS#**	**Acronym**	**Conc. (mg)**	**Aliquot (g)**	**Final Volume**	**Final Conc. TDCA Stock Solution (ppb)**
Sigma Alrich	T0557-500MG	Sodium Taurodeoxycholate hydrate	207737-97-1	TDCA	1000000	0.05	50mL	2000000

TDCA Working Solution A							
Solution Name	Analyte	CAS#	Acronym	Conc. (ng/mg)	Aliquot (mL)	Final Volume	Final Conc. TDCA Working Solution A (ppb)
TDCA Stock Intermediate	Sodium Taurodeoxycholate hydrate	207737-97-1	TDCA	2000000	1.25	4mL	625000

TDCA Working Solution B							
Solution Name	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/mg)**	**Aliquot (mL)**	**Final Volume**	**Final Conc. TDCA Working Solution B (ppb)**
TDCA Working Solution A	Sodium Taurodeoxycholate hydrate	207737-97-1	TDCA	625000	0.16	5mL	20000

1633 Linear/Branched TDCA Intermediate								
Vendor	**Catalog Number**	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/mL)**	**Aliquot (mL)**	**Final Volume**	**Final Conc. 1633 Linear/Branched TDCA Intermediate (ppb)**
Wellington	T-PFOA	Technical Ammonium, Perfluorooctanoa te (Technical Grade)	95328-99-7TG	T-PFOA	500	0.02	2mL	500
Camridge Isotope Laboratories, Inc.	ULM-11036-S	2-(N-ethylperfluoro-1-octanesulfonamido) ethanol	1691-99-2	NEtPFOSAE	500	0.02		500
Camridge Isotope Laboratories, Inc.	ULM-11034-S	2-(N-methylperfluoro-1-octanesulfonamido) ethanol	24448-09-7	NMePFOSAE	500	0.02		500
Camridge Isotope Laboratories, Inc.	ULM-10780-S	N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	500	0.01		500
Camridge Isotope Laboratories, Inc.	ULM-10779-S	N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	500	0.01		500
Camridge Isotope Laboratories, Inc.	ULM-10977-S	Perfluorooctanesulfonamide	754-91-6	PFOSA	500	0.02		500
Wellington	ipPFNA0516	Perfluoro-7-methyloctanoic acid	15899-31-7	PF7MOA	500	0.02		500

1633 Linear/Branched TDCA Solution

Solution Name	Analyte	CAS#	Acronym	Conc. (ng/mL)	Aliquot (mL)	Final Volume	Final Conc. 1633 Linear/Branched TDCA Solution (ppb)
TDCA Working Solution B	Sodium Taurodeoxycholate hydrate	207737-97-1	TDCA	5000	0.01	2mL	25
1633 Linear/Branched TDCA Intermediate	2-(N-ethylperfluoro-1-octanesulfonamido) ethanol	1691-99-2	NEtPFOSAE	500	0.02		5
	2-(N-methylperfluoro-1-octanesulfonamido) ethanol	24448-09-7	NMePFOSAE	500			5
	N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	500			5
	N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	500			5
	Perfluorooctanesfulonamide	754-91-6	PFOSA	500			5
	Perfluoro-7-methyloctanoic acid	15899-31-7	PF7MOA	500			5

PFAS 1633 ICV Working Standard

Solution Name	Analyte	CAS#	Acronym	Conc. (ug/mL)	Aliquot (mL)	Final Volume	Final Conc. PFAS 1633 ICV Working Standard (ppb)
Native PFAS Intermediate A	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9	11Cl-PF3OUdS	94.500	0.20	2mL	9.450
	9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1	9Cl-PF3ONS	93.500			9.350
	4,8-dioxa-3H-Perfluorononanoic acid	919005-14-4	DONA	94.500			9.450
	Perfluoro(2-propxypropanoic) acid	13252-13-6	HFPODA	100.000			10.000
	1H,1H,2H,2H perfluorotelomersulfonic acid	39108-34-4	4:2-FTS	93.750			4.690
	1H,1H,2H,2H perfluorotelomersulfonic acid	757124-72-4	6:2-FTS	95.000			4.755
	1H,1H,2H,2H perfluorotelomersulfonate acid	27619-97-2	8:2-FTS	96.000			4.800
	N-ethylperfluorooctanesulfonamidoacetic acid	2991-50-6	NEtFOSAA	25.000			2.500
	N-methylperfluorooctanesulfonamidoacetic acid	2355-31-9	NMeFOSAA	25.000			2.500
	Perfluorobutanesulfonic acid	375-73-5	PFBS	22.175			2.218
	Perfluorobutanoic acid	375-22-4	PFBA	100.000			10.000
	Perfluorodecanesulfonic acid	335-77-3	PFDS	24.125			2.413
	Perfluorodecanoic acid	335-76-2	PFDA	25.000			2.500
	Perfluorododecanesulfonic acid	79780-39-5	PFDoDS	24.250			2.425
	Perfluorododecanoic acid	307-55-1	PFDoDA	25.000			2.500
	Perfluoroheptanesulfonic acid	375-92-8	PFHpS	23.825			2.383
	Perfluoroheptanoic acid	375-85-9	PFHpA	25.000			2.500
	Perfluorohexanesulfonic acid	355-46-4	PFHxS	22.850			2.285
	Perfluorohexanoic acid	307-24-4	PFHxA	25.000			2.500
	Perfluorononanesulfonic acid	68259-12-1	PFNS	24.050			2.405
	Perfluorononanoic acid	375-95-1	PFNA	25.000			2.500
	Perfluorooctanesulfonamide	754-91-6	PFOSA	25.000			2.500
	Perfluorooctanesulfonic acid	1763-23-1	PFOS	23.200			2.320
	Perfluorooctanoic acid	335-67-1	PFOA	25.000			2.500
	Perfluoropentanesulfonic acid	2706-91-4	PFPeS	23.525			2.353
	Perfluoropentanoic acid	2706-90-3	PFPeA	50.000			5.000
	Perfluorotetradecanoic acid	376-06-7	PFTeDA	25.000			2.500
	Perfluorotridecanoic acid	72629-94-8	PFTrDA	25.000			2.500
	Perfluoroundecanoic acid	2058-94-8	PFUnDA	25.000			2.500
	Perfluoro-3-methoxypropanoic acid	377-73-1	PFMPA	50.000			5.000
	Perfluoro-4-methoxybutanoic acid	863090-89-5	PFMBA	50.000			5.000
	Nonafluoro-3,6-dioxaheptanoic acid	151722-58-6	NFDHA	50.000			5.000
	Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	PFEESA	44.500			4.450
	2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	24448-09-7	NMePFOSAE	250.000			25.000
	N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	25.000			2.500
	2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	1691-99-2	NEtPFOSAE	250.000			25.000
	N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	25.000			2.500
Native PFAS Intermediate B	3-Perfluoropropylpropanoic acid	763051-92-9	3:3 FTCA	100.000	0.25		12.500
	3-Perfluoropentylpropanoic acid	756426-58-1	5:3 FTCA	500.000			62.500
	3-Perfluoroheptylpropanoic acid	919005-14-4	7:3 FTCA	500.000			62.500
MPFACHIFES	Perfluoro-n-[^{13}C4]butanoic acid	STL00992	^{13}C4-PFBA	2000	0.01		10.000
	Perfluoro-n-[^{13}C5]pentanoic acid	STL01893	^{13}C5-PFPeA	1000			5.000
	Perfluoro-n-[1,2,3,4,6-^{13}C5]hexanoic acid	STL02577	^{13}C5 -PFHxA	500			2.500
	Perfluoro-n-[1,2,3,4-^{13}C4]heptanoic acid	STL01892	^{13}C4-PFHpA	500			2.500
	Perfluoro-n-[^{13}C8]octanoic acid	STL01052	^{13}C8-PFOA	5050			2.500
	Perfluoro-n-[^{13}C9]nonanoic acid	STL02578	^{13}C9-PFNA	250			1.250
	Perfluoro-n-[1,2,3,4,5,6-^{13}C6]decanoic acid	STL02579	^{13}C6-PFDA	250			1.250
	Perfluoro-n-[1,2,3,4,5,6,7-^{13}C7]undecanoic acid	STL02580	^{13}C7-PFUnA	250			1.250
	Perfluoro-n-[1,2-^{13}C2]dodecanoic acid	STL02703	^{13}C2-PFDoA	250			1.250
	Perfluoro-n-[1,2-^{13}C2]tetradecanoic acid	STL02116	^{13}C2-PFTeDA	250			1.250
	Perfluoro-1-[2,3,4-^{13}C3]butanesulfonic acid	STL02337	^{13}C3-PFBS	466			2.330
	Perfluoro-1-[1,2,3-^{13}C3]hexanesulfonic acid	STL02581	^{13}C3-PFHxS	474			2.370
	Perfluoro-1-[^{13}C8]octanesulfonic acid	STL01054	^{13}C8-PFOS	479			2.395
	Perfluoro-1-[^{13}C8]octanesulfonamide	STL01056	^{13}C8 -PFOSA	500			2.500
	N-methyl-d3-perfluoro-1-octanesulfonamidoacetic acid	STL02118	D3-NMeFOSAA	1000			5.000
	N-ethyl-d5-perfluoro-1-octanesulfonamidoacetic acid	STL02117	D5-NEtFOSAA	1000			5.000
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]hexan sulfonic acid	STL02395	^{13}C2-4:2FTS	938			4.690
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]octanesulfonic acid	STL02279	^{13}C2-6:2FTS	951			4.755
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]decanesulfonic acid	STL02280	^{13}C2-8:2FTS	960			4.800
	Tetrafluoro-2-heptafluoropropoxy-^{13}C3-propanoic acid	STL02255	^{13}C3-HFPO-DA	2000			10.000
	N-methyl-d7-perfluorooctanesulfonamidoethanol	STL02277	D7-NMeFOSE	5000			25.000
	N-ethyl-d9-perfluorooctanesulfonamidoethanol	STL02278	D9-NEtFOSE	5000			25.000
	N-ethyl-d5-perfluoro-1-octanesulfonamide	STL02704	D5-NEtFOSA	500			5.000
	N-methyl-d3-perfluoro-1-octanesulfonamide	STL02705	D3-NMeFOSA	500			5.000
MPFACHIFES	Perfluoro-n-[2,3,4-^{13}C3]butanoic acid	STL02680	^{13}C3-PFBA	1000	0.01		5.000
	Perfluoro-n-[1,2,3,4-^{13}C4]octanoic acid	STL00990	^{13}C4-PFOA	500			2.500
	Perfluoro-n-[1,2-^{13}C2]decanoic acid	STL00996	^{13}C2-PFDA	250			1.250
	Perfluoro-n-[1,2,3,4-^{13}C4]octanesulfonic acid	STL00991	^{13}C4-PFOS	479			2.395
	Perfluoro-n-[1,2,3,4,5-^{13}C5] nonanoic acid	STL00995	^{13}C5-PFNA	250			1.250
	Perfluoro-n-[1,2-^{13}C2]hexanoic acid	STL00993	^{13}C2-PFHxA	500			2.500
	Perfluoro-1-hexane[^{18}O2]sulfonic acid	STL00994	^{18}O2-PFHxS	474			2.370

1633 Labeled Ampulated Standards						
Ampulated Solution Name	Vendor	Catalog Number	Analyte	CAS#	Acronym	Conc. (ng/mL)
MPFACHIFES	Wellington	MPFACHIFES	Perfluoro-n-[^{13}C4]butanoic acid	STL00992	^{13}C4-PFBA	2000
			Perfluoro-n-[^{13}C5]pentanoic acid	STL01893	^{13}C5-PFPeA	1000
			Perfluoro-n-[1,2,3,4,6-^{13}C5]hexanoic acid	STL02577	^{13}C5 -PFHxA	500
			Perfluoro-n-[1,2,3,4-^{13}C4]heptanoic acid	STL01892	^{13}C4-PFHpA	500
			Perfluoro-n-[^{13}C8]octanoic acid	STL01052	^{13}C8-PFOA	5050
			Perfluoro-n-[^{13}C9]nonanoic acid	STL02578	^{13}C9-PFNA	250
			Perfluoro-n-[1,2,3,4,5,6-^{13}C6]decanoic acid	STL02579	^{13}C6-PFDA	250
			Perfluoro-n-[1,2,3,4,5,6,7-^{13}C7]undecanoic acid	STL02580	^{13}C7-PFUnA	250
			Perfluoro-n-[1,2-^{13}C2]dodecanoic acid	STL02703	^{13}C2-PFDoA	250
			Perfluoro-n-[1,2-^{13}C2]tetradecanoic acid	STL02116	^{13}C2-PFTeDA	250
			Perfluoro-1-[2,3,4-^{13}C3]butanesulfonic acid	STL02337	^{13}C3-PFBS	466
			Perfluoro-1-[1,2,3-^{13}C3]hexanesulfonic acid	STL02581	^{13}C3-PFHxS	474
			Perfluoro-1-[^{13}C8]octanesulfonic acid	STL01054	^{13}C8-PFOS	479
			Perfluoro-1-[^{13}C8]octanesulfonamide	STL01056	^{13}C8 -PFOSA	500
			N-methyl-d3-perfluoro-1-octanesulfonamidoacetic acid	STL02118	D3-NMeFOSAA	1000
			N-ethyl-d5-perfluoro-1-octanesulfonamidoacetic acid	STL02117	D5-NEtFOSAA	1000
			1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]hexan sulfonic acid	STL02395	^{13}C2-4:2FTS	938
			1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]octanesulfonic acid	STL02279	^{13}C2-6:2FTS	951
			1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]decanesulfonic acid	STL02280	^{13}C2-8:2FTS	960
			Tetrafluoro-2-heptafluoropropoxy-^{13}C3-propanoic acid	STL02255	^{13}C3-HFPO-DA	2000
			N-methyl-d7-perfluorooctanesulfonamidoethanol	STL02277	D7-NMeFOSE	5000
			N-ethyl-d9-perfluorooctanesulfonamidoethanol	STL02278	D9-NEtFOSE	5000
			N-ethyl-d5-perfluoro-1-octanesulfonamide	STL02704	D5-NEtFOSA	500
			N-methyl-d3-perfluoro-1-octanesulfonamide	STL02705	D3-NMeFOSA	500
MPFACHIFES	Wellington	MPFACHIFIS	Perfluoro-n-[2,3,4-^{13}C3]butanoic acid	STL02680	^{13}C3-PFBA	1000
			Perfluoro-n-[1,2,3,4-^{13}C4]octanoic acid	STL00990	^{13}C4-PFOA	500
			Perfluoro-n-[1,2-^{13}C2]decanoic acid	STL00996	^{13}C2-PFDA	250
			Perfluoro-n-[1,2,3,4-^{13}C4]octanesulfonic acid	STL00991	^{13}C4-PFOS	479
			Perfluoro-n-[1,2,3,4,5-^{13}C5] nonanoic acid	STL00995	^{13}C5-PFNA	250
			Perfluoro-n-[1,2-^{13}C2]hexanoic acid	STL00993	^{13}C2-PFHxA	500
			Perfluoro-1-hexane[^{18}O2]sulfonic acid	STL00994	^{18}O2-PFHxS	474

Attachment 2

PFAS Injection Standards/Extraction Standards/Native Compounds

Injection Standards

Inj Std	Internal Standard/Injection Standard
I13C3-PFBA	13C3-PFBA
I13C2-PFHxA	13C2-PFHxA
I13C4-PFOA	13C4-PFOA
I13C5-PFNA	13C5-PFNA
I13C2-PFDA	13C2-PFDA
I18O2-PFHxS	18O2-PFHxS
I13C4-PFOS	13C4-PFOS

Extraction Standards

Extraction Standard	Internal Standard
E13C4-PFBA	13C3-PFBA
E13C5-PFPeA	13C2-PFHxA
E13C5-PFHxA	
E13C4-PFHpA	
E13C3-HFPO-DA	
E13C8-PFOA	13C4-PFOA
E13C9-PFNA	13C5-PFNA
E13C6-PFDA	13C2-PFDA
E13C7-PFUnA	
E13C2-PFDoA	
E13C2-PFTeDA	
E13C3-PFBS	18O2-PFHxS
E13C3-PFHxS	
E13C2-4:2-FTS	
E13C2-6:2-FTS	
E13C2-8:2-FTS	

Extraction Standard	Internal Standard
E13C8-PFOS	13C4-PFOS
E13C8-PFOSA	
Ed3-NMeFOSA	
Ed5-NEtFOSA	
Ed3-NMeFOSAA	
Ed7-NMeFOSE	
Ed9-NEtFOSE	

Native PFAS Compounds

Native	Extraction Standard
PFBA	13C4-PFBA
PFPeA	13C5-PFPeA
3:3FTCA	
PFMPA	
PFMBA	
PFHxA	13C5-PFHxA
NFDHA	
5:3FTCA	
7:3FTCA	
PFEESA	
PFHpA	13C4-PFHpA
PFOA	13C8-PFOA
PFNA	13C9-PFNA
PFDA	13C6-PFDA
PFUnA	13C7-PFUnA
PFDoA	13C2-PFDoA
PFTrDA	Avg 13C2-PFTeDA and 13C2-PFDoA
PFTeDA	13C2-PFTeDA
PFBS	13C3-PFBS
PFPeS	13C3-PFHxS
PFHxS	
PFHpS	13C8-PFOS
PFOS	
PFNS	
PFDS	
PFDoS	

Native	**Extraction Standard**
4:2-FTS	13C2-4:2-FTS
6:2-FTS	13C2-6:2-FTS
8:2-FTS	13C2-8:2-FTS
PFOSA	13C8-PFOSA
NMeFOSA	D3-NMeFOSA
NEtFOSA	D5-NEtFOSA
NMeFOSAA	D3-NMeFOSAA
NEtFOSAA	D5-N-EtFOSAA
NMeFOSE	D7-NMeFOSE
NEtFOSE	D9-NEtFOSE
HFPO-DA	13C3-HFPO-DA
DONA	
9Cl-PF3ONS	
11Cl-PF3OUdS	

1633 Native Ampulated Standards

Ampulated Solution Name	Vendor	Catalog Number	Analyte	CAS#	Acronym	Conc. (ng/mL)
Native Replacement PFAS Solution/Mixture	Wellington	PFAC-MXF	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9	11Cl-PF3OUdS	1890
			9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1	9Cl-PF3ONS	1870
			4,8-dioxa-3H-Perfluorononanoic acid	919005-14-4	DONA	1890
			Perfluoro(2-propxypropanoic) acid	13252-13-6	HFPODA	2000
Native PFAS Solution/Mixture	Wellington	PFAC-MXH	1H,1H,2H,2H perfluorotelomersulfonic acid	39108-34-4	4:2-FTS	3840
			1H,1H,2H,2H perfluorotelomersulfonic acid	757124-72-4	6:2-FTS	3750
			1H,1H,2H,2H perfluorotelomersulfonate acid	27619-97-2	8:2-FTS	3800
			N-ethylperfluorooctanesulfonamidoacetic acid	2991-50-6	NEtFOSAA	1000
			N-methylperfluorooctanesulfonamidoacetic acid	2355-31-9	NMeFOSAA	1000
			Perfluorobutanesulfonic acid	375-73-5	PFBS	887
			Perfluorobutanoic acid	375-22-4	PFBA	4000
			Perfluorodecanesulfonic acid	335-77-3	PFDS	965
			Perfluorodecanoic acid	335-76-2	PFDA	1000
			Perfluorododecanesulfonic acid	79780-39-5	PFDoDS	970
			Perfluorododecanoic acid	307-55-1	PFDoDA	1000
			Perfluoroheptanesulfonic acid	375-92-8	PFHpS	953
			Perfluoroheptanoic acid	375-85-9	PFHpA	1000
			Perfluorohexanesulfonic acid	355-46-4	PFHxS	914
			Perfluorohexanoic acid	307-24-4	PFHxA	1000
			Perfluorononanesulfonic acid	68259-12-1	PFNS	962
			Perfluorononanoic acid	375-95-1	PFNA	1000
			Perfluorooctanesulfonamide	754-91-6	PFOSA	1000
			Perfluorooctanesulfonic acid	1763-23-1	PFOS	928
			Perfluorooctanoic acid	335-67-1	PFOA	1000
			Perfluoropentanesulfonic acid	2706-91-4	PFPeS	941
			Perfluoropentanoic acid	2706-90-3	PFPeA	2000
			Perfluorotetradecanoic acid	376-06-7	PFTeDA	1000
			Perfluorotridecanoic acid	72629-94-8	PFTrDA	1000
			Perfluoroundecanoic acid	2058-94-8	PFUnDA	1000
Native Perfluoroalkyl Ether Carboxylic Acids and Sulfonate Solution/Mixture	Wellington	PFAC-MXG	Perfluoro-3-methoxypropanoic acid	377-73-1	PFMPA	2000
			Perfluoro-4-methoxybutanoic acid	863090-89-5	PFMBA	2000
			Nonafluoro-3,6-dioxaheptanoic acid	151722-58-6	NFDHA	2000
			Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	PFEESA	1780
Native N-NMe/EtFOSA & N-Nme/EtFOSE Solution/Mixture	Wellington	PFAC-MXI	2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	24448-09-7	NMePFOSAE	10000
			N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	1000
			2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	1691-99-2	NEtPFOSAE	10000
			N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	1000
Native X:3 Flourotelomer Caroxylic Acid Solution/Mixture	Wellington	PFAC-MXJ	3-Perfluoropropylpropanoic acid	763051-92-9	3:3 FTCA	4000
			3-Perfluoropentylpropanoic acid	756426-58-1	5:3 FTCA	20000
			3-Perfluoroheptylpropanoic acid	919005-14-4	7:3 FTCA	20000

Attachment 3

Acquisition Method

```
EPA1633_DOD

Mass Spec  10.500 min
   Period  10.500 min
      -MRM
Integrated Valve
Sciex LC System
   Equilibrate
   Injection
```

Mass Spectrometer Method Properties

```
Period 1:
--------------
Scans in Period:        1050
Min. Dwell Time:        3 ms
Max. Dwell Time:        250 ms
Relative Start Time:    0.00 msec
Scheduled Ionization:   Off
Experiments in Period:  1
Use target Cycle Time:  No
Target Cycle Time:      N/A

Period 1  Experiment   1:
----------------------------
Scan Type:              MRM (MRM)
Scheduled MRM:          Yes
Polarity:               Negative
Scan Mode:              N/A
Ion Source:             Turbo Spray
sMRM Q1Q3 Resolution:   No
MRM detection window:   60 sec
Target Scan Time:       0.6000 sec
Resolution Q1:          Unit
Resolution Q3:          Unit
Intensity Thres.:       0.00 cps
Settling Time:          0.0000 msec
MR Pause:               5.0070 msec
MCA:                    No
Step Size:              0.00 Da

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
216.000       172.000       3.88      DP     -40.00 -40.00    13C3-PFBA
                                             CE     -14.00 -14.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
217.000       172.000       3.88      DP     -40.00 -40.00    13C4-PFBA
                                             CE     -14.00 -14.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
268.000       223.000       4.44      DP     -40.00 -40.00    13C5-PFPeA
                                             CE     -14.00 -14.00
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Attachment 3

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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
302.000       80.000        4.49      DP     -120.00-120.00    13C3-PFBS
                                             CE     -65.00-65.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
329.000       81.000        4.83      DP     -100.00-100.00    13C2-4:2-FTS
                                             CE     -28.00-28.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
315.000       270.000       4.86      DP     -30.00 -30.00     13C2-PFHxA
                                             CE     -15.00-15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
318.000       273.000       4.86      DP     -30.00 -30.00     13C5-PFHxA
                                             CE     -15.00-15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
287.000       169.000       5.00      DP     -20.00 -20.00     13C3-HFPODA
                                             CE     -10.00-10.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
367.000       322.000       5.27      DP     -40.00 -40.00     13C4-PFHpA
                                             CE     -15.00-15.00

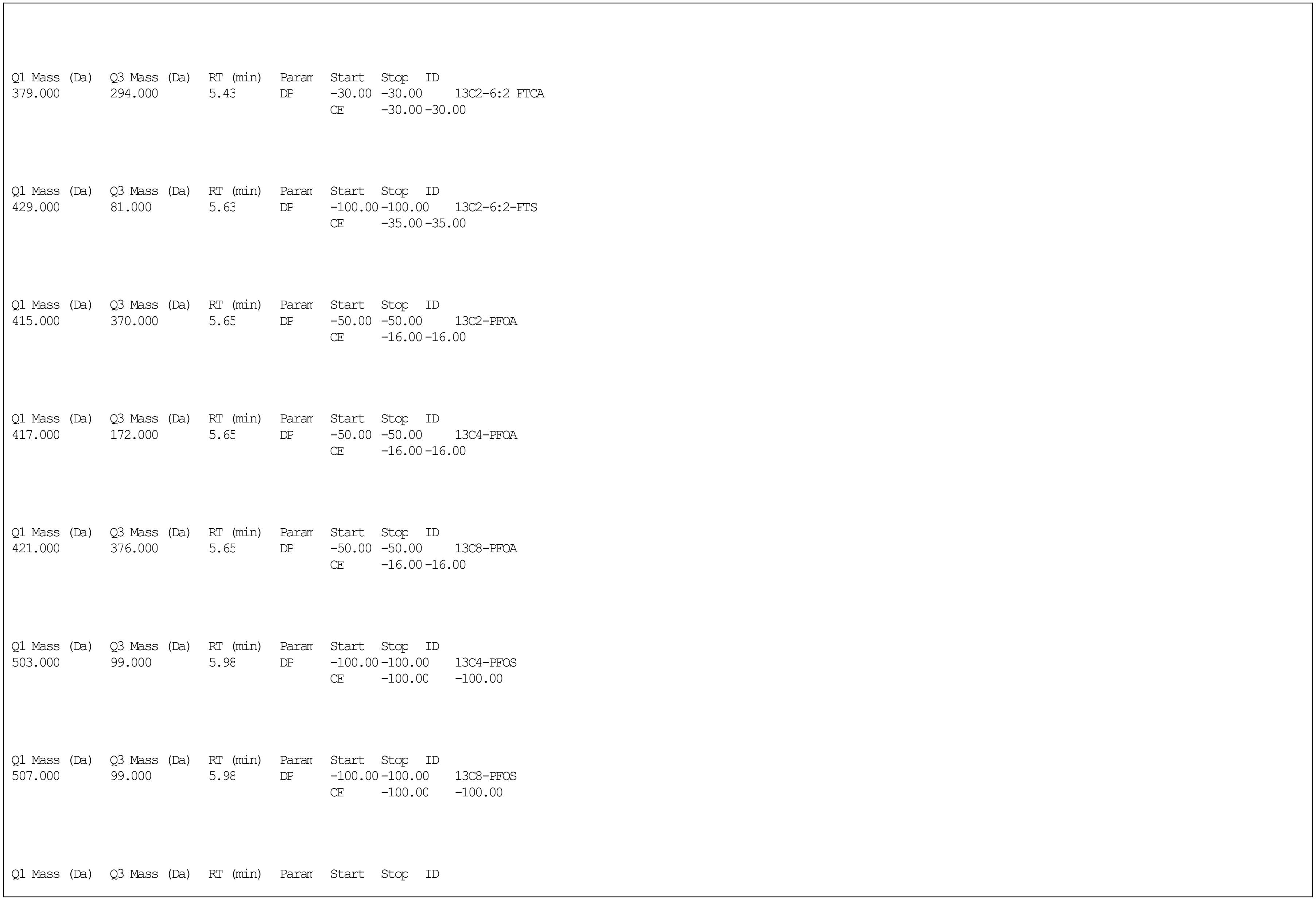


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
402.000       80.000        5.27      DP     -100.00-100.00    13C3-PFHxS
                                             CE     -80.00-80.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
359.000       294.000       5.42      DP     -40.00 -40.00     13C2-6:2 FTUCA
                                             CE     -25.00-25.00
```

Attachment 3



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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
379.000       294.000       5.43      DP     -30.00  -30.00    13C2-6:2 FTCA
                                             CE      -30.00 -30.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
429.000       81.000        5.63      DP     -100.00 -100.00   13C2-6:2-FTS
                                             CE      -35.00 -35.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
415.000       370.000       5.65      DP     -50.00  -50.00    13C2-PFOA
                                             CE      -16.00 -16.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
417.000       172.000       5.65      DP     -50.00  -50.00    13C4-PFOA
                                             CE      -16.00 -16.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
421.000       376.000       5.65      DP     -50.00  -50.00    13C8-PFOA
                                             CE      -16.00 -16.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
503.000       99.000        5.98      DP     -100.00 -100.00   13C4-PFOS
                                             CE      -100.00   -100.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
507.000       99.000        5.98      DP     -100.00 -100.00   13C8-PFOS
                                             CE      -100.00   -100.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
```
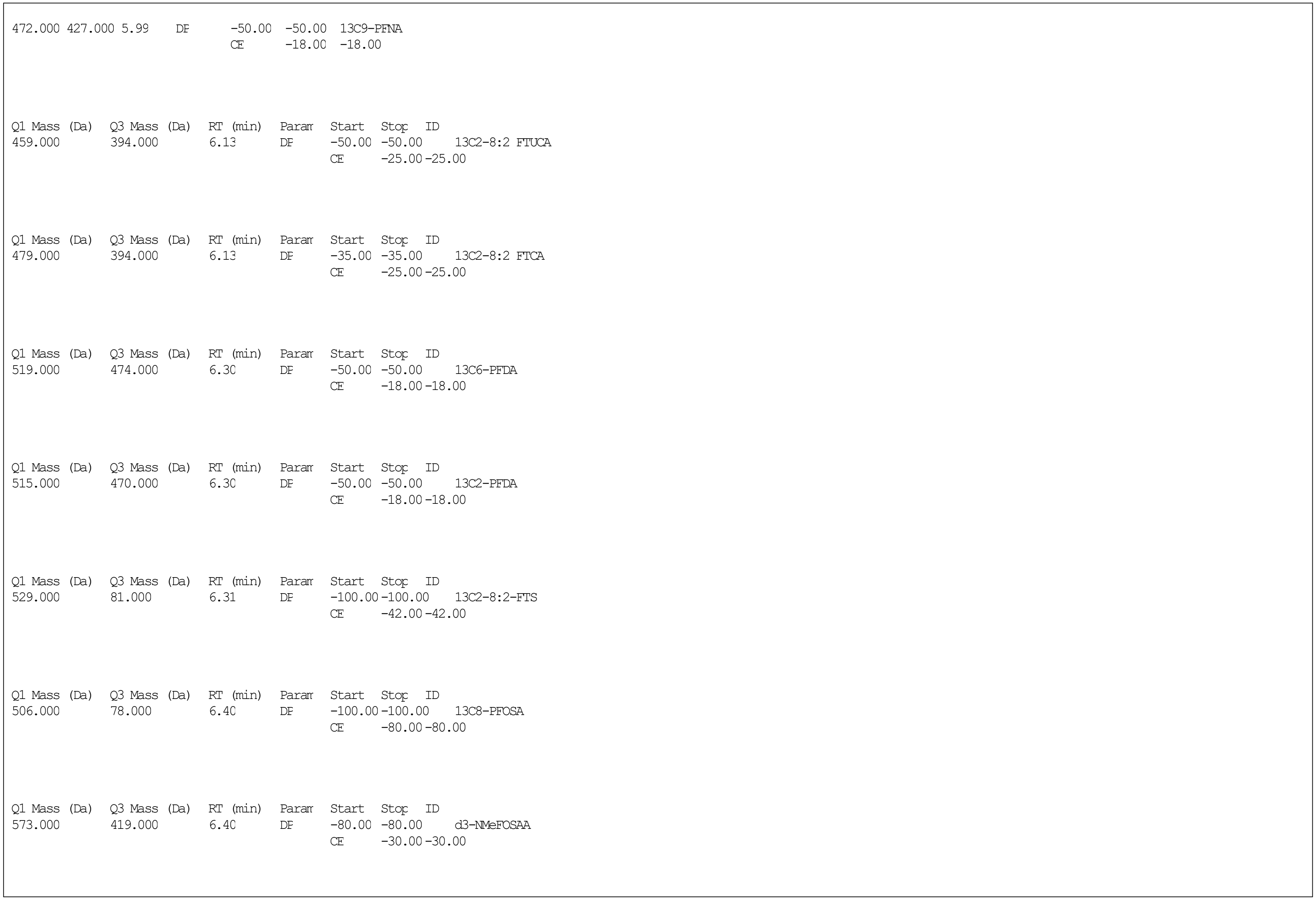

Attachment 3



```
472.000 427.000 5.99    DP      -50.00  -50.00  13C9-PFNA
                                CE      -18.00  -18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
459.000       394.000       6.13      DP     -50.00 -50.00    13C2-8:2 FTUCA
                                             CE     -25.00-25.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
479.000       394.000       6.13      DP     -35.00 -35.00    13C2-8:2 FTCA
                                             CE     -25.00-25.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
519.000       474.000       6.30      DP     -50.00 -50.00    13C6-PFDA
                                             CE     -18.00-18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
515.000       470.000       6.30      DP     -50.00 -50.00    13C2-PFDA
                                             CE     -18.00-18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
529.000       81.000        6.31      DP     -100.00-100.00   13C2-8:2-FTS
                                             CE     -42.00-42.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
506.000       78.000        6.40      DP     -100.00-100.00   13C8-PFOSA
                                             CE     -80.00-80.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
573.000       419.000       6.40      DP     -80.00 -80.00    d3-NMeFOSAA
                                             CE     -30.00-30.00
```

```
Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
565.000       520.000       6.58      DP     -70.00 -70.00    13C2-PFUnDA
                                      CE     -19.00 -19.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
570.000       525.000       6.58      DP     -70.00 -70.00    13C7-PFUnDA
                                      CE     -19.00 -19.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
589.000       419.000       6.50      DP     -90.00 -90.00    d5-NEtFOSAA
                                      CE     -30.00 -30.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
559.000       494.000       6.70      DP     -60.00 -60.00    13C2-10:2 FTUCA
                                      CE     -30.00 -30.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
579.000       494.000       6.72      DP     -50.00 -50.00    13C2-10:2 FTCA
                                      CE     -30.00 -30.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
615.000       570.000       6.81      DP     -60.00 -60.00    13C2-PFDoDA
                                      CE     -20.00 -20.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
623.000       59.000        6.85      DP     -50.00 -50.00    d7-NMePFOSAE
                                      CE     -70.00 -70.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
515.000       219.000       6.86      DP     -100.00 -100.00  d3-NMePFOSA
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                         CE      -37.00  -37.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
639.000       59.000        7.01      DP     -45.00  -45.00    d9-NEtPFOSAE
                                             CE      -70.00 -70.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
531.000       219.000       7.03      DP     -100.00 -100.00   d5-NEtPFOSA
                                             CE      -38.00 -38.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
715.000       670.000       7.21      DP     -60.00  -60.00    13C2-PFTeDA
                                             CE      -22.00 -22.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
163.000       119.000       1.83      DP     -30.00  -30.00    PPF Acid
                                             CE      -15.00 -15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
213.000       169.000       3.89      DP     -40.00  -40.00    PFBA
                                             CE      -14.00 -14.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
249.000       99.000        4.12      DP     -60.00  -60.00    PFPrS
                                             CE      -40.00 -40.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
229.000       85.000        4.17      DP     -40.00  -40.00    PFECA F
                                             CE      -25.00 -25.00
```

Attachment 3

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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
241.000       177.000       4.49      DP     -60.00  -60.00     3:3 FTCA
                                      CE     -12.00  -12.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
263.000       219.000       4.43      DP     -40.00  -40.00     PFPeA
                                      CE     -14.00  -14.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
299.000       80.000        4.49      DP     -120.00 -120.00    PFBS
                                      CE     -65.00  -65.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
279.000       85.000        4.62      DP     -40.00  -40.00     PFECA A
                                      CE     -20.00  -20.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
315.000       135.000       4.71      DP     -60.00  -60.00     PFEESA
                                      CE     -30.00  -30.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
295.000       201.000       4.84      DP     -70.00  -70.00     PFECA B
                                      CE     -25.00  -25.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
327.000       307.000       4.83      DP     -100.00 -100.00    4:2-FTS
                                      CE     -28.00  -28.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
313.000       269.000       4.86      DP     -30.00  -30.00     PFHxA
                                      CE     -15.00  -15.00
```

Attachment 3

```
Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param   Start  Stop  ID
349.000       80.000        4.89      DP      -90.00 -90.00     PFPeS
                                              CE     -70.00 -70.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param   Start  Stop  ID
285.000       169.000       5.00      DP      -20.00 -20.00     HFPODA
                                              CE     -10.00 -10.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param   Start  Stop  ID
363.000       319.000       5.27      DP      -40.00 -40.00     PFHpA
                                              CE     -15.00 -15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param   Start  Stop  ID
399.000       80.000        5.27      DP      -100.00 -100.00   PFHxS
                                              CE     -80.00 -80.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param   Start  Stop  ID
377.000       251.000       5.32      DP      -40.00 -40.00     DONA
                                              CE     -20.00 -20.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param   Start  Stop  ID
341.000       237.000       5.40      DP      -70.00 -70.00     5:3 FTCA
                                              CE     -20.00 -20.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param   Start  Stop  ID
357.000       293.000       5.42      DP      -45.00 -45.00     6:2 FTUCA
                                              CE     -25.00 -25.00
```

Attachment 3

```
Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
377.000       293.000       5.44      DP     -45.00  -45.00    6:2 FTCA
                                             CE      -30.00 -30.00




Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
461.000       381.000       5.63      DP     -70.00  -70.00    PFECHS
                                             CE      -40.00 -40.00




Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
427.000       407.000       5.62      DP     -100.00 -100.00   6:2-FTS
                                             CE      -35.00 -35.00




Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
449.000       80.000        5.63      DP     -100.00 -100.00   PFHpS
                                             CE      -90.00 -90.00




Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
413.000       369.000       5.65      DP     -50.00  -50.00    PFOA
                                             CE      -16.00 -16.00




Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
499.000       80.000        5.90      DP     -100.00 -100.00   PFOS
                                             CE      -100.00   -100.00




Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
463.000       419.000       5.99      DP     -50.00  -50.00    PFNA
                                             CE      -18.00 -18.00




Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
441.000       317.000       6.13      DP     -80.00  -80.00    7:3 FTCA
                                             CE      -20.00 -20.00
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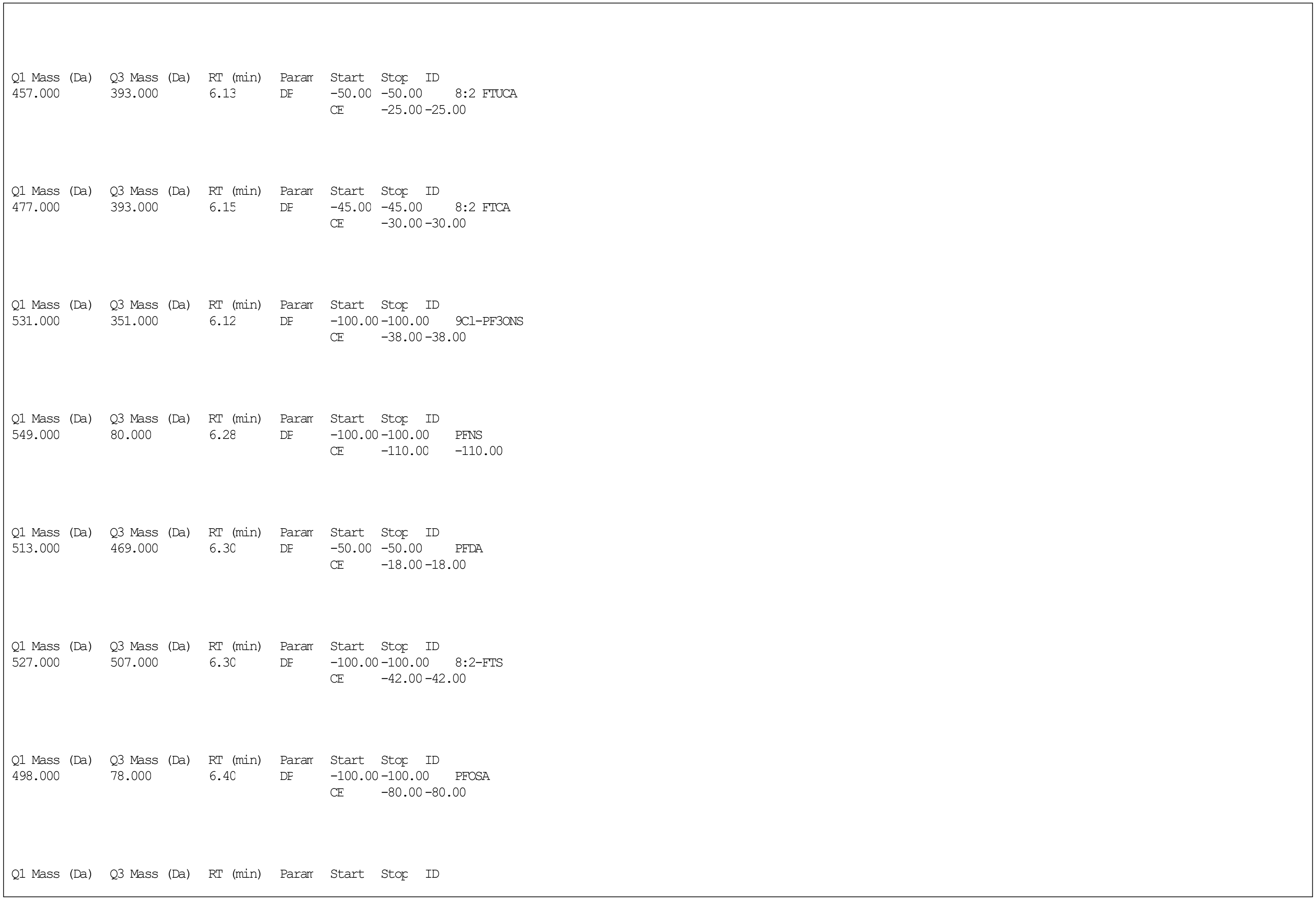
Attachment 3



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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
457.000       393.000       6.13      DP     -50.00  -50.00     8:2 FTUCA
                                             CE      -25.00 -25.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
477.000       393.000       6.15      DP     -45.00  -45.00     8:2 FTCA
                                             CE      -30.00 -30.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
531.000       351.000       6.12      DP     -100.00 -100.00    9Cl-PF3ONS
                                             CE      -38.00 -38.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
549.000       80.000        6.28      DP     -100.00 -100.00    PFNS
                                             CE      -110.00    -110.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
513.000       469.000       6.30      DP     -50.00  -50.00     PFDA
                                             CE      -18.00 -18.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
527.000       507.000       6.30      DP     -100.00 -100.00    8:2-FTS
                                             CE      -42.00 -42.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
498.000       78.000        6.40      DP     -100.00 -100.00    PFOSA
                                             CE      -80.00 -80.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
```

```
570.000 419.000 6.40    DP      -80.00  -80.00  NMeFOSAA
                                CE      -30.00  -30.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
599.000       80.000        6.54      DP     -100.00 -100.00    PFDS
                                             CE      -120.00    -120.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
563.000       519.000       6.58      DP     -70.00  -70.00     PFUnDA
                                             CE      -19.00 -19.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
584.000       419.000       6.50      DP     -90.00  -90.00     NEtFOSAA
                                             CE      -30.00 -30.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
557.000       493.000       6.70      DP     -70.00  -70.00     10:2 FTUCA
                                             CE      -25.00 -25.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
631.000       451.000       6.68      DP     -100.00 -100.00    11Cl-PF3OUdS
                                             CE      -43.00 -43.00

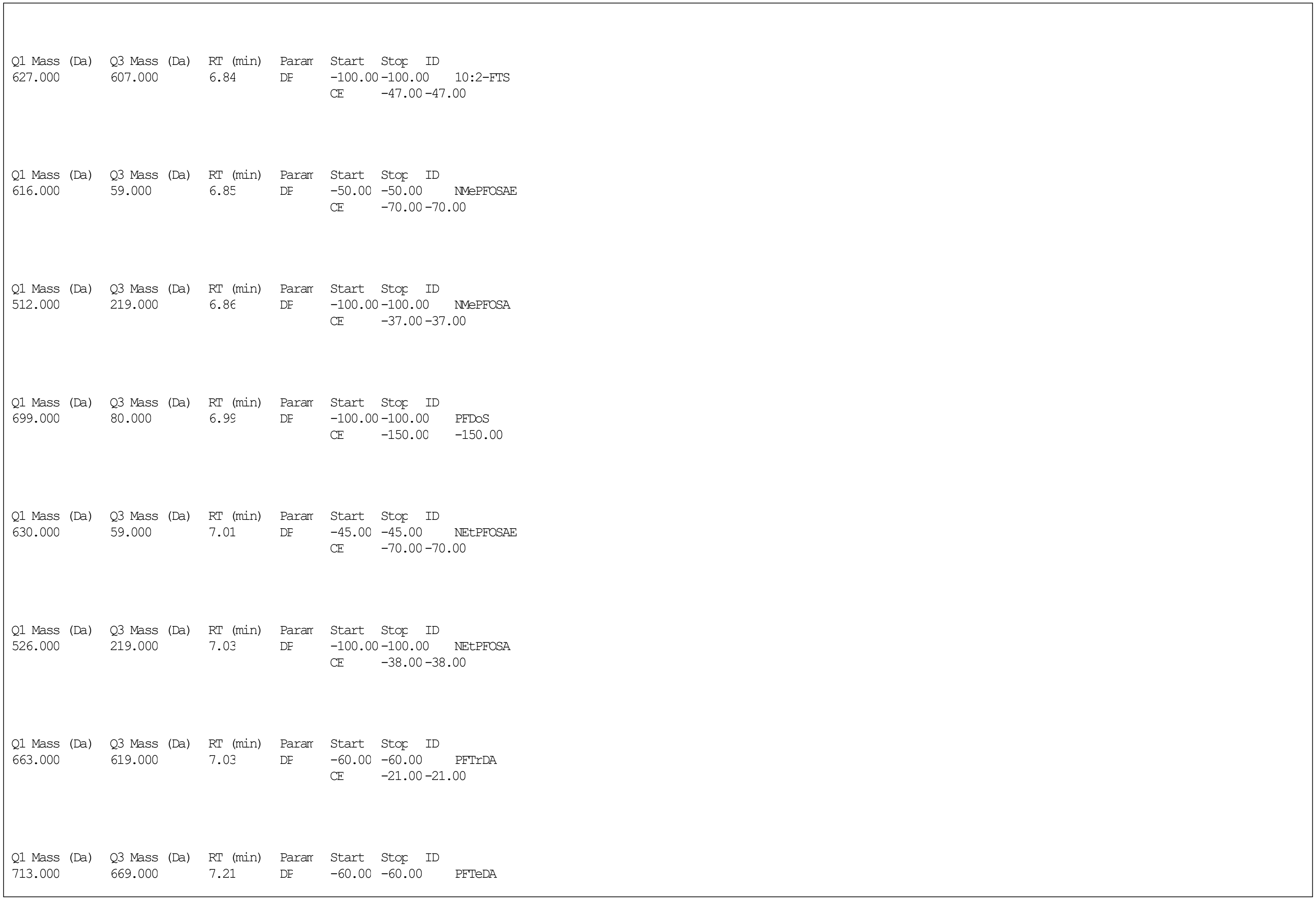


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
577.000       493.000       6.72      DP     -60.00  -60.00     10:2 FTCA
                                             CE      -30.00 -30.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
613.000       569.000       6.99      DP     -60.00  -60.00     PFDoDA
                                             CE      -20.00 -20.00
```

Attachment 3



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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
627.000       607.000       6.84      DP     -100.00-100.00    10:2-FTS
                                             CE     -47.00-47.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
616.000       59.000        6.85      DP     -50.00 -50.00     NMePFOSAE
                                             CE     -70.00-70.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
512.000       219.000       6.86      DP     -100.00-100.00    NMePFOSA
                                             CE     -37.00-37.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
699.000       80.000        6.99      DP     -100.00-100.00    PFDoS
                                             CE     -150.00    -150.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
630.000       59.000        7.01      DP     -45.00 -45.00     NEtPFOSAE
                                             CE     -70.00-70.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
526.000       219.000       7.03      DP     -100.00-100.00    NEtPFOSA
                                             CE     -38.00-38.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
663.000       619.000       7.03      DP     -60.00 -60.00     PFTrDA
                                             CE     -21.00-21.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
713.000       669.000       7.21      DP     -60.00 -60.00     PFTeDA
```
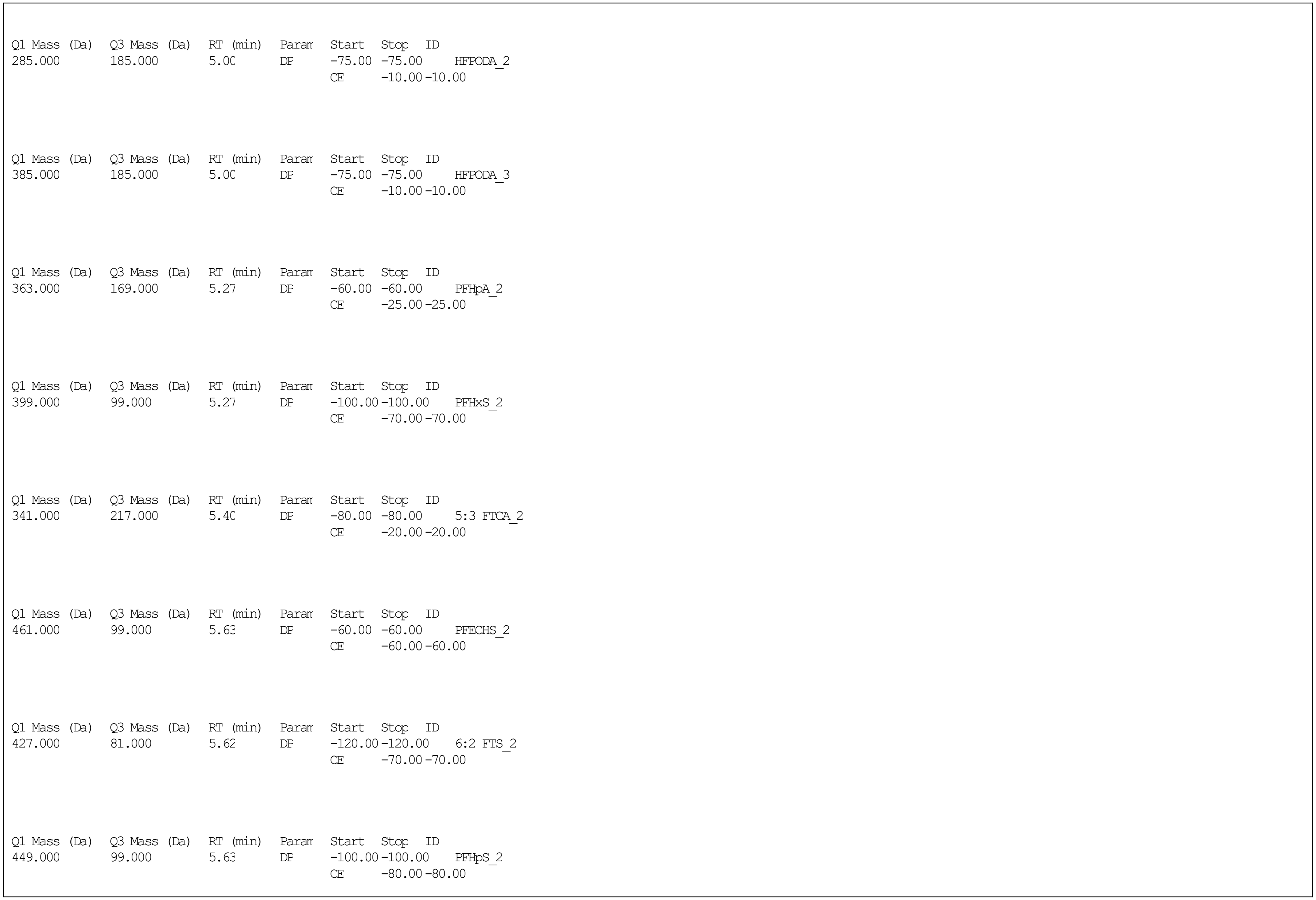

Attachment 3

```
                              CE      -22.00  -22.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
813.000       769.000       7.51      DP     -100.00-100.00   PFHxDA
                                             CE     -25.00-25.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
913.000       869.000       7.74      DP     -100.00-100.00   PFODA
                                             CE     -27.00-27.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
299.000       99.000        4.50      DP     -100.00-100.00   PFBS_2
                                             CE     -45.00-45.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
295.000       85.000        4.45      DP     -25.00 -25.00    PFECA B_2
                                             CE     -15.00-15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
327.000       81.000        4.83      DP     -100.00-100.00   4:2 FTS_2
                                             CE     -50.00-50.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
313.000       119.000       4.86      DP     -50.00 -50.00    PFHxA_2
                                             CE     -31.00-31.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
349.000       99.000        4.89      DP     -100.00-100.00   PFPeS_2
                                             CE     -50.00-50.00
```

Attachment 3



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Q1 Mass (Da)   Q3 Mass (Da)   RT (min)   Param   Start   Stop   ID
285.000        185.000        5.00       DP      -75.00  -75.00     HFPODA_2
                                                 CE      -10.00 -10.00

Q1 Mass (Da)   Q3 Mass (Da)   RT (min)   Param   Start   Stop   ID
385.000        185.000        5.00       DP      -75.00  -75.00     HFPODA_3
                                                 CE      -10.00 -10.00

Q1 Mass (Da)   Q3 Mass (Da)   RT (min)   Param   Start   Stop   ID
363.000        169.000        5.27       DP      -60.00  -60.00     PFHpA_2
                                                 CE      -25.00 -25.00

Q1 Mass (Da)   Q3 Mass (Da)   RT (min)   Param   Start   Stop   ID
399.000        99.000         5.27       DP      -100.00 -100.00    PFHxS_2
                                                 CE      -70.00 -70.00

Q1 Mass (Da)   Q3 Mass (Da)   RT (min)   Param   Start   Stop   ID
341.000        217.000        5.40       DP      -80.00  -80.00     5:3 FTCA_2
                                                 CE      -20.00 -20.00

Q1 Mass (Da)   Q3 Mass (Da)   RT (min)   Param   Start   Stop   ID
461.000        99.000         5.63       DP      -60.00  -60.00     PFECHS_2
                                                 CE      -60.00 -60.00

Q1 Mass (Da)   Q3 Mass (Da)   RT (min)   Param   Start   Stop   ID
427.000        81.000         5.62       DP      -120.00 -120.00    6:2 FTS_2
                                                 CE      -70.00 -70.00

Q1 Mass (Da)   Q3 Mass (Da)   RT (min)   Param   Start   Stop   ID
449.000        99.000         5.63       DP      -100.00 -100.00    PFHpS_2
                                                 CE      -80.00 -80.00
```

Attachment 3

```
Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop    ID
413.000       169.000       5.65      DP     -60.00  -60.00     PFOA_2
                                             CE      -26.00 -26.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop    ID
499.000       99.000        5.97      DP     -100.00 -100.00    PFOS_2
                                             CE      -80.00 -80.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop    ID
463.000       219.000       5.99      DP     -60.00  -60.00     PFNA_2
                                             CE      -30.00 -30.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop    ID
549.000       99.000        6.28      DP     -100.00 -100.00    PFNS_2
                                             CE      -90.00 -90.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop    ID
513.000       219.000       6.30      DP     -50.00  -50.00     PFDA_2
                                             CE      -31.00 -31.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop    ID
527.000       81.000        6.30      DP     -100.00 -100.00    8:2 FTS_2
                                             CE      -80.00 -80.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop    ID
570.000       483.000       6.40      DP     -80.00  -80.00     NMeFOSAA_2
                                             CE      -24.00 -24.00
```

Attachment 3

```
Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
599.000       99.000        6.54      DP     -100.00 -100.00   PFDS_2
                                      CE     -100.00   -100.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
563.000       269.000       6.58      DP     -80.00  -80.00    PFUnDA_2
                                      CE     -35.00 -35.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
584.000       526.000       6.50      DP     -100.00 -100.00   NEtFOSAA_2
                                      CE     -30.00 -30.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
613.000       319.000       6.81      DP     -60.00  -60.00    PFDoDA_2
                                      CE     -38.00 -38.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
627.000       81.000        6.84      DP     -120.00 -120.00   10:2 FTS_2
                                      CE     -100.00   -100.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
663.000       169.000       7.03      DP     -60.00  -60.00    PFTrDA_2
                                      CE     -40.00 -40.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
713.000       169.000       7.21      DP     -60.00  -60.00    PFTeDA_2
                                      CE     -40.00 -40.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
813.000       169.000       7.51      DP     -80.00  -80.00    PFHxDA_2
                                      CE     -45.00 -45.00
```

```
Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
913.000       169.000       7.74      DP     -80.00 -80.00   PFODA_2
                                             CE     -50.00 -50.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
179.000       85.000        2.90      DP     -15.00 -15.00   PFMOAA
                                             CE     -15.00 -15.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
441.000       241.000       3.92      DP     -80.00 -80.00   R-PSDA
                                             CE     -32.00 -32.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
405.000       217.000       3.92      DP     -60.00 -60.00   R-EVE
                                             CE     -25.00 -25.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
439.000       343.000       3.94      DP     -80.00 -80.00   Hydrolized PSDA
                                             CE     -35.00 -35.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
229.000       185.000       4.06      DP     -20.00 -20.00   PMPA
                                             CE     -12.00 -12.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
297.000       135.000       4.17      DP     -80.00 -80.00   NVHOS
                                             CE     -35.00 -35.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
```

Attachment 3

```
245.000 85.000  4.37    DP      -10.00  -10.00  PFO2HxA
                                CE      -15.00  -15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
279.000       235.000       4.59      DP     -10.00 -10.00    PEPA
                                             CE     -20.00 -20.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
311.000       85.000        4.97      DP     -20.00 -20.00    PFO3OA
                                             CE     -15.00 -15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
427.000       283.000       5.27      DP     -40.00 -40.00    Hydro-EVE Acid
                                             CE     -18.00 -18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
397.000       217.000       5.27      DP     -80.00 -80.00    R-PSDCA
                                             CE     -35.00 -35.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
463.000       263.000       5.26      DP     -80.00 -80.00    Hydro-PS Acid
                                             CE     -38.00 -38.00

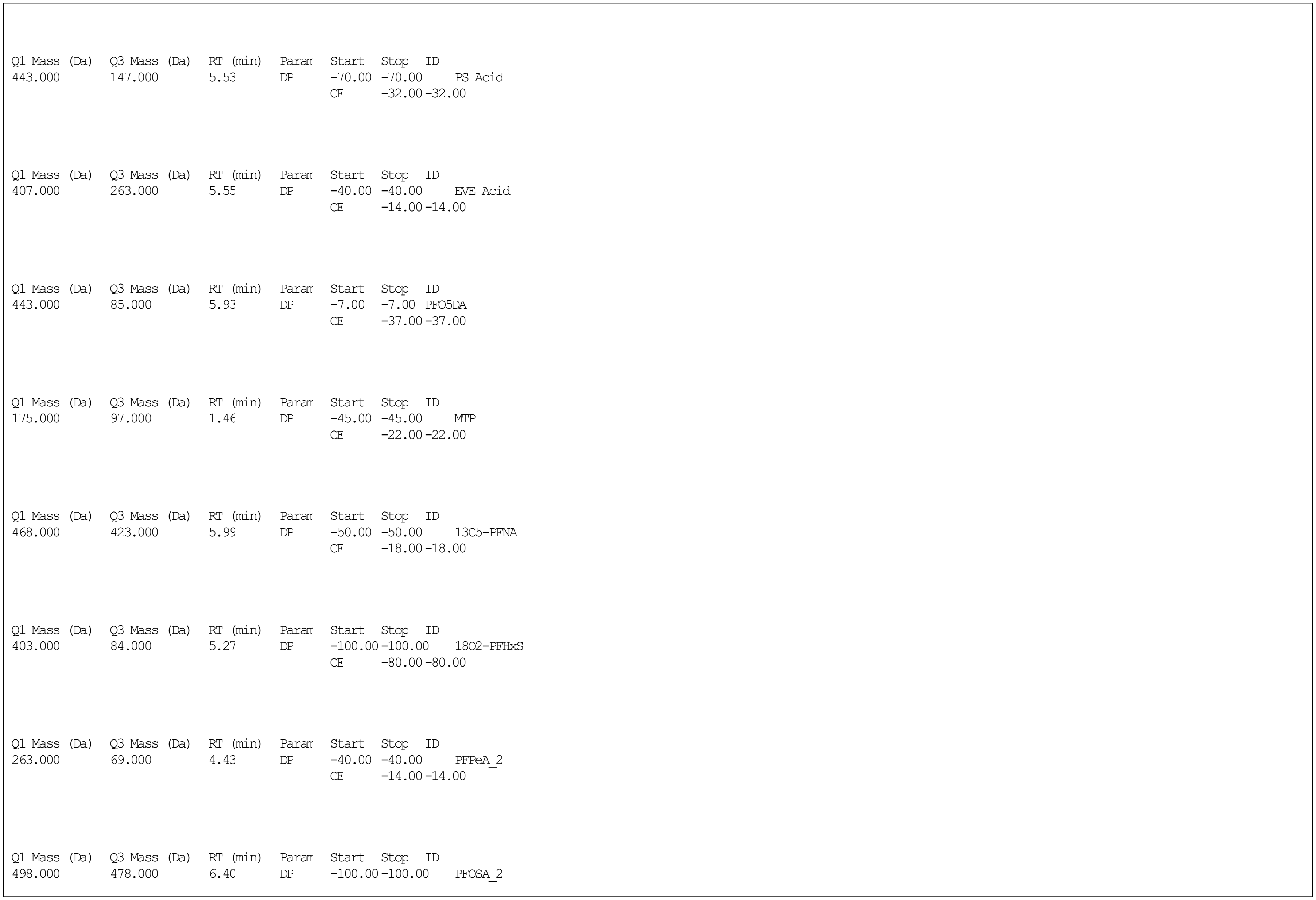


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
379.000       185.000       5.38      DP     -35.00 -35.00    PFECA-G
                                             CE     -20.00 -20.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
377.000       84.000        5.48      DP     -20.00 -20.00    PFO4DA
                                             CE     -40.00 -40.00
```

Attachment 3



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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
443.000       147.000       5.53      DP     -70.00 -70.00     PS Acid
                                             CE     -32.00 -32.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
407.000       263.000       5.55      DP     -40.00 -40.00     EVE Acid
                                             CE     -14.00 -14.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
443.000       85.000        5.93      DP     -7.00  -7.00  PFO5DA
                                             CE     -37.00 -37.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
175.000       97.000        1.46      DP     -45.00 -45.00     MTP
                                             CE     -22.00 -22.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
468.000       423.000       5.99      DP     -50.00 -50.00     13C5-PFNA
                                             CE     -18.00 -18.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
403.000       84.000        5.27      DP     -100.00 -100.00   18O2-PFHxS
                                             CE     -80.00 -80.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
263.000       69.000        4.43      DP     -40.00 -40.00     PFPeA_2
                                             CE     -14.00 -14.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
498.000       478.000       6.40      DP     -100.00 -100.00   PFOSA_2
```

Attachment 3

```
                          CE      -80.00  -80.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param   Start   Stop  ID
512.000       169.000       6.86      DP      -100.00 -100.00    NMePFOSA_2
                                              CE      -37.00 -37.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param   Start   Stop  ID
526.000       169.000       7.03      DP      -180.00 -180.00    NEtPFOSA_2
                                              CE      -40.00 -40.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param   Start   Stop  ID
377.000       85.000        5.32      DP      -40.00  -40.00     DONA_2
                                              CE      -20.00 -20.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param   Start   Stop  ID
533.000       353.000       6.12      DP      -100.00 -100.00    9Cl-PF3ONS_2
                                              CE      -38.00 -38.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param   Start   Stop  ID
633.000       453.000       6.68      DP      -180.00 -180.00    11Cl-PF3OUdS_2
                                              CE      -40.00 -40.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param   Start   Stop  ID
241.000       117.000       4.49      DP      -60.00  -60.00     3:3 FTCA_2
                                              CE      -12.00 -12.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param   Start   Stop  ID
441.000       337.000       6.13      DP      -80.00  -80.00     7:3 FTCA_2
                                              CE      -20.00 -20.00
```

Attachment 3

```
Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
315.000       83.000        4.71      DP     -60.00  -60.00     PFEESA_2
                                      CE     -30.00 -30.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
699.000       99.000        6.99      DP     -100.00 -100.00    PFDoS_2
                                      CE     -150.00    -150.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
318.000       120.000       4.86      DP     -180.00 -180.00    13C5-PFHxA_2
                                      CE     -40.00 -40.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
302.000       99.000        4.49      DP     -120.00 -120.00    13C3-PFBS_2
                                      CE     -65.00 -65.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
402.000       99.000        5.27      DP     -100.00 -100.00    13C3-PFHxS_2
                                      CE     -80.00 -80.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
507.000       80.000        5.98      DP     -100.00 -100.00    13C8-PFOS_2
                                      CE     -100.00    -100.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
329.000       309.000       4.83      DP     -100.00 -100.00    13C2-4:2-FTS_2
                                      CE     -28.00 -28.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
429.000       409.000       5.63      DP     -100.00 -100.00    13C2-6:2-FTS_2
                                      CE     -35.00 -35.00
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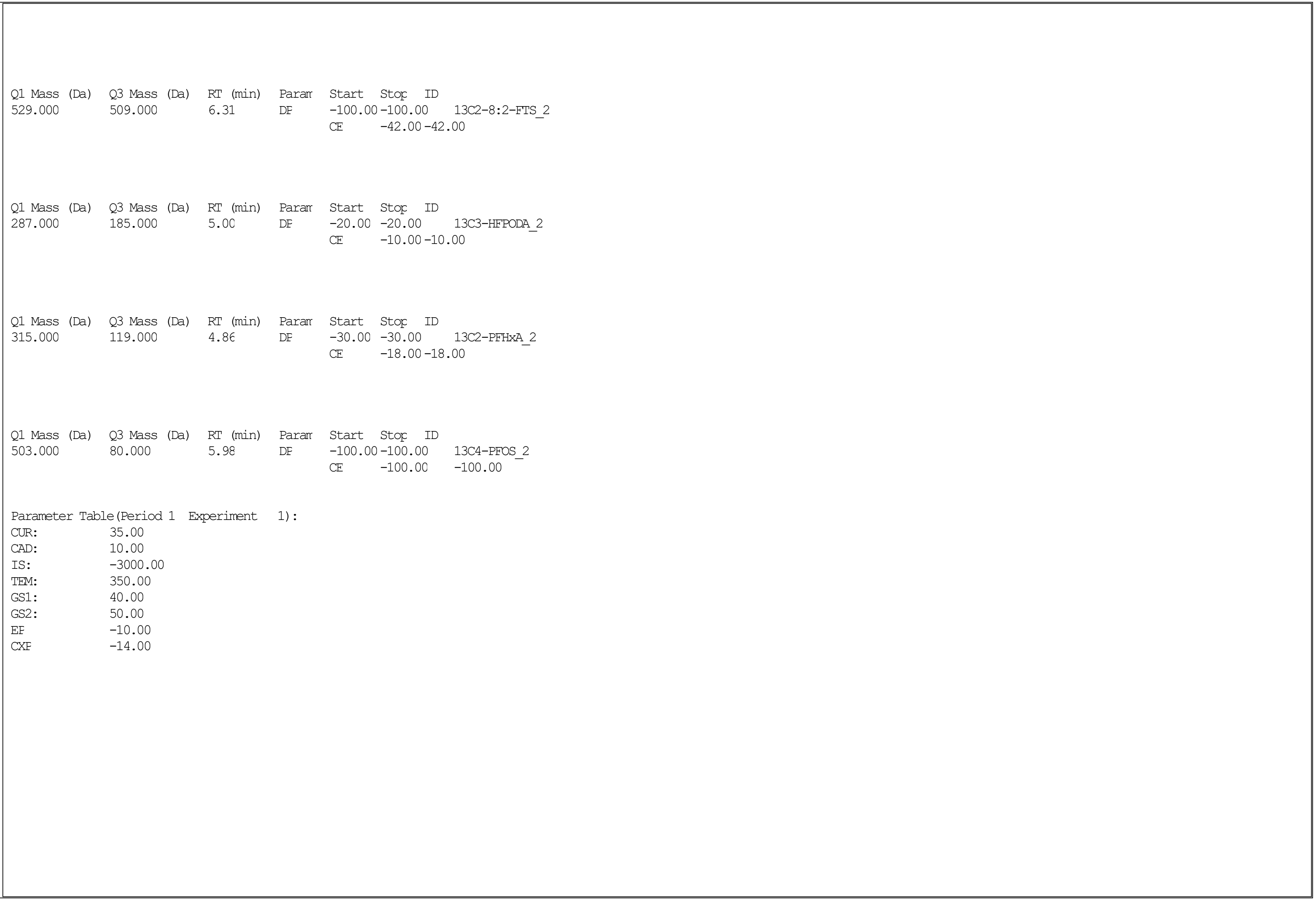

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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
529.000       509.000       6.31      DP     -100.00-100.00    13C2-8:2-FTS_2
                                             CE     -42.00-42.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
287.000       185.000       5.00      DP     -20.00 -20.00     13C3-HFPODA_2
                                             CE     -10.00-10.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
315.000       119.000       4.86      DP     -30.00 -30.00     13C2-PFHxA_2
                                             CE     -18.00-18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
503.000       80.000        5.98      DP     -100.00-100.00    13C4-PFOS_2
                                             CE     -100.00    -100.00

Parameter Table(Period 1  Experiment   1):
CUR:          35.00
CAD:          10.00
IS:           -3000.00
TEM:          350.00
GS1:          40.00
GS2:          50.00
EP            -10.00
CXP           -14.00
```

ATTACHMENT 4 ST1927333A

WELLINGTON
LABORATORIES

CERTIFICATE OF ANALYSIS
DOCUMENTATION

PFAC-MXC

Native Perfluorinated Compound Solution/Mixture

PRODUCT CODE:	PFAC-MXC
LOT NUMBER:	PFACMXC0617
SOLVENT(S):	Methanol / Water (<1%)
DATE PREPARED: (mm/dd/yyyy)	06/14/2017
LAST TESTED: (mm/dd/yyyy)	03/19/2019
EXPIRY DATE: (mm/dd/yyyy)	03/19/2024
RECOMMENDED STORAGE:	Store ampoule in a cool, dark place

DESCRIPTION:

PFAC-MXC is a solution/mixture of thirteen native perfluoroalkylcarboxylic acids (C_4-C_{14}, C_{16}, and C_{18}) and eight native perfluoroalkylsulfonates (C_4-C_{10} and C_{12}). The full name, abbreviation and concentration for each of the components are given in Table A.

The individual perfluoroalkylcarboxylic acids and perfluoroalkylsulfonates all have chemical purities of >98%.

DOCUMENTATION/ DATA ATTACHED:

Table A: Components and Concentrations of the Solution/Mixture
Figure 1: LC/MS Data (SIR)
Figure 2: LC/MS/MS Data (Selected MRM Transitions)

ADDITIONAL INFORMATION:

- See page 2 for further details.
- Contains 4 mole eq. of NaOH to prevent conversion of the carboxylic acids to their respective methyl esters.

FOR LABORATORY USE ONLY: NOT FOR HUMAN OR DRUG USE

Wellington Laboratories Inc., 345 Southgate Dr. Guelph ON N1G 3M5 CANADA
519-822-2436 • Fax: 519-822-2849 • info@well-labs.com

INTENDED USE:

The products prepared by Wellington Laboratories Inc. are for laboratory use only. This certified reference material (CRM) was designed to be used as a standard for the identification and/or quantification of the specific chemical compounds it contains.

HANDLING:

This product should only be used by qualified personnel familiar with its potential hazards and trained in the handling of hazardous chemicals. Due care should be exercised to prevent unnecessary human contact or ingestion. All procedures should be carried out in a well-functioning fume hood and suitable gloves, eye protection, and clothing should be worn at all times. Waste should be disposed of according to national and regional regulations. Safety Data Sheets (SDSs) are available upon request.

SYNTHESIS / CHARACTERIZATION:

Our products are synthesized using single-product unambiguous routes whenever possible. They are then characterized, and their structures and purities confirmed, using a combination of the most relevant techniques, such as NMR, GC/MS, LC/MS/MS, SFC/UV/MS/MS, x-ray crystallography, and melting point. Isotopic purities of mass-labelled compounds are also confirmed using HRGC/HRMS and/or LC/MS/MS.

HOMOGENEITY:

Prior to solution preparation, crystalline material is tested for homogeneity using a variety of techniques (as stated above) and its solubility in a given diluent is taken into consideration. Duplicate solutions of a new product are prepared from the same crystalline lot and, after the addition of an appropriate internal standard, they are compared by GC/MS, LC/MS/MS, and/or SFC/UV/MS/MS. The relative response factors of the analyte of interest in each solution are required to be <5% RSD. New solution lots of existing products, as well as mixtures and calibration solutions, are compared to older lots in a similar manner. This further confirms the homogeneity of the crystalline material as well as the stability and homogeneity of the solutions in the storage containers. In order to maintain the integrity of the assigned value(s), and associated uncertainty, the dilution or injection of a subsample of this product should be performed using calibrated measuring equipment.

UNCERTAINTY:

The maximum combined relative standard uncertainty of our reference standard solutions is calculated using the following equation:

The combined relative standard uncertainty, $u_c(y)$, of a value y and the uncertainty of the independent parameters x_1, x_2,...x_n on which it depends is:

$$u_c(y(x_1, x_2, \ldots x_n)) = \sqrt{\sum_{i=1}^{n} u(y, x_i)^2}$$

where x is expressed as a relative standard uncertainty of the individual parameter.

The individual uncertainties taken into account include those associated with weights (calibration of the balance) and volumes (calibration of the volumetric glassware). An expanded maximum combined percent relative uncertainty of ±5% (calculated with a coverage factor of 2 and a level of confidence of 95%) is stated on the Certificate of Analysis for all of our products.

TRACEABILITY:

All reference standard solutions are traceable to specific crystalline lots. The microbalances used for solution preparation are regularly calibrated by an external ISO/IEC 17025 accredited laboratory. In addition, their calibration is verified prior to each weighing using calibrated external weights traceable to an ISO/IEC 17025 accredited laboratory. All volumetric glassware used is calibrated, of Class A tolerance, and traceable to an ISO/IEC 17025 accredited laboratory. For certain products, traceability to international interlaboratory studies has also been established.

EXPIRY DATE / PERIOD OF VALIDITY:

Ongoing stability studies of this product have demonstrated stability in its composition and concentration, until the specified expiry date, in the unopened ampoule. Monitoring for any degradation or change in concentration of the listed analyte(s) is performed on a routine basis.

LIMITED WARRANTY:

At the time of shipment, all products are warranted to be free of defects in material and workmanship and to conform to the stated technical and purity specifications.

QUALITY MANAGEMENT:

This product was produced using a Quality Management System registered to the latest versions of ISO 9001 by SAI Global, ISO/IEC 17025 by the Canadian Association for Laboratory Accreditation Inc. (CALA; A 1226), and ISO 17034 by ANSI-ASQ National Accreditation Board (ANAB; AR-1523).

CALA
Testing
Accreditation No. A 1226

ANAB
ACCREDITED
ISO 17034
REFERENCE MATERIAL PRODUCER

For additional information or assistance concerning this or any other products from Wellington Laboratories Inc., please visit our website at www.well-labs.com or contact us directly at info@well-labs.com

ATTACHMENT 4

Table A: **PFAC-MXC; Components and Concentrations (ng/ml, ± 5% in Methanol / Water (<1%))**

Compound	Abbreviation	Concentration (ng/ml)*	Peak Assignment in Figure 1
Perfluoro-n-butanoic acid	PFBA	2000	A
Perfluoro-n-pentanoic acid	PFPeA	2000	B
Perfluoro-n-hexanoic acid	PFHxA	2000	D
Perfluoro-n-heptanoic acid	PFHpA	2000	F
Perfluoro-n-octanoic acid	PFOA	2000	H
Perfluoro-n-nonanoic acid	PFNA	2000	J
Perfluoro-n-decanoic acid	PFDA	2000	L
Perfluoro-n-undecanoic acid	PFUdA	2000	N
Perfluoro-n-dodecanoic acid	PFDoA	2000	P
Perfluoro-n-tridecanoic acid	PFTrDA	2000	Q
Perfluoro-n-tetradecanoic acid	PFTeDA	2000	S
Perfluoro-n-hexadecanoic acid	PFHxDA	2000	T
Perfluoro-n-octadecanoic acid	PFODA	2000	U

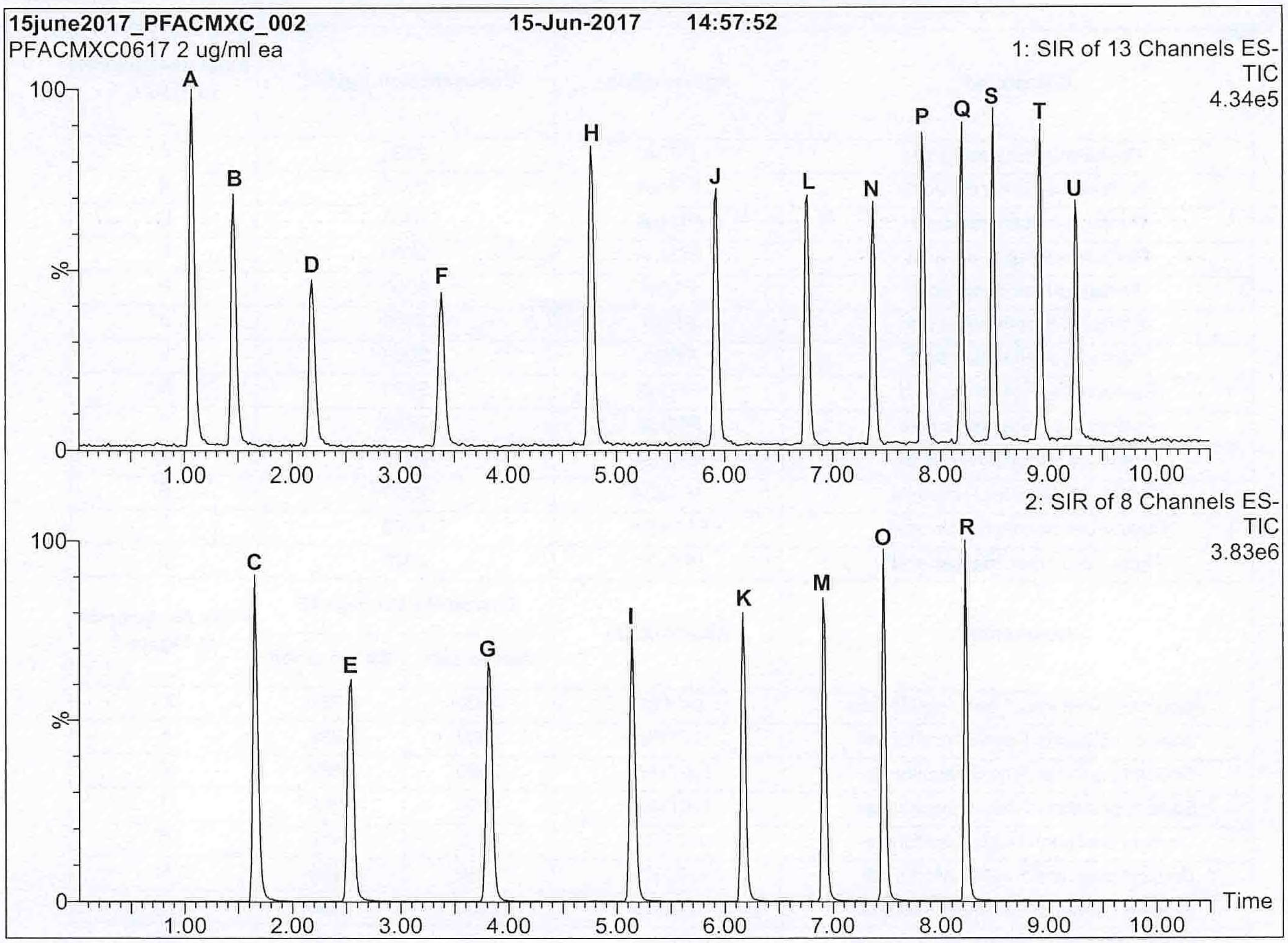
Compound	Abbreviation	Concentration (ng/ml)*		Peak Assignment in Figure 1
		As the salt	As the anion	
Potassium perfluoro-1-butanesulfonate	L-PFBS	2000	1770	C
Sodium perfluoro-1-pentanesulfonate	L-PFPeS	2000	1880	E
Sodium perfluoro-1-hexanesulfonate	L-PFHxS	2000	1890	G
Sodium perfluoro-1-heptanesulfonate	L-PFHpS	2000	1900	I
Sodium perfluoro-1-octanesulfonate	L-PFOS	2000	1910	K
Sodium perfluoro-1-nonanesulfonate	L-PFNS	2000	1920	M
Sodium perfluoro-1-decanesulfonate	L-PFDS	2000	1930	O
Sodium perfluoro-1-dodecanesulfonate	L-PFDoS	2000	1940	R

* Concentrations have been rounded to three significant figures.

Certified By: ______________________
B.G. Chittim, General Manager

Date: 06/06/2019
(mm/dd/yyyy)

Figure 1: **PFAC-MXC; LC/MS Data (Total Ion Current Chromatogram; SIR)**



Conditions for Figure 1:

LC: **Waters Acquity Ultra Performance LC**
MS: **Micromass Quattro *micro* API MS**

Chromatographic Conditions

Column: Acquity UPLC BEH Shield RP_{18}
1.7 µm, 2.1 x 100 mm

Mobile phase: Gradient
Start: 50% H_2O / 50% (80:20 MeOH:ACN)
(both with 10 mM NH_4OAc buffer)
Ramp to 90% organic over 8 min and hold for 2 min
before returning to initial conditions in 1 min.

Time: 12 min

Flow: 300 µl/min

MS Parameters

Experiment: SIR of 21 Channels

Source: Electrospray (negative)
Capillary Voltage (kV) = 3.00
Cone Voltage (V) = variable (10-80)
Cone Gas Flow (l/hr) = 50
Desolvation Gas Flow (l/hr) = 750

ATTACHMENT 4

Figure 2: **PFAC-MXC; LC/MS/MS Data (Selected MRM Transitions)**

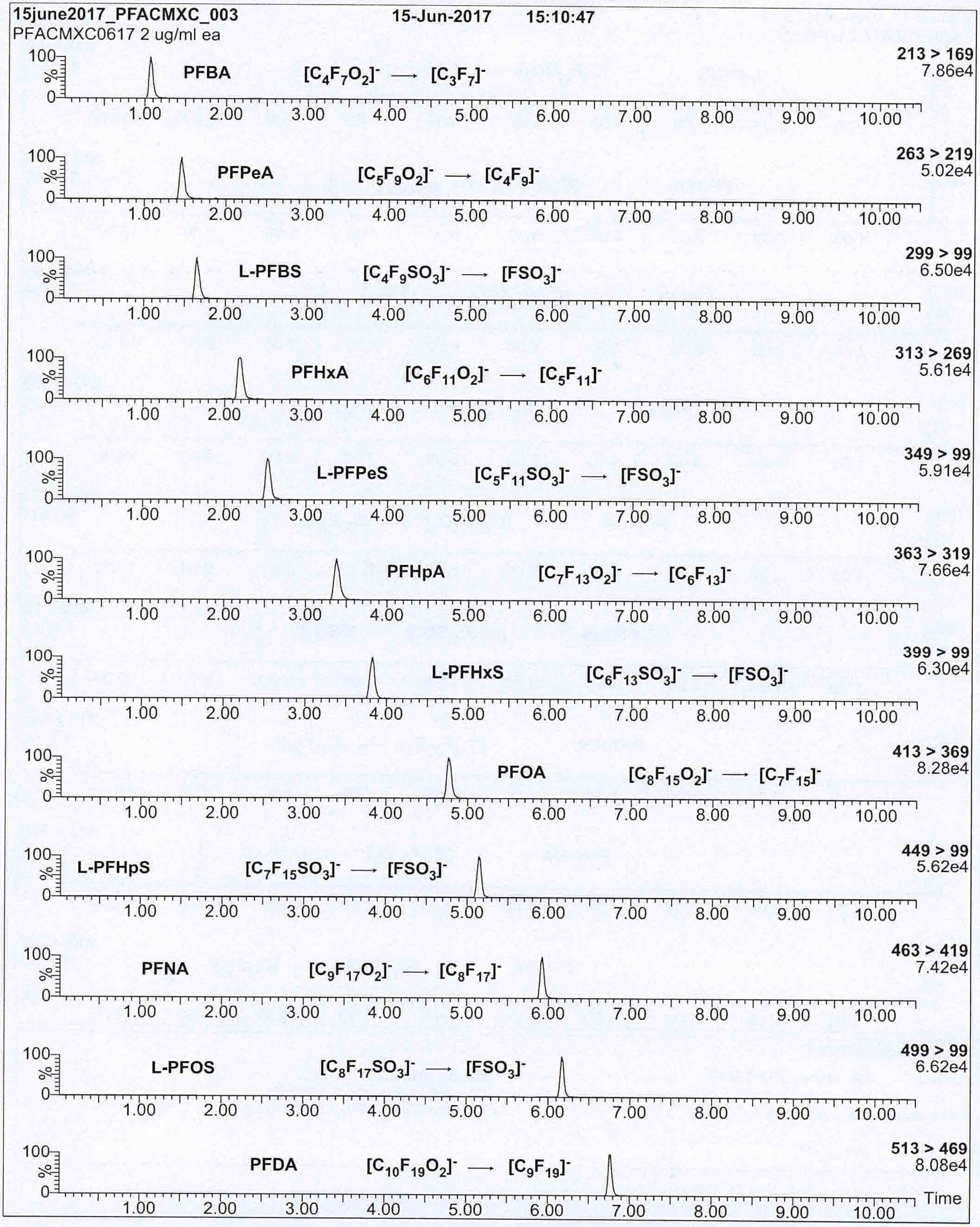
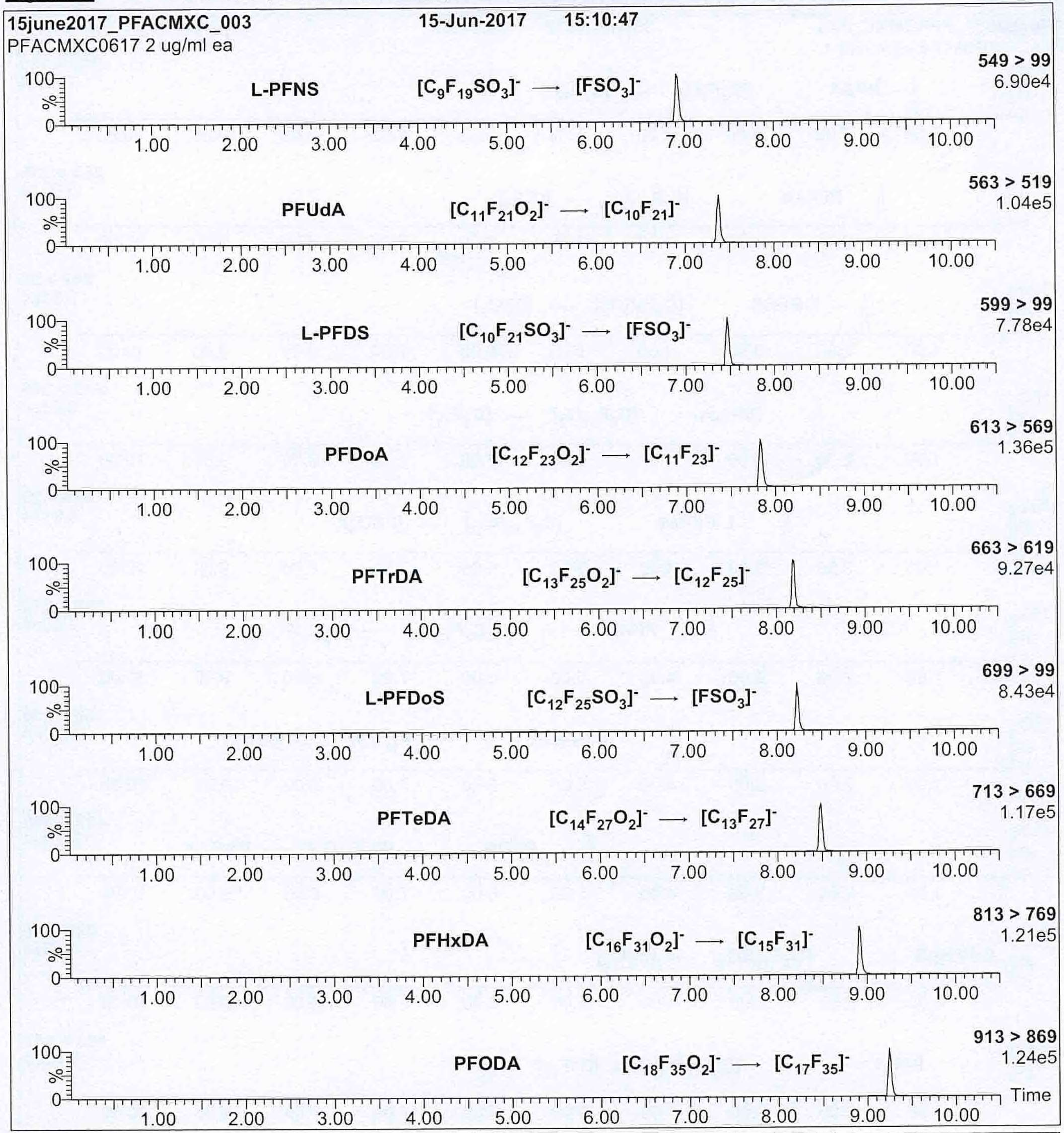


Figure 2: **PFAC-MXC; LC/MS/MS Data (Selected MRM Transitions)**



15june2017_PFACMXC_003 **15-Jun-2017** **15:10:47**
PFACMXC0617 2 ug/ml ea

Conditions for Figure 2:

Injection:	On-column (PFAC-MXC)	**MS Parameters**	
Mobile phase:	Same as Figure 1	Collision Gas (mbar) = 3.46e-3	
Flow:	300 µl/min	Collision Energy (eV) = 8-50 (variable)	

Native PFAS Intermediate A

Vendor	Catalog Number	Analyte	CAS#	Acronym	Conc. (ng/mL)	Aliquot (mL)	Final Volume (ml) Methanol	Final Conc. Native PFAS Intermediate A (ng/ml)
Wellington	PFAC-MXF	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9	11Cl-PF3OUdS	1890	0.10	2	94.5
		9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1	9Cl-PF3ONS	1870			93.5
		4,8-dioxa-3H-Perfluorononanoic acid	919005-14-4	DONA	1890			94.5
		Perfluoro(2-propxypropanoic) acid	13252-13-6	HFPODA	2000			100
Wellington	PFAC-MXH	1H,1H,2H,2H perfluorodecanesulfonic acid	39108-34-4	8:2-FTS	3840	0.05		96
		1H,1H,2H,2H perfluorohexanesulfonic acid	757124-72-4	4:2-FTS	3750			93.8
		1H,1H,2H,2H perfluorooctanesulfonic acid	27619-97-2	6:2-FTS	3800			95
		N-ethylperfluorooctanesulfonamidoacetic acid	2991-50-6	NEtFOSAA	1000			25
		N-methylperfluorooctanesulfonamidoacetic acid	2355-31-9	NMeFOSAA	1000			25
		Perfluorobutanesulfonic acid	375-73-5	PFBS	887			22.2
		Perfluorobutanoic acid	375-22-4	PFBA	4000			100
		Perfluorodecanesulfonic acid	335-77-3	PFDS	965			24.1
		Perfluorodecanoic acid	335-76-2	PFDA	1000			25
		Perfluorododecanesulfonic acid	79780-39-5	PFDoDS	970			24.3
		Perfluorododecanoic acid	307-55-1	PFDoDA	1000			25
		Perfluoroheptanesulfonic acid	375-92-8	PFHpS	953			23.8
		Perfluoroheptanoic acid	375-85-9	PFHpA	1000			25
		Perfluorohexanesulfonic acid	355-46-4	PFHxS	914			22.9
		Perfluorohexanoic acid	307-24-4	PFHxA	1000			25
		Perfluorononanesulfonic acid	68259-12-1	PFNS	962			24.1
		Perfluorononanoic acid	375-95-1	PFNA	1000			25
		Perfluorooctanesulfonamide	754-91-6	PFOSA	1000			25
		Perfluorooctanesulfonic acid	1763-23-1	PFOS	928			23.2
		Perfluorooctanoic acid	335-67-1	PFOA	1000			25
		Perfluoropentanesulfonic acid	2706-91-4	PFPeS	941			23.5
		Perfluoropentanoic acid	2706-90-3	PFPeA	2000			50
		Perfluorotetradecanoic acid	376-06-7	PFTeDA	1000			25
		Perfluorotridecanoic acid	72629-94-8	PFTrDA	1000			25
		Perfluoroundecanoic acid	2058-94-8	PFUnDA	1000			25
Wellington	PFAC-MXG	Perfluoro-3-methoxypropanoic acid	377-73-1	PFMPA	2000	0.05		50
		Perfluoro-4-methoxybutanoic acid	863090-89-5	PFMBA	2000			50
		Nonafluoro-3,6-dioxaheptanoic acid	151722-58-6	NFDHA	2000			50
		Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	PFEESA	1780			44.5
Wellington	PFAC-MXI	2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	24448-09-7	NMePFOSAE	10000	0.05		250
		N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	1000			25
		2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	1691-99-2	NEtPFOSAE	10000			250
		N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	1000			25

Native PFAS Intermediate B								
Vendor	Catalog Number	Analyte	CAS#	Acronym	Conc. (ug/mL)	Aliquot (mL)	Final Volume (ml) Methanol	Final Conc. Native PFAS Intermediate B (ug/ml)
Wellington	PFAC-MXJ	3-Perfluoropropylpropanoic acid	763051-92-9	3:3 FTCA	4	0.125	5	100
		3-Perfluoropentylpropanoic acid	756426-58-1	5:3 FTCA	20			500
		3-Perfluoroheptylpropanoic acid	919005-14-4	7:3 FTCA	20			500

Working Labeled Extraction Standard Spike*							
Solution Name	Analyte	CAS#	Acronym	Conc. (ng/mL)	Aliquot (mL)	Final Volume	Final Conc. Working Labeled Extraction Standard Spike (ng/ml)
Mass-Labelled PFAS Extraction Standard Solution/Mixture-ES*	Perfluoro-n-[^{13}C4]butanoic acid	STL00992	^{13}C4-PFBA	2000	1	1	2000
	Perfluoro-n-[^{13}C5]pentanoic acid	STL01893	^{13}C5-PFPeA	1000			1000
	Perfluoro-n-[1,2,3,4,6-^{13}C5]hexanoic acid	STL02577	^{13}C5 -PFHxA	500			500
	Perfluoro-n-[1,2,3,4-^{13}C4]heptanoic acid	STL01892	^{13}C4-PFHpA	500			500
	Perfluoro-n-[^{13}C8]octanoic acid	STL01052	^{13}C8-PFOA	500			500
	Perfluoro-n-[^{13}C9]nonanoic acid	STL02578	^{13}C9-PFNA	250			250
	Perfluoro-n-[1,2,3,4,5,6-^{13}C6]decanoic acid	STL02579	^{13}C6-PFDA	250			250
	Perfluoro-n-[1,2,3,4,5,6,7-^{13}C7]undecanoic acid	STL02580	^{13}C7-PFUnA	250			250
	Perfluoro-n-[1,2-^{13}C2]dodecanoic acid	STL02703	^{13}C2-PFDoA	250			250
	Perfluoro-n-[1,2-^{13}C2]tetradecanoic acid	STL02116	^{13}C2-PFTeDA	250			250
	Perfluoro-1-[2,3,4-^{13}C3]butanesulfonic acid	STL02337	^{13}C3-PFBS	466			466
	Perfluoro-1-[1,2,3-^{13}C3]hexanesulfonic acid	STL02581	^{13}C3-PFHxS	474			474
	Perfluoro-1-[^{13}C8]octanesulfonic acid	STL01054	^{13}C8-PFOS	479			479
	Perfluoro-1-[^{13}C8]octanesulfonamide	STL01056	^{13}C8 -PFOSA	500			500
	N-methyl-d3-perfluoro-1-octanesulfonamido acetic acid	STL02118	D3-NMeFOSAA	1000			1000
	N-ethyl-d5-perfluoro-1-octanesulfonamido acetic acid	STL02117	D5-NEtFOSAA	1000			1000
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]hexan sulfonic acid	STL02395	^{13}C2-4:2FTS	938			938
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]octanesulfonic acid	STL02279	^{13}C2-6:2FTS	951			951
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]decanesulfonic acid	STL02280	^{13}C2-8:2FTS	960			960
	Tetrafluoro-2-heptafluoropropoxy-^{13}C3-propanoic acid	STL02255	^{13}C3-HFPO-DA	2000			2000
	N-methyl-d7-perfluorooctanesulfonamidoethanol	STL02277	D7-NMeFOSE	5000			5000
	N-ethyl-d9-perfluorooctanesulfonamidoethanol	STL02278	D9-NEtFOSE	5000			5000
	N-ethyl-d5-perfluoro-1-octanesulfonamide	STL02704	D5-NEtFOSA	500			500
	N-methyl-d3-perfluoro-1-octanesulfonamide	STL02705	D3-NMeFOSA	500			500

* Solution used without dilution for spiking. Entered into LIMS as a 1:1 dilution to utilize the standardized naming

Internal Standard Spike				
Solution Name	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/mL)**
Mass-Labelled PFAS Injection Standard Solution/Mixture	Perfluoro-n-[2,3,4-^{13}C3]butanoic acid	STL02680	^{13}C3-PFBA	1000
	Perfluoro-n-[1,2,3,4-^{13}C4]octanoic acid	STL00990	^{13}C4-PFOA	500
	Perfluoro-n-[1,2-^{13}C2]decanoic acid	STL00996	^{13}C2-PFDA	250
	Perfluoro-n-[1,2,3,4-^{13}C4]octanesulfonic acid	STL00991	^{13}C4-PFOS	479
	Perfluoro-n-[1,2,3,4,5-^{13}C5] nonanoic acid	STL00995	^{13}C5-PFNA	250
	Perfluoro-n-[1,2-^{13}C2]hexanoic acid	STL00993	^{13}C2-PFHxA	500
	Perfluoro-1-hexane[^{18}O2]sulfonic acid	STL00994	^{18}O2-PFHxS	474

Native 1633 Mid-Level Spike								
Solution Name	**Catalog Number**	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/mL)**	**Aliquot (mL)**	**Final Volume**	**Final Conc. Native 1633 Mid-Level Spike (ppb)**
Wellington	PFAC-MXF	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9	11Cl-PF3OUdS	1890	0.63	5mL	236.250
		9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1	9Cl-PF3ONS	1870			233.750
		4,8-dioxa-3H-Perfluorononanoic acid	919005-14-4	DONA	1890			236.250
		Perfluoro(2-propxypropanoic) acid	13252-13-6	HFPODA	2000			250.000
Wellington	PFAC-MXH	1H,1H,2H,2H perfluorotelomersulfonic acid	39108-34-4	4:2-FTS	3840	0.31		480.000
		1H,1H,2H,2H perfluorotelomersulfonic acid	757124-72-4	6:2-FTS	3750			468.750
		1H,1H,2H,2H perfluorotelomersulfonate acid	27619-97-2	8:2-FTS	3800			475.000
		N-ethylperfluorooctanesulfonamidoacetic acid	2991-50-6	NEtFOSAA	1000			125.000
		N-methylperfluorooctanesulfonamidoacetic acid	2355-31-9	NMeFOSAA	1000			125.000
		Perfluorobutanesulfonic acid	375-73-5	PFBS	887			110.875
		Perfluorobutanoic acid	375-22-4	PFBA	4000			500.000
		Perfluorodecanesulfonic acid	335-77-3	PFDS	965			120.625
		Perfluorodecanoic acid	335-76-2	PFDA	1000			125.000
		Perfluorododecanesulfonic acid	79780-39-5	PFDoDS	970			121.250
		Perfluorododecanoic acid	307-55-1	PFDoDA	1000			125.000
		Perfluoroheptanesulfonic acid	375-92-8	PFHpS	953			119.125
		Perfluoroheptanoic acid	375-85-9	PFHpA	1000			125.000
		Perfluorohexanesulfonic acid	355-46-4	PFHxS	914			114.250
		Perfluorohexanoic acid	307-24-4	PFHxA	1000			125.000
		Perfluorononanesulfonic acid	68259-12-1	PFNS	962			120.250
		Perfluorononanoic acid	375-95-1	PFNA	1000			125.000
		Perfluorooctanesulfonamide	754-91-6	PFOSA	1000			125.000
		Perfluorooctanesulfonic acid	1763-23-1	PFOS	928			116.000
		Perfluorooctanoic acid	335-67-1	PFOA	1000			125.000
		Perfluoropentanesulfonic acid	2706-91-4	PFPeS	941			117.625
		Perfluoropentanoic acid	2706-90-3	PFPeA	2000			250.000
		Perfluorotetradecanoic acid	376-06-7	PFTeDA	1000			125.000
		Perfluorotridecanoic acid	72629-94-8	PFTrDA	1000			125.000
		Perfluoroundecanoic acid	2058-94-8	PFUnDA	1000			125.000
Wellington	PFAC-MXG	Perfluoro-3-methoxypropanoic acid	377-73-1	PFMPA	2000	0.31		250.000
		Perfluoro-4-methoxybutanoic acid	863090-89-5	PFMBA	2000			250.000
		Nonafluoro-3,6-dioxaheptanoic acid	151722-58-6	NFDHA	2000			250.000
		Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	PFEESA	1780			222.500
Wellington	PFAC-MXI	2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	24448-09-7	NMePFOSAE	10000	0.39		1250.000
		N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	1000			125.000
		2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	1691-99-2	NEtPFOSAE	10000			1250.000
		N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	1000			125.000
Wellington	PFAC-MXJ	3-Perfluoropropylpropanoic acid	763051-92-9	3:3 FTCA	4000	0.03		312.500
		3-Perfluoropentylpropanoic acid	756426-58-1	5:3 FTCA	20000			1562.500
		3-Perfluoroheptylpropanoic acid	919005-14-4	7:3 FTCA	20000			1562.500

eurofins	Always check on-line for validity. **Analysis of Per and Polyfluoroalkyl Substances (PFAS) in Tissue Samples by LC-MS/MS Using Draft Method 1633/QSM5.4 Table B24**	Level: **Work Instruction**
Document number: **T-PFAS-WI49212**		
Old Reference:		
Version: **1**		Organisation level: **5-Sub-BU**
Approved by: **XL3S** Effective Date: **27-OCT-2022**	Document users: **5_EUUSLA_PFAS_Manager, 6_EUUSLA_PFAS_Analyst, 6_EUUSLA_PFAS_Data_Reviewers, 6_EUUSLA_PFAS_Management_Team, 6_EUUSLA_PFAS_Sample_Prep**	Responsible: **5_EUUSLA_PFAS_Manager**

Revision Log

Revision:	1	**Effective date:** This version
Section	**Justification**	**Changes**
Revision Log	NEW	NEW

Reference

1. Per- and Polyfluoroalkyl Substances (PFAS) Analysis by LC/MS/MS (EPA Draft method 1633), Department of Defense Quality System Manual Version 5.4, Table B-24.

2. US EPA Method 1633, *Analysis of Per and Polyfluoroalkyl Substances(PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS*, Version 2nd DRAFT, June 2022.

3. *Chemical Hygiene Plan*, current version.

Cross Reference

1633

Document	Document Title
T-PFAS-WI21568	Manifold and N-EVAP Cleaning for PFAS Extractions
T-PEST-WI9847	Common Equations Used During Chromatographic Analyses
QA-SOP11178	Demonstrations of Capability
QA-SOP11892	Determining Method Detection Limits and Limits of Quantitation

Scope

This method is applicable for the determination of selected per- and polyfluorinated alkyl substances (PFAS) in tissue samples. The compounds analyzed in this method are listed in the table below. The most current MDLs and LOQs are listed in the LIMS. Compounds other than those listed may be analyzed by client request.

Analyte	Acronym	CAS#
Perfluorobutanesulfonic acid	PFBS	375-73-5
Perfluorodecanoic acid	PFDA	335-76-2
Perfluorododecanoic acid	PFDoDA	307-55-1
Perfluoroheptanoic acid	PFHpA	375-85-9
Perfluorohexanesulfonic acid	PFHxS	355-46-4
Perfluorohexanoic acid	PFHxA	307-24-4
Perfluorononanoic acid	PFNA	375-95-1
Perfluorooctanesulfonic acid	PFOS	1763-23-1
Perfluorooctanoic acid	PFOA	335-67-1
Perfluorotetradecanoic acid	PFTeDA	376-06-7

Analyte	Acronym	CAS#
Perfluorotridecanoic acid	PFTrDA	72629-94-8
Perfluoroundecanoic acid	PFUnDA	2058-94-8
Perfluoro-n-butanoic acid	PFBA	375-22-4
Perfluoro-n-pentanoic acid	PFPeA	2706-90-3
8:2 - Fluorotelomersulfonic acid	8:2FTS	39108-34-4
N-methylperfluoro-1-octanesulfonamidoacetic acid	NMeFOSAA	2355-31-9
N-ethylperfluoro-1-octanesulfonamidoacetic acid	NEtFOSAA	2991-50-6
4:2-Fluorotelomersulfonic acid	4:2-FTS	757124-72-4
Perfluoropentanesulfonic acid	PFPeS	2706-91-4
6:2-Fluorotelomersulfonic acid	6:2-FTS	27619-97-2
Perfluoroheptanesulfonic acid	PFHpS	375-92-8
Perfluorononanesulfonic acid	PFNS	68259-12-1
Perfluorodecanesulfonic acid	PFDS	335-77-3
Perfluorododecanesulfonic acid	PFDoDS	79780-39-5
Perfluorooctanesulfonamide	PFOSA	754-91-6
2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	NMePFOSAE	24448-09-7
N-methylperfluoro-1-octanesulfonamide	NMePFOSA	31506-32-8
2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	NEtPFOSAE	1691-99-2
N-ethylperfluoro-1-octanesulfonamide	NEtPFOSA	4151-50-2
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoic acid; (Hexafluoropropylene oxide dimer acid)	HFPODA	13252-13-6
Ammonium 4,8-dioxa-3H-perfluorononanoic acid	DONA **	919005-14-4 *
Potassium 9-chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS, F53B major	756426-58-1 *

Analyte	Acronym	CAS#
Potassium 11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS, F53B minor	763051-92-9 *
3-Perfluoropropylpropanoic acid	3:3 FTCA	356-02-5
3-Perfluoropentylpropanoic acid	5:3 FTCA	914637-49-3
3-Perfluoroheptylpropanoic acid	7:3 FTCA	812-70-4
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7

*CAS# for the free acid form of the analyte

**Acronym for the free acid form of the analyte

Basic Principles

A tissue is homogenized and is fortified with isotopically-labeled extraction standards. The sample extract is shaken, centrifuged, and the supernatant decanted. Carbon cleanup is performed on each sample extract. Sample extract is diluted to volume and then concentrated. The sample is then passed through a solid phase extraction (SPE) cartridge to extract the analytes. The compounds are eluted from the solid phase with a combination of solvents. The extract is fortified with Isotopically-labeled injection internal standards and filtered. It is then analyzed by LC/MS/MS operated in negative electrospray ionization (ESI) mode for detection and quantification of the analytes. Quantitative analysis is performed using isotope dilution.

Interferences

Compounds which have similar structures to the compounds of interest and similar molecular weights would potentially interfere. Method interferences may be caused by contaminants in solvents, reagents (including reagent water), sample bottles and caps, and other sample processing hardware that lead to discrete artifacts and/or elevated baselines in the chromatograms. The analytes in this method can also be found in many common laboratory supplies and equipment, such as PTFE (polytetrafluoroethylene) products, LC solvent lines, methanol, aluminum foil, etc. A laboratory blank is performed with each batch of samples to demonstrate that the extraction system is free of contaminants.

Precaution to Minimize Method Interference

1. LC system components contain many of the target analytes. To minimize the background PFAS peaks, PTFE solvent frits and tubing are replaced by PEEK™ solvent frits and tubing where possible.

2. A precolumn, Phenomenex Luna, 30 x 2 mm, 5 µm C18 column, is installed before the injection valve to separate PFAS in standards/samples from those from the LC system and mobile phases.

3. All parts of the SPE manifold must be cleaned as per *T-PFAS-WI21568*.

Safety Precautions and Waste Handling

See *Chemical Hygiene Plan* for general information regarding employee safety, waste management, and pollution prevention.

The toxicity or carcinogenicity of each reagent used in this method has not been precisely defined. PFOA has been described as "likely to be carcinogenic to humans". Each chemical should be treated as a potential health hazard and exposure to these chemicals should be minimized.

Exposure to these chemicals must be reduced to the lowest possible level by whatever means available, such as fume hoods, lab coats, safety glasses, and gloves. Gloves, lab coats, and safety glasses should be worn when preparing standards and handling samples. Avoid inhaling solvents and chemicals and getting them on the skin. Wear gloves when handling neat materials. When working with acids and bases, take care not to come in contact and to wipe any spills. Always add acid to water when preparing reagents containing concentrated acids.

All laboratory waste is accumulated, managed, and disposed of in accordance with all Federal, State, and local laws and regulations. All solvent waste and extracts are collected in approved solvent waste containers in the laboratory and subsequently emptied by personnel trained in hazardous waste disposal into the lab-wide disposal facility. HPLC vials are disposed of in the lab container for waste vials, and subsequently lab packed. Any solid waste material (disposable pipettes and broken glassware, etc.) may be disposed of in the normal solid waste collection containers.

Personnel Training and Qualifications

All personnel performing this procedure must have documentation of reading, understanding, and agreeing to follow the current version of this SOP and an annual documented Demonstration of Capability (DOC).

Each chemist performing the extraction must work with an experienced employee for a period of time until they can independently perform the extraction. Also, several batches of sample extractions must be performed under the direct observation of another experienced chemist to assure the trainee is capable of independent preparation. Proficiency is measured through a documented Initial Demonstration of Capability (IDOC).

Each LC/MS/MS analyst must work with an experienced employee for a period of time until they can independently calibrate the LC/MS/MS, review and process data, and perform maintenance procedures. Proficiency is measured through a documented Initial Demonstration of Capability (IDOC).

The IDOC and DOC consist of four laboratory control samples (or alternatively, one blind sample for the DOC) that is carried through all steps of the extraction and meets the defined acceptance criteria. The criteria include the calculation of mean accuracy and standard deviation. IDOC trials are spiked at the OPR Level.

See *QA-SOP11178* for additional information on IDOC and DOC.

Sample Collection, Preservation, and Handling

A. Sample Collection

The samples are collected in 500 mL HDPE widemouth sample bottle or jar with linerless HDPE or polypropylene caps. Collect samples as grab samples using wide-mouth jar and fill no more than ¾ full. Keep the sample sealed from time of collection until extraction.

NOTE: PFAS contamination during sampling can occur from a number of common sources, such as food packaging and certain foods and beverages. Proper hand washing and wearing nitrile gloves will aid in minimizing this type of accidental contamination of the samples.

B. Sample Storage and Shipment

1. Fish samples may be received as a whole fish, fish fillets, or other tissues for analysis. If whole fish are collected it will be wrapped in aluminum foil or food-grade polyethylene tubing and maintained at 0-6°C for a maximum of 24 hours. Sample temperature must be confirmed to be at or below 6°C when the samples are received at the laboratory.

2. Samples stored in the lab must be protected from light and held at a temperature of ≤-20°C until extraction.

3. Tissue samples must be extracted within 90 days, or as soon as possible if NFDHA is an analyte of interest. Extracts must be analyzed within 28 days after extraction. Extracts are stored in the refrigerator.

Apparatus and Equipment

A. Apparatus

1. 500-mL HDPE bottles: Scientific Specialties; # 334008-blk-1, or equivalent.
2. Centrifuge tubes – 15-mL conical polypropylene with polypropylene screw caps; Fisher Scientific, Cat. No. 05-539-5 or equivalent
3. 10-mL polypropylene volumetric flask, Class A – Fisher Scientific, Cat. No. S02288 or equivalent.
4. HDPE bottles for extraction fluid storage: L; Environmental Sampling Supply, Cat. No. 1000-1902-PC.
5. Analytical Balance – Capable of weighing to 0.0001 g
6. Top-Loading Balance – Capable of weighing to 0.01 g
7. Solid phase extraction (SPE) Weak Anion Exchange ("WAX") cartridge – Agilent; Sampli-Q WAX Polymer; 150mg/6mL; Cat. # 5982-3667.
8. Large-volume SPE Reservoir (25-mL) - Millipore-Sigma; Product # 54258-U.
9. SPE Tube Adapter - Millipore-Sigma; Product # 57020-U.
10. SPE vacuum extraction manifold –"Resprep" 24-port manifold; Restek Corp catalog # 26080, or equivalent.
11. Polypropylene SPE delivery needles – Agilent; Cat. No. 12234511.
12. Centrifuge – "Q-Sep 3000"; Restek Corp. Cat. No. 26230, or equivalent, capable of a minimum rotational speed of 3000 rpm.
13. Disposable polyethylene pipette – Fisher Scientific, Cat. No. S30467-1 or equivalent.
14. Auto Pipettes – Eppendorf; capable of accurately dispensing 10- to 1000-µL. FisherScientific cat # 14-287-150, or equivalent.
15. Polypropylene pipette tips: 0-200µl. Fisher; Cat. No. 02-681-135
16. Polypropylene pipette tips: 101-1000µl. Fisher, Cat. No. 02-707-508
17. Pipettes – Disposable transfer. FisherScientific, Cat. No. 13-711-7M
18. Vortex mixer, variable speed, Fisher Scientific or equivalent.
19. N-Evap sample extract concentrator with N_2 supply and water bath for temperature control. Organomation, Inc. Cat. #11250, or equivalent.

20. Reagent Water Purification System: Capable of producing ultrapure "Type 1/Milli-Q"-grade water from in-house deionized water system. Millipore SAS; Cat. No. FTPF08831.

21. Thermo Target PP Polyspring inserts, catalog number C4010-630P

22. Agilent 9mm vial kit pack, catalog number 5190-2278, or equivalent

23. Centrifuge tubes – 50-mL conical polypropylene with polypropylene screw caps; Fisher Scientific, Cat. No. 06-443-21 or equivalent

24. Polypropylene bottles for standard storage - 4 mL; Fisher Scientific, Cat. No. 2006-9125

25. Stainless steel spatula/scoop set. Bel-Art SP Scienceware; Product # 11-865-130.

26. pH paper, range 0-14, Whatman Panpeha or equivalent, 0.5 unit readability

27. Syringe filter - Acrodisc, Syringe Filter, GHP,13 mm, 0.2 µm, Aqueous, 100/pkg, Part # WAT097962.

28. Silanized glass wool (Sigma-Alrich, Cat #20411 or equivalent

29. Disposable syringe filter, 25-mm, 0.2um Nylon membrane, PALL/Acrodisc or equivalent

30. Glass fiber filter, 47 mm, 1 um, PALL A/E or equivalent

31. Variable speed mixing table (Fisherbrand^{TM} Nutating mixer or equivalent

32. Evaporation/concentrator tubes: 60 mL clear glass vial, 30x125 mm, without caps (Wheaton Cat # W226060 or eqvalent).

33. Wooden Tongue Depressors - Fisher; Cat. # 11-700-555, or equivalent.

34. Tissue homogenizer – Pro Scientific PRO400DS homogenizer or equivalent with stanless steel macro-shaft and turbo-shear blade

35. Meat Grinder – Hobart or equivalent with 3- to 5- mm holes in inner plate

36. Burrell, Model 75, Wrist-Action Shaker or equivalent

37. Wheaton Bottle, 15ml, Narrow mouth, HDPE, Leak resistant; DWK Life Sciences, Cat. No. 209044SP, or equivalent

B. Equipment

1. AB Sciex Triple Quad 4500/5500/5500 Plus Turbo V Ion Source

ExionLC Controller
ExionLC AC Pump
ExionLC AC Autosampler
Exion AC Column Oven
Data system –Analyst 1.6.3

2. HPLC columns

    a. Analytical column: Gemini 3µm C18, 50 x 3 mm, Phenomenex Cat# 00B-4439-YO or equivalent

    b. Pre-column: Luna, 5µm C18, 50 x 3 mm, Phenomenex Cat# 00B-4252-Y0, or equivalent

Reagents and Standards

All solvents, acids, and bases are stored in glass bottles in flammable proof cabinets or pressure resistant steel drums. Solvents, acids, and bases are stored at ambient temperature for up to 1 year. All non-solvents are stored according to manufacturer's storage conditions.

A. Reagents:

1. Methanol (MeOH) – Honeywell Burdick and Jackson "Chromasolv LC-MS" grade Cat. No. BJ34966-4L or equivalent

2. Acetonitrile (ACN) – Fisher Scientific, Optima Cat. No. A955-4 or equivalent

3. Ammonium acetate – Fisher Scientific, Cat. No. A637-500 or equivalent

4. Ammonium hydroxide, 30% in water, certified ACS+ grade or equivalent, store at room temperature

5. Methanolic ammonium hydroxide (0.3%) – add ammonium hydroxide (10 mL, 30%) to methanol (990 mL), store at room temperature, replace after 1 month

6. Methanolic ammonium hydroxide (1%) - add ammonium hydroxide (3.3 mL, 30%) to methanol (97 mL), store at room temperature, replace after 1 month

7. Methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid - add ammonium hydroxide (3.3 mL, 30%), reagent water (1.7 mL) and acetic acid (0.625 mL) to methanol (92 mL), store at room temperature, replace after 1 month.

8. Acetic Acid – ACS grade or equivalent, store at room temperature

9. Acetic Acid (0.1%) – dissolve acetic acid (1 mL) in reagent water (1 L), store at room temperature, replace after 3 months.

10. Formic acid

    a. Formic acid (aqueous, 0.1 M) - dissolve formic acid (4.6 g) in reagent water (1 L), store at room temperature, replace after 2 years

    b. Formic acid (aqueous, 0.3 M) - dissolve formic acid (13.8 g) in reagent water (1 L), store at room temperature, replace after 2 years

    c. Formic acid (aqueous, 5% v/v) - mix 5 mL formic acid with 95 mL reagent water, store at room temperature, replace after 2 years

    d. Formic acid (aqueous, 50% v/v) - mix 50 mL formic acid with 50 mL reagent water, store at room temperature, replace after 2 years

    e. Formic acid (methanolic 1:1, 0.1 M formic acid/methanol) - mix equal volumes of methanol and 0.1 M formic acid, store at room temperature, replace after 2 years

11. "Superclean Envi-Carb"; bulk sorbent. Millipore-Sigma; 50g; Product # 57210-U.

12. Tilapia- commercially sourced

13. 20 mM ammonium acetate solution in 95:5(v/v) Milli-Q water/acetonitrile-Weigh 3.08 ± 0.01g ammonium acetate into a 2-L glass mobile phase bottle. Add 1900 mL Milli-Q water and mix well to dissolve the ammonium acetate. Add 100 mL acetonitrile and mix well. Store at room temperature for up to 2 months. Different volumes can be prepared as long as final concentrations are equivalent.

14. 20 mM ammonium acetate solution in 90:10 acetonitrile/Milli-Q water – Weigh 3.08 ± 0.01g ammonium acetate into a 2-L glass mobile phase bottle. Add 200 mL of Milli-Q water and mix well to dissolve the Ammonium Acetate. Add 1800 mL of acetonitrile and mix well. Store at room temperature for up to 2 months. Different volumes can be prepared as long as final concentrations are equivalent.

B. Standards:

Standards are prepared using calibrated pipettes, polypropylene microcentrifuge tubes, polypropylene bottles, and 10 ml Class A PP volumetric flasks to create solutions at desired concentrations. The concentrated solution is injected below the surface of the diluting solvent. After preparation is completed, standards should be vortexed to ensure complete mixing. Measurement of volumes less than 5 µl should be avoided in routine production operations.

All stock, intermediate and spiking solutions are prepared using Methanol.

All initial calibration, initial calibration verification, and linear branched working standard solutions are prepared using Methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid.

All diluted solutions must be stored in HDPE containers that have been thoroughly rinsed with methanol.

Stock standard and intermediate standard solutions are stored in the refrigerator in labeled polypropylene screw-top vials, PP bottles, or PP centrifuge tubes.

Expiration dates are managed through LIMS Reagent. Solutions transferred from sealed glass ampules to screw-capped vials are given expiration dates of 1 year from the date opened or the expiration date provided by the vendor, whichever occurs sooner. Intermediate solutions are given an expiration date of 6 months from the preparation date, or the expiration date from the ampule provided by the vendor, whichever occurs sooner. The ampules and transferred solutions are stored in the refrigerator.

Working native and labeled (extraction surrogate and internal standard) compound spiking solutions are given an expiration date of 6 months, or the expiration date of the solutions used to prepare the working solution, whichever occurs sooner. The solutions are stored in labeled polypropylene screw-top vials in the refrigerator. When these solutions are prepared they must be tested prior to use in the PFAS extraction lab and verified monthly until they are consumed by operations or expire. Records of the standard verification are maintained by the laboratory. Prior to use, the working spiking solution should be evaluated against recovery windows of 85-115% for all compounds that will be analyzed using that solution. Should a standard fail to meet these criteria, the data must be reviewed by departmental management for acceptability and/or corrective action.

Working initial calibration solutions are given an expiration date of 6 months, or the expiration date of the solutions used to prepare the working initial calibration solution, whichever occurs sooner.

The primary/preferred standard vendor is Wellington Laboratories, Inc. Ontario, Canada. Listed catalog numbers are taken from Wellington product lists. Equivalent standards may be substituted, if the listed standards are unavailable.

The solution concentration listed is as presented on the certificate of analysis and includes adjustment for purity and the salt form of the compound used.

Note: The concentrations referenced for the sulfonate salts, (for example PFBS, PFHxS and PFOS) have already been corrected to the acid form by the standards supplier as noted in the example Certificate of analysis (CofA). See *Attachment 4*.
If the compound purity is assayed to be 96% or greater, weight can be used without correction to calculate concentrations.

Log purchased standards into LIMS Reagent. Select the solution category SOURCE for purchased mixes and/or single-compound ampules. LIMS Reagent system will assign formatted names to the purchased standard solutions. The automatically-generated name can be overwritten with a manually created name if desired. Use labels printed through the LIMS Reagent to identify and track standard solutions after transfer from original ampule to storage vial. The CofA for the ampulated stock standard is attached in LIMS Reagent for reference.

Standards are prepared by transferring a known quantity of Standard to a final volume of solvent. Standard Preparation is documented in LIMS Reagent. Solutions are stored by Type in LIMS Reagent, i.e., INTERMEDIATE=working solutions and intermediate standards and SOURCE=stocks (ampulated solutions). Each Standard is given a unique name.

The following attachments provide examples of standard preparation and purchasing information. Refer to the documentation in LIMS Reagent for standards preparation information.

Attachment 5 - Native PFAS Intermediate A
Attachment 6 - Native PFAS Intermediate B
Attachment 7 - Working Labeled Extraction Standard Spike
Attachment 8 - Internal Standard Spike
Attachment 9 - Native 1633 Mid-Level Spike
Attachment 10 - Native 1633 Low-Level Spike
Attachment 11 - 1633 Initial Calibration Standards Preparation
Attachment 12 - 1633 Initial calibration Standards Concentrations
Attachment 13 - TDCA Stock Solution
Attachment 14 - TDCA Working Solution A
Attachment 15 - TDCA Working Solution B
Attachment 16 - 1633 Linear/Branched TDCA Intermediate
Attachment 17 - 1633 Linear/Branched TDCA Solution
Attachment 18 - PFAS 1633 ICV Working Standard
Attachment 19 - 1633 Labeled Ampulated Standards
Attachment 20 - 1633 Native Ampulated Standards

Calibration

A. Initial Calibration

1. A minimum of six calibration standards are required when using an average or linear curve fit. A minimum of seven calibration standards are required for a second-order(quadratic) curve fit. In general, Cal1, Cal2, Cal3, Cal4, Cal5, Cal6, and Cal7 are included in the initial calibration. The calibration standards contain the branched isomers for PFHxS, PFOS, NMeFOSAA, and NEtFOSAA. S/N ratio must be greater than or equal to 3:1 for all ions used for quantification.

2. Analyze a Cal4 level standard that contains TDCA retention time marker and linear and branch chained isomers of PFOA, PFNA, PFOSA, NMeFOSA, NEtFOSA, NMeFOSE, and NEtFOSE. The analysis of this standard is used to evaluate the interference from bile salts in tissue samples, as well as evaluate where the branch chained isomers elute and not included in the calibration

curve. This will assist the chemist in identifying and properly integrating this compound in samples.

Example Initial Calibration Sequence:

1. Instrument Blank
2. Instrument Blank
3. Instrument Blank
4. CAL 1
5. CAL 2
6. CAL 3
7. CAL 4
8. CAL 5
9. CAL 6
10. CAL 7
11. ICB (Instrument Blank)
12. ICV
13. MDL
14. WDM (Linear Branched/TDCA standard)

3. Isotopically-labeled compounds are not available for some compounds. See below for compounds and their referenced extraction standards. See *Attachment 2* for additional information about compound relationships.

4. Analyze a standard at a concentration of 100 ppb containing Taurodeoxycholic Acid (TDCA). The analysis of this standard is used to evaluate the chromatographic program relative to the risk of an interference from bile salts in tissue samples. The analytical conditions must be set to allow a separation of at least 1 minute between the bile salts and PFOS.

   NOTE: For better accuracy, PFTrDA is quantitated using the average of the areas of labeled compounds 13C2-PFTeDA and 13C2-PFDoDA.

Compound	**Extraction Standard**
PFBA	13C4-PFBA
PFPeA	13C5-PFPeA
3:3FTCA	
PFMPA	
PFMBA	
PFHxA	13C5-PFHxA
NFDHA	

5:3FTCA	
7:3FTCA	
PFEESA	
PFHpA	13C4-PFHpA
PFOA	13C8-PFOA
PFNA	13C9-PFNA
PFDA	13C6-PFDA
PFUnA	13C7-PFUnA
PFDoA	13C2-PFDoA
PFTrDA	Avg 13C2-PFTeDA and 13C2-PFDoA
PFTeDA	13C2-PFTeDA
PFBS	13C3-PFBS
PFPeS	13C3-PFHxS
PFHxS	
PFHpS	13C8-PFOS
PFOS	
PFNS	
PFDS	
PFDoS	
4:2-FTS	13C2-4:2-FTS
6:2-FTS	13C2-6:2-FTS
8:2-FTS	13C2-8:2-FTS
PFOSA	13C8-PFOSA
NMeFOSA	D3-NMeFOSA
NEtFOSA	D5-NEtFOSA

NMeFOSAA	D3-NMeFOSAA
NEtFOSAA	D5-N-EtFOSAA
NMeFOSE	D7-NMeFOSE
NEtFOSE	D9-NEtFOSE
HFPO-DA	13C3-HFPO-DA
DONA	
9Cl-PF3ONS	
11Cl-PF3OUdS	

5. Fit the curve

   a. If the %RSD for the response factors is less than or equal to 20%, the average response factor (Ave RRF) can be used to quantitate the data.

   b. If the %RSD is greater than 20%, a linear regression with a concentration weighing factor of 1/x is tried for compounds not meeting the criteria in 5.a. The RSE for all method analytes must be less than or equal to 20%.

   c. For all curve fits, each calibration point is calculated back against the curve. The back calculated concentration for each calibration point should be within ±30% of its true value.

   d. If the criteria are not met, the source of the problem must be determined and corrected. Situations may exist where the initial calibration can be used. In those cases, the data will be reported with a qualifying comment.

   NOTE: The concentrations referenced for the sulfonate salts, (for example PFBS, PFHxS and PFOS) have already been corrected to the acid form by the standards supplier as noted in the example Certificate of Analysis (CofA). See *Attachment 4*.

6. Initial Calibration Verification (ICV)

   A check standard prepared from a second source (ICV) is injected to confirm the validity of the calibration curve/standard. If a second source is not available, a separate preparation from the same stock by a second analyst may be used. The calculated amount for each analyte must be within ±30% of the true value. If this criteria is not met, re-inject or remake the standard. If the criteria is still not met, recalibration is necessary. Instrument maintenance may be needed prior to recalibrating.

B. Continuing calibration

1. Once the calibration curve has been established, the continuing accuracy must be verified by analysis of a continuing calibration verification (CCV) standard every ten samples and at the end of the analysis sequence. Subsequent CCV standards should use the Cal4 level standard.

2. Acceptance criteria

   a. The calculated amount for each compound (native and extraction standard) in the CCV standard must be within ±30% of the true value. Samples that are not bracketed by acceptable CCV analyses must be reanalyzed. The exception to this would be if the CCV recoveries are high, indicating increased sensitivity, and there are no positive detections in the associated samples, the data may be reported with a qualifying comment. If two consecutive CCVs fail criteria for target analytes, two passing CCVs must be analyzed or the source of the problem determined and the system recalibrated before continuing sample analysis.

   b. The absolute areas of the injection internal standards should be greater than 30% of the average areas measured during the initial calibration.

Procedure

A. Sample Preparation

NOTE: If a laboratory must dissect a whole fish to obtain appropriate tissue for analysis, the benchtop should be covered with clean aluminum foil, and use clean processing equipment to dissect each sample. Samples should be handled in a semi-thawed state for compositing and/or homogenization. Collect the tissue sample in a stainless steel bowl during grinding and mix using a stainless-steel spoon. Store samples in clean HDPE containers and store frozen until used for sample preparation.

If using a grinder, mix the ground tissue with a spoon after the entire sample has been processed, and transfer back to the grinder. Repeat this process at least two more times until the homogenized tissue has consistent color and texture.

1. On a calibrated, top-loading balance, accurately weigh 2.0g ± 0.10g of tissue sample into a tared, labeled 50-mL centrifuge tube using a disposable polypropylene spatula. Record sample weight in the prep entry system.
2. For each batch - maximum 20 samples - include the following quality control samples:
   a. Method Blank: Weigh 2.0g ± 0.10g of tilapia
   b. LCS: Fortify 2.0g ± 0.10g of tilapia spiked with 200 µL of Native 1633 Mid-Level Spike Solution (PFC_1633_MID_XXXXX).
   c. LLCS: Fortify 2.0g ± 0.10g of tilapia spiked with 400 µL of Native 1633 Low-Level Spike Solution (PFC_1633_LOW_XXXXX).
   d. Matrix Spike/Matrix Spike Duplicate (MS/MSD): Fortify 2.0g ± 0.10 g of sample as specified in sample preparation log with 200 µL of Native 1633 Mid-Level Spike Solution

(PFC_1633_MID_XXXXX).

3. Add 25 µl working labeled extraction standard spike solution (PFC_1633_SS_XXXXX) to each sample/QC tube.
4. Cap and vortex for approximately 30 seconds.
5. Allow samples/QC to equilibrate for at least 30 minutes.
6. Add 10 mL of 0.3% NH_4OH in methanol to each centrifuge tube.
7. Cap and vortex each tube for 10-15 seconds to mix thoroughly.
8. Load the centrifuge tubes onto a bench-top wrist-action shaker and turn power switch “On”.
9. Shake for 16 hours.
10. After 16 hours, remove tubes from shaker.
11. Vortex for for 10-15 seconds to mix thoroughly.
12. Centrifuge at 3000 rpm for 15 minutes.
13. Transfer supernatant(s) to a labeled, clean 50 mL polypropylene centrifuge tube.
14. Cap supernatent tube and set aside.
15. Add 10 mL of acetonitrile to the remaining tissue sample in each centrifuge tube.
16. Cap and vortex 10-15 seconds to mix thoroughly.
17. Load the centrifuge tubes onto a bench-top wrist-action shaker and turn power switch “On”.
18. Shake for 30 minutes.
19. After 30 minutes, remove tubes from shaker.
20. Vortex for for 10-15 seconds to mix thoroughly.
21. Centrifuge at 3000 rpm for 15 minutes.
22. Transfer the ACN supernatant to the respective labeled centrifuge tube containing original 10ml 0.3% NH_4OH methanolic supernatant/extract. Cap the centrifuge tube and set aside.
23. To the original centrifuge tube containing the remaining tissue sample, add 5 ml of 0.3% NH_4OH in methanol.
24. Cap the centrifuge tube and vortex for 10-15 seconds to mix thoroughly.
25. Load the centrifuge tubes onto a bench-top wrist-action shaker and turn power switch “On”.
26. Shake for 10 minutes.
27. After 10 minutes, remove centrifuge tubes from shaker.
28. Vortex for for 10-15 seconds to mix thoroughly.
29. Centrifuge at 3000 rpm for 15 minutes.
30. Transfer the supernatant to the respective labeled centrifuge tube containing the combined supernatant form the first two extractions. Total combined extract volume should be approximately 25ml.
31. Cap the centrifuge tube and vortex for 10-15 seconds to mix thoroughly.
32. Add 10mg of supeclean Envi-Carb to each centrifuge tube.
33. Vortex for 30 seconds to mix thoroughly.
34. Centrifuge at 3000 rpm for 10 minutes.
35. Decant the extract from each tube into a labeled, clean 50 ml centrifuge tube making sure to leave the superclean Envi-Carb behind.
36. Concentrate the decanted extracts on N-Evap **at a temperature not exceeding 40°C. It is critical that the temperature remains at or below 40°C; otherwise, several target compounds will be lost due to their relative high volatility.**
37. Once extracts reach a level below 20ml, remove from the N-evap and cap the centrifuge tube. Vortex the centrifuge tube to rinse the inner walls of the centrifuge tube. Continue with the

concentration step above. The votex/rinse step should be done at 5ml-intervals (20ml; 15ml; 10ml; 5ml) until a final volume of 5ml is reached.

38. Once extracts are at 5ml, remove from N-Evap and reconstitute to the 40ml mark with Milli-Q water.
39. Vortex 10-15 seconds to mix thoroughly.
40. The extracts are now ready for SPE cleanup procedure below.

B. Solid Phase Extraction (SPE)

1. Place glass wool into the barrel of SPE WAX cartridge not exceeding half of the empty barrel volume. It is best to have a loose plug of wool sitting above the sorbent bed, rather than a tight plug up against the sorbent. This allows for filtering of particulate(s) onto the wool while facilitating optimum flow through the sorbent.
2. Connect a 25ml SPE reservoir to each SPE cartridge.
3. Condition the cartridges as follows:
    a. 15ml 1.0% NH_4OH:MeOH
    b. 5ml 0.3M aqueous formic acid
    c. Discard conditioning eluents
4. Load sample extracts onto their respective SPE cartridge.
5. Allow to pass through by gravity, if possible. Apply vacuum, as needed, if extracts do not pass through sorbent via gravity.
6. Once full extract volume has passed through, rinse the cartridges as follows:
   NOTE: All of the following rinses are to be added to the sample tube and the tube vortexed to rinse the inside of the tube prior to adding to the SPE cartridge
    a. 5ml Milli-Q water
    b. Another 5ml Milli-Q water
    c. 5ml 1:1 0.1M formic acid:MeOH

   After the 3 rinses above, discard the waste from the SPE manifold reservoir and dry the SPE cartridges.

7. Apply full vacuum (not exceeding 20” Hg) to the cartridges and dry until they are visually similar to an unused cartridge. This may take up to 15 minutes for some cartridges.
8. Once all cartridges are dried, rinse the delivery needles with MeOH.
9. Place labeled 15 ml collection tubes into rack and place under each respective cartridge.
10. Add 5ml 1% NH_4OH:MeOH to each sample tube and vortex to thoroughly mix.
11. Transfer elution solvent from sample/QC tube to the respective SPE cartridge.
12. Allow the elution solvent to soak into the sorbent bed and close the stopcock. Allow to soak for approximately 1 minute.
13. Open the stopcocks and collect elution solvent.
14. After all solvent has passed through the sorbent bed, apply slight vacuum to reclaim as much solvent from the sorbent bed as possible.
15. Remove the cartridge/reservoir from each port and discard.
16. Remove tube rack from manifold reservoir.
17. Add 25uL acetic acid to each extract/tube.
18. Cap & vortex each tube for 10-15 seconds to mix thoroughly.

Note: The following steps are performed in the instrument lab.

19. Add 25ul of internal standard spike solution (PFC_ST_XXXXX) to each tube created above and bring the volume up to 5ml with Methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid solution using a visual standard.
20. Cap and vortex to mix thoroughly.
21. Place a syringe filter (25-mm filter, 0.2-um nylon membrane) on a 3 mL polypropylene syringe. Take the plunger out and carefully decant ~1 mL of the sample supernatant into the syringe barrel. Replace the plunger and filter ~1 mL of sample into the correspondingly labeled auto-sampler vial. Cap the auto-sampler vial. Samples are now ready for analysis.
22. Cap the centrifuge tube. Store the remaining centrifuged extracts in the refrigerator for dilution or reinjection if needed.

C. LC/MS/MS Analysis

1. Mass Calibration and Tuning

    a. At instrument set up and installation, after the performance of major maintenance, or annually calibrate the mass scale of the MS with calibration compounds and procedures described by the manufacturer. The entire mass range must be calibrated.

    b. When masses fall outside of the ±0.5 amu of the true value, the instrument must be retuned using PPG according to the manufacturer's specifications. Mass assignments of the tuning standard must be within 0.5 amu of the true value. Refer to the instrument manufacturer's instructions for tuning and conditions. These values are stored in the tune file for future reference.

2. The mass spectral acquisition rate must include a minimum of 10 spectra scans across each chromatographic peak. See the AB Sciex (4500/5500/5500 Plus) Acquisition, Quantitation, Gradient, and detector condition files for the most up to date chromatographic conditions. Modifications to these conditions can be made at the discretion of the analyst to improve resolution or the chromatographic process.

3. Example acquisition method: See *Attachment 3*. Mass Transitions: See *Attachment 1*.
4. Instrument Sensitivity Check (ISC) and Instrument Blanks
    a. Prior to sample analysis, an instrument sensitivity check (ISC) must be performed. The ISC standard concentration must be at the LOQ. The CAL1 standard's concentration is at the LOQ. The CAL1 standard will be analyzed. All analyte concentrations must be within ±30% of their true values. The signal-to-noise ratio must be greater than or equal to 3:1. If the criteria is not met, correct problem and reanalyze the ISC. If problem persists, repeat the ICAL. No samples can be analyzed until the ISC meets acceptance criteria.
    b. Instrument blanks need to be analyzed immediately following the highest standard analyzed and daily or at the start of a sequence. The concentration of all analytes must be less than or

equal to 1/2 the LOQ. If acceptance criteria are not met the calibration must be performed using a lower concentration standard for the high standard until the criteria are met.

5. Load sample vials containing standards, quality control samples, and sample extracts into autosampler tray. Allow the instrument adequate time to equilibrate to ensure the mass spec and LC have reached operating conditions (approximately 5 minutes) before the first injection. Analyze several solvent blanks clean the instrument prior to sample acquisition.

6. After the initial calibration and when analyzing samples within the same tune, inject an instrument blank, followed by the ICV, Linear branched (L/B) standard, instrument sensitivity check, CCV standard using the CAL4, qualitative identification standard (includes TDCA RT marker), Instrument blank, extraction batch QC, and samples. Bracket each set of ten samples with a CCV standard at the CAL4 level, followed by an instrument blank.

   Example Sample Sequence:
    1. Instrument blank
    2. Instrument blank
    3. Instrument blank
    4. Instrument Sensitivity Check (CCV0 _CAL1)
    5. CCV 2_CAL4
    6. Linear Branched/TDCA marker (WDM)
    7. Instrument Blank (ICB)
    8. Method Blank (MB)
    9. Low Level LCS (LLCS)
    10. LCS
    11. Sample (10 or less)
    12. CCV 3_CAL4
    13. Instrument Blank

7. After injections are completed, check all CCV recoveries and absolute areas to make sure they are within method control limits. See Calibration section B.2 for acceptance criteria. Process each chromatogram and closely evaluate all integrations, baseline anomalies, and retention time differences. If manual integrations are performed, they must be documented and a reason given for the change in integrations. The manual integrations are documented during data processing and all original integrations are reported at the end of the sample PDF file with the reason for manual integration clearly listed.

8. Quantitate results for the extraction blank. No target analytes at or above the reporting limit, at or greater than one-third the regulatory compliance limit, at or greater than one-tenth the concentration in a sample in the extraction batch, whichever is greatest, may be found in the extraction blank for acceptable batch results. If this criteria is not met, the samples must be re-extracted.

9. Calculate the recoveries of spiked analytes for the LLCS, LCS, matrix spike and matrix spike duplicate (MS/MSD) by comparing concentrations observed to the true values.

   a. LLCS, LCS, MS, extraction standard recoveries and RPDs are calculated and compared to the limits stored on the LIMS.

   b. If LLCS and LCS recoveries are acceptable, proceed to sample quantitation.

   c. If the LCS and/or LLCS recoveries are above QC acceptance criteria and there are no detections for the compound(s) in the associated sample(s), the data can be reported with a qualifying comment. In all other cases, the samples associated with the LCS/LLCS must be reextracted.

   d. If MS/MSD recoveries are outside QC acceptance criteria, the associated data will be flagged or noted in the comments section of the report.

10. Isotopically-labeled extraction standards are added to all samples, extraction blank, LLCS/LCS, and MS/MSD prior to extraction. The recovery of the extraction standards should be within QC acceptance criteria. If the extraction standard recovery(ies) is(are) outside the QC limit(s), consult a supervisor to determine the appropriate course of action based on batch and sample results.

11. Isotopically-labeled injection standards are added to each QC and field sample extract prior to analysis. The absolute areas of the injection standards should be within 50-150% of the average areas measured during the initial calibration. If the internal standards are recovered outside 50-150%, consult a supervisor to determine the appropriate course of action based on batch and sample results.

12. Compare the retention times of all of the analytes, surrogates, and internals standards to the retention time from the initial calibration. The retention times should not vary from the expected retention time by more than

   a. 0.4 minutes for isotopically-labeled compounds

   b. 0.1 minutes from their analog for native compounds with an exact isotopically-labeled compound

   c. 0.4 minutes from their assigned analog for native compounds without an exact isotopically-labeled compound.

   If the retention time is outside of the criteria, the compound is considered a false positive unless it is a compound with branched isomers. Compounds with branched isomers can vary in intensity of the individual isomers that are used for reporting and must be reviewed and compared to the preceding CCV to determine if it should be reported.

13. Two ion transitions and the ion transition ratio per analyte shall be monitored and documented with the exception of 13C4-PFBA, 13C5-PFPeA, 13C4-PFHpA, 13C8-PFOA, 13C9-PFNA, 13C6-PFDA, 13C7-PFUnA, 13C2-PFDA,13C2-PFDoDA 13C2-PFTeDA, 13C8-PFOSA, D3-NMePFOSA, D5-NEtFOSAA, D3-NMeFOSAA, D5-NEtPFOSA, D7-NMePFOSAE, D9-NEtPFOSAE, 13C3-PFBA, 13C4-

PFOA, 13C5-PFNA, 13C2-PFOA, 18O2-PFHxS, PFBA, PFECA F(PFMPA), PFECA A(PFMBA), NMePFOSAE, and NEtPFOSAE. The expected ion ratio for each compound is calculated by using the average of ion ratios of each compound from initial calibration standards. When an ion ratio for a compound differs from the expected ion ratio by more than 50%, a qualifier is placed on the raw data and on the sample report. No corrective action is required.

14. The linear/branch chain standard is used when assessing the correctness of the computer generated peak integrations for PFOA, PFNA, PFOSA, NMeFOSA, NEtFOSA, NMeFOSE, and NEtFOSE.

15. If the calculated concentration exceeds the calibration range of the system, determine the appropriate dilution required and dilute the extract using Methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid solution and adjust the amount of internal spike standard in the diluted extract. Select the dilution so that the expected EIS recoveries in the diluted extract are >5%. Extracts requiring dilutions greater than 10X should be reextracted using a reduced aliquot.

    Dilution Example 1/10: Mix 895 µl of Methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid solution with 100 µl of sample extract and 5 uL of internal standard spike solution. Vortex to mix. Using an auto-pipette, transfer an aliquot of the mixed solution into a labeled auto-sampler vial. Cap and vortex thoroughly to mix.

Calculations

1. Peak Area Ratio

$$\text{Peak Area Ratio} = \frac{\text{Analyte Response}}{\text{Labeled Analyte Response}}$$

2. On-Column Analyte Concentration using average RRF

$$\text{On-column Concentration} = \text{peak area ratio} \div \text{AVE RRF}$$

3. On-Column Analyte Concentration using linear curve

$$\text{On-column Concentration} = (\text{peak area ratio} - \text{intercept}) \div \text{slope}$$

4. Sample Concentration

Sample concentration (ng/g) = (On-column concentration x Final Sample Volume x DF) ÷ Initial Sample Volume

5. Ion Ratio

ion ratio = (peak area or height of quantifier)/(peak area or height of qualifier)

6. See *T-PEST-WI9847* for additional calculations used to evaluate the calibrations and quality control samples.

Statistical Information/Method Performance

The LCS should contain all compounds of interest. LCS, MS, and extraction standard recoveries are compared to the limits stored on the LIMS. These limits are statistically derived when sufficient data points are available. If sufficient data points are not available to generate statistical windows advisory limits will be used.

QC parameter	Lower acceptance limit	High acceptance limit
Extracted Internal standard (EIS)	20%	150%
Non-extracted Internal Standard (NIS)	>30% of the average NIS from the initial calibration	200%
Analyte recoveries LCS/LLCS/MS/MSD	40%	150%

Note: lower acceptance limit for EIS cannot not be <20%, lower acceptance limit for analyte recovery cannot be <40%.

Historical data for MS/Ds, LCSs, measurement of uncertainty, is reviewed at least annually. Reporting limits including method detection limits (MDLs) and limits of quantitation (LOQs) are set according to EPA method requirements and are evaluated annually. Refer to *QA-SOP11892* for specific guidelines and procedures. Updates to the LIMS are made as needed by the QA Department and only as directed by the supervisor.

Quality Assurance/Quality Control

For each batch of samples extracted, a method blank(Tilapia) and an LCS/LLCS (Tilapia spiked with all compounds to be determined carried through the entire procedure) must be extracted and analyzed. MS/MSD is extracted only if submitted by the client. A batch is defined as the samples to be extracted on any given day, but not to exceed 20 field samples. If more than 20 samples are prepared in a day, an additional batch must be prepared.

If any client, state, or agency has more stringent QC or batching requirements, these must be followed.

Attachment:
Attachment 1 - Mass Transitions (.doc)
Attachment 10 - Native Low Level Spike (.pdf)
Attachment 11 - 1633 Initial Calibration Standard Concentrations (.pdf)
Attachment 12 - 1633 Initial Calibration Standard Concentrations (.pdf)
Attachment 13 - TDCA Stock Solution (.pdf)
Attachment 14 - TDCA working Solution A (.pdf)
Attachment 15 - TDCA Working Solution B (.pdf)
Attachment 16 - 1633 Linear Branched and TDCA Intermediate (.pdf)
Attachment 17 - 1633 Linear Branched and TDCA Solution (.pdf)
Attachment 18 - PFAS ICV Working Standard (.pdf)
Attachment 19 - 1633 Labeled Ampulated Standards (.pdf)
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Attachment 8 - Internal Standard Spike (.pdf)
Attachment 9 - Native Mid Level Spike (.pdf)

11178 Demonstrations of Capability
11892 Determining Method Detection Limits and Limits of Quantitation
21568 Manifold and N-EVAP Cleaning for PFAS Extractions
9847 Common Equations Used During Chromatographic Analyses
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Attachment: Attachment 3 - Acquisition Parameters (pdf)
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Attachment: Attachment 5 - 1633 Native PFAS Intermediate A (pdf)
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Attachment: Attachment 7 - Working Labeled Extraction Standard Spike (pdf)
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End of document

Version history

Version	Approval	Revision information	
1	13.OCT.2022		

Attachment 1

Mass Transitions AB Sciex 4500/5500/5500+

Compound	Parent Ion	Daughter Ion
13C3-PFBA	216.0	172.0
13C4-PFBA	216.8	171.9
PFBA	212.8	168.9
13C5-PFPeA	268.3	223
PFPeA	263.0	219.0
PFPeA (2)	263.0	68.9
13C3-PFBS	302.1	79.9
13C3-PFBS (2)	302.1	98.9
PFBS	298.7	79.9
PFBS (2)	298.7	98.8
13C2-4:2-FTS	329.1	80.9
13C2-4:2-FTS (2)	329.1	309.0
4:2-FTS	327.1	307.0
4:2-FTS (2)	327.1	80.9
13C2-PFHxA	315.1	270.0
13C2-PFHxA (2)	315.1	119.4
13C5-PFHxA	318.0	273.0
13C5-PFHxA (2)	318.0	120.3
PFHxA	313.0	269.0
PFHxA (2)	313.0	118.9
PFPeS	349.1	79.9
PFPeS (2)	349.1	98.9
18O2-PFHxS	403.0	83.9
13C3-PFHxS	402.1	79.9
13C3-PFHxS (2)	402.1	98.9
PFHxS	398.7	79.9
PFHxS (2)	398.7	98.9
13C4-PFHpA	367.1	322.0
PFHpA	363.1	319.0
PFHpA (2)	363.1	169.0
13C2-6:2-FTS	429.1	80.9
13C2-6:2-FTS (2)	429.1	409.0
6:2-FTS	427.1	407.0
6:2-FTS (2)	427.1	80.9
PFHpS	449.0	79.9
PFHpS (2)	449.0	98.8
13C4-PFOA	417.1	172.0

Attachment 1

Compound	Parent Ion	Daughter Ion
13C8-PFOA	421.1	376.0
PFOA	413.0	369.0
PFOA (2)	413.0	169.0
13C4-PFOS	502.8	79.9
13C4-PFOS (2)	502.8	98.9
13C8-PFOS	507.1	79.9
13C8-PFOS (2)	507.1	98.9
PFOS	498.9	79.9
PFOS (2)	498.9	98.8
13C5-PFNA	468.0	423.0
13C9-PFNA	472.1	427.0
PFNA	463.0	419.0
PFNA (2)	463.0	219.0
13C8-PFOSA	506.1	77.8
PFOSA	498.1	77.9
PFOSA (2)	498.1	478.0
PFNS	548.8	79.9
PFNS (2)	548.8	98.8
13C2-PFDA	515.1	470.1
13C6-PFDA	519.1	474.1
PFDA	512.9	469.0
PFDA (2)	512.9	219.0
13C2-8:2-FTS	529.1	80.9
13C2-8:2-FTS (2)	529.1	509.0
8:2-FTS	527.1	507.0
8:2-FTS (2)	527.1	80.8
d7-NMePFOSAE	623.2	58.9
NMePFOSAE	616.1	58.9
d3-NMePFOSA	515.0	219.0
NMEPFOSA	511.9	219.0
NMEPFOSA (2)	511.9	169.0
d3-NMeFOSAA	573.2	419.0
NMeFOSAA	570.1	419.0
NMeFOSAA (2)	570.1	483.0
d9-NEtPFOSAE	639.2	58.9
NEtPFOSAE	630.0	58.9
d5-NETPFOSA	531.1	219.0
NEtPFOSA	526.0	219.0
NEtPFOSA (2)	526.0	169.0
PFDS	599.0	79.9

Attachment 1

Compound	Parent Ion	Daughter Ion
PFDS (2)	599.0	98.8
13C7-PFUnDA	570.0	525.1
PFUnDA	563.1	519.0
PFUnDA (2)	563.1	269.1
d5-NEtFOSAA	589.2	419.0
NEtFOSAA	584.2	419.1
NEtFOSAA (2)	584.2	526.0
13C2-PFDoDA	615.1	570.0
PFDoDA	613.1	569.0
PFDoDA (2)	613.1	319.0
PFDoS	699.1	79.9
PFDoS (2)	699.1	98.8
PFTrDA	663.0	619.0
PFTrDA (2)	663.0	168.9
13C2-PFTeDA	715.2	670.0
PFTeDA	713.1	669.0
PFTeDA (2)	713.1	168.9
13C3-HFPODA	286.9	168.9
13C3-HFPODA (2)	286.9	184.9
HFPODA	284.9	168.9
HFPODA (2)	284.9	184.9
DONA	376.9	250.9
DONA (2)	376.9	84.8
9Cl-PF3ONS	530.8	351.0
9Cl-PF3ONS (2)	532.8	353.0
11Cl-PF3OUdS	630.9	450.9
11Cl-PF3OUdS (2)	632.9	452.9
PFECA B (NFDHA)	295.0	201.0
PFECA B(NFDHA) (2)	295.0	84.9
PFECA F (PFMPA)	229.0	84.9
3:3 FTCA	241.0	177.0
3:3 FTCA (2)	241.0	117.0
PFECA A (PFMBA)	279.0	85.1
PFEESA (PES)	314.8	134.9
PFEESA (PES) (2)	314.8	82.9
5:3 FTCA	341.0	237.1
5:3 FTCA (2)	341.0	217.0
7:3 FTCA	441.0	316.9
7:3 FTCA (2)	441.0	336.9

Attachment 10

Native 1633 Low-Level Spike								
Vendor	**Catalog Number**	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/mL)**	**Aliquot (mL)**	**Final Volume**	**Final Conc. Native 1633 Low-Level Spike (ng/ml)**
Wellington	PFAC-MXF	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9	11Cl-PF3OUdS	1890	0.1	10mL Methanol	18.9
		9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1	9Cl-PF3ONS	1870			18.7
		4,8-dioxa-3H-Perfluorononanoic acid	919005-14-4	DONA	1890			18.9
		Perfluoro(2-propxypropanoic) acid	13252-13-6	HFPODA	2000			10
Wellington	PFAC-MXH	1H,1H,2H,2H perfluorodecanesulfonic acid	39108-34-4	8:2-FTS	3840	0.05		19.2
		1H,1H,2H,2H perfluorohexanesulfonic acid	757124-72-4	4:2-FTS	3750			18.75
		1H,1H,2H,2H perfluorooctanesulfonic acid	27619-97-2	6:2-FTS	3800			19
		N-ethylperfluorooctanesulfonamidoacetic acid	2991-50-6	NEtFOSAA	1000			5
		N-methylperfluorooctanesulfonamidoacetic acid	2355-31-9	NMeFOSAA	1000			5
		Perfluorobutanesulfonic acid	375-73-5	PFBS	887			4.435
		Perfluorobutanoic acid	375-22-4	PFBA	4000			20
		Perfluorodecanesulfonic acid	335-77-3	PFDS	965			4.825
		Perfluorodecanoic acid	335-76-2	PFDA	1000			5
		Perfluorododecanesulfonic acid	79780-39-5	PFDoDS	970			4.850
		Perfluorododecanoic acid	307-55-1	PFDoDA	1000			5
		Perfluoroheptanesulfonic acid	375-92-8	PFHpS	953			4.765
		Perfluoroheptanoic acid	375-85-9	PFHpA	1000			5
		Perfluorohexanesulfonic acid	355-46-4	PFHxS	914			4.57
		Perfluorohexanoic acid	307-24-4	PFHxA	1000			5
		Perfluorononanesulfonic acid	68259-12-1	PFNS	962			4.81
		Perfluorononanoic acid	375-95-1	PFNA	1000			5
		Perfluorooctanesulfonamide	754-91-6	PFOSA	1000			5
		Perfluorooctanesulfonic acid	1763-23-1	PFOS	928			4.64
		Perfluorooctanoic acid	335-67-1	PFOA	1000			5
		Perfluoropentanesulfonic acid	2706-91-4	PFPeS	941			4.705
		Perfluoropentanoic acid	2706-90-3	PFPeA	2000			10
		Perfluorotetradecanoic acid	376-06-7	PFTeDA	1000			5
		Perfluorotridecanoic acid	72629-94-8	PFTrDA	1000			5
		Perfluoroundecanoic acid	2058-94-8	PFUnDA	1000			5
Wellington	PFAC-MXG	Perfluoro-3-methoxypropanoic acid	377-73-1	PFMPA	2000	0.05		10
		Perfluoro-4-methoxybutanoic acid	863090-89-5	PFMBA	2000			10
		Nonafluoro-3,6-dioxaheptanoic acid	151722-58-6	NFDHA	2000			10
		Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	PFEESA	1780			8.9
Wellington	PFAC-MXI	2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	24448-09-7	NMePFOSAE	10000	0.05		50
		N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	1000			5
		2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	1691-99-2	NEtPFOSAE	10000			50
		N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	1000			5
Wellington	PFAC-MXJ	3-Perfluoropropylpropanoic acid	763051-92-9	3:3 FTCA	4000	0.0626		25.04
		3-Perfluoropentylpropanoic acid	756426-58-1	5:3 FTCA	20000			125.2
		3-Perfluoroheptylpropanoic acid	919005-14-4	7:3 FTCA	20000			125.2

1633 Initial Calibration Standards Preparation

Solution Name	MDL	CAL1	CAL2	CAL3	CAL4	CAL5	CAL6	CAL7
Native Replacement PFAS Solution/Mixture Aliquot (mL)	NA	NA	NA	NA	NA	0.020	0.050	0.250
Native Perfluoroalkyl Ether Carboxylic Acids and Sulfonate Solution/Mixture Aliquot (mL)	NA	NA	NA	NA	NA	0.010	0.025	0.125
Native PFAS Solution/Mixture Aliquot (mL)	NA	NA	NA	NA	NA	0.010	0.025	0.125
Native N-NMe/EtFOSA & N-Nme/EtFOSE Solution/Mixture Aliquot (mL)	NA	NA	NA	NA	NA	0.010	0.025	0.125
Native X:3 Flourotelomer Caroxylic Acid Solution/Mixture Aliquot (mL)	NA	NA	NA	NA	NA	0.0125	0.0312	0.156
Native PFAS Intermediate A Aliquot (mL)	0.008	0.016	0.040	0.100	0.200	NA	NA	NA
Native PFAS Intermediate B Aliquot (mL)	0.010	0.020	0.050	0.125	0.250	NA	NA	NA
Mass-Labelled PFAS Injection Standard Solution/Mixture - IS Aliquot (mL)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Mass-Labelled PFAS Extraction Standard Solution/Mixture - ES Aliquot (mL)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Final Volume (mL) (methanol with 4% water, 1% ammonium hydroxide, and 0.625% acetic acid)	**2**	2	2	2	2	2	2	2

Attachment 12

1633 Initial Calibration Standards Concentrations

	MDL	CAL1	CAL2	CAL3	CAL4	CAL5	CAL6	CAL7
Compound Name	**Conc. (ng/ml)**	**Conc. (ng/ml)**	**Conc. (ng/ml)**	**Conc. (ng/ml)**	**Conc. (ng/ml)**	**Conc. (ng/ml)**	**Conc. (ng/ml)**	**Conc. (ng/ml)**
PFBA	0.4	0.8	2	5	10	20	50	250
PFPeA	0.2	0.4	1	2.5	5	10	25	125
PFHxA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFHpA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFOA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFNA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFDA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFUnA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFDoA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFTrDA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFTeDA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFBS	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFPeS	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFHxS	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFHpS	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFOS	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFNS	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFDS	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
PFDoS	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
8:2FTS	0.4	0.8	2	5	10	20	50	NA
4:2FTS	0.4	0.8	2	5	10	20	50	NA
6:2FTS	0.4	0.8	2	5	10	20	50	NA
PFOSA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
NMeFOSA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
NEtFOSA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
NMeFOSAA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
NEtFOSAA	0.1	0.2	0.5	1.25	2.5	5	12.5	62.5
NMeFOSE	1	2	5	12.5	25	50	125	625
NEtFOSE	1	2	5	12.5	25	50	125	625
HFPO-DA	0.4	0.8	2	5	10	20	50	250
ADONA	0.4	0.8	2	5	10	20	50	250
PFMPA	0.2	0.4	1	2.5	5	10	25	125
PFMBA	0.2	0.4	1	2.5	5	10	25	125
NFDHA	0.2	0.4	1	2.5	5	10	25	125
9Cl-PF3ONS	0.4	0.8	2	5	10	20	50	250
11Cl-PF3OUdS	0.4	0.8	2	5	10	20	50	250
PFEESA	0.2	0.4	1	2.5	5	10	25	125
3:3FTCA	0.5	1	2.5	6.26	12.5	25	62.4	312
5:3FTCA	2.5	5	12.5	31.3	62.5	125	312	1560
7:3FTCA	2.5	5	12.5	31.3	62.5	125	312	1560
^{13}C4-PFBA	10	10	10	10	10	10	10	10
^{13}C5-PFPeA	5	5	5	5	5	5	5	5
^{13}C5-PFHxA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C4-PFHpA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C8-PFOA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C9-PFNA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C6-PFDA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C7-PFUnA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C2-PFDoA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C2-PFTeDA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C3-PFBS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C3-PFHxS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C8-PFOS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C2-4:2 FTS	5	5	5	5	5	5	5	5
^{13}C2-6:2 FTS	5	5	5	5	5	5	5	5
^{13}C2-8:2 FTS	5	5	5	5	5	5	5	5
^{13}C8-PFOSA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
D3-NMeFOSA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
D5-NEtFOSA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
D3-NMeFOSAA	5	5	5	5	5	5	5	5
D5-NEtFOSAA	5	5	5	5	5	5	5	5
D7-NMeFOSE	25	25	25	25	25	25	25	25
D9-NEtFOSE	25	25	25	25	25	25	25	25
^{13}C3-HFPO-DA	10	10	10	10	10	10	10	10
^{13}C3-PFBA	5	5	5	5	5	5	5	5
^{13}C2-PFHxA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C4-PFOA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C5-PFNA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{13}C2-PFDA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
^{18}O2-PFHxS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
^{13}C4-PFOS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5

Attachment 13

TDCA Stock Solution

Vendor	Catalog Number	Analyte	CAS#	Acronym	Conc. (mg)	Aliquot (g)	Final Volume (ml) Methanol	Final Conc. TDCA Stock Solution (ng/ml)
Sigma Alrich	T0557-500MG	Sodium Taurodeoxycholate hydrate	207737-97-1	TDCA	1000000	0.05	50	1000000

TDCA Working Solution A							
Solution Name	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/ml)**	**Aliquot (mL)**	**Final Volume (mL) Methanol**	**Final Conc. TDCA Working Solution A (ng/ml)**
TDCA Stock Solution	Sodium Taurodeoxycholate hydrate	207737-97-1	TDCA	1000000	1	4	250000

TDCA Working Solution B							
Solution Name	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/ml)**	**Aliquot (mL)**	**Final Volume (ml) Methanol**	**Final Conc. TDCA Working Solution B (ng/ml)**
TDCA Working Solution A	Sodium Taurodeoxycholate hydrate	207737-97-1	TDCA	250000	0.10	5	5000

1633 Linear/Branched TDCA Intermediate								
Vendor	**Catalog Number**	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/mL)**	**Aliquot (mL)**	**Final Volume (ml) Methanol**	**Final Conc. 1633 Linear/ Branched TDCA Intermediate (ng/ml)**
Wellington	T-PFOA	Technical Ammonium, Perfluorooctanoa te (Technical Grade)	95328-99-7	T-PFOA	50000	0.02	2mL	500
		Perfluoroctanoic acid	335-67-1	PFOA	50000			500
Cambridge Isotope Laboratories, Inc.	ULM-11036-S	2-(N-ethylperfluoro-1-octanesulfonamido) ethanol	1691-99-2	NEtPFOSAE	50000	0.02		500
Cambridge Isotope Laboratories, Inc.	ULM-11034-S	2-(N-methylperfluoro-1-octanesulfonamido) ethanol	24448-09-7	NMePFOSAE	50000	0.02		500
Cambridge Isotope Laboratories, Inc.	ULM-10780-S	N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	100000	0.01		500
Cambridge Isotope Laboratories, Inc.	ULM-10779-S	N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMeFOSA	100000	0.01		500
Cambridge Isotope Laboratories, Inc.	ULM-10977-S	Perfluorooctanesfulonamide	754-91-6	PFOSA	50000	0.02		500
Wellington	ipPFNA	Perfluoro-7-methyloctanoic acid	15899-31-7	PF7MOA	50000	0.02		500
Wellington	PFNA	Perfluorononanoic acid	375-95-1	PFNA	50000	0.02		500

1633 Linear/Branched TDCA Solution

Solution Name	Analyte	CAS#	Acronym	Conc. (ng/mL)	Aliquot (mL)	Final Volume* (ml)	Final Conc. 1633 Linear/ Branched TDCA Solution (ng/ml)
TDCA Working Solution B	Sodium Taurodeoxycholate hydrate	207737-97-1	TDCA	5000	0.01	2	25
1633 Linear/Branched TDCA Intermediate	2-(N-ethylperfluoro-1-octanesulfonamido) ethanol	1691-99-2	NEtPFOSAE	500	0.02		5
	2-(N-methylperfluoro-1-octanesulfonamido) ethanol	24448-09-7	NMePFOSAE	500			5
	N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	500			5
	N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMeFOSA	500			5
	Perfluorooctanesfulonamide	754-91-6	PFOSA	500			5
	Perfluoro-7-methyloctanoic acid	15899-31-7	PF7MOA	500			5
	Perfluorononanoic acid	375-95-1	PFNA	500			5
	Technical Ammonium, Perfluorooctanoa te (Technical Grade)	95328-99-7	T-PFOA	500			5
	Perfluoroctanoic acid	335-67-1	PFOA	500			5
Mass-Labelled PFAS Extraction Standard Solution/Mixture-ES	Perfluoro-n-[^{13}C4]butanoic acid	STL00992	^{13}C4-PFBA	2000	0.01		10
	Perfluoro-n-[^{13}C5]pentanoic acid	STL01893	^{13}C5-PFPeA	1000			5
	Perfluoro-n-[1,2,3,4,6-^{13}C5]hexanoic acid	STL02577	^{13}C5 -PFHxA	500			2.5
	Perfluoro-n-[1,2,3,4-^{13}C4]heptanoic acid	STL01892	^{13}C4-PFHpA	500			2.5
	Perfluoro-n-[^{13}C8]octanoic acid	STL01052	^{13}C8-PFOA	500			2.5
	Perfluoro-n-[^{13}C9]nonanoic acid	STL02578	^{13}C9-PFNA	250			1.25
	Perfluoro-n-[1,2,3,4,5,6-^{13}C6]decanoic acid	STL02579	^{13}C6-PFDA	250			1.25
	Perfluoro-n-[1,2,3,4,5,6,7-^{13}C7]undecanoic acid	STL02580	^{13}C7-PFUnA	250			1.25
	Perfluoro-n-[1,2-^{13}C2]dodecanoic acid	STL02703	^{13}C2-PFDoA	250			1.25
	Perfluoro-n-[1,2-^{13}C2]tetradecanoic acid	STL02116	^{13}C2-PFTeDA	250			1.25
	Perfluoro-1-[2,3,4-^{13}C3]butanesulfonic acid	STL02337	^{13}C3-PFBS	466			2.33
	Perfluoro-1-[1,2,3-^{13}C3]hexanesulfonic acid	STL02581	^{13}C3-PFHxS	474			2.37
	Perfluoro-1-[^{13}C8]octanesulfonic acid	STL01054	^{13}C8-PFOS	479			2.4
	Perfluoro-1-[^{13}C8]octanesulfonamide	STL01056	^{13}C8 -PFOSA	500			2.5
	N-methyl-d3-perfluoro-1-octanesulfonamidoacetic acid	STL02118	D3-NMeFOSAA	1000			5
	N-ethyl-d5-perfluoro-1-octanesulfonamidoacetic acid	STL02117	D5-NEtFOSAA	1000			5
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]hexan sulfonic acid	STL02395	^{13}C2-4:2FTS	938			4.69
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]octanesulfonic acid	STL02279	^{13}C2-6:2FTS	951			4.76
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]decanesulfonic acid	STL02280	^{13}C2-8:2FTS	960			4.8
	Tetrafluoro-2-heptafluoropropoxy-^{13}C3-propanoic acid	STL02255	^{13}C3-HFPO-DA	2000			10
	N-methyl-d7-perfluorooctanesulfonamidoethanol	STL02277	D7-NMeFOSE	5000			25
	N-ethyl-d9-perfluorooctanesulfonamidoethanol	STL02278	D9-NEtFOSE	5000			25
	N-ethyl-d5-perfluoro-1-octanesulfonamide	STL02704	D5-NEtFOSA	500			2.5
	N-methyl-d3-perfluoro-1-octanesulfonamide	STL02705	D3-NMeFOSA	500			2.5
Mass-Labelled PFAS Injection Standard Solution/Mixture	Perfluoro-n-[2,3,4-^{13}C3]butanoic acid	STL02680	^{13}C3-PFBA	1000	0.01		5
	Perfluoro-n-[1,2,3,4-^{13}C4]octanoic acid	STL00990	^{13}C4-PFOA	500			2.5
	Perfluoro-n-[1,2-^{13}C2]decanoic acid	STL00996	^{13}C2-PFDA	250			1.25
	Perfluoro-n-[1,2,3,4-^{13}C4]octanesulfonic acid	STL00991	^{13}C4-PFOS	479			2.4
	Perfluoro-n-[1,2,3,4,5-^{13}C5] nonanoic acid	STL00995	^{13}C5-PFNA	250			1.25
	Perfluoro-n-[1,2-^{13}C2]hexanoic acid	STL00993	^{13}C2-PFHxA	500			2.5
	Perfluoro-1-hexane[^{18}O2]sulfonic acid	STL00994	^{18}O2-PFHxS	474			2.37

* Bring to final volume using methanol with 4% water, 1% ammonium hydroxide, and 0.625% acetic acid

Attachment 18

PFAS 1633 ICV Working Standard

Solution Name	Analyte	CAS#	Acronym	Conc. (ng/ml)	Aliquot (ml)	Final Volume* (ml)	Final Conc. PFAS 1633 ICV Working Standard (ng/ml)
Native PFAS Intermediate A	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9	11Cl-PF3OUdS	94.5	0.5	5	9.45
	9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1	9Cl-PF3ONS	93.5			9.35
	4,8-dioxa-3H-Perfluorononanoic acid	919005-14-4	DONA	94.5			9.45
	Perfluoro(2-propxypropanoic) acid	13252-13-6	HFPODA	100			10
	1H,1H,2H,2H perfluorodecanesulfonic acid	39108-34-4	8:2-FTS	96			4.69
	1H,1H,2H,2H perfluorohexanesulfonic acid	757124-72-4	4:2-FTS	93.8			4.76
	1H,1H,2H,2H perfluorooctanesulfonic acid	27619-97-2	6:2-FTS	95			4.8
	N-ethylperfluorooctanesulfonamidoacetic acid	2991-50-6	NEtFOSAA	25			2.5
	N-methylperfluorooctanesulfonamidoacetic acid	2355-31-9	NMeFOSAA	25			2.5
	Perfluorobutanesulfonic acid	375-73-5	PFBS	22.2			2.22
	Perfluorobutanoic acid	375-22-4	PFBA	100			10
	Perfluorodecanesulfonic acid	335-77-3	PFDS	24.1			2.41
	Perfluorodecanoic acid	335-76-2	PFDA	25			2.5
	Perfluorododecanesulfonic acid	79780-39-5	PFDoDS	24.3			2.43
	Perfluorododecanoic acid	307-55-1	PFDoDA	25			2.5
	Perfluoroheptanesulfonic acid	375-92-8	PFHpS	23.8			2.38
	Perfluoroheptanoic acid	375-85-9	PFHpA	25			2.5
	Perfluorohexanesulfonic acid	355-46-4	PFHxS	22.9			2.29
	Perfluorohexanoic acid	307-24-4	PFHxA	25			2.5
	Perfluorononanesulfonic acid	68259-12-1	PFNS	24.1			2.41
	Perfluorononanoic acid	375-95-1	PFNA	25			2.5
	Perfluorooctanesulfonamide	754-91-6	PFOSA	25			2.5
	Perfluorooctanesulfonic acid	1763-23-1	PFOS	23.2			2.32
	Perfluorooctanoic acid	335-67-1	PFOA	25			2.5
	Perfluoropentanesulfonic acid	2706-91-4	PFPeS	23.5			2.35
	Perfluoropentanoic acid	2706-90-3	PFPeA	50			5
	Perfluorotetradecanoic acid	376-06-7	PFTeDA	25			2.5
	Perfluorotridecanoic acid	72629-94-8	PFTrDA	25			2.5
	Perfluoroundecanoic acid	2058-94-8	PFUnDA	25			2.5
	Perfluoro-3-methoxypropanoic acid	377-73-1	PFMPA	50			5
	Perfluoro-4-methoxybutanoic acid	863090-89-5	PFMBA	50			5
	Nonafluoro-3,6-dioxaheptanoic acid	151722-58-6	NFDHA	50			5
	Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	PFEESA	44.5			4.45
	2-(N-methylperfluoro-1-octanesulfonamido)- ethanol	24448-09-7	NMePFOSAE	250			25
	N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	25			2.5
	2-(N-ethylperfluoro-1-octanesulfonamido)- ethanol	1691-99-2	NEtPFOSAE	250			25
	N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	25			2.5
Native PFAS Intermediate B	3-Perfluoropropylpropanoic acid	763051-92-9	3:3 FTCA	100	0.625		12.5
	3-Perfluoropentylpropanoic acid	756426-58-1	5:3 FTCA	500			62.5
	3-Perfluoroheptylpropanoic acid	919005-14-4	7:3 FTCA	500			62.5
Mass-Labelled PFAS Extraction Standard Solution/ Mixture-ES	Perfluoro-n-[^{13}C4]butanoic acid	STL00992	^{13}C4-PFBA	2000	0.025		10
	Perfluoro-n-[^{13}C5]pentanoic acid	STL01893	^{13}C5-PFPeA	1000			5
	Perfluoro-n-[1,2,3,4,6-^{13}C5]hexanoic acid	STL02577	^{13}C5 -PFHxA	500			2.5
	Perfluoro-n-[1,2,3,4-^{13}C4]heptanoic acid	STL01892	^{13}C4-PFHpA	500			2.5
	Perfluoro-n-[^{13}C8]octanoic acid	STL01052	^{13}C8-PFOA	500			2.5
	Perfluoro-n-[^{13}C9]nonanoic acid	STL02578	^{13}C9-PFNA	250			1.25
	Perfluoro-n-[1,2,3,4,5,6-^{13}C6]decanoic acid	STL02579	^{13}C6-PFDA	250			1.25
	Perfluoro-n-[1,2,3,4,5,6,7-^{13}C7]undecanoic acid	STL02580	^{13}C7-PFUnA	250			1.25
	Perfluoro-n-[1,2-^{13}C2]dodecanoic acid	STL02703	^{13}C2-PFDoA	250			1.25
	Perfluoro-n-[1,2-^{13}C2]tetradecanoic acid	STL02116	^{13}C2-PFTeDA	250			1.25
	Perfluoro-1-[2,3,4-^{13}C3]butanesulfonic acid	STL02337	^{13}C3-PFBS	466			2.33
	Perfluoro-1-[1,2,3-^{13}C3]hexanesulfonic acid	STL02581	^{13}C3-PFHxS	474			2.37
	Perfluoro-1-[^{13}C8]octanesulfonic acid	STL01054	^{13}C8-PFOS	479			2.4
	Perfluoro-1-[^{13}C8]octanesulfonamide	STL01056	^{13}C8 -PFOSA	500			2.5
	N-methyl-d3-perfluoro-1-octanesulfonamidoacetic acid	STL02118	D3-NMeFOSAA	1000			5
	N-ethyl-d5-perfluoro-1-octanesulfonamidoacetic acid	STL02117	D5-NEtFOSAA	1000			5
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]hexan sulfonic acid	STL02395	^{13}C2-4:2FTS	938			4.69
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]octanesulfonic acid	STL02279	^{13}C2-6:2FTS	951			4.76
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]decanesulfonic acid	STL02280	^{13}C2-8:2FTS	960			4.8
	Tetrafluoro-2-heptafluoropropoxy-^{13}C3-propanoic acid	STL02255	^{13}C3-HFPO-DA	2000			10
	N-methyl-d7-perfluorooctanesulfonamidoethanol	STL02277	D7-NMeFOSE	5000			25
	N-ethyl-d9-perfluorooctanesulfonamidoethanol	STL02278	D9-NEtFOSE	5000			25
	N-ethyl-d5-perfluoro-1-octanesulfonamide	STL02704	D5-NEtFOSA	500			5
	N-methyl-d3-perfluoro-1-octanesulfonamide	STL02705	D3-NMeFOSA	500			5
Mass-Labelled PFAS Injection Standard Solution/ Mixture-IS	Perfluoro-n-[2,3,4-^{13}C3]butanoic acid	STL02680	^{13}C3-PFBA	1000	0.025		5
	Perfluoro-n-[1,2,3,4-^{13}C4]octanoic acid	STL00990	^{13}C4-PFOA	500			2.5
	Perfluoro-n-[1,2-^{13}C2]decanoic acid	STL00996	^{13}C2-PFDA	250			1.25
	Perfluoro-n-[1,2,3,4-^{13}C4]octanesulfonic acid	STL00991	^{13}C4-PFOS	479			2.4
	Perfluoro-n-[1,2,3,4,5-^{13}C5] nonanoic acid	STL00995	^{13}C5-PFNA	250			1.25
	Perfluoro-n-[1,2-^{13}C2]hexanoic acid	STL00993	^{13}C2-PFHxA	500			2.5
	Perfluoro-1-hexane[^{18}O2]sulfonic acid	STL00994	^{18}O2-PFHxS	474			2.37

* Bring to final volume using methanol with 4% water, 1% ammonium hydroxide, and 0.625% acetic acid

1633 Labeled Ampulated Standards

Ampulated Solution Name	Vendor	Catalog Number	Analyte	CAS#	Acronym	Conc. (ng/mL)
Mass-Labelled PFAS Extraction Standard Solution/Mixture - ES	Wellington	MPFACHIFES	Perfluoro-n-[^{13}C4]butanoic acid	STL00992	^{13}C4-PFBA	2000
			Perfluoro-n-[^{13}C5]pentanoic acid	STL01893	^{13}C5-PFPeA	1000
			Perfluoro-n-[1,2,3,4,6-^{13}C5]hexanoic acid	STL02577	^{13}C5 -PFHxA	500
			Perfluoro-n-[1,2,3,4-^{13}C4]heptanoic acid	STL01892	^{13}C4-PFHpA	500
			Perfluoro-n-[^{13}C8]octanoic acid	STL01052	^{13}C8-PFOA	500
			Perfluoro-n-[^{13}C9]nonanoic acid	STL02578	^{13}C9-PFNA	250
			Perfluoro-n-[1,2,3,4,5,6-^{13}C6]decanoic acid	STL02579	^{13}C6-PFDA	250
			Perfluoro-n-[1,2,3,4,5,6,7-^{13}C7]undecanoic acid	STL02580	^{13}C7-PFUnA	250
			Perfluoro-n-[1,2-^{13}C2]dodecanoic acid	STL02703	^{13}C2-PFDoA	250
			Perfluoro-n-[1,2-^{13}C2]tetradecanoic acid	STL02116	^{13}C2-PFTeDA	250
			Perfluoro-1-[2,3,4-^{13}C3]butanesulfonic acid	STL02337	^{13}C3-PFBS	466
			Perfluoro-1-[1,2,3-^{13}C3]hexanesulfonic acid	STL02581	^{13}C3-PFHxS	474
			Perfluoro-1-[^{13}C8]octanesulfonic acid	STL01054	^{13}C8-PFOS	479
			Perfluoro-1-[^{13}C8]octanesulfonamide	STL01056	^{13}C8 -PFOSA	500
			N-methyl-d3-perfluoro-1-octanesulfonamidoacetic acid	STL02118	D3-NMeFOSAA	1000
			N-ethyl-d5-perfluoro-1-octanesulfonamidoacetic acid	STL02117	D5-NEtFOSAA	1000
			1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]hexan sulfonic acid	STL02395	^{13}C2-4:2FTS	938
			1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]octanesulfonic acid	STL02279	^{13}C2-6:2FTS	951
			1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]decanesulfonic acid	STL02280	^{13}C2-8:2FTS	960
			Tetrafluoro-2-heptafluoropropoxy-^{13}C3-propanoic acid	STL02255	^{13}C3-HFPO-DA	2000
			N-methyl-d7-perfluorooctanesulfonamidoethanol	STL02277	D7-NMeFOSE	5000
			N-ethyl-d9-perfluorooctanesulfonamidoethanol	STL02278	D9-NEtFOSE	5000
			N-ethyl-d5-perfluoro-1-octanesulfonamide	STL02704	D5-NEtFOSA	500
			N-methyl-d3-perfluoro-1-octanesulfonamide	STL02705	D3-NMeFOSA	500
Mass-Labelled PFAS Injection Standard Solution/Mixture - IS	Wellington	MPFACHIFIS	Perfluoro-n-[2,3,4-^{13}C3]butanoic acid	STL02680	^{13}C3-PFBA	1000
			Perfluoro-n-[1,2,3,4-^{13}C4]octanoic acid	STL00990	^{13}C4-PFOA	500
			Perfluoro-n-[1,2-^{13}C2]decanoic acid	STL00996	^{13}C2-PFDA	250
			Perfluoro-n-[1,2,3,4-^{13}C4]octanesulfonic acid	STL00991	^{13}C4-PFOS	479
			Perfluoro-n-[1,2,3,4,5-^{13}C5] nonanoic acid	STL00995	^{13}C5-PFNA	250
			Perfluoro-n-[1,2-^{13}C2]hexanoic acid	STL00993	^{13}C2-PFHxA	500
			Perfluoro-1-hexane[^{18}O2]sulfonic acid	STL00994	^{18}O2-PFHxS	474

Attachment 2

PFAS Injection Standards/Extraction Standards/Native Compounds

Injection Standards

Inj Std	Internal Standard/Injection Standard
I13C3-PFBA	13C3-PFBA
I13C2-PFHxA	13C2-PFHxA
I13C4-PFOA	13C4-PFOA
I13C5-PFNA	13C5-PFNA
I13C2-PFDA	13C2-PFDA
I18O2-PFHxS	18O2-PFHxS
I13C4-PFOS	13C4-PFOS

Extraction Standards

Extraction Standard	Internal Standard
E13C4-PFBA	13C3-PFBA
E13C5-PFPeA	13C2-PFHxA
E13C5-PFHxA	
E13C4-PFHpA	
E13C3-HFPO-DA	
E13C8-PFOA	13C4-PFOA
E13C9-PFNA	13C5-PFNA
E13C6-PFDA	13C2-PFDA
E13C7-PFUnA	
E13C2-PFDoA	
E13C2-PFTeDA	
E13C3-PFBS	18O2-PFHxS
E13C3-PFHxS	
E13C2-4:2-FTS	
E13C2-6:2-FTS	
E13C2-8:2-FTS	

Extraction Standard	Internal Standard
E13C8-PFOS	13C4-PFOS
E13C8-PFOSA	
Ed3-NMeFOSA	
Ed5-NEtFOSA	
Ed3-NMeFOSAA	
Ed5-NEtFOSAA	
Ed7-NMeFOSE	
Ed9-NEtFOSE	

Native PFAS Compounds

Native	Extraction Standard
PFBA	13C4-PFBA
PFPeA	13C5-PFPeA
3:3FTCA	
PFMPA	
PFMBA	
PFHxA	13C5-PFHxA
NFDHA	
5:3FTCA	
7:3FTCA	
PFEESA	
PFHpA	13C4-PFHpA
PFOA	13C8-PFOA
PFNA	13C9-PFNA
PFDA	13C6-PFDA
PFUnA	13C7-PFUnA
PFDoA	13C2-PFDoA
PFTrDA	Avg 13C2-PFTeDA and 13C2-PFDoA
PFTeDA	13C2-PFTeDA
PFBS	13C3-PFBS
PFPeS	13C3-PFHxS
PFHxS	
PFHpS	13C8-PFOS
PFOS	
PFNS	
PFDS	

Native	Extraction Standard
PFDoS	
4:2-FTS	13C2-4:2-FTS
6:2-FTS	13C2-6:2-FTS
8:2-FTS	13C2-8:2-FTS
PFOSA	13C8-PFOSA
NMeFOSA	D3-NMeFOSA
NEtFOSA	D5-NEtFOSA
NMeFOSAA	D3-NMeFOSAA
NEtFOSAA	D5-N-EtFOSAA
NMeFOSE	D7-NMeFOSE
NEtFOSE	D9-NEtFOSE
HFPO-DA	13C3-HFPO-DA
DONA	
9Cl-PF3ONS	
11Cl-PF3OUdS	

1633 Native Ampulated Standards

Ampulated Solution Name	Vendor	Catalog Number	Analyte	CAS#	Acronym	Conc. (ng/mL)
Native Replacement PFAS Solution/Mixture	Wellington	PFAC-MXF	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9	11Cl-PF3OUdS	1890
			9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1	9Cl-PF3ONS	1870
			4,8-dioxa-3H-Perfluorononanoic acid	919005-14-4	DONA	1890
			Perfluoro(2-propxypropanoic) acid	13252-13-6	HFPODA	2000
Native PFAS Solution/Mixture	Wellington	PFAC-MXH	1H,1H,2H,2H perfluorodecanesulfonic acid	39108-34-4	8:2-FTS	3840
			1H,1H,2H,2H perfluorohexanesulfonic acid	757124-72-4	4:2-FTS	3750
			1H,1H,2H,2H perfluorooctanesulfonic acid	27619-97-2	6:2-FTS	3800
			N-ethylperfluorooctanesulfonamidoacetic acid	2991-50-6	NEtFOSAA	1000
			N-methylperfluorooctanesulfonamidoacetic acid	2355-31-9	NMeFOSAA	1000
			Perfluorobutanesulfonic acid	375-73-5	PFBS	887
			Perfluorobutanoic acid	375-22-4	PFBA	4000
			Perfluorodecanesulfonic acid	335-77-3	PFDS	965
			Perfluorodecanoic acid	335-76-2	PFDA	1000
			Perfluorododecanesulfonic acid	79780-39-5	PFDoDS	970
			Perfluorododecanoic acid	307-55-1	PFDoDA	1000
			Perfluoroheptanesulfonic acid	375-92-8	PFHpS	953
			Perfluoroheptanoic acid	375-85-9	PFHpA	1000
			Perfluorohexanesulfonic acid	355-46-4	PFHxS	914
			Perfluorohexanoic acid	307-24-4	PFHxA	1000
			Perfluorononanesulfonic acid	68259-12-1	PFNS	962
			Perfluorononanoic acid	375-95-1	PFNA	1000
			Perfluorooctanesulfonamide	754-91-6	PFOSA	1000
			Perfluorooctanesulfonic acid	1763-23-1	PFOS	928
			Perfluorooctanoic acid	335-67-1	PFOA	1000
			Perfluoropentanesulfonic acid	2706-91-4	PFPeS	941
			Perfluoropentanoic acid	2706-90-3	PFPeA	2000
			Perfluorotetradecanoic acid	376-06-7	PFTeDA	1000
			Perfluorotridecanoic acid	72629-94-8	PFTrDA	1000
			Perfluoroundecanoic acid	2058-94-8	PFUnDA	1000
Native Perfluoroalkyl Ether Carboxylic Acids and Sulfonate Solution/Mixture	Wellington	PFAC-MXG	Perfluoro-3-methoxypropanoic acid	377-73-1	PFMPA	2000
			Perfluoro-4-methoxybutanoic acid	863090-89-5	PFMBA	2000
			Nonafluoro-3,6-dioxaheptanoic acid	151722-58-6	NFDHA	2000
			Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	PFEESA	1780
Native N-NMe/EtFOSA & N-Nme/EtFOSE Solution/Mixture	Wellington	PFAC-MXI	2-(N-methylperfluoro-1-octanesulfonamido)- ethanol	24448-09-7	NMePFOSAE	10000
			N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	1000
			2-(N-ethylperfluoro-1-octanesulfonamido)- ethanol	1691-99-2	NEtPFOSAE	10000
			N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	1000
Native X:3 Flourotelomer Caroxylic Acid Solution/Mixture	Wellington	PFAC-MXJ	3-Perfluoropropylpropanoic acid	763051-92-9	3:3 FTCA	4000
			3-Perfluoropentylpropanoic acid	756426-58-1	5:3 FTCA	20000
			3-Perfluoroheptylpropanoic acid	919005-14-4	7:3 FTCA	20000
	Wellington	T-PFOA	Technical Ammonium, Perfluorooctanoa te (Technical Grade)	95328-99-7	T-PFOA	50000
			Perfluoroctanoic acid	335-67-1	PFOA	50000
	Cambridge	ULM-11036-S	2-(N-ethylperfluoro-1-octanesulfonamido) ethanol	1691-99-2	NEtPFOSAE	50000
	Cambridge	ULM-11034-S	2-(N-methylperfluoro-1-octanesulfonamido) ethanol	24448-09-7	NMePFOSAE	50000
	Cambridge	ULM-10780-S	N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	100000
	Cambridge	ULM-10779-S	N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMeFOSA	100000
	Cambridge	ULM-10977-S	Perfluorooctanesfulonamide	754-91-6	PFOSA	50000
	Wellington	ipPFNA	Perfluoro-7-methyloctanoic acid	15899-31-7	PF7MOA	50000
	Wellington	PFNA	Perfluorononanoic acid	375-95-1	PFNA	50000

Attachment 3

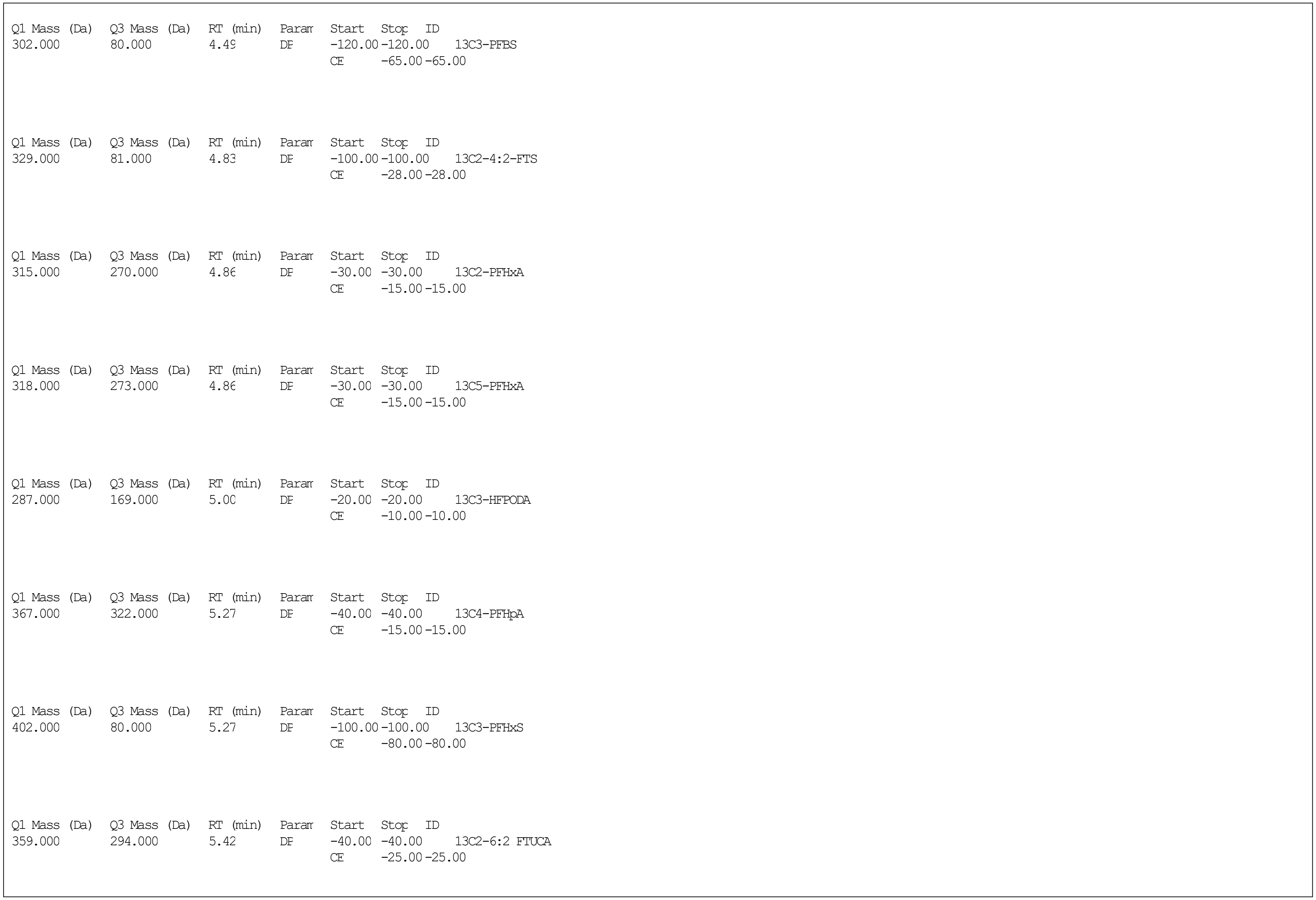
Acquisition Method

```
EPA1633_DOD

Mass Spec  10.500 min
   Period  10.500 min
      -MRM
Integrated Valve
Sciex LC System
   Equilibrate
   Injection
```

Mass Spectrometer Method Properties

```
Period 1:
--------------
Scans in Period:        1050
Min. Dwell Time:        3 ms
Max. Dwell Time:        250 ms
Relative Start Time:    0.00 msec
Scheduled Ionization:   Off
Experiments in Period:  1
Use target Cycle Time:  No
Target Cycle Time:      N/A

Period 1  Experiment   1:
----------------------------
Scan Type:              MRM (MRM)
Scheduled MRM:          Yes
Polarity:               Negative
Scan Mode:              N/A
Ion Source:             Turbo Spray
sMRM Q1Q3 Resolution:   No
MRM detection window:   60 sec
Target Scan Time:       0.6000 sec
Resolution Q1:          Unit
Resolution Q3:          Unit
Intensity Thres.:       0.00 cps
Settling Time:          0.0000 msec
MR Pause:               5.0070 msec
MCA:                    No
Step Size:              0.00 Da

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
216.000       172.000       3.88      DP     -40.00 -40.00    13C3-PFBA
                                             CE     -14.00 -14.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
217.000       172.000       3.88      DP     -40.00 -40.00    13C4-PFBA
                                             CE     -14.00 -14.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
268.000       223.000       4.44      DP     -40.00 -40.00    13C5-PFPeA
                                             CE     -14.00 -14.00
```

Attachment 3



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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
302.000       80.000        4.49      DP     -120.00 -120.00   13C3-PFBS
                                      CE     -65.00  -65.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
329.000       81.000        4.83      DP     -100.00 -100.00   13C2-4:2-FTS
                                      CE     -28.00  -28.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
315.000       270.000       4.86      DP     -30.00  -30.00    13C2-PFHxA
                                      CE     -15.00  -15.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
318.000       273.000       4.86      DP     -30.00  -30.00    13C5-PFHxA
                                      CE     -15.00  -15.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
287.000       169.000       5.00      DP     -20.00  -20.00    13C3-HFPODA
                                      CE     -10.00  -10.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
367.000       322.000       5.27      DP     -40.00  -40.00    13C4-PFHpA
                                      CE     -15.00  -15.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
402.000       80.000        5.27      DP     -100.00 -100.00   13C3-PFHxS
                                      CE     -80.00  -80.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
359.000       294.000       5.42      DP     -40.00  -40.00    13C2-6:2 FTUCA
                                      CE     -25.00  -25.00
```

Attachment 3

```
Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
379.000       294.000       5.43      DP     -30.00 -30.00    13C2-6:2 FTCA
                                             CE     -30.00 -30.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
429.000       81.000        5.63      DP     -100.00 -100.00   13C2-6:2-FTS
                                             CE     -35.00 -35.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
415.000       370.000       5.65      DP     -50.00 -50.00    13C2-PFOA
                                             CE     -16.00 -16.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
417.000       172.000       5.65      DP     -50.00 -50.00    13C4-PFOA
                                             CE     -16.00 -16.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
421.000       376.000       5.65      DP     -50.00 -50.00    13C8-PFOA
                                             CE     -16.00 -16.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
503.000       99.000        5.98      DP     -100.00 -100.00   13C4-PFOS
                                             CE     -100.00    -100.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
507.000       99.000        5.98      DP     -100.00 -100.00   13C8-PFOS
                                             CE     -100.00    -100.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
```

```
472.000 427.000 5.99    DP      -50.00  -50.00  13C9-PFNA
                                CE      -18.00  -18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
459.000       394.000       6.13      DP     -50.00 -50.00     13C2-8:2 FTUCA
                                             CE     -25.00-25.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
479.000       394.000       6.13      DP     -35.00 -35.00     13C2-8:2 FTCA
                                             CE     -25.00-25.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
519.000       474.000       6.30      DP     -50.00 -50.00     13C6-PFDA
                                             CE     -18.00-18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
515.000       470.000       6.30      DP     -50.00 -50.00     13C2-PFDA
                                             CE     -18.00-18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
529.000       81.000        6.31      DP     -100.00-100.00    13C2-8:2-FTS
                                             CE     -42.00-42.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
506.000       78.000        6.40      DP     -100.00-100.00    13C8-PFOSA
                                             CE     -80.00-80.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
573.000       419.000       6.40      DP     -80.00 -80.00     d3-NMeFOSAA
                                             CE     -30.00-30.00
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Attachment 3

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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
565.000       520.000       6.58      DP     -70.00 -70.00    13C2-PFUnDA
                                             CE     -19.00 -19.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
570.000       525.000       6.58      DP     -70.00 -70.00    13C7-PFUnDA
                                             CE     -19.00 -19.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
589.000       419.000       6.50      DP     -90.00 -90.00    d5-NEtFOSAA
                                             CE     -30.00 -30.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
559.000       494.000       6.70      DP     -60.00 -60.00    13C2-10:2 FTUCA
                                             CE     -30.00 -30.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
579.000       494.000       6.72      DP     -50.00 -50.00    13C2-10:2 FTCA
                                             CE     -30.00 -30.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
615.000       570.000       6.81      DP     -60.00 -60.00    13C2-PFDoDA
                                             CE     -20.00 -20.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
623.000       59.000        6.85      DP     -50.00 -50.00    d7-NMePFOSAE
                                             CE     -70.00 -70.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
515.000       219.000       6.86      DP     -100.00 -100.00  d3-NMePFOSA
```

```
                              CE      -37.00  -37.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
639.000       59.000        7.01      DP     -45.00 -45.00    d9-NEtPFOSAE
                                             CE     -70.00 -70.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
531.000       219.000       7.03      DP     -100.00 -100.00   d5-NEtPFOSA
                                             CE     -38.00 -38.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
715.000       670.000       7.21      DP     -60.00 -60.00    13C2-PFTeDA
                                             CE     -22.00 -22.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
163.000       119.000       1.83      DP     -30.00 -30.00    PPF Acid
                                             CE     -15.00 -15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
213.000       169.000       3.89      DP     -40.00 -40.00    PFBA
                                             CE     -14.00 -14.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
249.000       99.000        4.12      DP     -60.00 -60.00    PFPrS
                                             CE     -40.00 -40.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
229.000       85.000        4.17      DP     -40.00 -40.00    PFECA F
                                             CE     -25.00 -25.00
```

Attachment 3

```
Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
241.000       177.000       4.49      DP     -60.00 -60.00    3:3 FTCA
                                             CE     -12.00-12.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
263.000       219.000       4.43      DP     -40.00 -40.00    PFPeA
                                             CE     -14.00-14.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
299.000       80.000        4.49      DP     -120.00-120.00   PFBS
                                             CE     -65.00-65.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
279.000       85.000        4.62      DP     -40.00 -40.00    PFECA A
                                             CE     -20.00-20.00

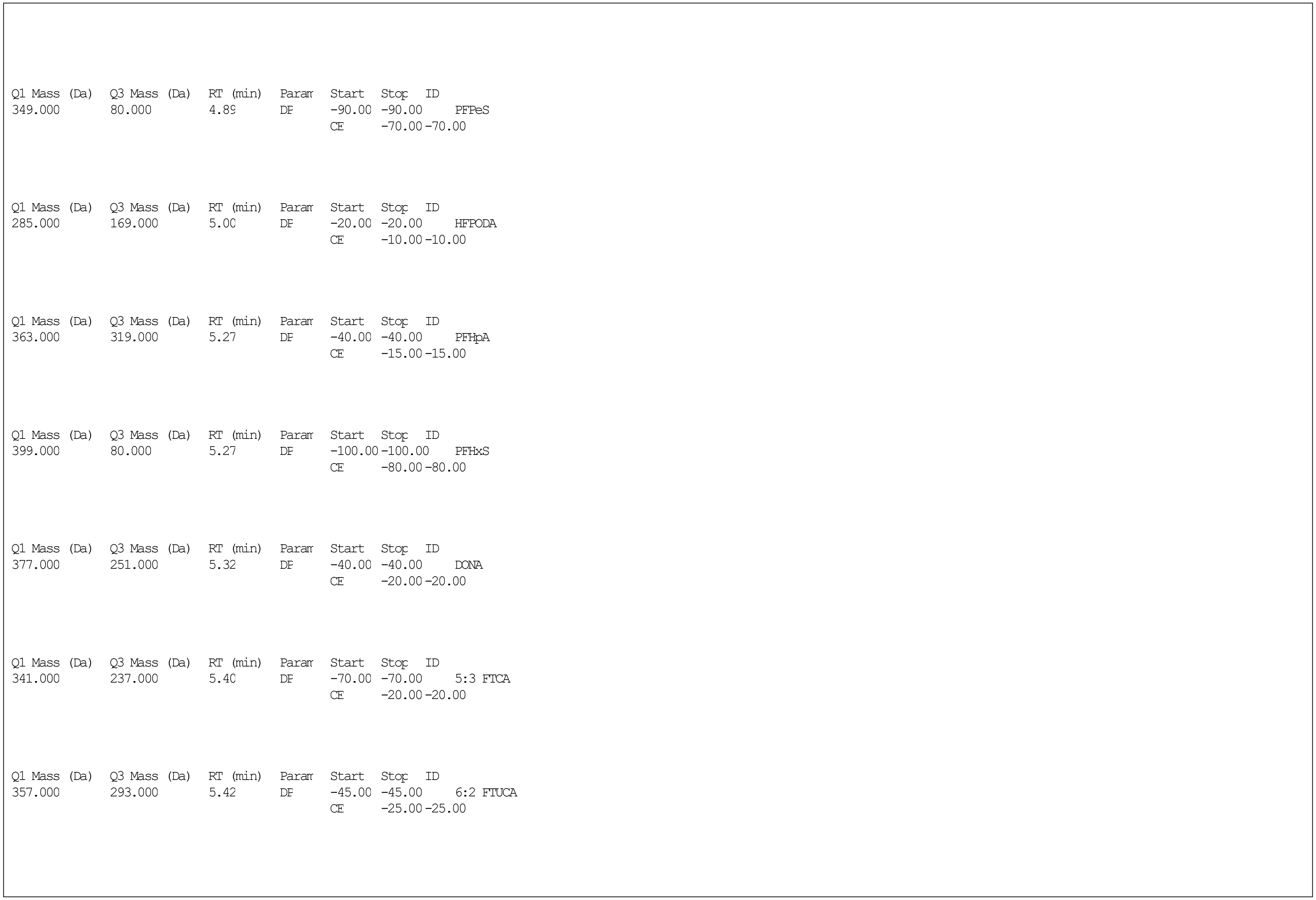
Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
315.000       135.000       4.71      DP     -60.00 -60.00    PFEESA
                                             CE     -30.00-30.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
295.000       201.000       4.84      DP     -70.00 -70.00    PFECA B
                                             CE     -25.00-25.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
327.000       307.000       4.83      DP     -100.00-100.00   4:2-FTS
                                             CE     -28.00-28.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
313.000       269.000       4.86      DP     -30.00 -30.00    PFHxA
                                             CE     -15.00-15.00
```

Attachment 3



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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
349.000       80.000        4.89      DP     -90.00 -90.00     PFPeS
                                             CE     -70.00 -70.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
285.000       169.000       5.00      DP     -20.00 -20.00     HFPODA
                                             CE     -10.00 -10.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
363.000       319.000       5.27      DP     -40.00 -40.00     PFHpA
                                             CE     -15.00 -15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
399.000       80.000        5.27      DP     -100.00-100.00    PFHxS
                                             CE     -80.00 -80.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
377.000       251.000       5.32      DP     -40.00 -40.00     DONA
                                             CE     -20.00 -20.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
341.000       237.000       5.40      DP     -70.00 -70.00     5:3 FTCA
                                             CE     -20.00 -20.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
357.000       293.000       5.42      DP     -45.00 -45.00     6:2 FTUCA
                                             CE     -25.00 -25.00
```
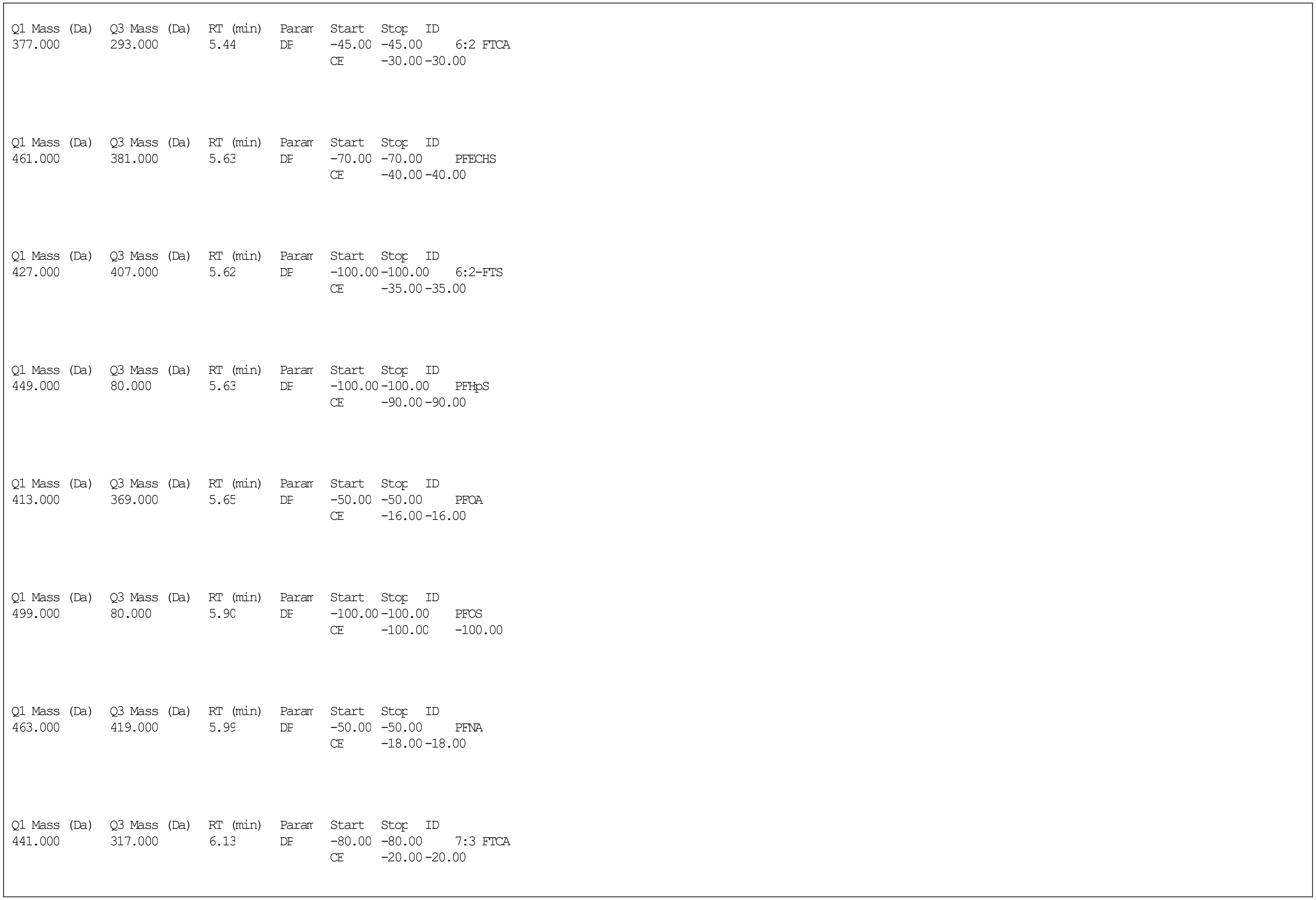

Attachment 3



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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
377.000       293.000       5.44      DP     -45.00  -45.00     6:2 FTCA
                                      CE     -30.00 -30.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
461.000       381.000       5.63      DP     -70.00  -70.00     PFECHS
                                      CE     -40.00 -40.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
427.000       407.000       5.62      DP     -100.00 -100.00    6:2-FTS
                                      CE     -35.00 -35.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
449.000       80.000        5.63      DP     -100.00 -100.00    PFHpS
                                      CE     -90.00 -90.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
413.000       369.000       5.65      DP     -50.00  -50.00     PFOA
                                      CE     -16.00 -16.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
499.000       80.000        5.90      DP     -100.00 -100.00    PFOS
                                      CE     -100.00    -100.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
463.000       419.000       5.99      DP     -50.00  -50.00     PFNA
                                      CE     -18.00 -18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
441.000       317.000       6.13      DP     -80.00  -80.00     7:3 FTCA
                                      CE     -20.00 -20.00
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Attachment 3

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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
457.000       393.000       6.13      DP     -50.00 -50.00     8:2 FTUCA
                                             CE     -25.00 -25.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
477.000       393.000       6.15      DP     -45.00 -45.00     8:2 FTCA
                                             CE     -30.00 -30.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
531.000       351.000       6.12      DP     -100.00 -100.00   9Cl-PF3ONS
                                             CE     -38.00 -38.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
549.000       80.000        6.28      DP     -100.00 -100.00   PFNS
                                             CE     -110.00    -110.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
513.000       469.000       6.30      DP     -50.00 -50.00     PFDA
                                             CE     -18.00 -18.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
527.000       507.000       6.30      DP     -100.00 -100.00   8:2-FTS
                                             CE     -42.00 -42.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
498.000       78.000        6.40      DP     -100.00 -100.00   PFOSA
                                             CE     -80.00 -80.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
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Attachment 3

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570.000 419.000 6.40    DP      -80.00  -80.00  NMeFOSAA
                                CE      -30.00  -30.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
599.000       80.000        6.54      DP     -100.00-100.00    PFDS
                                             CE     -120.00    -120.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
563.000       519.000       6.58      DP     -70.00 -70.00     PFUnDA
                                             CE     -19.00-19.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
584.000       419.000       6.50      DP     -90.00 -90.00     NEtFOSAA
                                             CE     -30.00-30.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
557.000       493.000       6.70      DP     -70.00 -70.00     10:2 FTUCA
                                             CE     -25.00-25.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
631.000       451.000       6.68      DP     -100.00-100.00    11Cl-PF3OUdS
                                             CE     -43.00-43.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
577.000       493.000       6.72      DP     -60.00 -60.00     10:2 FTCA
                                             CE     -30.00-30.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
613.000       569.000       6.99      DP     -60.00 -60.00     PFDoDA
                                             CE     -20.00-20.00
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Attachment 3

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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
627.000       607.000       6.84      DP     -100.00-100.00    10:2-FTS
                                             CE     -47.00-47.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
616.000       59.000        6.85      DP     -50.00 -50.00     NMePFOSAE
                                             CE     -70.00-70.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
512.000       219.000       6.86      DP     -100.00-100.00    NMePFOSA
                                             CE     -37.00-37.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
699.000       80.000        6.99      DP     -100.00-100.00    PFDoS
                                             CE     -150.00    -150.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
630.000       59.000        7.01      DP     -45.00 -45.00     NEtPFOSAE
                                             CE     -70.00-70.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
526.000       219.000       7.03      DP     -100.00-100.00    NEtPFOSA
                                             CE     -38.00-38.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
663.000       619.000       7.03      DP     -60.00 -60.00     PFTrDA
                                             CE     -21.00-21.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
713.000       669.000       7.21      DP     -60.00 -60.00     PFTeDA
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Attachment 3

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                                 CE        -22.00  -22.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
813.000       769.000       7.51      DP     -100.00 -100.00   PFHxDA
                                             CE      -25.00 -25.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
913.000       869.000       7.74      DP     -100.00 -100.00   PFODA
                                             CE      -27.00 -27.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
299.000       99.000        4.50      DP     -100.00 -100.00   PFBS_2
                                             CE      -45.00 -45.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
295.000       85.000        4.45      DP     -25.00  -25.00    PFECA B_2
                                             CE      -15.00 -15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
327.000       81.000        4.83      DP     -100.00 -100.00   4:2 FTS_2
                                             CE      -50.00 -50.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
313.000       119.000       4.86      DP     -50.00  -50.00    PFHxA_2
                                             CE      -31.00 -31.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop  ID
349.000       99.000        4.89      DP     -100.00 -100.00   PFPeS_2
                                             CE      -50.00 -50.00
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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
285.000       185.000       5.00      DP     -75.00 -75.00    HFPODA_2
                                             CE     -10.00-10.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
385.000       185.000       5.00      DP     -75.00 -75.00    HFPODA_3
                                             CE     -10.00-10.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
363.000       169.000       5.27      DP     -60.00 -60.00    PFHpA_2
                                             CE     -25.00-25.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
399.000       99.000        5.27      DP     -100.00-100.00   PFHxS_2
                                             CE     -70.00-70.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
341.000       217.000       5.40      DP     -80.00 -80.00    5:3 FTCA_2
                                             CE     -20.00-20.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
461.000       99.000        5.63      DP     -60.00 -60.00    PFECHS_2
                                             CE     -60.00-60.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
427.000       81.000        5.62      DP     -120.00-120.00   6:2 FTS_2
                                             CE     -70.00-70.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
449.000       99.000        5.63      DP     -100.00-100.00   PFHpS_2
                                             CE     -80.00-80.00
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Attachment 3

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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
413.000       169.000       5.65      DP     -60.00 -60.00     PFOA_2
                                             CE     -26.00 -26.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
499.000       99.000        5.97      DP     -100.00 -100.00   PFOS_2
                                             CE     -80.00 -80.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
463.000       219.000       5.99      DP     -60.00 -60.00     PFNA_2
                                             CE     -30.00 -30.00

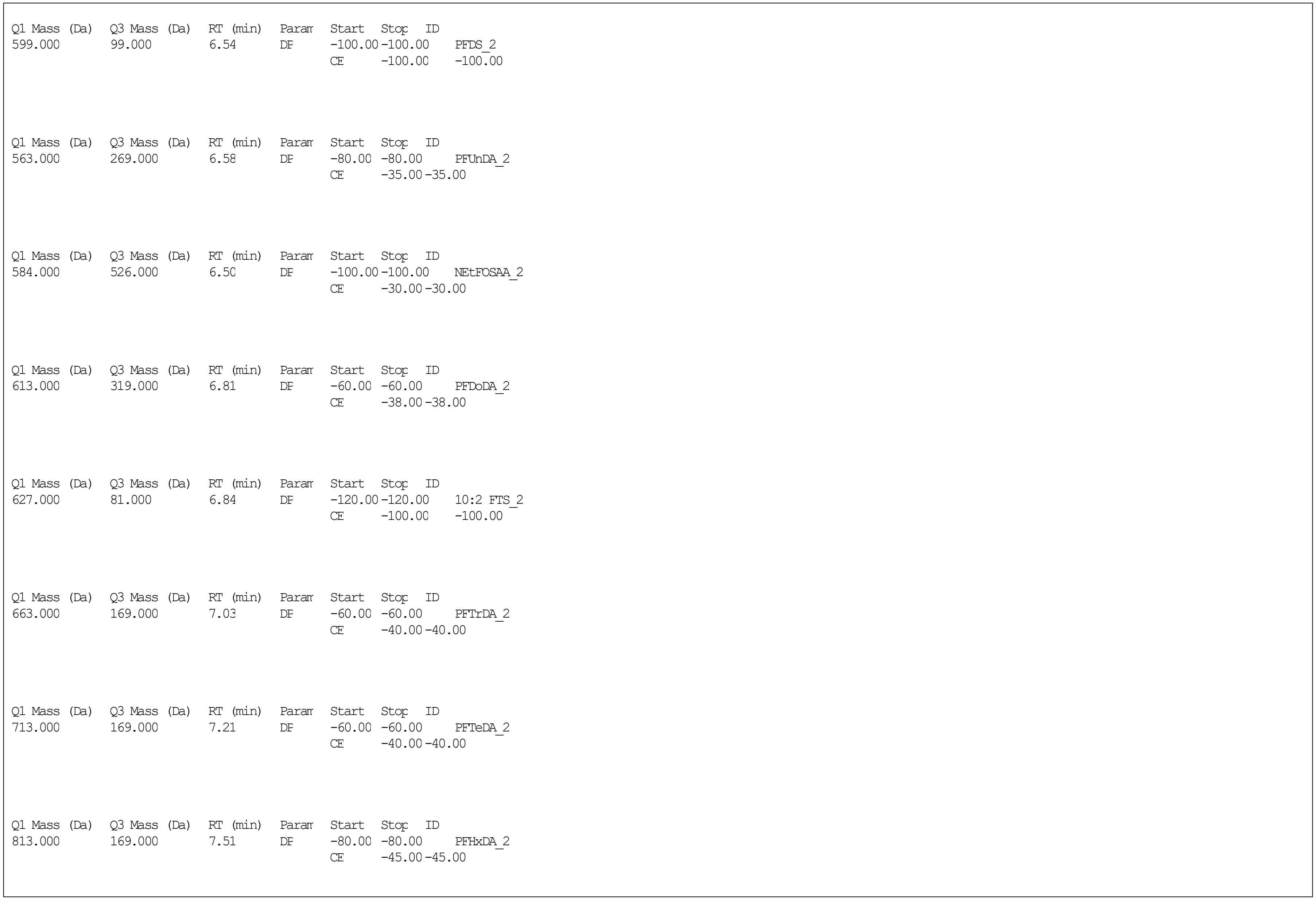

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
549.000       99.000        6.28      DP     -100.00 -100.00   PFNS_2
                                             CE     -90.00 -90.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
513.000       219.000       6.30      DP     -50.00 -50.00     PFDA_2
                                             CE     -31.00 -31.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
527.000       81.000        6.30      DP     -100.00 -100.00   8:2 FTS_2
                                             CE     -80.00 -80.00


Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
570.000       483.000       6.40      DP     -80.00 -80.00     NMeFOSAA_2
                                             CE     -24.00 -24.00
```

Attachment 3



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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
599.000       99.000        6.54      DP     -100.00 -100.00    PFDS_2
                                             CE      -100.00    -100.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
563.000       269.000       6.58      DP     -80.00  -80.00     PFUnDA_2
                                             CE      -35.00 -35.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
584.000       526.000       6.50      DP     -100.00 -100.00    NEtFOSAA_2
                                             CE      -30.00 -30.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
613.000       319.000       6.81      DP     -60.00  -60.00     PFDoDA_2
                                             CE      -38.00 -38.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
627.000       81.000        6.84      DP     -120.00 -120.00    10:2 FTS_2
                                             CE      -100.00    -100.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
663.000       169.000       7.03      DP     -60.00  -60.00     PFTrDA_2
                                             CE      -40.00 -40.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
713.000       169.000       7.21      DP     -60.00  -60.00     PFTeDA_2
                                             CE      -40.00 -40.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
813.000       169.000       7.51      DP     -80.00  -80.00     PFHxDA_2
                                             CE      -45.00 -45.00
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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
913.000       169.000       7.74      DP     -80.00 -80.00    PFODA_2
                                             CE     -50.00 -50.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
179.000       85.000        2.90      DP     -15.00 -15.00    PFMOAA
                                             CE     -15.00 -15.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
441.000       241.000       3.92      DP     -80.00 -80.00    R-PSDA
                                             CE     -32.00 -32.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
405.000       217.000       3.92      DP     -60.00 -60.00    R-EVE
                                             CE     -25.00 -25.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
439.000       343.000       3.94      DP     -80.00 -80.00    Hydrolized PSDA
                                             CE     -35.00 -35.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
229.000       185.000       4.06      DP     -20.00 -20.00    PMPA
                                             CE     -12.00 -12.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
297.000       135.000       4.17      DP     -80.00 -80.00    NVHOS
                                             CE     -35.00 -35.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
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Attachment 3

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245.000 85.000  4.37    DP      -10.00  -10.00  PFO2HxA
                                CE      -15.00  -15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
279.000       235.000       4.59      DP     -10.00 -10.00    PEPA
                                             CE     -20.00-20.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
311.000       85.000        4.97      DP     -20.00 -20.00    PFO3OA
                                             CE     -15.00-15.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
427.000       283.000       5.27      DP     -40.00 -40.00    Hydro-EVE Acid
                                             CE     -18.00-18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
397.000       217.000       5.27      DP     -80.00 -80.00    R-PSDCA
                                             CE     -35.00-35.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
463.000       263.000       5.26      DP     -80.00 -80.00    Hydro-PS Acid
                                             CE     -38.00-38.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
379.000       185.000       5.38      DP     -35.00 -35.00    PFECA-G
                                             CE     -20.00-20.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
377.000       84.000        5.48      DP     -20.00 -20.00    PFO4DA
                                             CE     -40.00-40.00
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Attachment 3

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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
443.000       147.000       5.53      DP     -70.00 -70.00     PS Acid
                                             CE     -32.00-32.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
407.000       263.000       5.55      DP     -40.00 -40.00     EVE Acid
                                             CE     -14.00-14.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
443.000       85.000        5.93      DP     -7.00  -7.00  PFO5DA
                                             CE     -37.00-37.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
175.000       97.000        1.46      DP     -45.00 -45.00     MTP
                                             CE     -22.00-22.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
468.000       423.000       5.99      DP     -50.00 -50.00     13C5-PFNA
                                             CE     -18.00-18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
403.000       84.000        5.27      DP     -100.00-100.00    18O2-PFHxS
                                             CE     -80.00-80.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
263.000       69.000        4.43      DP     -40.00 -40.00     PFPeA_2
                                             CE     -14.00-14.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
498.000       478.000       6.40      DP     -100.00-100.00    PFOSA_2
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Attachment 3

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                              CE      -80.00  -80.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
512.000       169.000       6.86      DP     -100.00-100.00    NMePFOSA_2
                                             CE     -37.00-37.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
526.000       169.000       7.03      DP     -180.00-180.00    NEtPFOSA_2
                                             CE     -40.00-40.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
377.000       85.000        5.32      DP     -40.00 -40.00     DONA_2
                                             CE     -20.00-20.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
533.000       353.000       6.12      DP     -100.00-100.00    9Cl-PF3ONS_2
                                             CE     -38.00-38.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
633.000       453.000       6.68      DP     -180.00-180.00    11Cl-PF3OUdS_2
                                             CE     -40.00-40.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
241.000       117.000       4.49      DP     -60.00 -60.00     3:3 FTCA_2
                                             CE     -12.00-12.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
441.000       337.000       6.13      DP     -80.00 -80.00     7:3 FTCA_2
                                             CE     -20.00-20.00
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Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
315.000       83.000        4.71      DP     -60.00  -60.00     PFEESA_2
                                      CE     -30.00 -30.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
699.000       99.000        6.99      DP     -100.00 -100.00    PFDoS_2
                                      CE     -150.00     -150.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
318.000       120.000       4.86      DP     -180.00 -180.00    13C5-PFHxA_2
                                      CE     -40.00 -40.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
302.000       99.000        4.49      DP     -120.00 -120.00    13C3-PFBS_2
                                      CE     -65.00 -65.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
402.000       99.000        5.27      DP     -100.00 -100.00    13C3-PFHxS_2
                                      CE     -80.00 -80.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
507.000       80.000        5.98      DP     -100.00 -100.00    13C8-PFOS_2
                                      CE     -100.00     -100.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
329.000       309.000       4.83      DP     -100.00 -100.00    13C2-4:2-FTS_2
                                      CE     -28.00 -28.00

Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start   Stop   ID
429.000       409.000       5.63      DP     -100.00 -100.00    13C2-6:2-FTS_2
                                      CE     -35.00 -35.00
```

```
Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
529.000       509.000       6.31      DP     -100.00-100.00    13C2-8:2-FTS_2
                                             CE     -42.00-42.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
287.000       185.000       5.00      DP     -20.00 -20.00     13C3-HFPODA_2
                                             CE     -10.00-10.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
315.000       119.000       4.86      DP     -30.00 -30.00     13C2-PFHxA_2
                                             CE     -18.00-18.00



Q1 Mass (Da)  Q3 Mass (Da)  RT (min)  Param  Start  Stop  ID
503.000       80.000        5.98      DP     -100.00-100.00    13C4-PFOS_2
                                             CE     -100.00    -100.00

Parameter Table(Period 1  Experiment   1):
CUR:          35.00
CAD:          10.00
IS:           -3000.00
TEM:          350.00
GS1:          40.00
GS2:          50.00
EP            -10.00
CXP           -14.00
```

ATTACHMENT 4 ST1927333A

WELLINGTON LABORATORIES

CERTIFICATE OF ANALYSIS DOCUMENTATION

PFAC-MXC

Native Perfluorinated Compound Solution/Mixture

PRODUCT CODE:	PFAC-MXC
LOT NUMBER:	PFACMXC0617
SOLVENT(S):	Methanol / Water (<1%)
DATE PREPARED: (mm/dd/yyyy)	06/14/2017
LAST TESTED: (mm/dd/yyyy)	03/19/2019
EXPIRY DATE: (mm/dd/yyyy)	03/19/2024
RECOMMENDED STORAGE:	Store ampoule in a cool, dark place

DESCRIPTION:

PFAC-MXC is a solution/mixture of thirteen native perfluoroalkylcarboxylic acids (C_4-C_{14}, C_{16}, and C_{18}) and eight native perfluoroalkylsulfonates (C_4-C_{10} and C_{12}). The full name, abbreviation and concentration for each of the components are given in Table A.

The individual perfluoroalkylcarboxylic acids and perfluoroalkylsulfonates all have chemical purities of >98%.

DOCUMENTATION/ DATA ATTACHED:

Table A: Components and Concentrations of the Solution/Mixture
Figure 1: LC/MS Data (SIR)
Figure 2: LC/MS/MS Data (Selected MRM Transitions)

ADDITIONAL INFORMATION:

- See page 2 for further details.
- Contains 4 mole eq. of NaOH to prevent conversion of the carboxylic acids to their respective methyl esters.

FOR LABORATORY USE ONLY: NOT FOR HUMAN OR DRUG USE

ATTACHMENT 4

INTENDED USE:

The products prepared by Wellington Laboratories Inc. are for laboratory use only. This certified reference material (CRM) was designed to be used as a standard for the identification and/or quantification of the specific chemical compounds it contains.

HANDLING:

This product should only be used by qualified personnel familiar with its potential hazards and trained in the handling of hazardous chemicals. Due care should be exercised to prevent unnecessary human contact or ingestion. All procedures should be carried out in a well-functioning fume hood and suitable gloves, eye protection, and clothing should be worn at all times. Waste should be disposed of according to national and regional regulations. Safety Data Sheets (SDSs) are available upon request.

SYNTHESIS / CHARACTERIZATION:

Our products are synthesized using single-product unambiguous routes whenever possible. They are then characterized, and their structures and purities confirmed, using a combination of the most relevant techniques, such as NMR, GC/MS, LC/MS/MS, SFC/UV/MS/MS, x-ray crystallography, and melting point. Isotopic purities of mass-labelled compounds are also confirmed using HRGC/HRMS and/or LC/MS/MS.

HOMOGENEITY:

Prior to solution preparation, crystalline material is tested for homogeneity using a variety of techniques (as stated above) and its solubility in a given diluent is taken into consideration. Duplicate solutions of a new product are prepared from the same crystalline lot and, after the addition of an appropriate internal standard, they are compared by GC/MS, LC/MS/MS, and/or SFC/UV/MS/MS. The relative response factors of the analyte of interest in each solution are required to be <5% RSD. New solution lots of existing products, as well as mixtures and calibration solutions, are compared to older lots in a similar manner. This further confirms the homogeneity of the crystalline material as well as the stability and homogeneity of the solutions in the storage containers. In order to maintain the integrity of the assigned value(s), and associated uncertainty, the dilution or injection of a subsample of this product should be performed using calibrated measuring equipment.

UNCERTAINTY:

The maximum combined relative standard uncertainty of our reference standard solutions is calculated using the following equation:

The combined relative standard uncertainty, $u_c(y)$, of a value y and the uncertainty of the independent parameters $x_1, x_2, \ldots x_n$ on which it depends is:

$$u_c(y(x_1, x_2, \ldots x_n)) = \sqrt{\sum_{i=1}^{n} u(y, x_i)^2}$$

where x is expressed as a relative standard uncertainty of the individual parameter.

The individual uncertainties taken into account include those associated with weights (calibration of the balance) and volumes (calibration of the volumetric glassware). An expanded maximum combined percent relative uncertainty of ±5% (calculated with a coverage factor of 2 and a level of confidence of 95%) is stated on the Certificate of Analysis for all of our products.

TRACEABILITY:

All reference standard solutions are traceable to specific crystalline lots. The microbalances used for solution preparation are regularly calibrated by an external ISO/IEC 17025 accredited laboratory. In addition, their calibration is verified prior to each weighing using calibrated external weights traceable to an ISO/IEC 17025 accredited laboratory. All volumetric glassware used is calibrated, of Class A tolerance, and traceable to an ISO/IEC 17025 accredited laboratory. For certain products, traceability to international interlaboratory studies has also been established.

EXPIRY DATE / PERIOD OF VALIDITY:

Ongoing stability studies of this product have demonstrated stability in its composition and concentration, until the specified expiry date, in the unopened ampoule. Monitoring for any degradation or change in concentration of the listed analyte(s) is performed on a routine basis.

LIMITED WARRANTY:

At the time of shipment, all products are warranted to be free of defects in material and workmanship and to conform to the stated technical and purity specifications.

QUALITY MANAGEMENT:

This product was produced using a Quality Management System registered to the latest versions of ISO 9001 by SAI Global, ISO/IEC 17025 by the Canadian Association for Laboratory Accreditation Inc. (CALA; A 1226), and ISO 17034 by ANSI-ASQ National Accreditation Board (ANAB; AR-1523).

CALA
Testing
Accreditation No. A 1226

ANAB
ACCREDITED
ISO 17034
REFERENCE MATERIAL PRODUCER

For additional information or assistance concerning this or any other products from Wellington Laboratories Inc., please visit our website at www.well-labs.com or contact us directly at info@well-labs.com

ATTACHMENT 4

Table A: **PFAC-MXC; Components and Concentrations (ng/ml, ± 5% in Methanol / Water (<1%))**

Compound	Abbreviation	Concentration (ng/ml)*	Peak Assignment in Figure 1
Perfluoro-n-butanoic acid	PFBA	2000	A
Perfluoro-n-pentanoic acid	PFPeA	2000	B
Perfluoro-n-hexanoic acid	PFHxA	2000	D
Perfluoro-n-heptanoic acid	PFHpA	2000	F
Perfluoro-n-octanoic acid	PFOA	2000	H
Perfluoro-n-nonanoic acid	PFNA	2000	J
Perfluoro-n-decanoic acid	PFDA	2000	L
Perfluoro-n-undecanoic acid	PFUdA	2000	N
Perfluoro-n-dodecanoic acid	PFDoA	2000	P
Perfluoro-n-tridecanoic acid	PFTrDA	2000	Q
Perfluoro-n-tetradecanoic acid	PFTeDA	2000	S
Perfluoro-n-hexadecanoic acid	PFHxDA	2000	T
Perfluoro-n-octadecanoic acid	PFODA	2000	U

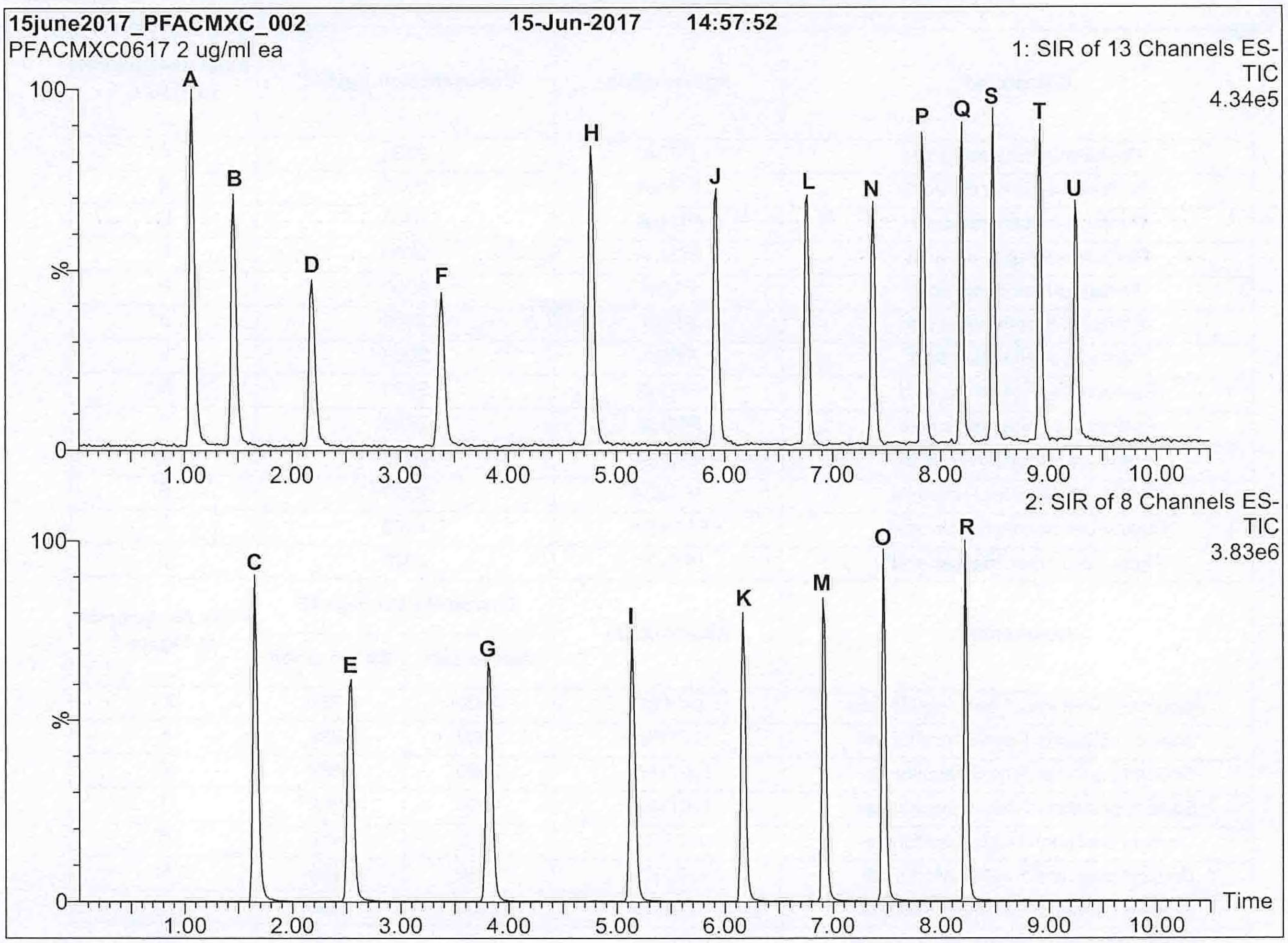
Compound	Abbreviation	Concentration (ng/ml)*		Peak Assignment in Figure 1
		As the salt	As the anion	
Potassium perfluoro-1-butanesulfonate	L-PFBS	2000	1770	C
Sodium perfluoro-1-pentanesulfonate	L-PFPeS	2000	1880	E
Sodium perfluoro-1-hexanesulfonate	L-PFHxS	2000	1890	G
Sodium perfluoro-1-heptanesulfonate	L-PFHpS	2000	1900	I
Sodium perfluoro-1-octanesulfonate	L-PFOS	2000	1910	K
Sodium perfluoro-1-nonanesulfonate	L-PFNS	2000	1920	M
Sodium perfluoro-1-decanesulfonate	L-PFDS	2000	1930	O
Sodium perfluoro-1-dodecanesulfonate	L-PFDoS	2000	1940	R

* Concentrations have been rounded to three significant figures.

Certified By: ____________________
B.G. Chittim, General Manager

Date: 06/06/2019
(mm/dd/yyyy)

Figure 1: **PFAC-MXC; LC/MS Data (Total Ion Current Chromatogram; SIR)**



Conditions for Figure 1:

LC: **Waters Acquity Ultra Performance LC**
MS: **Micromass Quattro *micro* API MS**

Chromatographic Conditions

Column: Acquity UPLC BEH Shield RP_{18}
1.7 µm, 2.1 x 100 mm

Mobile phase: Gradient
Start: 50% H_2O / 50% (80:20 MeOH:ACN)
(both with 10 mM NH_4OAc buffer)
Ramp to 90% organic over 8 min and hold for 2 min before returning to initial conditions in 1 min.

Time: 12 min

Flow: 300 µl/min

MS Parameters

Experiment: SIR of 21 Channels

Source: Electrospray (negative)
Capillary Voltage (kV) = 3.00
Cone Voltage (V) = variable (10-80)
Cone Gas Flow (l/hr) = 50
Desolvation Gas Flow (l/hr) = 750

Figure 2: **PFAC-MXC; LC/MS/MS Data (Selected MRM Transitions)**

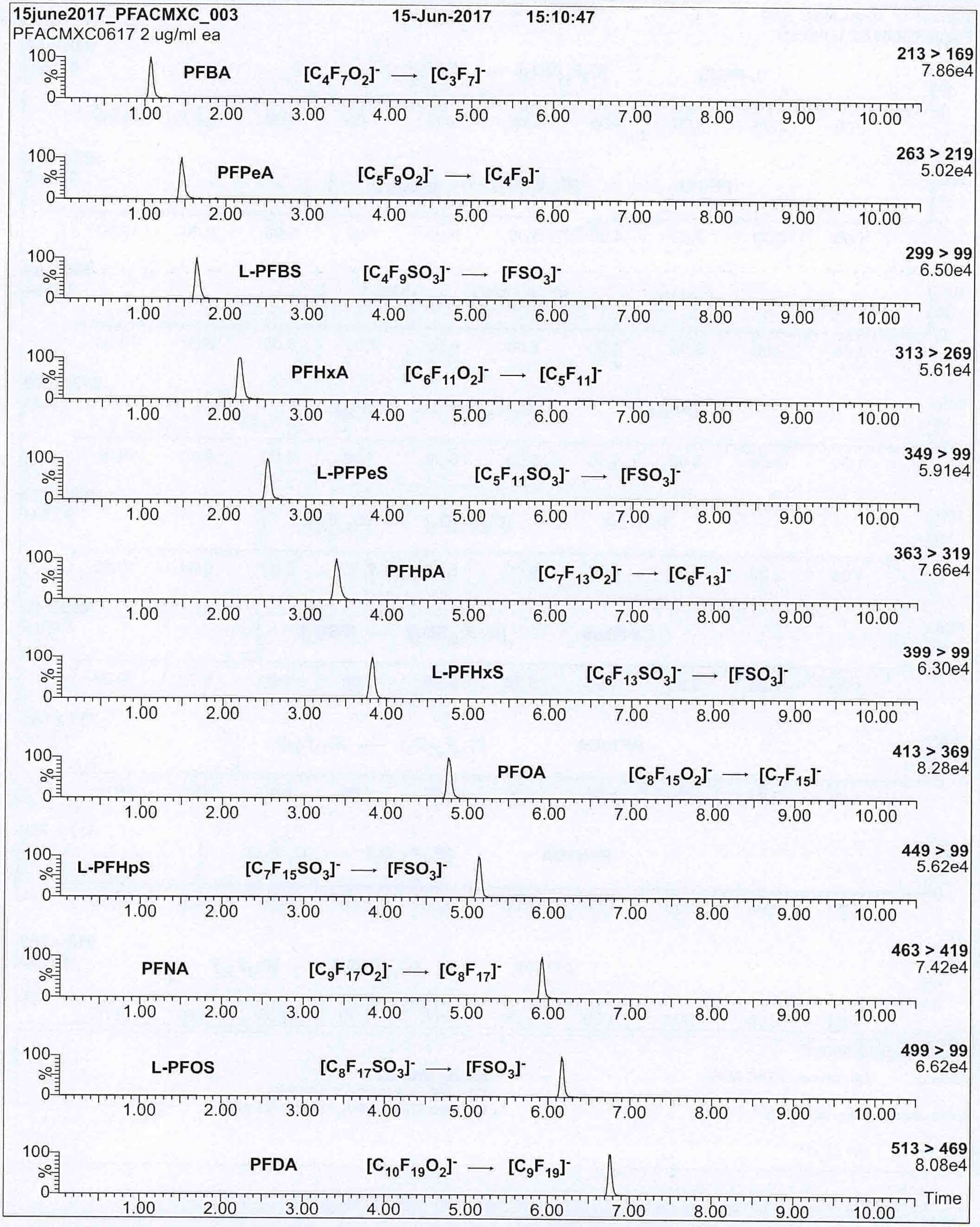
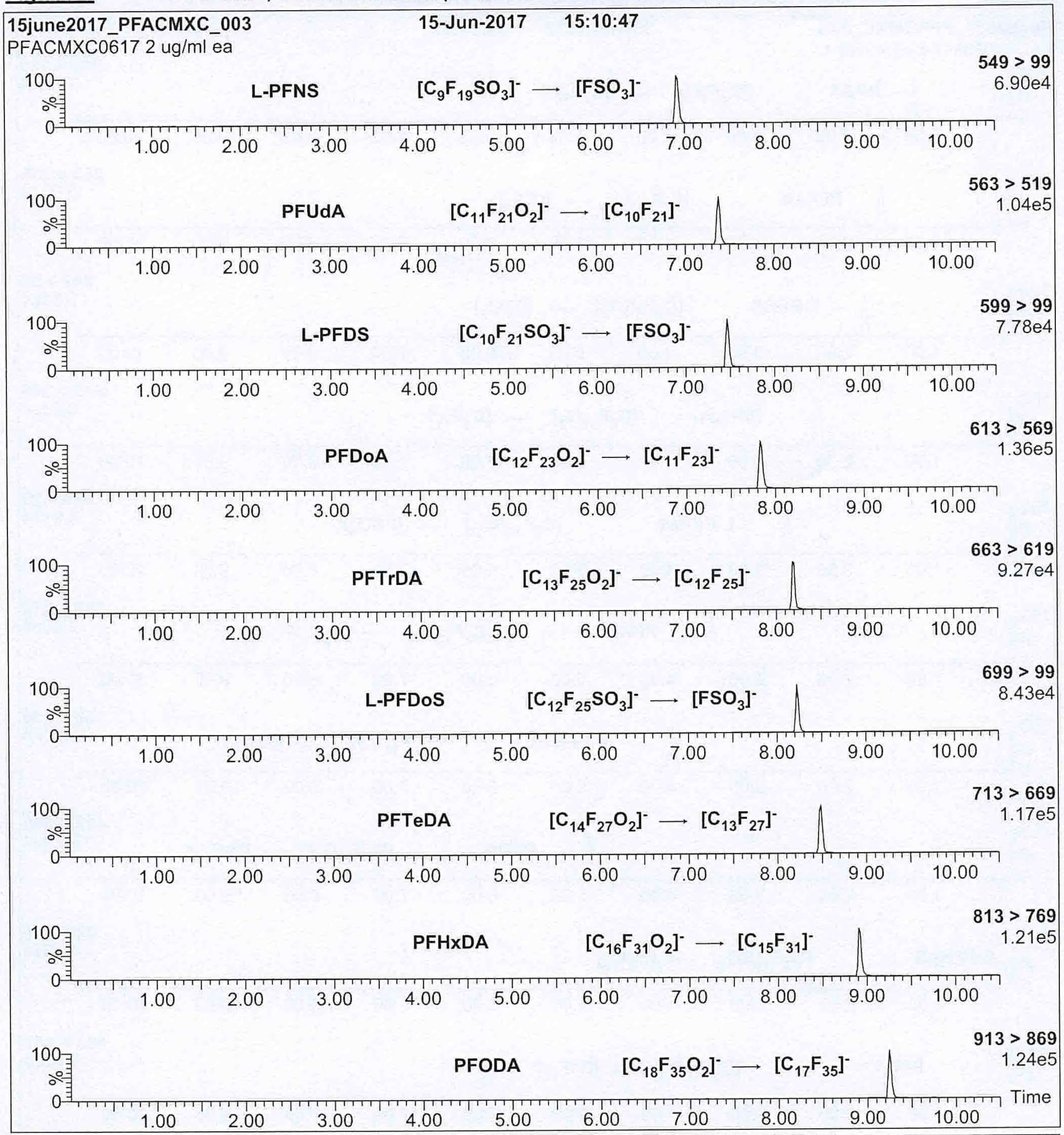


Figure 2: **PFAC-MXC; LC/MS/MS Data (Selected MRM Transitions)**



15june2017_PFACMXC_003 **15-Jun-2017** **15:10:47**

PFACMXC0617 2 ug/ml ea

Conditions for Figure 2:

Injection: On-column (PFAC-MXC)

Mobile phase: Same as Figure 1

Flow: 300 µl/min

MS Parameters

Collision Gas (mbar) = 3.46e-3

Collision Energy (eV) = 8-50 (variable)

Native PFAS Intermediate A

Vendor	Catalog Number	Analyte	CAS#	Acronym	Conc. (ng/mL)	Aliquot (mL)	Final Volume (ml) Methanol	Final Conc. Native PFAS Intermediate A (ng/ml)
Wellington	PFAC-MXF	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9	11Cl-PF3OUdS	1890	0.10	2	94.5
		9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1	9Cl-PF3ONS	1870			93.5
		4,8-dioxa-3H-Perfluorononanoic acid	919005-14-4	DONA	1890			94.5
		Perfluoro(2-propxypropanoic) acid	13252-13-6	HFPODA	2000			100
Wellington	PFAC-MXH	1H,1H,2H,2H perfluorodecanesulfonic acid	39108-34-4	8:2-FTS	3840	0.05		96
		1H,1H,2H,2H perfluorohexanesulfonic acid	757124-72-4	4:2-FTS	3750			93.8
		1H,1H,2H,2H perfluorooctanesulfonic acid	27619-97-2	6:2-FTS	3800			95
		N-ethylperfluorooctanesulfonamidoacetic acid	2991-50-6	NEtFOSAA	1000			25
		N-methylperfluorooctanesulfonamidoacetic acid	2355-31-9	NMeFOSAA	1000			25
		Perfluorobutanesulfonic acid	375-73-5	PFBS	887			22.2
		Perfluorobutanoic acid	375-22-4	PFBA	4000			100
		Perfluorodecanesulfonic acid	335-77-3	PFDS	965			24.1
		Perfluorodecanoic acid	335-76-2	PFDA	1000			25
		Perfluorododecanesulfonic acid	79780-39-5	PFDoDS	970			24.3
		Perfluorododecanoic acid	307-55-1	PFDoDA	1000			25
		Perfluoroheptanesulfonic acid	375-92-8	PFHpS	953			23.8
		Perfluoroheptanoic acid	375-85-9	PFHpA	1000			25
		Perfluorohexanesulfonic acid	355-46-4	PFHxS	914			22.9
		Perfluorohexanoic acid	307-24-4	PFHxA	1000			25
		Perfluorononanesulfonic acid	68259-12-1	PFNS	962			24.1
		Perfluorononanoic acid	375-95-1	PFNA	1000			25
		Perfluorooctanesulfonamide	754-91-6	PFOSA	1000			25
		Perfluorooctanesulfonic acid	1763-23-1	PFOS	928			23.2
		Perfluorooctanoic acid	335-67-1	PFOA	1000			25
		Perfluoropentanesulfonic acid	2706-91-4	PFPeS	941			23.5
		Perfluoropentanoic acid	2706-90-3	PFPeA	2000			50
		Perfluorotetradecanoic acid	376-06-7	PFTeDA	1000			25
		Perfluorotridecanoic acid	72629-94-8	PFTrDA	1000			25
		Perfluoroundecanoic acid	2058-94-8	PFUnDA	1000			25
Wellington	PFAC-MXG	Perfluoro-3-methoxypropanoic acid	377-73-1	PFMPA	2000	0.05		50
		Perfluoro-4-methoxybutanoic acid	863090-89-5	PFMBA	2000			50
		Nonafluoro-3,6-dioxaheptanoic acid	151722-58-6	NFDHA	2000			50
		Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	PFEESA	1780			44.5
Wellington	PFAC-MXI	2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	24448-09-7	NMePFOSAE	10000	0.05		250
		N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	1000			25
		2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	1691-99-2	NEtPFOSAE	10000			250
		N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	1000			25

Native PFAS Intermediate B								
Vendor	**Catalog Number**	**Analyte**	**CAS#**	**Acronym**	**Conc. (ug/mL)**	**Aliquot (mL)**	**Final Volume (ml) Methanol**	**Final Conc. Native PFAS Intermediate B (ug/ml)**
Wellington	PFAC-MXJ	3-Perfluoropropylpropanoic acid	763051-92-9	3:3 FTCA	4	0.125	5	100
		3-Perfluoropentylpropanoic acid	756426-58-1	5:3 FTCA	20			500
		3-Perfluoroheptylpropanoic acid	919005-14-4	7:3 FTCA	20			500

Working Labeled Extraction Standard Spike*							
Solution Name	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/mL)**	**Aliquot (mL)**	**Final Volume**	**Final Conc. Working Labeled Extraction Standard Spike (ng/ml)**
Mass-Labelled PFAS Extraction Standard Solution/Mixture-ES*	Perfluoro-n-[^{13}C4]butanoic acid	STL00992	^{13}C4-PFBA	2000	1	1	2000
	Perfluoro-n-[^{13}C5]pentanoic acid	STL01893	^{13}C5-PFPeA	1000			1000
	Perfluoro-n-[1,2,3,4,6-^{13}C5]hexanoic acid	STL02577	^{13}C5 -PFHxA	500			500
	Perfluoro-n-[1,2,3,4-^{13}C4]heptanoic acid	STL01892	^{13}C4-PFHpA	500			500
	Perfluoro-n-[^{13}C8]octanoic acid	STL01052	^{13}C8-PFOA	500			500
	Perfluoro-n-[^{13}C9]nonanoic acid	STL02578	^{13}C9-PFNA	250			250
	Perfluoro-n-[1,2,3,4,5,6-^{13}C6]decanoic acid	STL02579	^{13}C6-PFDA	250			250
	Perfluoro-n-[1,2,3,4,5,6,7-^{13}C7]undecanoic acid	STL02580	^{13}C7-PFUnA	250			250
	Perfluoro-n-[1,2-^{13}C2]dodecanoic acid	STL02703	^{13}C2-PFDoA	250			250
	Perfluoro-n-[1,2-^{13}C2]tetradecanoic acid	STL02116	^{13}C2-PFTeDA	250			250
	Perfluoro-1-[2,3,4-^{13}C3]butanesulfonic acid	STL02337	^{13}C3-PFBS	466			466
	Perfluoro-1-[1,2,3-^{13}C3]hexanesulfonic acid	STL02581	^{13}C3-PFHxS	474			474
	Perfluoro-1-[^{13}C8]octanesulfonic acid	STL01054	^{13}C8-PFOS	479			479
	Perfluoro-1-[^{13}C8]octanesulfonamide	STL01056	^{13}C8 -PFOSA	500			500
	N-methyl-d3-perfluoro-1-octanesulfonamidoacetic acid	STL02118	D3-NMeFOSAA	1000			1000
	N-ethyl-d5-perfluoro-1-octanesulfonamidoacetic acid	STL02117	D5-NEtFOSAA	1000			1000
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]hexan sulfonic acid	STL02395	^{13}C2-4:2FTS	938			938
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]octanesulfonic acid	STL02279	^{13}C2-6:2FTS	951			951
	1H,1H,2H,2H-Perfluoro-1-[1,2-^{13}C2]decanesulfonic acid	STL02280	^{13}C2-8:2FTS	960			960
	Tetrafluoro-2-heptafluoropropoxy-^{13}C3-propanoic acid	STL02255	^{13}C3-HFPO-DA	2000			2000
	N-methyl-d7-perfluorooctanesulfonamidoethanol	STL02277	D7-NMeFOSE	5000			5000
	N-ethyl-d9-perfluorooctanesulfonamidoethanol	STL02278	D9-NEtFOSE	5000			5000
	N-ethyl-d5-perfluoro-1-octanesulfonamide	STL02704	D5-NEtFOSA	500			500
	N-methyl-d3-perfluoro-1-octanesulfonamide	STL02705	D3-NMeFOSA	500			500

* Solution used without dilution for spiking. Entered into LIMS as a 1:1 dilution to utilize the standardized naming

Attachment 8

Internal Standard Spike				
Solution Name	**Analyte**	**CAS#**	**Acronym**	**Conc. (ng/mL)**
Mass-Labelled PFAS Injection Standard Solution/Mixture	Perfluoro-n-[2,3,4-^{13}C3]butanoic acid	STL02680	^{13}C3-PFBA	1000
	Perfluoro-n-[1,2,3,4-^{13}C4]octanoic acid	STL00990	^{13}C4-PFOA	500
	Perfluoro-n-[1,2-^{13}C2]decanoic acid	STL00996	^{13}C2-PFDA	250
	Perfluoro-n-[1,2,3,4-^{13}C4]octanesulfonic acid	STL00991	^{13}C4-PFOS	479
	Perfluoro-n-[1,2,3,4,5-^{13}C5] nonanoic acid	STL00995	^{13}C5-PFNA	250
	Perfluoro-n-[1,2-^{13}C2]hexanoic acid	STL00993	^{13}C2-PFHxA	500
	Perfluoro-1-hexane[^{18}O2]sulfonic acid	STL00994	^{18}O2-PFHxS	474

Native 1633 Mid-Level Spike

Vendor	Catalog Number	Analyte	CAS#	Acronym	Conc. (ng/mL)	Aliquot (mL)	Final Volume	Final Conc. Native 1633 Mid-Level Spike (ng/ml)
Wellington	PFAC-MXF	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9	11Cl-PF3OUdS	1890	0.625	5mL Methanol	236.25
		9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1	9Cl-PF3ONS	1870			233.75
		4,8-dioxa-3H-Perfluorononanoic acid	919005-14-4	DONA	1890			236.25
		Perfluoro(2-propxypropanoic) acid	13252-13-6	HFPODA	2000			250
Wellington	PFAC-MXH	1H,1H,2H,2H perfluorodecanesulfonic acid	39108-34-4	8:2-FTS	3840	0.313		240.38
		1H,1H,2H,2H perfluorohexanesulfonic acid	757124-72-4	4:2-FTS	3750			234.75
		1H,1H,2H,2H perfluorooctanesulfonic acid	27619-97-2	6:2-FTS	3800			237.88
		N-ethylperfluorooctanesulfonamidoacetic acid	2991-50-6	NEtFOSAA	1000			62.6
		N-methylperfluorooctanesulfonamidoacetic acid	2355-31-9	NMeFOSAA	1000			62.6
		Perfluorobutanesulfonic acid	375-73-5	PFBS	887			55.53
		Perfluorobutanoic acid	375-22-4	PFBA	4000			250.4
		Perfluorodecanesulfonic acid	335-77-3	PFDS	965			60.41
		Perfluorodecanoic acid	335-76-2	PFDA	1000			62.6
		Perfluorododecanesulfonic acid	79780-39-5	PFDoDS	970			60.72
		Perfluorododecanoic acid	307-55-1	PFDoDA	1000			62.6
		Perfluoroheptanesulfonic acid	375-92-8	PFHpS	953			59.66
		Perfluoroheptanoic acid	375-85-9	PFHpA	1000			62.6
		Perfluorohexanesulfonic acid	355-46-4	PFHxS	914			57.22
		Perfluorohexanoic acid	307-24-4	PFHxA	1000			62.6
		Perfluorononanesulfonic acid	68259-12-1	PFNS	962			60.22
		Perfluorononanoic acid	375-95-1	PFNA	1000			62.6
		Perfluorooctanesulfonamide	754-91-6	PFOSA	1000			62.6
		Perfluorooctanesulfonic acid	1763-23-1	PFOS	928			58.09
		Perfluorooctanoic acid	335-67-1	PFOA	1000			62.6
		Perfluoropentanesulfonic acid	2706-91-4	PFPeS	941			58.91
		Perfluoropentanoic acid	2706-90-3	PFPeA	2000			125.2
		Perfluorotetradecanoic acid	376-06-7	PFTeDA	1000			62.6
		Perfluorotridecanoic acid	72629-94-8	PFTrDA	1000			62.6
		Perfluoroundecanoic acid	2058-94-8	PFUnDA	1000			62.6
Wellington	PFAC-MXG	Perfluoro-3-methoxypropanoic acid	377-73-1	PFMPA	2000	0.313		125.2
		Perfluoro-4-methoxybutanoic acid	863090-89-5	PFMBA	2000			125.2
		Nonafluoro-3,6-dioxaheptanoic acid	151722-58-6	NFDHA	2000			125.2
		Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	PFEESA	1780			111.4
Wellington	PFAC-MXI	2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	24448-09-7	NMePFOSAE	10000	0.313		626
		N-methylperfluoro-1-octanesulfonamide	31506-32-8	NMePFOSA	1000			62.6
		2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	1691-99-2	NEtPFOSAE	10000			626
		N-ethylperfluoro-1-octanesulfonamide	4151-50-2	NEtPFOSA	1000			62.6
Wellington	PFAC-MXJ	3-Perfluoropropylpropanoic acid	763051-92-9	3:3 FTCA	4000	0.391		312.8
		3-Perfluoropentylpropanoic acid	756426-58-1	5:3 FTCA	20000			1564
		3-Perfluoroheptylpropanoic acid	919005-14-4	7:3 FTCA	20000			1564

eurofins	Always check on-line for validity. **Particle Size Distribution of Soils and Solids/Grain Size Classification by ASTM D422-63 (reapproved 2007) - Modified**	Level: **Work Instruction**
Document number: **T-WC-WI46354**		
Old Reference: **NA**		
Version: **1**		Organisation level: **5-Sub-BU**
Approved by: **XL3S** Effective Date **25-NOV-2021**	Document users: **6_EUUSLA_Water Quality_Misc Analysis, 6_EUUSLA_Water Quality_Misc Verification**	Responsible: **5_EUUSLA_Water Quality_Manager**

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Revision Log

<table>
<tr><td>Revision</td><td colspan="2">1</td><td>Effective Date:</td><td>This version</td></tr>
<tr><td colspan="2">Section</td><td colspan="2">Justification</td><td>Changes</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td>New Procedure</td></tr>
</table>

Reference

1. ASTM Standard D422-63 (Re-approved 2007) “Standard Test Method for Particle-Size Analysis of Soils”, ASTM International, West Conshohocken, PA 2003, DOI: 10.1520/C0033-03, www.astm.org

2. ASTM Standard D2217-8585 (Re-approved 1998) “Standard Practice for Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants”, ASTM International, West

Conshohocken, PA 2003, DOI: 10.1520/C0033-03, www.astm.org

4. ASTM Standard D6913-17 “Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using SieveAnalysis”

5. STM Standard D7928-17 “Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained SoilsUsing the Sedimentation (Hydrometer) Analysis”

6. *Chemical Hygiene Plan*, current version.

Cross Reference

Document	Document Title
S-SS-WI10697	% Moisture Calculation and % Solids Calculation (Gravimetric)
T-WC-FRM46355	D422-Mod Particle Size Distribution / Grain Size Classification
T-WC-WI9901	Equipment Muffle Furnaces and Ovens

Scope

This procedure is applicable to the determination of the distribution of particle sizes in soils and solids. Particle sizes in the range 75 to 0.075 mm are determined by sieving. Distribution of particle sizes smaller than 0.075 mm is determined by a sedimentation process using a hydrometer.

Basic Principles

A portion of sample is soaked in a dispersing agent then partitioned into separate portions: material retained on a #10 sieve and material passing the #10 sieve. The material retained on the #10 sieve is dried to constant weight then passed through a large size sieve stack; the material retained on each sieve is measured and recorded. Material passing the #10 sieve is subject to hydrometer analysis then passed through a small size sieve stack; the material retained on each sieve is measured and recorded. All measurements: large and small sieves and hydrometer readings, and the hygroscopic moisture are used to establish the particle size distribution of the sample.

This SOP is based on the following reference methods: ASTM Standard D2217-8585 (Re-approved 1998), ASTM Standard D422-63 (Re-approved 2007), ASTM Standard D6913-17, and ASTM Standard D7928-17.

NOTE: ASTM D2217 was withdrawn without replacement by ASTM in 2007. A withdrawn standard is an ASTM standard that has been discontinued by the ASTM Sponsoring Committee responsible for the standard.

NOTE: ASTM D422-63 was withdrawn by ASTM in January 2016. Individual methods for gradation by sieve analysis (ASTM D6913-17) and gradation by sedimentation/hydrometer analysis (ASTM D7928-17) were promulgated as replacement approaches. At the time of this writing, ASTM has not yet developed a combined sieve/hydrometer approach. The laboratory’s procedure will utilize elements of these two new methods into a combined approach.

Interferences

Not Applicable.

Safety Precautions and Waste Handling

All laboratory waste is accumulated, managed, and disposed of in accordance with all federal, state, and local laws and regulations.

See *Chemical Hygiene Plan* for general information regarding employee safety, waste management, and pollution prevention.

Personnel Training and Qualifications

All personnel performing this procedure must have documentation of reading, understanding, and agreeing to follow the current version of this SOP and an annual documented Demonstration of Capability (DOC) which is maintained in the analyst's training records.

Initially, each technician performing these techniques must work with an experienced technician for a period of time until they can independently perform the procedure. Analysts are considered proficient when they have successfully demonstrated competency under supervision of a supervisor or other trained analyst, with a documented OJT form.

Sample Collection, Preservation, and Handling

Sample are collected in a glass jar or plastic bag. A minimum of 500g of sample is recommended. There is no holding time for this analysis. Samples are stored at 0 to 6 degrees C; not frozen.

Apparatus and Equipment

1. Top-Loading Balance, capable of weight measurement to 0.01 g
2. Mechanical Stirring Device and Dispersion Cup
3. Thermometer: Accurate to 0.5°C
4. Mortar and Rubber Tipped Pestle
5. Sedimentation Cylinder(s) 1000 mL
6. Hydrometer: ASTM 151H in specification E 100.
7. Sieves, of the following size(s): Gilson Company, Inc. or equivalent
    1. 3.0" (75.00 mm)
    2. 2.0" (50.00 mm)
    3. 1.5" (37.50 mm)
    4. 1.0" (25.00 mm)
    5. 3/4" (19.00 mm)
    6. 3/8" (9.50 mm)
    7. # 4 (4.75 mm)
    8. #10 (2.00 mm)
    9. #20 (850.0 um)
    10. #40 (425 um)
    11. #60 (250.0 um)

    12. #80 (180.0 um)
    13. #100 (150.0 um)
    14. #200 (75.0 um)

8. Drying Oven with temperature range of 60-110°C
9. Stainless Steel Spatulas & Spoons
10. Metal & Bristle Brushes
11. Sieve Shaker
12. Timer

Reagents and Standards

Alternate weights may be used as long as the final concentrations remain the same.

1. Sodium hexametaphosphate solution
    a. Using a 1000-mL volumetric flask, dissolve 40 g of sodium hexametaphosphate in reagent water.
    b. Dilute to final volume once dissolved.
    c. Store at room temperature in a glass or plastic container.
    d. Solution expires one month from date of preparation.

Calibration

Balance calibration must be checked each day before use.

Procedure

A. % Solids Test

Check to be sure that the balance has been calibrated each day before use.

1. Label an aluminum pan with the Lab ID for each sample.

2. Tare the balance. Weigh the aluminum pan and record in spreadsheet *T-WC-FRM46355*.

3. Mix the sample with a stainless steel spatula. Measure at least 10-15 g of each sample into the labeled aluminum pan and record the weight of sample in the spreadsheet.

4. Place the pan and sample in an oven maintained at a temperature of 110°C +/- 5°C and dry the sample for at least 16 hours. Reweigh each pan and record the weight measurement in the spreadsheet.

B. Hydrometer Analysis

Check to be sure that the balance has been calibrated each day before use.

1. Use calculated % Solids from Procedure A. and Table 2 to determine the amount needed for analysis. Add an NCM and contact the PM if there is insufficient sample to perform the test.

2. Using the sample in the 250-mL beaker add 125 mL of sodium hexametaphosphate solution. Stir the soil-water slurry until it is thoroughly moistened. Cover and label beaker with sample number. Allow this slurry to soak for at least 16 hours.

3. At the end of the soaking period, transfer the soil-water slurry into a dispersion cup using room temperature reagent water. Be sure to rinse all residue from the beaker into the dispersion cup.

NOTE: Extra care needs to be taken when rinsing the sample into another container or when using any apparatus. **All particles need to be rinsed into the new container or a loss in sample weight is possible to occur.**

4. Stir for one minute using the stirring apparatus. **Rinse stirring apparatus well into dispersion cup to prevent loss of sample.**

5. Place the #10 sieve in a funnel above a 1000-mL glass sedimentation cylinder. Transfer the soil-water slurry into the cylinder, rinsing well. Add room temperature reagent water until the total volume is 1000 mL.

   a. Label an aluminum pan with the sample ID. Transfer the sample retained on the #10 sieve to the aluminum pan. Place the pan in the oven set to 110°C +/- 5°C and dry the sample for at least 16 hours. Inspect materials in Procedure C.1 and perform Sieve Analysis in procedure C.2.

6. Cover the open end of the cylinder with parafilm, then placing the palm of the hand over the end, invert the cylinder and agitate for a period of one minute. Place the cylinder in a location where it will not be disturbed or moved during the sedimentation readings (for 24 hours). Start a timer.

7. Remove the parafilm and immediately begin the hydrometer readings, recording the temperature reading after each suspension. Record the readings at the following intervals (measured from the beginning of sedimentation): 2, 5,15, 30, 60, 250, and 1440 minutes. Insert the hydrometer about 20 to 25 seconds before the reading is due to the approximate depth. Read the hydrometer from the top of the meniscus to the nearest 0.0005 and enter the reading on the worksheet *T-WC-FRM46355*. Clean the hydrometer before the first reading, and between readings, by placing it into reagent water and twisting with a spinning motion.

NOTE: The hydrometer used in the process will be calibrated on an annually basis by a certified vendor.

8. After hydrometer reading, insert a calibrated thermometer into the cylinder to the same depth as the hydrometer reading. Read the temperature to the nearest 0.5°C and enter the temperature measurement on the worksheet. Rinse the temperature probe in the hydrometer rinse bath.

9. After hydrometer analysis, proceed to Small Sieve Analysis in Procedure C.3.

C. Sieve Procedure

1. Inspect the sample material in the aluminum pan and record a description of the non-soil material (e.g.- sticks, grass, wood, plastic), hardness of material, and shape of material in the worksheet. Hardness qualifiers include hard, soft, and brittle. Shape qualifiers include well-rounded, rounded, subrounded, subangular, and angular.

2. Sieve Analysis

   a. Weigh the 3/4”, 3/8”, #4 and #10 sieves and enter the weight measurements in the worksheet as the tare weight.

   b. Stack the sieves and then transfer the sample material from the aluminum dish to the sieve stack. If the sample material is less than 30 g, manually shake the sieve stack for 2 minutes. If the sample material is greater than 30 g, place the sieve stack into the Ro-tap machine and shake the sieve stack for 10 minutes.

c. Weigh each sieve and record these measurements in the worksheet.

3. Small Sieve Analysis

a. Quantitatively transfer the sample from the graduated cylinder to a #200 wet wash sieve. Ensure the entire sample has been transferred to the #200 wet wash sieve by rinsing the graduated cylinder several time with reagent water. Using reagent water, wash the sample through the #200 sieve until the water runs clear, then transfer the material retained on the sieve into a 250-mL glass beaker labeled with the sample ID.

b. Place the beaker in the drying oven and dry at a temperature of 110ºC for at least 16 hours. After 16 hours, remove the beaker from the oven and allow it to cool.

c. Gently mix the dried contents of the beaker with a rubber-tipped pestle to break up any soil aggregates that may have formed during the drying stage.

d. Tare the balance and weigh the sieve stack sized between #20 and #200 and record the tare weights.

e. Transfer the sample to the sieve stack and ensure complete transfer. Use hair or wire brushes to clean the beaker. Place the sieve stack on the RoTap machine and shake for ten minutes.

f. Weigh each sieve and record these measurements in the worksheet.

Calculations

A. Sample Used (SU): Dry Preparation

SU = (pan+ dry sample - pan) - (pan + non- soil material - pan) x HMCF

Where:
HMCF = Hygroscopic moisture correction factor.

B. Sieve Analysis (Percent Finer = PF)

Large Sieves:

3 inch: PF = 100-100* (Sieve and Sample (3 inch) - Sieve (3 inch))/SU

2 inch: PF = PF (3 inch) - 100*(Sieve and Sample (2 inch) - Sieve (2 inch))/SU

and so on through the #10 Sieve.

Small Sieves:

#20: PF = PF(#10) - 100*(mass passing #10/sample mass (Hyd))*(sieve and sample (#20) - sieve(#20))/sample used

#40: PF = PF (#20) - 100*(mass passing #10/sample mass (Hyd))*(sieve and sample (#40) - sieve (#40))/sample used and so on up through #10 sieve.

B. Hydrometer Analysis

Particle size, Micron

1000*sqrt [930*viscosity/980*(SG-1))*(effective depth/time)]

Viscosity at sample temperature, poises

Effective Depth, cm = 16.29-264.5*(actual Hydrometer reading - 1) above equation for effective depth based on equation found with table 2 in method, in which 16.29 = 0.5*(14.0-67.0/27.8)+10.5 and 264.5 = (10.5-2.3)/0.031

Time, minutes = Time of hydrometer reading from beginning of sedimentation

Sqrt - square root

SG - Specific Gravity of soil

Viscosity - is the resistance of a liquid to flow

C. Percent Finer (PF):

PF = Constant*(actual hydrometer reading - hydrometer correction factor - 1)

Where:

Constant = (100,000/W)*SG/(SG-1)

W = (Total sample used *sample used for hydrometer analysis*HMCF)/Amount of total sample passing #10 sieve

Hydrometer Correction = slope*sample temperature + Intercept

Slope = ((low temp. reading -1)-(high temp. reading -1)/(low temp. - high temp.))

Intercept = (low temp. reading -1) - (low temp. * slope)

Statistical Information/Method Performance

Not applicable to this procedure

Quality Assurance/Quality Control

When possible, perform duplicate analyses for particle size on a routine basis.

Batch size is limited to 20 samples or less.

Table 1 - Hydrometer Reading Table (For up to 12 Sedimentation Cylinders)

Table 1: Hydrometer Reading Table (For up to 12 Sedimentation Cylinders)

Elapsed Time (hr:min)	Task	Cyl. No.	Actual Time (min)	Elapsed Time (hr:min)	Task	Cyl. No.	Actual Time (min)
0:00	Shake	1		1:01	Read	10	5
0:01	**Place**	**1**		**1:02**	Shake	11	
0:01	**Shake**	**2**		**1:03**	Place	11	
0:02	Place	2		1:04	Read	9	15
0:03	Read	1	2	1:05	Read	11	2
0:04	Read	2	2	1:06	Read	7	31
0:06	Read	1	5	1:07	Read	3	58
0:07	Read	2	5	1:08	Read	11	5
0:08	Shake	3		**1:09**	Shake	12	
0:09	Place	3		**1:10**	Place	12	
0:09	**Shake**	**4**		1:11	Read	10	15
0:10	Place	4		1:12	Read	12	2
0:11	Read	3	2	1:13	Read	4	63
0:12	Read	4	2	1:14	Read	8	32
0:14	Read	3	5	1:15	Read	12	5
0:15	Read	4	5	1:18	Read	11	15
0:16	Read	1	15	1:19	Read	9	30
0:17	Read	2	15	1:21	Read	5	60
0:20	Shake	5		1:25	Read	12	15
0:21	Place	5		1:26	Read	10	30
0:23	Read	5	2	1:27	Read	6	59
0:24	Read	3	15	1:33	Read	11	30
0:25	Read	4	15	1:34	Read	7	59
0:26	Read	5	5	1:41	Read	12	31
0:27	Shake	6		1:42	Read	8	60
0:28	Place	6		1:52	Read	9	63
0:30	Read	6	2	1:53	Read	10	57
0:31	Read	1	30	2:06	Read	11	63
0:32	Read	2	30	2:07	Read	12	57
0:33	Read	6	5	4:17	Read	1	256
0:34	Shake	7		4:18	Read	2	256
0:35	Place	7		4:19	Read	3	250
0:36	Read	5	15	4:20	Read	4	250
0:37	Read	7	2	4:21	Read	5	240
0:38	Read	3	29	4:22	Read	6	234
0:39	Read	4	29	5:00	Read	7	265
0:40	Read	7	5	5:01	Read	8	259
0:41	Shake	8		5:02	Read	9	253
0:42	Place	8		5:03	Read	10	247
0:43	Read	6	15	5:04	Read	11	241
0:44	Read	8	2	5:05	Read	12	235
0:47	Read	8	5	24:01	Read	1	1440
0:48	Shake	9		24:02	Read	2	1440
0:49	Place	9		24:03	Read	3	1434
0:50	Read	7	15	24:04	Read	4	1434
0:51	Read	9	2	24:05	Read	5	1424
0:52	Read	5	31	24:06	Read	6	1418
0:54	Read	9	5	24:07	Read	7	1412
0:55	Shake	10		24:08	Read	8	1406
0:56	Place	10		24:09	Read	9	1400
0:57	Read	8	15	24:10	Read	10	1394
0:58	Read	10	2	24:11	Read	11	1388
0:59	Read	6	31	24:12	Read	12	1382
1:00	**Read**	**1**	**59**				
1:00	**Read**	**2**	**58**				

Table 2 - Percent Solids Table for Weight Determination for D422

% solids	Specific Gravity	Silt/Clay	Silt/Sand	Sand	Sand/Gravel
1	2500	5000	7500	10000	20000
2	1250	2500	3750	5000	10000
3	833	1667	2500	3333	6667
4	625	1250	1875	2500	5000
5	500	1000	1500	2000	4000
6	417	833	1250	1667	3333
7	357	714	1071	1429	2857
8	313	625	938	1250	2500
9	278	556	833	1111	2222
10	250	500	750	1000	2000
11	227	455	682	909	1818
12	208	417	625	833	1667
13	192	385	577	769	1538
14	179	357	536	714	1429
15	167	333	500	667	1333
16	156	313	469	625	1250
17	147	294	441	588	1176
18	139	278	417	556	1111
19	132	263	395	526	1053
20	125	250	375	500	1000
21	119	238	357	476	952
22	114	227	341	455	909
23	109	217	326	435	870
24	104	208	313	417	833
25	100	200	300	400	800
26	96	192	288	385	769
27	93	185	278	370	741
28	89	179	268	357	714
29	86	172	259	345	690
30	83	167	250	333	667
31	81	161	242	323	645
32	78	156	234	313	625
33	76	152	227	303	606
34	74	147	221	294	588
35	71	143	214	286	571
36	69	139	208	278	556
37	68	135	203	270	541
38	66	132	197	263	526
39	64	128	192	256	513
40	63	135	188	250	500
41	61	122	183	244	488
42	60	119	179	238	476
43	58	116	174	233	465
44	57	114	170	227	466
45	56	111	167	222	444
46	54	109	163	217	435

47	53	106	160	213	426
48	52	104	156	208	417
49	51	102	153	204	408
50	50	100	150	200	400
51	49	98	147	196	392
52	48	96	144	192	385
53	47	94	142	189	377
54	46	93	139	185	370
55	45	91	136	182	364
56	45	89	134	179	357
57	44	88	132	175	351
58	43	86	129	172	345
59	42	85	127	169	339
60	42	83	125	167	333
61	41	82	123	164	328
62	40	81	121	161	323
63	40	79	119	159	317
64	39	78	117	156	313
65	38	77	115	154	308
66	38	76	114	152	303
67	37	75	112	149	299
68	37	74	110	147	294
69	36	72	109	145	290
70	36	71	107	143	286
71	35	70	106	141	282
72	35	69	104	139	278
73	34	68	103	137	274
74	34	68	101	135	270
75	33	67	100	133	267
76	33	66	99	132	263
77	32	65	97	130	260
78	32	64	96	128	256
79	32	63	95	127	253
80	31	63	94	125	250
81	31	62	93	123	247
82	30	61	91	122	244
83	30	60	90	120	241
84	30	60	89	119	238
85	29	59	88	118	235
86	29	58	87	116	233
87	29	57	86	115	230
88	28	57	85	114	227
89	28	56	84	112	225
90	28	56	83	111	222
91	27	55	82	110	220
92	27	54	82	109	217
93	27	54	81	108	215
94	27	53	80	106	213
95	26	53	79	105	211

96	26	52	78	104	208
97	26	52	77	103	206
98	26	51	77	102	204
99	25	51	76	101	202
100	25	50	75	100	200

Use the attachment of Table 2 to determine the amount of sample to use in Procedure B.1.

Attachment:
Table 2 - Percent Solids Table for Weight Determination for D422 (.xls)

QA-SOP11188 Reagents and Standards
QA-SOP11880 Laboratory Equipment Verifications - Balance, Syringe, Pipette, Weights, and Other Equipment
S-SS-WI10697 % Moisture Calculation and % Solids Calculation (Gravimetric)
T-WC-FRM46355 D422-Mod Particle Size Distribution / Grain Size Classification
T-WC-WI9901 Equipment Muffle Furnaces and Ovens

End of document

Version history

Version	Approval	Revision information	
1	11.NOV.2021		

eurofins	Always check on-line for validity.	Level:
Document number: **T-IWC-WI11627**	**TOC and TC in Solids and Sludges by Combustion by SW-846 9060/9060A, Lloyd Kahn**	**Work Instruction**
Old Reference: **1-P-QM-WI-9013418**		
Version: **18**		Organisation level: **5-Sub-BU**
Approved by: **X6TJ** Effective Date: **04-NOV-2022**	Document users: **6_EUUSLA_ Instrumental Water Quality _TOC Analyst, 6_EUUSLA_ Instrumental Water Quality _TOC Verifier**	Responsible: **5_EUUSLA_Instrumental Water Quality_Manager**

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Revision Log

Revision: 18	**Effective Date:**	This version
Section	**Justification**	**Changes**
Revision Log	Formatting requirement	Removed revision logs up to the previous version.
Basic Principles	Updated	Changed Temperature and wording
Reference Modifications	Process correction	Added modifications to 9060
Personnel Training and Qualifications	Enhancement	IDOC and DOC requirements added
Calibration	Regulatory Requirement	Added relative error requirements

Revision: 18	**Effective Date:**	This version
Throughout Document	Current Process	Changed wording to match standards names

Revision: 17.1	**Effective Date:**	
Section	**Justification**	**Changes**
Revision Log	Formatting requirement	Removed revision logs up to the previous version.
Throughout Document	Updated methods	Removed all references to SM5310B
Reference Modifications	Process correction	Added modifications to 9060
Throughout Document	Current Process	Changed wording to match standards used and CRM acceptance windows

Reference

1. Standard Methods for the Examination of Water and Wastewater, 21st Edition, 2005, Method 5310B-2011,

2. Standard Methods for the Examination of Water and Wastewater, Method 5310B-2014.

3. *Method 415.1, Methods for Chemical Analysis of Water and Wastes USEPA 600.*

4. *Test Methods for Evaluating Solid Wastes, SW-846 Method 9060, September 1986.*

5. Test Methods for Evaluating Solid Wastes, SW-846 Method 9060A, November 2004

6. *The Primacs SNC-100 Analyzer Manual*, Skalar..

7. *Determination of Total Organic Carbon in Sediment, U. S. EPA, Region II, July 27, 1988. ("Lloyd Kahn Method.").*

8. *Chemical Hygiene Plan*, current version.

Cross Reference

Document	Document Title
QA-SOP11892	Determining Method Detection Limits and Limits of Quantitation
QA-SOP11896	Establishing Control Limits
QA-SOP11188	Reagents and Standards

Scope

This method is applicable for the determination of total organic carbon (TOC) in soils and other samples not easily analyzed by the TOC waters method. The limit of quantitation (LOQ) for this method can be found in the analysis information file. Quantitative TOC results up to 1,000,000 mg/kg may be obtained by this method.

Basic Principles

TOC is determined by acidifying a sample and heating it to remove the TIC. An aliquot of sample (1 mg to 1 g) is weighed into a sample cup. The sample is then heated to 1100°C for combustion of the remaining TOC. The resulting carbon dioxide from the TOC is detected by a nondispersive infrared (NDIR) detector that has been calibrated to directly display the mass of carbon dioxide detected. The mass is proportional to the mass of TOC in the sample. Samples analyzed by this method include solids such as soils or sediments, slurries, sludges, brines, and corrosives.

The TC method is identical to the TOC method, with the exception that there is not an acidification and heating step to remove the TIC.

TIC is the calculation subtracting the TOC soil result from the result obtained when analyzing the TC.

Reference Modifications

The calibration standards, QC standards, and LCS employed for this analysis are composed of only organic sources of carbon (Sucrose for the calibration and a purchased standard for the LCS and CCV standards). Therefore, the Total Organic Carbon content is equal to the Total Carbon content in these standards.

Method SW-846 9060 is a quadruplicate analysis that is designed for water analysis, the lab does not run the solids in quadruplicate the analysis runs a single injection of all samples.

Interferences

Carbon is ubiquitous in nature. Therefore, extra care must be taken to avoid contamination of reagents, glassware, and any other materials that come in contact with the sample. Samples which are light in weight may need to be analyzed at smaller aliquots to fit within a sample cup. These samples are reported with an elevated LOQ.

Safety Precautions and Waste Handling

All laboratory waste is accumulated, managed, and disposed of in accordance with all federal, state, and local laws and regulations.

1. Normal laboratory practices for safety must be followed.

2. Extreme caution must be used when handling sample cups after they have been analyzed.

3. Discard acid waste in acid waste containers.

4. See *Chemical Hygiene Plan* for general information regarding employee safety, waste management, and pollution prevention.

Personnel Training and Qualifications

All personnel performing this procedure must have documentation of reading, understanding, and agreeing to follow the current version of this SOP and an annual documented Demonstration of Capability (DOC) which is maintained in the analyst’s training records.

Initially, each technician performing these techniques must work with an experienced technician for a period of time until they can independently perform the procedure. Proficiency is measured through an Initial Demonstration of Capability (IDOC).

The IDOC consists of four aliquots spiked with sucrose at 1-4X the RL that are carried through all steps of the procedure and meet the defined acceptance criteria. The criteria include the calculation of mean accuracy of 50-150%, and relative standard deviation of less than or equal to 20%.

The DOC consists of four laboratory control samples (or alternatively, one blind sample) that are carried through all steps of the procedure. The DOC includes calculation of mean accuracy and standard deviation. The mean accuracy criteria are the LCS windows. The RSD criteria is 20%.

Sample Collection, Preservation, and Handling

Samples must be collected and stored in glass containers unpreserved. Samples must be stored under refrigeration at 0° to 6°C, not frozen.

Because very small amounts (1 mg to 1 g) of sample are used for the analysis, the sample must be as homogeneous as possible.

The holding time for analysis by SW-846 9060/9060A is 28 days. The holding time for analysis by the Lloyd Kahn method is 14 days.

Apparatus and Equipment

1. Skalar-Primacs SC100

2. PC and SNAccess software

3. 2-stage gas regulator (two required)

4. Sample cups

5. Fiber quartz wool

6. Analytical balance, capable of accurately weighing to 1. mg

7. Glassware – General laboratory glassware as needed for preparing reagents and standards

8. Microliter syringe, various volumes

Reagents and Standards

NOTE: All chemical used must be ACS reagent grade unless otherwise noted.
Different volumes or weights may be used provided the ratios remain equivalent.
See *QA-SOP11188*, for the appropriate labeling and documentation of reagent and standard preparation.

1. Ultra pure oxygen gas (60 psi)

2. 1+1 Phosphoric acid (WC_TOC_1:1PA)

Phosphoric acid (H3PO4)	50 mL
Reagent water	50 mL

Take 50 mL of H3PO4 and add slowly while swirling to a 100-mL volumetric flask containing 50 mL reagent water. Store at room temperature. Prepare fresh every 6 months.

5. TOC stock calibration standard (sucrose containing 30% carbon) (WC_TOC_30%SUC), purchased. See label for expiration date. Store at room temperature.

6. TOC LCS standard, purchased (WC_TOC_SLCSCC). See label for expiration date, and the certified concentration. Store at room temperature.

Sample Cup Preparation

Sample cups must be conditioned prior to analysis. This is achieved by heating the cups to at least 900°C for a period of 5 minutes.

Calibration

1. Working standards for calibration

Pipette a volume of the Sucrose calibration standard into the sample cups as follows:

Working Std. (mg C)	Vol. Sucrose (µL)
0.30	1.0
0.90	3.0
3.0	10.0
6.0	20.0

2. Continuing calibration verification standard (CCV)

This is a purchased standard, and the acceptable range is specified by the manufacturer.

Procedure

1. Turn on oxygen to 60 psig.

2. Measure the carrier gas (oxygen) flow rate and adjust to 200 mL/min.

3. Power up instrument.

4. Program in a sequence file.

5. Run the calibration sequence as follows: 0.30, 0.90, 3.0, and 6.0 mg C (Performed monthly).

6. The instrument automatically calculates the R and list the calibration data.

7. Samples are analyzed along with the appropriate laboratory control standard and preparation blank. A check standard (CCV) and a continuing calibration blank (CCB) must be run at the beginning of each run and after every ten samples.

8. Add sufficient glass wool to each cup to cover the bottom surface.

9. Weigh samples into sample cups (up to 1000 mg). Add 1+1 H_3PO_4 drop wise until effervescence stops. Heat at 75°C for 15 minutes. Record the oven ID, time and temperature of this step in the log book.

NOTE: This procedure will convert inorganic carbonates and bicarbonates to carbon dioxide and eliminate it from the sample. The addition of H_3PO_4 and the heating to 75°C is not performed for samples requesting Total Carbon analysis.

10. Analyze the residue according to the instrument manufacturer’s instructions for the remaining TOC result.

Calculations

1. To determine mg/kg TOC or TC

   mg/kg = (Raw result in mg C) x (1000/weight in mg) x (1000)

2. To determine LOQ/MDL factors

$$Factor = \frac{Maximum\ sample\ aliquot\ weight\ (1000.mg)}{weight\ of\ sample\ (mg)}$$

3. To determine Total Inorganic Carbon (TIC)

   TIC = Total Carbon (TC) - Total Organic Carbon (TOC)

4. Relative Error

   % Relative Error = $[(x'_i - x_i) / x_i]*100$

   where:
   x_i = True value for the calibrated standard
   x'_i = Measured concentration of the calibration standard

Statistical Information/Method Performance

1. The method detection limit (MDL) is determined annually by following the procedure outlined in *QA-SOP11892*.

2. The quality control acceptance windows are based off the manufacture data. The lab evaluates these windows per CRM received.

Quality Assurance/Quality Control

1. A calibration must be performed every 30 days. The acceptable range for the calibration is R = 0.995 or greater. Calculate the relative error (%RE) of the lowpoint and midpoint calibration standard. The low point must be less than or equal to 30% and the mid point must be less than or equal to 10%. If this criteria is not met, the instrument must be recalibrated.

2. A batch must contain no more than 20 field samples.

3. A batch blank (MB) must be analyzed with every batch (not to exceed 20 samples). An acceptable result is < the limit of quantitation. If the MB does not meet this criterion, it must be rerun twice. If either of the two additional trials do not meet the acceptance criterion, all samples in the batch must be repeated.

4. A laboratory control standard (LCS) must be analyzed with every batch (not to exceed 20 field samples). For TOC this is a purchased standard and the acceptable range is specified by the manufacturer. The LCS should undergo the same steps as the samples. If the LCS does not meet the acceptable criterion, it must be repeated twice. If either of the two additional trials do not meet the acceptance criterion, all samples in the batch must be reanalyzed.

5. Based upon client requirements, a laboratory control standard duplicate (LCSD) may need prepared and analyzed under the same conditions as the LCS. The acceptance criterion for the LCSD is the same as that of the LCS. The relative percent difference between the LCS and the LCSD is calculated statistically.

6. Lloyd Kahn - one sample is analyzed in quadruplicate every batch. The acceptable relative percent difference is statistically determined. The duplicate relative percent differences must be tracked to continually monitor method performance.

7. 9060- A matrix spike (MS) and matrix spike duplicate (MSD)must be analyzed for every 20 samples. The sample is spiked with 3 ul of the Sucrose standard. The acceptance range is determined statistically. The spike recoveries must be tracked to continually monitor method performance.

8. A check standard (CCV) and blank (CCB) must be run after every ten injections (including blanks and standards). The acceptable range for the CCV determined by the manufacturer. An acceptable CCB result is < the limit of quantitation. If either, or both, of these injections do not meet the acceptance criterion, the unacceptable original must be repeated twice. If either of the two additional trials do not meet the acceptance criterion, all samples since the last compliant CCV/CCB must be reanalyzed.

9. A CCV and CCB shall be analyzed at the beginning and the end of each run. At any time when the instrument has been idle for a period of 4 hours or more, a CCV and CCB must be analyzed. If either of these parameters cannot meet specifications, the instrument must be recalibrated.

QA-SOP11188 Reagents and Standards
QA-SOP11892 Determining Method Detection Limits and Limits of Quantitation
QA-SOP11896 Establishing Control Limits

End of document

Version history

Version	Approval	Revision information
17	03.JUL.2019	
17.1	22.JUN.2021	
18	04.NOV.2022	

Appendix B

Phase I Area 1 Preliminary Site Characterization Summary

AREA 1 PRELIMINARY SITE CHARACTERIZATION SUMMARY
PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS) REMEDIAL INVESTIGATION

FORMER FORT DEVENS ARMY INSTALLATION, DEVENS, MA

JUNE 2020

Prepared for:
U.S. Army Corps of Engineers
New England District
Concord, Massachusetts

Prepared by:
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Contract No.: W912WJ-18-C-0011

NOTICE

The United States Department of Defense, Department of Army, funded wholly or in part the preparation of this document and work described herein under Contract No. W912WJ-18-C-0011. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Area 1 Preliminary Site Characterization Summary
Per- and Polyfluoroalkyl Substances (PFAS) Remedial Investigation
Former Fort Devens Army Installation
Devens, Massachusetts

June 2020

CERTIFICATION:

I hereby certify that the enclosed Report, shown and marked in this submittal, is that proposed to be incorporated with Contract Number W912WJ-18-C-0011. This document was prepared in accordance with the U.S. Army Corps of Engineers (USACE) Scope of Work and is hereby submitted for Government approval.

Reviewed By:

06/03/2020

KGS Project Manager **Date**

Received By:

REDDY.PENELOPE.W.1502105066 Digitally signed by REDDY.PENELOPE.W.1502105066
Date: 2020.06.03 09:43:06 -04'00'

USACE Project Manager **Date**

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ACRONYMS AND ABBREVIATIONS

ABB	ABB Environmental Services, Inc.
AFFF	aqueous film forming foam
AOC	area of contamination
Army	U.S. Army
BERS-Weston	BERS-Weston Services JVA, LLC
bgs	below ground surface
BRAC	Base Realignment and Closure
BTEX	benzene, toluene, ethylbenzene, and xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSMS	Consolidated Support Maintenance Shop
DPT	direct push technology
DRFTA	Devens Reserve Forces Training Area
DQO	data quality objectives
E&E	Ecology and Environment, Inc.
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Differences
FOSET	Finding of Suitability for Early Transfer
FS	Feasibility Study
FSP	field sampling plan
ft	feet
GAC	Granular Activated Carbon
GERE	Grant of Environmental Restriction and Easement
gpm	gallons per minute
GW-1	Massachusetts Contingency Plan Method 1 Groundwater
HLA	Harding Lawson Associates
H&S	H&S Environmental, Inc.
J	estimated result
KGS	KOMAN Government Solutions, LLC
LHA	lifetime health advisory
LTM	long-term monitoring
MAARNG	Massachusetts Army National Guard
MassDEP	Massachusetts Department of Environmental Protection
MassDevelopment	Massachusetts Development and Finance Agency
MCP	Massachusetts Contingency Plan
MNA	monitored natural attenuation
NAVD88	North America Vertical Datum 1988
ng/L	nanograms per liter
PA	Preliminary Assessment
PCB	polychlorinated biphenyls
PFDA	perfluorodecanoic acid
PFAS	per- and polyfluoroalkyl substances
PFHpA	perfluoroheptanoic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluoronanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PSCS	preliminary site characterization summary
RI	Remedial Investigation
ROD	Record of Decision

SA	Study Area
SSSL	site-specific screening level
S&W	Stone and Webster Environmental Technology and Services
S-1	MCP Method 1 S-1 Soil Category
TCRA	time-critical removal action
TOP	total oxidizable precursor
μg/kg	micrograms per kilogram
USACE	U.S. Army Corps of Engineers
UST	underground storage tank

1.0 INTRODUCTION

KOMAN Government Solutions, LLC (KGS), on behalf of the U.S. Army Corps of Engineers (USACE) New England District, has prepared this Preliminary Site Characterization Summary (PSCS) for the Per- and Polyfluoroalkyl Substances (together, "PFAS") Remedial Investigation (RI) at the former Fort Devens Army Installation (Devens) located in Devens, Massachusetts.

The PSCS summarizes data that have been collected at numerous Areas of Contamination (AOC) identified in the *Draft Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018a) and as shown on Figure 1-1.

To expedite the field investigations, the identified AOCs, Grove Pond wellfield, and MacPherson, Patton, and Shabokin water supply well areas were grouped into three areas (Areas 1, 2, and 3). This PSCS addresses Area 1 and part of Area 2 as indicated below. Future PSCS submittals will include the remainder of Area 2 and Area 3.

Area 1:

- AOC 57 Building 3713 Fuel Oil Spill Site;
- AOC 74 Barnum Road Firefighting Exercise Site;
- AOC 75 Former Building T-1445 Warehouse Fire; and,
- Grove Pond wellfield.

Area 2 (partial):

- AOC 40 Cold Spring Brook Landfill;
- AOC 43G Historical Gas Station G;
- AOC 43J Historical Gas Station J;
- Patton water supply well; and,
- Shabokin water supply well.

The PSCS is a summary of site data following completion of the initial field sampling and analysis (EPA, 1988). The intent is to better understand and assess any potential data gaps remaining at the AOCs, and determine additional data gathering activities. The U.S. Army (Army) will prepare a bulleted list of data gaps following discussions at the Base Cleanup Team (BCT) meetings, which will be used to develop specific Data Quality Objectives (DQO) for the development of an RI Addendum work plan.

1.1 Investigation Approach

The initial field activities for the RI were detailed in the *Draft Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018a), the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b), and the *Area 2 Field Sampling Plan (FSP) Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018c). The initial activities were planned based on results from the *Final Base-Wide Preliminary Assessment for Evaluation of Perfluoroalkyl Substances* (KGS, 2017), the *Site Inspection (SI) Addendum for Additional Per- and Polyfluoroalkyl Substances (PFAS) Sampling at Area of Contamination (AOC) 76-Devens Fire Department and Long Term Monitoring (LTM) Wells at AOCs 57, 43G, 43J, 32, 43A, 50 and Shepley's Hill Landfill (SHL) Former Fort Devens Army Installation Devens, Massachusetts* (BERS-Weston, 2018a), and the *Final Site Inspection Report for Per- and Polyfluoroalkyl Substances (PFAS) at Former Fort Devens Army Installation, Devens, MA* (BERS-Weston, 2018b). Knowledge of the sites through previous investigations, operation and maintenance activities, and long-term monitoring activities, which included various groundwater models were also used to plan field activities.

The field work was conducted in an iterative manner. The field work commenced with the work detailed in the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b). While executing the field work, analytical data from sampling of existing monitoring wells, groundwater vertical profiling, soil sampling, and surface water and sediment sampling was shared with U.S. Environmental Protection Agency (EPA) and Massachusetts Department of Environmental Protection (MassDEP) as it was received from the laboratory. The results were discussed with EPA and MassDEP and additional activities, not detailed in the FSP, needed to achieve the study goals and DQOs were recommended. The recommendations were developed based on review of the analytical data and understanding of groundwater flow direction based on analysis of field data or review of information from previous field investigations or groundwater flow models. Additional activities included additional vertical profiles, additional soil borings, additional surface water and sediment sampling, sampling of additional existing monitoring wells, installation of piezometers, synoptic water level surveys, and selection of samples to be analyzed for total oxidizable precursor (TOP) assay. As additional results were received and reviewed, further work was conducted, which sometimes resulted in numerous phases of field activities at different AOCs. The field work at each AOC is discussed in subsequent sections.

Review of the data was also used to develop addendums to the FSPs. The *Final Area 2 Field Sampling Plan Area of Contamination 40 Addendum* (KGS, 2020a) details activities at AOC 40. The *Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS) Area 1 Field Sampling Plan Addendum No. 2* (KGS, 2020b) details activities in Cold Spring Brook. The *Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances* and the *Area 1 Field Sampling Plan – Monitoring Well Plan Addendum Remedial Investigation Work Plan for PFAS* (KGS, 2019b) details additional drilling activities at the Area 1 AOCs using a variety of drilling techniques (sonic, drive and wash, and direct push technology), specific activities included: 1) overburden and bedrock groundwater monitoring well installation; 2) piezometer installation; 3) groundwater vertical profiling using direct push technology, 4) deep groundwater vertical profiling; 5) soil core collection for field lithologic classification (with grain size and total organic carbon sample collection), and 6) confirmation of bedrock.

After existing monitoring wells were sampled in Area 1 and Area 2, additional sampling of existing monitoring wells was detailed in the *Work Plan for Additional Sampling of Existing Wells to Support the PFAS Remedial Investigation Former Fort Devens Army Installation, Devens, MA* (KGS, 2019c). This supplemental sampling of existing monitoring wells is intended to provide additional data regarding the nature and extent of PFAS at these sites for the RI and can be used to support evaluation of trends in PFAS concentrations in groundwater over time.

There were minor deviations to the FSPs and FSP addendums related to locations of drilling activities, additions and deletions of locations, or activities at specific locations. As is typical with field investigations, some locations were adjusted based on field conditions (e.g., steep terrain, proximity to wetlands, safety considerations). None of the adjustments to the locations negatively impacted meeting the DQOs. There were no major deviations to the methods detailed in the work plan, FSPs, and FSP addendums.

1.2 Report Organization

The site characteristics, general geology, and regional hydrogeology at former Fort Devens are described in Section 2. The results of synoptic water level events conducted in the areas addressed in this report are reported in Section 2 and site-specific groundwater flow conditions are described in the subsequent site-specific sections. Sections 3 through 9 each address a specific area of investigation listed above. The PFAS results related to each area of investigation are discussed in the applicable section. The PFAS results in various media are described in each applicable section with respect to the media-specific criteria (Table 1-1). The field sheets, soil boring logs, well construction logs, and results are presented in appendices.

2.0 FORMER FORT DEVENS SITE LOCATION AND DESCRIPTION

Devens is located in the towns of Ayer and Shirley in Middlesex County, and the towns of Harvard and Lancaster in Worcester County, Massachusetts, approximately 35 miles northwest of Boston, Massachusetts. The installation occupied approximately 9,260 acres. Fort Devens was divided into the North Post, Main Post, and South Post. Route 2 divides the South Post from the Main Post. The Nashua River runs through the North, Main, and South Posts. The area surrounding Devens is primarily comprises rural residential properties. Portions of Devens have been redeveloped for commercial/industrial use.

Camp Devens was established in 1917 as a temporary training area for soldiers during World War I. In 1932, the site was named Fort Devens and made a permanent installation with the primary mission of commanding, training, and providing logistical support for non-divisional troop units. Fort Devens was used for a variety of training missions between 1917 and 1990. Pursuant to the CERCLA, Fort Devens was placed on the National Priorities List on November 21, 1989, due to environmental contamination at several sites.

Fort Devens was identified for cessation of operations and closure under Public Law 101-510, the Defense Base Realignment and Closure (BRAC) Act of 1990, and officially closed in March 1996. As part of the Devens BRAC program, portions of the property formerly occupied by Devens were retained by the U.S. Army for reserve forces training and renamed the Devens Reserve Forces Training Area (DRFTA). Areas not retained as part of the DRFTA were transferred to new owners, the Massachusetts Development and Finance Agency (MassDevelopment), U.S. Department of Labor, U.S. Department of Justice, and the U.S. Fish and Wildlife Service, for reuse and redevelopment. In 2009, the DRFTA was renamed the U.S. Army Garrison Fort Devens.

2.1 Physical Characteristics

Devens lies within the Nashua River basin. The Nashua River flows north through the former North, Main, and South Posts (Figures 2-1 and 2-2). The Nashua River forms the western installation boundary on the former Main Post. Other notable surface water features include: Grove Pond located north of the Grove Pond wellfield, Plow Shop Pond located west of Grove Pond, Nonacoicus Brook flowing from Plow Shop Pond to the Nashua River, Cold Spring Brook located east of AOCs 57, 74, and 75, an unnamed stream located east of AOC 43G, Robbins Pond located east of AOC 43G, Willow Brook flowing north from Robbins Pond to Nonacoicus Brook, Cold Spring Brook Pond (AOC 40), and Mirror Lake and Little Mirror Lake located between Patton and Shabokin wells. The specific surface water bodies and their relations to specific areas of investigation are discussed in applicable sections.

The geography of Devens is characterized by undulating glacial terrain. The landforms are products of glacial erosion and deposition on a crystalline bedrock terrain. Terrain at Devens falls generally into three types. The least common is bedrock terrain, where rocks that have been resistant to both glacial and fluvial erosion remain as topographic highs, sometimes thinly veneered by glacial deposits. A more common terrain at Devens consists of tills deposited by glaciers. These landforms often conform to the shape of the underlying bedrock surface. They range from areas of comparatively low topographic relief to elongated hills (drumlins) [Harding Lawson Associates (HLA), 2000].

The most common terrain at Devens was formed by sediment accumulations in glacial-meltwater streams and lakes (glaciofluvial and glaciolacustrine deposits). Other prominent glacial meltwater features are kame and kettle topography present on the former Main Post near Mirror Lake and Little Mirror Lake located between the Patton and Shabokin wells.

2.2 Geology

The major glacial units consist of till, deltaic deposits from former glacial Lake Nashua, and deposits from glacial meltwater streams (Figure 2-3). Glacial till at Devens consists of unstratified gravel to silt and typically contains boulders. The till at the site is typically approximately 10 feet thick but is up to 60 feet thick in the cores of drumlins. The glacial lake deposits consist chiefly of sand and gravelly sand. Lake bottom deposits consist of sand, silt, and clay. Post-glacial deposits consist of river terrace sands and gravels, fine alluvial sands and silts, as well as peat and silt and sands in swampy areas. Generalized surficial geology by AOC is described below and is based on the Geologic Map of the Ayer Quadrangle, Massachusetts, Surficial Geology (Jahns, 1953).

- AOC 57 and 75 – Primarily coarse terrace deposits, chiefly kame terraces, with some shore and near-shore deposits of Glacial Lake Nashua along the edge of Cold Spring Brook and swamp deposits, chiefly muck and peat in Cold Spring Brook.
- AOC 74 – Similar to AOCs 57 and 75, but generally missing the shore and near-shore deposits of Glacial Lake Nashua.
- Grove Pond Area - Primarily coarse terrace deposits, with lesser amounts of kame deposits and shore and near-shore deposits of Glacial Lake Nashua along the shoreline of Grove Pond.
- AOC 40 – Primarily coarse kame-plain or ice-contact plain deposits, with some kame deposits, shore and near-shore deposits of Glacial Lake Nashua, and swamp deposits (chiefly muck and peat).
- AOC 43G – Mix of coarse kame deposits, terrace and delta-outwash plain deposits, bottom sands and clays of Glacial Lake Nashua, and artificial fill.
- AOC 43J – Primarily coarse terrace and delta-outwash plain deposits, and kame deposits, with some shore and near-shore deposits of Glacial Lake Nashua, as well as bottom sands and clays of Glacial Lake Nashua.
- Patton Well Area – Primarily coarse kame, kame-plain, or ice-contact plain deposits, with some swamp deposits (chiefly muck and peat), shore and near-shore deposits of Glacial Lake Nashua, and terrace deposits.
- Shabokin Well Area - Primarily kame-plain or ice-contact plain deposits, with some kame deposits, bottom sands and clays of Glacial Lake Nashua, wind deposits (chiefly dune sand), and shore and near-shore deposits of Glacial Lake Nashua.

Bedrock beneath the portion of Devens covered under this PSCS has been mapped as part of the *Preliminary Bedrock Geologic Map of the Ayer Quadrangle, Massachusetts* (Kopera, 2006). Bedrock chiefly consists of low-grade metasedimentary rocks, gneisses, and granites. The principal bedrock units are described below and illustrated on Figure 2-4.

- The Oakdale Formation underlies AOCs 57, 74, 43G, 43J, and the Shabokin well areas. The formation is described by Kopera as thinly laminated, light tan micaceous quartz-muscovite-ankerite siltstone and quartzite interbedded with thin, dark greenish-grey, chlorite-muscovite-quartz- ankerite phyllite. At biotite and actinolite grade, consists of fine grained reddish and greenish siltstone granofels.
- The Devens Gneiss Complex underlies AOCs 40, 75, Grove Pond area, and Patton Well area and is believed to be of Silurian age. The unit is described by Kopera as light to medium grey, buff to pink weathering, coarse-grained quartz-potassium (k)-spar biotite granite-gneiss, with subordinate tonalitic and dioritic gneiss near Harvard Center. Biotite content varies locally as much as approximately 15 percent. Sheared to a medium to dark grey fine- to medium-grained S/C mylonite with k-spar porphyroclasts near the Clinton-Newbury fault zone. Intruded by the Ayer Granite.

Other bedrock units beneath or in the general vicinity of Devens and depicted on Figure 2-4 include:

- The Ayer Granite of Silurian age and described by Kopera as light to dark grey, buff weathering, coarse-grained, porphyritic quartz-k-spar biotite granite with distinctive k-spar megacrysts up to 8 cm in diameter. Locally foliated, sheared and altered to an augen gneiss and talc-bearing schist near the Clinton-Newbury fault zone. A non-porphyritic phase has been mapped separately northwest of Harvard center.

- The Chelmsford Granite of Devonian age and described by Kopera as white to buff weathering, light grey medium- to coarse-grained feldspar-quartzbiotite granite. Biotite occurs in isolated rusty weathering clots. Commonly contains screens and xenoliths of presumed Berwick formation. Distinctive quartz veins, up to 2 cm in width and several meters in length, are common. Locally foliated and/or sheared near the Clinton-Newbury fault zone. Also includes a medium grey, buff weathering, fine- to medium-grained quartz-feldspar-muscovite-biotite granite-gneiss, and a well-foliated light grey k-spar-quartz-muscovite granite-gneiss near the Clinton-Newbury fault. Intrudes the Ayer granite and Devens gneiss complex.
- The Berwick Formation of Silurian age and described by Kopera as thinly to massively bedded, light green-grey, fine-grained metamorphosed calcareous siltstone, quartzite, and quartzo-feldspathic granofels. Also contains a fine-grained, massively bedded muscovite-quartz-biotite quartzite and schist containing distinctive 1-mm knots of biotite.
- The Tadmuck Brook Schist is possibly of late Proterozoic or early Paleozoic age. The formation is described by Kopera as rusty weathering, sulfidic, quartz-muscovite-biotite with or without sillimanite, andalusite, or staurolite, schist. Metamorphic grade increases from west to east across strike.

The bedrock elevation contours were mapped using data gathered as part of the PFAS RI, previous investigations at Devens, well drilling records available through the Massachusetts Energy & Environmental Affairs Data Portal (eeaonline.eea.state.ma.us), and Massachusetts Geological Survey (Figure 2-4, Table 2-1). There is significant relief in bedrock elevations across Devens and the surrounding area. The area shown has bedrock elevations ranging from -49 feet (ft) North America Vertical Datum 1988 (NAVD88) to 408 ft NAVD88.

2.3 Regional Hydrogeology

The Nashua River is the eventual discharge locus for surface water and groundwater flow at Devens. The tributaries of the Nashua River at Devens are Nonacoicus Brook and Walker Brook on the former North Post; Cold Spring Brook (which is a tributary of the Nonacoicus Brook through Grove Pond and Plow Shop Pond) on the former Main Post. There is also a lesser stream, Willow Brook that discharges to Nonacoicus Brook to the north. Willow Brook originates from Robbins Pond and is fed by Robbins Pond, surface water runoff, storm water discharge, and groundwater. The groundwater flow direction at each AOC is addressed in applicable sections.

Glacial meltwater deposits constitute the primary overburden aquifer at Devens. Groundwater also occurs in the underlying bedrock; however, flow is limited because regional bedrock lacks primary porosity and/or has been affected by metamorphism that limits transmissivity (an example would be the degree of development of transmissive partings parallel to layering). The result is bedrock groundwater flow that is primarily via fractures and dissolution voids.

The zones of highest transmissivity within the overburden are found in areas of thick glacial meltwater (outwash) deposits on the former Main Post at Devens, and these encompass deposits in which the Shabokin, Patton, MacPherson, and Grove Pond water supply wells are screened (Figure 2-16). Due to the high transmissivity of these overburden deposits, these areas are preferential groundwater flow areas. The zones of lowest transmissivity are typically associated with exposed till and bedrock.

Groundwater recharge occurs in upland areas and groundwater flows generally from the topographic highs to topographic lows. Groundwater discharges in wetlands, ponds, streams, and directly into the Nashua River.

The synoptic water level measurements taken for the PFAS RI in the areas addressed in this report are presented in Tables 2-2 through 2-5. The groundwater elevation contour maps based on those measurements are on Figures 2-6 through 2-15 The contour intervals vary between figures based on the level of scale and area of interest. The vertical gradients are presented in Table 2-6. The groundwater flow directions and gradients are discussed in the applicable sections.

The Devens Groundwater Use and Value is categorized as “High” as determined by MassDEP (MassDEP, 2003) and the MassDEP groundwater classification of GW-1 is applied throughout Devens. The MassDEP approved water supply Zone I’s and Zone II’s, as well as the potentially productive aquifer areas, and the Devens Aquifer Protection and Watershed Protection Districts are shown on Figure 2-16.

3.0 AOC 57 PRELIMINARY SITE CHARACTERIZATION SUMMARY

3.1 Site Description

AOC 57 was first identified for investigation of PFAS based on analysis of groundwater samples collected from existing long-term monitoring (LTM) wells at the site in December 2017/January 2018. AOC 57 consists of three sub-areas (Area 1, Area 2, and Area 3) that are located between Barnum Road and Cold Spring Brook, south to southeast of former Building 3713 (Figure 3-1). The three sub-areas are located on undeveloped MassDevelopment land designated as Open Space/Recreational. The three sub-areas are all in areas that are sloped downward to Cold Spring Brook in varying degrees. The elevation of the brook is approximately 220 ft NAVD88. The areas upslope of the AOC 57 sub-areas are generally flat at approximately 240 ft NAVD88, have all been developed, and are privately owned or owned by the Army. The current and previous subsurface features are shown on Figures 3-2 and 3-3. There is a large storm water detention area that was constructed between AOC 57 Area 1 and Area 2 between 2003 and 2005 (Figure 3-3).

3.2 Facility History and Utilities

Area 1 is a storm water drain that collects rainfall from the paved areas around Building 3713. The runoff from the storm drain flows to the outfall at Area 1, and eventually into Cold Spring Brook (HLA, 2000). Area 2 is located 800 feet northeast of Area l, and adjacent to a vehicle storage yard associated with the former motor repair shops (Figure 3-1). Area 2 formerly consisted of an eroded drainage ditch created by periodic rain runoff. Area 3 is located approximately 600 feet to the northeast of Area 2, south of former vehicle maintenance motor pools and north of the Cold Spring Brook floodplain. The site is characterized by a historical garage and vehicle waste disposal area (HLA, 2000). Area 3 was identified after test pits were excavated east of Area 2 where soil staining was identified on historical photographs, which was later determined to be an area impacted by total petroleum hydrocarbon and chlorinated volatile organic compounds in 1995 (Harding, 2001).

In 1977, an estimated 50 to 100-gallon spill of No. 4 fuel oil was discharged through the Area 1 outfall (Harding, 2001). The fuel oil spill occurred from an overfilled underground storage tank (UST) at Building 3713 into a nearby storm drain (HLA, 2000). Approximately 3,000 gallons of impacted mixed soil and water were removed through use of containment dikes and absorbent booms set up across Cold Spring Brook adjacent to Area 2 in 1977 (Harding, 2001). The remediation, investigations and monitoring of AOC 57 related to the fuel oil spill is discussed in Section 3.3.

The property at 112 Barnum Road was sold through the base closure process. Evergreen Solar constructed a manufacturing facility at 112 Barnum Road in 2008/2009 to manufacture silicon wafers used in solar power systems (Figure 3-2). The building was constructed with oversized/complex air handling and humidification, air and process cooling, power supply and distribution, compressed air production and distribution, specialty gas distribution, and wastewater and hazardous material treatment systems. Evergreen Solar went bankrupt in 2011 and the property was sold to Calare Properties/Hackman Capital Properties. In 2012, Calare leased half the facility to Saint-Gobain Ceramics & Plastics. Saint-Gobain upgraded the facility for the manufacture of components used in LED lights. In 2013, Calare leased the other half of the building to Nypro Healthcare. In 2014, Nypro started manufacturing of precision plastic products for customers in the healthcare, packaging, and consumer electronics industries (e.g., medical device manufacturing). In August 2014, Saint-Gobain ceased operations and Nypro moved into their space. In May 2015, Calare sold the property to an LLC/institutional buyer.

The property at former Building 3713 was retained by the Army during the base closure process. Building 3713 was demolished and the Major David S. Connolly Armed Forces Reserve Center was constructed on the property between 2008 and 2010.

The current and previous subsurface features are shown on Figures 3-2 and 3-3. The historic storm sewer system drained paved and unpaved areas and a discharge point to Cold Spring Brook near AOC 57 Area 1. The system was revised and there are numerous detention pond areas across the area.

3.3 Remedial Status

In September 1992, an investigation was performed at Area 1 and 2 to determine the presence or absence of environmental contamination at AOC 57 resulting from the 1977 fuel oil spill. Polycyclic aromatic hydrocarbons and total petroleum hydrocarbon content, possibly associated with fuel oil, were detected at Area 1; however, a preliminary risk evaluation indicated that there was no unacceptable risk for presumed commercial/industrial site reuse (HLA, 2000). At Area 2, naphthalene and total petroleum hydrocarbon content were detected in surface soils, and fingerprint analysis of soil indicated contaminated soil was most likely derived from lubricating oil, possibly from the release of vehicle crank case oil and not likely related to the No. 4 fuel oil release.

In 1994, a soil removal action was conducted at Area 2 in response to newly promulgated MCP standards (Harding, 2001). During the removal action, it was discovered that the soil and groundwater contamination were more widespread than expected, the soil removal was stopped after 1,300 cubic yards of soil were excavated, and AOC 57 Area 2 was administratively transferred to the RI/feasibility study (FS) process. Following the soil removal action, the area was regraded, and a stone drainage swale was installed that discharges into Cold Spring Brook (HLA, 2000).

In 1997, excavation of Area 1 outfall soil was conducted to address soil contamination resulting from releases of petroleum oil in response to newly promulgated MCP standards (HLA, 2000). The time-critical removal action included excavation of a 22-foot by 22.5-foot area to a maximum depth of 3 feet below ground surface (bgs) at the outfall location, approximately 25 cubic yards of contaminated soil were removed (Harding, 2001).

In the spring of 1999, a total of 1,860 cubic yards of soil was removed from Area 3 focusing on polychlorinated biphenyls (PCB) and extractable petroleum hydrocarbons (HLA, 2000) (Figure 3-17). In June 2000, the Army completed an RI at AOC 57 Areas 2 and 3 that revealed the presence of residual contamination at both sites (HLA, 2000). The record of decision (ROD) selected no further action for Area 1, Excavation (For Possible Future Use) and land use controls for Area 2, and Excavation (To Accelerate Groundwater Cleanup) and land use controls for Area 3 (Harding, 2001). The remedies for Area 2 and 3 also included long-term monitoring of groundwater and surface water.

The soil excavations in Area 2 and 3 were initiated in January 2002 and completed in February 2003 (H&S, 2015). At Area 2, the contamination extended beyond the assumed limits and petroleum waste seeped into the excavation. A petroleum product recovery system was operated while additional sampling was conducted. In 2003, the remaining contaminated soil was removed. A total of 4,361 tons of contaminated material were excavated from Area 2 (H&S, 2015). At Area 3, the excavation was completed to the target limits and the planned volume of soil was removed within these limits to depths ranging between 2 and 4 feet resulting in the removal of 197 tons of soil. The confirmatory samples met the ROD cleanup criterion and the area was backfilled (H&S, 2015).

Data obtained and observations made at Area 2 between 2002 and 2003 (during the soil excavation activities and subsequent investigations) prompted the submittal of an explanation of significant differences (ESD) in March 2004. The ESD expanded the Area 2 LTM activities to include extractable petroleum hydrocarbons C_{11}-C_{22} aromatics and PCB Aroclors (BRAC, 2004).

Per the ROD and ESD, LTM activities have continued at AOC 57 Area 2 and Area 3.

3.4 PFAS Field Investigation

The RI field investigation at AOC 57 included sampling existing monitoring wells, collecting surface water and sediment samples in Cold Spring Brook, groundwater vertical profiling using direct push technology

(DPT), soil borings using DPT, groundwater vertical profiling and soil borings using rotosonic drilling, installation of piezometers and monitoring wells, sampling of monitoring wells, and synoptic water level measurements. The work was completed in general accordance with the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b). Field activities were added as the data was received and reviewed. Field activities were added as the data was received and reviewed. Sampling locations are presented on Figures 3-4, 3-5, and 3-6 and summarized in Table 3-1. The results are discussed in Section 3.5.

3.4.1 Existing Wells

Groundwater samples were collected from existing monitoring wells at AOC 57 Area 2 and AOC 57 Area 3 in September 2018 in accordance with the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b) (Table 3-1, Figure 3-4, 3-5, 3-6). 57WP-05-01 could not be located. Monitoring well 57M-96-10X was blocked by roots and could not be sampled.

Groundwater samples were collected from four existing monitoring wells at AOC 57 Area 2 and AOC 57 Area 3 in January and February 2020 in accordance with the *Work Plan for Additional Sampling of Existing Wells to Support the PFAS Remedial Investigation Former Fort Devens Army Installation, Devens, MA* (KGS, 2019c). The groundwater results are discussed in Section 3.5.

3.4.2 Surface Water and Sediment

Surface water and sediment samples were collected in Cold Spring Brook in September 2018, including samples collected near AOC 57 Area 2 and AOC 57 Area 3 in accordance with the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b). Samples in close proximity to AOC 57 included a sample upstream of AOC 57 Area 2 (CSB-18-02), a sample at AOC 57 Area 2 (CSB-18-02), a sample at AOC 57 Area 3 (CSB-18-04), and from a location downstream of AOC 57 Area 3 (CSB-18-05) (Table 3-1, Figures 3-4, 3-5, and 3-6).

Two surface water and sediment samples were subsequently collected in Cold Spring Brook (CSB-20-04 and -05) at AOC 57 Area 2 and Area 3 (Table 3-1, Figures 3-4, 3-5, and 3-6). The samples were collected in accordance with *Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS) Area 1 Field Sampling Plan Addendum No. 2*. (KGS, 2020b). The samples were collected in April 2020. All of the results are discussed in Section 3.5.

3.4.3 DPT Vertical Profiles

Numerous phases of DPT vertical profiles were conducted at AOC 57. As results were received and reviewed, additional profiles were conducted to better delineate the PFAS contamination. The DPT vertical profiles are described below, are shown on Figures 3-4, 3-5, and 3-6, and are summarized in Table 3-1.

AOC 57 Area 1

The vertical profiles at AOC 57 Area 1 were conducted in December 2018 just downgradient of the AOC 57 Area 1 soil removal area (Table 3-1, Figure 3-4). Based on review of the results [maximum perfluorooctanoic acid (PFOA) + perfluorooctanesulfonic acid (PFOS) of 12.2 nanograms per liter (ng/L)], additional vertical profiles were not conducted at AOC 57 Area 1. The results are discussed in Section 3.5.

AOC 57 Area 2

The first round of vertical profiles at AOC 57 Area 2 (5702VP-18-01 through -08) was conducted in November and December 2018 in and around the area of historic AOC 57 Area 2 contamination (Table 3-1, Figure 3-5).

Review of the initial vertical profile results at AOC 57 Area 2 indicated that the upgradient extent of PFAS in groundwater at concentrations above the EPA life-time health advisory (LHA) was not defined, specifically based on results at 5702VP-18-01 and -03. Two additional vertical profiles were conducted upgradient of AOC 57 Area 2 along Barnum Road (5702VP-19-01 and -02) to help bound the western extent of PFAS in groundwater. Vertical profiles 5702VP-19-01 and -02 were conducted in January 2019.

Review of the second set of vertical profile results at AOC 57 Area 2 indicated that the upgradient extent of PFAS in groundwater at concentrations above the EPA LHA was not defined, specifically based on results at 5702VP-19-01. Four additional vertical profiles (5702VP-19-03, -04, -05, and -06) were conducted west (presumed to be upgradient) of 5702VP-19-01. Vertical profiles 5702VP-19-03 through -06 were conducted in March 2019.

Review of the results from 5702VP-19-06 indicated that the extent of PFAS in groundwater at concentrations above the EPA LHA was not defined at AOC 57 along Barnum Road. An additional vertical profile (5702VP-19-07) was conducted northeast (presumed crossgradient) of 5702VP-19-06. Vertical profile 5702VP-19-07 was conducted in May 2019.

Review of results at 5702VP-18-08 and 57M-95-07X indicated that the extent of PFAS in groundwater at concentrations above the EPA LHA was not defined at AOC 57 to the southwest. An additional vertical profile (5702VP-19-08) was conducted to the west (crossgradient) of 5702VP-18-08 and 57M-95-07X. Vertical profile 5702VP-19-08 was conducted in June 2019. All of the results are discussed in Section 3.5.

AOC 57 Area 3

The first round of vertical profiles at AOC 57 Area 3 (5703VP-18-01 through -08) were conducted in October and November 2018 in and around the area of historic AOC 57 Area 3 contamination (Table 3-1, Figure 3-6).

Review of the initial vertical profile results at AOC 57 Area 3 indicated that the upgradient extent of PFAS in groundwater at concentrations above the EPA LHA was not defined, specifically based on results from 5703VP-18-02 and -03. Two additional vertical profiles were conducted to help bound the northern and western extent of PFAS in groundwater. Vertical profile 5703VP-19-01 was conducted northeast of 5703VP-18-03 to bound the crossgradient extent to the north and 5703VP-18-09 was conducted west of 5703VP-18-02 to bound the upgradient extent. Vertical profile 5703VP-18-09 was conducted in December 2018 and vertical profile 5703VP-19-01 was conducted in January 2019. All of the results are discussed in Section 3.5.

3.4.4 DPT Soil Borings

The soil borings at AOC 57 Area 1 were not conducted as specified in the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b). Based on review of the vertical profile results at AOC 57 Area 1, EPA and Massachusetts Department of Environmental Protection (MassDEP) agreed that soils borings at AOC 57 Area 1 were not necessary.

The soil borings at AOC 57 Area 2 (5702SB-19-01 through -07) were conducted in January 2019. The soil borings were planned to be conducted in and around the area of historic AOC 57 Area 2 contamination. Soil borings 5702-19-01 through -06 were drilled at locations specified in the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b). An additional soil boring (5702SB-19-07) was added next to 5702VP-18-01 based on the high detections of PFOA and PFOS in the shallow intervals of the vertical profile 5702VP-18-01.

The soil borings at AOC 57 Area 3 (5703SB-19-01 through -04) were conducted in January 2019 at locations specified in the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b). All of the results are discussed in Section 3.5.

3.4.5 Monitoring Well Installation and Vertical Profiling with Sonic

In accordance with the cover letter to the Army Responses to EPA and MassDEP Comments, *Area 1 Field Sampling Plan – Monitoring Well Plan Addendum Remedial Investigation Work Plan for PFAS* dated October 8, 2019 (KGS, 2019d), select drilling activities were conducted at AOC 57 Area 2 and AOC 57 Area 3. Specific activities included vertical profiling at 5702MW-19-01; piezometer 5703PZ-19-01 was installed; and drilling and well installation at locations 5702MW-20-01 through -07 and 5703MW-20-01 through -04. Vertical profiling at 5702MW-20-03 and -05 was added during the field implementation. Although not originally part of the work plan, it was conducted in the same fashion as the vertical profiling conducted at 5702MW-19-01. Specifically, vertical profiling was started at the refusal depth of the collocated DPT vertical profile and samples were collected every 10 feet to bedrock. These activities were conducted in December 2019 through February 2020.

The newly installed monitoring wells were sampled for PFAS from February to March 2020. All of the results are discussed in Section 3.5.

3.4.6 Synoptic Water Level Surveys

An Area 1 synoptic water level monitoring event, that encompassed all of the AOC 57 Area 2 and AOC 57 Area 3 piezometers and monitoring wells, was conducted on March 12, 2020. All of the results are discussed in Section 3.5.

3.5 Nature and Extent

Groundwater results are summarized on Figures 3-7 through 3-9 and in cross section (Figures 3-10 through 3-13). Soil sampling results are summarized on Figures 3-14 and 3-15. Surface water and sediment sampling results are summarized on Figure 3-16. Area and site-specific groundwater contour figures are presented on Figures 2-9, and 2-12 through 2-15. All of the results are presented in tables in Appendix H. The media specific criteria are presented in (Table 1-1).

3.5.1 Groundwater

Groundwater in the overburden at AOC 57 was characterized through groundwater samples collected from existing wells, via DPT vertical profiles, via sonic vertical profiles, and samples from new monitoring wells. During the RI, DPT vertical profile samples were collected from 29 locations and sonic vertical profiles samples were collected from three locations. A total of 245 vertical profile samples were collected. Table 3-2 provides summary statistics of the results of the vertical profile samples. Of those samples, 41 samples (17%) had concentrations greater than the EPA LHA and 124 samples (86%) had concentrations greater than the GW-1 standard. A total of 37 monitoring well samples were collected. Table 3-3 provides summary statistics o the result of the monitoring well samples. Of the 37 monitoring well samples collected, 20 samples (54%) had concentrations greater than the EPA LHA and 31 samples (84%) had concentrations greater than the GW-1 standard. None of the concentrations were greater than the GW-3 standard (protective of surface water).

The summary statistics table provides statistics with respect to individual compounds (e.g., number of samples with PFOA that exceed the EPA LHA and the GW-1 standard) and with respect to the sum of applicable compounds in the EPA LHA and the GW-1 standard (e.g., numbers of samples with the sum of PFOA+PFOS that exceed the EPA LHA, and number of samples with the sum PFOA+PFOS+ perfluorohexanesulfonic acid (PFHxS) + perfluorononanoic acid (PFNA) + perfluoroheptanoic acid (PFHpA)+perfluorodecanoic acid (PFDA) that exceed the GW-1 standard]. Due to the summing of concentrations needed for comparison to the EPA LHA and the GW-1 standard, the numbers of samples that exceed the EPA LHA or GW-1 standard for individual compounds may not equal the numbers of samples that exceed the sum of the appropriate compounds for the EPA LHA or GW-1 standard. One example is, if individual results of PFOA and PFOS were both below the EPA LHA, but the sum of the results exceeded the EPA LHA, then the sample would be counted as an exceedance of the EPA LHA even though the individual compounds would not be counted as exceedances.

At AOC 57 Area 1, all of the samples from both the vertical profile locations had concentrations lower than the EPA LHA and some sample intervals had PFAS concentrations greater than the GW-1 standard at both vertical profile locations. The maximum concentrations were detected at 5701VP-18-02 at 32-36 ft bgs (89.8 ng/L, for the sum of the six GW-1 compounds). The thickness of aquifer with concentrations greater than the GW-1 standard is 34 ft (22 to 56 ft bgs).

At AOC 57 Area 2, PFAS was detected at concentrations greater than the EPA LHA at locations in and around the historic AOC 57 Area 2 groundwater contamination as well as at locations upgradient of the historic AOC 57 Area 2 (5702VP-18-01), at locations along Barnum Road (5702VP-19-01, -06, and -07) and west of Barnum Road (5702VP-19-09). The extent of PFAS at concentrations greater than the EPA LHA are bounded to the south by lower concentrations detected at 5702VP-19-02 and -08 and to the west at 5702VP-19-03, -04, and -05. PFAS was detected at concentrations greater than the GW-1 standard in at least one sample interval or well screen at every AOC 57 Area 2 location.

The highest PFAS concentrations were detected at 5702VP-18-08 (PFOA + PFOS = 4,390 ng/L and 8,760 ng/L, sum of six GW-1 compounds), which is slightly crossgradient to the south of the center of the historic AOC 57 Area 2 contamination. Another area of higher concentrations was observed along a groundwater flow path that is crossgradient to the north and upgradient of 5702VP-18-08 at 5702VP-19-01 (PFOA + PFOS = 1,480 ng/L and 2,300 ng/L sum of six GW-1 compounds), 5702VP-18-01 (PFOA + PFOS = 1,950 ng/L and 4,660 ng/L, sum of six GW-1 compounds), and migrating toward 5702VP-18-02 (PFOA + PFOS = 560 ng/L and 1,740 ng/L, sum of six GW-1 compounds) and through 57WP-06-02 (PFOA + PFOS = 381 ng/L and 1,120 ng/L, sum of six GW-1 compounds) before discharging to the Cold Spring Brook. Crossgradient to the northeast and southwest of both of these areas of contamination the PFAS concentrations are lower suggesting the extent of the high concentrations in limited in the crossgradient extent (Figure 3-8).

The PFAS concentrations detected above the EPA LHA along Barnum Road (5702VP-19-06 and -07) and west of Barnum Road (5702VP-19-09) may not be related to the same source of the historical AOC 57 Area 2 and Area 3 and may be attributable to other Army legacy activities.

Most the PFAS concentrations greater than the EPA LHA were detected shallow in the aquifer (above 56 ft bgs), except at 5702VP-19-07 where PFAS was detected greater than the EPA LHA at 62-66 ft bgs. A similar pattern is observed with the PFAS concentrations greater than the GW-1 standard. Overall, beneath the zones of higher concentrations in the shallow aquifer, concentrations decreased with depth (sometimes PFOA and PFOS and the six GW-1 compounds were not detected) in the aquifer down to bedrock. The lowest concentrations, below both the EPA LHA and GW-1 standard, were observed in the deeper vertical profiles conducted using sonic drilling techniques at 5702VP-19-01/5702MW-19-01 (sampled down to 144 ft bgs), 5702VP-19-03/5702MW-20-03 (sampled down to 140 ft bgs), and 5702MW-20-05 (sampled down to 130 ft bgs), which sampled groundwater down to bedrock. The bedrock was confirmed with coring.

The groundwater flow at AOC 57 Area 2 close to Cold Spring Brook is toward the Brook in the shallow aquifer (above 40 ft bgs) and in the deeper aquifer (below 40 ft bgs). For Area 2, slight downward vertical gradients (ranging from +0.0008 to +0.0071) were identified at Well Pair 2 (57M-03-01X/5702MW-20-06A) and Well Pair 3 (57M-95-06X/5702MW-20-04A), which are located on at the top of the slope above Cold Spring Brook. Upward vertical gradients were observed at Well Triplets 1 and 2 and Well Pair 4 located mid-way down the slope toward Cold Spring Brook (5702MW-20-05A,B) or at the bottom of the slope adjacent to the Cold Spring Brook wetlands. For the well triplets, upward vertical gradients were identified between the deep and shallow wells, between the deep and mid-depth wells, and between the mid-depth and shallow wells. The upward gradients ranged from -0.0028 to -0.0333. These upward gradients suggest that deep groundwater at Area 2 moves upward toward Cold Spring Brook.

At AOC 57 Area 3, the highest PFAS concentrations were detected along the axis of the previous soil removal area, specifically at 5703VP-18-04 at the water table (PFAO + PFOS = 1,800 ng/L and 2,010 ng/L, sum of six GW-1 compounds, 12-16 ft bgs) and at 5703VP-18-02 (PFAO + PFOS = 988 ng/ L and 1,190 ng/L, sum of six GW-1 compounds, at 22-26 ft bgs). The shallowness of the maximum concentrations suggest a nearby source of PFAS. The upgradient extent of PFAS concentrations greater than the EPA LHA is limited by results from 5703VP-18-09, and the crossgradient extent to the north is limited by results from 5703VP-19-01. PFAS concentrations greater than the GW-1 standard was detected at all AOC 57 Area 3 locations in at least one sample interval or well screen.

The PFAS concentrations greater than the EPA LHA were detected in the shallow and mid-portion of the aquifer (above 46 ft bgs) with lesser concentrations deeper in the aquifer. A similar pattern is observed with PFAS concentrations with respect to the GW-1 standard, expect those lower concentrations were detected deeper in the aquifer down to 76 ft bgs (5703VP-18-03).

The groundwater flow at AOC 57 Area 3 is toward Cold Spring Brook in the shallow aquifer (above 40 ft bgs) and in the deeper aquifer (below 40 ft bgs). Downward vertical gradients were identified in the groundwater at Well Pairs 1, 2, and 3 located close to the top of the slope and at the mid-slope above Cold Spring Brook. The downward gradients ranged from 0.0059 to 0.0179. Upward vertical gradients were identified at Well Triplet 1 located adjacent to the Cold Spring Brook wetlands. Upward vertical gradients were identified between the deep and shallow wells, between the deep and mid-depth wells, and between the mid-depth and shallow wells at this well triplet. The upward gradients ranged from 0.0021 to 0.0228. These upward gradients suggest that deep groundwater at Area 3 moves upward toward Cold Spring Brook.

3.5.2 Soil

At AOC 57 Area 2, seven soil borings were advanced to a maximum depth of 16 feet bgs. Six locations had one or more sample intervals with detections of PFAS compounds greater than the MCP Method 1 S-1 Soil Category (S-1)/GW-1 standard. At 5702SB-19-01 PFAS compounds were not detected at concentrations greater than the S-1/GW-1 standards. All six of the PFAS compounds in the MCP Method 1 Soil Category (S-1)/GW-1 standard were detected at concentrations above the S-1/GW-1 standards (Figure 3-14, Appendix H). Location 5702SB-19-07 had the largest number of samples with concentrations above the S-1/GW-1 standards and also had the highest concentrations of five PFAS compounds. The maximum concentrations were PFOS = 17.0 micrograms per kilogram (µg/kg), PFOA = 17.0 µg/kg, PFNA = 4.60 µg/kg, PFHpA = 1.80 µg/kg, PFDA = 43.0 µg/kg. At 5702SB-19-04, concentrations of three PFAS compounds were greater than the S-1/GW-1 standards and the maximum concentration of PFHxS was detected (4.80 µg/kg). The other locations had lower concentrations with few samples that had concentrations greater than the S-1/GW-1 standards.

At AOC 57 Area 3, four soil borings were advanced to a maximum depth of 12 feet bgs. Two soil borings had one or more sample intervals with detections of PFAS compounds greater than the S-1/GW-1 standards. At 5703SB-19-01 and -03 PFAS compounds were not detected at concentrations greater than the S-1/GW-1 standards. Four of the PFAS compounds with S-1/GW-1 standards were detected at concentrations above the S-1/GW-1 standards (Figure 3-15, Appendix H). Location 5703SB-19-02 had the largest number of samples with concentrations above the S-1/GW-1 standards and also had the highest concentrations. The maximum concentrations were PFOS = 2.70 µg/kg, PFOA = 1.00 µg/kg, PFNA = 2.10 µg/kg, PFDA = 5.60 µg/kg. Two locations did not have any PFAS concentrations greater than the S-1/GW-1 standards. At 5703SB-19-04, PFDA (1.90 µg/kg) and PFOS (2.20 µg/kg) were detected in the 0-0.5 ft bgs sample at concentrations above the S-1/GW-1 standards.

As part of prior removal activities, soil has been removed from AOC 57 Area 2 and Area 3. The highest PFAS concentrations in both areas are on the edges or outside of the estimated areas where soil was removed.

3.5.3 Surface Water and Sediment

Five surface water and sediment samples were collected near AOC 57 Area 2 and Area 3 (CSB-18-02 through -05, CSB-20-04 and -05). All of the detections in surface water and sediment in Cold Spring Brook were below the EPA site-specific screening levels (SSSL) for PFAS at former Fort Devens (Table 1-1). The sampling locations and data are summarized on Figure 3-18 and the data are presented in Appendix H. Other sample locations in Cold Spring Brook are discussed in Section 4.4.4 (AOC 74) and Section 5.4.4 (AOC 75).

The PFOA concentrations in the surface water ranged from 12.0 ng/L to 190 ng/L, the PFOS concentrations ranged from 2.80 estimated result (J) ng/L to 35.0 ng/L, and the PFBS concentrations ranged from 3.6 ng/L to 11.0 ng/L. The highest concentrations were detected at CSB-20-04 (AOC 57 Area 2) and CSB-20-05 (AOC 57 Area 3) suggesting the areas where these samples were collected is receiving groundwater with the higher concentrations as compared to adjacent areas.

In the sediment samples, PFOA concentration ranged from 0.460J ng/L to 2.40 ng/L, PFOA concentrations ranged from non-detect to 5.60 µg/kg, and PFBS was non-detect.

4.0 AOC 74 PRELIMINARY SITE CHARACTERIZATION SUMMARY

4.1 Site Description

AOC 74 (Barnum Road Firefighting Exercise Site) is a former firefighting exercise site where aqueous film-forming foam (AFFF) was used during firefighting training behind former Building 3773 (Figure 4-1) [BERS-Weston Services JVA, LLC (BERS-Weston), 2018b]. The property is currently owned by 78 Barnum Road, LLC.

The portion of the property near Barnum Road, buildings, and parking lots is fairly flat with little change in ground surface elevations (generally 240 ft NAVD88). Behind the main building the topography has been altered by the installation of two storm water detention ponds. Between the storm water detention ponds the land slopes down to a drainage swale that discharges to Cold Spring Brook where the shoreline is approximately 222 ft NAVD88.

4.2 Facility History and Utilities

AOC 74 was first identified for PFAS investigation based on interviews conducted as part of the Devens PFAS Preliminary Assessment (PA) (KGS, 2017). The site was identified as study area (SA) 74 as part of the PFAS PA. No previous environmental investigations were found for former Building T-3773 during historical document review (KGS, 2017).

A base-wide PA was performed in 2016 to determine if a release of PFAS had occurred at Devens (KGS, 2017). Evaluation of SA 74 found no historical documentation that indicated the use, storage, or disposal of AFFF at SA 74. However, interviews conducted with personnel knowledgeable about this site indicated historical use of AFFF by the Army during firefighting training behind the building. Former Building 3773 was used as an administrative building as part of the Army Reserve Center. Firefighting equipment was stored at this location during the closure of the former Moore Army Airfield (KGS, 2017).

The PA concluded that a SI was warranted to determine if additional action is required at SA 74. SA 74 was included in the *Final Site Inspection Report for Per- and Polyfluoroalkyl Substances (PFS) at Former Fort Devens Army Installation* (BERS-Weston, 2018b). Based on the results, the SI recommended that a RI be conducted at SA 74.

The current and previous subsurface features are shown on Figures 4-2 and 4-3. The historic storm sewer system drained paved and unpaved areas and had numerous discharge points to Cold Spring Brook behind former Building 3773. The system was revised and there are numerous detention pond areas across the area.

4.3 PFAS Field Investigation

The RI field investigation at AOC 74 included sampling the existing irrigation well, collecting surface water and sediment samples in Cold Spring Brook, groundwater vertical profiling using DPT, soil borings using DPT, installation of piezometers and monitoring wells, sampling of monitoring wells, and synoptic water level measurements. The work was completed in general accordance with the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b). Field activities were added as the data was received and reviewed. Sampling locations are presented on Figure 4-4 and summarized in Table 4-1. The results are discussed in Section 4.5.

4.3.1 Irrigation Well

A groundwater sample was collected from the irrigation well, located southeast of the building, in October 2018.

4.3.2 Surface Water and Sediment

Surface water and sediment samples were collected in Cold Spring Brook in September 2018, including samples collected near AOC 74. Sample CSB-18-06 was collected east of the former building and CSB-18-07 and -08, which are located downstream of AOC 74.

One additional surface water and sediment sample was collected in Cold Spring Brook in accordance with the *Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS) Area 1 Field Sampling Plan Addendum No. 2* (KGS, 2020b). The sample, CSB-20-06, was collected in April 2020.

4.3.3 DPT Vertical Profiles

Numerous phases of DPT vertical profiles were conducted at AOC 74. As results were received and reviewed, additional profiles were conducted to better delineate the PFAS contamination. The DPT vertical profiles are described below, are shown on Figure 4-4, and are summarized in Table 4-1.

The first round of vertical profiles 74VP-18-01 through -11 were conducted in October 2018 through December 2018 as planned in the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b). The locations were conducted within as well as cross-gradient, upgradient, and downgradient of the suspected source area (the area impacted by the firefighter training), to assess the nature and extent of PFAS in groundwater in this area.

Review of some of the initial vertical profile results at AOC 74 indicated there were high PFAS concentrations (sum of PFOA and PFOS = 2,270 ng/L) at 74VP-18-05 and the extent of PFAS in groundwater at concentrations above the EPA LHA was not defined. Two additional vertical profiles were conducted downgradient of 74VP-18-05 (74VP-18-12 and -13) to help define the extent of PFAS in groundwater. The vertical profiles were conducted in December 2018.

Review of additional initial vertical profile results at AOC 74 (specifically 74VP-18-01 and -03) indicated the southwest extent of PFAS in groundwater was not defined. One additional vertical profile (74VP-19-01) was conducted west of 74VP-18-01 and -03 to help define the extent of PFAS in groundwater. Location 74VP-19-01 was drilled in February 2019.

Results of vertical profiles 74VP-18-12 and GPVP-19-05 suggested that the high PFAS concentrations detected at 74VP-18-05 were migrating to the north. One additional vertical profile (74VP-19-02) was conducted east of GPVP-19-05 to help define the eastern extent of PFAS in groundwater. Location 74VP-19-02 was drilled in February 2019.

Review of AOC 74 groundwater level contours (Figure 2-3) developed from data collected from the new AOC 74 piezometers installed in February and March 2019 indicated there is a component of groundwater flow from behind former building 3773 toward Cold Spring Brook. The groundwater level contours indicated that groundwater with PFAS concentrations greater than the EPA LHA at 74VP-18-01, -04, -09 may potentially flow toward Cold Springs Brook. Therefore, vertical profile 74VP-19-03 was conducted at a location downgradient of 74VP-18-01 and -04 to further characterize PFAS concentrations in groundwater that is discharging to Cold Springs Brook. A second additional vertical profile, 74VP-19-04, was conducted along Cold Spring Brook at a location that is hydraulically crossgradient to 74VP-19-03 to confirm the crossgradient extent to the northeast of the PFAS concentrations greater than the EPA LHA that are discharging to Cold Springs Brook. Location 74VP-19-03 and -04 were drilled in June 2019.

In accordance with the cover letter to the Army Responses to EPA and MassDEP Comments, *Area 1 Field Sampling Plan – Monitoring Well Plan Addendum Remedial Investigation Work Plan for PFAS* (KGS, 2019d), select drilling activities were conducted at AOC 74. Specific activities included vertical profiling at 74VP-20-01. The vertical profiling was conducted in February 2020. The groundwater data are discussed in Section 4.4.1.

4.3.4 Soil Borings

The AOC 74 soil borings identified in the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b) (74SB-19-01 through -07) were drilled in January 2019. One soil boring (74SB-18-04) was moved to be collocated with 74VP-19-04 because the original planned location was inaccessible because it was within a steep-sided storm water detection basin. The borings were conducted in the general area of the presumed source area. The data are discussed in Section 4.4.3.

4.3.5 Monitoring Wells and Piezometers

A series of piezometers (74PZ-19-01 through -09) were installed in February and March 2019.

In accordance with the cover letter to the Army Responses to EPA and MassDEP Comments, *Area 1 Field Sampling Plan – Monitoring Well Plan Addendum Remedial Investigation Work Plan for PFAS* (KGS, 2019d), select drilling activities were conducted at AOC 74. Specific activities included installation of piezometers 74PZ-19-10 and 74PZ-20-01 through -05, installation of monitoring well 74MW-19-04A, and sampling of the new monitoring well 74MW-19-04A. These activities were conducted in December 2019 through March 2020.

4.3.6 Synoptic Water Level Event

An AOC 74/Grove Pond area synoptic water level event was conducted on March 19, 2019.

An Area 1 synoptic water level monitoring event, that encompassed all of the Grove Pond area piezometers and monitoring wells, was conducted on March 12, 2020. The groundwater flow contours estimated based on the data from the synoptic water level events are discussed in Section 4.4.1.

4.4 Nature and Extent

Groundwater results are summarized on Figure 4-5 and in cross section (Figures 4-6 through 4-8). Soil sampling results are summarized on Figure 4-9. Surface water and sediment sampling results are summarized on Figure 3-18. Area and site-specific groundwater contour figures are presented on Figures 2-3, 2-5, and 2-6. All of the results are presented in tables in Appendix H. The media specific criteria are presented in (Table 1-1).

4.4.1 Groundwater in Overburden

Groundwater in the overburden at AOC 74 was characterized through three groundwater samples collected during the SI (BERS-Weston, 2018b), and during the RI via DPT vertical profiles, and a sample from a new monitoring well. During the RI, vertical profile samples were collected from 18 locations. A total of 133 vertical profile samples were collected. Table 4-2 provides summary statistics of the results of the vertical profile samples. Of those samples, 17 samples (13%) had concentrations greater than the EPA LHA and 48 samples (36%) had concentrations greater than the GW-1 standard. One monitoring well (74MW-19-04A) was installed and sampled in the overburden and had concentrations greater than the EPA LHA and the GW-1 standard (Table 4-3). None of the concentrations were greater than the GW-3 standard (protective of surface water).

The maximum concentrations were detected at 74VP-18-05 at 52-56 ft bgs (PFOA + PFOS = 2,270 ng/L and 3,660 ng/L, for the sum of the six GW-1 compounds). High concentrations were also detected at 74VP-20-01 at the water table (12-16 ft bgs, PFAO + PFOS = 969 ng/L and 2,010 ng/L, for the sum of the six GW-1 compounds).

Based on the highest PFAS concentrations detected in soil at 74SB-19-01 and -03 (discussed in Section 4.4.3) and the high PFAS concentrations detected at the water table at 74VP-20-01, SA74-17-02 and -03 (SI locations) the source area is likely located behind former Building 3773 in the vicinity of these locations. Based on the groundwater level contours (Figures 2-3 and 2-6) some of the groundwater from this area flows to the southeast toward Cold Spring Brook and some flows to the north toward 74VP-18-05 and then north towards Grove Pond.

The higher PFAS concentrations detected at 74VP-18-05, flowing with groundwater to the north and detected at 74VP-18-12, and GPVP-19-05 are bounded to the east by lower PFAS concentrations (below the EPA LHA) detected in crossgradient locations 74VP-18-13 and 74VP-19-02 (Figure 4-5). Farther downgradient, the eastern extent of PFAS concentrations defined by the EPA LHA are limited by results at GPVP-18-06, -07, and CSMS-11-02. To the west of 74VP-18-05, 74VP-18-12, and GPVP-19-05, there appears to be PFAS impacts to the groundwater separate from AOC 74. This area is discussed in Section 6, the Grove Pond Area.

The higher PFAS concentrations detected behind the building at 74VP-20-01, -18-01, SA74-17-02 and -03, are migrating with groundwater to the east toward Cold Spring Brook and were detected at 74VP-18-09 at concentrations above the EPA LHA. Crossgradient of this area to the south, PFAS concentrations were detected at concentrations below the EPA LHA at SA-17-01, -04, -05 and 74VP-18-02, -06, and -10. Crossgradient of this area to the north, PFAS concentrations were detected at concentrations below the EPA LHA at 74VP-19-03 and -04.

The downgradient extent of the AOC 74 plume that is flowing toward Grove Pond is not clearly defined and may be comingling with PFAS impacted groundwater in the Grove Pond area as the groundwater migrates north toward Grove Pond and the Town of Ayer Grove Pond water supply wellfield.

The upgradient extent of the AOC 74 plume is defined by PFAS concentrations less than the EPA LHA at 74VP-18-11 and 74VP-19-01.

All of the AOC 74 locations had at least on sample with PFAS concentrations greater than the GW-1 standard except for SA-17-04 and 74VP-18-10, located south of the portion of the plume migrating toward Cold Spring Brook, 74VP-19-04, located north of the portion of the plume migrating toward Cold Spring Brook, and at 74VP-19-02, located east of the portion of the plume migrating toward Grove Pond.

At 74VP-20-01 the highest PFAS concentrations were detected at the water table (12-16 ft bgs, PFOA + PFOS = 969 ng/L and 2,010 ng/L, for the sum of the six GW-1 compounds) and in the next sample interval (19-23 ft bgs, PFOA + PFOS = 705 ng/L and 1,260 ng/L, for the sum of the six GW-1 compounds). Most of the rest of the sample intervals had concentrations lower than the EPA LHA and the GW-1 standard, except at 49-53 ft bgs (PFOA + PFOS = 74.9 ng/L and 110 ng/L, for the sum of the six GW-1 compounds) and at 88-92 ft bgs (PFOA + PFOS = 29.0 ng/L and 55.9 ng/L, for the sum of the six GW-1 compounds). The highest concentrations were detected at 74VP-18-09 in the middle sample interval (22-26 ft bgs, PFOA + PFOS = 76.0 ng/L and 110 ng/L, for the sum of the six GW-1 compounds) with the deepest interval 32-36 ft bgs) only having a concentration of 0.950 ng/L (for the sum of the six GW-1 compounds) and no detections of PFOA and PFOS. A similar pattern was observed at crossgradient locations 74VP-18-02 and 74VP-19-04, where the higher PFAS concentrations were detected in the shallowest intervals at or close to the water table and the deepest intervals were nondetect (74VP-18-02) or very low concentrations (74VP-19-04, below 1 ng/L for PFOA + PFPOS and below 2 ng/L for the sum of the six GW-1 compounds).

For the portion of groundwater just north of 74VP-20-01 that flows toward 74VP-18-05, 74VP-18-12 and GPVP-19-05, the highest PFAS concentrations (above the EPA LHA) were observed in the shallowest four intervals at 74VP-18-05 but the plume appears to dive slightly in the aquifer as the groundwater flows to 74VP-18-12 and GPVP-19-05. At 74VP-18-12 and GPVP-19-05, the shallowest two sample intervals had PFAS concentrations less than the EPA LHA followed by concentrations greater than the EPA LHA in the deeper four intervals at 74VP-18-12 and the deeper three intervals at GPVP-19-05. The plume does not appear to continue to dive as groundwater migrates toward Grove Pond and the Town of Ayer Grove Pond wellfield. The highest PFAS concentrations were observed in the shallowest five intervals at GPVP-18-08 and the wells set in the shallow aquifer at MNG-3R and CSMS-11-02 with lower concentrations deeper in the aquifer. PFAS was not detected (for PFOA and PFOS and the six GW-1 compounds) in deeper intervals at GPVP-19-08 (five deeper intervals) and GPVP-19-07 had two non-detect intervals and two intervals with a maximum concentration of 5.57 ng/L (sum of six GW-1 compounds). The Town of Ayer Grove Pond water supply wells are set from 42 to 73 ft bgs, which is in the approximate middle of the saturated aquifer in that area.

4.4.2 Groundwater in Bedrock

The irrigation well off the southeast corner of former Bldg. 3773 is 505 feet deep and sampled in October 2018. The screen information of the irrigation well is unknown. It is assumed to be cased into bedrock and that it is an open bedrock hole. A sample was collected from the output of the existing pump within the well. The sample was nondetect for all PFAS compounds.

4.4.3 Soil

At AOC 74 three soil borings were conducted during the SI (BERS-Weston, 2018b) and seven borings were conducted during the RI. The PFAS concentrations from the soil samples collected during the SI were less than the S-1/GW-1 standards. At three of the boring conducted during the RI, PFAS concentrations were less than the S-1/GW-1 standards, including at 74SB-19-04 where no PFAS compounds were detected. At the other four borings, five of the six PFAS compounds that have S-1/GW-1 standards were detected at concentrations above the S-1/GW-1 standards (Figure 4-9, Appendix H). Three locations (74SB-19-01, -02, -03) all had concentrations greater than the S-1/GW-1 standards in all intervals sampled. The largest number of analytes at concentrations greater than the S-1/GW-1 standards were detected at 74SB-19-03, which is also where the maximum concentrations of PFOA, PFOS, PFDA were detected. At 74SB-19-03, the maximum concentrations were PFOS = 9.30 µg/kg, PFOA = 5.50 µg/kg, PFNA = 1.40 µg/kg, PFHpA = 1.30 µg/kg, PFDA = 11.0 µg/kg. The highest PFHpA (2.40 µg/kg) and PFNA (2.80J µg/kg) concentrations were detected at 74SB-19-01. The other locations had lower concentrations with few samples that had concentrations greater than the S-1/GW-1 standards. The data suggest the greatest impact of fire-fighting training exercises was directly behind former Building 3773 in the vicinity of 74SB-19-01 and -03 with lesser impacts to the south, east, and north.

4.4.4 Surface Water and Sediment

Three surface water and sediment samples were collected east of former Building 3773 (CSB-18-06, -07 and CSB-20-06) and one sample was collected downstream (CSB-18-08). Five surface water and sediment samples were collected near AOC 57 Area 2 and Area 3 (CSB-18-02 through -05, CSB-20-04 and -05). All of the detections in surface water and sediment in Cold Spring Brook were below the EPA SSSLs for PFAS at former Fort Devens (Table 1-1). The sampling locations and data are summarized on Figure 3-18 and the data are presented in Appendix H. Other sample locations in Cold Spring Brook are discussed in Section 3.5.3 (AOC 57) and Section 5.4.4 (AOC 75).

The PFOA concentrations in the surface water ranged from 7.90 ng/L to 26.0 ng/L, the PFOS concentrations ranged from 3.10J ng/L to 4.10 ng/L, and the PFBS concentrations ranged from 0.800J ng/L to 1.70 ng/L. The highest concentrations were detected at CSB-20-06 suggesting that area is receiving groundwater with the higher concentrations as compared to adjacent areas.

In the sediment samples, PFOA concentration ranged from non-detect to 1.70 µg/kg, PFOS concentrations ranged from non-detect to 1.90J µg/kg, and PFBS was non-detect.

5.0 AOC 75 PRELIMINARY SITE CHARACTERIZATION SUMMARY

5.1 Site Description

AOC 75 is located off Saratoga Street and was first identified for PFAS investigation based on interviews conducted as part of the Devens PFAS PA (KGS, 2017). AOC 75 was identified as the former Building T-1445, where a large fire occurred during the late 1980s/early 1990s (Figure 5-1). AFFF was reportedly used to suppress the fire (KGS, 2017). Former Building T-1445 has been described as a shed that connected two other buildings (former Buildings T-1422 and T-1423) (KGS, 2017).

The property where former Building T-1445 was located is currently zoned as Rail, Industrial & Trade Related. After the closure of Fort Devens, the property was redeveloped, and a building was constructed between 2001 and 2003 (18 Saratoga Street) (Figure 5-2). Currently the building is occupied by Waiteco Machine Inc., which is a manufacturer and assembler of machined components.

To the west of 18 Saratoga Street, the property was commercially developed. Immediately to the north and east of 18 Saratoga Street is a drainage swale that is oriented east-west along the northern edge of the property and north-south along the eastern edge of the property. Water in the drainage swale flows to the south and empties into a man-made detention pond. Active railroad tracks exist north and east of the drainage swale in the same pattern as the swale (i.e., oriented east-west to the north of the property and north-south to the east of the property. East of the railroad tracks to Barnum Road is land owned by MassDevelopment that is currently undeveloped and is zoned as Rail, Industrial & Trade Related. East of Barnum Road, the land is undeveloped and zoned Open Space/Recreational. East of the open space is Cold Spring Brook and the former Fort Devens boundary. It is not anticipated that the land use at AOC 75 will change in the future.

There are currently no wells at AOC 75 that are used for drinking water supply, irrigation water supply, or any other water supply purposes. A permit is required from Devens Enterprise Commission for installation of any water supply well.

Overall, the area is generally flat with little change in ground surface elevation. There is a gentle slope from 18 Saratoga Street toward Cold Spring Brook. The ground surface elevation at 18 Saratoga Street is approximately 250 ft NAVD88 and the ground surface elevation at the edge of Cold Spring Brook is approximately 220 ft NAVD88.

5.2 Site History and Utilities

AOC 75 was first identified for PFAS investigation based on interviews conducted as part of the Devens PFAS PA (KGS, 2017). The site was identified as SA 75 as part of the PFAS PA. No previous environmental investigations were found for former Building T-1445 during historical document review (KGS, 2017).

A base-wide PA was performed in 2016 to determine if a release of PFAS had occurred at Devens (KGS, 2017). Although there was no historical documentation indicating the use, storage or disposal of AFFF at SA 75, interviews with personnel knowledgeable about these sites indicated historical use of AFFF by the Army to extinguish a warehouse fire at SA 75 The warehouse, Former Building T-1445, was reportedly used for storage of lumber and pipe (KGS, 2017). During the 22 December 2016 interview with the current Devens Fire Chief and Deputy Chief Scott Adams, they indicated a fire occurred at this warehouse in the late 1980s/early 1990s, resulting in alarm calls to neighboring fire departments. They described the building as a shed that connected two other buildings. The fire became out of control and numerous items that contained flammables were reportedly stored in the warehouses. Since the fire was so intense, it was dangerous to the crew. A decision was made to use all the foam available at Devens to put the fire out. After the fire, the buildings were inspected, and vehicles were found inside. (KGS, 2017). The PA concluded that a SI was warranted to determine if additional action is required at SA 75. SA 75 was included in the *Final Site Inspection Report for Per- and Polyfluoroalkyl Substances (PFAS) at Former Fort Devens Army*

Installation (BERS-Weston, 2018b). Based on the results, the SI recommended that a RI be conducted at SA 75.

The current and previous subsurface features are shown on Figures 5-2 and 5-3. As part of the evaluation of storm sewers completed in 1994 (Arthur D. Little, Inc., 1994), System #9 was identified east and west of former Building 1445. System #9 was an extensive system that drained paved residential areas, unpaved railroad tracks, and unpaved storage yards. There were catch basins to System #9 immediately adjacent to the east of former Building 1445. The system drains south along Saratoga Street (Figure 5-2) and discharges into Cold Spring Brook at the junction of Saratoga Street and Barnum Road. By 2001, redevelopment activities had started in the area and the storm sewer system revised. The current subsurface features are shown on Figure 5-3.

5.3 AOC 75 Field Investigation

The AOC 75 field investigation included groundwater vertical profiling using DPT, soil borings, installation of piezometers and monitoring wells, groundwater vertical profiling and soil borings using rotosonic drilling, sampling of monitoring wells, collection of surface water and sediment samples, and synoptic water level measurements. The work was completed in general accordance with the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b). Field activities were added as the data was received and reviewed. Sampling locations are presented on Figure 5-4 and summarized in Table 5-1. The results are discussed in Section 5.5.

5.3.1 DPT Vertical Profiles

Numerous phases of DPT vertical profiles were conducted at AOC 75. As results were received and reviewed, additional profiles were conducted to better delineate the PFAS contamination. The DPT vertical profiles are described below, are shown on Figure 5-4, and are summarized in Table 5-1.

The RI field investigation at AOC 75 began with vertical profiles planned in the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b). The first round of vertical profiles 75VP-18-01 through -09 were conducted in October 2018 within as well as cross-gradient, upgradient, and downgradient of the suspected source area (the area impacted by the warehouse fire), to assess the nature and extent of PFAS in groundwater in this area and assess if PFAS in groundwater was contributing to the PFAS detected in Town of Ayer water supply wells at Grove Pond.

Based on the results from 75VP-18-01, -03, -04, -07, -08, and -09, there appeared to be PFAS with higher concentrations (greater than the EPA LHA) located at 75VP-18-03, -04, and -07 and lower PFAS concentrations (less than the EPA LHA) at 75VP-18-01, -08, and -09. These data indicated groundwater with higher concentrations of PFAS was located near the presumed source of the warehouse fire (75VP-18-07) and groundwater was flowing toward Cold Spring Brook based on the concentrations observed at 75VP-18-03 and -04. Based on the results observed at 75VP-18-08 and -09 (less than the EPA LHA) it appeared that groundwater from the presumed source of the warehouse fire was not flowing toward the northeast (toward the Town of Ayer Grove Pond wellfield) but rather the groundwater was flowing to the east toward Cold Spring Brook. After review of the results, five vertical profiles (75VP-18-10 through -13 and 75VP-19-01) were conducted. One location (75VP-18-10) was conducted south of 75VP-18-04 to bound the southern extent of PFAS detected at 75VP-18-04. Three locations were conducted along Barnum Road (75VP-18-11, -12, -13) to bound the PFAS downgradient of 75VP-18-03 and -04. One location (75VP-19-01) was conducted upgradient of 75VP-18-07 to bound the upgradient extent of PFAS detected at 75VP-18-07. These vertical profiles were completed in December 2018 and January 2019.

The results from 75VP-19-01 (seven sample intervals with PFAS detections above the EPA LHA) indicated that the upgradient and crossgradient extent of PFAS in groundwater was not defined. Three additional vertical profiles were conducted upgradient of 75VP-19-01 to define the extent of PFAS in groundwater. One vertical profile was crossgradient to the south of 75VP-19-01 (75VP-19-02) and two vertical profiles were conducted upgradient of 75VP-19-01 (75VP-19-03 and -04). These vertical profiles were completed in February 2019.

PFAS was detected greater than the EPA LHA at 75VP-19-02 and -04 but below the EPA LHA at 75VP-19-03. Based on these results, four vertical profiles (75VP-19-05, -06, -07, and -08) were conducted with the purpose of defining the crossgradient and upgradient extent of PFAS in groundwater at concentrations greater than the EPA LHA at AOC 75. One location (75VP-19-05) was conducted to the south of 75VP-19-02 and three locations (75VP-19-06, -07, and -08) were conducted to the west of 75VP-19-02, -03, and -04). These vertical profiles were completed in May 2019.

The results from 75VP-19-05 through -08 were reviewed. Based on results from 75VP-19-05 (one sample interval with PFAS detections above the EPA LHA) and -06 (one sample interval with PFAS detections above the EPA LHA), one additional vertical profile (75VP-19-09) was conducted. Vertical profile 75VP-19-09 was conducted southwest of 75VP-19-05 to delineate the crossgradient extent of PFAS concentrations above the EPA LHA south of 75VP-19-05 and -06. The vertical profile was completed in June 2019.

In accordance with the cover letter to the Army Responses to EPA and MassDEP Comments, *Area 1 Field Sampling Plan – Monitoring Well Plan Addendum Remedial Investigation Work Plan for PFAS* (KGS, 2019d), select drilling activities were conducted at AOC 75. Specific activities included vertical profiling at 75VP-20-01. Vertical profiling was also conducted at 75MW-19-02. These activities were conducted in December 2019 through February 2020.

5.3.2 DPT Soil Borings

The AOC 75 soil borings identified in the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b) (75SB-19-01 through -07) were drilled in January 2019. The borings were conducted in the presumed source area.

The PFAS concentrations were generally low (maximum PFOS = 1.80 µg/kg and PFOA = 0.670 µg/kg) in 75SB-19-01 through -07. Based on the results of the first soil borings, the results from vertical profile 75VP-19-01 (detections of PFAS greater than the EPA LHA at the water table), and the low PFAS concentrations (less than the EPA LHA) detected at the water table at 75VP-18-06 and -07, the data indicated that the soils to the east of the former warehouse footprint might not be a source of the higher PFAS concentrations detected in groundwater at AOC 75. The higher concentrations of PFAS at the water table at 75VP-19-01 suggest a potential source area may be located to the west of the former warehouse.

Three additional soil borings were drilled closer to 75VP-19-01. One soil boring (75SB-19-08) was conducted at 75VP-19-01. Two soil borings (75SB-19-09 and -10) were conducted in a low topographic area southeast of 75VP-19-01. A review of historical aerial photographs indicated the land between 75VP-19-01 and Saratoga St., where 75SB-19-09 and -10 were conducted, was likely not reworked after the warehouse fire in support of construction activities to the east and west. The ground surface in this area is also lower in elevation than the immediately adjacent parking lots and building. During the warehouse fire, the AFFF may have accumulated in this low area. The soil borings were completed in May 2019.

5.3.3 Monitoring Well, Piezometer Installation and Vertical Profiling with Sonic

In accordance with the cover letter to the Army Responses to EPA and MassDEP Comments, *Area 1 Field Sampling Plan – Monitoring Well Plan Addendum Remedial Investigation Work Plan for PFAS* (KGS, 2019d), select drilling activities were conducted at AOC 75. Specific activities included installation of piezometers 75VP-19-01 through -04 and 75PZ-20-01 through -07; drilling and well installation at locations 75MW-19-01, -02, and -04. Based on vertical profiling results and lithology observed during drilling of 75MW-19-02, an additional overburden well (75MW-19-02C) was installed at this location. These activities were conducted in December 2019 through February 2020.

Newly installed monitoring wells 75MW-19-01BR, 75MW-19-02A, B, C, BR, and 75MW-19-04A, B were sampled in March 2020.

5.3.4 Synoptic Water Level Event

An Area 1 synoptic water level monitoring event, that encompassed all of the AOC 75 piezometers and monitoring wells, was conducted on March 12, 2020.

5.3.5 Surface Water and Sediment Sampling

Two surface water and sediment samples were collected in Cold Spring Brook (CSB-20-02 and -03) where the AOC 75 PFAS impacted groundwater discharges to the brook. The samples were collected in accordance with the *Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS) Area 1 Field Sampling Plan Addendum No. 2*. (KGS, 2020b). The samples were collected in April 2020.

5.4 Nature and Extent

Groundwater results are presented on Figure 5-5 and in and in cross section (Figures 5-4 through 5-9). Soil sampling results are summarized on Figure 5-10. Surface water and sediment sampling results are summarized on Figure 3-18. Area and sitewide groundwater contours are presented on Figures 2-5 and 2-7. All of the results are presented in Appendix H. The discussions below are focused on results with respect to the media specific criteria (Table 1-1).

5.4.1 Groundwater in Overburden

Groundwater in the overburden at AOC 75 was characterized through three groundwater samples collected during the SI (BERS-Weston, 2018b), and during the RI via DPT vertical profiles, sonic vertical profiles, and samples from new monitoring wells. During the RI, vertical profile samples were collected from 24 locations. A total of 194 vertical profile samples were collected. Table 5-2 provides summary statistics of the results of the vertical profile samples. Of those samples, 33 samples (17%) had concentrations greater than the EPA LHA and 119 samples (61%) had concentrations greater than the GW-1 standard. Five monitoring wells were installed and sampled in the overburden. Table 5-3 provides summary statistics of the results of the monitoring well samples. Of the five monitoring wells installed and sampled in the overburden, three samples had concentrations greater than the EPA LHA and four samples had concentrations greater than the GW-1 standard. None of the concentrations were greater than the GW-3 standard (protective of surface water).

The extent of the AOC 75 PFAS contamination defined by PFAS concentrations greater than the EPA LHA are present along the same flow path, extending from the far western locations 75VP-19-04 and -06, to the site of the warehouse fire and downgradient toward 75VP-18-11 at Barnum Road and toward Cold Spring Brook. Groundwater is flowing west to east toward Cold Spring Brook. The maximum concentrations were detected at 75VP-18-07 (PFOA + PFOS = 1,400 ng/L, 62-66 ft bgs) and 75VP-19-01 at 27-31 ft bgs (2,050 ng/L, for the sum of the six GW-1 compounds). The high PFAS concentrations at 75VP-19-01 and shallow depth, combined with the proximity to the former warehouse fire, suggest that 75VP-19-01 is within the source area caused by AFFF used to extinguish the warehouse fire. The presence of PFAS upgradient of the former warehouse fire may be a result of legacy Army activities. There are numerous locations crossgradient to the north (75VP-19-18, -19-03, -18-01, -18-02, -18-05, 18-08, 18-09, 18-12, and -20-01) and to the south (75VP-19-09, -18-10, and -18-13) with PFAS concentrations less than the EPA LHA (Figure 5-5). Upgradient the extent of the PFAS defined by concentrations of the EPA LHA was defined by results at 75VP-19-07. All of the locations had at least one sample interval where PFAS concentrations were greater than the GW-1 standard.

The overburden is thin in the western portion of the site where the bedrock is shallow (75MW-19-01-BR, 26 ft bgs) and then bedrock deepens rapidly toward the east, with the maximum depth of bedrock observed at 75MW-19-02 (297 ft bgs), and then rises to the east to 95 ft bgs at 75MW-19-04. The PFAS impacted water is also thin in the western portion of the site with PFAS detected above the EPA LHA in as little as

4 (75VP-19-06) to 13 (75VP-19-04) vertical feet of the aquifer. At these same locations, PFAS was detected at concentrations greater than the GW-1 standard in all of the sample intervals, which were 22-26 to 27.8-31.8 ft bgs at 75VP-19-06 and 22-26 ft bgs to 41-40 ft bgs at 75VP-19-04.

The overburden is thicker and the PFAS plume is thicker in the area of and just downgradient of the warehouse fire at 75VP-19-01 and 75VP-18-06/75MW-19-02. At 75VP-19-01, PFAS concentrations detected greater than the EPA LHA were detected from the water table (17-21 ft bgs) to 47-51 ft bgs, at 67-72 ft bgs, and from 97-109 ft bgs. The maximum PFAS concentrations at this location were detected in the shallowest portion of the aquifer. All of the sample intervals at this location had PFAS concentrations greater than the GW-1 standard.

Just downgradient of 75VP-19-01, the PFAS plume is slightly diving in the aquifer. The downward -vertical gradients at 75MW-19-02, the deepening of PFAS concentrations greater than the EPA LHA and the GW-1 standard at 75VP-018-06 and -07 compared to 75VP-19-01, and the deepening of the high PFAS concentrations at 75VP-18-106 and -07 indicate some downward flow of the groundwater downgradient of the source area. As groundwater migrates downgradient from the general area of the warehouse fire (i.e., 75VP-19-01, 75VP-18-06 and -07), the thickness of the aquifer with PFAS concentrations greater than the EPA LHA thins. At 75VP-19-01 the overall impacted thickness of the aquifer with PFAS concentrations greater than the EPA LHA is 92 ft thick (with some lower concentrations observed in some of the middle intervals) and 54 ft at 75VP-18-06, which thins downgradient in the area of 75VP-18-03 (44 ft) and 75VP-18-04 (24 ft), and continues to thin downgradient at 75VP-18-11 (14 ft). A similar overall pattern is observed with concentrations greater than the GW-1 standard; thicker at 75VP-19-01 (17-109 ft bgs) and 75VP-18-06/75MW-19-02 (22-120 ft bgs and from 205-230 ft bgs) and thinner at Barnum Road areas, specifically at 75VP-19-11/75MW-19-04 (12-46 ft bgs) and 75VP-20-01 (13-27 ft bgs and 53-77 ft bgs).

The shallowness of the PFAS concentrations greater than the EPA LHA concentrations in the aquifer at 75VP-18-03 (203-159 ft NAVD88), -04 (190-166 ft NAVD88), and -11 (255-241 ft NAVD88) and the upward vertical gradients at 75PZ-19-01/75MW-19-04A suggest the higher PFAS concentrations in this portion of the aquifer are rising in the aquifer in response to upward vertical gradients closer to Cold Spring Brook.

5.4.2 Groundwater in Bedrock

Two wells were installed in bedrock at AOC 75. The results from both wells were below the GW-1 standard. At 75MW-19-01BR the result was 19.8 ng/L for the sum of the six GW-1 compounds. At 75MW-19-02BR the result was 2.80 ng/L for the sum of the six GW-1 compounds. The data suggest there is not a significant impact from PFAS to the groundwater in bedrock at these locations.

5.4.3 Soil

At AOC 75, three soil borings were conducted during the SI (BERS-Weston, 2018b) and ten borings were conducted during the RI. PFAS were detected at all 13 locations. The PFAS concentrations from the soil samples collected during the SI were less than the S-1/GW-1 standards. At nine of the borings conducted during the RI, PFAS concentrations were less than the S-1/GW-1 standards. PFAS was detected at concentrations above the S-1/GW-1 standards at one location (75SB-19-09) in the shallowest sample (0-0.5 ft bgs). The PFAS concentrations greater than the S-1/GW-1 standards included PFDA detected at 0.560 µg/kg, PFNA detected at 0.420 J µg/kg, PFOS detected at 2.00 µg/kg, and PFOA detected at 1.2 µg/kg. Presently low concentrations of PFAS compounds are present in the soil. During the fire, much of the AFFF may have flowed into the storm drains at the site and either discharged to the groundwater via breaks in the storm drain or directly into Cold Spring Brook.

5.4.4 Surface Water and Sediment

All of the detections in surface water and sediment in Cold Spring Brook were below the EPA SSSLs for PFAS at former Fort Devens (Table 1-1). The sampling locations and data are summarized on Figure 3-18 and the data are presented in Appendix H.

Two surface water and sediment samples (CSB-20-02 and -03) were collected where AOC 75 groundwater discharges to Cold Spring Brook (Figure 3-18, 5-4). The PFOA concentrations in the surface water ranged from 22.0 ng/L to 28.0 ng/L, the PFOS concentrations ranged from 33.0 ng/L to 41.0 ng/L, and the PFBS concentrations ranged from 3.30 ng/L to 4.30 ng/L.

PFAS compounds were detected in the surface water upstream (CSB-18-01) (Figure 7-9) of where AOC 75 is discharging suggesting there are other PFAS impacts to Cold Spring Brook upstream of AOC 75. PFAS was detected in surface water downstream (CSB-18-02) of where AOC 75 is discharging but at lower concentrations than at CSB-20-02 and -03. The data indicates there is a limited area of higher PFAS concentrations in the brook, resulting from PFAS impacted groundwater discharging to the brook, and the PFAS impacted surface water at AOC 75 mixes with other surface water inputs resulting in lower concentrations downstream.

In the sediment samples, PFAS compounds where only detected in CSB-20-02. The PFOS concentration was 4.40 µg/kg, the PFOA concentration was 1.10 µg/kg, and PFBS was not detected. PFOA was detected in sediment upstream (CSB-18-01 PFOA = 2.50 J µg/kg) and downstream (CSB-18-02 PFOA = 0.630 J µg/kg) of CSB-20-02.

6.0 GROVE POND AREA PRELIMINARY SITE CHARACTERIZATION SUMMARY

6.1 Site Description

The Grove Pond Area includes the Town of Ayer Grove Pond wellfield and areas upgradient of the wellfield. The Town of Ayer operates the wellfield on the south shore of Grove Pond as part of the town municipal water supply. There are five supply wells on the south shore of Grove Pond. The screen for Well 1 is set at 42 to 62 ft bgs, Well 2 is 42 to 62 ft bgs, Well 6 is 47 to 57 ft bgs, Well 7 is 56 to 71 ft bgs, and Well 8 is 60 to 73 ft bgs. The wells are operated as they are needed with generally two to three wells operated at a time. In 2019, the approximate flow rates for the wells were 450 gallons per minute (gpm) for Well 1, 250 gpm for Well 6, 275 gpm for Well 7, and 230 gpm for Well 8. Upgradient of the Town of Ayer property is Massachusetts Army National Guard property (outside of the former Fort Devens boundary) and the Army retains property south of the MAARNG property. Most of the area is developed. MassDevelopment retains a small portion of property in the area that is zoned Open Space/Recreational.

The MAARNG property is home to the Consolidated Support Maintenance Shop (CSMS), the Annex, and a recruiting office. The MAARNG CSMS facility functions as a motor vehicle maintenance, repair, rebuilding, and cannibalization facility.

Overall, the MAARNG property and Army property west of MAARNG property is generally flat with little change in ground surface elevation (generally 247 to 250 ft NAVD88). East of the developed portion of the MAARNG property, the land is sloped downward to Grove Pond where the shoreline is approximately 220 ft NAVD88.

6.2 Facility History and Utilities

The MAARNG property has been used primarily for vehicle maintenance and storage for its entire history. The facility currently and previously has relied on former Fort Devens fire department for support. There was reportedly a fire in a warehouse in the western portion of the facility in the early 1960's. It is unknown if AFFF was used to extinguish the fire, but due to the early date, it is unlikely. There are no other known use, storage, or disposal of AFFF at the MAARNG property.

The current and previous subsurface features are shown on Figures 4-2 and 4-3. The historic storm sewer system drained paved and unpaved areas and had numerous discharge points to Cold Spring Brook. The system was revised and there are numerous detention pond areas across the area.

6.3 Remedial Status

The Town of Ayer operates the wellfield on the south shore of Grove Pond as part of the town municipal water supply. There are five supply wells on the south shore of Grove Pond. The Town of Ayer was operating Wells 6, 7, and 8 in September 2016 and the combined flow from the wells is treated at a facility to reduce concentrations of metals. The Town of Ayer first sampled the supply wells and the combined flow after treatment in September 2016. The results indicated PFAS was present in the flow from all three wells with the highest concentrations from Well 8. The sum of the PFOS and PFOA concentrations from Well 8 exceeded the LHA. The supply wells and the combined flow after treatment were sampled on a quarterly basis since September 2016.

On February 26, 2018, the Town of Ayer discontinued use of Well 8 as a water supply well after MassDEP informed them that MassDEP was considering adopting recommendations addressing five PFAS chemicals (PFOS, PFOA, PFNA, PFHxS, and PFHpA) at a sum of 70 ng/L. Well 8 was pumped at a reduced rate of 150 to 200 gpm and the water was discharged to Grove Pond rather than contributing to the town drinking water supply. The Town of Ayer supplemented the water supply by reinitiating use of Well 1 (Town of Ayer, 2018).

The Army wrote an action memorandum to document the approval and decision to conduct a time-critical removal action (TCRA) in response to the release of PFOS and PFOA from operations associated with the former Fort Devens (USACE, 2019). The removal action objective for the TCRA is to prevent unacceptable risk to human health posed by PFOS/PFOA in groundwater migrating or likely migrating toward public drinking water supply wells through removal of PFOS/PFOA from water pumped by the Town of Ayer Grove Pond Public Water Supply Wells. The proposed actions are:

- Eliminate the current discharge of extracted groundwater with PFOS/PFOA from Grove Pond Well 8 into Grove Pond by installing a temporary treatment system that will reduce PFOS/PFOA from the extracted water. The treated water from Grove Pond Well 8 will then be returned to the Town of Ayer Grove Pond Treatment Facility.
- Install a drinking water treatment system to address PFOS/PFOA in Grove Pond public drinking water supply wells to ensure combined PFOS/PFOA levels in drinking water are below 70 ppt.

The Well 8 temporary treatment system was installed in June 2019. The permanent upgrade to Grove Pond water treatment plant to address PFOS/PFOA is anticipated to be completed in June 2020.

6.4 PFAS Field Investigation

The Grove Pond area RI field investigation included sampling of existing monitoring wells, collection of surface water and sediment samples, groundwater vertical profiling using DPT, soil borings, installation of piezometers and monitoring wells, groundwater vertical profiling and soil borings using rotosonic drilling, sampling of new monitoring wells, and synoptic water level measurements. The work was completed in general accordance with the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b). Field activities were added as the data was received and reviewed. Sampling locations are presented on Figure 6-1 and summarized in Table 6-1. The results are discussed in Section 6.5.

6.4.1 Existing Wells

Groundwater samples were collected from existing monitoring wells in the Grove Pond area in September 2018 in accordance with the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b). One well was blocked with equipment (92-5) and one was bent (92-2); neither well could be sampled.

6.4.2 Surface Water and Sediment

Surface water and sediment samples were collected in Grove Pond in accordance with the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b) in September 2018 and Balch Pond in December 2018.

6.4.3 DPT Vertical Profiles

Numerous phases of DPT vertical profiles were conducted at the Grove Pond area. As results were received and reviewed, additional profiles were conducted to better delineate the PFAS contamination. The DPT vertical profiles are described below, are shown on Figure 6-1, and are summarized in Table 6-1.

The initial set of vertical profiles at the Grove Pond area (GPVP-18-01 through -12) were conducted from October 2018 through March 2019 as planned in the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b). The initial set of vertical profiles were located in all directions around the Grove Pond wellfield because the source of PFAS to these wells was unknown.

Of the initial set of vertical profiles, locations GPVP-18-07, -08, -09, -10, -11 were drilled in October and November 2018. Based on results from those vertical profiles and results from the existing wells it appeared the area with higher PFAS concentrations included MNG-3R and west of GPVP-18-08. Two additional transects of vertical profiles for a total of ten additional vertical profiles were conducted upgradient of the

GPVP-18-08, -09, -10, -11. Those vertical profiles (GPVP-19-01 through -10) were conducted in January 2019.

The results of some of the second set of vertical profiles, specifically GPVP-19-06, -07, -08, -09, and -10 indicated that the extent of the PFAS in groundwater greater than the EPA LHA was mostly limited to the MAARNG. The results from GPVP-19-08 were above the EPA LHA, which indicated that the extent of PFAS in groundwater at concentrations above the EPA LHA was not defined in that area. Based on those results, two additional vertical profiles (GPVP-19-11 and -12) (the third set of vertical profiles) were conducted in February 2019.

Based on discussions during the March 25, 2019 BRAC Cleanup Team meeting, three additional vertical profiles around GPVP-18-12 were proposed. These locations GPVP-19-13, -14, and -15 (fourth set of vertical profiles), were selected with regulatory agency input. The purpose of these additional vertical profiles was to better define the extent of PFAS in groundwater at locations upgradient, crossgradient and downgradient of the PFAS contamination observed at GPVP-18-12. These vertical profiles were conducted in April and May 2019.

6.4.4 DPT Soil Borings

The nine soil borings at the Grove Pond area (GPSB-19-01 through -09) were conducted in July 2019. The soil boring locations were selected based on review of the groundwater vertical profile results, review of historical documents, and review of historical aerial photography.

6.4.5 Monitoring Well, Piezometer Installation and Vertical Profiling with Sonic

In accordance with the cover letter to the Army Responses to EPA and MassDEP Comments, *Area 1 Field Sampling Plan – Monitoring Well Plan Addendum Remedial Investigation Work Plan for PFAS* dated October 8, 2019 (KGS, 2019d), select drilling activities were conducted at the Grove Pond area. Specific activities included vertical profiling at GPMW-19-01; piezometer GPPZ-19-01 was installed; and monitoring wells GPMW-19-01A and BR were installed. These activities were commenced in December 2019 and concluded in February 2020.

The newly installed monitoring wells were sampled for PFAS in March 2020.

6.4.6 Synoptic Water Level Surveys

A Grove Pond synoptic water level event was conducted on October 2, 2018 (Figure 2-2).

An AOC 74/Grove Pond area synoptic water level event was conducted on March 19, 2019 (Figure 2-3).

An Area 1 synoptic water level monitoring event, that encompassed all of the Grove Pond area piezometers and monitoring wells, was conducted on March 12, 2020 (Figure 2-5 and 2-6).

6.5 Nature and Extent

Groundwater results are presented on Figure 6-2 and in and in cross section (Figures 6-3 through 6-7). Soil sampling results are summarized on Figure 6-8. Surface water and sediment sampling results are summarized on Figure 6-9. Area and sitewide groundwater contours are presented on Figures 2-3, 2-4, 2-5 and 2-6. All of the results are presented in Appendix H. The discussions below are focused on results with respect to the media specific criteria (Table 1-1).

6.5.1 Groundwater in Overburden

Groundwater in the overburden in the Grove Pond area was characterized through sampling of existing monitoring wells, via DPT vertical profiles, sonic vertical profiles, and samples from new monitoring wells. Vertical profile samples were collected from 28 locations. A total of 208 vertical profile samples were collected. Table 6-2 provides summary statistics of the results of the vertical profile samples. Of those samples, 41 samples (20%) had concentrations greater than the EPA LHA and 129 samples (62%) had concentrations greater than the GW-1 standard. A total of the 13 samples were collected from existing and new monitoring wells sampled in the overburden. Table 6-3 provides summary statistics of the results of the monitoring well samples. Six samples had concentrations greater than the EPA LHA and nine samples had concentrations greater than the GW-1 standard. None of the concentrations were greater than the GW-3 standard (protective of surface water).

The extent of PFAS detected at concentrations greater than the EPA LHA covers a broad area covering most of the MAARNG property. AOC 74 PFAS contamination appears to cross the MAARNG property on the east side as groundwater migrates toward Grove Pond and the Town of Ayer Grove Pond wellfield. The extent is bounded by lesser concentrations to the south (upgradient) by results from locations GPVP-19-06, -07, -11, -12, and -09, to the west (crossgradient) by results from locations GPVP-19-06 and -10), and the AOC 74 and Grove Pond area contamination is bounded on the east (crossgradient) by results from locations 74VP-19-02, GPVP-18-06, -06, -07, CSMS-11-02. The downgradient extent is undefined as the groundwater migrates toward Grove Pond and the Town of Ayer Grove Pond wellfield. PFAS was not detected at concentrations greater than the EPA LHA on the north side of Grove Pond. Most of the locations had at least one sample interval where PFAS concentrations were greater than the GW-1 standard. Lower concentrations were detected in the overburden, in the eastern portion at 74VP-19-02, CSMS-11-02, north of Grove Pond at GPVP-18-04, and at a few wells within the Town of Ayer Grove Pond wellfield (i.e., 92-1 and GF-4).

North of Grove Pond the PFAS concentrations are fairly low with the maximum concentration detected at GPVP-18-03 (31.3 ng/L, sum of the six GW-1 compounds). These data suggest the groundwater north of Grove Pond is impacted by PFAS. Groundwater flow in this area is toward Grove Pond (Gannett Fleming, Inc., 2002).

As described in Section 4.4.1, PFAS impacted water from AOC 74 is flowing north along the eastern side of the Grove Pond Area toward Grove Pond, specifically water at 74VP-18-12, GPVP-19-05, and likely GPVP-18-08. West of these locations, it appears a broad portion of the shallow to mid-portion of the aquifer has been impacted by activities on the MAARNG property and legacy Army activities that may have occurred on the Army property to the south. The highest PFAS concentrations in this area were detected at GPVP-19-12 (PFOA + PFOS = 919 ng/L and 1,160 ng/L, sum of six GW-1 compounds). The distribution of PFAS in the Grove Pond Area covers a broad area and specific source areas have not been identified. The overall groundwater flow is toward Grove Pond and it appears PFAS impacted groundwater south of the Town of Ayer Grove Pond wellfield is entering the water supply wells.

In the upgradient (southern) portion, the PFAS concentrations greater than the EPA LHA were detected in the shallowest one or two sample intervals (GPVP-19-08, -01, -02, -03, and -04) with lesser concentration deeper in the aquifer, suggesting a local source. A similar pattern was observed with PFAS concentrations compared to the GW-1 standard; the higher concentrations were detected in the shallower sample intervals. Except at GPVP-19-07, the deepest sample intervals had PFAS concentrations less than the GW-1 standard with some intervals non-detect for the six compounds in the GW-1 standard.

The area closest to Grove Pond had the greatest variability in PFAS concentrations in groundwater. A larger portion of the aquifer had PFAS concentrations greater than the EPA LHA, the highest concentrations were not always detected at the water table, and the highest PFAS concentrations were detected in this area. In this western area around GPVP-18-12 and GPVP-19-15, PFAS was detected at concentrations greater than the EPA LHA throughout most of the aquifer. The lowest concentrations (below the EPA LHA) were still detected in the deepest sample intervals.

East of this area at GPVP-18-11, PFAS was only detected at concentrations greater than the EPA LHA (shallowest sample interval) and GW-1 standard (in the shallowest two sample intervals) with the eight deepest sample intervals (82 feet thick) with very low PFAS concentrations (below 10.2 ng/L, sum of the six GW-1 compounds) or non-detect.

East of GPVP-19-11 a slightly different pattern of PFAS in the groundwater is observed at GPVP-18-09 and -10. The highest PFAS concentrations and the concentrations greater than the EPA LHA are detected in the shallower portion of the aquifer (top 50 feet) but the maximum concentrations are not at the water table. Concentrations decrease with depth, but more intervals have PFAS concentrations greater than the GW-1 standard. At GPVP-19-09, there was a deep sample with PFOA+PFOS = 70.0 ng/L (178 ng/L, sum of the six GW-1 compounds) at 142-146 ft bgs and similar, deep detections at GPVP-18-10 (PFOA + PFOS = 56.7 ng/L and 150 ng/L, sum of the six GW-1 compounds) at 131-135 ft bgs. Both of these samples appear to have been collected from a portion of the aquifer that had more clay and the PFAS might have absorbed to the clay or the PFAS in groundwater might not be moving as fast as in the surrounding higher conductivity units. But a deeper sample, just above bedrock from GPMW-19-01 (146-151 ft bgs) was non-detect for PFOA and PFOS and the six compounds in the GW-1 standard.

6.5.2 Groundwater in Bedrock

There are three wells installed in bedrock in the Grove Pond Area, GF-1, GF-2, and GPMW-19-01BR. The results from all three wells were below the GW-1 standard. At GF-1 the result was 7.58 ng/L for the sum of the six GW-1 compounds. At GF-2 the result was 4.10 ng/L for the sum of the six GW-1 compounds. At GPMW-19-01BR the result was 0.620 ng/L for the sum of the six GW-1 compounds. The data suggest there is not a significant impact from PFAS to the groundwater in bedrock at these locations.

6.5.3 Soil

At the Grove Pond Area, nine soil borings were advanced to a maximum depth of 38 ft bgs. PFAS were detected at all nine locations sampled. Five of the locations (GPSB-19-01, -02, -05, -07, and -08) had one or more sample intervals with detections of PFAS compounds greater than the S-1/GW-1 standards (Figure 6-8, Appendix H). Four of the locations (GPSB-19-03, -04, -06, and -09) had concentrations of PFAS compounds lower than the S-1/GW-1 standards. All six PFAS compounds in the S-1/GW-1 standards were detected at concentrations above the S-1/GW-1 standards (Figure 6-8, Appendix H). Three locations (GPSB-19-01, -05, and -08) had PFAS detected at concentrations greater than the S-1/GW-1 standards in all samples collected from each location with exceedances as deep as 28 feet below grade. The maximum concentrations of the six PFAS compounds in the S-1/GW-1 standards detected in the Grove Pond area are below:

- PFDA = 32.0 µg/kg at GPSB-19-08
- PFHpA = 2.00 µg/kg at GPSB-19-05
- PFHxS = 0.390 µg/kg at GPSB-19-01
- PFNA = 3.60 µg/kg at GPSB-19-08
- PFOS = 29.0 µg/kg at GPSB-19-08
- PFOA = 15.0 µg/kg at GPSB-19-05

All of the samples with PFAS concentrations greater than the S-1/GW-1 standards were collected on MAARNG property at five different locations around the property. These data suggest there are potential sources of PFAS in the soil within the MAARNG property.

6.5.4 Surface Water and Sediment

Six locations were sampled for surface water and sediment in Balch and Grove ponds. All concentrations were below the EPA SSSLs for PFAS at former Fort Devens (Table 1-1). The PFAS concentrations were fairly consistent across the different locations in Grove Pond. PFOA concentrations in surface water ranged from 7.50 ng/L to 10.0 ng/L, and PFOS concentrations ranged from 3.30J ng/L to 4.00 ng/L. None of the PFAS compounds in the EPA SSSLs were detected in sediment samples collected from Grove Pond. The PFOA and PFOS in surface water in Balch Pond was slightly higher at 16.0 ng/L and 6.50 ng/L, respectively. Also, PFOA was detected in the sediment sample from Balch Pond (0.160J ng/L). Balch Pond is hydraulically upgradient from Devens (not affected by conditions at Devens) and drains into Grove Pond from the north.

7.0 PATTON WATER SUPPLY WELL AREA AND AOC 40 PRELIMINARY SITE CHARACTERIZATION SUMMARY

7.1 Site Description

MassDevelopment operates the Patton water supply well as part of the Devens municipal water supply. The Patton well screen is set at 61 to 83 ft bgs and is operated at 330 gpm. The well is located just south of Patton Road, north of Mirror Lake (Figure 7-1).

AOC 40 was first identified for investigation of PFAS based on results from vertical profiling around the Patton water supply well. AOC 40 is located along the edge of Patton Road just east of Patton water supply well. AOC 40 consists of an abandoned landfill that was remediated in 2000 through the removal of debris, contaminated soil, and contaminated sediment (KGS, 2019a).

AOC 40 is part of the remediated Cold Spring Brook Pond. North of the pond is a steep wooded slope on top of which is a portion of Red Tail Golf Course (300 to 315 ft NAVD88), approximately 55 to 70 feet higher than the pond (approximately 245 ft NAVD88) (Figure 7-2). South of AOC 40 is Patton Road and further south is another steep wooded slope up to another portion of the Red Tail Golf Course (315 ft NAVD88). To the east, Cold Spring Brook Pond empties to Cold Spring Brook under Patton Road. Cold Spring Brook continues to flow to the north. West of AOC 40, the land is owned by the Red Tail Golf Course and is currently undeveloped.

Patton well is located on property owned by MassDevelopment. North of Patton Road the land is owned by the Red Tail Golf Course and is undeveloped. To the east of Patton well, the land is sloped steeply upward to portions of the Red Tail Golf Course. To the south and west of Patton well, the land is owned by MassDevelopment, it is undeveloped, and there are steep hills between the well and Mirror Lake to the south. All of the land around Patton well and AOC 40 is zoned as Open Space/Recreational.

7.2 Facility History and Utilities

AOC 40 consists of an abandoned landfill that was remediated in 2000 through the removal of debris, contaminated soil, and contaminated sediment (KGS, 2019a). The impacted area was approximately four acres and was used for the disposal of construction debris (masonry, asphalt, wire, and metal), ash, stumps, and logs (KGS, 2019a). AOC 40 was estimated to contain 110,000 cubic yards of debris. Portions of the landfill area were situated in a wetland and were subsequently submerged under Cold Spring Brook Pond. The abandoned landfill was discovered in November 1987, when drums were uncovered along Cold Spring Brook. An identification number on the drums indicated that the original contents had been antifreeze manufactured by Union Carbide and that they were 15 to 20 years old. Apparently, the drums had been painted yellow and reused. In March 1988, the drums were examined by a response team from Union Carbide, New Hampshire (E&E, 1993). A RI was completed in 1993 (E&E, 1993).

A ROD was issued in July 1999 (HLA, 1999). The selected remedial alternative (Alternative 4c) required full excavation of AOC 40, with on-site consolidation or off-site disposal options. In a separate evaluation after the ROD was issued, an evaluation of on-site versus off-site disposal options was conducted and disposal of the remedial debris in an on-site landfill to be built at the former golf course driving range on Patton Road was chosen (S&W, 2000). Excavation activities at AOC 40 began in November 2000 and were completed in September 2002. A total of 148,450 cubic yards of debris was removed from AOC 40 and disposed of at the Devens Consolidation Landfill, which was constructed to accommodate excavated material from numerous removal areas within Devens.

The current and previous subsurface features in the area are shown on Figures 7-2 and 7-3.

7.3 Remedial Status

MassDevelopment first sampled the Patton well for PFAS in July 2016. The well was taken out of service in August 2019 after MassDEP informed MassDevelopment that MassDEP is proposing a standard for drinking water addressing six PFAS (PFOS, PFOA, PFNA, PFHxS, PFHpA, and PFDA) at a sum of 20 ng/L.

MassDevelopment installed temporary treatment for PFAS at the Patton well and brought the well back into service in March 2020. MassDevelopment is planning a permanent treatment system of granular activated carbon (GAC) followed by ion exchange that would treat water from Patton and Shabokin wells. MassDevelopment is also planning permanent treatment for iron and manganese using green sand filters. The permanent treatment plant for Patton and Shabokin water supply wells is planned to be online in early 2022.

At AOC 40, the remedial excavation activities at AOC 40 began in November 2000 and were completed in September 2002.

7.4 PFAS Field Investigation

The RI field investigation at Patton well area/AOC 40 included DPT groundwater vertical profiling, piezometer installation, soil borings using DPT, collecting surface water and sediment samples in Cold Spring Brook Pond and Cold Spring Brook, and synoptic water level measurements. The methods used to complete the work are detailed in the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b). Field activities were added as the data was received and reviewed. Sampling locations are presented on Figure 7-4 and summarized in Table 7-1. The results are discussed in Section 7.5.

7.4.1 DPT Vertical Profiles

Numerous phases of DPT vertical profiles were conducted at the Patton Well area/AOC 40. As results were received and reviewed, additional profiles were conducted to better delineate the PFAS contamination. The DPT vertical profiles are described below, are shown on Figure 7-4, and are summarized in Table 7-1.

An initial series of eight vertical profiles (PWVP-19-01 through -08) was conducted in May and June 2019. The vertical profiles were sited based on review of historical aerial photography and were located west, north, and east of the Patton well. The locations were chosen focusing on groundwater coming to Patton well from areas of previous Army activities and locations bounding those areas.

Results from the initial series of vertical profiles indicated greater impact to groundwater from PFAS at PWVP-19-04 (607 ng/L, sum of the six GW-1 compounds) and at PWVP-19-06 (109 ng/L, sum of the six GW-1 compounds) compared to other locations. In accordance with *Final Area 2 Field Sampling Plan Area of Contamination 40 Addendum, Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances* (KGS, 2020a), six additional vertical profiles (PWVP-19-09 through -13 and PWVP-20-01) were conducted to gather additional information on the nature and extent of PFAS in groundwater around AOC 40. The vertical profiles PWVP-19-09 through -13 were conducted in October and November 2019. Vertical profile PWVP-20-01 was conducted in February 2020.

7.4.2 DPT Soil Borings

The four soil borings at AOC 40 were conducted in November 2019 and March 2020. The soil boring locations were selected based on review of the groundwater vertical profile results and review of historical documents. The borings were conducted in accordance with the *Final Area 2 Field Sampling Plan Area of Contamination 40 Addendum, addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances* (KGS, 2020a).

7.4.3 Piezometer and Staff Gauge Installation

Four staff gauges were installed (Cold Spring Brook, Cold Spring Brook Pond, Mirror Lake, pond northwest of Patton well) in accordance with the *Final Area 2 Field Sampling Plan Area of Contamination 40 Addendum, addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances* (KGS, 2020a). The staff gauges were installed in December 2019 and March 2020.

A series of piezometers (PWPZ-19-01 through -10 and PWPZ-20-01) were installed in accordance with the *Final Area 2 Field Sampling Plan Area of Contamination 40 Addendum, addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances* (KGS, 2020a). The installation effort was started in October 2019 and was complete in March 2020. During two failed attempts at installation of PWPZ-19-04, water was not encountered during installation but PWPZ-19-04 was successfully installed at a third location.

7.4.4 Synoptic Water Level Surveys

A synoptic water level event was conducted on January 2-3, 2020 (Figure 2-8). A separate Area 1 synoptic water level monitoring event, that encompassed all of the area piezometers and monitoring wells, was conducted on March 13, 2020 (Figure 2-9).

7.4.5 Surface Water and Sediment

Three surface water and sediment samples were collected in Cold Spring Brook Pond and one sample was collected in Cold Spring Brook (Figure 7-4, Table 7-1). The samples were collected in accordance with *Final Area 2 Field Sampling Plan Area of Contamination 40 Addendum, addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances* (KGS, 2020a). The samples were collected in March 2020. The results are discussed in Section 7.5.

7.4.6 Irrigation Well Sampling

A sample was collected from the outflow of the irrigation well. The sample was collected in April 2020. The results are discussed in Section 7.5.

7.5 Nature and Extent

Groundwater results are presented on Figure 7-5 and in and in cross section (Figures 7-6 and 7-7). Soil sampling results are summarized on Figure 7-8. Surface water and sediment sampling results are summarized on Figure 7-11. Groundwater contours are presented on Figures 2-8 and 2-9. All of the results are presented in Appendix H. The discussions below are focused on results with respect to the media specific criteria (Table 1-1).

7.5.1 Groundwater

Groundwater in the Patton well area/AOC 40 was characterized through vertical profiles. Four vertical profile locations had PFAS concentrations greater than the EPA LHA, 11 locations had PFAS concentrations greater than the GW-1 standard, and three locations had PFAS concentrations less than the GW-1 standard. A total of 84 vertical profile samples were collected. Table 7-2 provides summary statistics of the results of the vertical profile samples. Of those samples, eight samples (10%) had concentrations greater than the EPA LHA and 42 (50%) samples had concentrations greater than the GW-1 standard. None of the concentrations were greater than the GW-3 standard (protective of surface water).

The maximum concentrations were detected at PWVP-19-04 at the water table (PFOA + PFOS = 394 ng/L, sum of the six GW-1 compounds + 607 ng/L, 22-26 ft bgs). The highest concentrations were detected at PWPV-19-04 and -13 west of Cold Spring Brook Pond and at PWVP-19-06 and -11 east of Cold Spring Brook Pond. Based on the AOC 40 RI, groundwater on the west side of Cold Spring Brook Pond is flowing west toward Patton well and groundwater on the east side of Cold Spring Brook Pond is flowing to the east toward Cold Spring Brook. Locations to the north and south of the highest concentrations were less than the EPA LHA. Specifically, PWVP-19-05, -03, -09 and -10 and the irrigation well to the north of Cold Spring Brook Pond and locations PWVP-20-01, PWVP-19-07, and -12 to the south of Cold Spring Brook Pond.

The vertical portion of aquifer with PFAS concentrations greater than the EPA LHA is thickest at PWVP-19-04 with PFAS concentrations greater than the EPA LHA detected from the water table (22-26 ft bgs) to 92-96 ft bgs (although not continuously detected at concentrations above the EPA LHA) and PFAS concentrations greater than the GW-1 standard detected in every sample interval from the water table to the end of the boring at 106 ft bgs. Downgradient of PWVP-19-04 at PWVP-19-13, the thickness of the aquifer with PFAS concentrations greater than the EPA LHA is thinner (only one sample interval 73-77 ft bgs) but PFAS was detected at concentrations above the GW-1 standard in almost every sample interval at from 43-47 ft bgs to 102-106 ft bgs. To the east of Cold Spring Brook Pond the thickness of the aquifer with higher PFAS concentrations thins at PWVP-19-06 with only sample interval with concentrations greater than the EPA LHA (37-41 ft bgs) and only 40 feet of the aquifer (7-11 ft bgs to 37-41 ft bgs) with PFAS concentrations greater than the GW-1 standard. The thinning of the portion of the aquifer with higher PFAS concentrations continues downgradient at PWVP-19-11 (only one sample interval with PFAS concentrations greater than the EPA LHA and two sample intervals with PFAS concentrations greater than the GW-1 standard).

To the west of the Patton well where groundwater is flowing to the east, PFAS was not detected at concentrations greater than the EPA LHA and was detected at concentrations above the GW-1 standard in multiple sample intervals. To the northwest at PWVP-19-01 and -08, both locations had only three sample intervals and all samples had concentrations greater than the GW-1 standard, with a maximum concentration of 82.4 ng/L (PWVP-19-08, 23-27 ft bgs). Closer to Patton well the overburden is thicker and the thickness of the aquifer with PFAS concentrations greater than the GW-1 standard varied from 14 feet at PWVP-19-05 (maximum 25.2 ng/L, sum of the six GW-1 compounds), to 34feet at PWVP-19-02 (maximum 36.2 ng/L, sum of the six GW-1 compounds), to 52 feet at PWVP-19-03 (maximum 37.9 ng/L, sum of the six GW-1 compounds).

7.5.2 Soil

At AOC 40, four soil borings were advanced to a maximum depth of 21.5 ft bgs. Three of the locations had one or more sample intervals with detections of PFAS compounds greater than the S-1/GW-1 standards (Figure 7-8, Appendix H). At PWXB-19-04, PFAS compounds were not detected at concentrations greater than the S-1/GW-1 standards. Five of the PFAS compounds with S-1/GW-1 standards were detected at concentrations above the S-1/GW-1 standards. The locations west of the debris removal area at AOC 40 had lower PFAs concentrations and only one sample had PFDA at a concentration that was greater than the S-1/GW-1 standards. The two soil borings east of the debris removal area only had one soil sample collected at each location due to the shallow water table. The maximum concentrations of the five PFAS compounds with concentrations above the S-1/GW-1 standards detected at AOC 40 are below:

- PFDA = 0.630J µg/kg at PWSB-19-03
- PFHxS = 1.70 µg/kg at PWSB-19-03
- PFNA = 0.510J µg/kg at PWSB-19-03
- PFOS = 4.30 µg/kg at PWSB-19-02
- PFOA = 1.30 µg/kg at PWSB-19-03

These data suggest there are potential sources of PFAS in the soil east of the debris removal area at AOC 40.

7.5.3 Surface Water and Sediment

All of the detections in surface water and sediment in Cold Spring Brook, Cold Spring Brook Pond, and Mirror Lake were below the EPA SSSLs for PFAS at former Fort Devens (Table 1-1). The sampling locations and data are summarized on Figure 7-9 and the data are presented in Appendix H.

Three surface water and sediment samples were collected in Cold Spring Brook Pond, one in the upper reaches of Cold Spring Brook (sampling in the lower reaches of Cold Spring Brook are discussed in Sections 3, 4, and 5), and one in Mirror Lake. The PFOA concentrations in the surface water in Cold Spring Brook Pond ranged from 57.0 ng/L to 67.0 ng/L, the PFOS concentrations ranged from 5.50 ng/L to 7.70 ng/L, and the PFBS concentrations ranged from 1.80 ng/L to 2.60 ng/L. The PFOA and PFOS concentrations were lower in Cold Spring Brook (PFOA = 8.60 ng/L, PFOS = 2.20J ng/L), and the PFBS concentrations were higher in the brook (PFBS = 3.20 ng/L). The higher PFAS concentrations in Cold Spring Brook Pond compared to Cold Spring Brook, suggest a potential source of PFAS in the vicinity of Cold Spring Brook Pond.

The PFAS concentrations in Mirror Lake surface water were PFOA = 12.0 ng/L, PFOS = 11.0 ng/L, PFBS = 1.10J ng/L.

In the sediment samples, PFAS compounds were also detected at higher concentration in the Cold Spring Brook Pond versus the Cold Spring Brook location. The maximum PFOS concentration was 1.00J µg/kg (CP-20-01), the maximum PFOA concentration was 0.400 µg/kg (CP-20-01), and PFBS was not detected in any of the four locations.

There were no detections of PFAS in the sediment sample collected from Mirror Lake.

8.0 SHABOKIN WATER SUPPLY WELL AREA PRELIMINARY SITE CHARACTERIZATION SUMMARY

8.1 Site Description

MassDevelopment operates the Shabokin water supply well as part of the Devens municipal water supply. The well is located south of Mirror Lake (Figure 8-1). The well screen is set at 55 to 85 ft bgs and is operated at 500 gpm.

Shabokin well is located on property owned by MassDevelopment, is undeveloped, and is zoned Open Space/Recreational. The land south and west of the Shabokin well is generally flat, but the land north and east has steep hills and farther north is Mirror Lake.

8.2 Facility History and Utilities

MassDevelopment first sampled the Shabokin well for PFAS in July 2016.

The current and previous subsurface features in the area are shown on Figures 8-2 and 8-3.

8.3 Remedial Status

MassDevelopment installed a GAC treatment system at the Shabokin well to remove PFAS in September 2019. MassDevelopment is planning a permanent treatment system of GAC followed by ion exchange that would treat water from Patton and Shabokin wells. MassDevelopment is also planning permanent treatment for iron and manganese using green sand filters. The permanent treatment plant for Patton and Shabokin water supply wells is planned to be online in early 2022.

8.4 PFAS Field Investigation

The RI field investigation at Shabokin well area included DPT groundwater vertical profiling, piezometer installation, monitoring well installation, sampling of the new monitoring well, and synoptic water level measurements. The methods used to complete the work are detailed in the *Area 1 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018b) and *Area 1 Field Sampling Plan – Monitoring Well Plan Addendum Remedial Investigation Work Plan for PFAS* (KGS, 2019b). Surface water and sediment were sampled, and a staff gauge was installed at Mirror Lake and are addressed as part of the Patton well area. Field activities were added as the data was received and reviewed. Sampling locations are presented on Figure 8-4 and summarized in Table 8-1. The results are discussed in Section 8.5.

8.4.1 DPT Vertical Profiles

Two phases of DPT vertical profiles were conducted at the Shabokin well area. As results were received and reviewed, additional profiles were conducted to better delineate the PFAS contamination. The DPT vertical profiles are described below, are shown on Figure 8-4, and are summarized in Table 8-1.

An initial series of five vertical profiles (SWVP-19-01 through -05) was conducted in May and June 2019. The vertical profiles were sited based on review of historical aerial photography and were located west and east of the Shabokin well. The locations were chosen focusing on groundwater coming to the Shabokin well from areas of previous Army activities. Water was not encountered at vertical profile SWVP-19-02.

Results from the initial series of vertical profiles indicated a greater impact of PFAS in groundwater was located to the southwest of the Shabokin well at SWVP-19-04 and to the north at SWVP-19-01. Five additional vertical profiles (SWVP-19-06, SWVP-20-01 through -04) were conducted to gather additional information on the nature and extent of PFAS in groundwater west and north of the Shabokin well. Vertical profile SWVP-19-06 was conducted in October 2019 and vertical profiles SWVP-20-01 through -04 were conducted in February 2020. Water was not encountered at vertical profiles SWVP-20-01 and -02.

8.4.2 Piezometers and Monitoring Well

A series of six piezometers (SWPZ-19-01 through -04, SWPZ-20-01 and -02) were planned to be installed across the Shabokin well area. Water was not encountered when drilling SWPZ-19-02 and thus a piezometer was not installed. The installation effort was started in October 2019 and was complete in February 2020.

Based on the lack of water encountered during drilling vertical profile SWVP-20-02, subsequent drilling was conducted at this location using MacroCore to collect soils to bedrock and drive and wash drilling to advance casing. A monitoring well (SWMW-20-01A) was installed and sampled for PFAS.

8.4.3 Synoptic Water Level Survey

An Area 1 synoptic water level monitoring event, that encompassed all of the area piezometers and monitoring wells, was conducted on March 13, 2020 (Figure 2-9).

8.5 Nature and Extent

Groundwater analytical results are presented on Figure 8-5 and in cross section (Figures 8-6 through 8-8). All of the results are presented in Appendix H. The discussions below are focused on results with respect to the media specific criteria (Table 1-1).

8.5.1 Groundwater

There were no detections of PFAS in groundwater that were greater than the EPA LHA or the GW-3 standard (protective of surface water). Most of the locations where PFAS was sampled in the overburden in the Shabokin well area had PFAS concentrations greater than the GW-1 standard. The only location with concentrations less than the GW-1 standard was SWVP-19-03.

Ten vertical profiles were attempted, water was only recovered at seven of the vertical profiles. A total of 46 vertical profile samples were collected. Table 8-2 provides summary statistics of the results of the vertical profile samples. Of those samples, no samples had concentrations greater than the EPA LHA and 19 samples (41%) had concentrations greater than the GW-1 standard. One sample was collected from one new monitoring well (SWMW-20-01A); the sample did not have PFAS concentrations above the EPA LHA and did have PFAS concentrations greater than the GW-1 standard (35.4 ng/L) (Table 8-3). The maximum concentrations were detected at SWVP-20-04 (48.3 ng/L, sum of the six GW-1 compounds, 64-68 ft bgs).

To the northeast of the Shabokin well, PFAS was detected at concentrations greater than the GW-1 standard at SWVP-19-05 in the shallowest two sample intervals with approximately 80 feet of aquifer with lesser PFAS concentrations deeper in the aquifer.

To the northwest of Shabokin well, the locations farthest away from the Shabokin wells had the higher PFAS detects shallowest in the aquifer. At the farthest northwest location considered as part of the Shabokin area, SWMW-20-01A, PFAS was detected in the well set at the water table at concentrations greater than the GW-1 standard (35.3 ng/L, sum of the six GW-1 compounds, 5-15 ft bgs). The groundwater is flowing to the east toward Mirror Lake and may be a result of groundwater flowing to the southeast from AOC 43J. At SWVP-20-03, PFAS was detected at concentrations greater than the GW-1 standard in the shallowest sample interval and the deeper sample interval had lower concentrations.

Closer to the Shabokin well, locations SWVP-19-06, -19-01, -19-04 and SWVP-20-04 had PFAS at concentrations greater than the GW-1 standard in the middle and deeper portions of the aquifer with approximately 25 to 60 feet thick of aquifer with PFAS concentrations greater than the GW-1 standard. These data suggest the source of PFAS in the groundwater at these areas is a result of activities that occurred upgradient of these locations.

Based on the lack of any knowledge of historic AFFF use, storage, disposal in areas around the Shabokin well, and the broad occurrence of lower PFAS concentrations (below the EPA LHA and below 50 ng/L for the sum of the six GW-1 compounds) around the Shabokin well a primary source of the PFAS impact to the Shabokin well has not been identified.

9.0 AOC 43J PRELIMINARY SITE CHARACTERIZATION SUMMARY

9.1 Site Description

AOC 43J is located in the northwest quadrant of the Queenstown Street and Patton Road intersection (Figure 8-1). The area is developed and currently used for parking and storage. The property is currently owned by Bristol Meyers Squibb. The area is flat, developed currently used for parking and storage. The property is zoned as Innovation & Technology Business.

9.2 Facility History and Utilities

The Army historically used AOC 43J as a gas station/motor pool and subsequently as a vehicle storage yard and maintenance facility for Fort Devens. The property at AOC 43J was transferred to MassDevelopment in 2006 as a condition of Bristol Meyers Squibb's commitment to develop facilities at Devens. USEPA and the MassDEP currently administer AOC 43J jointly (Haley and Aldrich, 2017).

AOC 43J was first identified as a possible source of contamination in 1988 (Argonne National Laboratory, 1992). The Army identified several leaking USTs which held gasoline, waste oil, and diesel. At the time of base closure in 1996, the area around AOC 43J was used as a vehicle storage yard and maintenance facility (former Buildings T-2446 and T-2479) for a Special Forces Unit of the Army. The former maintenance facility used a 1,000-gallon UST for storage of maintenance wastes. This UST was located just south of former Building T-2446 (Figure 9-1) (Haley and Aldrich, 2017).

Prior to construction of the vehicle maintenance facility, this area had been used as a gas station/motor pool (gas station J) during the 1940s and 1950s. The structures of this historical gas station consisted of a pump island and a small gasoline pump house. This gas station was reported to be a Type A station, with one 5,000-gallon UST located between the gasoline pump house and pump island. The station was used during World War II as a vehicle motor pool to support military operations. The motor pool operations were discontinued during the late 1940s or early 1950s. No records were available on the decommissioning of this motor pool or the removal of the associated UST (Haley and Aldrich, 2017).

The current and previous subsurface features for the area are shown on Figures 8-2 and 8-3.

9.3 Remedial Status

In 1991, Site Investigations were conducted at 13 SAs at Devens including historical gas stations [ABB Environmental Services, Inc (ABB), 1993a]. Based on the results of the SIs at these SAs, the Army decided to conduct SSIs at 14 of the original 32 SAs (ABB, 1996a). Upon completion of the Supplemental Data Package, it was recommended that three SAs (SA 41, 43G, and 43J) should progress to the RI and FS phase. The name designation for each of these SAs were administratively changed to AOCs (i.e., AOC 43J).

During the 1992 SI, an abandoned 5,000-gallon UST was found in the area of the historical gas station J. This UST was added to the Devens UST removal program and removed in August 1992. The former waste oil UST was also removed during May of the same year. During both UST removals, contaminated soil was removed and disposed of by the Army. Based on the data and the findings of the 1992 SI, additional investigation was recommended (ABB, 1996c).

The RI was conducted to evaluate the nature and distribution of the contamination in soil and groundwater downgradient and cross-gradient of the former waste oil and historical gas station USTs. Based on the results and interpretations of the RI and the human health risk assessment, it was recommended that a FS be performed to evaluate alternatives to reduce potential human health risks associated with potential future exposure to groundwater at the source area directly downgradient of the former UST locations.

The FS Report identified and screened response actions and potential remedial technologies that were capable of attaining the remedial action objectives (ABB, 1996b) and the preferred alternatives was presented in a proposed plan. The ROD documented the final choice of remedy as Intrinsic Bioremediation, which included: intrinsic bioremediation [i.e., monitored natural attenuation (MNA)], intrinsic bioremediation assessment data collection and groundwater modeling, installing additional groundwater monitoring wells, long-term groundwater monitoring, annual data reports to USEPA and MassDEP, and five-year reviews (ABB, 1996d).

An Intrinsic Remediation Assessment was completed in 1999 to assess the effectiveness of the selected alternative (Intrinsic Bioremediation) at AOC 43J (S&W, 1999). The assessment concluded that intrinsic remediation was demonstrated to be an effective remedial action at AOC 43J, and no contingency action was required at that time. Future actions would consist of implementing the remaining components as specified in the ROD (including a long-term monitoring program, annual reporting, and 5-year reviews) (S&W, 1999).

In 2006, an Explanation of Significant Differences (ESD) (U.S. Department of Army, 2006) was completed following a Finding of Suitability for Early Transfer (FOSET) that addresses the changes that are necessary for the remedy to remain protective of human health and the environment. The purpose of the ESD was to allow land use controls to be implemented to allow the property to be transferred from Army to MassDevelopment. AOC 43J property was transferred from the Army to MassDevelopment in June 2006. The land use controls were detailed in a June 2006 Grant of Environmental Restriction and Easement (GERE) issued by MassDEP (MassDEP, 2006).

It was noted during a five-year review that MNA would not reach the ROD goals within the required 30-year performance period. Subsequent pilot testing of remedial-amendment injections was performed using two separate pilot tests. A sulfate injection pilot study was conducted in December 2009. The effects of the initial injection test were unclear, so an additional sulfate injection was performed in 2010 followed by the annual groundwater monitoring event. After evaluation of the 2009 and 2010 results, it was concluded that enhanced anaerobic degradation by sulfate was a slow process that showed minimal effects on residual concentrations of volatile petroleum hydrocarbons. An alternate amendment (OBC™, a proprietary sodium persulfate/calcium peroxide product manufactured by Redox Tech, LLC) was injected during 2012. Subsequent groundwater sampling conducted in 2013 and 2014 indicated that benzene, toluene, ethylbenzene, and xylene (BTEX) concentrations had generally decreased over time in most monitoring wells; however, continued monitoring was recommended (Haley and Aldrich, 2015 and 2017). Annual LTM sampling events continue to evaluate the effects of the OBC™ treatment (Haley and Aldrich, 2017).

9.4 PFAS Field Investigation

The RI field investigation at AOC 43J included sampling existing monitoring wells. The work was completed in general accordance with the *Area 2 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018c). Field activities were added as the data was received and reviewed. Sampling locations are presented on Figure 9-1 and summarized in Table 9-1. The results are discussed in Section 9.5.

9.4.1 Existing Wells

Groundwater samples were collected from existing monitoring wells at AOC 43J in December 2018 through January 2019 in accordance with the *Area 2 Field Sampling Plan Addendum to Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS)* (KGS, 2018c) (Table 9-1, Figure 9-1).

Groundwater samples were collected from an additional three existing monitoring in March 2020. All of the results are discussed in Section 9.5.

9.5 Nature and Extent

Groundwater results are presented on Figure 9-2 and in cross section (Figures 8-6 and 8-7). All of the results are presented in Appendix H. The discussions below are focused on results with respect to the media specific criteria (Table 1-1).

9.5.1 Groundwater

Groundwater samples were collected from 14 existing monitoring wells at AOC 43J. Table 9-2 provides summary statistics of the results of the vertical profile samples. None of the samples had PFAS concentrations greater than the EPA LHA. One monitoring well (XJM-94-07X) (7%) had PFAS concentrations (51.0 ng/L, sum of the six GW-1 compounds) greater than the GW-1 standard. The wells at AOC 43J are located in overburden and shallow bedrock. Groundwater flows from AOC 43J in an easterly direction on the eastern side of the site and in a more southeasterly direction on the southern part of the site (Haley and Aldrich, 2017). The PFAS observed in downgradient location SWMW-20-01A (35.3 ng/L, sum of the six GW-1 compounds) may be related to the PFAS observed at AOC 43J. SWMW-20-01A is associated with the Shabokin Well area and is discussed in Section 8.5.

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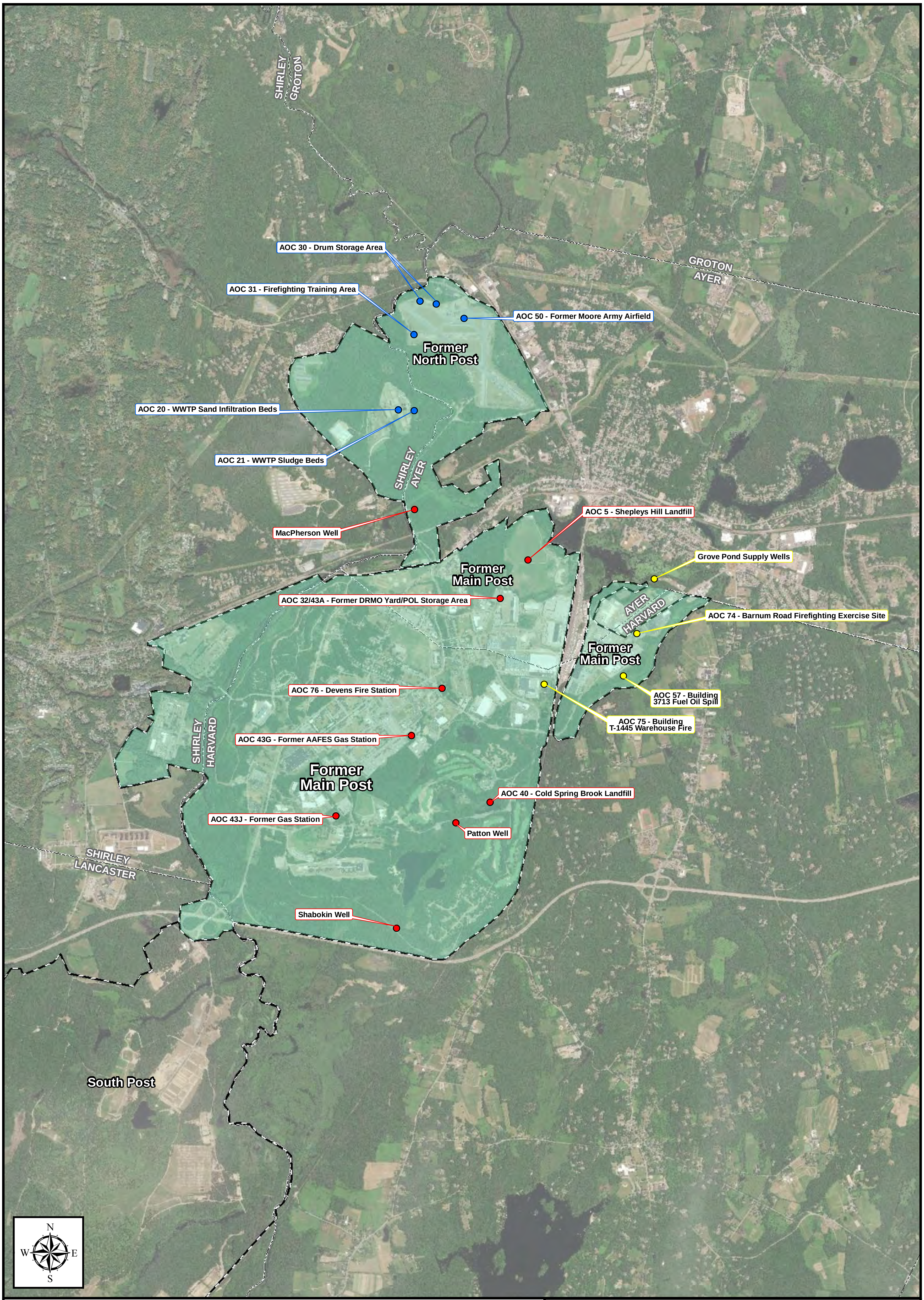
FIGURES



Legend

● Area 1 - Grove Pond Supply Wells, AOCs 57, 74, and 75

● Area 2 - MacPherson, Patton and Shabokin Water Supply Wells, SHL, AOCs 32/43A, 40, 43G, 43J and 76

● Area 3 - AOCs 20, 21, 30, 31, and 50

🟩 Devens Regional Enterprise Zone

City/Town Boundary

Former Fort Devens Boundary

Devens PFAS Remedial Investigation Areas
Devens PFAS RI - Area 1 PSCS

Former Army Installation Devens
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

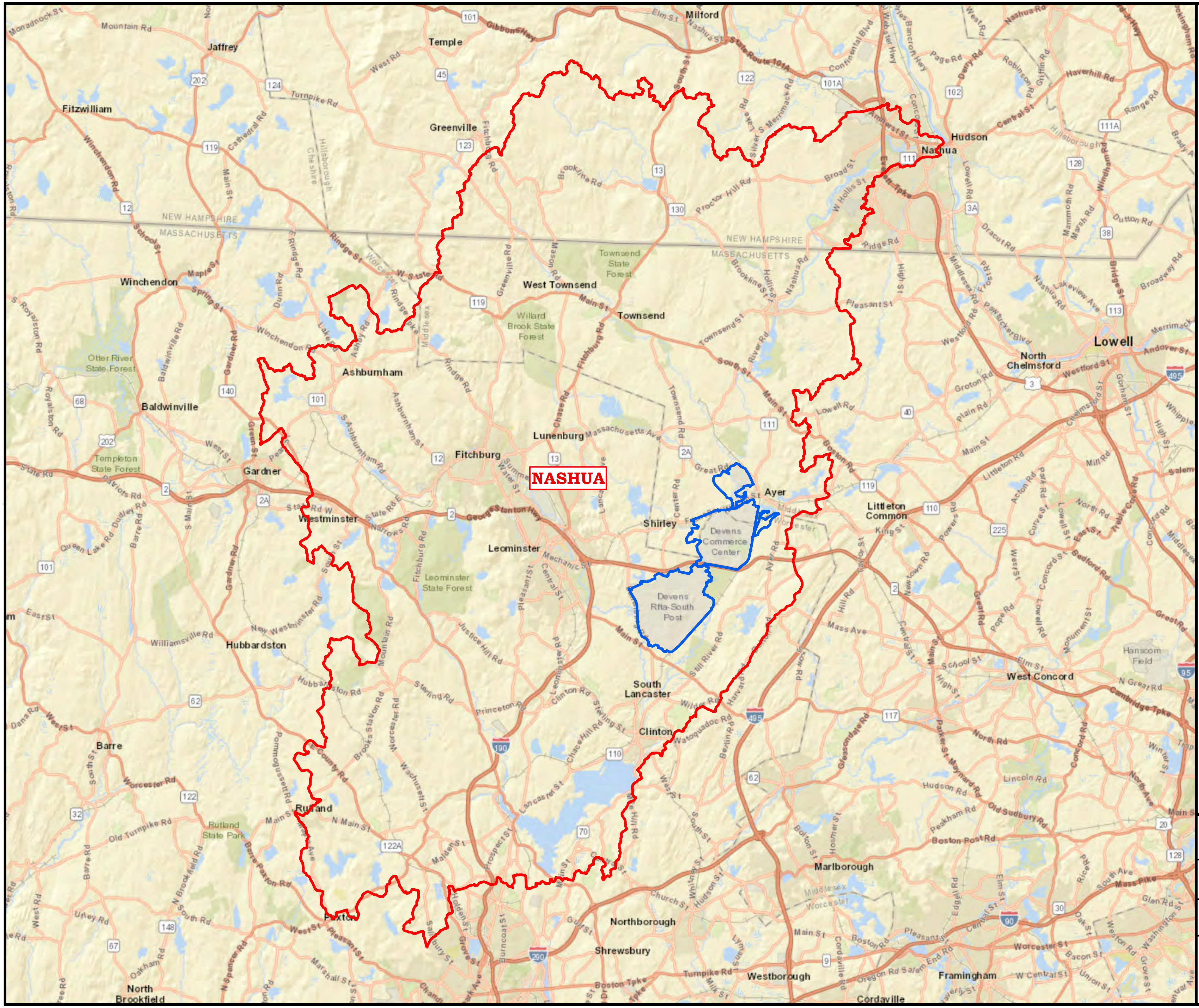
0 1,500 3,000
Feet

Date:
03/10/2020

Figure
1-1

File: PFAS2018_RI_WP_F1-2_Areas.mxd

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

Legend

🟥 Watershed Boundary

🟦 Former Fort Devens Boundary

N
W E
S

Nashua River Watershed
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 2 4
Miles

Date:
05/28/2020

Figure
2-1

File: PFAS_RI_A1_PSC_F_NashuaRiverBasin.mxd

Legend

● Area 1 - Grove Pond Supply Wells, AOCs 57, 74, and 75

● Area 2 - MacPherson, Patton, Shabokin Water Supply Wells, SHL, AOCs 32/43A, 40, 43G, 43J and 76

● Area 3 - AOCs 20, 21, 30, 31, and 50

← Surface Water Flow Direction

City/Town Boundary

Former Fort Devens Boundary

National Hydrography Dataset

Stream/River

Lake/Pond

Swamp/Marsh

N
W E
S

Surface Water Bodies
Devens PFAS RI - Area 1 PSCS

Former Army Installation Devens
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 1,250 2,500
Feet

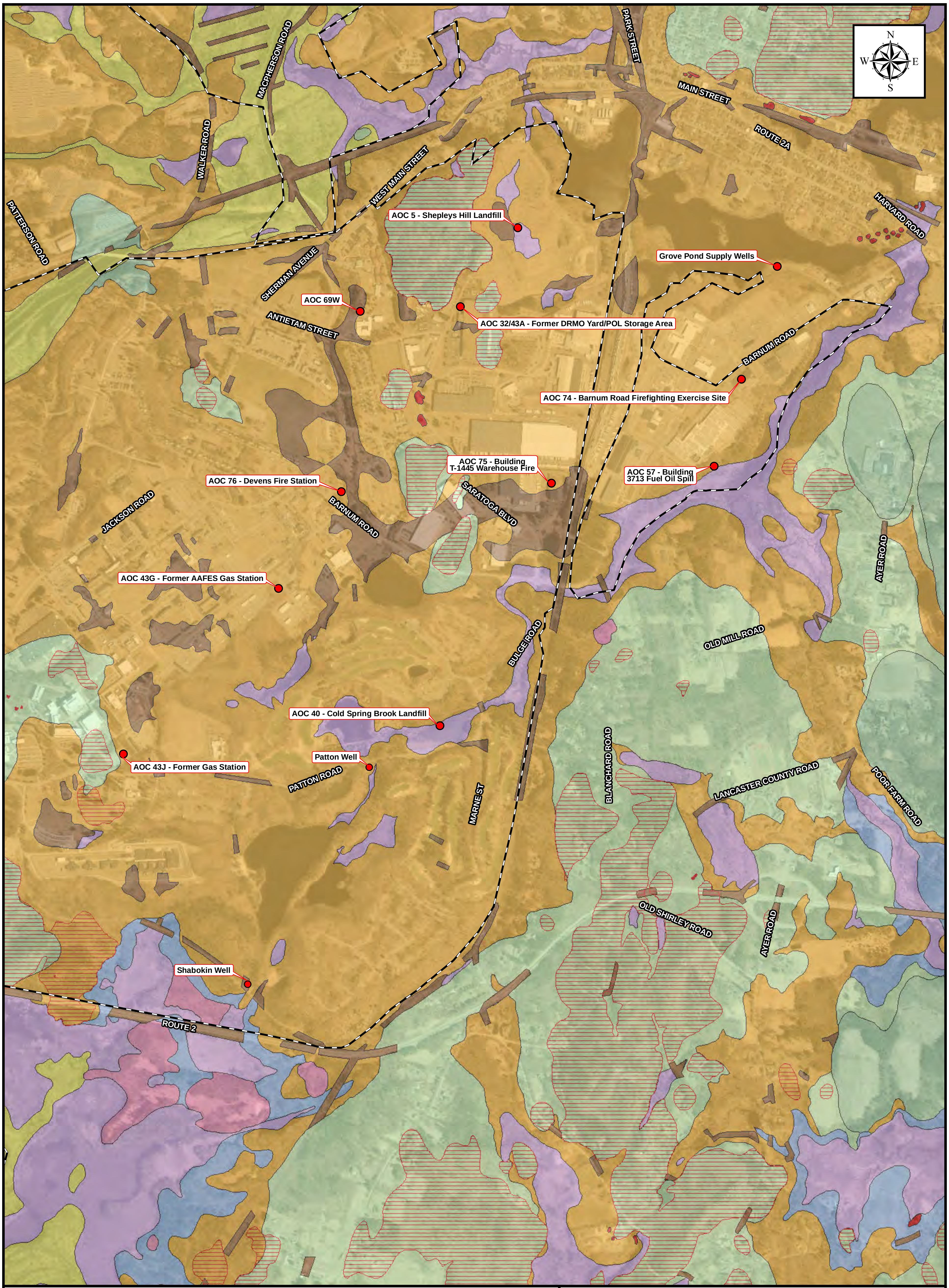
Date:
05/14/2020

Figure
2-2

KGS

File: PFAS_RI_A1_PSC_F1-2_SurfaceWaterBodies_NHD.mxd

Aerial Source: USGS, MassGIS Orthoimagery 2019



Legend

● AOC Location

▭ Former Fort Devens Boundary

Surficial Geology (1:24,000)

▤	Abundant Outcrop and Shallow Bedrock
🟫	Artificial Fill
🟪	Swamp and Marsh Deposits
🟨	Alluvium
🟪	Inland Dune
🟧	Coarse
🟦	Glaciolacustrine Fine
🟩	Thick Till
🟥	Bedrock Outcrop
🟩	Thin Till

USGS Overburden Geology
Devens PFAS RI - Area 1 PSCS

Former Army Installation Devens
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

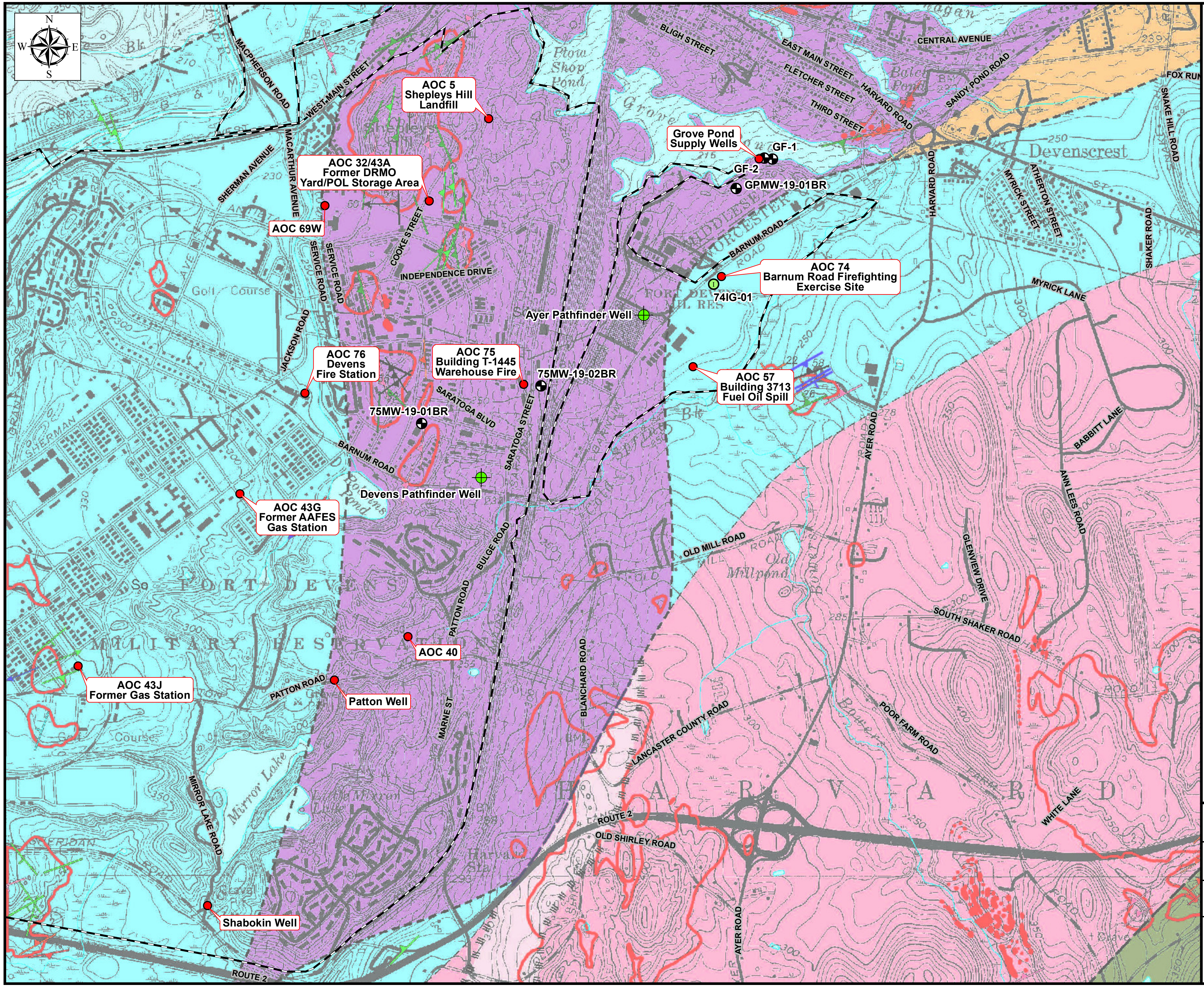
0 750 1,500
Feet

Date:
04/17/2020

Figure
2-3

File: PFAS_RI_A1_PSC_USGS_OverburdenGeol.mxd

Aerial Source: 2019, USGS, MassGIS



Legend

● AOC Location

◐ Shallow Bedrock Monitoring Well

Ⓘ Irrigation Well (Approximate Location)

⊕ Pathfinder Well

▭ Former Fort Devens Boundary

Lithologic Units

Sb Sbbks — Berwick Formation (Silurian)

So — Oakdale Formation (Silurian)

Dcgrm Dcgr Dcgm — Chelmsford Granite (Devonian)

Sayg Saygp — Ayer Granite (Silurian)

Sdge — Devens gneiss complex (Silurian(?))

OZtb — Tadmuck Brook schist

● Bedrock outcrop

○ Area where bedrock is shallow (<3 meters below surface) and/or outcrop is extensive

Map Reference: Preliminary Fracture Characterization Map of the Ayer Quadrangle Massachusetts Hydrostructural Domain Map Sheet 1

Bedrock Geology
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

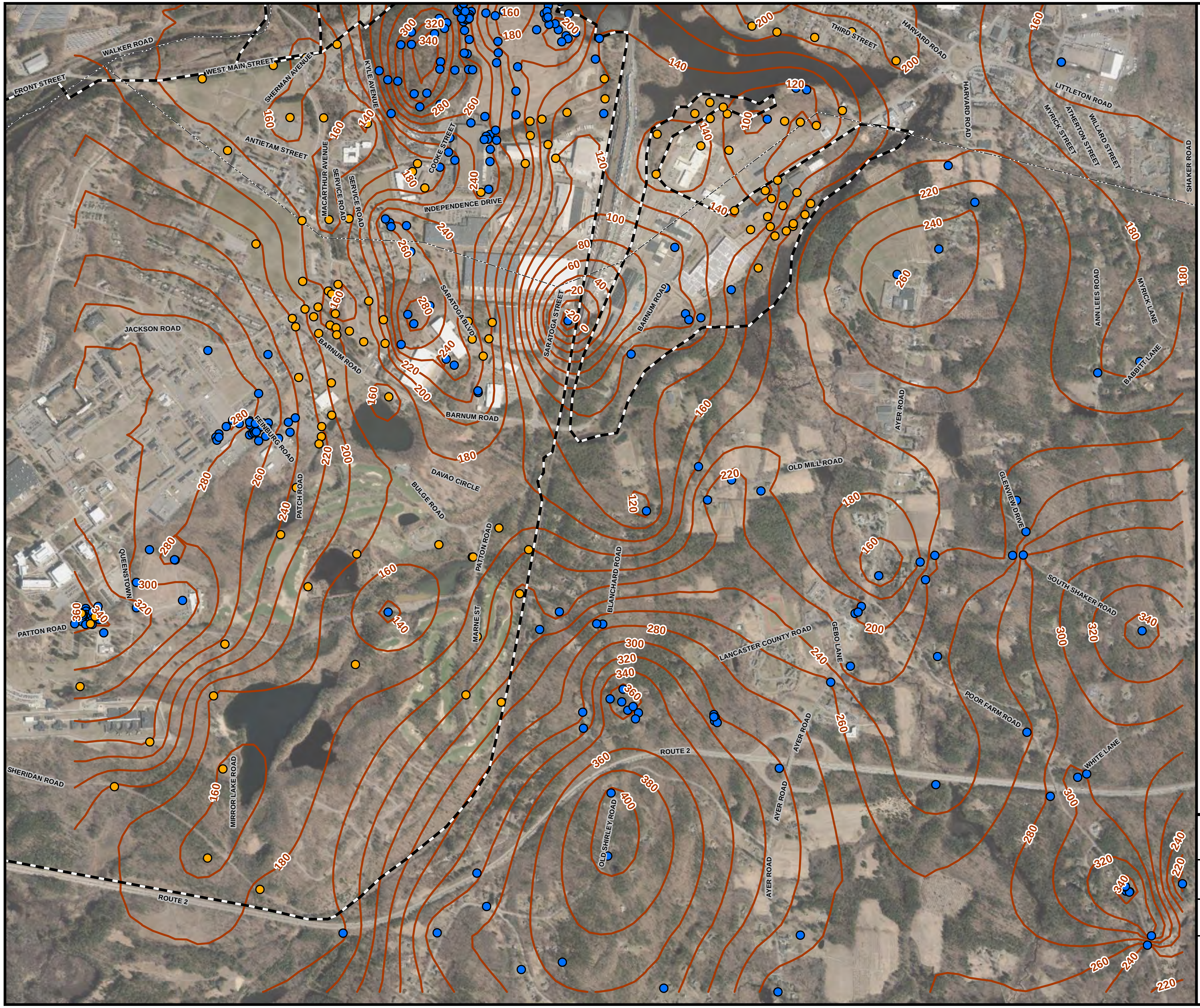
0 750 1,500
Feet

Date:
05/29/2020

Figure
2-4

KGS

File: PFAS_RI_A1_PSC_BedGeology_JPG.mxd



Legend

● Bedrock confirmed

● Refusal

Bedrock Elevation Contour (ft NAVD88)

Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

Bedrock Contours
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 750 1,500
Feet

Date:
05/28/2020

Figure
2-5

File: PFAS_RI_A1_PSC_F2-1_Bedrock_Contours.mxd

Legend

●	Monitoring Well
⊕	Public Water Supply Well
(219.21)	Groundwater Elevation (Feet)
∼	Groundwater Contour (ft NAVD 88) (Contour Interval = 1 Foot)
▭	Former Fort Devens Boundary

Notes:

Well 92-2 is bent and unable to provide an accurate reading

Aerial Source: USGS, MassGIS Orthoimagery 2019

Groundwater Elevation Contours
Grove Pond Area
October 2, 2018
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 75 150
Feet

Date:
05/12/2020

Figure
2-6

File: PFAS_RI_A1_PSC_GrovePond_GWC.mxd

Legend

⊕ Public Water Supply Well

◉ Monitoring Well/Piezometer

△ Vertical Profiling Location

ⓘ Irrigation Well (Approximate Location)

— Groundwater Contours (March 19, 2019)
Contour Elevation is in Ft NAVD88

(214.91) Groundwater Elevation

⬚ Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

Groundwater Elevation Contours AOC 74/Grove Pond Area
March 19, 2019
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

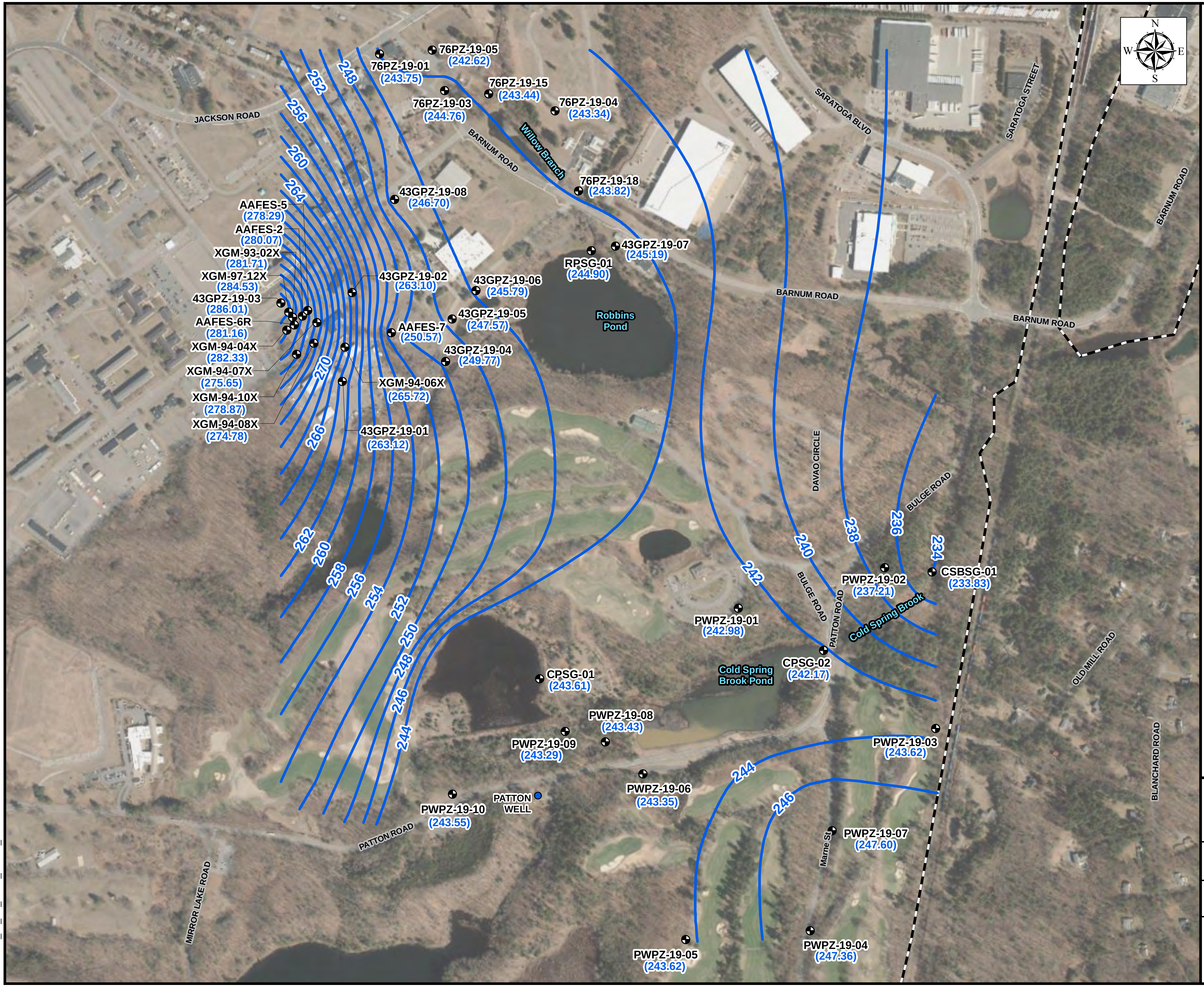
0 150 300
Feet

Date:
05/12/2020

Figure
2-7

KGS

File: PFAS_RI_A1_PSC_AOC74_GWC031919.mxd



Legend

● Public Water Supply Well

⊕ Monitoring Well/Piezometer

AAFES-2 Well Identification

Groundwater Elevation Contour (ft NAVD 88)
(Contour Interval = 2 ft) January 2-3, 2020

(245.79) Groundwater Elevation (ft NAVD 88)

Former Fort Devens Boundary

Note: The Patton water supply well was not operating at the time these measurements were recorded.

Aerial Source: USGS, MassGIS Orthoimagery 2019

Groundwater Elevation Contours - Patton Well Area/AOC 40
January 2-3, 2020
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 300 600
Feet

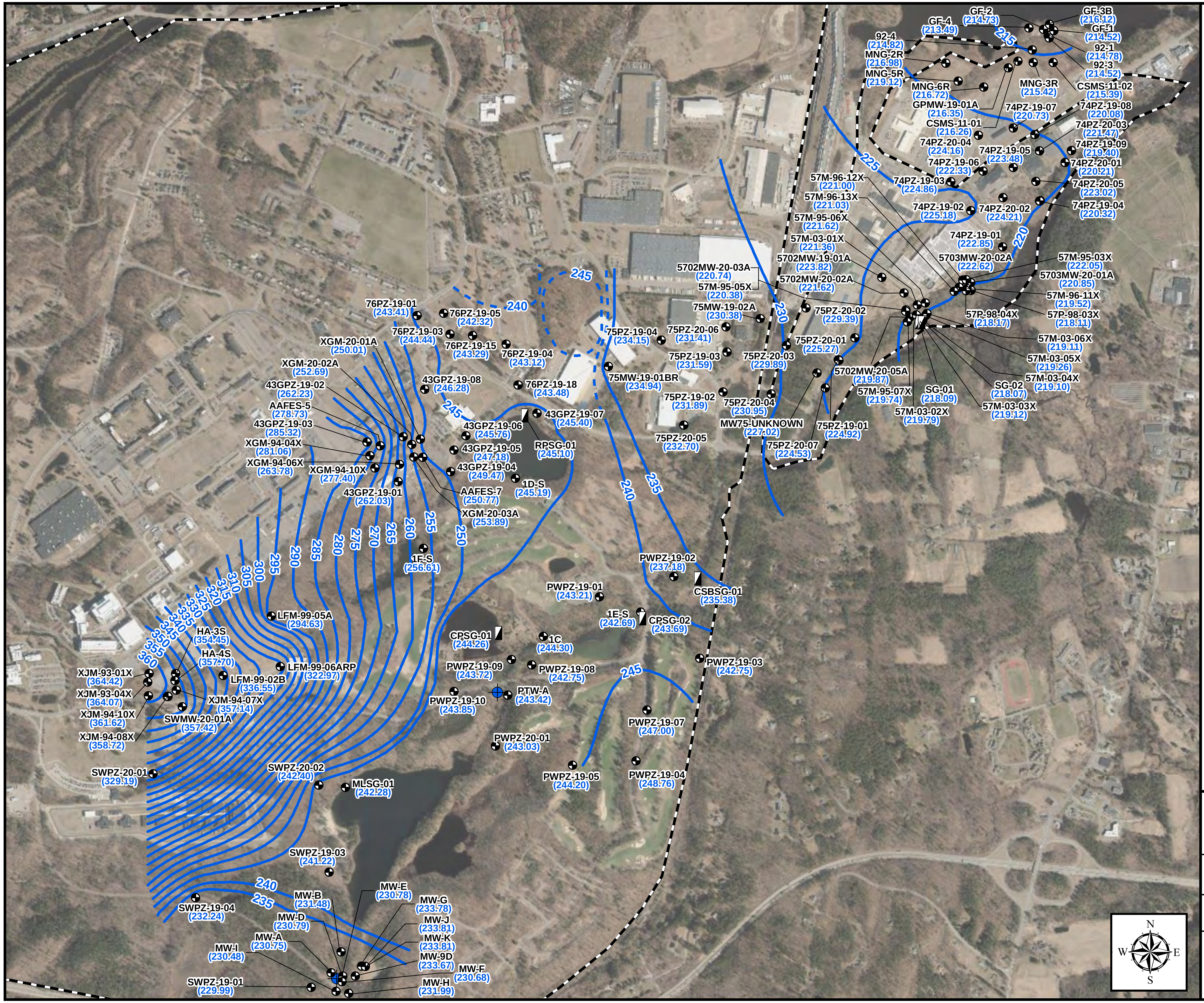
Date:
05/12/2020

Figure
2-8

KGS

File: PFAS_RI_A1_GWC_Patton_010220.mxd

Aerial Sources: 2019, USGS, MassGIS



Legend

● Monitoring Well/Piezometer

◪ Staff Gauge

⊕ Public Water Supply Well

～ Groundwater Contour (ft NAVD 88) (Contour Interval = 5 Feet)

⁓ Inferred Groundwater Contour (ft NAVD 88) (Contour Interval = 5 Feet)

(357.14) Groundwater Elevation (Feet)

▭ Former Fort Devens Boundary

Note: The Patton water supply well was operating at the time of these measurements were recorded.

Aerial Source: USGS, MassGIS Orthoimagery 2019

Groundwater Elevations Contours
March 12-13, 2020
Devens PFAS RI - Area 1 PSCS

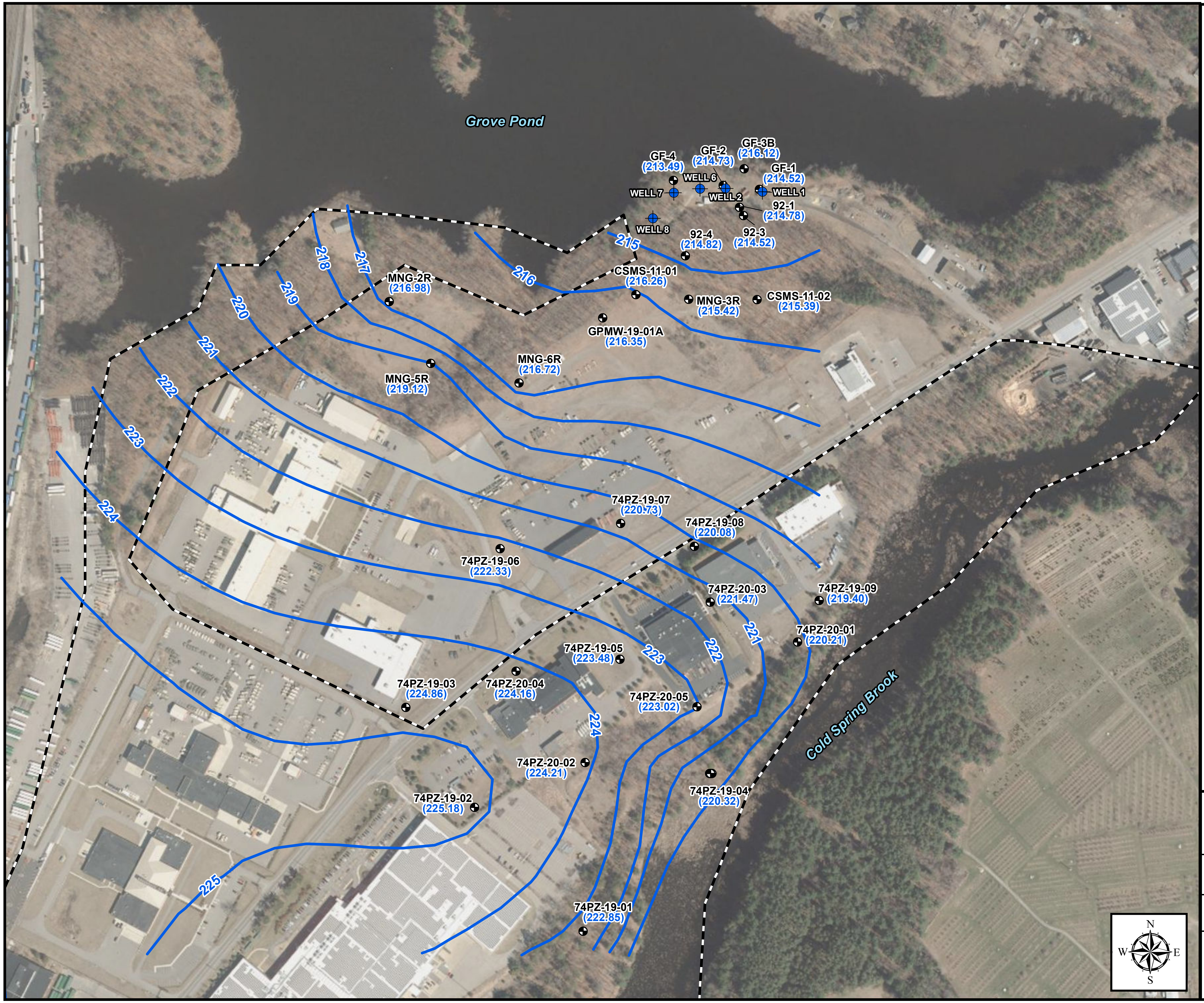
Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

Date: 05/27/2020

Figure 2-9

File: PFAS_RI_A1_PSC_A1_SynopticGWC_V2.mxd



Legend

⊕	Public Water Supply Well
◕	Monitoring Well/Piezometer
∼	Groundwater Contour (ft NAVD 88) (Contour Interal = 1 Foot)
(357.14)	Groundwater Elevation (Feet)
▭	Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

Groundwater Elevations Contours AOC 74/Grove Pond Area
March 12-13, 2020
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 175 350
Feet

Date:
05/27/2020

Figure
2-10

KGS

File: PFAS_RI_A1_PSC_AOC74_Grove_SynopticGWC.mxd

Legend

● Monitoring Well/Piezometer

∼ Groundwater Contour (ft NAVD 88)
(Contour Interval = 1 Foot)

(231.41) Groundwater Elevation (Feet)

▭ Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

Groundwater Elevations Contours AOC 75
March 12-13, 2020
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 150 300
Feet

Date:
05/27/2020

Figure
2-11

File: PFAS_RI_A1_PSC_AOC75_SynopticGWC.mxd

Legend

●	Monitoring Well Location
◩	Staff Gauge
(219.52)	Shallow Groundwater Elevation (Feet)
∼	Shallow Groundwater Contour (ft NAVD88) (Contour Interval = 1 ft)
‐ ‐	Inferred Shallow Groundwater Contour (ft NAVD88) (Contour Interval = 1 ft)
—	Stream
—	Topographic Contour (Ft
▭	Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

Shallow Water Table Elevation
Area of Contamination 57 - Area 2
March 2020
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 30 60
Feet

Date:
05/27/2020

Figure
2-12

File: PFAS_RI_A1_PSC_AOC57-2_Shallow_GWC0320.mxd

Legend

●	Monitoring Well Location
(232.84)	Deep Groundwater Elevation (Feet)
～	Deep Groundwater Contour (ft NAVD88) (Contour Interval = 0.5 ft)
- - -	Inferred Deep Groundwater Contour (ft NAVD88) (Contour Interval = 0.5 ft)
—	Stream
—	Topographic Contour (Ft
▭	Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

Deep Water Table Elevation
Area of Contamination 57 - Area 2
March 2020
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 30 60
Feet

Date:
05/27/2020

Figure
2-13

KGS

File: PFAS_RI_A1_PSC_AOC57-2_Deep_GWC0320.mxd

Legend

⊕ Monitoring Well Location

(219.52) Shallow Groundwater Elevation (Feet)

~ Shallow Groundwater Contour
(ft NAVD88) (Contour Interval = 1 ft)

⁓ Inferred Shallow Groundwater Contour
(ft NAVD88) (Contour Interval = 1 ft)

— Stream

— Topographic Contour (Ft AMSL)

Aerial Sources: UGSS, MassGIS Orthoimagery 2019

Shallow Water Table Elevation
Area of Contamination 57 - Area 3
March 2020
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 30 60 Feet	Date: 05/12/2020	Figure 2-14	

File: PFAS_RI_A1_PSC_AOC57-3_Shallow_GWC0320.mxd

Legend

● Monitoring Well Location

(232.84) Deep Groundwater Elevation (Feet)

〜 Deep Groundwater Contour (ft NAVD88) (Contour Interval = 0.5 ft)

- - Inferred Deep Groundwater Contour (ft NAVD88) (Contour Interval = 0.5 ft)

— Stream

— Topographic Contour (Ft AMSL)

▭ Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

Deep Water Table Elevation
Area of Contamination 57 - Area 3
March 2020
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

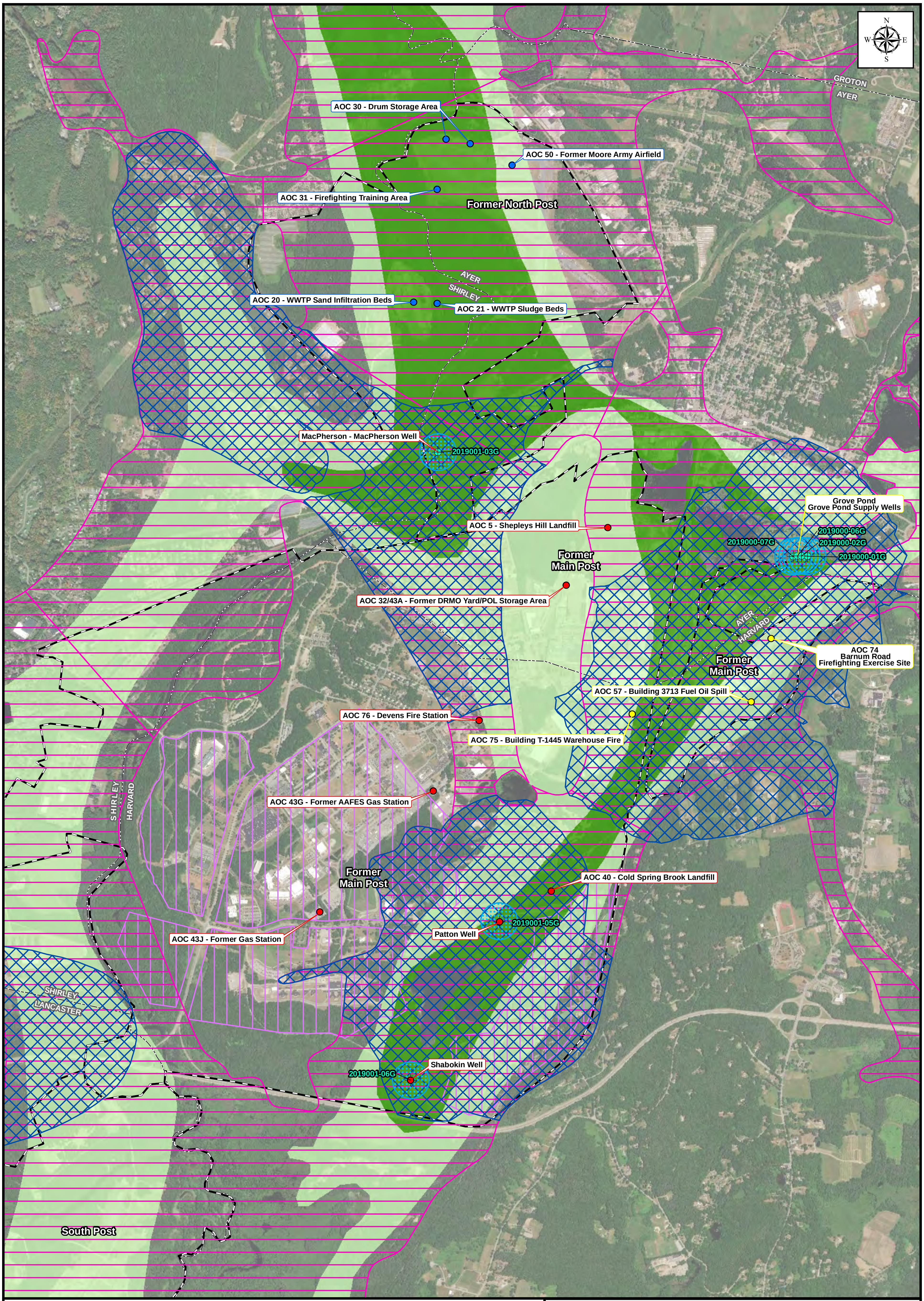
KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 30 60
Feet

Date:
05/27/2020

Figure
2-15

File: PFAS_RI_A1_PSC_AOC57-3_Deep_GWC0320.mxd



Legend

- ✣ Public Water Supply Well
- ● Area 1 - Grove Pond Supply Wells, AOCs 57, 74, and 75
- ● Area 2 - MacPherson, Patton, Shabokin Water Supply Wells, SHL, AOCs 32/43A, 40, 43G, 43J and 76
- ● Area 3 - AOCs 20, 21, 30, 31, and 50
- ☐ City/Town Boundary
- ☐ Former Fort Devens Boundary
- ▦ MassDEP Approved Zone I
- ☒ MassDEP Approved Zone II
- ▥ Devens Watershed Protection District
- ▤ Devens Aquifer Protection District

Potentially Productive Aquifers

- 🟩 High Yield
- 🟩 Medium Yield

Devens Groundwater
Devens PFAS RI - Area 1 PSCS

Former Army Installation Devens
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 1,000 2,000
Feet

Date:
05/29/2020

Figure
2-16

File: PFAS_RI_A1_PSC_F_Aquifer.mxd

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

Current Road

Stream

Former Fort Devens Boundary

Note:

Aerial Source: MassGIS - 1:5,000 Black and
White Digital Orthophoto Images - 1992

AOC 57 1992 Aerial Imagery
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC

0 100 200
Feet

Date:
05/12/2020

Figure
3-1

File: PFAS_RI_A1_PSC_2020_AOC57_1992Imagery.mxd

Legend

Historic Subsurface Features

—	Communication Line
●	Electric
—	Electric Line
UST	Underground Tank
- - -	Steam
●	Storm
—	Storm Line
▨	Storm Feature
●	Sanitary
—	Sanitary Line
🟩	Sanitary Feature
●	Water
—	Water Line
▬	Water Feature
●	Abandoned Feature
- - -	Abandoned Line
●	Gas
—	Gas Line
⬚	Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 57 Area Historic Subsurface Features
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 100 200
Feet

Date:
04/26/2020

Figure
3-2

File: PFAS_RI_A1_PSC_AOC57_HistoricUtilities.mxd

Legend

Water 01/06/2020
- Hydrant
- ■ Main Fitting
- ⊠ Service Fitting
- △ Main Valve
- ▽ Service Valve
- ○ Manhole
- — Main Line
- ┈ Service Line
- — Tie

Sewer 01/06/2020
- ● Force Fitting, Main Fitting, Service Fitting, Manhole
- — Force Main, Gravity Main, Service Line, Tie
- 🟩 DBox, Grease Trap, Lift Station, Oil/Water

Electric 01/07/2020
- ● Connection Box, Handhole, Junction Box, Manhole, Meter, Switch, or Transformer
- — Inservice/Abandoned
- 🟥 Vault

Gas 01/06/2020
- ○ Main Fitting, Main Valve, Meter, Rectifier, Service Fitting, Service Regulator, Service Valve, Test Station, Anode
- — Main, Service, Tie, Cathodic Loop

Stormwater 12/11/2019
- ■ Catch Basin
- ✚ Outfall
- ● Manhole
- — Pipe, Culvert
- ▨ Detention Pond
- ┅ Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 57 Area Current Subsurface Features
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

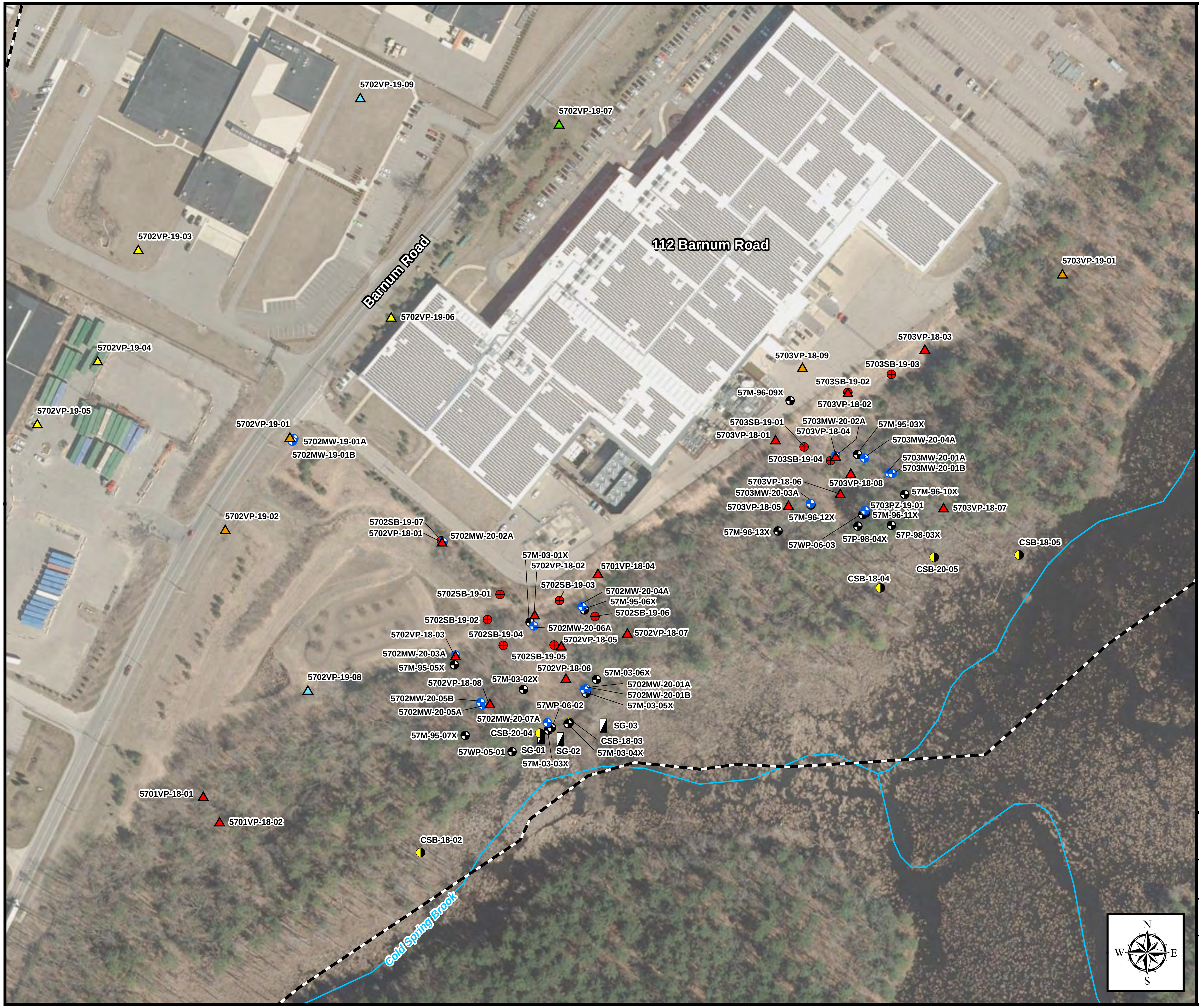
KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 100 200
Feet

Date:
04/26/2020

Figure
3-3

File: PFAS_RI_A1_PSC_AOC57_SubsurfaceUtilities.mxd



Legend

◑	Existing Monitoring Well
◑	New Monitoring Well
◐	Surface Water/Sediment Sample
⊕	Soil Boring Location
▲	Vertical Profiling Location Installation Phase 1
▲	Vertical Profiling Location Installation Phase 2
▲	Vertical Profiling Location Installation Phase 3
▲	Vertical Profiling Location Installation Phase 4
▲	Vertical Profiling Location Installation Phase 5
◪	Staff Gauge
⬚	Former Fort Devens Boundary
—	Stream

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 57 Field Activities
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

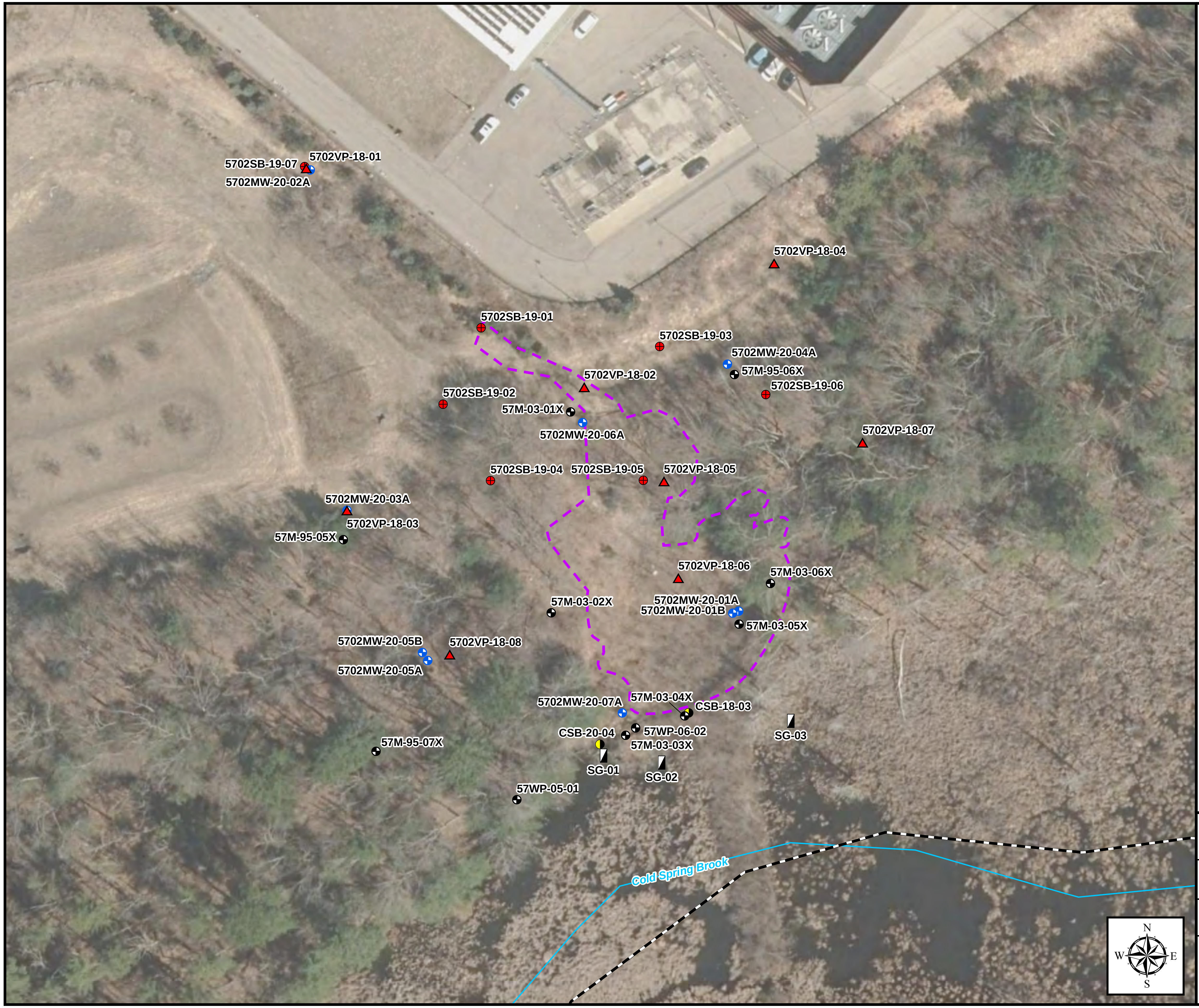
N
W E
S

0 90 180
Feet

Date:
05/12/2020

Figure
3-4

File: PFAS_RI_A1_PSC_AOC57_FieldActivities.mxd



Legend

- ● Existing Monitoring Well
- ● New Monitoring Well
- ◐ Surface Water/Sediment Sample
- ● Soil Boring Location
- ▲ Vertical Profiling Location Installation Phase 1
- ◪ Staff Gauge
- — Stream
- ▭ Approximate Soil Removal
- ▭ Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 57 Area 2 Field Activities
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 30 60
Feet

Date:
05/28/2020

Figure
3-5

File: PFAS_RI_A1_PSC_AOC57-2_FieldActivities.mxd

Legend

⊕ Existing Monitoring Well
⊕ New Monitoring Well
⊕ Destroyed Monitoring Well
◐ Surface Water/Sediment Sample
⊕ Soil Boring Location
▲ Vertical Profiling Location Installation Phase 1
▲ Vertical Profiling Location Installation Phase 2
— Stream
▭ Approximate Soil Removal Area
▭ Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

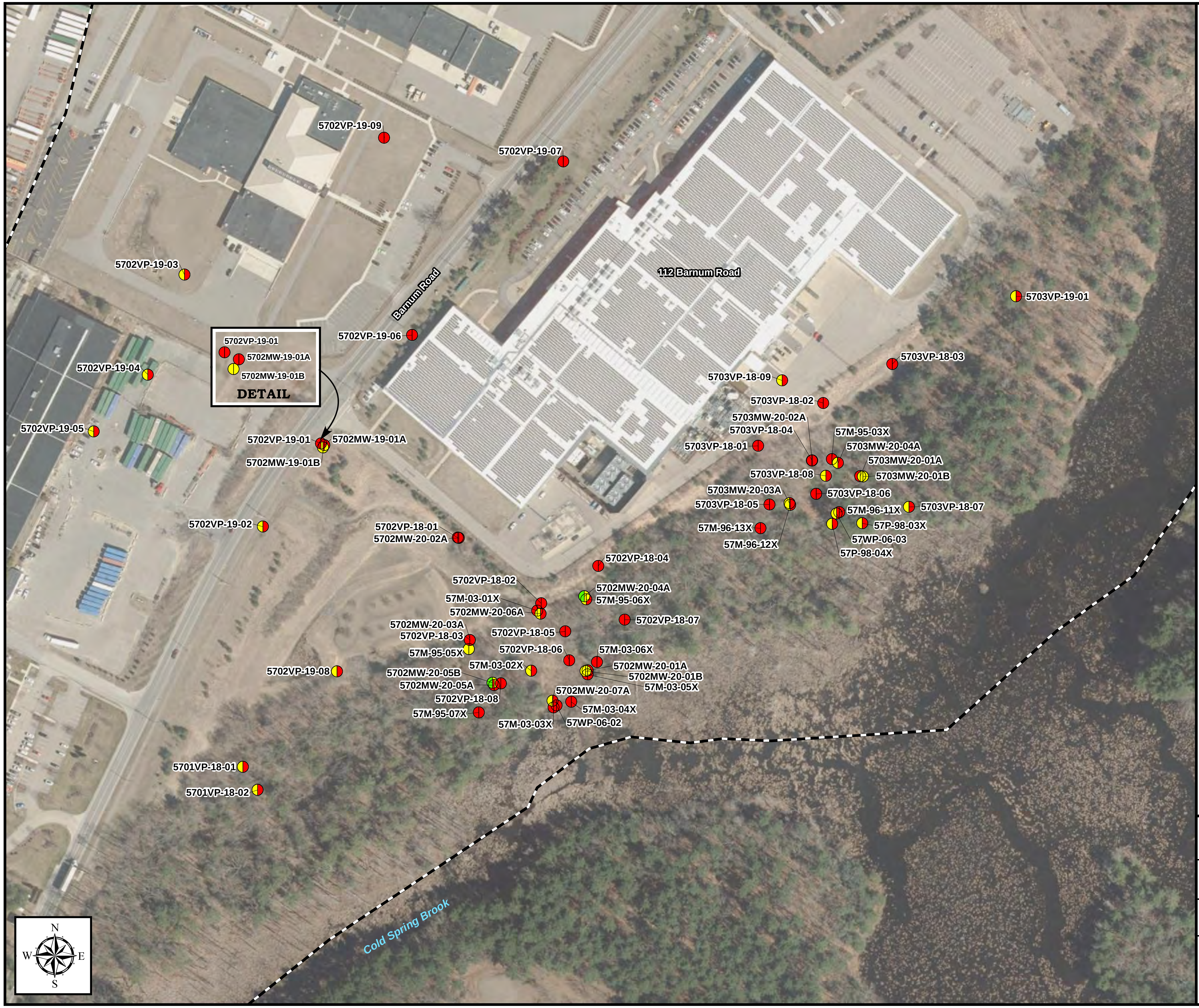
AOC 57 Area 3 Field Activities
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 30 60 Feet	Date: 05/28/2020	Figure 3-6	KGS

File: PFAS_RI_A1_PSC_AOC57-3_FieldActivities.mxd



Legend

◐ Monitoring Well/Vertical Profiling Location

EPA LHA
(sum of PFOA and PFOS) (ng/L)

◐ EPA LHA ≥ 70 ng/L

◐ EPA LHA < 70 ng/L

◐ EPA LHA No detection

MassDEP
(sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA) (ng/L)

◐ MassDEP ≥ 20 ng/L

◐ MassDEP < 20ng/L

▭ Former Fort Devens Boundary

Notes:

MassDEP GW-1 = sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA
MassDEP Exceedance Criteria is defined as equal to or greater than 20 ng/L

EPA LHA (Lifetime Health Advisory) = sum of PFOA and PFOS
EPA LHA Exceedance Criteria is defined as equal to or greater than 70 ng/L

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 57 Groundwater Results
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

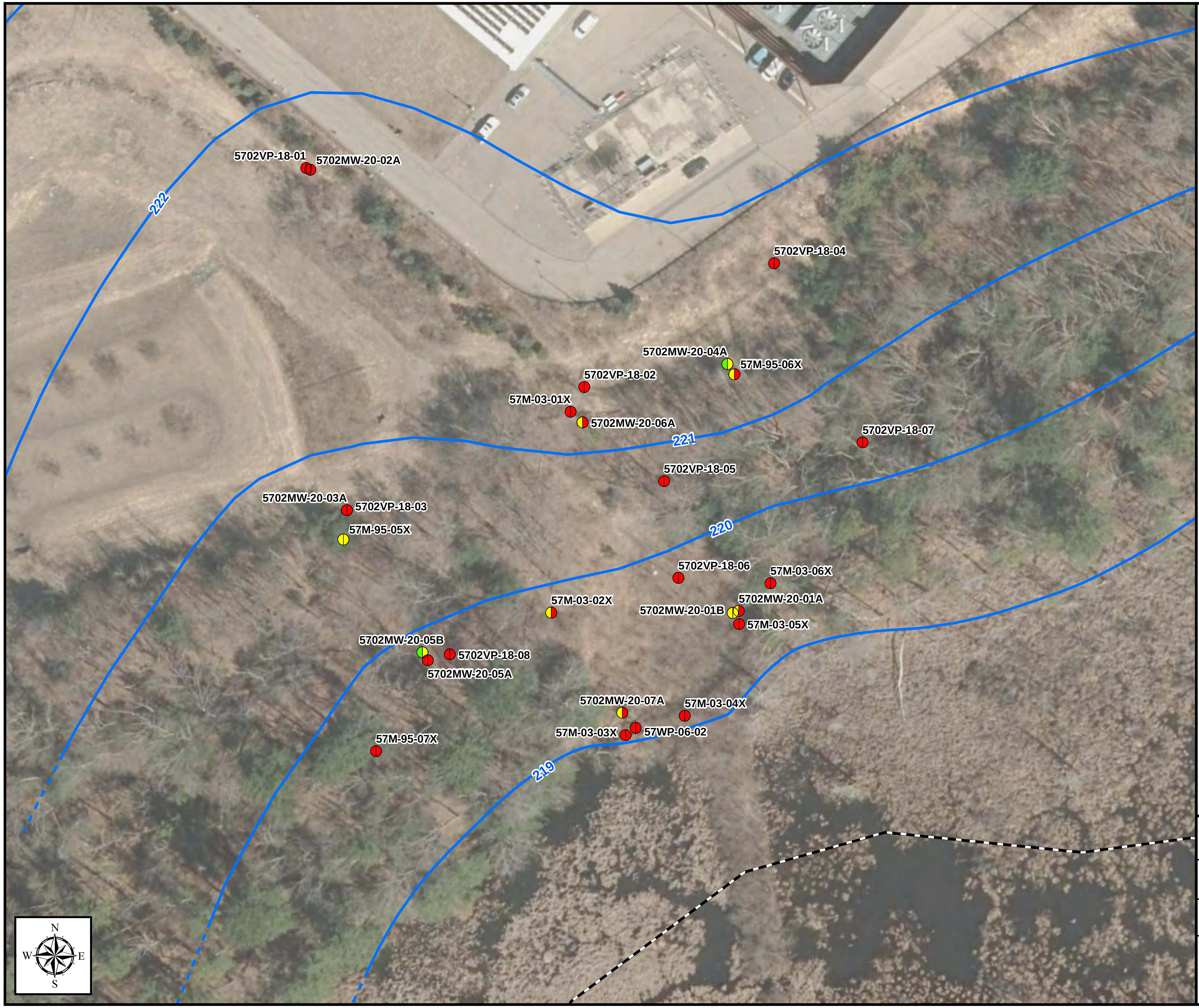
0 100 200
Feet

Date:
05/04/2020

Figure
3-7

KGS

File: PFAS_RI_A1_PSC_AOC57_GWResults.mxd



Legend

◐ Monitoring Well/Vertical Profiling Location

EPA LHA
(sum of PFOA and PFOS) (ng/L)

◐ EPA LHA ≥ 70 ng/L

◐ EPA LHA < 70 ng/L

◐ EPA LHA No detection

MassDEP
(sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA) (ng/L)

◑ MassDEP ≥ 20 ng/L

◑ MassDEP < 20ng/L

◑ MassDEP no detection

Shallow Groundwater Contour - March 2020
(ft NAVD88) (Contour Interval = 1 ft)

Inferred Shallow Groundwater Contour - March 2020
(ft NAVD88) (Contour Interval = 1 ft)

Former Fort Devens Boundary

Notes:

MassDEP GW-1 = sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA
MassDEP Exceedance Criteria is defined as equal to or greater than 20 ng/L

EPA LHA (Lifetime Health Advisory) = sum of PFOA and PFOS
EPA LHA Exceedance Criteria is defined as equal to or greater than 70 ng/L

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 57 Area 2 Groundwater Results
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 30 60
Feet

Date:
05/28/2020

Figure
3-8

KGS

File: PFAS_RI_A1_PSC_AOC57-2_GWResults.mxd

Legend

◐ Monitoring Well/Vertical Profiling Location

EPA LHA
(sum of PFOA and PFOS) (ng/L)

◐ EPA LHA ≥ 70 ng/L

◐ EPA LHA < 70 ng/L

◐ EPA LHA No detection

MassDEP
(sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA) (ng/L)

◑ MassDEP ≥ 20 ng/L

◑ MassDEP < 20ng/L

◑ MassDEP no detection

~ Shallow Groundwater Contour - March 2020
(ft NAVD88) (Contour Interval = 1 ft)

~ Inferred Shallow Groundwater Contour - March 2020
(ft NAVD88) (Contour Interval = 1 ft)

▭ Former Fort Devens Boundary

Notes:

MassDEP GW-1 = sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA
MassDEP Exceedance Criteria is defined as equal to or greater than 20 ng/L

EPA LHA (Lifetime Health Advisory) = sum of PFOA and PFOS
EPA LHA Exceedance Criteria is defined as equal to or greater than 70 ng/L

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 57 Area 3 Groundwater Results
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 30 60
Feet

Date:
05/28/2020

Figure
3-9

File: PFAS_RI_A1_PSC_AOC57-3_GWResults.mxd

Legend

△	Vertical Profiling Location
⊕	Soil Boring Location
◐	Surface Water/Sediment Sample
◑	Monitoring Well
◑	Abandoned or Unlocated Monitoring Well
◪	Staff Gauge
—	Cross Section Location
▭	Former Fort Devens Boundary
—	Stream

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 57 Cross Section Location Map
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

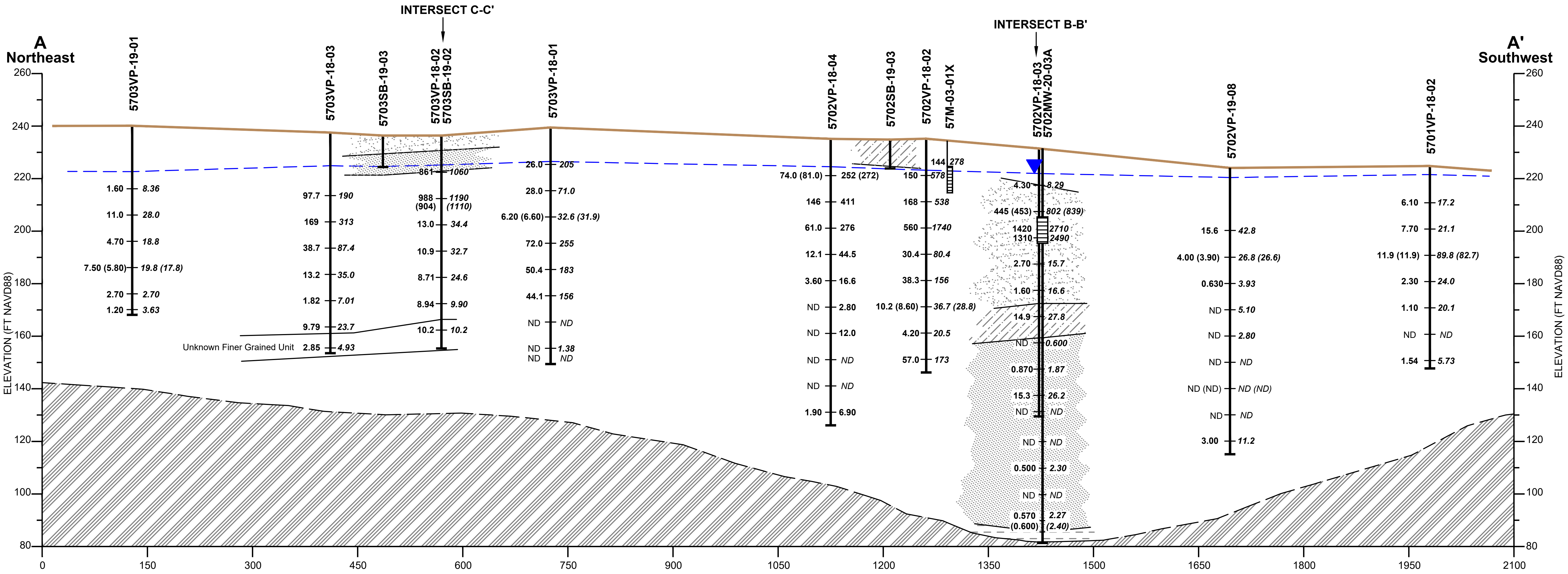
0 100 200
Feet

Date:
05/15/2020

Figure
3-10

KGS

File: PFAS_RI_A1_PSC_AOC57_XSLoc.mxd



Legend

Vertical Profile

1.39 U
EPA LHA
Concentration
(sum of PFOA
and PFOS)

2.59 U
MassDEP
Concentration
(sum of PFOS + PFOA
+ PFDA + PFHpA +
PFHxS + PFNA)

Monitoring Well

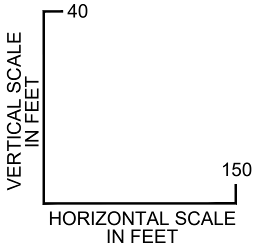
Screened
Interval

░	Sand with Gravel/Sand
▨	Sand with Silt/Silty Sand
░	Silt
░	Silt, Sand, Gravel, with Clay
┄	Till
▩	Weathered Bedrock
▨	Bedrock
☐	Unknown
▼	Water Table

Notes:

All results in ng/L
ng/L = nanograms per liter
ND = non-detect
( ) = field duplicate

Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorodecanoic acid (PFDA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorononanoic acid (PFNA)

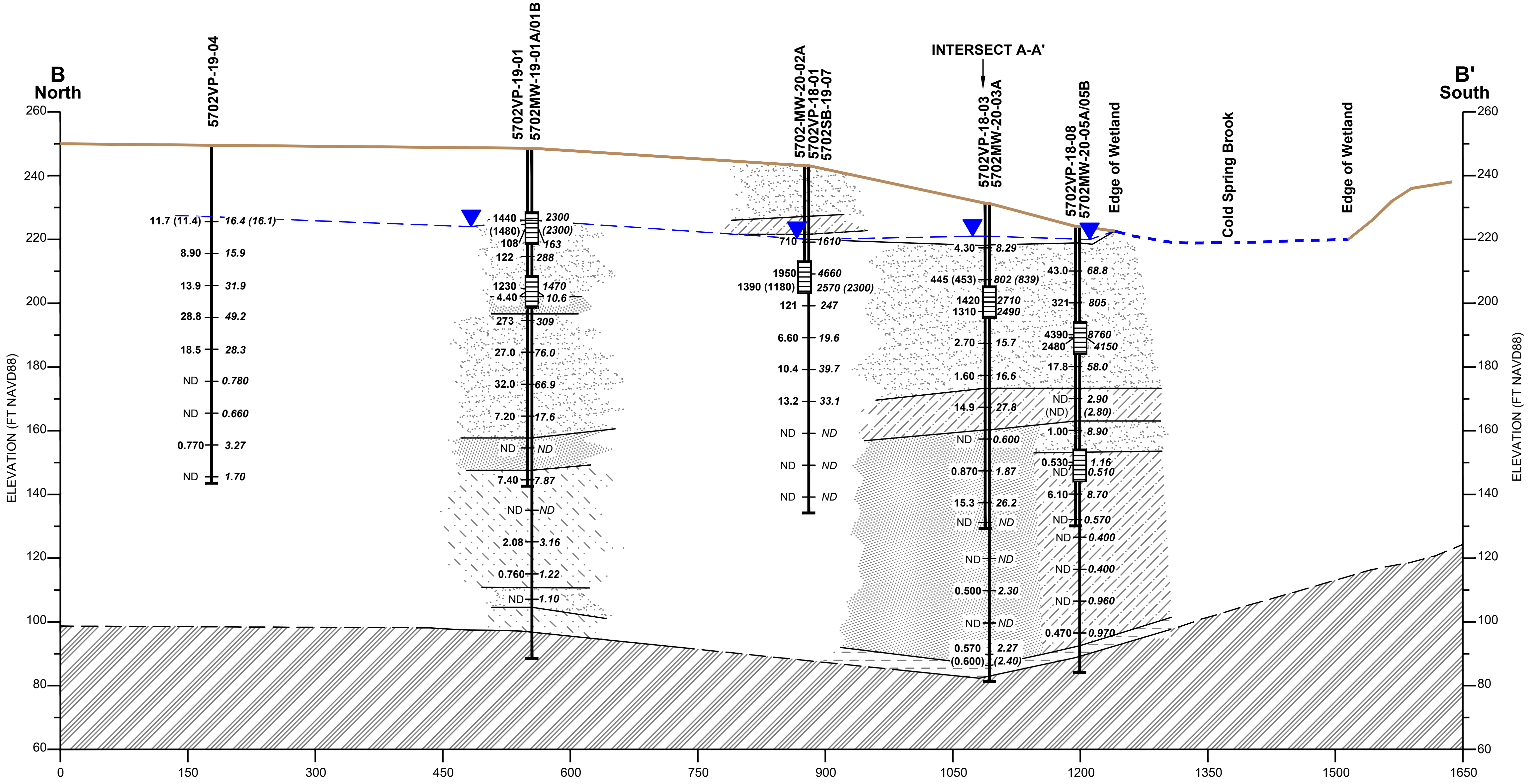


AOC 57 - Cross Section, A-A'
Devens PFAS RI - Area I PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

Scale as Shown	Date: 05/27/2020	Figure 3-11



Legend

Vertical Profile

1.39 U
EPA LHA
Concentration
(sum of PFOA
and PFOS)

2.59 U
MassDEP
Concentration
(sum of PFOS + PFOA
+ PFDA + PFHpA +
PFHxS + PFNA)

Monitoring Well

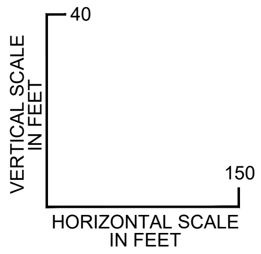
Screened
Interval

- ░ Sand with Gravel/Sand
- ▨ Sand with Silt/Silty Sand
- ▒ Silt
- ░ Silt, Sand, Gravel, with Clay
- ▭ Till
- ▩ Weathered Bedrock
- ▨ Bedrock
- ☐ Unknown
- ▼ Water Table

Notes:

All results in ng/L
ng/L = nanograms per liter
ND = non-detect
( ) = field duplicate

Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorodecanoic acid (PFDA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorononanoic acid (PFNA)



AOC 57 - Cross Section, B-B'
Devens PFAS RI - Area I PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
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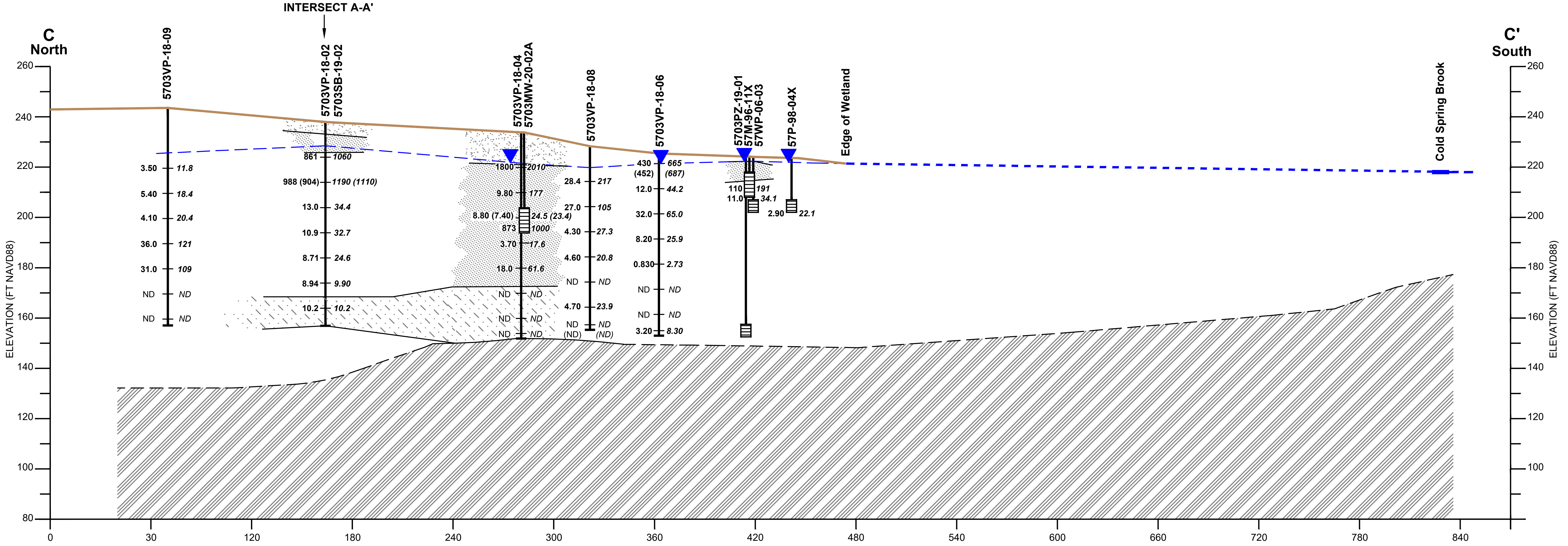
Scale as Shown	Date: 05/27/2020	Figure 3-12

KGS



Legend

Vertical Profile

1.39 U
EPA LHA
Concentration
(sum of PFOA
and PFOS)

2.59 U
MassDEP
Concentration
(sum of PFOS + PFOA
+ PFDA + PFHpA +
PFHxS + PFNA)

Monitoring Well

Screened
Interval

░	Sand with Gravel/Sand
▨	Sand with Silt/Silty Sand
▒	Silt
░	Silt, Sand, Gravel, with Clay
┄	Till
▩	Weathered Bedrock
▨	Bedrock
☐	Unknown
▼	Water Table

Notes:

All results in ng/L
ng/L = nanograms per liter
ND = non-detect
( ) = field duplicate

Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorodecanoic acid (PFDA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorononanoic acid (PFNA)

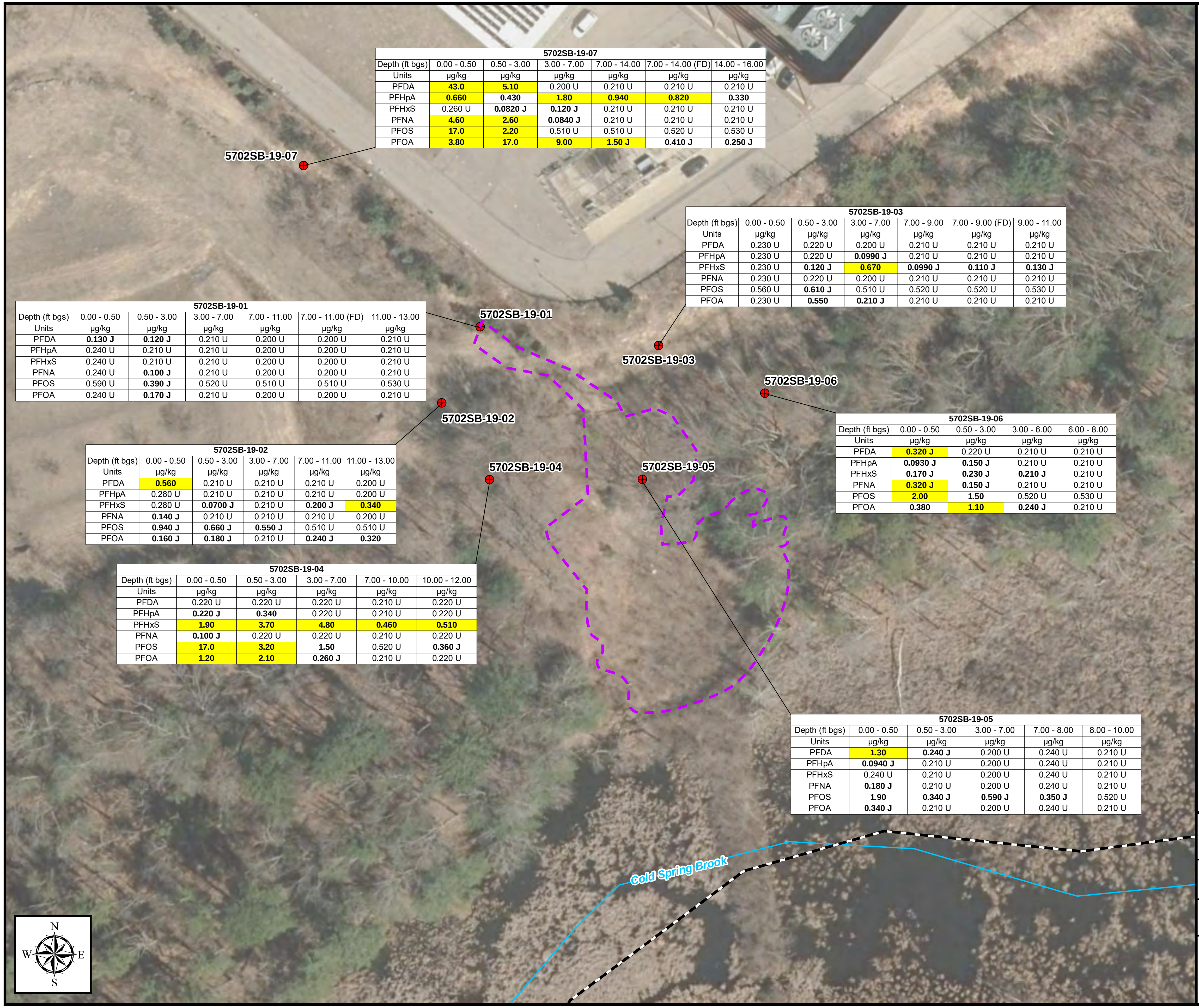
40
VERTICAL SCALE
IN FEET
60
HORIZONTAL SCALE
IN FEET

AOC 57 - Cross Section, C-C'
Devens PFAS RI - Area I PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

Scale as Shown	Date: 05/27/2020	Figure 3-13



5702SB-19-07						
Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 14.00	7.00 - 14.00 (FD)	14.00 - 16.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**43.0**	**5.10**	0.200 U	0.210 U	0.210 U	0.210 U
PFHpA	**0.660**	**0.430**	**1.80**	**0.940**	**0.820**	**0.330**
PFHxS	0.260 U	**0.0820 J**	**0.120 J**	0.210 U	0.210 U	0.210 U
PFNA	**4.60**	**2.60**	**0.0840 J**	0.210 U	0.210 U	0.210 U
PFOS	**17.0**	**2.20**	0.510 U	0.510 U	0.520 U	0.530 U
PFOA	**3.80**	**17.0**	**9.00**	**1.50 J**	**0.410 J**	**0.250 J**

5702SB-19-03						
Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 9.00	7.00 - 9.00 (FD)	9.00 - 11.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	0.230 U	0.220 U	0.200 U	0.210 U	0.210 U	0.210 U
PFHpA	0.230 U	0.220 U	**0.0990 J**	0.210 U	0.210 U	0.210 U
PFHxS	0.230 U	**0.120 J**	**0.670**	**0.0990 J**	**0.110 J**	**0.130 J**
PFNA	0.230 U	0.220 U	0.200 U	0.210 U	0.210 U	0.210 U
PFOS	0.560 U	**0.610 J**	0.510 U	0.520 U	0.520 U	0.530 U
PFOA	0.230 U	**0.550**	**0.210 J**	0.210 U	0.210 U	0.210 U

5702SB-19-01						
Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 11.00	7.00 - 11.00 (FD)	11.00 - 13.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**0.130 J**	**0.120 J**	0.210 U	0.200 U	0.200 U	0.210 U
PFHpA	0.240 U	0.210 U	0.210 U	0.200 U	0.200 U	0.210 U
PFHxS	0.240 U	0.210 U	0.210 U	0.200 U	0.200 U	0.210 U
PFNA	0.240 U	**0.100 J**	0.210 U	0.200 U	0.200 U	0.210 U
PFOS	0.590 U	**0.390 J**	0.520 U	0.510 U	0.510 U	0.530 U
PFOA	0.240 U	**0.170 J**	0.210 U	0.200 U	0.200 U	0.210 U

5702SB-19-06				
Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 6.00	6.00 - 8.00
Units	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**0.320 J**	0.220 U	0.210 U	0.210 U
PFHpA	**0.0930 J**	**0.150 J**	0.210 U	0.210 U
PFHxS	**0.170 J**	**0.230 J**	**0.210 J**	0.210 U
PFNA	**0.320 J**	**0.150 J**	0.210 U	0.210 U
PFOS	**2.00**	**1.50**	0.520 U	0.530 U
PFOA	**0.380**	**1.10**	**0.240 J**	0.210 U

5702SB-19-02					
Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 11.00	11.00 - 13.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**0.560**	0.210 U	0.210 U	0.210 U	0.200 U
PFHpA	0.280 U	0.210 U	0.210 U	0.210 U	0.200 U
PFHxS	0.280 U	**0.0700 J**	0.210 U	**0.200 J**	**0.340**
PFNA	**0.140 J**	0.210 U	0.210 U	0.210 U	0.200 U
PFOS	**0.940 J**	**0.660 J**	**0.550 J**	0.510 U	0.510 U
PFOA	**0.160 J**	**0.180 J**	0.210 U	**0.240 J**	**0.320**

5702SB-19-04					
Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 10.00	10.00 - 12.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	0.220 U	0.220 U	0.220 U	0.210 U	0.220 U
PFHpA	**0.220 J**	**0.340**	0.220 U	0.210 U	0.220 U
PFHxS	**1.90**	**3.70**	**4.80**	**0.460**	**0.510**
PFNA	**0.100 J**	0.220 U	0.220 U	0.210 U	0.220 U
PFOS	**17.0**	**3.20**	**1.50**	0.520 U	**0.360 J**
PFOA	**1.20**	**2.10**	**0.260 J**	0.210 U	0.220 U

5702SB-19-05					
Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 8.00	8.00 - 10.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**1.30**	**0.240 J**	0.200 U	0.240 U	0.210 U
PFHpA	**0.0940 J**	0.210 U	0.200 U	0.240 U	0.210 U
PFHxS	0.240 U	0.210 U	0.200 U	0.240 U	0.210 U
PFNA	**0.180 J**	0.210 U	0.200 U	0.240 U	0.210 U
PFOS	**1.90**	**0.340 J**	**0.590 J**	**0.350 J**	0.520 U
PFOA	**0.340 J**	0.210 U	0.200 U	0.240 U	0.210 U

Legend

●	Soil Boring Location
▭	Approximate Soil Removal Area
▭	Former Fort Devens Boundary
—	Stream

Notes:

Criteria = S-1/GW-1,Massachusetts Contingency Plan, 2019 Proposed PFAS Revisions

PFAS	Limits (µg/kg)
Perfluorodecanoic acid (PFDA)	0.300
Perfluoroheptanoic acid (PFHpA)	0.500
Perfluorohexanesulfonic acid (PFHxS)	0.300
Perfluorononanoic acid (PFNA)	0.320
Perfluorooctanesulfonic acid (PFOS)	2.00
Perfluorooctanoic acid (PFOA)	0.720

2.00 = detection of PFAS

2.00 = detection of PFAS above criteria

Data reported to three significant figures

µg/kg = micrograms per kilogram
U = non-detect
J = estimated result

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 57 Area 2 Soil Sampling Results
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

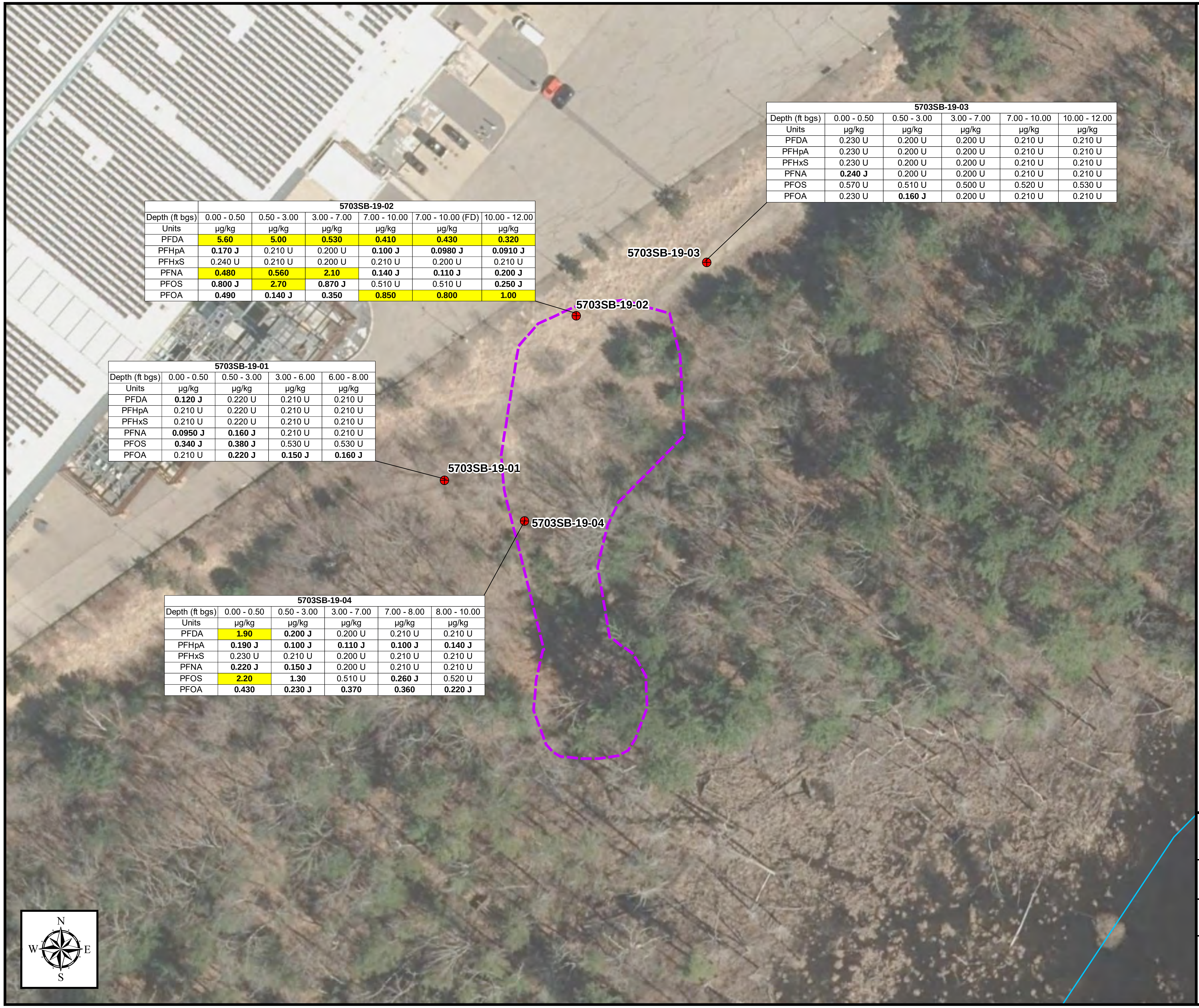
KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 30 60
Feet

Date:
05/06/2020

Figure
3-14

File: PFAS_RI_A1_PSC_AOC57-2_SoilResults.mxd



	5703SB-19-02					
Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 10.00	7.00 - 10.00 (FD)	10.00 - 12.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**5.60**	**5.00**	**0.530**	**0.410**	**0.430**	**0.320**
PFHpA	**0.170 J**	0.210 U	0.200 U	**0.100 J**	**0.0980 J**	**0.0910 J**
PFHxS	0.240 U	0.210 U	0.200 U	0.210 U	0.200 U	0.210 U
PFNA	**0.480**	**0.560**	**2.10**	**0.140 J**	**0.110 J**	**0.200 J**
PFOS	**0.800 J**	**2.70**	**0.870 J**	0.510 U	0.510 U	**0.250 J**
PFOA	**0.490**	**0.140 J**	**0.350**	**0.850**	**0.800**	**1.00**

	5703SB-19-03				
Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 10.00	10.00 - 12.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	0.230 U	0.200 U	0.200 U	0.210 U	0.210 U
PFHpA	0.230 U	0.200 U	0.200 U	0.210 U	0.210 U
PFHxS	0.230 U	0.200 U	0.200 U	0.210 U	0.210 U
PFNA	**0.240 J**	0.200 U	0.200 U	0.210 U	0.210 U
PFOS	0.570 U	0.510 U	0.500 U	0.520 U	0.530 U
PFOA	0.230 U	**0.160 J**	0.200 U	0.210 U	0.210 U

	5703SB-19-01			
Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 6.00	6.00 - 8.00
Units	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**0.120 J**	0.220 U	0.210 U	0.210 U
PFHpA	0.210 U	0.220 U	0.210 U	0.210 U
PFHxS	0.210 U	0.220 U	0.210 U	0.210 U
PFNA	**0.0950 J**	**0.160 J**	0.210 U	0.210 U
PFOS	**0.340 J**	**0.380 J**	0.530 U	0.530 U
PFOA	0.210 U	**0.220 J**	**0.150 J**	**0.160 J**

	5703SB-19-04				
Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 8.00	8.00 - 10.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**1.90**	**0.200 J**	0.200 U	0.210 U	0.210 U
PFHpA	**0.190 J**	**0.100 J**	**0.110 J**	**0.100 J**	**0.140 J**
PFHxS	0.230 U	0.210 U	0.200 U	0.210 U	0.210 U
PFNA	**0.220 J**	**0.150 J**	0.200 U	0.210 U	0.210 U
PFOS	**2.20**	**1.30**	0.510 U	**0.260 J**	0.520 U
PFOA	**0.430**	**0.230 J**	**0.370**	**0.360**	**0.220 J**

Legend

●	Soil Boring Location
▭	Approximate Soil Removal Area
▭	Former Fort Devens Boundary
―	Stream

Notes:

Criteria = S-1/GW-1, Massachusetts Contingency Plan, 2019 Proposed PFAS Revisions

PFAS	Limits (µg/kg)
Perfluorodecanoic acid (PFDA)	0.300
Perfluoroheptanoic acid (PFHpA)	0.500
Perfluorohexanesulfonic acid (PFHxS)	0.300
Perfluorononanoic acid (PFNA)	0.320
Perfluorooctanesulfonic acid (PFOS)	2.00
Perfluorooctanoic acid (PFOA)	0.720

2.00 = detection of PFAS

2.00 = detection of PFAS above criteria

Data reported to three significant figures

µg/kg = micrograms per kilogram
U = non-detect
J = estimated result

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 57 Area 3 Soil Results
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

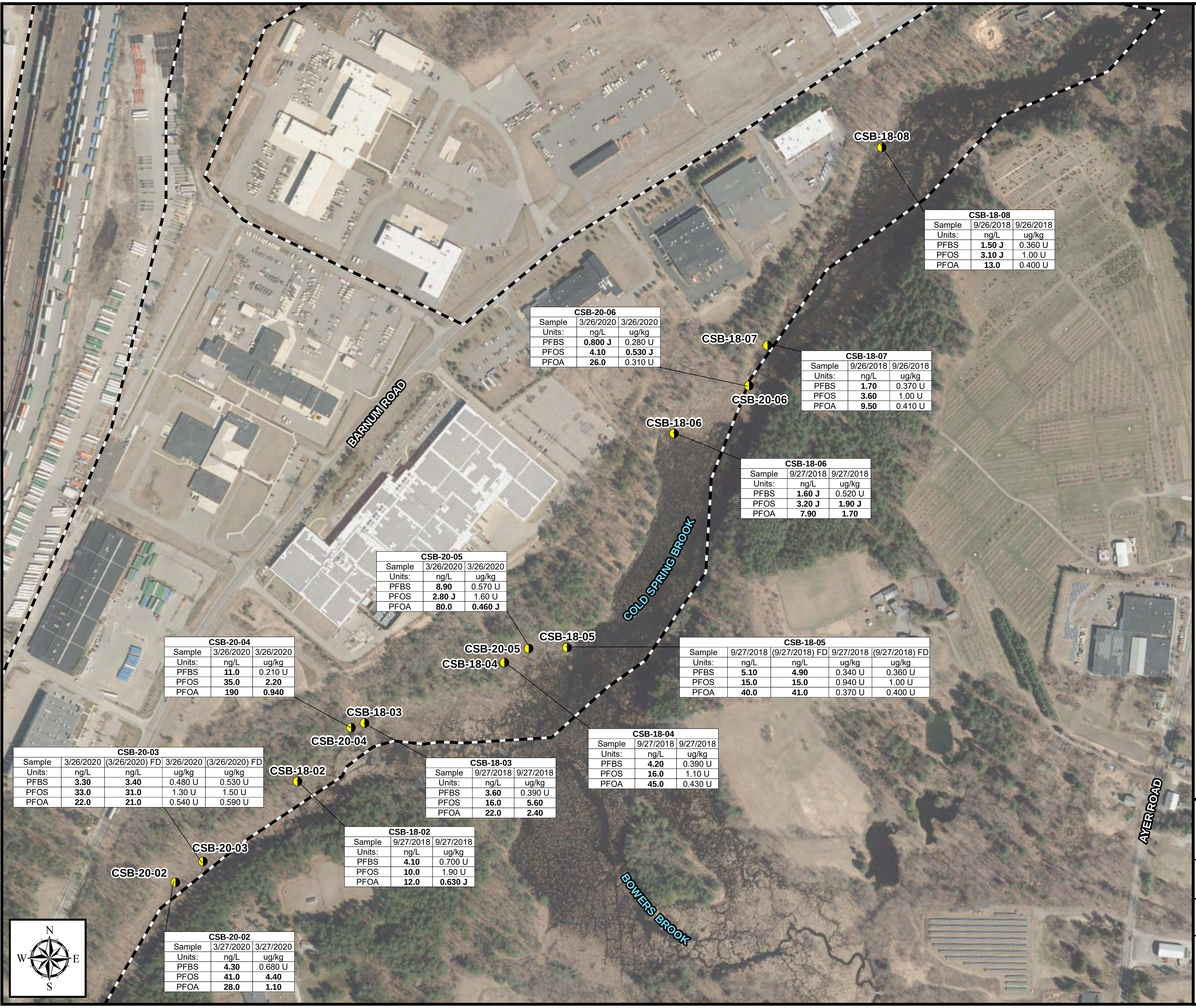
KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 30 60
Feet

Date:
05/06/2020

Figure
3-15

File: PFAS_RI_A1_PSC_AOC57-3_SoilResults.mxd



CSB-18-08		
Sample	9/26/2018	9/26/2018
Units:	ng/L	ug/kg
PFBS	**1.50 J**	0.360 U
PFOS	**3.10 J**	1.00 U
PFOA	**13.0**	0.400 U

CSB-20-06		
Sample	3/26/2020	3/26/2020
Units:	ng/L	ug/kg
PFBS	**0.800 J**	0.280 U
PFOS	**4.10**	**0.530 J**
PFOA	**26.0**	0.310 U

CSB-18-07		
Sample	9/26/2018	9/26/2018
Units:	ng/L	ug/kg
PFBS	**1.70**	0.370 U
PFOS	**3.60**	1.00 U
PFOA	**9.50**	0.410 U

CSB-18-06		
Sample	9/27/2018	9/27/2018
Units:	ng/L	ug/kg
PFBS	**1.60 J**	0.520 U
PFOS	**3.20 J**	**1.90 J**
PFOA	**7.90**	**1.70**

CSB-20-05		
Sample	3/26/2020	3/26/2020
Units:	ng/L	ug/kg
PFBS	**8.90**	0.570 U
PFOS	**2.80 J**	1.60 U
PFOA	**80.0**	**0.460 J**

CSB-18-05				
Sample	9/27/2018	(9/27/2018) FD	9/27/2018	(9/27/2018) FD
Units:	ng/L	ng/L	ug/kg	ug/kg
PFBS	**5.10**	**4.90**	0.340 U	0.360 U
PFOS	**15.0**	**15.0**	0.940 U	1.00 U
PFOA	**40.0**	**41.0**	0.370 U	0.400 U

CSB-20-04		
Sample	3/26/2020	3/26/2020
Units:	ng/L	ug/kg
PFBS	**11.0**	0.210 U
PFOS	**35.0**	**2.20**
PFOA	**190**	**0.940**

CSB-18-04		
Sample	9/27/2018	9/27/2018
Units:	ng/L	ug/kg
PFBS	**4.20**	0.390 U
PFOS	**16.0**	1.10 U
PFOA	**45.0**	0.430 U

CSB-20-03				
Sample	3/26/2020	(3/26/2020) FD	3/26/2020	(3/26/2020) FD
Units:	ng/L	ng/L	ug/kg	ug/kg
PFBS	**3.30**	**3.40**	0.480 U	0.530 U
PFOS	**33.0**	**31.0**	1.30 U	1.50 U
PFOA	**22.0**	**21.0**	0.540 U	0.590 U

CSB-18-03		
Sample	9/27/2018	9/27/2018
Units:	ng/L	ug/kg
PFBS	**3.60**	0.390 U
PFOS	**16.0**	**5.60**
PFOA	**22.0**	**2.40**

CSB-18-02		
Sample	9/27/2018	9/27/2018
Units:	ng/L	ug/kg
PFBS	**4.10**	0.700 U
PFOS	**10.0**	1.90 U
PFOA	**12.0**	**0.630 J**

CSB-20-02		
Sample	3/27/2020	3/27/2020
Units:	ng/L	ug/kg
PFBS	**4.30**	0.680 U
PFOS	**41.0**	**4.40**
PFOA	**28.0**	**1.10**

Aerial Sources: 2019, USGS, MassGIS

File: PFAS_RI_A1_PSC_North_ColdSpringBrook_SWSD_Results.mxd

Legend

◐ Surface Water and Sediment Sample Location

⬚ Former Fort Devens Boundary

EPA PFAS Site Specific Screening Levels for Former Fort Devens			
Surface Water		Sediment	
Units:	ng/L	Units:	µg/kg
PFOA	2,030	PFOA	609
PFOS	2,030	PFOS	609
PFBS	2,030,000	PFBS	609,000

Notes:

Perfluorooctane Sulfonic Acid (PFOS)
Perfluorooctanoic Acid (PFOA)
Perfluorobutanesulfonic acid (PFBS)
ng/L = nanograms per liter (Surface Water Result Value)
µg/kg = microgram per kilogram (Sediment Result value)

J = estimated result
U= not detected above the reported sample quantitation limit
Bold = detection

Northern Extent Cold Spring Brook PFAS Results in Surface Water and Sediment Samples Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

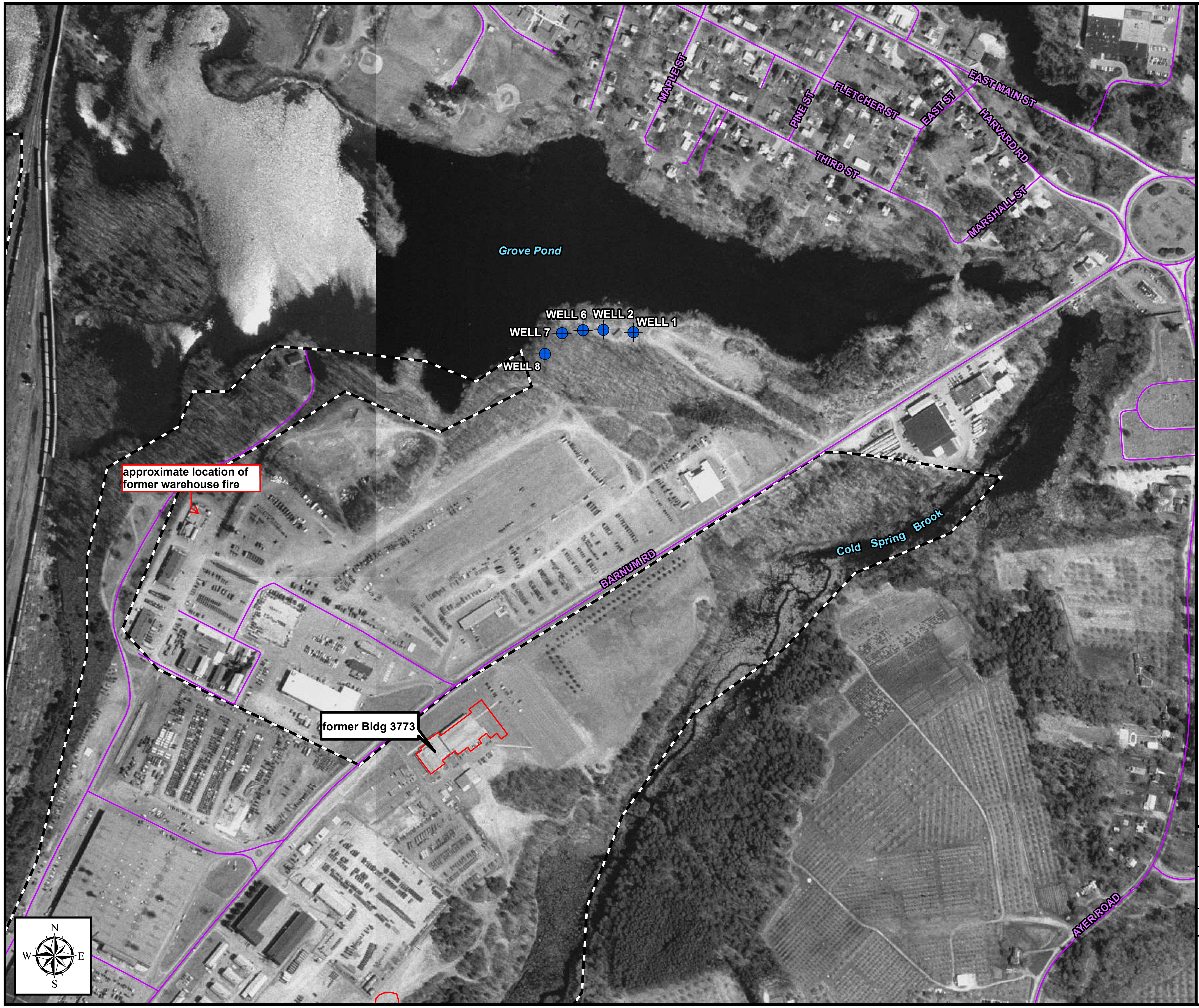
KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 200 400
Feet

Date:
05/05/2020

Figure
3-16

KGS



Legend

⊕ Public Water Supply Well

Current Road

▭ Former Fort Devens Boundary

Note:

Aerial Source: MassGIS - 1:5,000 Black and
White Digital Orthophoto Images - 1992

Grove Pond Area/AOC 74 1992 Aerial Imagery
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC

0 200 400
Feet

Date:
04/02/2020

Figure
4-1

KGS

File: PFAS_IDE_2020_GrovePond_AOC74_1992Imagery.mxd

Legend

Historic Subsurface Features

— Communication Line

● Electric

— Electric Line

ufueltank_ful.dwg Point

RefName

UST Underground Tank

- - Steam

● Storm

— Storm Line

▨ Storm Feature

● Sanitary

— Sanitary Line

▬ Sanitary Feature

● Water

— Water Line

▬ Water Feature

● Abandoned Feature

- - Abandoned Line

● Gas

— Gas Line

▭ Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

Grove Pond and AOC 74 Area Historic Subsurface Features
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

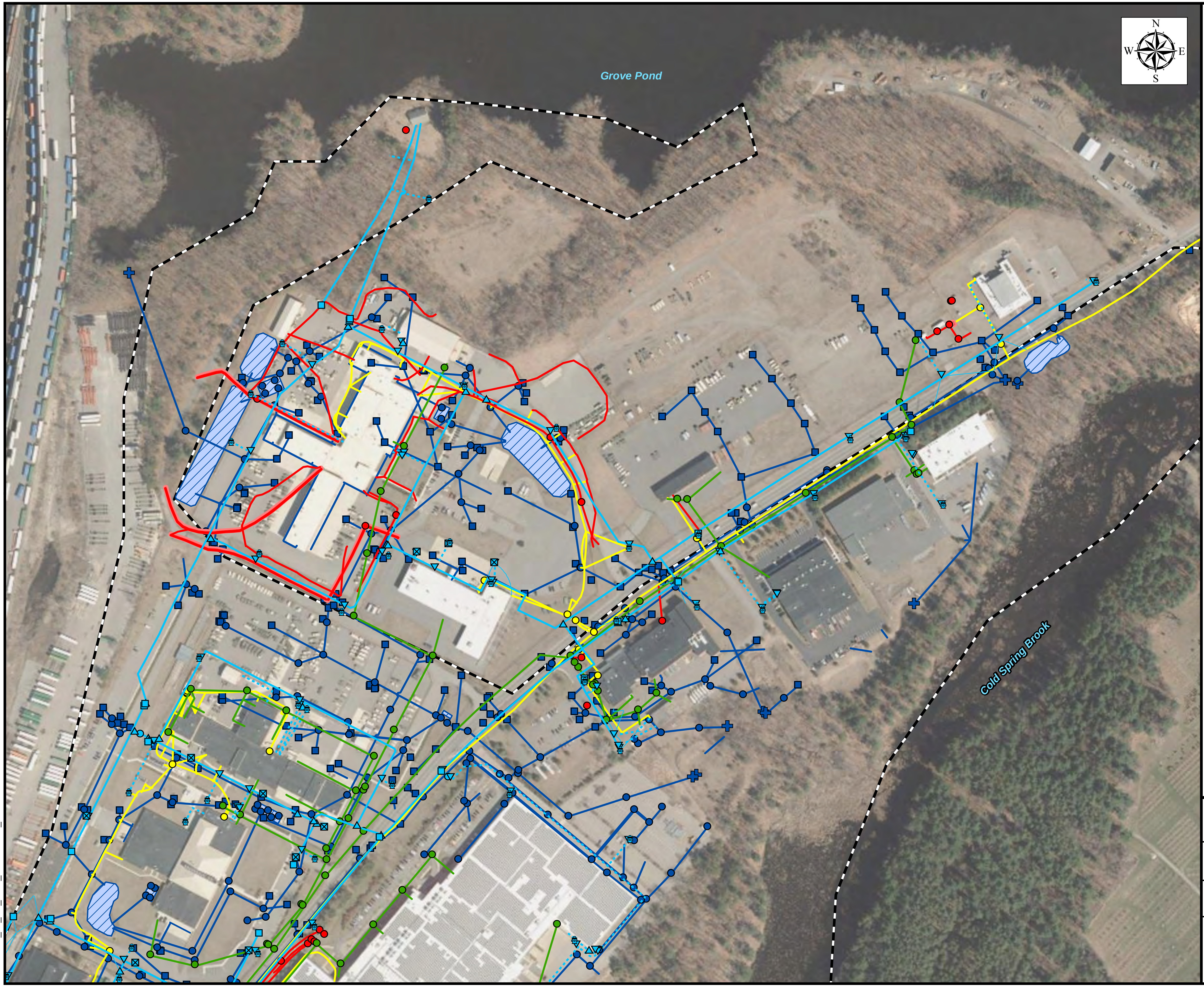
0 150 300
Feet

Date:
04/26/2020

Figure
4-2

KGS

File: PFAS_RI_A1_PSC_GrovePond_HistoricUtilities.mxd



Legend

Water 01/06/2020
- ⊕ Hydrant
- ■ Main Fitting
- ☒ Service Fitting
- ▲ Main Valve
- ▼ Service Valve
- ● Manhole
- — Main Line
- ┈ Service Line
- — Tie

Sewer 01/06/2020
- ● Force Fitting, Main Fitting, Service Fitting, Manhole
- — Force Main, Gravity Main, Service Line, Tie
- 🟩 DBox, Grease Trap, Lift Station, Oil/Water

Electric 01/07/2020
- ● Connection Box, Handhole, Junction Box, Manhole, Meter, Switch, or Transformer
- — Inservice/Abandoned
- 🟥 Vault

Gas 01/06/2020
- ● Main Fitting, Main Valve, Meter, Rectifier, Service Fitting, Service Regulator, Service Valve, Test Station, Anode
- — Main, Service, Tie, Cathodic Loop

Stormwater 12/11/2019
- ■ Catch Basin
- ✚ Outfall
- ● Manhole
- — Pipe, Culvert
- ▨ Detention Pond
- ⬚ Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

Grove Pond and AOC 74 Area Current Subsurface Features
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 150 300
Feet

Date:
04/26/2020

Figure
4-3

File: PFAS_RI_A1_PSC_GrovePond_SubsurfaceUtilities.mxd

Legend

●	Initial Monitoring Well/Piezometer
●	New Monitoring Well/Piezometer
●	Soil Boring Location
▲	Vertical Profiling Location Installation Phase 1
▲	Vertical Profiling Location Installation Phase 2
▲	Vertical Profiling Location Installation Phase 3
▲	Vertical Profiling Location Installation Phase 4
▲	Vertical Profiling Location Installation Phase 5
△	Grove Pond Vertical Profiling Location
◐	Surface Water and Sediment Sampling Location
●	Irrigation Well (Approximate Location)
▭	Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 74 Field Activities
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

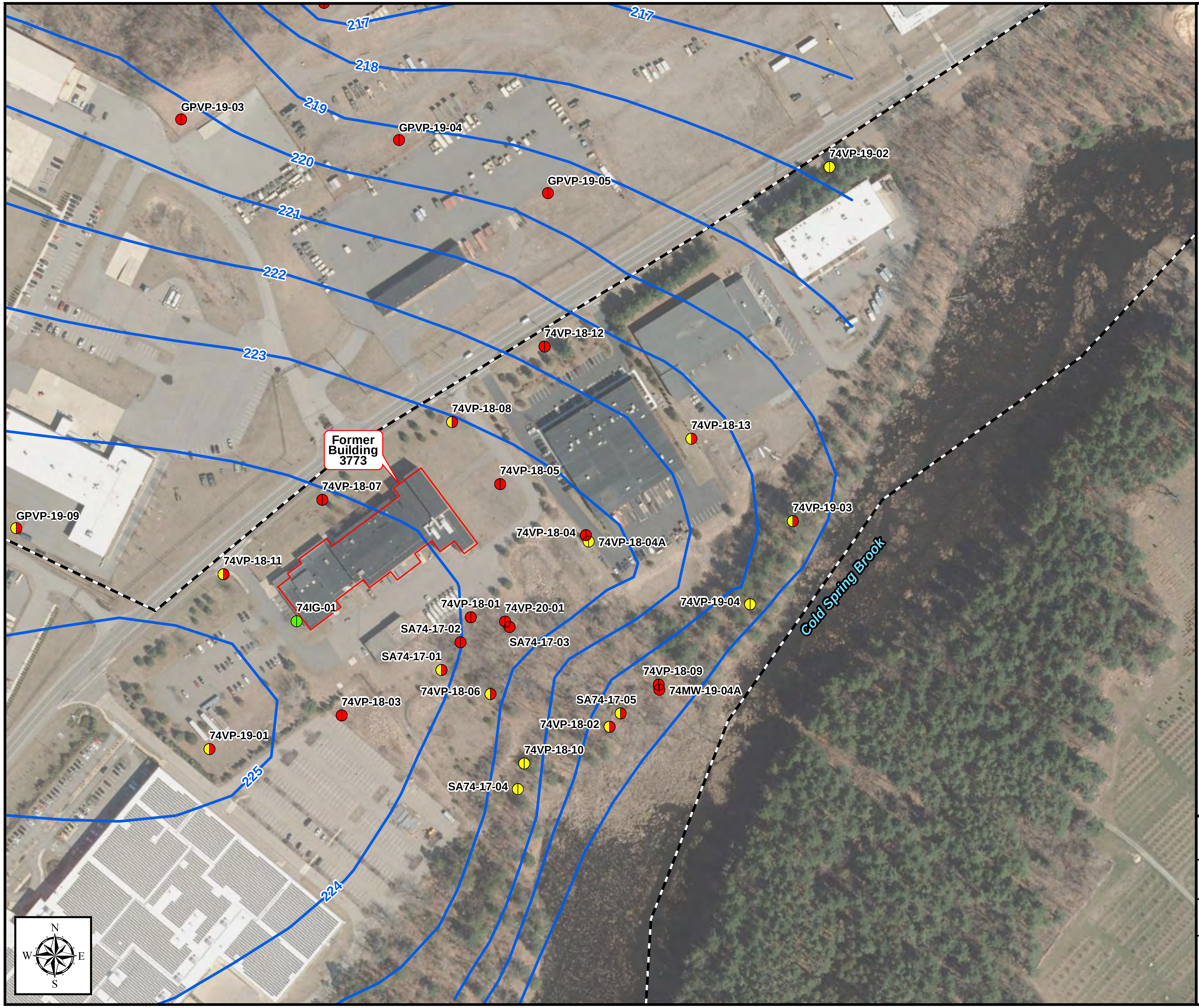
KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 100 200
Feet

Date:
05/12/2020

Figure
4-4

File: PFAS_RI_A1_PSC_AOC74_FieldActivities.mxd



Legend

◐ Monitoring Well/Vertical Profiling Location

EPA LHA
(sum of PFOA and PFOS) (ng/L)

◐ EPA LHA ≥ 70 ng/L

◐ EPA LHA < 70 ng/L

◐ EPA LHA No detection

MassDEP
(sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA) (ng/L)

◑ MassDEP ≥ 20 ng/L

◑ MassDEP < 20ng/L

◑ MassDEP no detection

～ Groundwater Contour (ft NAVD 88)
(Contour Interal = 1 Foot) - March 2020

▭ Former Fort Devens Boundary

Notes:

Samples collected during the PFAS SI (e.g., SA74-17-01 through -05) were not analyzed for PFDA.

MassDEP GW-1 = sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA
MassDEP Exceedance Criteria is defined as equal to or greater than 20 ng/L

EPA LHA (Lifetime Health Advisory) = sum of PFOA and PFOS
EPA LHA Exceedance Criteria is defined as equal to or greater than 70 ng/L

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 74 Groundwater Results
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 100 200
Feet

Date:
05/28/2020

Figure
4-5

KGS

File: PFAS_RI_A1_PSC_AOC74_GWResults.mxd

Legend

◒	Monitoring Well/Piezometer
△	Vertical Profiling Location
⊕	Soil Boring Location
◐	Surface Water and Sediment Sampling Location
Ⓘ	Irrigation Well (Approximate Location)
⊕	Public Water Supply Well
⊕	Temporary Well Location from SI
▬	Cross Section Location
⬚	Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 74 Cross Section Location Map
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

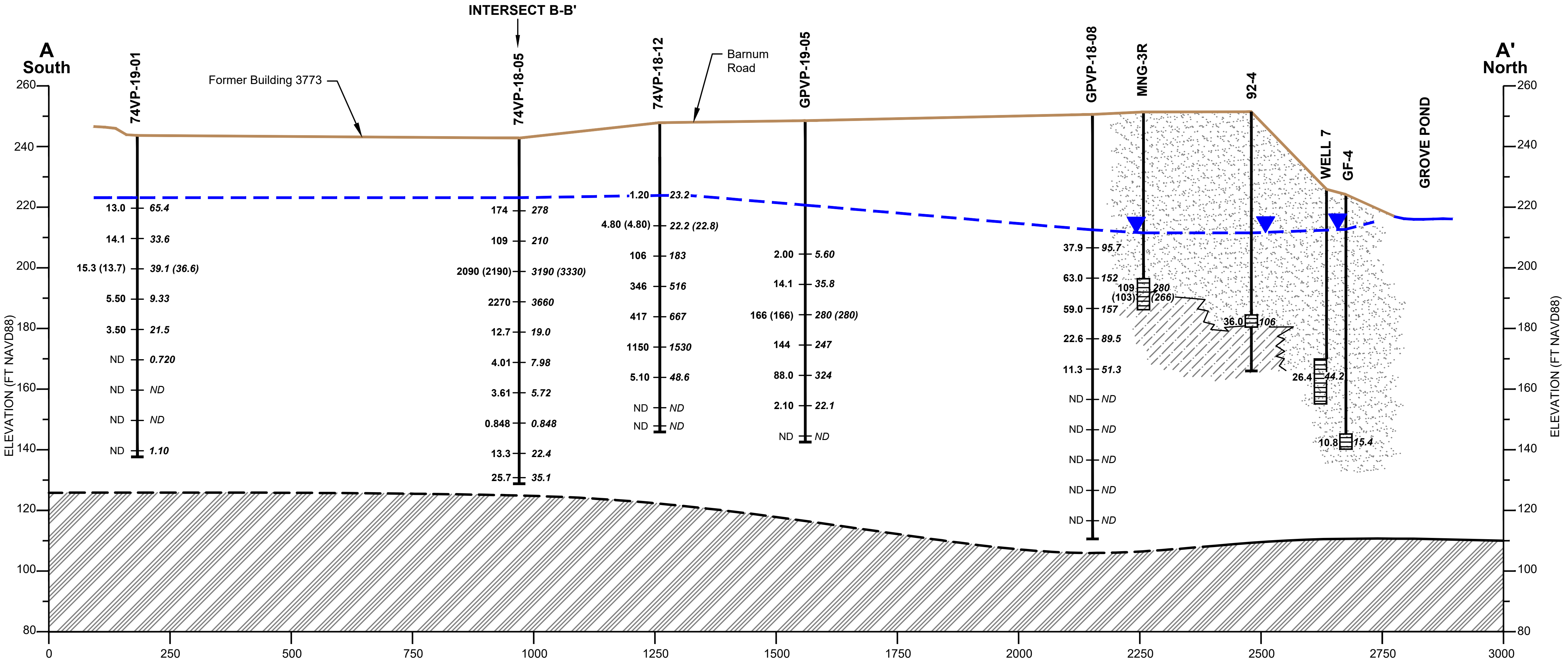
KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 150 300
Feet

Date:
05/08/2020

Figure
4-6

KGS



Legend

Vertical Profile

1.39 U
EPA LHA
Concentration
(sum of PFOA
and PFOS)

2.59 U
MassDEP
Concentration
(sum of PFOS + PFOA
+ PFDA + PFHpA +
PFHxS + PFNA)

Monitoring Well

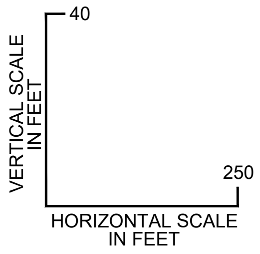
Screened
Interval

⛆	Sand with Gravel/Sand
▨	Sand with Silt/Silty Sand
░	Silt
⛆	Silt, Sand, Gravel, with Clay
▤	Till
▩	Weathered Bedrock
▨	Bedrock
☐	Unknown
▼	Water Table

Notes:

All results in ng/L
ng/L = nanograms per liter
ND = non-detect
( ) = field duplicate

Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorodecanoic acid (PFDA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorononanoic acid (PFNA)

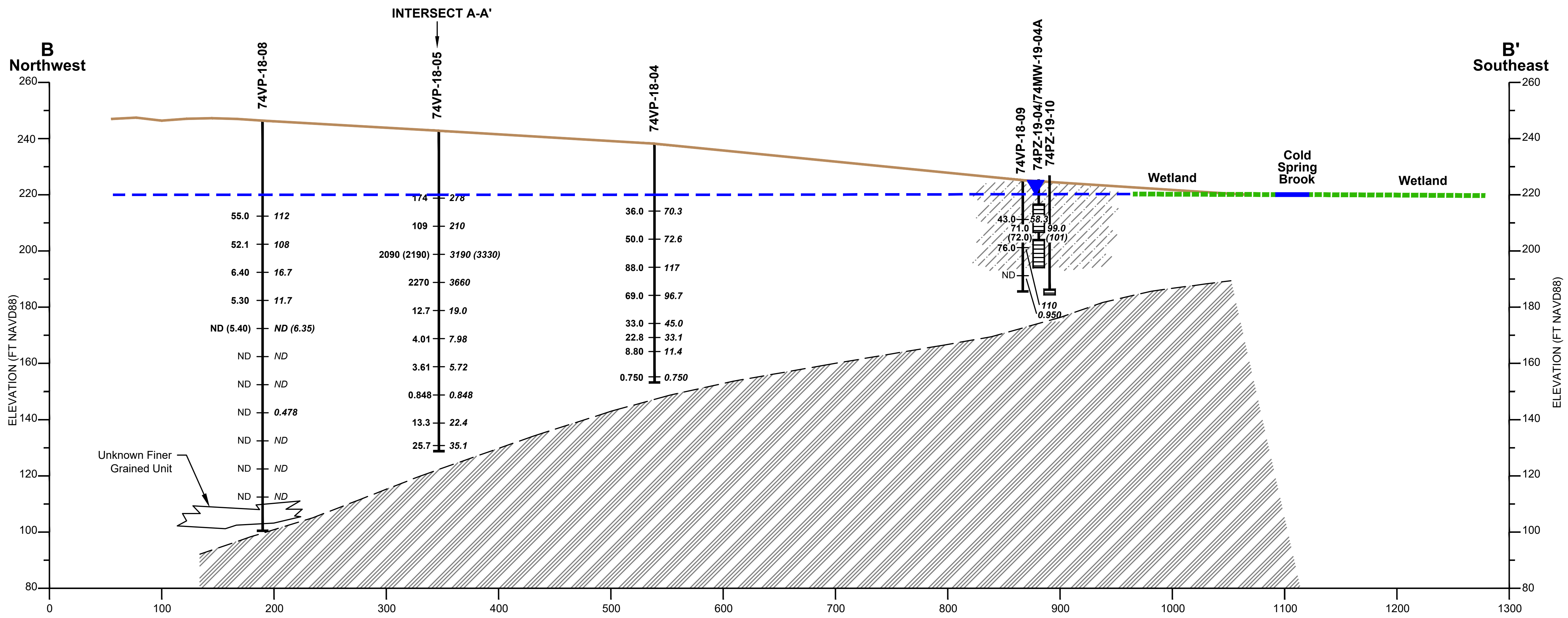


AOC 74 Cross Section, A-A'
Devens PFAS RI - Area I PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

Scale as Shown	Date: 05/28/2020	Figure 4-7	KGS



Legend

Vertical Profile

1.39 U
EPA LHA
Concentration
(sum of PFOA and PFOS)

2.59 U
MassDEP
Concentration
(sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA)

Monitoring Well

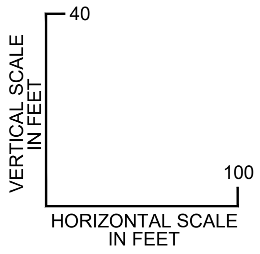
Screened Interval

▨ Sand with Gravel/Sand
▨ Sand with Silt/Silty Sand
▨ Silt
▨ Silt, Sand, Gravel, with Clay
▨ Till
▨ Weathered Bedrock
▨ Bedrock
☐ Unknown
▼ Water Table

Notes:

All results in ng/L
ng/L = nanograms per liter
ND = non-detect
( ) = field duplicate

Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorodecanoic acid (PFDA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorononanoic acid (PFNA)

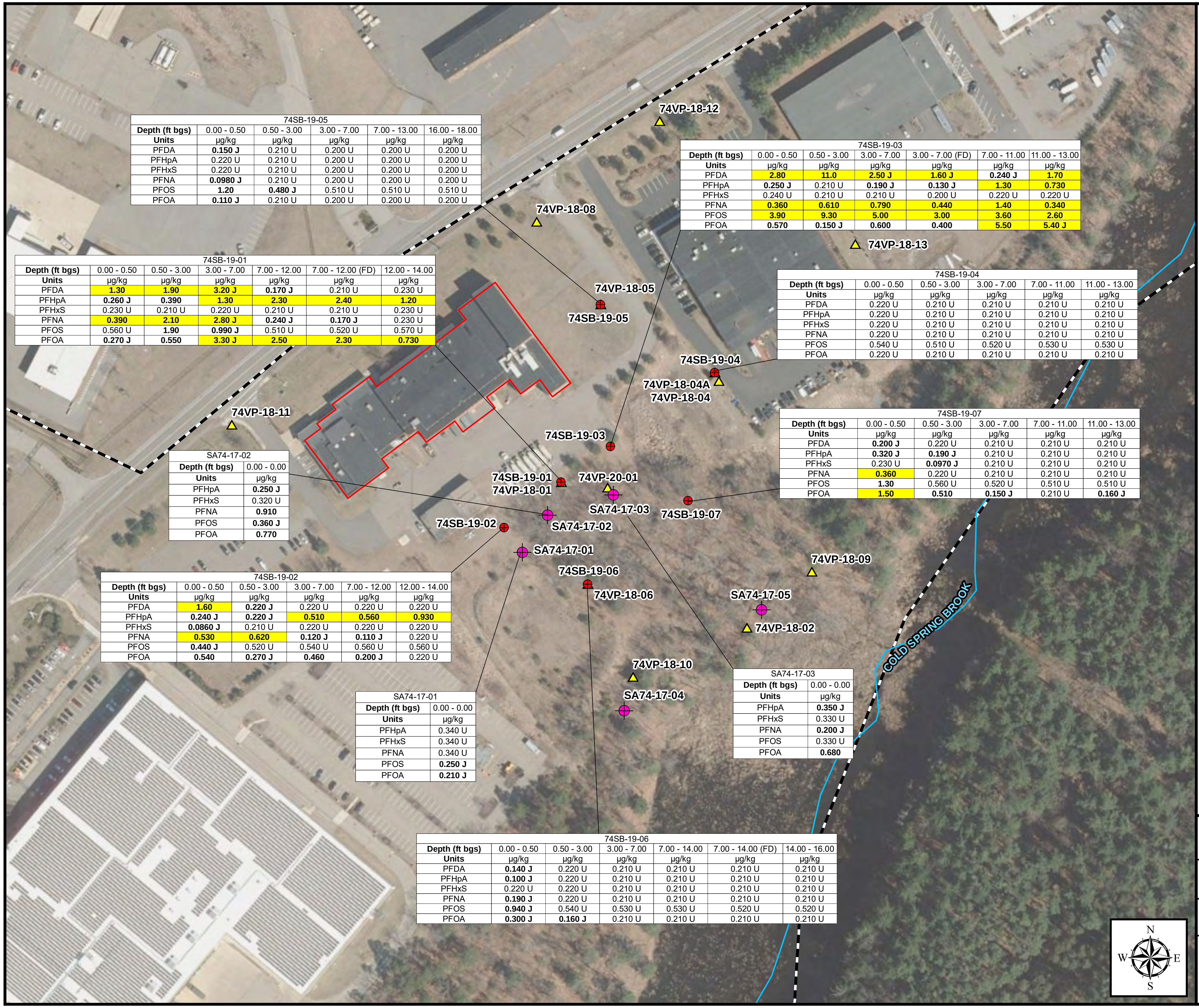


AOC 74 Cross Section, B-B'
Devens PFAS RI - Area I PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

Scale as Shown	Date: 05/28/2020	Figure 4-8	KGS



74SB-19-05

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 13.00	16.00 - 18.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**0.150 J**	0.210 U	0.200 U	0.200 U	0.200 U
PFHpA	0.220 U	0.210 U	0.200 U	0.200 U	0.200 U
PFHxS	0.220 U	0.210 U	0.200 U	0.200 U	0.200 U
PFNA	**0.0980 J**	0.210 U	0.200 U	0.200 U	0.200 U
PFOS	**1.20**	**0.480 J**	0.510 U	0.510 U	0.510 U
PFOA	**0.110 J**	0.210 U	0.200 U	0.200 U	0.200 U

74SB-19-03

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	3.00 - 7.00 (FD)	7.00 - 11.00	11.00 - 13.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**2.80**	**11.0**	**2.50 J**	**1.60 J**	**0.240 J**	**1.70**
PFHpA	**0.250 J**	0.210 U	**0.190 J**	**0.130 J**	**1.30**	**0.730**
PFHxS	0.240 U	0.210 U	0.210 U	0.200 U	0.220 U	0.220 U
PFNA	**0.360**	**0.610**	**0.790**	**0.440**	**1.40**	**0.340**
PFOS	**3.90**	**9.30**	**5.00**	**3.00**	**3.60**	**2.60**
PFOA	**0.570**	**0.150 J**	**0.600**	**0.400**	**5.50**	**5.40 J**

74SB-19-01

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 12.00	7.00 - 12.00 (FD)	12.00 - 14.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**1.30**	**1.90**	**3.20 J**	**0.170 J**	0.210 U	0.230 U
PFHpA	**0.260 J**	**0.390**	**1.30**	**2.30**	**2.40**	**1.20**
PFHxS	0.230 U	0.210 U	0.220 U	0.210 U	0.210 U	0.230 U
PFNA	**0.390**	**2.10**	**2.80 J**	**0.240 J**	**0.170 J**	0.230 U
PFOS	0.560 U	**1.90**	**0.990 J**	0.510 U	0.520 U	0.570 U
PFOA	**0.270 J**	**0.550**	**3.30 J**	**2.50**	**2.30**	**0.730**

74SB-19-04

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 11.00	11.00 - 13.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	0.220 U	0.210 U	0.210 U	0.210 U	0.210 U
PFHpA	0.220 U	0.210 U	0.210 U	0.210 U	0.210 U
PFHxS	0.220 U	0.210 U	0.210 U	0.210 U	0.210 U
PFNA	0.220 U	0.210 U	0.210 U	0.210 U	0.210 U
PFOS	0.540 U	0.510 U	0.520 U	0.530 U	0.530 U
PFOA	0.220 U	0.210 U	0.210 U	0.210 U	0.210 U

74SB-19-07

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 11.00	11.00 - 13.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**0.200 J**	0.220 U	0.210 U	0.210 U	0.210 U
PFHpA	**0.320 J**	**0.190 J**	0.210 U	0.210 U	0.210 U
PFHxS	0.230 U	**0.0970 J**	0.210 U	0.210 U	0.210 U
PFNA	**0.360**	0.220 U	0.210 U	0.210 U	0.210 U
PFOS	**1.30**	0.560 U	0.520 U	0.510 U	0.510 U
PFOA	**1.50**	**0.510**	**0.150 J**	0.210 U	**0.160 J**

SA74-17-02

Depth (ft bgs)	0.00 - 0.00
Units	µg/kg
PFHpA	**0.250 J**
PFHxS	0.320 U
PFNA	**0.910**
PFOS	**0.360 J**
PFOA	**0.770**

74SB-19-02

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 12.00	12.00 - 14.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**1.60**	**0.220 J**	0.220 U	0.220 U	0.220 U
PFHpA	**0.240 J**	**0.220 J**	**0.510**	**0.560**	**0.930**
PFHxS	**0.0860 J**	0.210 U	0.220 U	0.220 U	0.220 U
PFNA	**0.530**	**0.620**	**0.120 J**	**0.110 J**	0.220 U
PFOS	**0.440 J**	0.520 U	0.540 U	0.560 U	0.560 U
PFOA	**0.540**	**0.270 J**	**0.460**	**0.200 J**	0.220 U

SA74-17-01

Depth (ft bgs)	0.00 - 0.00
Units	µg/kg
PFHpA	0.340 U
PFHxS	0.340 U
PFNA	0.340 U
PFOS	**0.250 J**
PFOA	**0.210 J**

SA74-17-03

Depth (ft bgs)	0.00 - 0.00
Units	µg/kg
PFHpA	**0.350 J**
PFHxS	0.330 U
PFNA	**0.200 J**
PFOS	0.330 U
PFOA	**0.680**

74SB-19-06

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 14.00	7.00 - 14.00 (FD)	14.00 - 16.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**0.140 J**	0.220 U	0.210 U	0.210 U	0.210 U	0.210 U
PFHpA	**0.100 J**	0.220 U	0.210 U	0.210 U	0.210 U	0.210 U
PFHxS	0.220 U	0.220 U	0.210 U	0.210 U	0.210 U	0.210 U
PFNA	**0.190 J**	0.220 U	0.210 U	0.210 U	0.210 U	0.210 U
PFOS	**0.940 J**	0.540 U	0.530 U	0.530 U	0.520 U	0.520 U
PFOA	**0.300 J**	**0.160 J**	0.210 U	0.210 U	0.210 U	0.210 U

Legend

●	Soil Boring Location
△	Vertical Profiling Location
⊕	Temporary Well Location from SI
—	Stream
▭	Former Fort Devens Boundary

Notes:

Criteria = S-1/GW-1 Massachusetts Contingency Plan, 2019 Proposed PFAS Revisions

PFAS	Limits (µg/kg)
Perfluorodecanoic acid (PFDA)	0.300
Perfluoroheptanoic acid (PFHpA)	0.500
Perfluorohexanesulfonic acid (PFHxS)	0.300
Perfluorononanoic acid (PFNA)	0.320
Perfluorooctanesulfonic acid (PFOS)	2.00
Perfluorooctanoic acid (PFOA)	0.720

2.00 = detection of PFAS

2.00 🟨 = detection of PFAS above criteria

Data reported to three significant figures

µg/kg = micrograms per kilogram
U = non-detect
J = estimated result

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 74 Soil Results
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 75 150
Feet

Date: 05/12/2020

Figure 4-9

File: PFAS_RI_A1_PSC_AOC74_SoilResults.mxd

Legend

—	Current Road
▭	Former Building T-1445 Warehouse Fire
⬚	Former Fort Devens Boundary

Note:

Aerial Source: MassGIS - 1:5,000 Black and White Digital Orthophoto Images - 1992

AOC 75 1992 Aerial Imagery
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

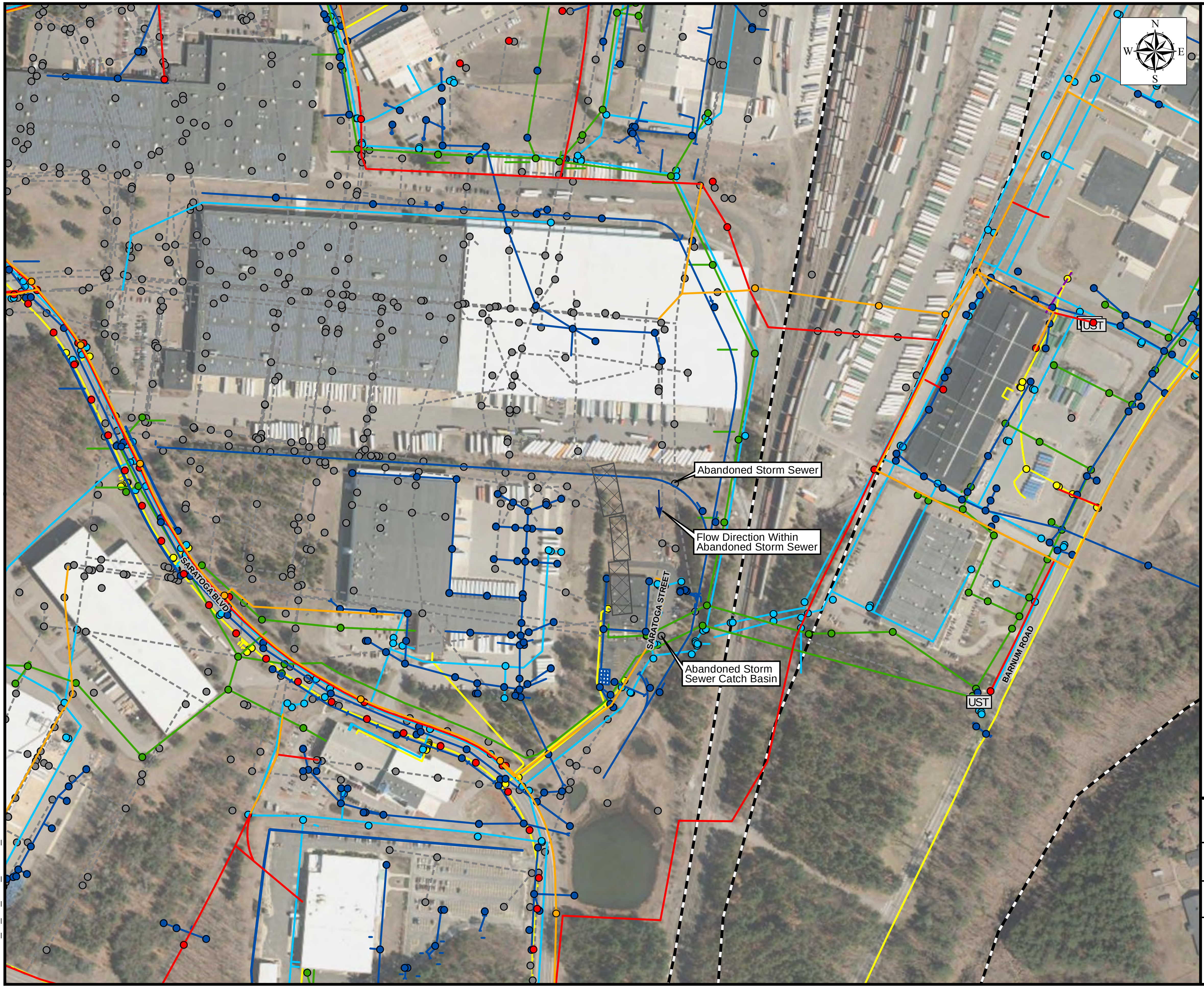
KOMAN Government Solutions, LLC

0 125 250
Feet

Date:
05/12/2020

Figure
5-1

File: PFAS_IDE_2020_AOC75_1992Imagery.mxd



Legend

Historic Subsurface Features

- ● Communication
- — Communication Line
- ● Electric
- — Electric Line
- UST Underground Tank
- - - Steam
- ● Storm
- — Storm Line
- ▨ Storm Feature
- ● Sanitary
- — Sanitary Line
- 🟩 Sanitary Feature
- ● Water
- — Water Line
- ▭ Water Feature
- ● Abandoned Feature
- - - Abandoned Line
- ● Gas
- — Gas Line
- ☒ Former Warehouse Building
- ▭ Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 75 Area Historic Subsurface Features
Devens PFAS - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 150 300
Feet

Date:
05/12/2020

Figure
5-2

File: PFAS_RI_A1_PSC_AOC75_HistoricUtilities.mxd

Legend

Water 01/06/2020
- Hydrant
- ◻ Main Fitting
- ☒ Service Fitting
- △ Main Valve
- ▽ Service Valve
- ○ Manhole
- — Main Line
- ┄ Service Line
- — Tie

Sewer 01/06/2020
- ● Force Fitting, Main Fitting, Service Fitting, Manhole
- — Force Main, Gravity Main, Service Line, Tie
- 🟩 DBox, Grease Trap, Lift Station, Oil/Water

Electric 01/07/2020
- ● Connection Box, Handhole, Junction Box, Manhole, Meter, Switch, or Transformer
- — Inservice/Abandoned
- 🟥 Vault

Gas 01/06/2020
- ● Main Fitting, Main Valve, Meter, Rectifier, Service Fitting, Service Regulator, Service Valve, Test Station, Anode
- — Main, Service, Tie, Cathodic Loop

Stormwater 12/11/2019
- ■ Catch Basin
- ✚ Outfall
- ● Manhole
- — Pipe, Culvert
- ▨ Detention Pond
- ▭ Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 75 Area Current Subsurface Features
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

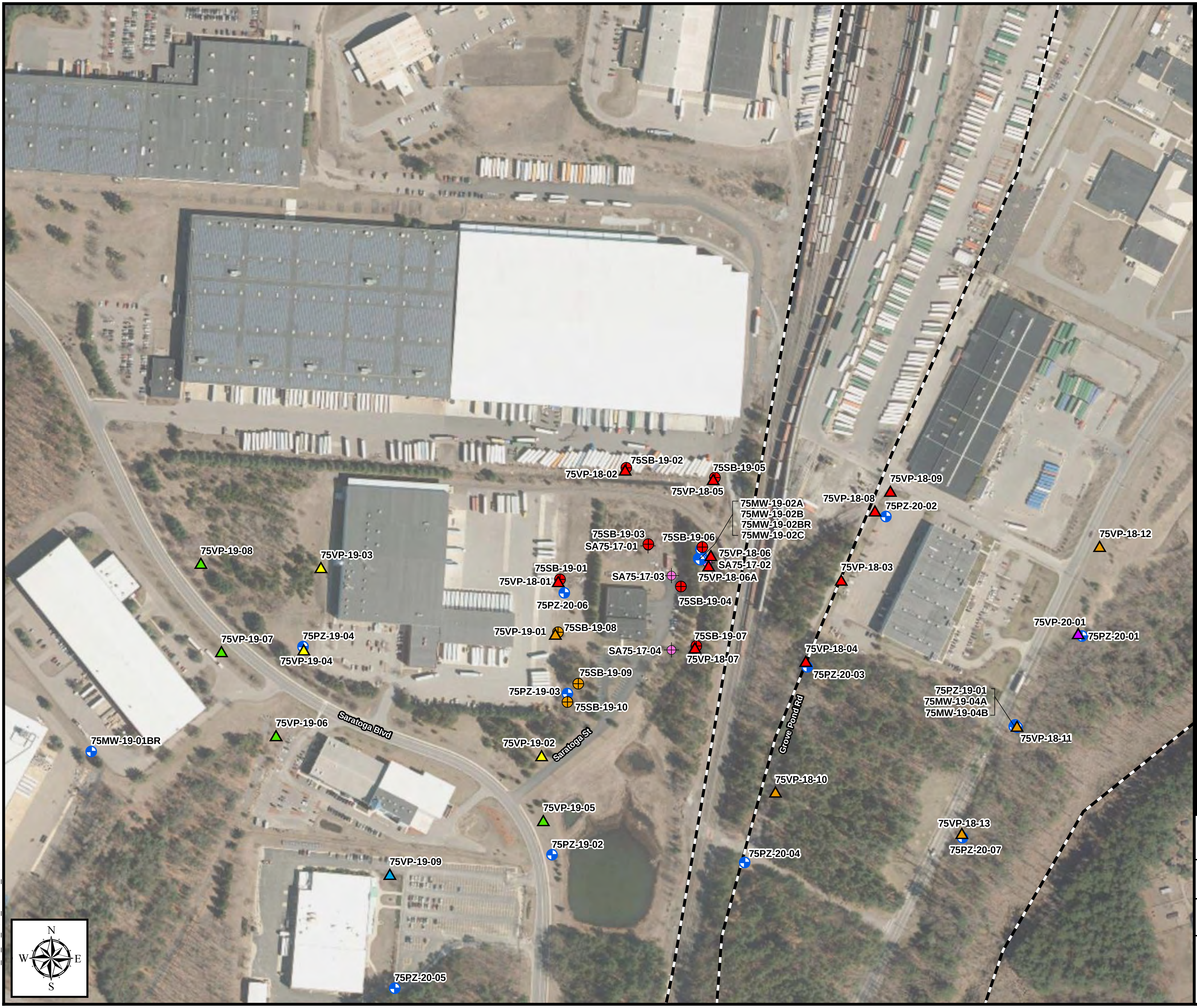
KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 150 300
Feet

Date:
04/26/2020

Figure
5-3

File: PFAS_RI_A1_PSC_AOC75_SubsurfaceUtilities.mxd



Legend

⊕ Soil Boring Location Installation Phase 1

⊕ Soil Boring Location Installation Phase 2

▲ Vertical Profiling Location Installation Phase 1

▲ Vertical Profiling Location Installation Phase 2

▲ Vertical Profiling Location Installation Phase 3

▲ Vertical Profiling Location Installation Phase 4

▲ Vertical Profiling Location Installation Phase 5

▲ Vertical Profiling Location Installation Phase 6

● New Monitoring Well/Piezometer

⊕ Temporary Well Location from SI

▭ Former Fort Devens Boundary

AOC 75 Field Activities
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 150 300
Feet

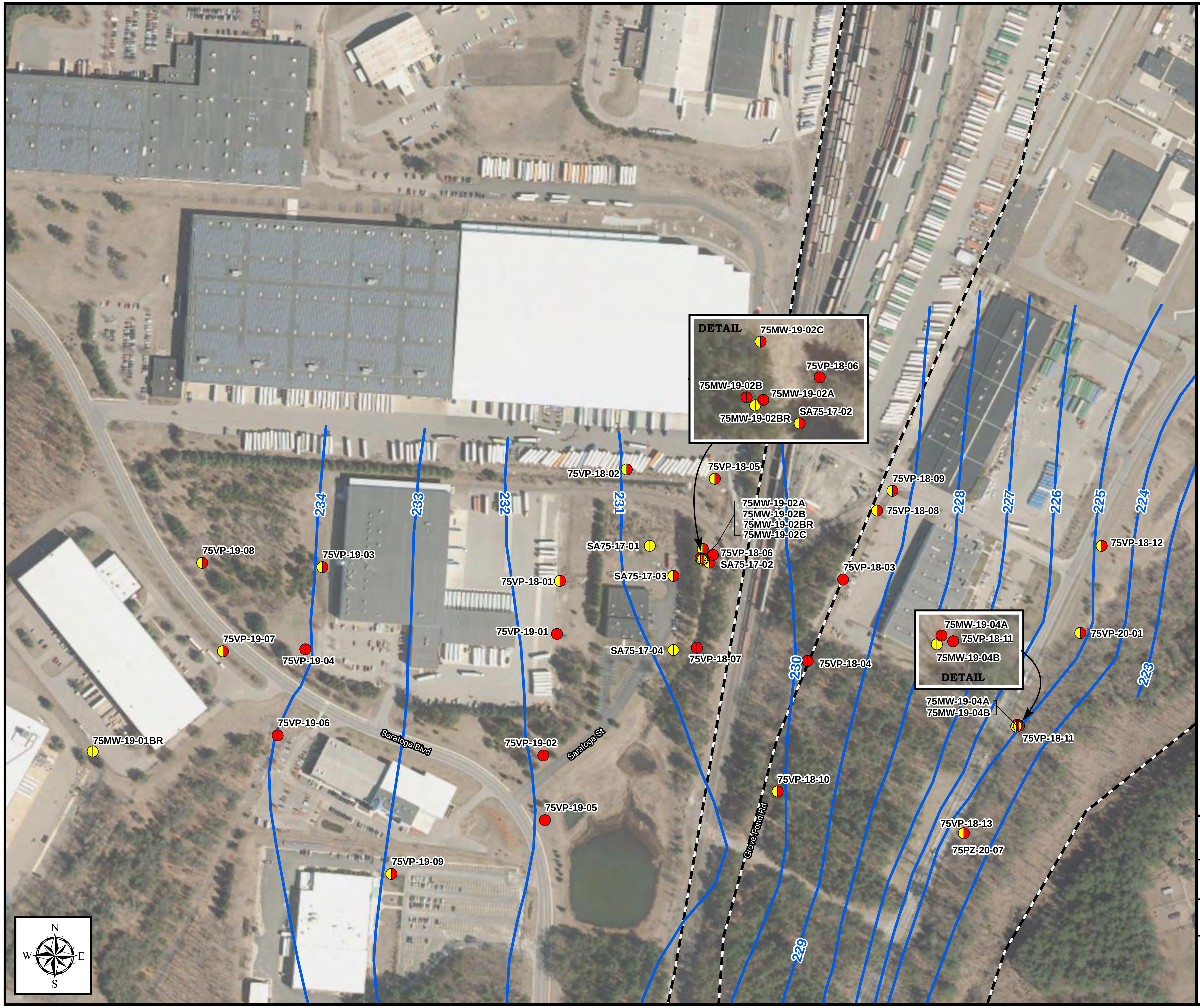
Date:
05/12/2020

Figure
5-4

KGS

Aerial Sources: 2019, USGS, MassGIS

File: PFAS_RI_A1_PSC_AOC75_FieldActivities.mxd



Legend

⦶ Monitoring Well/Vertical Profiling Location

EPA LHA
(sum of PFOA and PFOS) (ng/L)

◐ EPA LHA ≥ 70 ng/L

◐ EPA LHA < 70 ng/L

◐ EPA LHA No detection

MassDEP
(sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA) (ng/L)

◑ MassDEP ≥ 20 ng/L

◑ MassDEP < 20ng/L

◑ MassDEP no detection

~ Groundwater Contour (ft NAVD 88)
(Contour Interval = 1 Foot) - March 2020

▭ Former Fort Devens Boundary

Notes:

Samples collected during the PFAS SI (e.g., SA75-17-01 through -04) were not analyzed for PFDA.

MassDEP GW-1 = sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA
MassDEP Exceedance Criteria is defined as equal to or greater than 20 ng/L

EPA LHA (Lifetime Health Advisory) = sum of PFOA and PFOS
EPA LHA Exceedance Criteria is defined as equal to or greater than 70 ng/L

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 75 Groundwater Results
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

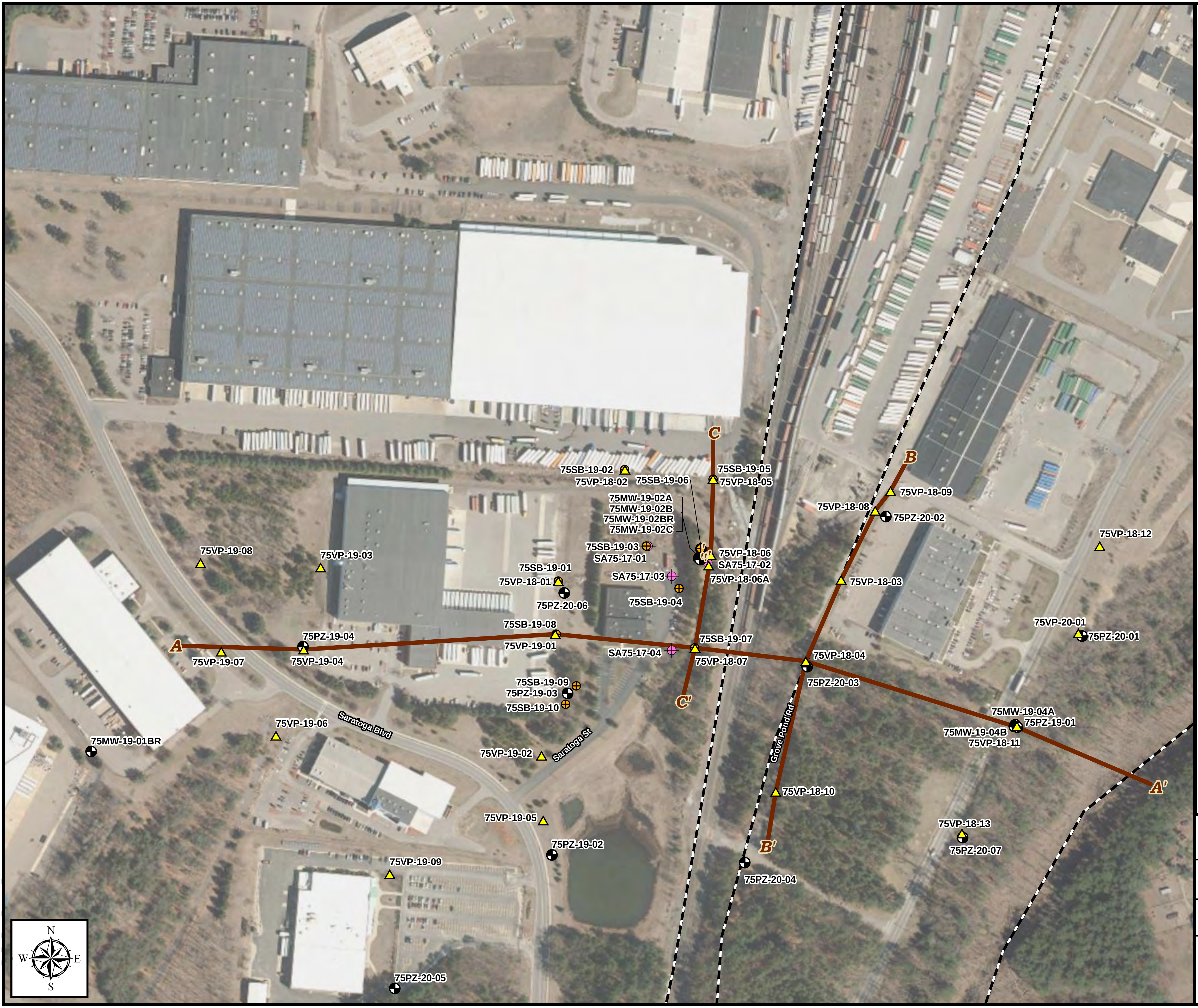
0 150 300
Feet

Date:
05/28/2020

Figure
5-5

KGS

File: PFAS_RI_A1_PSC_AOC75_GWResults.mxd



Legend

- ⊕ Soil Boring Location
- △ Vertical Profiling Location
- ◐ Monitoring Well/Piezometer
- ⊕ Temporary Well Location from SI
- ━ Cross Section Location
- ☐ Former Fort Devens Boundary

Aerial Source: 2019, USGS, MassGIS

AOC 75 Cross Section Location Map
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

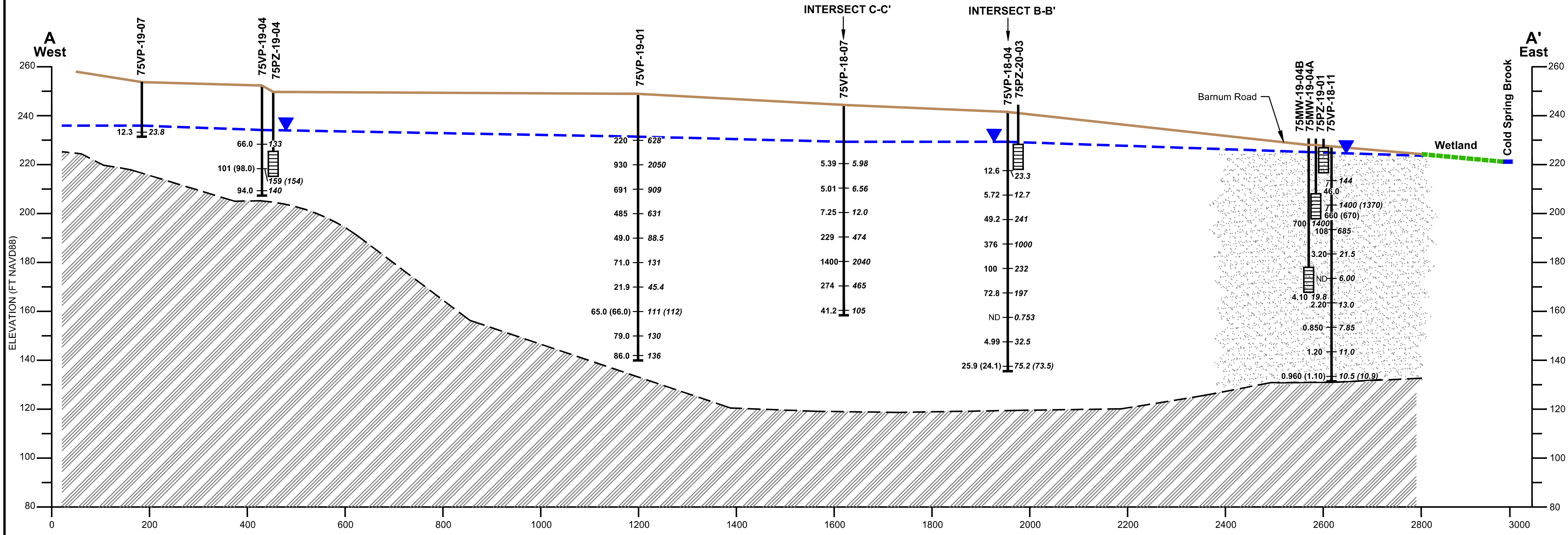
KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 150 300
Feet

Date:
05/08/2020

Figure
5-6

File: PFAS_RI_A1_PSC_AOC75_XSLoc.mxd



Legend

Vertical Profile

1.39 U
EPA LHA
Concentration
(sum of PFOA
and PFOS)

2.59 U
MassDEP
Concentration
(sum of PFOS + PFOA
+ PFDA + PFHpA +
PFHxS + PFNA)

Monitoring Well

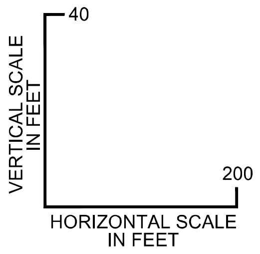
Screened
Interval

░	Sand with Gravel/Sand
▨	Sand with Silt/Silty Sand
░	Silt
░	Silt, Sand, Gravel, with Clay
☐	Till
▩	Weathered Bedrock
▨	Bedrock
☐	Unknown
▼	Water Table

Notes:

All results in ng/L
ng/L = nanograms per liter
ND = non-detect
( ) = field duplicate

Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorodecanoic acid (PFDA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorononanoic acid (PFNA)

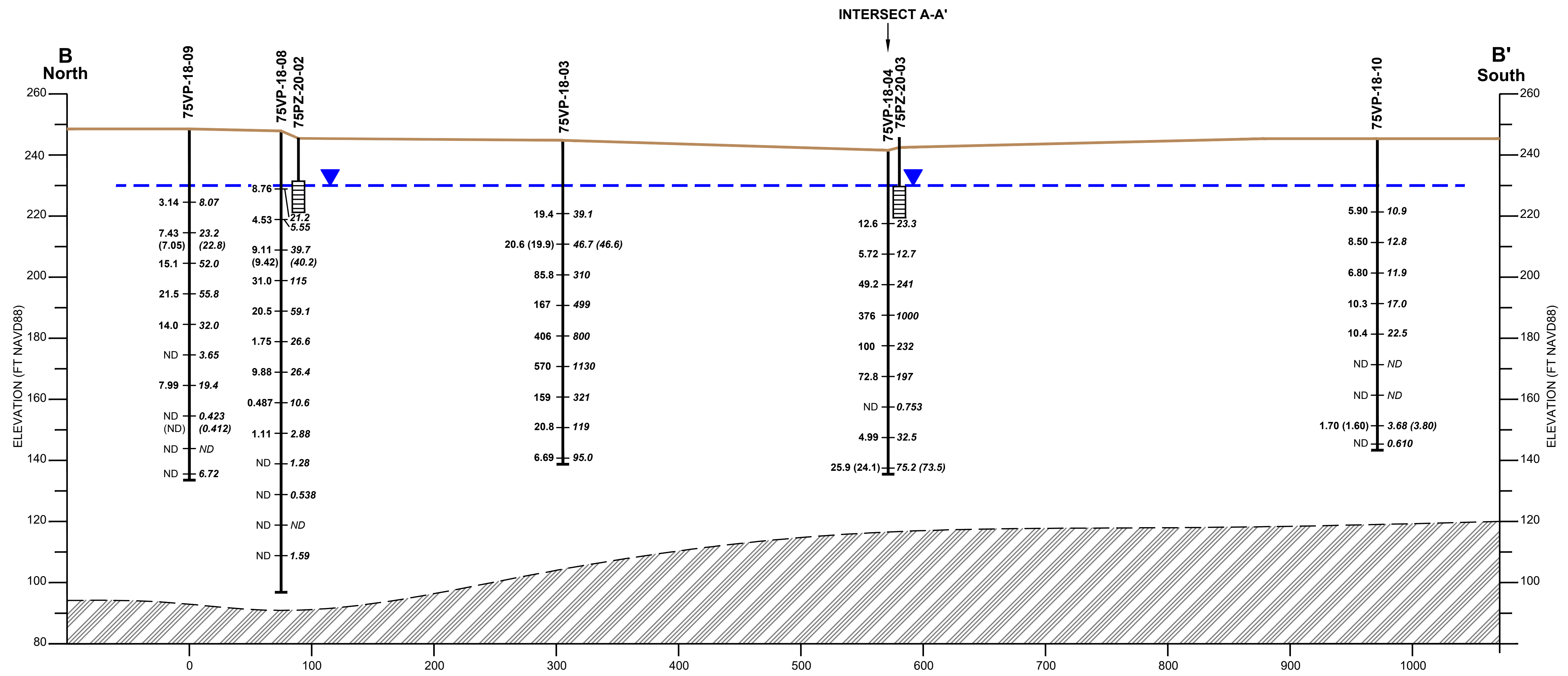


AOC 75 Cross Section A-A'
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

Scale as Shown	Date: 05/28/2020	Figure 5-7



<u>Legend</u>

Vertical Profile

1.39 U
EPA LHA
Concentration
(sum of PFOA
and PFOS)

2.59 U
MassDEP
Concentration
(sum of PFOS + PFOA
+ PFDA + PFHpA +
PFHxS + PFNA)

Monitoring Well

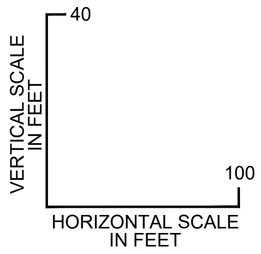
Screened
Interval

- ▒ Sand with Gravel/Sand
- ▨ Sand with Silt/Silty Sand
- ░ Silt
- ▒ Silt, Sand, Gravel, with Clay
- ▭ Till
- ▩ Weathered Bedrock
- ▨ Bedrock
- ☐ Unknown
- ▼ Water Table

Notes:

All results in ng/L
ng/L = nanograms per liter
ND = non-detect
( ) = field duplicate

Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorodecanoic acid (PFDA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorononanoic acid (PFNA)

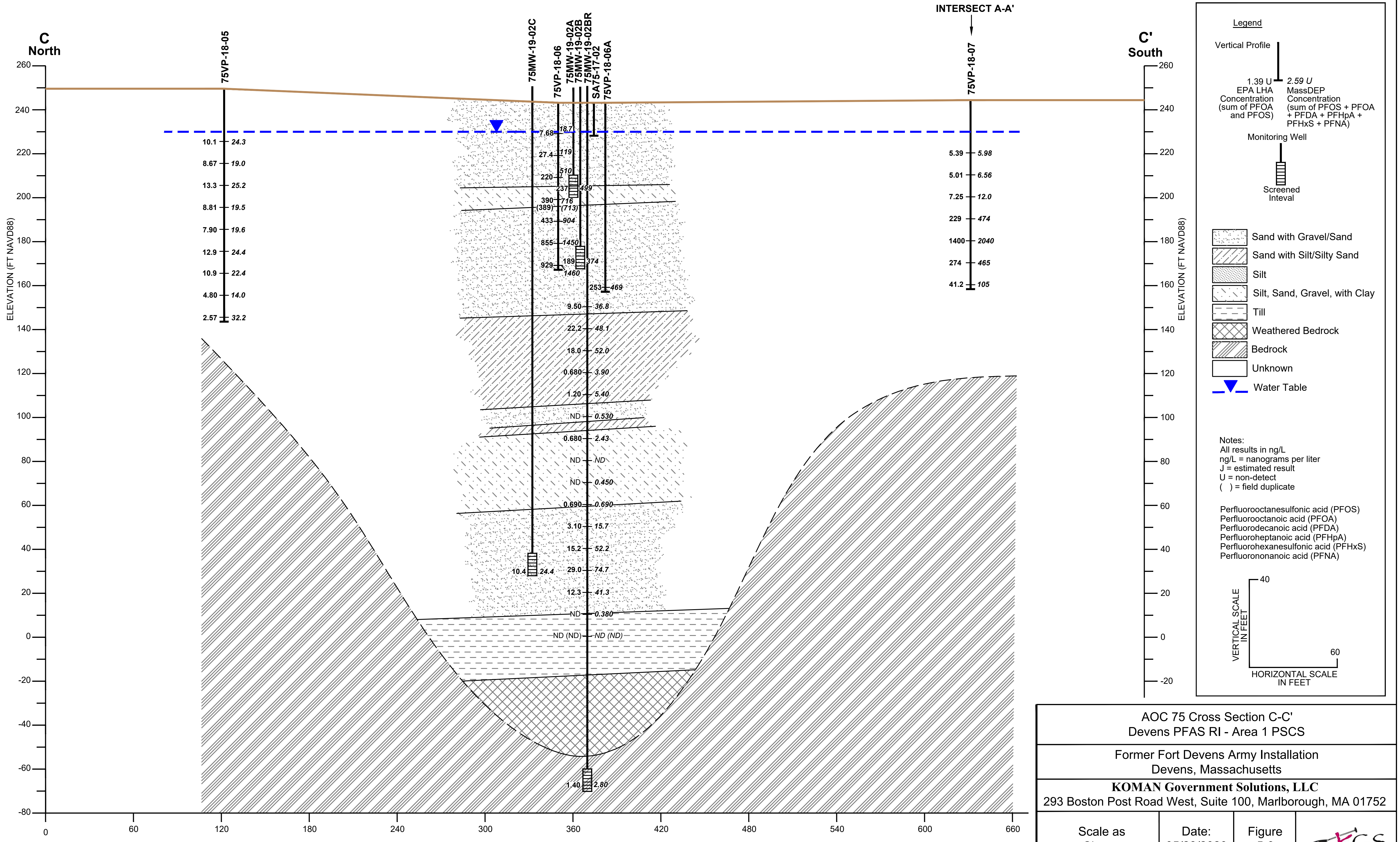


AOC 75 Cross Section B-B'
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

Scale as Shown	Date: 05/28/2020	Figure 5-8



Notes:
All results in ng/L
ng/L = nanograms per liter
J = estimated result
U = non-detect
( ) = field duplicate

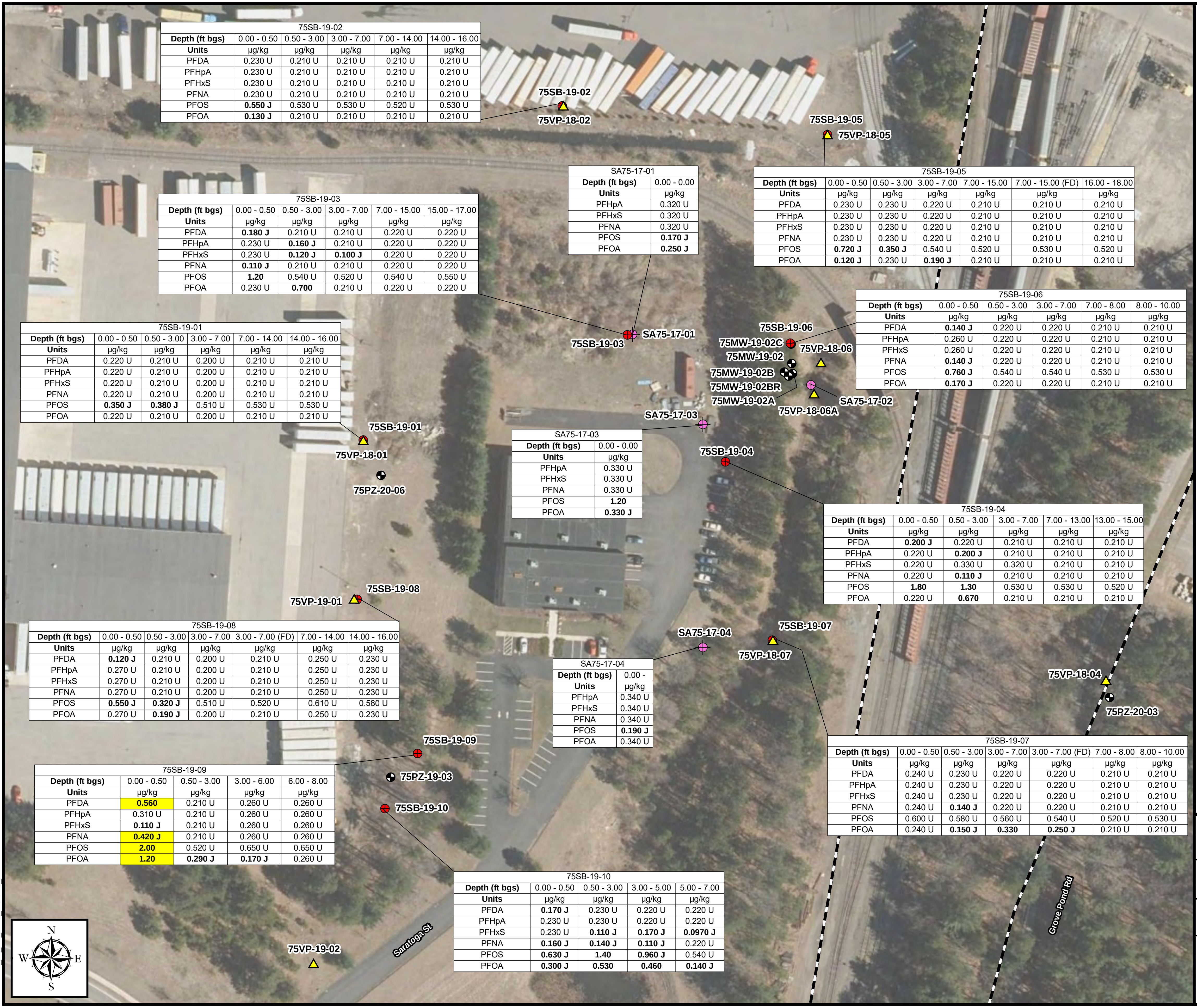
Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorodecanoic acid (PFDA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorononanoic acid (PFNA)

AOC 75 Cross Section C-C'
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

Scale as Shown	Date: 05/28/2020	Figure 5-9



75SB-19-02

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 14.00	14.00 - 16.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	0.230 U	0.210 U	0.210 U	0.210 U	0.210 U
PFHpA	0.230 U	0.210 U	0.210 U	0.210 U	0.210 U
PFHxS	0.230 U	0.210 U	0.210 U	0.210 U	0.210 U
PFNA	0.230 U	0.210 U	0.210 U	0.210 U	0.210 U
PFOS	**0.550 J**	0.530 U	0.530 U	0.520 U	0.530 U
PFOA	**0.130 J**	0.210 U	0.210 U	0.210 U	0.210 U

SA75-17-01

Depth (ft bgs)	0.00 - 0.00
Units	µg/kg
PFHpA	0.320 U
PFHxS	0.320 U
PFNA	0.320 U
PFOS	**0.170 J**
PFOA	**0.250 J**

75SB-19-05

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 15.00	7.00 - 15.00 (FD)	16.00 - 18.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	0.230 U	0.230 U	0.220 U	0.210 U	0.210 U	0.210 U
PFHpA	0.230 U	0.230 U	0.220 U	0.210 U	0.210 U	0.210 U
PFHxS	0.230 U	0.230 U	0.220 U	0.210 U	0.210 U	0.210 U
PFNA	0.230 U	0.230 U	0.220 U	0.210 U	0.210 U	0.210 U
PFOS	**0.720 J**	**0.350 J**	0.540 U	0.520 U	0.530 U	0.520 U
PFOA	**0.120 J**	0.230 U	**0.190 J**	0.210 U	0.210 U	0.210 U

75SB-19-03

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 15.00	15.00 - 17.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**0.180 J**	0.210 U	0.210 U	0.220 U	0.220 U
PFHpA	0.230 U	**0.160 J**	0.210 U	0.220 U	0.220 U
PFHxS	0.230 U	**0.120 J**	**0.100 J**	0.220 U	0.220 U
PFNA	**0.110 J**	0.210 U	0.210 U	0.220 U	0.220 U
PFOS	**1.20**	0.540 U	0.520 U	0.540 U	0.550 U
PFOA	0.230 U	**0.700**	0.210 U	0.220 U	0.220 U

75SB-19-06

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 8.00	8.00 - 10.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**0.140 J**	0.220 U	0.220 U	0.210 U	0.210 U
PFHpA	0.260 U	0.220 U	0.220 U	0.210 U	0.210 U
PFHxS	0.260 U	0.220 U	0.220 U	0.210 U	0.210 U
PFNA	**0.140 J**	0.220 U	0.220 U	0.210 U	0.210 U
PFOS	**0.760 J**	0.540 U	0.540 U	0.530 U	0.530 U
PFOA	**0.170 J**	0.220 U	0.220 U	0.210 U	0.210 U

75SB-19-01

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 14.00	14.00 - 16.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	0.220 U	0.210 U	0.200 U	0.210 U	0.210 U
PFHpA	0.220 U	0.210 U	0.200 U	0.210 U	0.210 U
PFHxS	0.220 U	0.210 U	0.200 U	0.210 U	0.210 U
PFNA	0.220 U	0.210 U	0.200 U	0.210 U	0.210 U
PFOS	**0.350 J**	**0.380 J**	0.510 U	0.530 U	0.530 U
PFOA	0.220 U	0.210 U	0.200 U	0.210 U	0.210 U

SA75-17-03

Depth (ft bgs)	0.00 - 0.00
Units	µg/kg
PFHpA	0.330 U
PFHxS	0.330 U
PFNA	0.330 U
PFOS	**1.20**
PFOA	**0.330 J**

75SB-19-04

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 13.00	13.00 - 15.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**0.200 J**	0.220 U	0.210 U	0.210 U	0.210 U
PFHpA	0.220 U	**0.200 J**	0.210 U	0.210 U	0.210 U
PFHxS	0.220 U	0.330 U	0.320 U	0.210 U	0.210 U
PFNA	0.220 U	**0.110 J**	0.210 U	0.210 U	0.210 U
PFOS	**1.80**	**1.30**	0.530 U	0.530 U	0.520 U
PFOA	0.220 U	**0.670**	0.210 U	0.210 U	0.210 U

75SB-19-08

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	3.00 - 7.00 (FD)	7.00 - 14.00	14.00 - 16.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**0.120 J**	0.210 U	0.200 U	0.210 U	0.250 U	0.230 U
PFHpA	0.270 U	0.210 U	0.200 U	0.210 U	0.250 U	0.230 U
PFHxS	0.270 U	0.210 U	0.200 U	0.210 U	0.250 U	0.230 U
PFNA	0.270 U	0.210 U	0.200 U	0.210 U	0.250 U	0.230 U
PFOS	**0.550 J**	**0.320 J**	0.510 U	0.520 U	0.610 U	0.580 U
PFOA	0.270 U	**0.190 J**	0.200 U	0.210 U	0.250 U	0.230 U

SA75-17-04

Depth (ft bgs)	0.00 -
Units	µg/kg
PFHpA	0.340 U
PFHxS	0.340 U
PFNA	0.340 U
PFOS	**0.190 J**
PFOA	0.340 U

75SB-19-07

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	3.00 - 7.00 (FD)	7.00 - 8.00	8.00 - 10.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	0.240 U	0.230 U	0.220 U	0.220 U	0.210 U	0.210 U
PFHpA	0.240 U	0.230 U	0.220 U	0.220 U	0.210 U	0.210 U
PFHxS	0.240 U	0.230 U	0.220 U	0.220 U	0.210 U	0.210 U
PFNA	0.240 U	**0.140 J**	0.220 U	0.220 U	0.210 U	0.210 U
PFOS	0.600 U	0.580 U	0.560 U	0.540 U	0.520 U	0.530 U
PFOA	0.240 U	**0.150 J**	**0.330**	**0.250 J**	0.210 U	0.210 U

75SB-19-09

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 6.00	6.00 - 8.00
Units	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**0.560**	0.210 U	0.260 U	0.260 U
PFHpA	0.310 U	0.210 U	0.260 U	0.260 U
PFHxS	**0.110 J**	0.210 U	0.260 U	0.260 U
PFNA	**0.420 J**	0.210 U	0.260 U	0.260 U
PFOS	**2.00**	0.520 U	0.650 U	0.650 U
PFOA	**1.20**	**0.290 J**	**0.170 J**	0.260 U

75SB-19-10

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 5.00	5.00 - 7.00
Units	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**0.170 J**	0.230 U	0.220 U	0.220 U
PFHpA	0.230 U	0.230 U	0.220 U	0.220 U
PFHxS	0.230 U	**0.110 J**	**0.170 J**	**0.0970 J**
PFNA	**0.160 J**	**0.140 J**	**0.110 J**	0.220 U
PFOS	**0.630 J**	**1.40**	**0.960 J**	0.540 U
PFOA	**0.300 J**	**0.530**	**0.460**	**0.140 J**

Aerial Sources: 2019, USGS, MassGIS

File: PFAS_RI_A1_PSC_AOC75_SoilResults.mxd

Legend

⊕	Monitoring Well/Piezometer
●	Soil Boring Location
△	Vertical Profiling Location
⊕	Temporary Well Location from SI
▭	Former Fort Devens Boundary

Notes:

Criteria = S-1/GW-1, Massachusetts Contingency Plan, 2019 Proposed PFAS Revisions

PFAS	Limits (ug/kg)
Perfluorodecanoic acid (PFDA)	0.300
Perfluoroheptanoic acid (PFHpA)	0.500
Perfluorohexanesulfonic acid (PFHxS)	0.300
Perfluorononanoic acid (PFNA)	0.320
Perfluorooctanesulfonic acid (PFOS)	2.00
Perfluorooctanoic acid (PFOA)	0.720

1.80 = detection of PFAS

🟨 **1.80** = detection of PFAS above criteria

Data reported to three significant figures

µg/kg = micrograms per kilogram
U = non-detect
J = estimated result

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 75 Soil Results
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 50 100
Feet

Date:
04/30/2020

Figure
5-10

KGS

Legend

- ● Existing Monitoring Well/Piezometer
- ● New Monitoring Well/Piezometer
- ● Soil Boring Location
- ▲ Vertical Profiling Location Installation Phase 1
- ▲ Vertical Profiling Location Installation Phase 2
- ▲ Vertical Profiling Location Installation Phase 3
- ▲ Vertical Profiling Location Installation Phase 4
- △ AOC 74 Vertical Profiling Location
- ◐ Surface Water and Sediment Sampling Location
- ⊕ Public Water Supply Well
- ○ Irrigation Well (Approximate Location)
- ⬚ Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

Grove Pond Area Field Activities
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

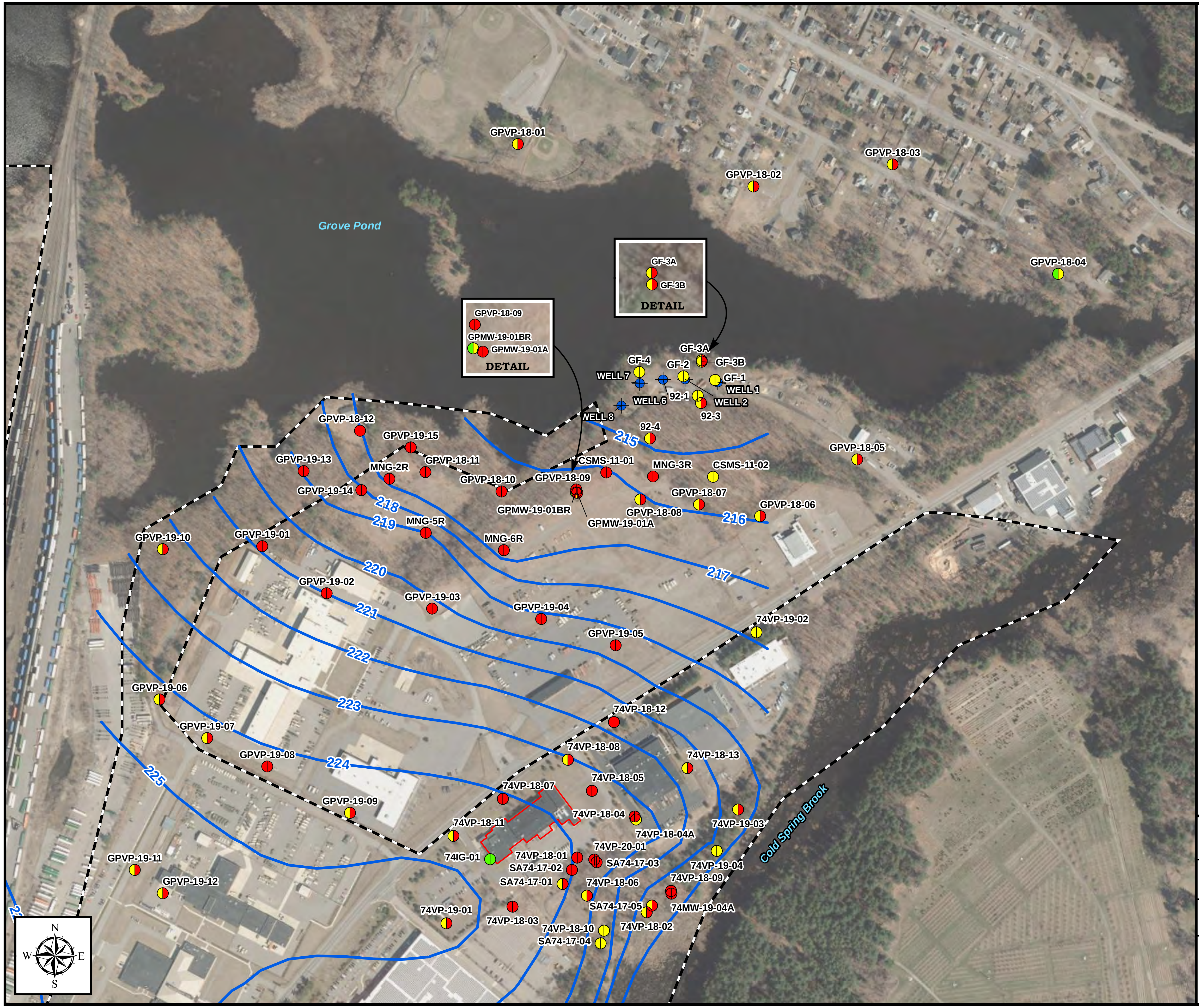
KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 200 400
Feet

Date:
04/23/2020

Figure
6-1

File: PFAS_RI_A1_PSC_GrovePond_FieldActivities.mxd



Legend

◐ Monitoring Well/Vertical Profiling Location

EPA LHA
(sum of PFOA and PFOS) (ng/L)

◐ EPA LHA ≥ 70 ng/L

◐ EPA LHA < 70 ng/L

◐ EPA LHA No detection

MassDEP
(sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA) (ng/L)

◐ MassDEP ≥ 20 ng/L

◐ MassDEP < 20ng/L

◐ MassDEP no detection

⊕ Public Water Supply Well

~ Groundwater Contour (ft NAVD 88) (Contour Interal = 1 Foot) - March 2020

▭ Former Fort Devens Boundary

Notes:

MassDEP GW-1 = sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA
MassDEP Exceedance Criteria is defined as equal to or greater than 20 ng/L

EPA LHA (Lifetime Health Advisory) = sum of PFOA and PFOS
EPA LHA Exceedance Criteria is defined as equal to or greater than 70 ng/L

Aerial Source: USGS, MassGIS Orthoimagery 2019

Grove Pond Groundwater Results
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

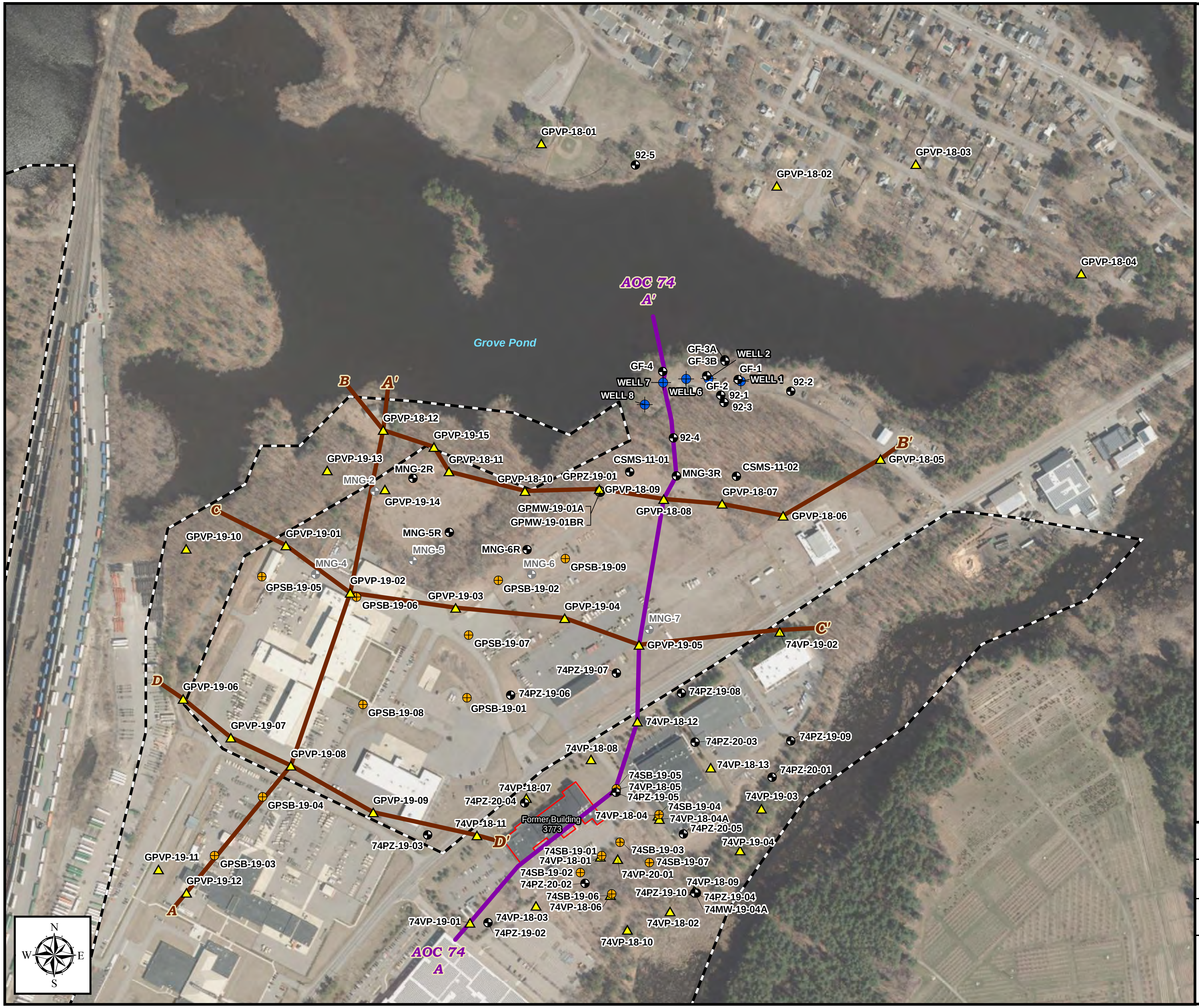
0 200 400
Feet

Date: 05/28/2020

Figure 6-2

KGS

File: PFAS_RI_A1_PSC_GrovePond_GWResults.mxd



Legend

△	Vertical Profiling Location
⊕	Soil Boring Location
●	Monitoring Well
●	Abandoned Monitoring Well
⊕	Public Water Supply Well
—	Cross Section Location
—	AOC 74 Cross Section Location
▭	Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

Grove Pond Area Cross Section Locations
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

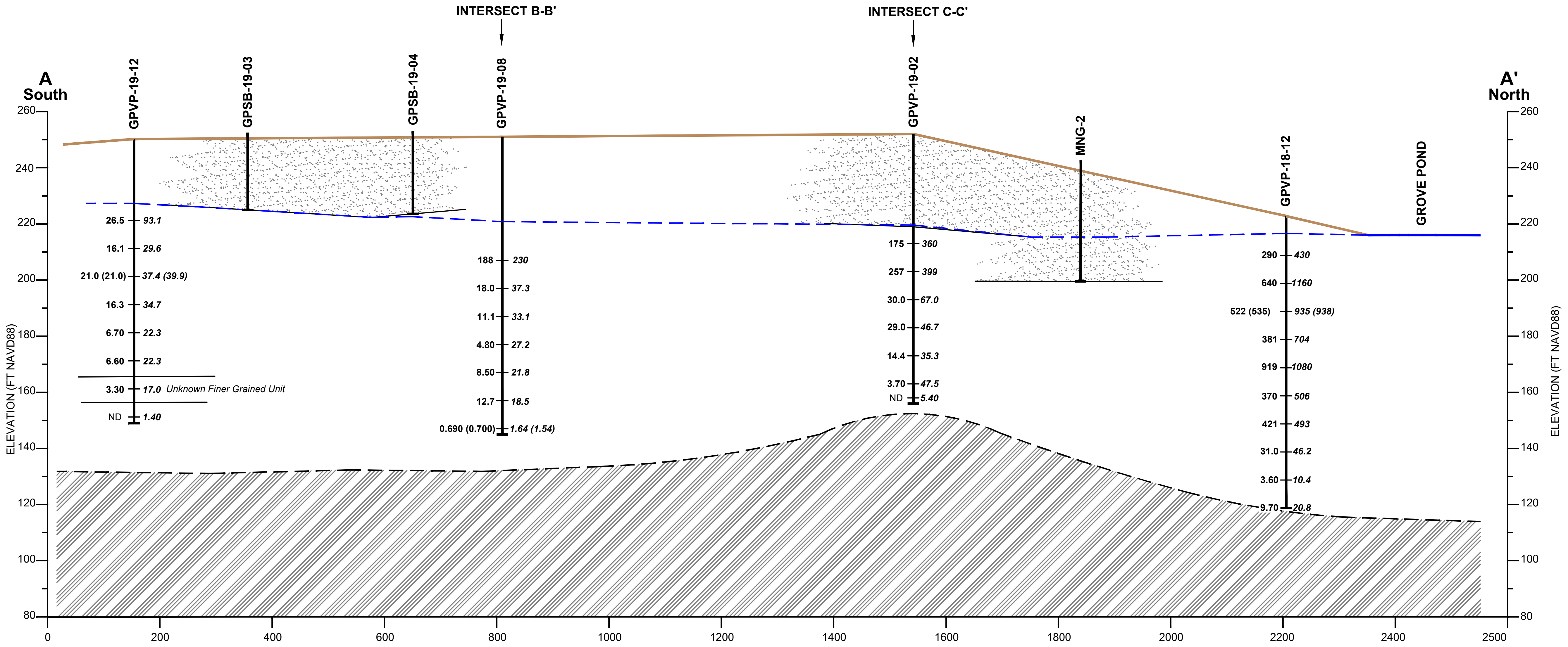
KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 200 400
Feet

Date:
05/08/2020

Figure
6-3

File: PFAS_RI_A1_PSC_GrovePond_XSLoc.mxd



Legend

Vertical Profile

1.39 U EPA LHA Concentration (sum of PFOA and PFOS)

2.59 U MassDEP Concentration (sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA)

Monitoring Well

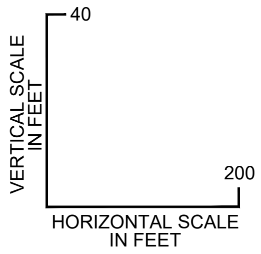
Screened Interval

▒ Sand with Gravel/Sand
▨ Sand with Silt/Silty Sand
▒ Silt
▒ Silt, Sand, Gravel, with Clay
☐ Till
▩ Weathered Bedrock
▨ Bedrock
☐ Unknown
▼ Water Table

Notes:

All results in ng/L
ng/L = nanograms per liter
ND = non-detect
( ) = field duplicate

Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorodecanoic acid (PFDA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorononanoic acid (PFNA)

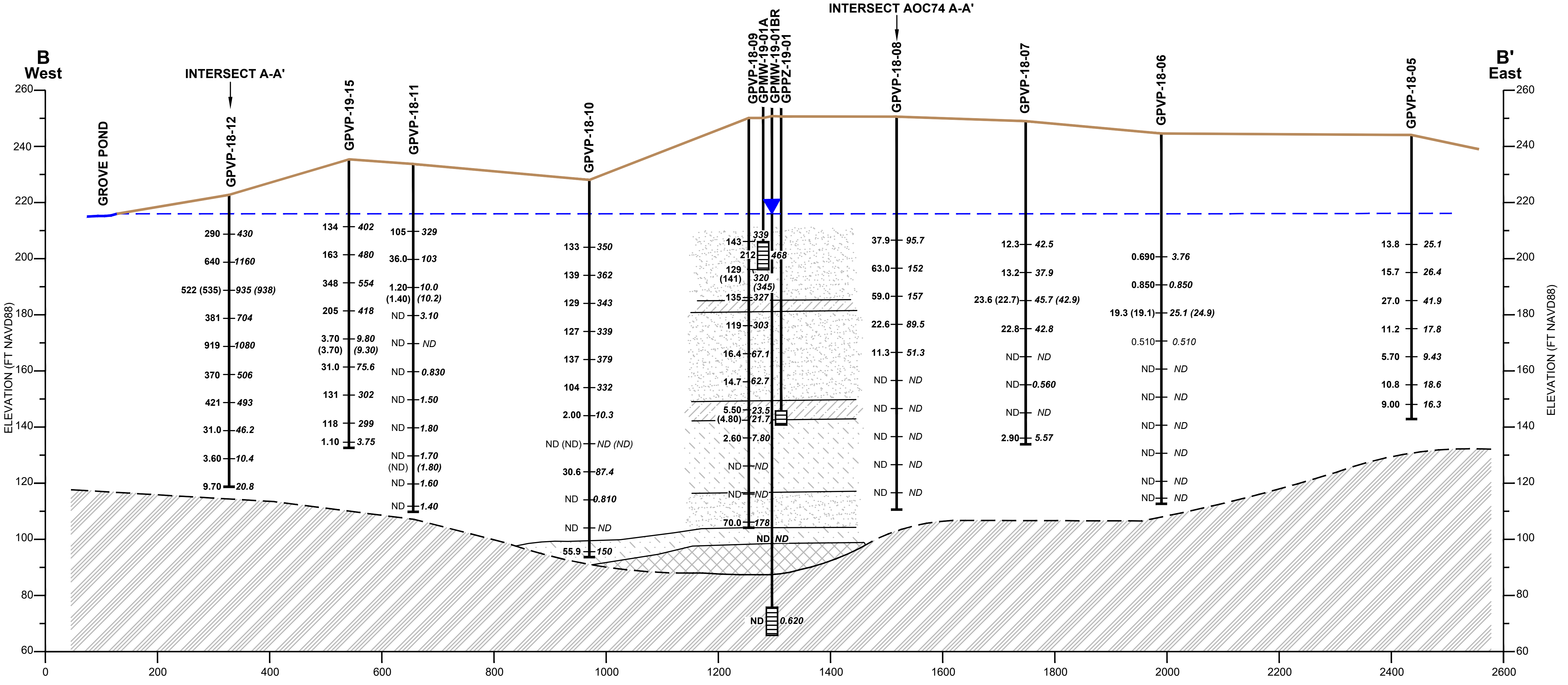


Grove Pond Area - Cross Section, A-A'
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

Scale as Shown	Date: 05/13/2020	Figure 6-4	KGS



<u>Legend</u>

Vertical Profile

1.39 U
EPA LHA
Concentration
(sum of PFOA
and PFOS)

2.59 U
MassDEP
Concentration
(sum of PFOS + PFOA
+ PFDA + PFHpA +
PFHxS + PFNA)

Monitoring Well

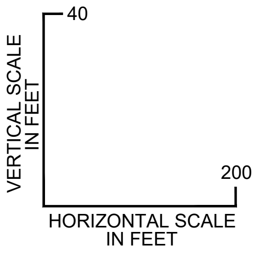
Screened
Interval

░	Sand with Gravel/Sand
▨	Sand with Silt/Silty Sand
▒	Silt
⋰	Silt, Sand, Gravel, with Clay
┄	Till
▩	Weathered Bedrock
▨	Bedrock
☐	Unknown
▼	Water Table

Notes:

All results in ng/L
ng/L = nanograms per liter
ND = non-detect
( ) = field duplicate

Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorodecanoic acid (PFDA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorononanoic acid (PFNA)



Grove Pond Area - Cross Section, B-B'
Devens PFAS RI - Area 1 PSCS

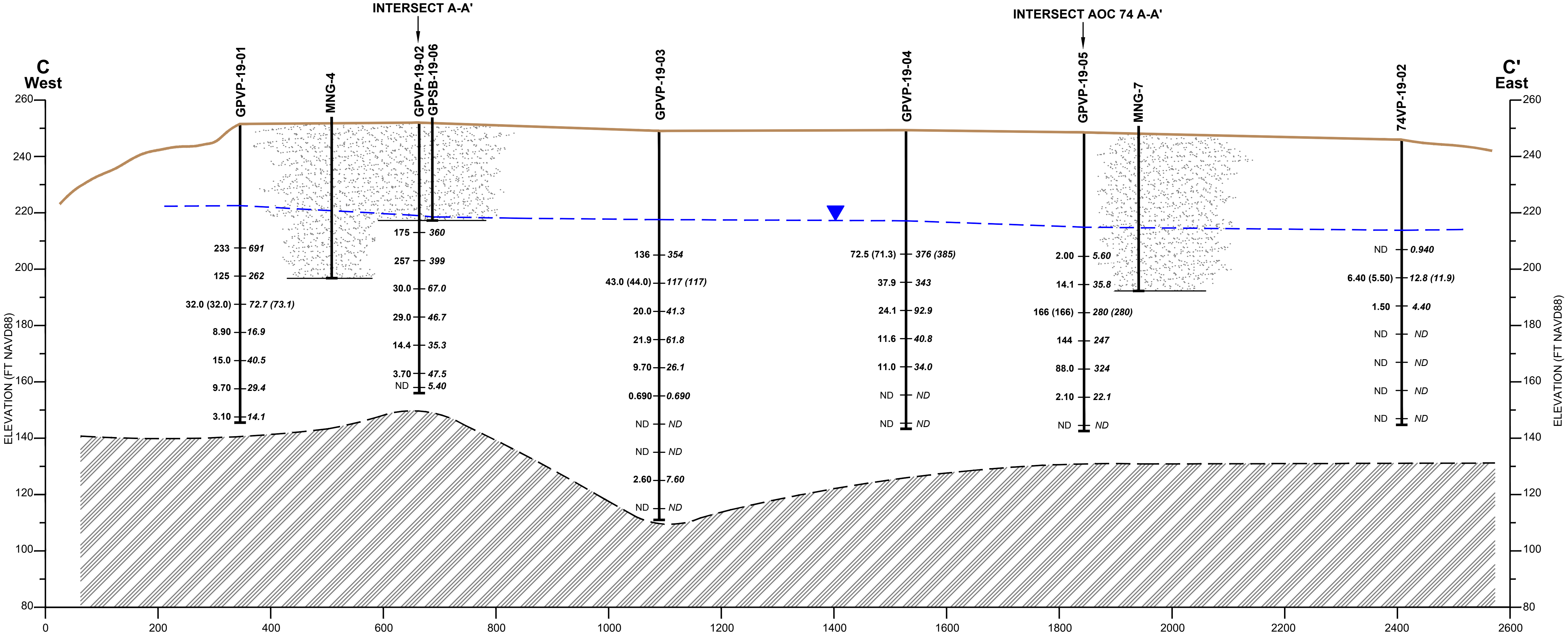
Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

Scale as Shown	Date: 05/28/2020	Figure 6-5

KGS

File: X:\HS_Environmental\FortDevens_Mass\Drawings\PSC_Report\Area1\PSC_A1_GrovePond_XS.dwg B-B



Legend

Vertical Profile

1.39 U
EPA LHA
Concentration
(sum of PFOA
and PFOS)

2.59 U
MassDEP
Concentration
(sum of PFOS + PFOA
+ PFDA + PFHpA +
PFHxS + PFNA)

Monitoring Well

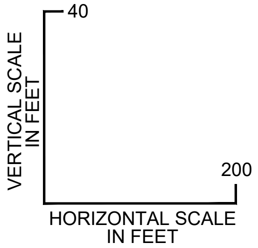
Screened
Interval

░	Sand with Gravel/Sand
▨	Sand with Silt/Silty Sand
▒	Silt
░	Silt, Sand, Gravel, with Clay
┄	Till
▩	Weathered Bedrock
▨	Bedrock
☐	Unknown
▼	Water Table

Notes:

All results in ng/L
ng/L = nanograms per liter
ND = non-detect
( ) = field duplicate

Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorodecanoic acid (PFDA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorononanoic acid (PFNA)

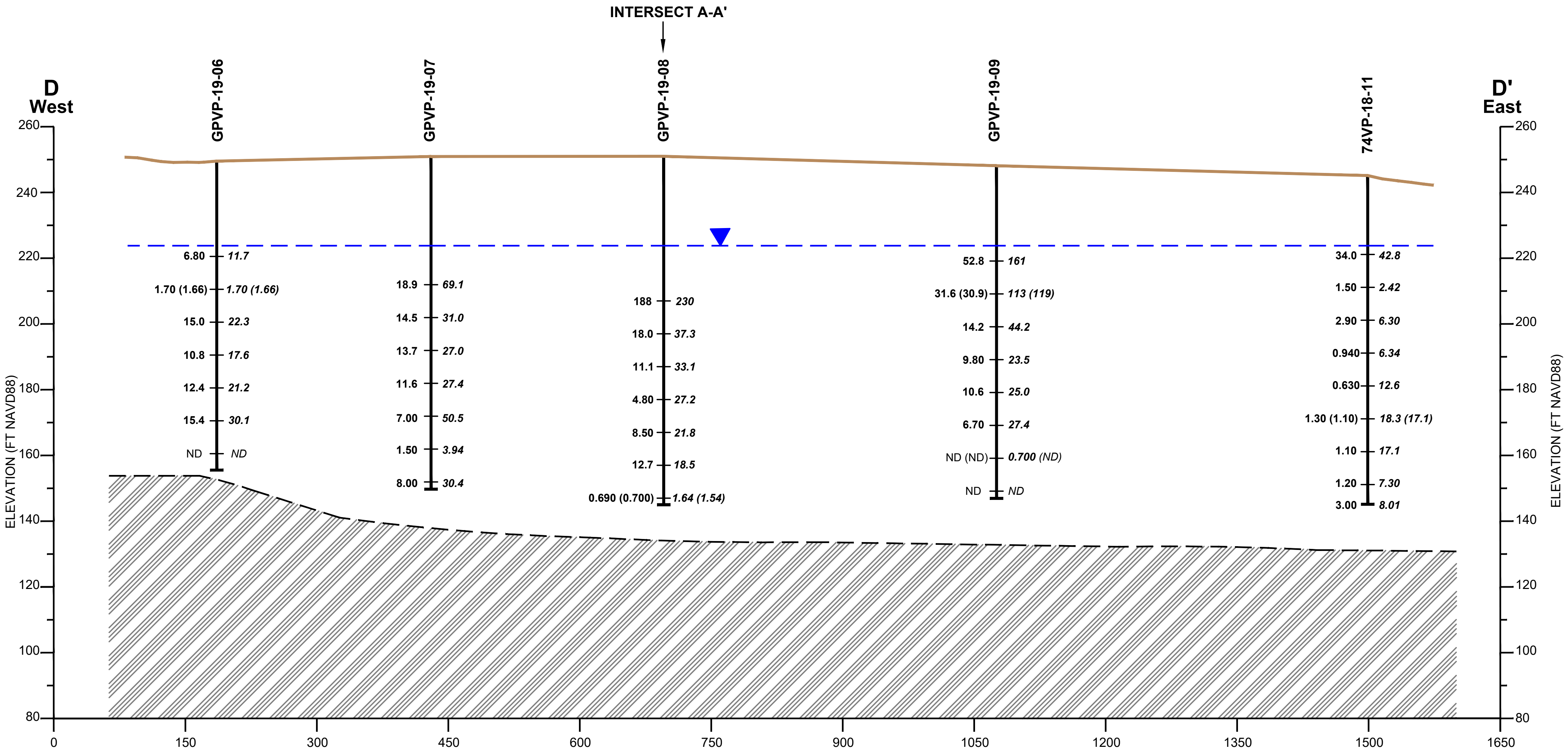


Grove Pond Area - Cross Section, C-C'
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

Scale as Shown	Date: 05/28/2020	Figure 6-6



Legend

Vertical Profile

1.39 U
EPA LHA
Concentration
(sum of PFOA
and PFOS)

2.59 U
MassDEP
Concentration
(sum of PFOS + PFOA
+ PFDA + PFHpA +
PFHxS + PFNA)

Monitoring Well

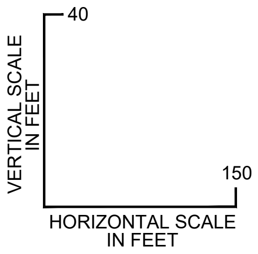
Screened
Interval

- ░ Sand with Gravel/Sand
- ▨ Sand with Silt/Silty Sand
- ░ Silt
- ░ Silt, Sand, Gravel, with Clay
- ▭ Till
- ▩ Weathered Bedrock
- ▨ Bedrock
- ☐ Unknown
- ▼ Water Table

Notes:

All results in ng/L
ng/L = nanograms per liter
ND = non-detect
(   ) = field duplicate

Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorodecanoic acid (PFDA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorononanoic acid (PFNA)

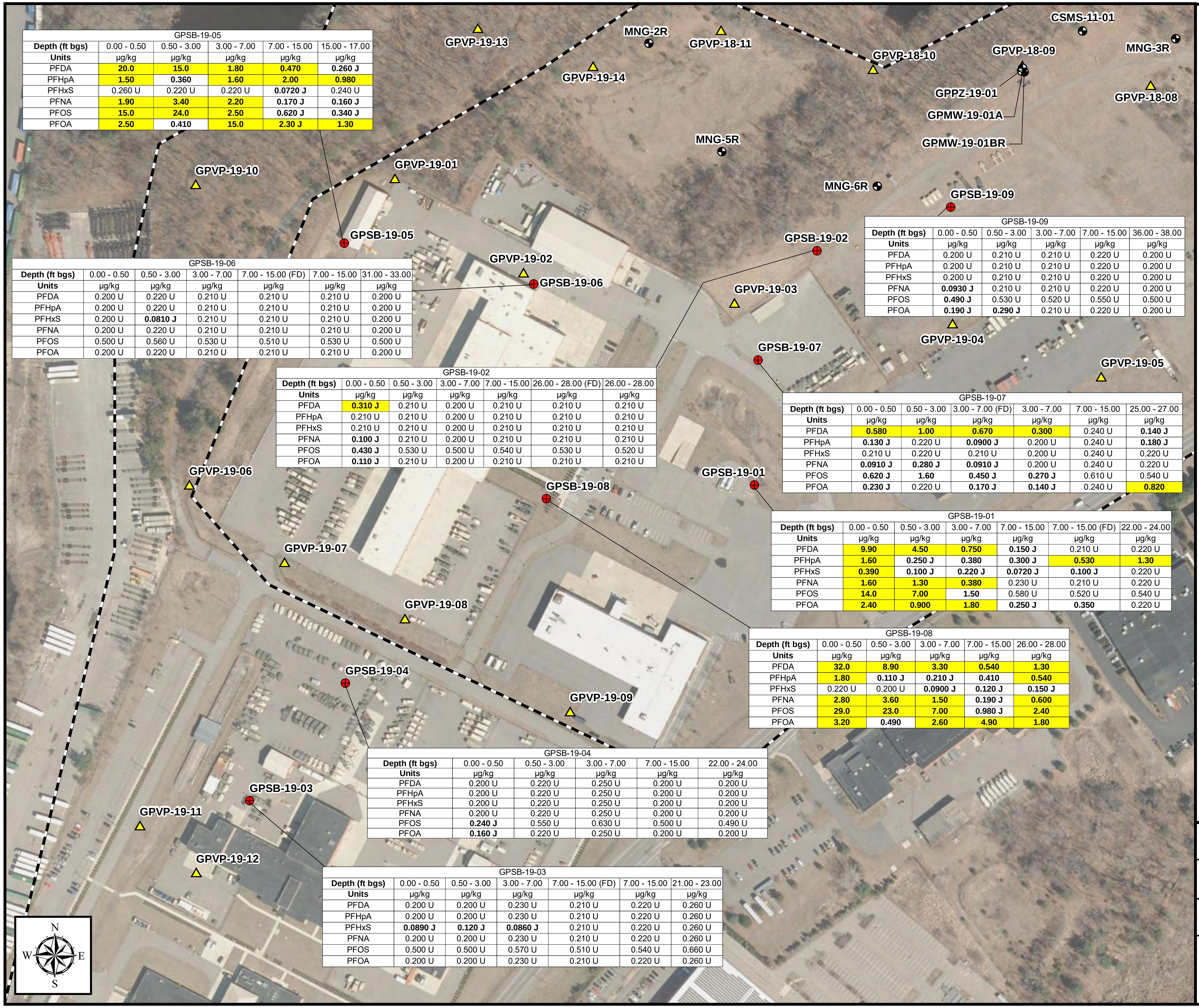


Grove Pond Area - Cross Section, D-D'
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

Scale as Shown	Date: 05/28/2020	Figure 6-7	KGS



GPSB-19-05

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 15.00	15.00 - 17.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	🟨 **20.0**	🟨 **15.0**	🟨 **1.80**	🟨 **0.470**	**0.260 J**
PFHpA	🟨 **1.50**	**0.360**	🟨 **1.60**	🟨 **2.00**	🟨 **0.980**
PFHxS	0.260 U	0.220 U	0.220 U	**0.0720 J**	0.240 U
PFNA	🟨 **1.90**	🟨 **3.40**	🟨 **2.20**	**0.170 J**	**0.160 J**
PFOS	🟨 **15.0**	🟨 **24.0**	🟨 **2.50**	**0.620 J**	**0.340 J**
PFOA	🟨 **2.50**	**0.410**	🟨 **15.0**	🟨 **2.30 J**	🟨 **1.30**

GPSB-19-06

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 15.00 (FD)	7.00 - 15.00	31.00 - 33.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	0.200 U	0.220 U	0.210 U	0.210 U	0.210 U	0.200 U
PFHpA	0.200 U	0.220 U	0.210 U	0.210 U	0.210 U	0.200 U
PFHxS	0.200 U	**0.0810 J**	0.210 U	0.210 U	0.210 U	0.200 U
PFNA	0.200 U	0.220 U	0.210 U	0.210 U	0.210 U	0.200 U
PFOS	0.500 U	0.560 U	0.530 U	0.510 U	0.530 U	0.500 U
PFOA	0.200 U	0.220 U	0.210 U	0.210 U	0.210 U	0.200 U

GPSB-19-02

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 15.00	26.00 - 28.00 (FD)	26.00 - 28.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	🟨 **0.310 J**	0.210 U	0.200 U	0.210 U	0.210 U	0.210 U
PFHpA	0.210 U	0.210 U	0.200 U	0.210 U	0.210 U	0.210 U
PFHxS	0.210 U	0.210 U	0.200 U	0.210 U	0.210 U	0.210 U
PFNA	**0.100 J**	0.210 U	0.200 U	0.210 U	0.210 U	0.210 U
PFOS	**0.430 J**	0.530 U	0.500 U	0.540 U	0.530 U	0.520 U
PFOA	**0.110 J**	0.210 U	0.200 U	0.210 U	0.210 U	0.210 U

GPSB-19-09

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 15.00	36.00 - 38.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	0.200 U	0.210 U	0.210 U	0.220 U	0.200 U
PFHpA	0.200 U	0.210 U	0.210 U	0.220 U	0.200 U
PFHxS	0.200 U	0.210 U	0.210 U	0.220 U	0.200 U
PFNA	**0.0930 J**	0.210 U	0.210 U	0.220 U	0.200 U
PFOS	**0.490 J**	0.530 U	0.520 U	0.550 U	0.500 U
PFOA	**0.190 J**	**0.290 J**	0.210 U	0.220 U	0.200 U

GPSB-19-07

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00 (FD)	3.00 - 7.00	7.00 - 15.00	25.00 - 27.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	🟨 **0.580**	🟨 **1.00**	🟨 **0.670**	🟨 **0.300**	0.240 U	**0.140 J**
PFHpA	**0.130 J**	0.220 U	**0.0900 J**	0.200 U	0.240 U	**0.180 J**
PFHxS	0.210 U	0.220 U	0.210 U	0.200 U	0.240 U	0.220 U
PFNA	**0.0910 J**	**0.280 J**	**0.0910 J**	0.200 U	0.240 U	0.220 U
PFOS	**0.620 J**	**1.60**	**0.450 J**	**0.270 J**	0.610 U	0.540 U
PFOA	**0.230 J**	0.220 U	**0.170 J**	**0.140 J**	0.240 U	🟨 **0.820**

GPSB-19-01

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 15.00	7.00 - 15.00 (FD)	22.00 - 24.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	🟨 **9.90**	🟨 **4.50**	🟨 **0.750**	**0.150 J**	0.210 U	0.220 U
PFHpA	🟨 **1.60**	**0.250 J**	**0.380**	**0.300 J**	🟨 **0.530**	🟨 **1.30**
PFHxS	🟨 **0.390**	**0.100 J**	**0.220 J**	**0.0720 J**	**0.100 J**	0.220 U
PFNA	🟨 **1.60**	🟨 **1.30**	🟨 **0.380**	0.230 U	0.210 U	0.220 U
PFOS	🟨 **14.0**	🟨 **7.00**	**1.50**	0.580 U	0.520 U	0.540 U
PFOA	🟨 **2.40**	🟨 **0.900**	🟨 **1.80**	**0.250 J**	**0.350**	0.220 U

GPSB-19-08

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 15.00	26.00 - 28.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	🟨 **32.0**	🟨 **8.90**	🟨 **3.30**	🟨 **0.540**	🟨 **1.30**
PFHpA	🟨 **1.80**	**0.110 J**	**0.210 J**	**0.410**	🟨 **0.540**
PFHxS	0.220 U	0.200 U	**0.0900 J**	**0.120 J**	**0.150 J**
PFNA	🟨 **2.80**	🟨 **3.60**	🟨 **1.50**	**0.190 J**	🟨 **0.600**
PFOS	🟨 **29.0**	🟨 **23.0**	🟨 **7.00**	**0.980 J**	🟨 **2.40**
PFOA	🟨 **3.20**	**0.490**	🟨 **2.60**	🟨 **4.90**	🟨 **1.80**

GPSB-19-04

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 15.00	22.00 - 24.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	0.200 U	0.220 U	0.250 U	0.200 U	0.200 U
PFHpA	0.200 U	0.220 U	0.250 U	0.200 U	0.200 U
PFHxS	0.200 U	0.220 U	0.250 U	0.200 U	0.200 U
PFNA	0.200 U	0.220 U	0.250 U	0.200 U	0.200 U
PFOS	**0.240 J**	0.550 U	0.630 U	0.500 U	0.490 U
PFOA	**0.160 J**	0.220 U	0.250 U	0.200 U	0.200 U

GPSB-19-03

Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 15.00 (FD)	7.00 - 15.00	21.00 - 23.00
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	0.200 U	0.200 U	0.230 U	0.210 U	0.220 U	0.260 U
PFHpA	0.200 U	0.200 U	0.230 U	0.210 U	0.220 U	0.260 U
PFHxS	**0.0890 J**	**0.120 J**	**0.0860 J**	0.210 U	0.220 U	0.260 U
PFNA	0.200 U	0.200 U	0.230 U	0.210 U	0.220 U	0.260 U
PFOS	0.500 U	0.500 U	0.570 U	0.510 U	0.540 U	0.660 U
PFOA	0.200 U	0.200 U	0.230 U	0.210 U	0.220 U	0.260 U

Legend

⊕	Monitoring Well/Piezometer
🔴	Soil Boring Location
△	Vertical Profiling Location
⬚	Former Fort Devens Boundary

Notes:
Criteria = S-1/GW-1, Massachusetts Contingency Plan, 2019 Proposed PFAS Revisions

PFAS	Limits (ug/kg)
Perfluorodecanoic acid (PFDA)	0.300
Perfluoroheptanoic acid (PFHpA)	0.500
Perfluorohexanesulfonic acid (PFHxS)	0.300
Perfluorononanoic acid (PFNA)	0.320
Perfluorooctanesulfonic acid (PFOS)	2.00
Perfluorooctanoic acid (PFOA)	0.720

1.30 = detection of PFAS

🟨 **1.30** = detection of PFAS above criteria

Data reported to three significant figures

µg/kg = micrograms per kilogram
U = non-detect
J = estimated result

Aerial Source: USGS, MassGIS Orthoimagery 2019

Grove Pond Area Soil Results
Devens PFAS R I - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 100 200
Feet

Date:
04/29/2020

Figure
6-8

File: PFAS_RI_A1_PSC_GrovePond_SoilResults.mxd

GP-18-05		
Sample	10/3/2018	10/3/2018
Units:	ng/L	ug/kg
PFBS	**1.40 J**	0.350 U
PFOS	**3.30 J**	0.970 U
PFOA	**9.30**	0.390 U

GP-18-03				
Sample	10/3/2018	(10/3/2018) FD	10/3/2018	(10/3/2018) FD
Units:	ng/L	ng/L	ug/kg	ug/kg
PFBS	**1.70 J**	**1.80 J**	0.330 U	0.320 U
PFOS	**4.00**	**3.80 J**	0.910 U	0.900 U
PFOA	**9.20**	**9.10**	0.360 U	0.360 U

BP-18-01		
Sample	12/21/2018	12/21/2018
Units:	ng/L	ug/kg
PFBS	**1.00 J**	0.260 U
PFOS	**6.50**	0.710 U
PFOA	**16.0**	**0.160 J**

GP-18-04		
Sample	10/3/2018	10/3/2018
Units:	ng/L	ug/kg
PFBS	**1.50 J**	0.350 U
PFOS	**3.80 J**	0.970 U
PFOA	**8.00**	0.390 U

GP-18-02		
Sample	10/4/2018	10/4/2018
Units:	ng/L	ug/kg
PFBS	**1.40 J**	0.300 U
PFOS	**3.90**	0.840 U
PFOA	**10.0**	0.340 U

GP-18-01		
Sample Date:	10/4/2018	10/4/2018
Units:	ng/L	ug/kg
PFBS	**1.50 J**	0.260 U
PFOS	**3.80**	0.710 U
PFOA	**7.50**	0.280 U

Aerial Sources: 2019, USGS, MassGIS

File: PFAS_RI_A1_PSC_Grove_Balch_Pond_SWSD_Results.mxd

Legend

◐ Surface Water and Sediment Sample Location

▭ Former Fort Devens Boundary

EPA PFAS Site Specific Screening Levels for Former Fort Devens			
Surface Water		Sediment	
Units:	ng/L	Units:	µg/kg
PFOA	2,030	PFOA	609
PFOS	2,030	PFOS	609
PFBS	2,030,000	PFBS	609,000

Notes:

Perfluorooctane Sulfonic Acid (PFOS)
Perfluorooctanoic Acid (PFOA)
Perfluorobutanesulfonic acid (PFBS)
ng/L = nanograms per liter (Surface Water Result Value)
µg/kg = microgram per kilogram (Sediment Result value)

J = estimated result
U= not detected above the reported sample quantitation limit
Bold = detection

Grove Pond and Balch Pond
PFAS Results in Surface Water and Sediment Samples
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 200 400
Feet

Date:
05/05/2020

Figure
6-9

Legend

⊕ Public Water Supply Well

— Current Road

🟧 AOC 40 Debris Disposal Area

🟪 AOC 40 Sediment Removal Area

▭ Former Fort Devens Boundary

Note:

Aerial Source: MassGIS - 1:5,000 Black and White Digital Orthophoto Images - 1992

Patton Well Area/AOC 40 1992 Aerial Imagery
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC

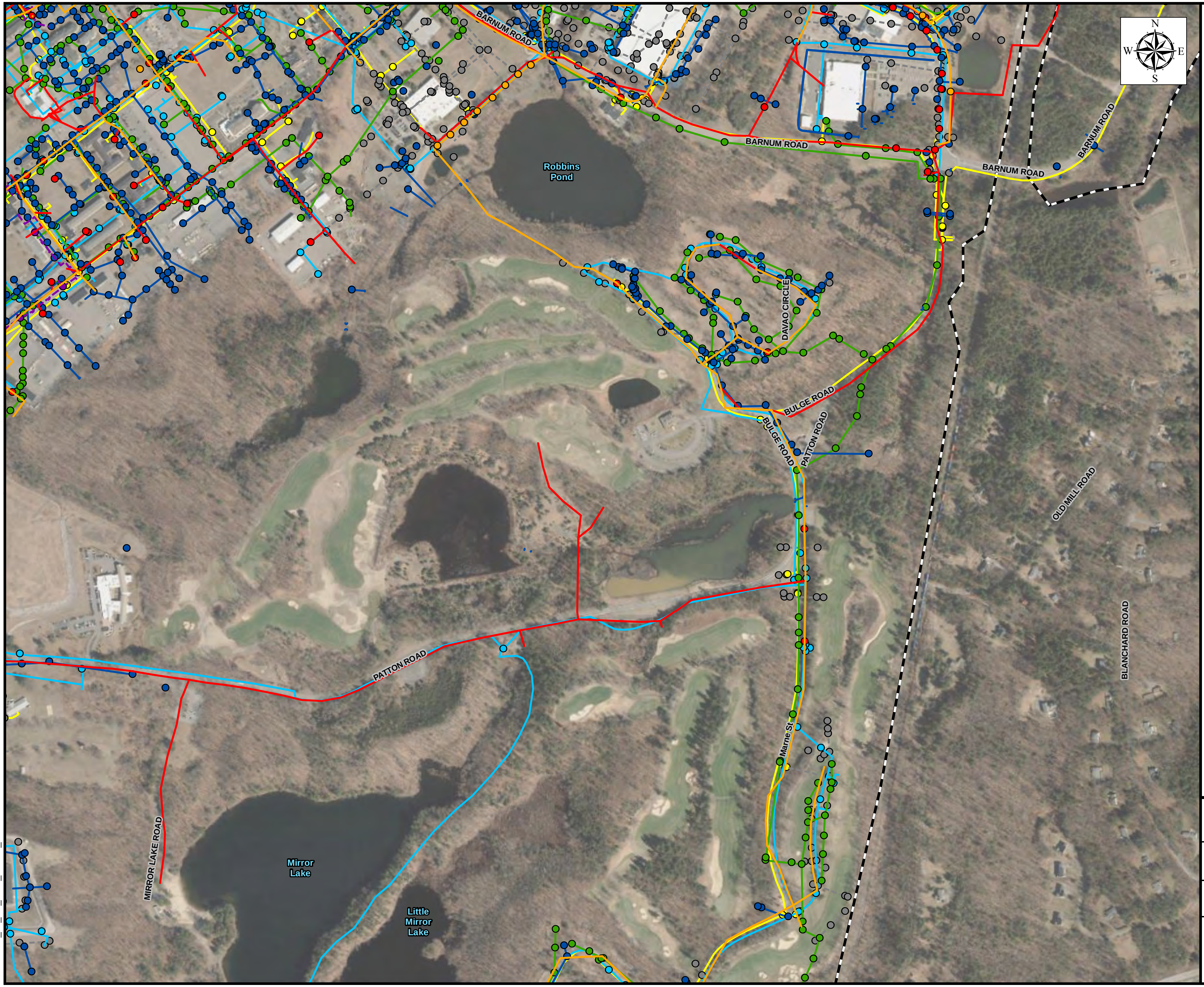
0 250 500
Feet

Date:
05/13/2020

Figure
7-1

KGS

File: PFAS_IDE_2020_PattonWell_AOC40_1992Imagery.mxd



Legend

Historic Subsurface Features

- ● Communication
- — Communication Line
- ● Electric
- — Electric Line
- ● Steam Manhole
- - - Steam
- ● Storm
- — Storm Line
- ▨ Storm Feature
- ● Sanitary
- — Sanitary Line
- ■ Sanitary Feature
- ● Water
- — Water Line
- ■ Water Feature
- ● Abandoned Feature
- - - Abandoned Line
- ● Gas
- — Gas Line
- ▭ Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

Patton Well Area/AOC 40 Area Historic Subsurface Features
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

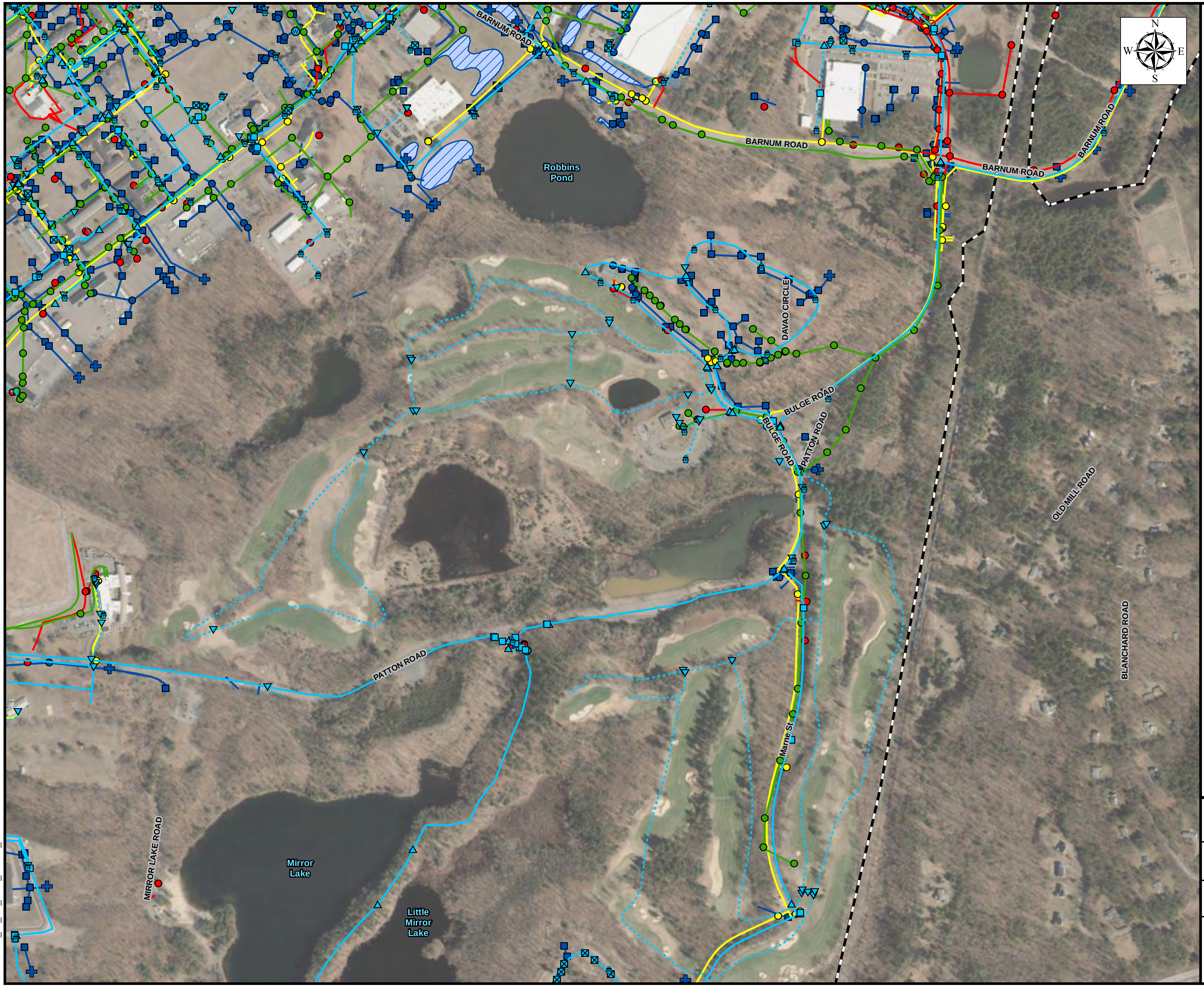
KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 300 600
Feet

Date: 04/26/2020

Figure 7-2

File: PFAS_RI_A1_PSC_Patton_HistoricUtilities.mxd



Legend

Water 01/06/2020
- ♁ Hydrant
- ■ Main Fitting
- ☒ Service Fitting
- △ Main Valve
- ▽ Service Valve
- ◎ Wellhead
- — Main Line
- ┄ Service Line
- — Tie

Sewer 01/06/2020
- ● Force Fitting, Main Fitting, Service Fitting, Manhole
- — Force Main, Gravity Main, Service Line, Tie
- 🟩 DBox, Grease Trap, Lift Station, Oil/Water

Electric 01/07/2020
- ● Connection Box, Handhole, Junction Box, Manhole, Meter, Switch, or Transformer
- — Inservice/Abandoned
- 🟥 Vault

Gas 01/06/2020
- ● Main Fitting, Main Valve, Meter, Rectifier, Service Fitting, Service Regulator, Service Valve, Test Station, Anode
- — Main, Service, Tie, Cathodic Loop

Stormwater 12/11/2019
- ■ Catch Basin
- ✚ Outfall
- ● Manhole
- — Pipe, Culvert
- ▨ Detention Pond
- ☐ Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

Patton Well Area/AOC 40 Area Current Subsurface Features
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 300 600
Feet

Date:
04/26/2020

Figure
7-3

KGS

File: PFAS_RI_A1_PSC_Patton_SubsurfaceUtilities.mxd

Legend

- ◐ Surface Water and Sediment Sampling Location
- ⊗ Initial Monitoring Well/Piezometer
- ⊕ New Monitoring Well/Piezometer
- ⊕ Soil Boring Location
- ▲ Vertical Profiling Location Installation Phase 1
- ▲ Vertical Profiling Location Installation Phase 2
- ▲ Vertical Profiling Location Installation Phase 3
- △ AOC 43G Vertical Profiling Location
- ◐ Surface Water and Sediment Sampling Results
- Ⓘ Irrigation Well
- ⊕ Public Water Supply Well
- ◪ Staff Gauge
- ⬚ Former Fort Devens Boundary

Aerial Sources: USGS, MassGIS Orthoimagery 2019

Patton Well Area/AOC 40 Field Activities
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

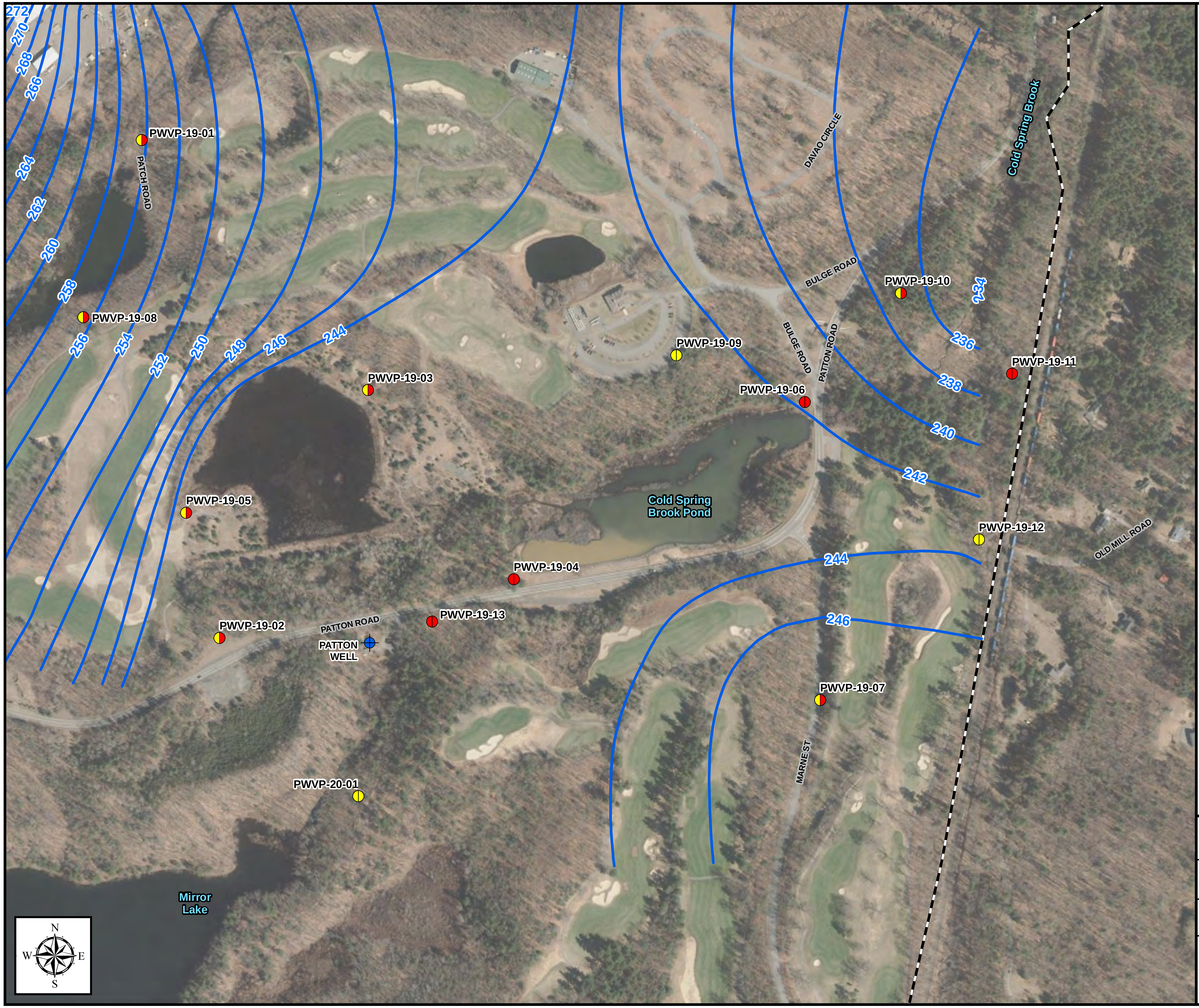
0 200 400
Feet

Date:
05/27/2020

Figure
7-4

KGS

File: PFAS_RI_A1_PSC_PattonWell_AOC40_FieldActivities.mxd



Legend

◐ Monitoring Well/Vertical Profiling Location

EPA LHA
(sum of PFOA and PFOS) (ng/L)

◐ EPA LHA ≥ 70 ng/L

◐ EPA LHA < 70 ng/L

◐ EPA LHA No detection

MassDEP
(sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA) (ng/L)

◐ MassDEP ≥ 20 ng/L

◐ MassDEP < 20ng/L

◐ MassDEP no detection

〜 Groundwater Elevation Contour (ft NAVD 88)
(Contour Interval = 2 ft) January 2-3, 2020

▭ Former Fort Devens Boundary

Notes:

MassDEP GW-1 = sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA
MassDEP Exceedance Criteria is defined as equal to or greater than 20 ng/L

EPA LHA (Lifetime Health Advisory) = sum of PFOA and PFOS
EPA LHA Exceedance Criteria is defined as equal to or greater than 70 ng/L

Aerial Source: USGS, MassGIS Orthoimagery 2019

Patton Well Area/AOC 40 Groundwater Results
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 200 400
Feet

Date:
05/28/2020

Figure
7-5

File: PFAS_RI_A1_PSC_Patton_GWResults.mxd

Legend

●	Monitoring Well/Piezometer
●	Abandoned Well
●	Soil Boring Location
△	Vertical Profiling Location
●	Irrigation Well
⊕	Public Water Supply Well
◩	Staff Gauge
—	Cross Section Location
⬚	Former Fort Devens Boundary

Aerial Sources: USGS, MassGIS Orthoimagery 2019

Patton Well Area/AOC 40 Cross Section Location Map
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

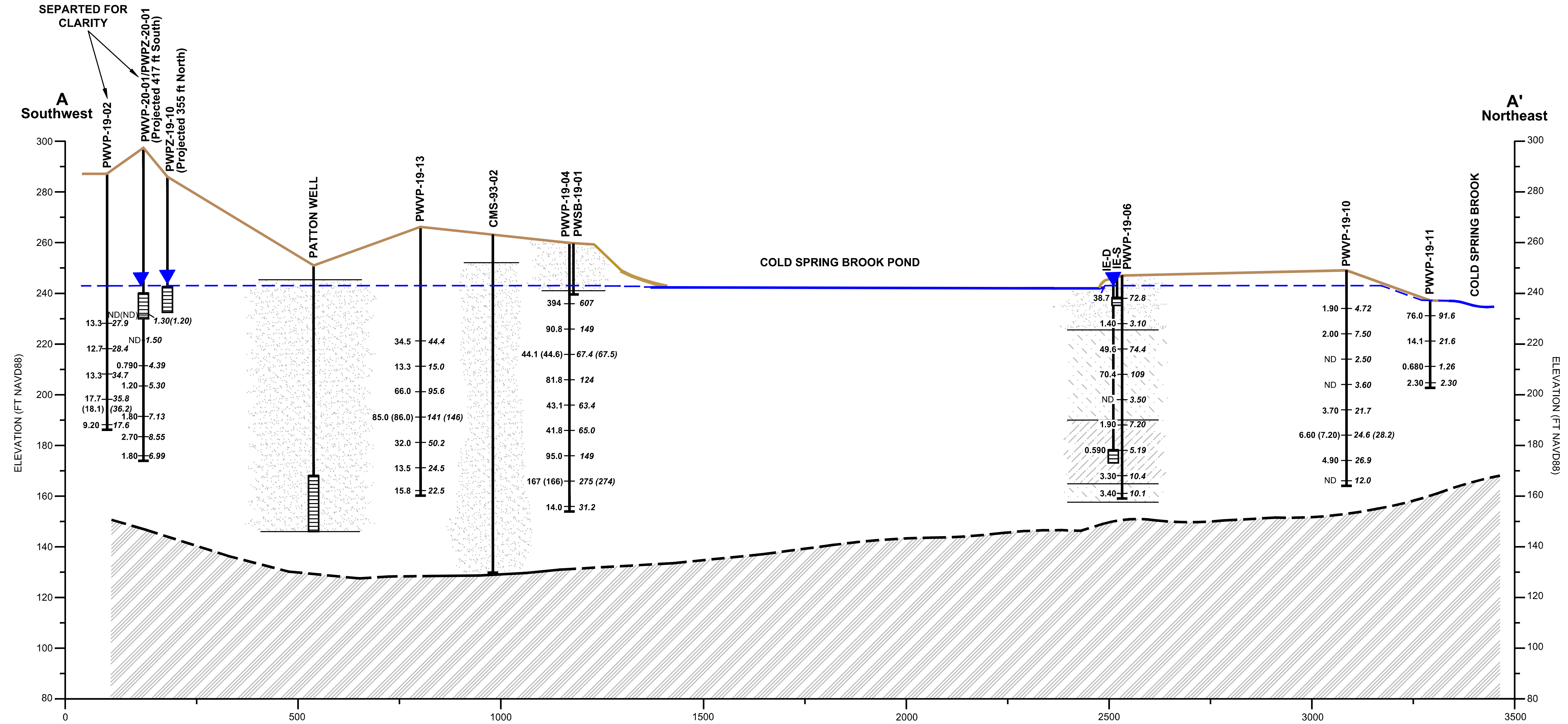
KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 200 400
Feet

Date:
05/14/2020

Figure
7-6

File: PFAS_RI_A1_PSC_Patton_XSLoc.mxd



Legend

Vertical Profile

1.39 U
EPA LHA
Concentration
(sum of PFOA
and PFOS)

2.59 U
MassDEP
Concentration
(sum of PFOS + PFOA
+ PFDA + PFHpA +
PFHxS + PFNA)

Monitoring Well

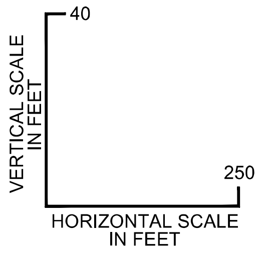
Screened
Interval

░	Sand with Gravel/Sand
▨	Sand with Silt/Silty Sand
▒	Silt
▧	Silt, Sand, Gravel, with Clay
┅	Till
▩	Weathered Bedrock
▨	Bedrock
☐	Unknown
▼	Water Table

Notes:

All results in ng/L
ng/L = nanograms per liter
ND = non-detect
( ) = field duplicate

Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorodecanoic acid (PFDA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorononanoic acid (PFNA)



Patton Well Area/AOC 40 - Cross Section, A-A'
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

Scale as Shown	Date: 05/28/2020	Figure 7-7

File: X:\HS_Environmental\FortDevens_Mass\Drawings\PSC_Report\Area1\PSC_A1_Patton_XS.dwg A-A

PWSB-19-04						
Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 15.00	19.50 - 21.50	19.50 - 21.50 (FD)
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**0.110 J**	0.210 U	0.200 U	0.200 U	0.200 U	0.220 U
PFHpA	**0.190 J**	0.210 U	0.200 U	0.200 U	0.200 U	0.220 U
PFHxS	**0.0900 J**	0.210 U	0.200 U	0.200 U	0.200 U	0.220 U
PFNA	**0.120 J**	0.210 U	0.200 U	0.200 U	0.200 U	0.220 U
PFOS	**1.40**	**0.470 J**	0.500 U	**0.340 J**	**0.330 J**	**0.330 J**
PFOA	**0.560**	0.210 U	0.200 U	0.200 U	0.200 U	0.220 U

PWSB-19-03	
Depth (ft bgs)	0.00 - 0.50
Units	µg/kg
PFDA	**0.630 J**
PFHpA	**0.390 J**
PFHxS	**1.70**
PFNA	**0.510 J**
PFOS	**4.00**
PFOA	**1.30**

PWSB-19-02	
Depth (ft bgs)	0.00 - 0.50
Units	µg/kg
PFDA	**0.300 J**
PFHpA	**0.240 J**
PFHxS	**0.870**
PFNA	**0.290 J**
PFOS	**4.30**
PFOA	**0.600**

PWSB-19-01					
Depth (ft bgs)	0.00 - 0.50	0.50 - 3.00	3.00 - 7.00	7.00 - 15.00	16.50 - 18.50
Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
PFDA	**0.38**	0.210 U	0.190 U	0.200 U	0.200 U
PFHpA	**0.0840 J**	0.210 U	0.190 U	0.200 U	0.200 U
PFHxS	0.200 U	0.210 U	0.190 U	0.200 U	0.200 U
PFNA	0.200 U	0.210 U	0.190 U	0.200 U	0.200 U
PFOS	**1.80**	**0.530 J**	**0.400 J**	**0.270 J**	**0.270 J**
PFOA	**0.200 J**	0.210 U	0.190 U	0.200 U	**0.110 J**

Legend

⊕	Monitoring Well/Piezometer
●	Soil Boring Location
▲	Vertical Profiling Location
⊕	Public Water Supply Well
◪	Staff Gauge
▭	Former Fort Devens Boundary

Notes:

Criteria = S-1/GW-1, Massachusetts Contingency Plan, 2019 Proposed PFAS Revisions

PFAS	Limits (ug/kg)
Perfluorodecanoic acid (PFDA)	0.300
Perfluoroheptanoic acid (PFHpA)	0.500
Perfluorohexanesulfonic acid (PFHxS)	0.300
Perfluorononanoic acid (PFNA)	0.320
Perfluorooctanesulfonic acid (PFOS)	2.00
Perfluorooctanoic acid (PFOA)	0.720

1.70 = detection of PFAS

1.70 = detection of PFAS above criteria

Data reported to three significant figures

µg/kg = micrograms per kilogram
U = non-detect
J = estimated result

Aerial Source: USGS, MassGIS Orthoimagery 2019

Patton Well Area/AOC 40 Soil Results
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 100 200
Feet

Date:
04/27/2020

Figure
7-8

File: PFAS_RI_A1_PSC_PattonWell_AOC40_SoilResults.mxd

CSB-18-01		
Sample	9/27/2018	9/27/2018
Units:	ng/L	ug/kg
PFBS	**1.60 J**	2.50 U
PFOS	**4.10**	6.90 U
PFOA	**4.50**	**2.50 J**

CP-20-02		
Sample	3/27/2020	3/27/2020
Units:	ng/L	ug/kg
PFBS	**2.20**	0.230 U
PFOS	**5.50**	**0.340 J**
PFOA	**67.0**	**0.250 J**

CSB-20-01		
Sample	3/27/2020	3/27/2020
Units:	ng/L	ug/kg
PFBS	**3.20**	0.370 U
PFOS	**2.20 J**	1.00 U
PFOA	**8.60**	**0.270 J**

CP-20-03		
Sample	3/30/2020	3/30/2020
Units:	ng/L	ug/kg
PFBS	**1.80**	0.270 U
PFOS	**5.70**	0.740 U
PFOA	**57.0**	**0.230 J**

CP-20-01				
Sample	3/27/2020	(3/27/2020) FD	3/27/2020	(3/27/2020) FD
Units:	ng/L	ng/L	ug/kg	ug/kg
PFBS	**2.60**	**2.60**	0.450 U	0.470 U
PFOS	**7.40**	**7.70**	**1.00 J**	**0.910 J**
PFOA	**60.0**	**54.0**	**0.400 J**	**0.310 J**

ML-20-01		
Sample	3/30/2020	3/30/2020
Units:	ng/L	ug/kg
PFBS	**1.10 J**	0.230 U
PFOS	**11.0**	0.630 U
PFOA	**12.0**	0.250 U

Legend

◐	Surface Water and Sediment Sample Location
⊕	Public Water Supply Well
⬚	Former Fort Devens Boundary

EPA PFAS Site Specific Screening Levels for Former Fort Devens			
Surface Water		Sediment	
Units:	ng/L	Units:	µg/kg
PFOA	2,030	PFOA	609
PFOS	2,030	PFOS	609
PFBS	2,030,000	PFBS	609,000

Notes:

Perfluorooctane Sulfonic Acid (PFOS)
Perfluorooctanoic Acid (PFOA)
Perfluorobutanesulfonic acid (PFBS)
ng/L = nanograms per liter (Surface Water Result Value)
µg/kg = microgram per kilogram (Sediment Result value)

J = estimated result
U= not detected above the reported sample quantitation limit
Bold = detection

Southern Extent Cold Spring Brook, Cold Spring Brook Pond, and Mirror Lake PFAS Results in Surface Water and Sediment Samples Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 300 600
Feet

Date:
05/05/2020

Figure
7-9

KGS

File: PFAS_RI_A1_PSC_South_ColdSpringBrook_SWSD_Results.mxd

Aerial Sources: 2019, USGS, MassGIS

Legend

⊕ Public Water Supply Well

— Current Road

▭ Former Fort Devens Boundary

Note:

Aerial Source: MassGIS - 1:5,000 Black and White Digital Orthophoto Images - 1992

Shabokin Well Area and AOC 43J 1992 Aerial Imagery
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, MA

KOMAN Government Solutions, LLC

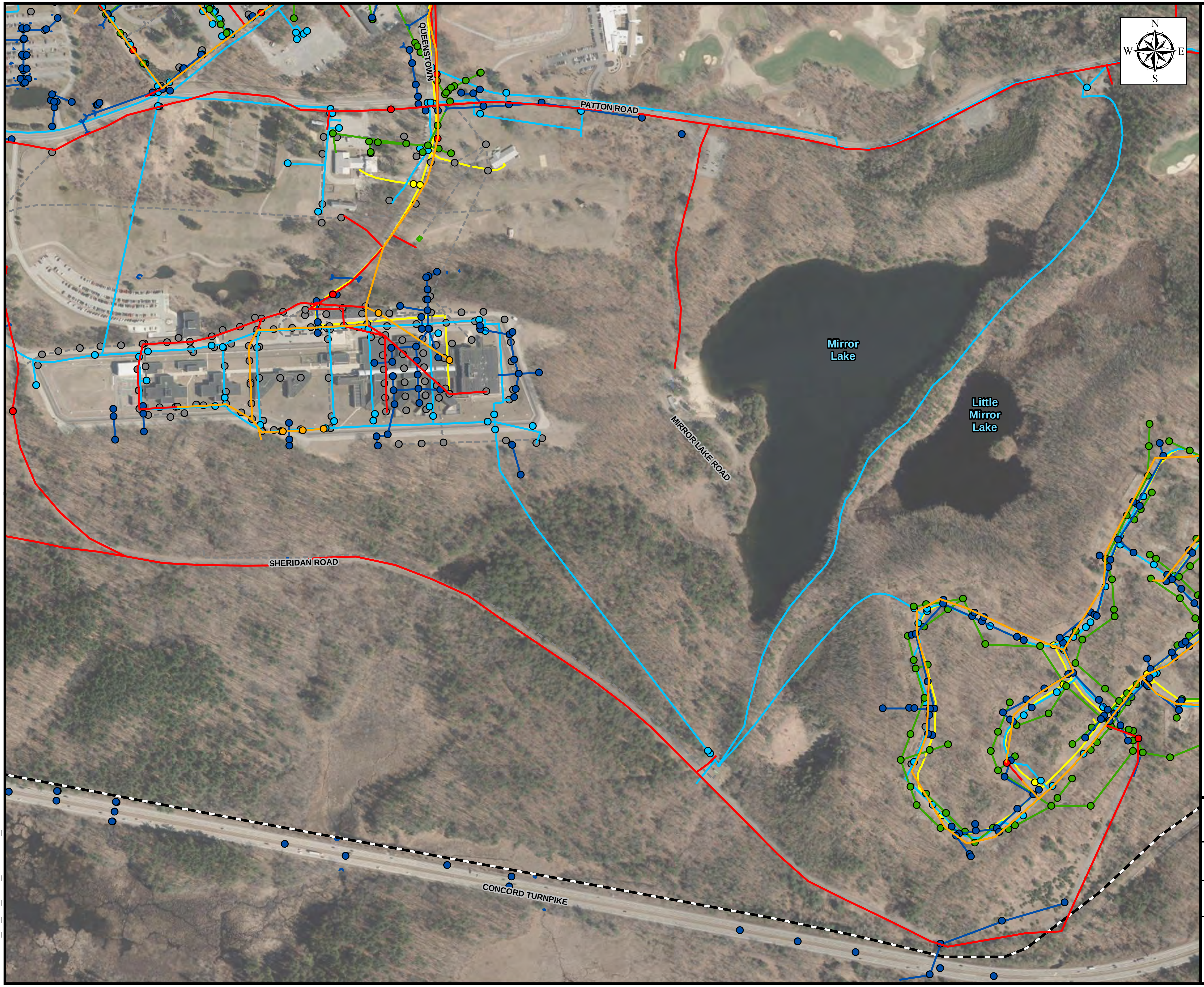
0 200 400
Feet

Date:
04/02/2020

Figure
8-1

KGS

File: PFAS_IDE_2020_ShabokinWell_1992Imagery.mxd



Legend

Historic Subsurface Features

- ● Communication
- — Communication Line
- ● Electric
- — Electric Line
- ● Storm
- — Storm Line
- ▨ Storm Feature
- ● Sanitary
- — Sanitary Line
- ▬ Sanitary Feature
- ● Water
- — Water Line
- ▬ Water Feature
- ● Abandoned Feature
- - - Abandoned Line
- ● Gas
- — Gas Line
- ⬚ Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

Shabokin Well Area and AOC 43J Historic Subsurface Features

Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

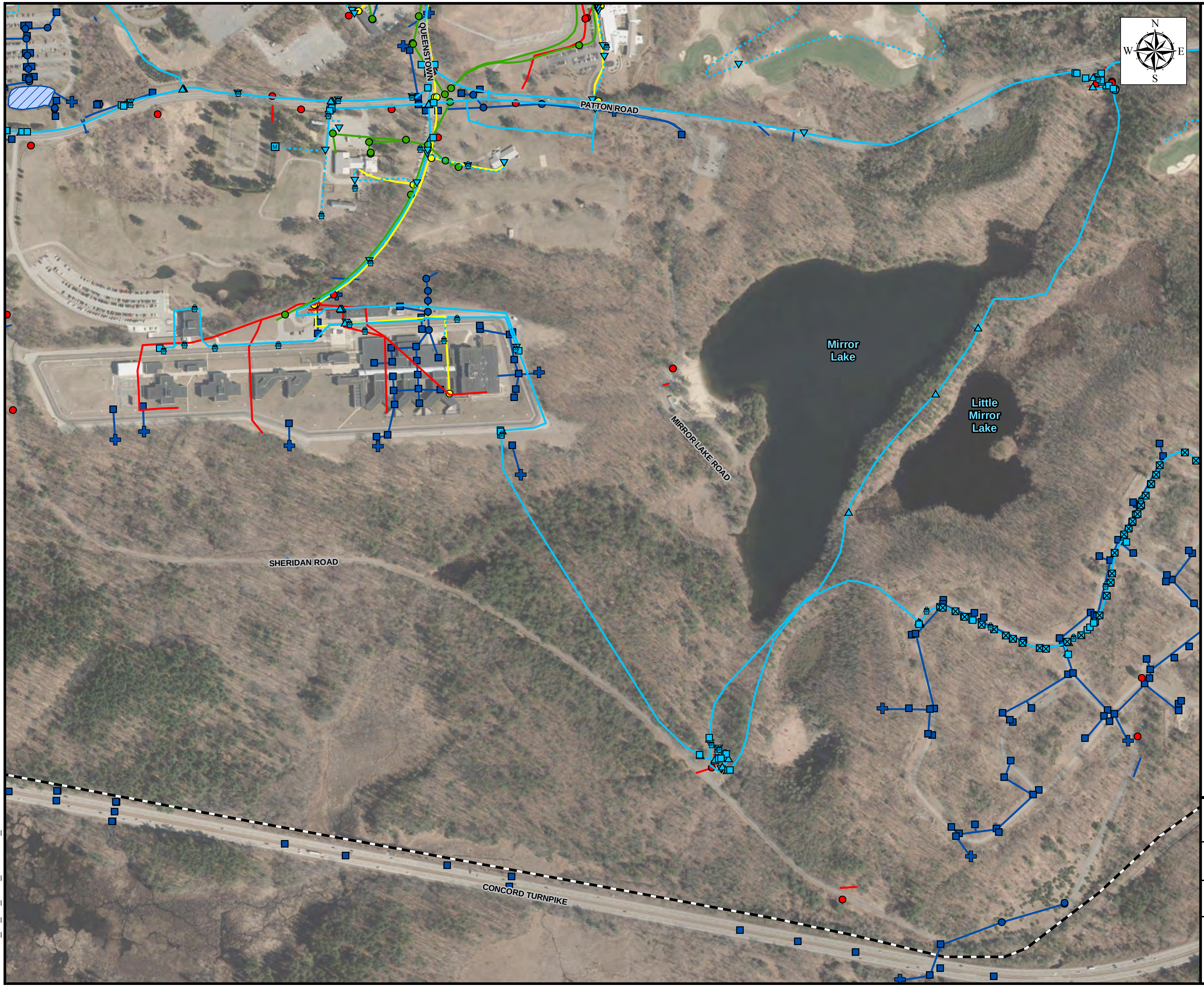
KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 250 500
Feet

Date:
04/26/2020

Figure
8-2

File: PFAS_RI_A1_PSC_Shabokin_HistoricUtilities.mxd



Legend

Water 01/06/2020	
🧯	Hydrant
■	Main Fitting
☒	Service Fitting
▲	Main Valve
▼	Service Valve
M	Meter
W	Wellhead
—	Main Line
----	Service Line
—	Tie
Sewer 01/06/2020	
●	Force Fitting, Main Fitting, Service Fitting, Manhole
—	Force Main, Gravity Main, Service Line, Tie
🟩	DBox, Grease Trap, Lift Station, Oil/Water
Electric 01/07/2020	
●	Connection Box, Handhole, Junction Box, Manhole, Meter, Switch, or Transformer
—	Inservice/Abandoned
🟥	Vault
Gas 01/06/2020	
●	Main Fitting, Main Valve, Meter, Rectifier, Service Fitting, Service Regulator, Service Valve, Test Station, Anode
—	Main, Service, Tie, Cathodic Loop
Stormwater 12/11/2019	
■	Catch Basin
✚	Outfall
●	Manhole
—	Pipe, Culvert
▨	Detention Pond
☐	Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

Shabokin Well Area and AOC 43J Current Subsurface Features
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 250 500
Feet

Date:
04/26/2020

Figure
8-3

File: PFAS_RI_A1_PSC_Shabokin_SubsurfaceUtilities.mxd

Legend

●	Existing Monitoring Well/Piezometer
●	New Monitoring Well/Piezometer
▲	Vertical Profiling Location Installation Phase 1
▲	Vertical Profiling Location Installation Phase 2
◐	Surface Water and Sediment Sampling Location
⊕	Public Water Supply Well
◩	Staff Gauge

Aerial Source: USGS, MassGIS Orthoimagery 2019

Shabokin Well Area Field Activities
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

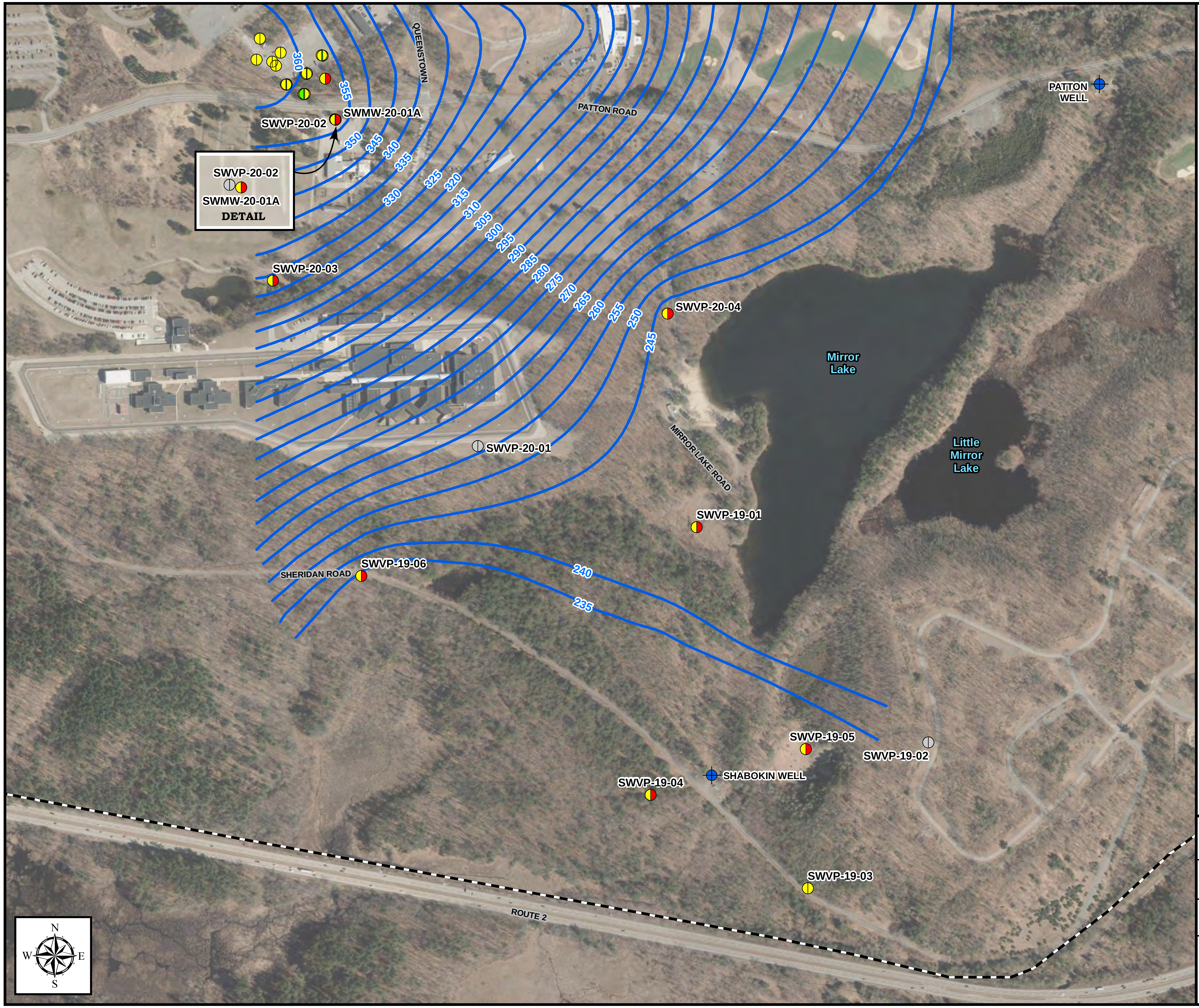
KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 250 500
Feet

Date:
05/12/2020

Figure
8-4

File: PFAS_RI_A1_PSC_ShabokinWell_FieldActivities.mxd



Legend

◐ Monitoring Well/Vertical Profiling Location

EPA LHA
(sum of PFOA and PFOS) (ng/L)

◐ EPA LHA ≥ 70 ng/L

◐ EPA LHA < 70 ng/L

◐ EPA LHA No detection

◐ Dry

MassDEP
(sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA) (ng/L)

◐ MassDEP ≥ 20 ng/L

◐ MassDEP < 20ng/L

◐ MassDEP no detection

◐ Dry

〰 Groundwater Contour (ft NAVD 88)
(Contour Interval = 5 Feet) - March 2020

▭ Former Fort Devens Boundary

Notes:

MassDEP GW-1 = sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA
MassDEP Exceedance Criteria is defined as equal to or greater than 20 ng/L

EPA LHA (Lifetime Health Advisory) = sum of PFOA and PFOS
EPA LHA Exceedance Criteria is defined as equal to or greater than 70 ng/L

Aerial Source: USGS, MassGIS Orthoimagery 2019

Shabokin Well Area Groundwater Results
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 250 500
Feet

Date:
05/28/2020

Figure
8-5

File: PFAS_RI_A1_PSC_Shabokin_GWResults.mxd

Legend

- ◕ Monitoring Well/Piezometer
- ◕ Piezometer not installed (no water encountered during drilling)
- △ Vertical Profiling Location
- ◑ Surface Water and Sediment Sampling Location
- ◪ Staff Gauge
- ⊕ Public Water Supply Well
- ━ Cross Section Location

Aerial Source: USGS, MassGIS Orthoimagery 2019

Shabokin Well Area Cross Section Locations
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

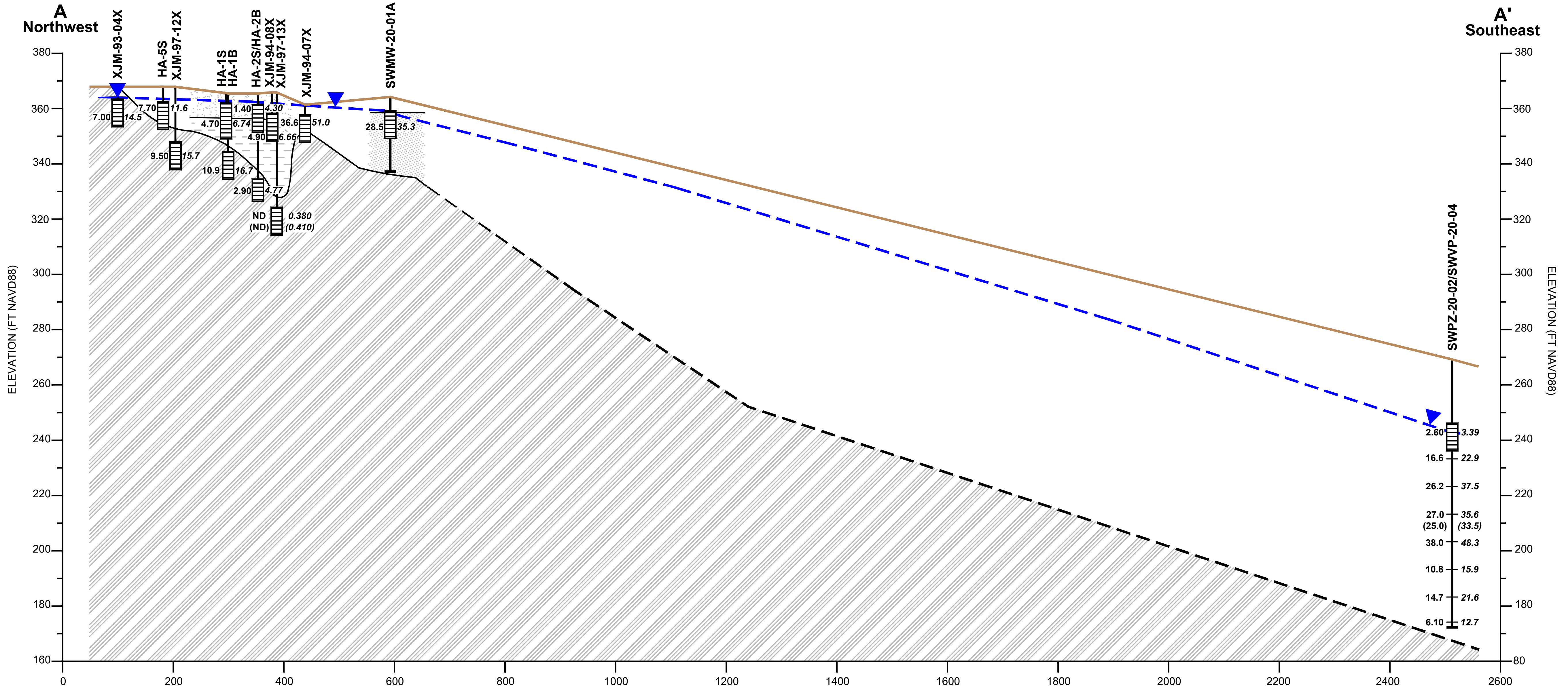
KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 250 500
Feet

Date:
05/27/2020

Figure
8-6

File: PFAS_RI_A1_PSC_ShabokinWell_XSLoc.mxd



Legend

Vertical Profile

1.39 U
EPA LHA Concentration (sum of PFOA and PFOS)

2.59 U
MassDEP Concentration (sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA)

Monitoring Well

Screened Interval

▨ Sand with Gravel/Sand
▨ Sand with Silt/Silty Sand
▨ Silt
▨ Silt, Sand, Gravel, with Clay
▨ Till
▨ Weathered Bedrock
▨ Bedrock
☐ Unknown
▼ Water Table

Notes:

All results in ng/L
ng/L = nanograms per liter
ND = non-detect
( ) = field duplicate

Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorodecanoic acid (PFDA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorononanoic acid (PFNA)

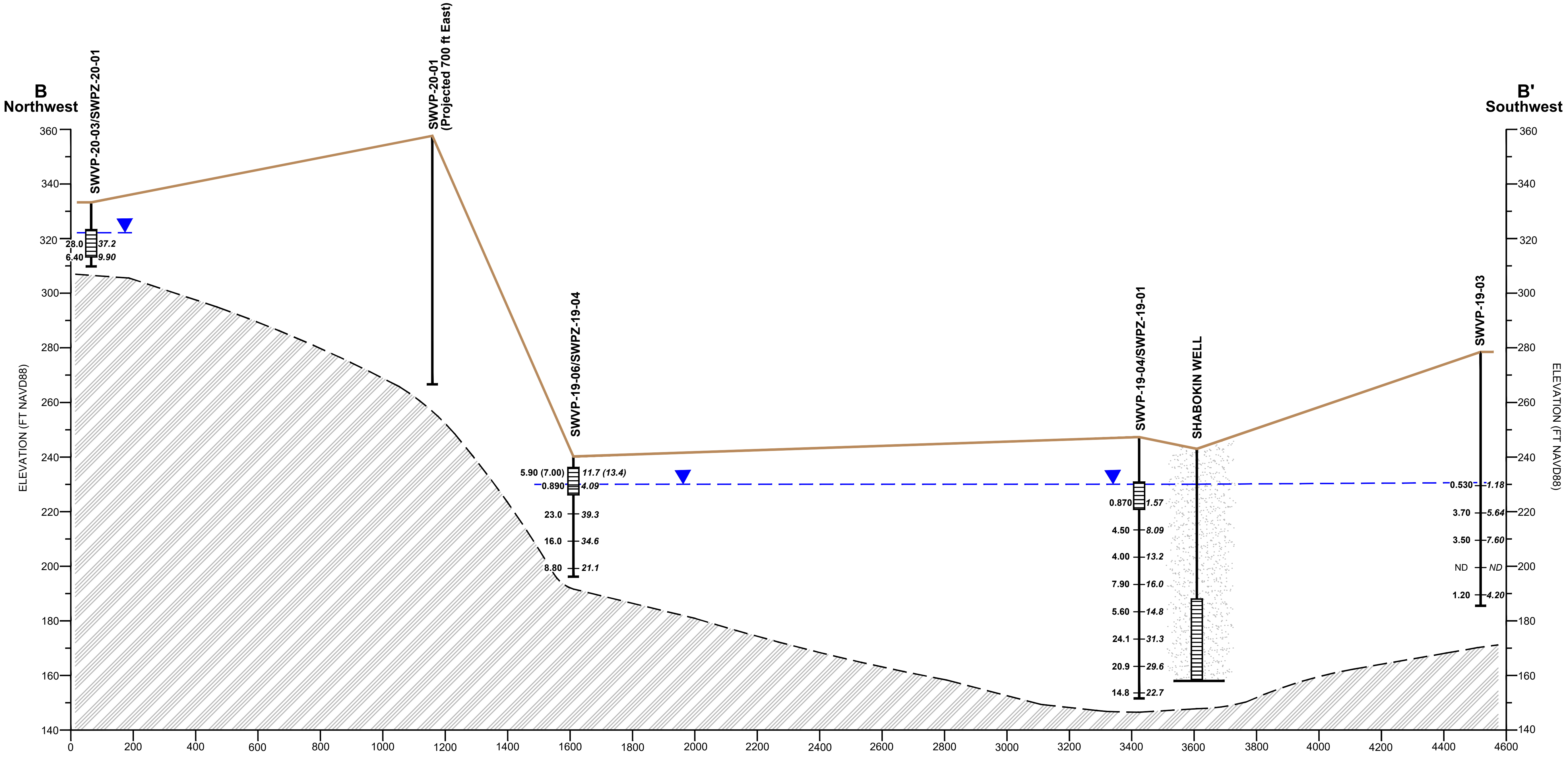
VERTICAL SCALE IN FEET 40
200
HORIZONTAL SCALE IN FEET

Shabokin Well Area - Cross Section, A-A'
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

Scale as Shown	Date: 05/14/2020	Figure 8-7	KGS



Legend

Vertical Profile

1.39 U
EPA LHA
Concentration
(sum of PFOA
and PFOS)

2.59 U
MassDEP
Concentration
(sum of PFOS + PFOA
+ PFDA + PFHpA +
PFHxS + PFNA)

Monitoring Well

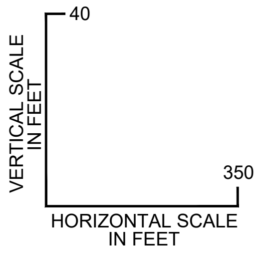
Screened
Interval

░	Sand with Gravel/Sand
▨	Sand with Silt/Silty Sand
▒	Silt
░	Silt, Sand, Gravel, with Clay
☐	Till
▩	Weathered Bedrock
▨	Bedrock
☐	Unknown
▼	Water Table

Notes:

All results in ng/L
ng/L = nanograms per liter
ND = non-detect
( ) = field duplicate

Perfluorooctanesulfonic acid (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorodecanoic acid (PFDA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorononanoic acid (PFNA)



Shabokin Well Area - Cross Section, B-B'
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

Scale as Shown	Date: 05/14/2020	Figure 8-8

File: X:\HS_Environmental\FortDevens_Mass\Drawings\PSC_Report\Area1\PSC_A1_Shabokin_XS.dwg B-B

Legend

▲	Approximate Location of Potential Former Source Area
⊕	Monitoring Well
●	Injection Well
▨	Approximate Location of Former UST
⬚	Approximate Location of 2009 and 2010 Pilot Test Area
☐	Former Building

References:
HGL. LTMMP 2010, Haley Aldrich Inc. 2015

Aerial Sources: 2019, USGS, MassGIS

AOC 43J Site Layout
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 30 60
Feet

Date:
05/14/2020

Figure
9-1

KGS

File: PFAS_RI_A1_PSC_AOC43J_SL.mxd

Legend

◐ Monitoring Well/Vertical Profiling Location

EPA LHA
(sum of PFOA and PFOS) (ng/L)

🔴 EPA LHA ≥ 70 ng/L

🟡 EPA LHA < 70 ng/L

🟢 EPA LHA No detection

⚪ Dry

MassDEP
(sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA) (ng/L)

🔴 MassDEP ≥ 20 ng/L

🟡 MassDEP < 20ng/L

🟢 MassDEP no detection

⚪ Dry

⬚ Former Fort Devens Boundary

Notes:

MassDEP GW-1 = sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA
MassDEP Exceedance Criteria is defined as equal to or greater than 20 ng/L

EPA LHA (Lifetime Health Advisory) = sum of PFOA and PFOS
EPA LHA Exceedance Criteria is defined as equal to or greater than 70 ng/L

Aerial Source: USGS, MassGIS Orthoimagery 2019

AOC 43J Groundwater Results
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 30 60
Feet

Date:
05/04/2020

Figure
9-2

File: PFAS_RI_A1_PSC_AOC43J_GWResults.mxd

Legend

- △ Vertical Profiling Location
- ● Monitoring Well/Piezometer
- ⊕ Soil Boring
- ◐ Surface Water/Sediment Sample
- ▲ Staff Gauge
- ○ Irrigation Well
- ◆ Public Water Supply Well
- ▭ Former Fort Devens Boundary

Aerial Source: USGS, MassGIS Orthoimagery 2019

File: PFAS_RI_A1_PSC_Plate_Samples.mxd

Sample Locations
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 200 400 800 1,200
Feet

Date:
05/20/2020

Plate
1

KGS

Legend

◌ Monitoring Well/ Vertical Profiling Location

┅ Former Fort Devens Boundary

EPA LHA (sum of PFOA and PFOS) (ng/L)

◐ EPA LHA ≥ 70 ng/L

◐ EPA LHA < 70 ng/L

◐ EPA LHA No detection

◐ Dry

MassDEP (sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA) (ng/L)

◑ MassDEP ≥ 20 ng/L

◑ MassDEP < 20ng/L

◑ MassDEP no detection

◑ Dry

Notes:

MassDEP GW-1 = sum of PFOS + PFOA + PFDA + PFHpA + PFHxS + PFNA
MassDEP Exceedance Criteria is defined as equal to or greater than 20 ng/L

EPA LHA (Lifetime Health Advisory) = sum of PFOA and PFOS
EPA LHA Exceedance Criteria is defined as equal to or greater than 70 ng/L

Aerial Source: USGS, MassGIS Orthoimagery 2019

Groundwater Results
Devens PFAS RI - Area 1 PSCS

Former Fort Devens Army Installation
Devens, Massachusetts

KOMAN Government Solutions, LLC
293 Boston Post Road West, Suite 100, Marlborough, MA 01752

0 200 400 800 1,200
Feet

Date:
05/19/2020

Plate
2

File: PFAS_RI_A1_PSC_Plate_GWResults.mxd

TABLES

Table 1-1
Select PFAS Criteria
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

	EPA											Massachusetts			
	Lifetime Health Advisory Drinking Water		Site-Specific PFAS Screening Levels For the Former Fort Devens									ORSG Guidelines for Drinking Water and GW-1 Standard		GW-3 Standard	S-1 SOIL & GW-1
	Summed Value	Individual Concentrations	Ingestion, Surface water	Ingestion, Groundwater		Dermal + Ingestion, Soil				Ingestion, Fish		Summed Value	Individual Concentrations	Individual Concentrations	Individual Concentrations
			Child Recreator	Child Resident	Adult Commercial Worker	Child Recreator	Child Resident	Adult Commercial Worker	Adult Construction Worker	Adult	Child				
	ng/L		ng/L	ng/L		µg/kg				mg/kg		ng/L		ng/L	µg/kg
PFBS			2,030,000	40,100	234,000	609,000	126,000	428,000	631,000	7.95	6.13				
PFOS	70	70	2,030	40.1	234	609	126	631	428	7.95X10-3	6.13X10-3	20	20	5.0E+05	2
PFOA		70	2,030	40.1	234	609	126	631	428	7.95X10-3	6.13X10-3		20	4.0E+07	0.72
PFDA													20	4.0E+07	0.3
PFHpA													20	4.0E+07	0.5
PFHxS													20	5.0E+05	0.3
PFNA													20	4.0E+07	0.32

ORSG = Office of Standards and Guidelines
PFBS = Perfluorobutanesulfonic Acid
PFDA = Perfluorodecanoic Acid
PFHpA = Perfluoroheptanoic Acid
PFHxS = Perfluorohexanesulfonic Acid
PFNA = Perfluorononanoic Acid
PFOS = Perfluorooctanesulfonic Acid
PFOA = Perfluorooctanoic Acid
ng/L = nanograms per liter
µg/L = micrograms per liter
mg/kg = milligrams per kilogram
µg/kg = micrograms per kilogram

Table 2-1
Bedrock Elevations
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location Name	Northing	Easting	Bedrock Elevation (ft NAVD88)	Notes
6892	3019369.81	637629.81	232.91	Bedrock confirmed
6899	3015693.68	638403.63	317.50	Bedrock confirmed
6902	3012476.05	633915.96	264.81	Bedrock confirmed
19466	3013984.65	639129.95	367.30	Bedrock confirmed
19474	3013314.33	639509.69	344.50	Bedrock confirmed
19539	3013178.34	639451.17	225.47	Bedrock confirmed
19541	3018147.46	635070.53	215.14	Bedrock confirmed
19542	3018251.61	635163.35	208.33	Bedrock confirmed
19568	3013978.98	639185.57	358.34	Bedrock confirmed
19569	3013973.93	639180.18	341.34	Bedrock confirmed
19572	3014051.74	639116.87	340.52	Bedrock confirmed
19573	3014046.69	639111.48	330.52	Bedrock confirmed
19576	3019022.54	637590.83	286.51	Bedrock confirmed
19578	3014056.67	639122.13	362.88	Bedrock confirmed
19581	3016366.19	637642.97	253.95	Bedrock confirmed
19597	3013755.82	629547.79	333.04	Bedrock confirmed
19606	3018167.83	635115.57	180.18	Bedrock confirmed
19612	3014513.16	631363.78	408.40	Bedrock confirmed
19617	3018167.83	635115.57	170.18	Bedrock confirmed
19638	3016867.57	631398.99	365.78	Bedrock confirmed
19643	3018712.75	635422.80	138.48	Bedrock confirmed
19647	3017885.98	639368.35	351.59	Bedrock confirmed
19672	3019682.65	631942.43	109.53	Bedrock confirmed
19679	3016655.01	631825.75	358.79	Bedrock confirmed
19683	3016565.04	631781.72	338.20	Bedrock confirmed
19684	3016696.72	631664.33	375.76	Bedrock confirmed
19685	3016753.85	631746.61	365.45	Bedrock confirmed
19687	3016823.64	631575.78	377.77	Bedrock confirmed
19689	3017010.22	631593.50	368.84	Bedrock confirmed
20642	3026405.03	638157.73	145.46	Bedrock confirmed
20644	3026405.03	638157.73	218.46	Bedrock confirmed
20645	3026405.03	638157.73	170.46	Bedrock confirmed
20648	3026405.03	638157.73	148.46	Bedrock confirmed
20649	3026405.03	638157.73	148.46	Bedrock confirmed
20650	3026405.03	638157.73	147.46	Bedrock confirmed
3-2	3027010.14	629207.26	267.28	Bedrock confirmed
100172	3017116.80	634702.45	265.61	Bedrock confirmed
112915	3019842.31	637491.04	228.40	Bedrock confirmed
116354	3023227.20	635700.46	262.00	Bedrock confirmed
116380	3012811.73	630070.84	348.30	Bedrock confirmed
120605	3019016.07	636262.35	220.47	Bedrock confirmed
122636	3013326.81	634249.15	290.38	Bedrock confirmed

Table 2-1
Bedrock Elevations
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location Name	Northing	Easting	Bedrock Elevation (ft NAVD88)	Notes
124393	3022025.87	626272.36	247.65	Bedrock confirmed
124394	3022084.27	625375.53	294.83	Bedrock confirmed
125411	3024306.14	636865.17	240.00	Bedrock confirmed
125983	3021921.85	639335.32	172.58	Bedrock confirmed
135693	3016427.39	631000.37	313.00	Bedrock confirmed
137190	3017905.67	630347.19	236.69	Bedrock confirmed
139875	3012922.31	630685.34	370.31	Bedrock confirmed
141452	3017358.63	634999.39	200.28	Bedrock confirmed
154142	3019981.57	633661.25	201.42	Bedrock confirmed
155274	3016667.93	630989.31	287.68	Bedrock confirmed
158532	3019845.70	632862.23	229.94	Bedrock confirmed
163457	3015455.46	631414.93	406.66	Bedrock confirmed
259017	3025319.25	629598.32	253.10	Bedrock confirmed
263203	3021440.75	626136.84	282.44	Bedrock confirmed
272055	3015740.44	638542.01	289.56	Bedrock confirmed
600579	3021455.28	629423.52	229.57	Bedrock confirmed
604832	3016596.62	632954.37	332.40	Bedrock confirmed
608632	3018915.67	636043.13	170.21	Bedrock confirmed
636470	3018173.46	630637.85	206.42	Bedrock confirmed
654229	3024855.22	636465.80	200.99	Bedrock confirmed
655357	3020348.84	632723.00	179.58	Bedrock confirmed
658624	3013361.80	628807.50	338.03	Bedrock confirmed
659493	3012530.73	632203.64	350.51	Bedrock confirmed
659713	3014094.68	639975.00	180.19	Bedrock confirmed
661314	3023606.29	636323.12	249.29	Bedrock confirmed
661407	3017990.62	631198.31	272.71	Bedrock confirmed
662300	3018649.56	636126.46	221.07	Bedrock confirmed
1E-D	3018993.00	629332.90	159.10	Refusal
20-1	3027170.82	629112.41	277.78	Bedrock confirmed
20-2	3027166.71	629111.41	277.30	Bedrock confirmed
2125021-01G	3016629.42	632957.09	298.00	Bedrock confirmed
2125021-02G	3016589.32	632973.23	307.00	Bedrock confirmed
2125021-03G	3016538.30	632965.09	306.00	Bedrock confirmed
2125021-04G	3016509.11	633002.80	309.00	Bedrock confirmed
2446-02 MW-2	3018147.75	623480.94	353.20	Refusal
27-1	3027214.79	629165.47	268.09	Bedrock confirmed
27-2	3027240.60	629172.50	273.07	Bedrock confirmed
27-30B-1	3027281.23	629203.61	271.56	Bedrock confirmed
27-30B-2	3027284.76	629206.48	271.75	Bedrock confirmed
32M-01-13XBR	3025296.45	629547.21	251.30	Bedrock confirmed
32M-01-14XBR	3025386.10	629684.78	224.90	Bedrock confirmed
32M-01-15XBR	3025254.04	629568.09	253.20	Bedrock confirmed

Table 2-1
Bedrock Elevations
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location Name	Northing	Easting	Bedrock Elevation (ft NAVD88)	Notes
32M-01-16XBR	3025101.97	629604.12	240.72	Bedrock confirmed
32M-01-17XBR	3025238.37	629698.54	218.30	Bedrock confirmed
32M-01-18XBR	3025246.91	629515.04	248.60	Bedrock confirmed
32VP-19-01	3025306.37	630204.66	176.96	Refusal
32VP-19-02	3025523.59	630202.20	170.46	Refusal
32VP-19-03	3024888.63	630129.63	202.86	Refusal
32VP-19-06	3025854.25	631324.64	133.01	Refusal
32VP-19-07	3026159.02	631312.89	143.77	Refusal
32VP-19-08	3024454.76	629466.05	245.91	Refusal
32VP-19-09	3025549.90	630381.43	150.65	Refusal
32VP-19-10	3025650.83	630756.50	130.86	Refusal
32VP-19-11	3025173.29	630471.70	145.79	Refusal
32VP-19-12	3024968.92	630585.90	118.31	Refusal
32Z-01-04XBR	3024501.97	629578.95	252.70	Bedrock confirmed
32Z-01-06XBR	3025592.12	629526.37	248.80	Bedrock confirmed
32Z-01-10XBR	3024914.37	629597.33	250.32	Bedrock confirmed
32Z-01-11XBR	3025496.11	629315.82	254.04	Bedrock confirmed
32Z-01-12XBR	3025272.70	629002.21	231.30	Bedrock confirmed
3A-2	3027046.42	629233.07	263.27	Bedrock confirmed
43AVP-19-01	3024626.48	628433.51	179.97	Refusal
43AVP-19-02	3024764.19	628440.23	177.49	Refusal
43AVP-19-03	3024888.29	628514.41	193.30	Refusal
43AVP-19-04	3024520.26	628624.35	190.09	Refusal
43GVP-19-04	3020797.50	627076.93	226.74	Refusal
43GVP-19-05	3020945.00	627082.00	218.09	Refusal
43GVP-19-06	3021117.00	627228.00	204.02	Refusal
43GVP-19-07	3020685.00	627042.00	229.20	Refusal
43GVP-19-08	43GVP-19-08	43GVP-19-08	140.73	Refusal
43GVP-19-09	43GVP-19-09	43GVP-19-09	195.51	Refusal
43GVP-19-10	43GVP-19-10	43GVP-19-10	232.85	Refusal
43J-92-01X	3018162.47	623451.62	361.80	Bedrock confirmed
43M-01-16XBR	3025055.12	628980.91	211.50	Bedrock confirmed
43M-01-17XBR	3024934.85	629073.30	214.00	Bedrock confirmed
43M-01-20XBR	3024830.04	628852.12	193.36	Bedrock confirmed
48-OMR	3020148.74	633218.82	235.91	Bedrock confirmed
5702MW-19-01	3023020.86	632237.00	97.60	Bedrock confirmed
5702MW-20-01	3022574.41	632761.63	107.27	Bedrock confirmed
5702MW-20-03	3022636.00	632530.26	89.70	Bedrock confirmed
5702MW-20-05	3022545.98	632578.79	92.09	Bedrock confirmed
5703MW-20-02A	3022994.58	633213.60	149.46	Bedrock confirmed
5703VP-19-01	3023322.79	633621.49	168.14	Refusal
74PZ-19-10	3023949.00	634140.80	188.03	Refusal

Table 2-1
Bedrock Elevations
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location Name	Northing	Easting	Bedrock Elevation (ft NAVD88)	Notes
74VP-18-01	3024093.50	633760.55	131.85	Refusal
74VP-18-02	3023875.13	634038.49	168.12	Refusal
74VP-18-03	3023897.80	633502.96	123.19	Refusal
74VP-18-04	3024257.72	633990.70	153.48	Refusal
74VP-18-05	3024359.94	633819.70	128.87	Refusal
74VP-18-06	3023940.54	633800.45	142.32	Refusal
74VP-18-08	3024483.67	633723.43	101.44	Refusal
74VP-18-09	3023987.55	634147.17	182.85	Refusal
74VP-18-10	3023801.51	633867.83	176.22	Refusal
74VP-18-11	3024179.62	633266.66	145.19	Refusal
74VP-18-12	3024634.59	633907.92	145.94	Refusal
74VP-18-13	3024450.12	634201.21	159.03	Refusal
74VP-19-03	3024285.56	634403.90	188.96	Refusal
74VP-19-04	3024119.61	634318.93	182.49	Refusal
75MW-19-01BR	3021955.16	628945.47	232.79	Bedrock confirmed
75MW-19-02	3022530.02	630771.18	-49.13	Bedrock confirmed
75MW-19-04	3022030.68	631713.03	135.57	Bedrock confirmed
75VP-19-03	3022507.51	629633.92	203.90	Refusal
75VP-19-04	3022260.89	629582.86	205.23	Refusal
75VP-19-06	3022003.80	629499.80	221.76	Refusal
75VP-19-07	3022255.47	629335.90	231.42	Refusal
75VP-19-08	3022520.54	629274.19	220.89	Refusal
76VP-19-01	3022565.00	626638.00	219.79	Refusal
76VP-19-02	3022441.24	626688.54	221.99	Refusal
76VP-19-03	3022341.00	627036.00	191.17	Refusal
76VP-19-04	3022704.43	626829.69	204.34	Refusal
76VP-19-05	3022590.00	626959.00	184.68	Refusal
76VP-19-06	3022466.41	627204.18	171.91	Refusal
76VP-19-07	3023123.00	626796.00	179.80	Refusal
76VP-19-08	3022734.83	627023.84	189.71	Refusal
76VP-19-09	3022978.06	627177.65	183.56	Refusal
76VP-19-10	3022933.00	627231.00	165.31	Refusal
76VP-19-11	3022635.00	627283.00	149.02	Refusal
76VP-19-12	3022376.81	627495.79	164.05	Refusal
76VP-19-13	3022828.00	627783.00	172.04	Refusal
76VP-19-14	3022424.82	627295.82	174.70	Refusal
76VP-19-15	3022322.00	627305.00	186.85	Refusal
76VP-19-16	3024060.00	627490.00	170.93	Refusal
76VP-19-17	3022897.48	627335.14	158.17	Refusal
76VP-19-18	3023076.01	627324.01	156.99	Refusal
76VP-19-19	3024048.00	627189.00	145.02	Refusal
76VP-19-20	3022218.00	627711.00	168.56	Refusal

Table 2-1
Bedrock Elevations
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location Name	Northing	Easting	Bedrock Elevation (ft NAVD88)	Notes
76VP-19-21	3024032.00	626786.00	181.85	Refusal
76VP-19-22	3025578.00	626606.00	148.80	Refusal
76VP-19-23	3025570.85	627108.29	182.05	Refusal
76VP-19-24	3025486.34	627766.68	130.05	Refusal
76VP-19-25	3026471.00	626845.00	143.31	Refusal
76VP-19-26	3026673.00	627309.00	172.68	Refusal
76VP-19-27	3026356.00	626355.00	179.07	Refusal
76VP-19-28	3026155.00	625292.00	168.20	Refusal
76VP-19-29	3022191.20	628031.25	184.15	Refusal
76VP-19-31	3022548.97	628006.90	212.41	Refusal
76VP-19-32	3023682.00	626097.00	226.50	Refusal
76VP-19-33	3025081.01	625671.43	185.25	Refusal
92-5	3026858.08	633898.88	181.87	Refusal
AAFES-2	3020965.13	626168.53	274.47	Bedrock confirmed
AAFES-3	3021032.38	626005.31	281.95	Bedrock confirmed
AAFES-5	3020999.40	626200.16	269.51	Bedrock confirmed
AAFES-6R	3020910.95	626119.77	271.77	Bedrock confirmed
AAFES-ID	3020929.41	626148.56	274.20	Bedrock confirmed
Ayer Pathfinder	3023629.40	632370.90	93.00	Bedrock confirmed
Br. # H-9-10, C-W Hwy. over Bower's Brook	3015582.91	636278.85	224.34	Bedrock confirmed
Br. # H-9-11, C-W Hwy. under Rte. 110	3015825.60	633936.72	302.30	Bedrock confirmed
Br. # H-9-12, C-W Hwy. under Boxboro Rd.	3015406.21	637995.12	280.96	Bedrock confirmed
Br. # H-9-17, C-W Hwy. over B&M R.R.	3013356.47	627399.96	194.04	Bedrock confirmed
Br. # H-9-18, C-W Hwy. over Depot Street	3014254.21	629402.55	315.89	Bedrock confirmed
CAP-1B	3027165.45	629318.93	236.13	Bedrock confirmed
CAP-2B	3027118.86	629296.39	240.66	Bedrock confirmed
CAP-3	3027047.54	629269.85	245.45	Bedrock confirmed
CAP-4	3027088.57	629284.53	237.73	Bedrock confirmed
CH-1D	3027062.71	629287.99	230.46	Bedrock confirmed
CSM-93-02A	3018164.08	628075.66	132.30	Bedrock confirmed
Deven Pathfinder	3021479.60	629419.20	215.31	Bedrock confirmed
GF-1	3025991.64	634345.89	111.04	Bedrock confirmed
GF-2	3026015.85	634184.51	111.58	Bedrock confirmed
GPMW-19-01	3025551.65	633756.22	99.33	Bedrock confirmed
GPVP-18-01	3026944.26	633523.97	203.44	Refusal
GPVP-18-02	3026775.09	634465.62	189.84	Refusal

Table 2-1
Bedrock Elevations
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location Name	Northing	Easting	Bedrock Elevation (ft NAVD88)	Notes
GPVP-18-03	3026862.72	635021.12	195.67	Refusal
GPVP-18-04	3026424.94	635682.46	204.81	Refusal
GPVP-18-05	3025683.86	634879.86	143.17	Refusal
GPVP-18-06	3025456.71	634491.63	112.71	Refusal
GPVP-18-07	3025504.43	634247.71	134.14	Refusal
GPVP-18-08	3025523.94	634013.75	110.70	Refusal
GPVP-18-10	3025555.89	633458.74	93.66	Refusal
GPVP-18-11	3025633.51	633154.97	109.82	Refusal
GPVP-18-12	3025799.18	632892.79	118.83	Refusal
GPVP-19-02	3025149.35	632760.07	156.09	Refusal
GPVP-19-03	3025088.32	633181.86	111.12	Refusal
GPVP-19-06	3024725.06	632092.00	155.60	Refusal
GPVP-19-10	3025325.41	632104.79	144.91	Refusal
GPVP-19-13	3025637.86	632668.47	130.36	Refusal
GPVP-19-14	3025561.54	632898.81	141.84	Refusal
GPVP-19-15	3025731.59	633095.54	132.58	Refusal
HA-1B	3018026.98	623550.04	346.50	Bedrock confirmed
HA-2B	3018078.41	623648.13	338.60	Bedrock confirmed
HA-3B	3018253.33	623729.29	330.70	Bedrock confirmed
HA-4B	3018170.43	623729.51	332.80	Bedrock confirmed
HA-5S	3018140.12	623478.15	352.10	Bedrock confirmed
LFM-99-01B	3018613.31	624305.81	293.60	Bedrock confirmed
LFM-99-02B	3018229.31	624305.59	329.23	Bedrock confirmed
LFM-99-03B	3019102.62	624498.69	293.78	Bedrock confirmed
LFM-99-04B	3019101.41	624498.82	297.65	Bedrock confirmed
LFM-99-05A	3018947.95	624886.54	287.48	Bedrock confirmed
LFM-99-05B	3018950.88	624874.17	259.98	Bedrock confirmed
LFM-99-06A	3018340.60	624993.40	318.01	Bedrock confirmed
LIDAR1	3025637.95	628118.41	237.48	Bedrock confirmed
LIDAR10	3025734.83	628548.77	313.49	Bedrock confirmed
LIDAR11	3025930.46	628467.01	338.44	Bedrock confirmed
LIDAR12	3026669.19	628423.21	341.14	Bedrock confirmed
LIDAR14	3026287.17	629073.02	279.61	Bedrock confirmed
LIDAR15	3026997.72	628952.41	316.61	Bedrock confirmed
LIDAR16	3027063.38	628837.83	312.56	Bedrock confirmed
LIDAR18	3025939.42	628656.35	330.17	Bedrock confirmed
LIDAR19	3022628.36	628369.57	295.05	Bedrock confirmed
LIDAR2	3026140.69	628069.90	266.46	Bedrock confirmed
LIDAR21	3026912.16	628922.09	328.42	Bedrock confirmed
LIDAR23	3026829.79	628767.76	347.80	Bedrock confirmed
LIDAR24	3026298.85	629280.33	284.22	Bedrock confirmed
LIDAR25	3026293.01	629338.73	281.31	Bedrock confirmed

Table 2-1
Bedrock Elevations
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location Name	Northing	Easting	Bedrock Elevation (ft NAVD88)	Notes
LIDAR26	3024003.36	628102.21	263.54	Bedrock confirmed
LIDAR27	3023940.86	628119.57	260.77	Bedrock confirmed
LIDAR28	3021864.47	629064.01	262.95	Bedrock confirmed
LIDAR29	3024055.45	628036.24	265.52	Bedrock confirmed
LIDAR3	3026278.09	627940.79	245.09	Bedrock confirmed
LIDAR30	3022176.97	628268.87	269.10	Bedrock confirmed
LIDAR31	3022486.00	628459.85	286.74	Bedrock confirmed
LIDAR32	3023956.84	628349.08	260.32	Bedrock confirmed
LIDAR33	3026411.30	628858.46	342.61	Bedrock confirmed
LIDAR34	3026300.30	628847.36	328.42	Bedrock confirmed
LIDAR35	3023568.81	628414.19	261.78	Bedrock confirmed
LIDAR36	3022756.84	628699.43	281.76	Bedrock confirmed
LIDAR4	3026856.07	628426.13	308.11	Bedrock confirmed
LIDAR5	3026666.62	628262.72	312.85	Bedrock confirmed
LIDAR6	3025777.65	628856.88	279.28	Bedrock confirmed
LIDAR9	3026123.17	628218.82	306.62	Bedrock confirmed
MA-HIW_116	3017499.88	636306.43	236.63	Bedrock confirmed
MA-HIW_117	3019017.42	637430.83	216.71	Bedrock confirmed
MA-HIW_122	3021749.68	638705.74	180.59	Bedrock confirmed
N2-P2	3027311.05	630658.72	178.03	Bedrock confirmed
N3-P2	3027130.23	630777.95	192.23	Bedrock confirmed
N4-P1	3026763.55	631241.15	133.10	Bedrock confirmed
N5-P2	3027173.21	629805.75	151.89	Bedrock confirmed
N6-P1	3026338.61	630017.06	176.78	Bedrock confirmed
N7-P2	3025618.25	629990.92	193.51	Bedrock confirmed
PWPZ-19-04-F1	3016816.68	629767.37	251.17	Refusal
PWPZ-19-04-F2	3016928.42	629238.35	219.67	Refusal
PWVP-19-01	3020032.16	626701.74	236.29	Refusal
PWVP-19-03	3019038.18	627604.00	182.96	Refusal
PWVP-19-05	3018548.45	626877.05	192.95	Refusal
PWVP-19-06	3018991.14	629350.01	159.03	Refusal
PWVP-19-07	3017800.39	629411.02	191.19	Refusal
PWVP-19-08	3019328.79	626466.48	237.88	Refusal
PWVP-19-09	3019177.00	628836.70	169.76	Refusal
PWVP-19-10	3019425.00	629733.70	164.06	Refusal
PWVP-19-11	3019103.36	630177.38	202.70	Refusal
PWVP-19-12	3018441.00	630045.00	229.11	Refusal
PWVP-20-01	3017383.20	627584.88	173.94	Refusal
PZ-12-09	3026801.42	630740.93	208.26	Bedrock confirmed
Q4-1	3027091.94	629194.72	266.20	Bedrock confirmed
Q4-2	3027060.36	629172.56	262.55	Bedrock confirmed
Q5-1	3027166.14	629228.23	259.32	Bedrock confirmed

Table 2-1
Bedrock Elevations
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location Name	Northing	Easting	Bedrock Elevation (ft NAVD88)	Notes
SAJ08	3017990.09	623616.53	338.49	Refusal
SAJ09	3018096.19	623685.27	355.02	Refusal
SEA-1/SHL-1	3026531.80	629259.23	245.28	Bedrock confirmed
SHB-99-30X	3026397.00	629701.20	228.30	Bedrock confirmed
SHL-10	3026867.70	630877.27	207.58	Bedrock confirmed
SHL-11	3027316.40	630495.92	193.97	Bedrock confirmed
SHL-14A	3026748.58	629288.95	256.20	Bedrock confirmed
SHL-20	3027329.59	630463.33	186.69	Bedrock confirmed
SHL-24	3025638.53	631302.97	122.20	Bedrock confirmed
SHM-10-07	3026889.79	630301.42	196.76	Bedrock confirmed
SHM-10-11	3025971.51	629990.62	199.86	Bedrock confirmed
SHM-10-12	3026718.54	629717.49	182.52	Bedrock confirmed
SHM-10-13	3027156.89	629906.12	157.41	Bedrock confirmed
SHM-10-15	3027101.42	629680.93	181.91	Bedrock confirmed
SHM-11-02	3027075.65	630457.81	194.63	Bedrock confirmed
SHM-11-03	3026892.95	630622.47	211.38	Bedrock confirmed
SHM-11-04	3027252.60	630473.96	197.13	Bedrock confirmed
SHM-11-05	3026979.39	630573.68	204.65	Bedrock confirmed
SHM-11-07	3027132.51	630414.59	192.19	Bedrock confirmed
SHM-11-08	3026970.62	630486.79	199.48	Bedrock confirmed
SHM-12-01	3026755.83	630771.77	213.28	Bedrock confirmed
SHM-12-02	3027066.64	630443.83	174.82	Bedrock confirmed
SHM-12-04	3027168.22	630452.46	191.11	Bedrock confirmed
SHM-12-06	3027082.93	630468.55	194.66	Bedrock confirmed
SHM-93-01A	3026711.96	630676.98	214.10	Bedrock confirmed
SHM-93-10C	3026846.23	630886.09	209.30	Bedrock confirmed
SHM-93-18B	3026453.24	631180.16	141.79	Bedrock confirmed
SHP-2016-07	3026881.95	629219.76	254.98	Bedrock confirmed
SHP-99-01C	3026540.97	629215.98	262.36	Bedrock confirmed
SHP-99-29X	3027143.35	629539.09	203.88	Bedrock confirmed
SHP-99-35X	3026547.20	629722.70	220.69	Bedrock confirmed
SWMW-20-01A	3017855.05	623813.13	338.96	Bedrock confirmed
SWPZ-19-02	3017684.34	625630.18	255.58	Refusal
SWPZ-19-02-F1	3017684.34	625630.18	255.58	Refusal
SWVP-19-01	3015815.08	625598.71	155.64	Refusal
SWVP-19-03	3014012.64	626152.94	185.50	Refusal
SWVP-19-04	3014479.30	625367.56	151.56	Refusal
SWVP-19-06	3015553.23	623974.74	194.20	Refusal
SWVP-20-01	3016220.83	624504.24	266.65	Refusal
SWVP-20-03	3017049.30	623460.84	309.80	Refusal
SWVP-20-04	3016909.50	625457.38	172.20	Refusal
XGB-93-04X	3020838.60	625538.97	283.54	Bedrock confirmed

Table 2-1
Bedrock Elevations
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location Name	Northing	Easting	Bedrock Elevation (ft NAVD88)	Notes
XGB-93-05X	3020787.70	625494.76	281.00	Bedrock confirmed
XGB-93-06X	3020742.78	625510.90	282.45	Bedrock confirmed
XGB-93-07X	3020785.78	625541.21	288.53	Bedrock confirmed
XGB-93-08X	3021041.37	625745.09	280.34	Bedrock confirmed
XGB-93-09X	3020945.01	625,648.166	277.50	Bedrock confirmed
XGB-94-10X	3020982.03	626105.93	281.20	Bedrock confirmed
XGB-94-11X	3020998.24	626103.88	280.91	Bedrock confirmed
XGB-94-12X	3020989.51	626109.49	278.60	Bedrock confirmed
XGB-94-13X	3020973.25	626113.27	279.25	Bedrock confirmed
XGB-94-14X	3020965.34	626009.38	281.10	Bedrock confirmed
XGB-94-15X	3021012.01	626000.61	280.00	Bedrock confirmed
XGM-20-01A	3021077.41	626682.57	242.91	Bedrock confirmed
XGM-20-02A	3021013.90	626578.52	254.36	Bedrock confirmed
XGM-20-03A	3020862.35	626603.92	243.88	Bedrock confirmed
XGM-93-01X	3020993.26	625846.17	280.75	Bedrock confirmed
XGM-93-02X	3020956.87	626109.44	274.90	Bedrock confirmed
XGM-94-03X	3020946.00	626168.33	272.40	Bedrock confirmed
XGM-94-04X	3020880.04	626072.55	280.30	Bedrock confirmed
XGM-94-05X	3021000.89	626277.72	271.50	Bedrock confirmed
XGM-94-06X	3020773.57	626429.96	254.40	Bedrock confirmed
XGM-94-07X	3020925.63	626257.94	271.70	Bedrock confirmed
XGM-94-08X	3020799.50	626239.62	269.40	Bedrock confirmed
XGM-94-09X	3020819.91	626001.97	277.10	Bedrock confirmed
XGM-94-10X	3020730.49	626132.59	269.00	Bedrock confirmed
XGM-97-12X	3020989.42	626086.01	279.26	Bedrock confirmed
XGP-94-01X	3020846.68	626040.75	274.90	Bedrock confirmed
XGP-94-02X	3020768.42	626434.35	253.90	Bedrock confirmed
XGP-94-05X	3020869.14	626065.06	282.00	Bedrock confirmed
XGP-94-06X	3020852.70	626079.34	276.50	Bedrock confirmed
XGP-94-07X	3020867.18	626100.74	277.80	Bedrock confirmed
XJB-94-03X / SAJ02	3018130.28	623514.40	351.12	Bedrock confirmed
XJB-94-04X	3018202.56	623516.36	346.97	Bedrock confirmed
XJB-94-05X	3018188.62	623499.66	351.31	Bedrock confirmed
XJB-94-06X	3018176.42	623486.34	351.39	Bedrock confirmed
XJB-94-07X	3018221.36	623542.94	348.19	Bedrock confirmed
XJB-94-08X	3018153.80	623479.82	355.85	Bedrock confirmed
XJB-94-09X	3018180.58	623552.12	348.07	Bedrock confirmed
XJB-94-10X	3018130.37	623548.48	346.47	Bedrock confirmed
XJB-94-11X	3018103.90	623511.42	349.13	Bedrock confirmed
XJB-94-12X	3018061.35	623457.25	352.20	Bedrock confirmed
XJB-94-13X	3018027.38	623482.80	347.78	Bedrock confirmed
XJB-94-15X	3017980.93	623544.51	343.77	Bedrock confirmed

Table 2-1
Bedrock Elevations
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location Name	Northing	Easting	Bedrock Elevation (ft NAVD88)	Notes
XJM-93-01X	3018256.15	623416.31	355.30	Bedrock confirmed
XJM-93-04X	3018150.54	623399.70	367.20	Bedrock confirmed
XJM-94-05X	3018126.42	623509.51	352.00	Bedrock confirmed
XJM-94-06X	3018168.62	623646.69	351.10	Bedrock confirmed
XJM-94-07X	3018055.81	623743.83	352.40	Bedrock confirmed
XJM-94-09X	3018066.02	623414.43	346.20	Bedrock confirmed
XJM-94-10X	3017979.67	623640.39	345.70	Bedrock confirmed
XJM-97-11X	3017992.65	623378.02	347.00	Bedrock confirmed
XJM-97-12X	3018120.60	623496.13	352.00	Bedrock confirmed
XJM-97-13X	3017979.53	623640.48	328.30	Bedrock confirmed

ft NAVD88 = feet North America Vertical Datum 1988

Table 2-2
Synoptic Water Level Event Grove Pond Area, October 2, 2018
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location ID	Measuring Point Elevation (ft NAVD88)	Measurement Date	Depth to Water from MPE (ft)	Groundwater Elevation (ft NAVD88)	Notes
92-1	223.35	10/2/2018	8.95	214.4	
92-2	NA	NA	NA	NA	Well is bent, unable to get accurate reading
92-3	219.39	10/2/2018	8.4	210.99	
92-4	254.56	10/2/2018	40.11	214.45	
92-5	NA	NA	NA	NA	Well is blocked with equipment, unable to get a reading
CSMS-11-01	253.6	10/2/2018	37.53	216.07	
CSMS-11-02	252.04	10/2/2018	36.99	215.05	
GF-1	223.65	10/2/2018	9.57	214.08	
GF-2	223.27	10/2/2018	9.1	214.17	
GF-3A	220.67	10/2/2018	6.1	214.57	
GF-3B	220.63	10/2/2018	4.56	216.07	
GF-4	225.93	10/2/2018	13.43	212.5	
MNG-2R	236.08	10/2/2018	19.18	216.9	
MNG-3R	254.36	10/2/2018	39.32	215.04	
MNG-5R	235.91	10/2/2018	16.7	219.21	
MNG-6R	252.39	10/2/2018	35.7	216.69	

MPE = Measuring Point Elevation
NAVD88 = North America Vertical Datum 1988

Table 2-3
Synoptic Water Level Event AOC 74/Grove Pond Area March 19, 2019
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location ID	Measuring Point Elevation (ft NAVD88)	Measurement Date	Depth to Water from MPE (ft)	Groundwater Elevation (ft NAVD88)
CSMS-11-01	253.60	03/19/2019	37.55	216.05
CSMS-11-02	252.04	03/19/2019	37.13	214.91
MNG-2R	236.08	03/19/2019	18.92	217.16
MNG-3R	254.36	03/19/2019	39.42	214.94
MNG-5R	235.91	03/19/2019	16.46	219.45
MNG-6R	252.39	03/19/2019	35.62	216.77
74PZ-19-01	244.37	03/19/2019	20.72	223.65
74PZ-19-02	244.41	03/19/2019	17.90	226.51
74PZ-19-03	246.48	03/19/2019	20.30	226.18
74PZ-19-04	225.13	03/19/2019	4.32	220.81
74PZ-19-05	242.69	03/19/2019	17.90	224.79
74PZ-19-06	249.10	03/19/2019	25.90	223.20
74PZ-19-07	248.40	03/19/2019	27.30	221.10
74PZ-19-08	248.89	03/19/2019	28.55	220.34
74PZ-19-09	237.42	03/19/2019	17.10	220.32

MPE = Measuring Point Elevation

NAVD88 = North America Vertical Datum 1988

Table 2-4
Synoptic Water Level Event Patton Well Area/AOC 40, January 2-3, 2020
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location ID	Measuring Point Elevation (ft NAVD88)	Measurement Date	Depth to Water from MPE (ft)	Groundwater Elevation (ft NAVD88)
43GPZ-19-03	307.99	01/2/2020	21.98	286.01
43GPZ-19-02	290.09	01/2/2020	26.99	263.10
43GPZ-19-01	280.67	01/2/2020	17.55	263.12
43GPZ-19-04	256.75	01/2/2020	6.98	249.77
43GPZ-19-05	254.82	01/2/2020	7.25	247.57
43GPZ-19-06	254.86	01/2/2020	9.07	245.79
43GPZ-19-07	246.59	01/2/2020	1.40	245.19
43GPZ-19-08	257.69	01/2/2020	10.99	246.70
AAFES-2	301.72	01/2/2020	21.65	280.07
AAFES-5	299.80	01/2/2020	21.51	278.29
AAFES-6R	298.74	01/2/2020	17.58	281.16
XGM-93-02X	309.01	01/2/2020	27.30	281.71
XGM-94-04X	300.69	01/2/2020	18.36	282.33
XGM-94-06X	284.07	01/2/2020	18.35	265.72
XGM-94-07X	294.82	01/2/2020	19.17	275.65
XGM-94-08X	298.98	01/2/2020	24.20	274.78
XGM-94-10X	301.96	01/2/2020	23.09	278.87
XGM-97-12X	308.7	01/2/2020	24.17	284.53
AAFES-7	257.77	01/2/2020	7.20	250.57
76PZ-19-18	248.01	01/2/2020	4.19	243.82
76PZ-19-04	249.14	01/2/2020	5.80	243.34
76PZ-19-15	245.83	01/2/2020	2.39	243.44
76PZ-19-03	256.74	01/2/2020	11.98	244.76
76PZ-19-05	262.10	01/2/2020	19.48	242.62
76PZ-19-01	264.51	01/2/2020	20.76	243.75
PWPZ-19-01	304.94	01/3/2020	61.96	242.98
PWPZ-19-02	251.52	01/3/2020	14.31	237.21
PWPZ-19-03	256.02	01/3/2020	12.40	243.62
PWPZ-19-04	288.00	01/3/2020	40.64	247.36
PWPZ-19-05	312.43	01/3/2020	68.81	243.62
PWPZ-19-06	266.22	01/3/2020	22.87	243.35
PWPZ-19-07	260.29	01/3/2020	12.69	247.60
PWPZ-19-08	256.53	01/3/2020	13.10	243.43
PWPZ-19-09	253.09	01/3/2020	9.80	243.29
PWPZ-19-10	288.42	01/3/2020	44.87	243.55
CPSG-01	247.28	01/3/2020	3.675	243.61
CPSG-02	244.09	01/3/2020	1.92	242.17
CSBSG-01	236.80	01/3/2020	2.97	233.83
RPSG-01	247.10	01/2/2020	2.20	244.90

MPE = Measuring Point Elevation

NAVD88 = North America Vertical Datum 1988

The Patton water supply well was not operating in January

Table 2-5
Synoptic Water Level Event Area 1, March 12-13, 2020
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location ID	Measuring Point Elevation (ft NAVD88)	Measurement Date	Depth to Water from MPE (ft)	Groundwater Elevation (ft NAVD88)	Depth to Top of Screen (ft bgs)	Depth to Bottom of Screen (ft bgs)
1C	251.22	03/13/2020	6.92	244.3	49	54
1D-D	247.72	03/13/2020	2.52	245.2	49	54
1D-S	247.63	03/13/2020	2.44	245.19	10	13
1E-D	248.05	03/13/2020	5.89	242.16	63	68
1E-S	248.01	03/13/2020	5.32	242.69	5	8
1F-D	262.77	03/13/2020	9.57	253.2	27	32
1F-S	263.39	03/13/2020	6.78	256.61	7	12
43GPZ-19-01	280.67	03/13/2020	18.64	262.03	9.83	19.83
43GPZ-19-02	290.09	03/13/2020	27.86	262.23	19.33	29.33
43GPZ-19-03	307.99	03/13/2020	22.67	285.32	15	25
43GPZ-19-04	256.75	03/13/2020	7.28	249.47	2	12
43GPZ-19-05	254.82	03/13/2020	7.64	247.18	6	16
43GPZ-19-06	254.86	03/13/2020	9.1	245.76	10	20
43GPZ-19-07	246.59	03/12/2020	1.4	245.19	3	13
43GPZ-19-07	246.59	03/13/2020	1.19	245.4	3	13
43GPZ-19-08	257.69	03/13/2020	11.41	246.28	13	23
5702MW-19-01A	247.37	03/12/2020	23.55	223.82	20	30
5702MW-19-01B	247.6	03/12/2020	23.76	223.84	40	50
5702MW-20-01A	222.23	03/12/2020	2.82	219.41	30	40
5702MW-20-01B	222.27	03/12/2020	1.82	220.45	70	80
5702MW-20-02A	244.32	03/12/2020	21.7	222.62	30	40
5702MW-20-03A	237.7	03/12/2020	16.96	220.74	26	36
5702MW-20-04A	235.62	03/12/2020	14.41	221.21	70	80
5702MW-20-05A	226.09	03/12/2020	6.22	219.87	30	40
5702MW-20-05B	226.07	03/12/2020	4.87	221.2	70	80
5702MW-20-06A	236.52	03/12/2020	15.21	221.31	70	80
5702MW-20-07A	221.71	03/12/2020	2.48	219.23	30	40
5703MW-20-01A	228.18	03/12/2020	7.33	220.85	2	12
5703MW-20-01B	228.1	03/12/2020	7.62	220.48	50	60
5703MW-20-02A	235.75	03/12/2020	13.44	222.31	10	20
5703MW-20-03A	225.8	03/12/2020	5.08	220.72	50	60
5703MW-20-04A	231.74	03/12/2020	10.65	221.09	60	70
5703PZ-19-01	222.93	03/12/2020	3.08	219.85	62.5	67.5
57M-03-01X	235.73	03/12/2020	14.37	221.36	10	20
57M-03-02X	224.84	03/12/2020	5.05	219.79	2	12
57M-03-03X	220	03/12/2020	0.88	219.12	2	12
57M-03-04X	221.39	03/12/2020	2.29	219.1	2	12
57M-03-05X	221.88	03/12/2020	2.62	219.26	2	12
57M-03-06X	221.87	03/12/2020	2.76	219.11	2	12
57M-95-03X	232.79	03/12/2020	10.74	222.05	7	17
57M-95-05X	235.15	03/12/2020	14.77	220.38	10	20
57M-95-06X	234.39	03/12/2020	12.77	221.62	11.87	21.87
57M-95-07X	222.36	03/12/2020	2.62	219.74	3	13
57M-96-11X	222.2	03/12/2020	2.68	219.52	2	12
57M-96-12X	225.8	03/12/2020	4.8	221	2	12
57M-96-13X	225.58	03/12/2020	4.55	221.03	2	12
57P-98-03X	220.39	03/12/2020	2.28	218.11	2.5	5.5
57P-98-04X	221.75	03/12/2020	3.58	218.17	2	5
57WP-06-02	220.29	03/12/2020	1.13	219.16	18.92	23.92
57WP-06-03	220.51	03/12/2020	0.76	219.75	13.85	18.85
74MW-19-04A	225.48	03/12/2020	4.81	220.67	18	28
74PZ-19-01	244.37	03/12/2020	21.52	222.85	16	26
74PZ-19-02	244.41	03/12/2020	19.23	225.18	18	28
74PZ-19-03	246.48	03/12/2020	21.62	224.86	26	36

Table 2-5
Synoptic Water Level Event Area 1, March 12-13, 2020
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location ID	Measuring Point Elevation (ft NAVD88)	Measurement Date	Depth to Water from MPE (ft)	Groundwater Elevation (ft NAVD88)	Depth to Top of Screen (ft bgs)	Depth to Bottom of Screen (ft bgs)
74PZ-19-04	225.13	03/12/2020	4.81	220.32	6	16
74PZ-19-05	242.69	03/12/2020	19.21	223.48	20	30
74PZ-19-06	249.1	03/12/2020	26.77	222.33	32	42
74PZ-19-07	248.4	03/12/2020	27.67	220.73	30	40
74PZ-19-08	248.89	03/12/2020	28.81	220.08	25	35
74PZ-19-09	237.42	03/12/2020	18.02	219.4	18	28
74PZ-19-10	226.03	03/12/2020	7.04	218.99	36	38
74PZ-20-01	238.62	03/12/2020	18.41	220.21	17.5	27.5
74PZ-20-02	240.92	03/12/2020	16.71	224.21	20.5	30.5
74PZ-20-03	243.04	03/12/2020	21.57	221.47	16.2	26.2
74PZ-20-04	243.73	03/12/2020	19.57	224.16	18.5	28.5
74PZ-20-05	237.64	03/12/2020	14.62	223.02	13.5	23.5
75MW-19-01BR	258.79	03/12/2020	23.85	234.94	35	45
75MW-19-02A	250.08	03/12/2020	19.7	230.38	37.5	47.5
75MW-19-02B	250.47	03/12/2020	20.2	230.27	70	80
75MW-19-02BR	250.78	03/12/2020	21.35	229.43	308	318
75MW-19-02C	250.64	03/12/2020	21.22	229.42	210	220
75MW-19-04A	230.51	03/12/2020	5.4	225.11	20	30
75MW-19-04B	230.57	03/12/2020	5.56	225.01	50	60
75PZ-19-01	230.47	03/12/2020	5.55	224.92	0.8	10.8
75PZ-19-02	247.94	03/12/2020	16.05	231.89	15.2	25.2
75PZ-19-03	240.39	03/12/2020	8.8	231.59	8.2	18.2
75PZ-19-04	249.7	03/12/2020	15.55	234.15	24.6	34.6
75PZ-20-01	236.21	03/12/2020	10.94	225.27	11.5	21.5
75PZ-20-02	245.44	03/12/2020	16.05	229.39	14.25	24.25
75PZ-20-03	245.82	03/12/2020	15.93	229.89	13	23
75PZ-20-04	246.17	03/12/2020	15.22	230.95	14	24
75PZ-20-05	243.2	03/12/2020	10.5	232.7	10	20
75PZ-20-06	249.11	03/12/2020	17.9	231.21	16	26
75PZ-20-07	228.63	03/12/2020	4.1	224.53	1	11
76PZ-19-01	264.51	03/13/2020	21.1	243.41	21.5	31.5
76PZ-19-03	256.74	03/13/2020	12.3	244.44	15	25
76PZ-19-04	249.14	03/13/2020	6.02	243.12	5	15
76PZ-19-05	262.1	03/13/2020	19.78	242.32	13	23
76PZ-19-15	245.83	03/13/2020	2.54	243.29	4	14
76PZ-19-18	248.01	03/12/2020	4.53	243.48	6	16
76PZ-19-18	248.01	03/13/2020	4.44	243.57	6	16
92-1	223.35	03/12/2020	8.57	214.78	49	55
92-3	219.39	03/12/2020	4.87	214.52	49	55
92-4	254.56	03/12/2020	39.74	214.82	67	71
AAFES-5	299.8	03/13/2020	21.07	278.73	15.5	30.5
AAFES-7	258.8	03/13/2020	8.03	250.77	4.5	14.5
CSMS-11-01	253.6	03/12/2020	37.34	216.26	30	40
CSMS-11-02	252.04	03/12/2020	36.65	215.39	30	40
GF-1	223.65	03/12/2020	9.13	214.52	116	121
GF-2	223.27	03/12/2020	8.54	214.73	114	121
GF-3A	220.67	03/12/2020	5.07	215.6	97	102
GF-3B	220.63	03/12/2020	4.51	216.12	8	13
GF-4	225.93	03/12/2020	12.44	213.49	79	84
GPMW-19-01A	253.93	03/12/2020	37.58	216.35	45	55
GPMW-19-01BR	253.75	03/12/2020	37.65	216.1	175	185
GPPZ-19-01	253.63	03/12/2020	37.64	215.99	105	110
HA-3B	362.9	03/13/2020	6.05	356.85	36	44
HA-3S	362.8	03/13/2020	8.35	354.45	4	17

Table 2-5
Synoptic Water Level Event Area 1, March 12-13, 2020
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location ID	Measuring Point Elevation (ft NAVD88)	Measurement Date	Depth to Water from MPE (ft)	Groundwater Elevation (ft NAVD88)	Depth to Top of Screen (ft bgs)	Depth to Bottom of Screen (ft bgs)
HA-4B	365.3	03/13/2020	6	359.3	35.8	43.8
HA-4S	365.5	03/13/2020	7.8	357.7	4	17
LFM-99-02B	353.83	03/13/2020	17.28	336.55	14.5	23.8
LFM-99-05A	316.58	03/13/2020	21.95	294.63	19	28.3
LFM-99-05B	316.58	03/13/2020	19.12	297.46	51.5	55.8
LFM-99-06ARP	337.84	03/13/2020	14.87	322.97	10.09	19.39
MNG-2R	236.08	03/12/2020	19.1	216.98	14	24
MNG-3R	254.36	03/12/2020	38.94	215.42	55	65
MNG-5R	235.91	03/12/2020	16.79	219.12	10	20
MNG-6R	252.39	03/12/2020	35.67	216.72	30	40
MW75-UNKNOWN	233.47	03/12/2020	6.45	227.02	5	15
PWPZ-19-01	304.94	03/13/2020	61.73	243.21	60	70
PWPZ-19-02	251.52	03/13/2020	14.34	237.18	12	22
PWPZ-19-03	256.02	03/13/2020	13.27	242.75	13	23
PWPZ-19-04	288	03/13/2020	39.24	248.76	36.2	46.2
PWPZ-19-05	312.43	03/13/2020	68.23	244.2	70	80
PWPZ-19-07	260.29	03/13/2020	13.29	247	16	25.9
PWPZ-19-08	256.53	03/13/2020	13.78	242.75	9.3	19.3
PWPZ-19-09	253.09	03/13/2020	9.37	243.72	5.6	15.6
PWPZ-19-10	288.42	03/13/2020	44.57	243.85	43.5	53.5
PWPZ-20-01	299.82	03/13/2020	56.79	243.03	58	68
PTW-A	253.54	03/13/2020	10.12	243.42	57	62
PTW-B	253.36	03/13/2020	10.88	242.48	64	69
XGM-20-01A	257.5	03/13/2020	7.49	250.01	10.5	20.5
XGM-20-02A	265.1	03/13/2020	12.41	252.69	13	23
XGM-20-03A	268.69	03/13/2020	14.8	253.89	20	30
XGM-94-04X	300.69	03/13/2020	19.63	281.06	18.2	28.2
XGM-94-06X	284.07	03/13/2020	20.29	263.78	17	27
XGM-94-10X	301.96	03/13/2020	24.56	277.4	21.5	31.5
XJM-93-01X	370.6	03/13/2020	6.18	364.42	6.5	16.5
XJM-93-04X	370.37	03/13/2020	6.3	364.07	4.5	14.5
XJM-94-07X	364.24	03/13/2020	7.1	357.14	3.7	13.7
XJM-94-08X	368.5	03/13/2020	9.78	358.72	7.6	17.6
XJM-94-10X	370.6	03/13/2020	8.98	361.62	7.8	17.8
XJM-97-11X	370.7	03/13/2020	8.85	361.85	25.5	35.5
XJM-97-13X	368.5	03/13/2020	8.82	359.68	41.5	51.5
CPSG-01	247.28	03/13/2020	3.02	244.26	NA	NA
CPSG-02	244.09	03/13/2020	0.4	243.69	NA	NA
CSBSG-01	236.8	03/13/2020	1.42	235.38	NA	NA
RPSG-01	247.1	03/13/2020	2	245.1	NA	NA
SG-01	220.72	03/12/2020	2.63	218.09	NA	NA
SG-02	220.65	03/12/2020	2.58	218.07	NA	NA
MW-9D	246.35	03/13/2020	12.68	233.67	71	81
MW-A	249.1	03/13/2020	18.35	230.75	30	40
MW-B	262.98	03/13/2020	31.50	231.48	72	82
MW-C	262.91	03/13/2020	31.45	231.46	87	97
MW-D	244.01	03/13/2020	13.22	230.79	60	70
MW-E	243.76	03/13/2020	12.98	230.78	62	72
MW-F	245.46	03/13/2020	14.78	230.68	22	32
MW-G	250.64	03/13/2020	16.86	233.78	79	84
MW-H	243.91	03/13/2020	11.92	231.99	24	34
MW-I	245.91	03/13/2020	15.43	230.48	9	19
MW-J	245.34	03/13/2020	11.53	233.81	40	50
MW-K	245.41	03/13/2020	11.60	233.81	40	50

Table 2-5
Synoptic Water Level Event Area 1, March 12-13, 2020
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location ID	Measuring Point Elevation (ft NAVD88)	Measurement Date	Depth to Water from MPE (ft)	Groundwater Elevation (ft NAVD88)	Depth to Top of Screen (ft bgs)	Depth to Bottom of Screen (ft bgs)
SWMW-20-01A	362.55	03/13/2020	5.13	357.42	5	15
SWPZ-19-01	250.62	03/13/2020	20.63	229.99	16.5	26.5
SWPZ-19-03	245.26	03/13/2020	4.04	241.22	3	13
SWPZ-19-04	240.63	03/13/2020	8.39	232.24	4	14
SWPZ-20-01	333.38	03/13/2020	4.19	329.19	10	20
SWPZ-20-02	267.19	03/13/2020	24.79	242.4	23	33

bgs = below ground surface

MPE = Measuring Point Elevation

NAVD88 = North America Vertical Datum 1988

The Patton water supply well was operating at the time of synoptic water level survey.

Table 2-6
Vertical Groundwater Gradients
Water Level Gauging Event - 3/12/2020 and 3/13/2020*
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location ID	Location	Screen Interval	Bottom of Screen Interval	Top of Screen Interval	Mid-Point of Screen	Difference Between Mid-Screen	Groudwater Elevation	Difference GW Elevation	Downward Gradient	Upward Gradient
		(ft bgs)	(ft NAVD88)	(ft NAVD88)	(ft NAVD88)	(ft)	(ft NAVD88)	(ft)	(unitless)	(unitless)
AOC 57 - Area 2										
AOC 57 - Area 2 - Well Pair 1										
5702MW-19-01A	Shallow Well	20-30	217.72	227.72	222.72	19.89	223.82	0.02	--	-0.0010
5702MW-19-01B	Deep Well	40-50	197.86	207.86	202.83		223.84			
AOC 57 - Area 2 - Well Pair 2										
57M-03-01X	Shallow Well	10-20	214.44	224.44	219.44	60.34	221.36	0.05	+0.0008	--
5702MW-20-06A	Deep Well	70-80	154.10	164.10	159.10		221.31			
AOC 57 - Area 2 - Well Pair 3										
57M-95-06X	Shallow Well	11.87-21.87	210.76	220.76	215.76	58.07	221.62	0.41	+0.0071	--
5702MW-20-04A	Deep Well	70-80	152.69	162.69	157.69		221.21			
AOC 57 - Area 2 - Well Pair 4										
5702MW-20-05A	Mid-Depth Well	30-40	183.25	193.25	188.25	39.96	219.87	1.33	--	-0.0333
5702MW-20-05B	Deep Well	70-80	143.29	153.29	148.29		221.20			
AOC 57 - Area 2 - Well Triplet 1										
57M-03-05X	Shallow Well	2-12	207.58	217.58	212.58		219.26			
5702MW-20-01A	Mid-Depth Well	30-40	179.59	189.59	184.59		219.41			
5702MW-20-01B	Deep Well	70-80	139.69	149.69	144.69		220.45			
	57M-03-05X Shallow					67.89		1.19	--	-0.0175
	5702MW-20-01B Deep									
	57M-03-05X Shallow					27.99		0.15	--	-0.0054
	5702MW-20-01A Mid-Depth									
	5702MW-20-01A Mid-Depth					39.90		1.04	--	-0.0261
	5702MW-20-01B Deep									
AOC 57 - Area 2 - Well Triplet 2										
57M-03-03X	Shallow Well	2-12	206.98	216.98	211.98		219.12			
57WP-06-02	Mid-Depth Well	18.92-23.92	195.25	200.25	197.75		219.16			
5702MW-20-07A	Deep Well	30-40	179.42	189.42	184.42		219.23			
	57M-03-03X Shallow					27.56		0.11	--	-0.0040
	5702MW-20-07A Deep									
	57M-03-03X Shallow					14.23		0.04	--	-0.0028
	57WP-06-02 Mid-Depth									
	57WP-06-02 Mid-Depth					13.33		0.07	--	-0.0053
	5702MW-20-07A Deep									

Table 2-6
Vertical Groundwater Gradients
Water Level Gauging Event - 3/12/2020 and 3/13/2020*
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location ID	Location	Screen Interval	Bottom of Screen Interval	Top of Screen Interval	Mid-Point of Screen	Difference Between Mid-Screen	Groudwater Elevation	Difference GW Elevation	Downward Gradient	Upward Gradient
		(ft bgs)	(ft NAVD88)	(ft NAVD88)	(ft NAVD88)	(ft)	(ft NAVD88)	(ft)	(unitless)	(unitless)
AOC 57 - Area 3										
AOC 57 - Area 3 - Well Pair 1										
57M-95-03X	Shallow Well	7-17	213.80	223.80	218.80	53.59	222.05	0.96	+0.0179	--
5703MW-20-04A	Deep Well	60-70	159.21	169.21	165.21		221.09			
AOC 57 - Area 3 - Well Pair 2										
57M-96-12X	Shallow Well	2-12	210.78	220.78	215.78	47.83	221.00	0.28	+0.0059	--
5703MW-20-03A	Deep Well	50-60	162.95	172.95	167.95		220.72			
AOC 57 - Area 3 - Well Pair 3										
5703MW-20-01A	Shallow Well	2-12	213.24	223.24	218.24	48.12	220.85	0.37	+0.0077	--
5703MW-20-01B	Deep Well	50-60	165.12	175.12	170.12		220.48			
AOC 57 - Area 3 - Well Triplet 1										
57M-96-11X	Shallow Well	2-12	208.04	218.04	213.04		219.52			
57WP-06-03	Mid-Depth Well	13.85-18.85	200.46	205.46	202.96		219.75			
5703PZ-19-01	Deep Well	62.5-67.5	152.66	157.66	155.16		219.85			
	57M-96-11X Shallow					57.88		0.33	--	-0.0057
	5703PZ-19-01 Deep									
	57M-96-11X Shallow					10.08		0.23	--	-0.0228
	57WP-06-03 Mid-Depth									
	57WP-06-03 Mid-Depth					47.80		0.10	--	-0.0021
	5703PZ-19-01 Deep									
Grove Pond Area										
Grove Pond Area Well Triplet 1										
GPMW-19-01A	Shallow Well	45-55	196.09	206.09	201.09		216.35			
GPPZ-19-01	Deep Piezometer	105-110	140.72	145.72	143.22		215.99			
GPMW-19-01BR	Bedrock Well	175-185	65.83	75.83	70.83		216.10			
	GPMW-19-01A Shallow					57.87		0.36	+0.0062	--
	GPPZ-19-01 Deep Piezometer									
	GPMW-19-01A Shallow					130.26		0.25	+0.0019	--
	GPMW-19-01BR Bedrock									
	GPPZ-19-01 Deep Piezometer					72.39		0.11	--	-0.0015
	GPMW-19-01BR Bedrock									

Table 2-6
Vertical Groundwater Gradients
Water Level Gauging Event - 3/12/2020 and 3/13/2020*
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location ID	Location	Screen Interval	Bottom of Screen Interval	Top of Screen Interval	Mid-Point of Screen	Difference Between Mid-Screen	Groudwater Elevation	Difference GW Elevation	Downward Gradient	Upward Gradient
		(ft bgs)	(ft NAVD88)	(ft NAVD88)	(ft NAVD88)	(ft)	(ft NAVD88)	(ft)	(unitless)	(unitless)
AOC 75										
AOC 75 Well Quadruplet 1										
75MW-19-02A	Shallow Well	37.5-47.5	200.26	210.26	205.26		230.38			
75MW-19-02B	Mid-Depth Well	70-80	167.86	177.86	172.86		230.27			
75MW-19-02C	Deep Well	210-220	28.01	38.01	35.01		229.42			
75MW-19-02BR	Bedrock Well	308-318	-70.13	-60.13	-65.13		229.43			
	75MW-19-01A Shallow					270.39		0.95	+0.0035	--
	75MW-19-02BR Bedrock									
	75MW-19-01A Shallow					170.25		0.96	+0.0056	--
	75MW-19-02C Deep									
	75MW-19-01A Shallow					32.40		0.11	+0.0034	--
	75MW-19-02B Mid-Depth									
	75MW-19-02B Mid-Depth					137.85		0.85	+0.0062	--
	75MW-19-02C Deep									
	75MW-19-02B Mid-Depth					237.99		0.84	+0.0035	--
	75MW-19-02BR Bedrock									
	75MW-19-02C Deep					100.14		0.01	--	-0.0001
	75MW-19-02BR Bedrock									
AOC 75 Well Triplet 1										
75PZ-19-01	Shallow Piezometer	0.8-10.8	216.83	226.83	221.83		224.92			
75MW-19-04A	Mid-Depth Well	20-30	198.06	208.06	203.06		225.11			
75MW-19-04B	Deep Well	50-60	167.99	177.99	172.99		225.01			
	75PZ-19-01 Shallow Piezometer					48.84		0.09	--	-0.0018
	75MW-19-04B Deep									
	75PZ-19-01 Shallow Piezometer					18.77		0.19	--	-0.0101
	75MW-19-02A Mid-Depth									
	75MW-19-04A Mid-Depth					30.07		0.10	+0.0033	--
	75MW-19-04B Deep									

Table 2-6
Vertical Groundwater Gradients
Water Level Gauging Event - 3/12/2020 and 3/13/2020*
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Location ID	Location	Screen Interval	Bottom of Screen Interval	Top of Screen Interval	Mid-Point of Screen	Difference Between Mid-Screen	Groudwater Elevation	Difference GW Elevation	Downward Gradient	Upward Gradient
		(ft bgs)	(ft NAVD88)	(ft NAVD88)	(ft NAVD88)	(ft)	(ft NAVD88)	(ft)	(unitless)	(unitless)
Patton/AOC 40										
Patton - Well Pair 1										
1D-S	Shallow Well	10-13	232.70	235.70	234.20	39.90	245.19	0.01	--	-0.0003
1D-D	Deep Well	49-54	191.80	196.80	194.30		245.20			
Patton - Well Pair 2										
1E-S	Shallow Well	5-8	238.20	241.20	239.70	59.10	242.69	0.53	+0.0090	--
1E-D	Deep Well	63-68	178.10	183.10	180.60		242.16			
Patton - Well Pair 3										
1F-S	Shallow Well	7-12	248.90	253.90	251.40	20.10	256.61	3.41	+0.1697	--
1F-D	Deep Well	27-32	228.80	233.80	231.30		253.20			

*Vertical gradients calculated using water level measurements collected on 3/12/2020 and 3/13/2020 (Patton only)

bgs = below ground surface

MPE = Measuring Point Elevation

NAVD88 = North America Vertical Datum 1988

Table 3-1
AOC 57 Field Activities
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

	Location	North Coordinate (ft NAD83)	East Coordinate (ft NAD83)	Construction Method	Establishing Date	Surface Elevation (ft NAVD88)	Total Depth (ft BGS)	Description of Total Depth	Top of Casing Elevation (ft NAVD88)	Depth to Top of Screen (ft BGS)	Depth to Bottom of Screen (ft BGS)	Elevation of Top of Screen (ft NAVD88)	Elevation of Bottom of Screen (ft NAVD88)
Existing Monitoring Well Sampling													
Initial Existing MW Sampling	57M-03-01X	3022695.05	632664.39	UKN	01/1/2003	234.45	UKN	UKN	235.73	10	20	224.45	214.45
	57M-03-02X	3022574.56	632652.66	UKN	01/1/2003	224.5	UKN	UKN	224.84	2	12	222.5	212.5
	57M-03-03X	3022501.24	632697.32	UKN	01/1/2003	218.99	UKN	UKN	220	2	12	216.99	206.99
	57M-03-04X	3022512.76	632732.81	UKN	01/1/2003	219.46	UKN	UKN	221.39	2	12	217.46	207.46
	57M-03-05X	3022567.79	632765.26	UKN	01/1/2003	219.58	UKN	UKN	221.88	2	12	217.58	207.58
	57M-03-06X	3022592.27	632784.14	UKN	01/1/2003	220.26	UKN	UKN	221.87	2	12	218.26	208.26
	57M-95-03X	3022997.24	633253.39	UKN	01/1/1995	230.8	UKN	UKN	232.79	7	17	223.8	213.8
	57M-95-05X	3022618.45	632528.15	UKN	01/1/1995	232.99	UKN	UKN	235.15	10	20	222.99	212.99
	57M-95-06X	3022717.48	632762.54	UKN	01/1/1995	232.64	UKN	UKN	234.39	11.87	21.87	220.77	210.77
	57M-95-07X	3022491.56	632547.82	UKN	01/1/1995	221.5	UKN	UKN	222.36	3	13	218.5	208.5
	57M-96-09X	3023093.82	633132.27	UKN	01/1/1900	239.44	UKN	UKN	241.82	12.8	22.8	226.64	216.64
	57M-96-10X	3022925.35	633338.47	UKN	01/1/1996	226.29	UKN	UKN	228.75	3	13	223.29	213.29
	57M-96-11X	3022891.53	633267.79	UKN	01/1/1996	220.05	UKN	UKN	222.2	2	12	218.05	208.05
	57M-96-12X	3022906.05	633169.85	UKN	01/1/1996	222.78	UKN	UKN	225.8	2	12	220.78	210.78
	57M-96-13X	3022859.27	633110.57	UKN	01/1/1996	223.23	UKN	UKN	225.58	2	12	221.23	211.23
	57P-98-03X	3022869.57	633313.90	UKN	01/1/1998	218.62	UKN	UKN	220.39	2.5	5.5	216.12	213.12
	57P-98-04X	3022867.92	633254.15	UKN	01/1/1998	218.24	UKN	UKN	221.75	2	5	216.24	213.24
	57WP-05-01	3022462.51	632632.11	UKN	01/1/2005	UKN	UKN	UKN	UKN	UKN	UKN	UKN	UKN
	57WP-06-02	3022505.52	632703.32	UKN	01/1/2006	219.17	UKN	UKN	220.29	18.92	23.92	200.25	195.25
	57WP-06-03	3022888.60	633262.66	UKN	01/1/2006	219.31	UKN	UKN	220.51	13.85	18.85	205.46	200.46
Second Set of Existing MW Sampling	57M-03-01X	3022695.05	632664.39	UKN	01/1/2003	234.45	UKN	UKN	235.73	10	20	224.45	214.45
	57M-03-04X	3022512.76	632732.81	UKN	01/1/2003	219.46	UKN	UKN	221.39	2	12	217.46	207.46
	57M-95-03X	3022997.24	633253.39	UKN	01/1/1995	230.8	UKN	UKN	232.79	7	17	223.8	213.8
	57WP-06-02	3022505.52	632703.32	UKN	01/1/2006	219.17	UKN	UKN	220.29	18.92	23.92	200.25	195.25
Suface Water and Sediment Sampling													
Initial Surface Water and Sediment Sampling	CSB-18-02	3022280.93	632467.46	NA	09/27/2018	NA	NA	NA	NA	NA	NA	NA	NA
	CSB-18-03	3022514.63	632735.04	NA	09/27/2018	NA	NA	NA	NA	NA	NA	NA	NA
	CSB-18-04	3022756.78	633294.49	NA	09/27/2018	NA	NA	NA	NA	NA	NA	NA	NA
	CSB-18-05	3022816.30	633543.83	NA	09/27/2018	NA	NA	NA	NA	NA	NA	NA	NA
Second Set of Surface Water and Sediment Sampling	CSB-20-04	3022495.83	632682.01	NA	03/26/2020	NA	NA	NA	NA	NA	NA	NA	NA
	CSB-20-05	3022812.20	633391.11	NA	03/26/2020	NA	NA	NA	NA	NA	NA	NA	NA

Table 3-1
AOC 57 Field Activities
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

	Location	North Coordinate (ft NAD83)	East Coordinate (ft NAD83)	Construction Method	Establishing Date	Surface Elevation (ft NAVD88)	Total Depth (ft BGS)	Description of Total Depth	Top of Casing Elevation (ft NAVD88)	Depth to Top of Screen (ft BGS)	Depth to Bottom of Screen (ft BGS)	Elevation of Top of Screen (ft NAVD88)	Elevation of Bottom of Screen (ft NAVD88)
Vertical Profiles													
Initial Vertical Profiles	5701VP-18-01	3022382.86	632076.87	GP	12/5/2018	227.14	78	Refusal	NA	NA	NA	NA	NA
	5701VP-18-02	3022337.07	632105.82	GP	12/6/2018	224.79	77	Refusal	NA	NA	NA	NA	NA
	5702VP-18-01	3022841.00	632506.00	GP	11/9/2018	241.65	109	Refusal	NA	NA	NA	NA	NA
	5702VP-18-02	3022709.84	632672.62	GP	11/19/2018	235.21	89	Refusal	NA	NA	NA	NA	NA
Initial Vertical Profiles	5702VP-18-03	3022636.00	632530.26	GP	11/12/2018	234.8	102	Refusal	NA	NA	NA	NA	NA
	5702VP-18-04	3022784.08	632786.35	GP	11/12/2018	233.46	109	Refusal	NA	NA	NA	NA	NA
	5702VP-18-05	3022653.38	632720.38	GP	11/14/2018	232	84	Refusal	NA	NA	NA	NA	NA
	5702VP-18-06	3022595.40	632728.94	GP	11/15/2018	222.96	85.5	Refusal	NA	NA	NA	NA	NA
	5702VP-18-07	3022676.66	632839.27	GP	11/29/2018	226.06	79.5	Refusal	NA	NA	NA	NA	NA
	5702VP-18-08	3022549.53	632592.00	GP	11/14/2018	224.12	94	Refusal	NA	NA	NA	NA	NA
	5703VP-18-01	3023024.23	633105.77	GP	11/9/2018	239.44	90	Refusal	NA	NA	NA	NA	NA
	5703VP-18-02	3023109.39	633236.20	GP	10/22/2018	237.94	81	Refusal	NA	NA	NA	NA	NA
	5703VP-18-03	3023187.59	633374.13	GP	10/19/2018	237.56	84	Refusal	NA	NA	NA	NA	NA
	5703VP-18-04	3022994.58	633213.70	GP	11/7/2018	233.5	82	Refusal	NA	NA	NA	NA	NA
	5703VP-18-05	3022906.67	633128.82	GP	11/27/2018	225.29	77.5	Refusal	NA	NA	NA	NA	NA
	5703VP-18-06	3022927.89	633221.90	GP	11/26/2018	225.45	72.5	Refusal	NA	NA	NA	NA	NA
	5703VP-18-07	3022902.14	633407.52	GP	11/28/2018	220.16	64	Refusal	NA	NA	NA	NA	NA
	5703VP-18-08	3022964.14	633241.22	GP	11/8/2018	228.33	73	Refusal	NA	NA	NA	NA	NA
Second Set of Vertical Profiles	5702VP-19-01	3023029.13	632232.46	GP	01/25/2019	248.62	106	EOB	NA	NA	NA	NA	NA
	5702VP-19-02	3022862.83	632116.43	GP	01/29/2019	248.32	106	EOB	NA	NA	NA	NA	NA
	5703VP-18-09	3023154.56	633153.93	GP	12/19/2018	243.56	86.5	Refusal	NA	NA	NA	NA	NA
	5703VP-19-01	3023322.79	633621.49	GP	01/24/2019	240.14	72	Refusal	NA	NA	NA	NA	NA
Third Set of Vertical Profiles	5702VP-19-03	3023366.33	631959.75	GP	03/20/2019	247.47	101	EOB	NA	NA	NA	NA	NA
	5702VP-19-04	3023166.21	631886.95	GP	03/18/2019	249.55	106	EOB	NA	NA	NA	NA	NA
	5702VP-19-05	3023052.98	631778.62	GP	03/18/2019	250.02	106	EOB	NA	NA	NA	NA	NA
	5702VP-19-06	3023245.20	632414.51	GP	03/22/2019	246.88	106	EOB	NA	NA	NA	NA	NA
Fourth Set of Vertical Profiles	5702VP-19-07	3023592.23	632716.56	GP	05/2/2019	246.47	78.5	Refusal	NA	NA	NA	NA	NA
Fifth Set of Vertical Profiles	5702VP-19-08	3022573.81	632265.00	GP	06/1/2019	233.53	106	Refusal	NA	NA	NA	NA	NA
	5702VP-19-09	3023639.65	632359.01	GP	06/21/2019	247.29	101	EOB	NA	NA	NA	NA	NA

Table 3-1
AOC 57 Field Activities
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

	Location	North Coordinate (ft NAD83)	East Coordinate (ft NAD83)	Construction Method	Establishing Date	Surface Elevation (ft NAVD88)	Total Depth (ft BGS)	Description of Total Depth	Top of Casing Elevation (ft NAVD88)	Depth to Top of Screen (ft BGS)	Depth to Bottom of Screen (ft BGS)	Elevation of Top of Screen (ft NAVD88)	Elevation of Bottom of Screen (ft NAVD88)
Soil Borings													
Initial Soil Borings	5702SB-19-01	3022745.36	632610.70	GP	01/28/2019	239.31	13	EOB	NA	NA	NA	NA	NA
	5702SB-19-02	3022699.67	632587.84	GP	01/29/2019	237.11	13	EOB	NA	NA	NA	NA	NA
	5702SB-19-03	3022734.15	632717.76	GP	01/28/2019	234.88	11	EOB	NA	NA	NA	NA	NA
	5702SB-19-04	3022653.72	632616.31	GP	01/28/2019	234.36	12	EOB	NA	NA	NA	NA	NA
	5702SB-19-05	3022654.00	632708.00	GP	01/29/2019	232.82	10	EOB	NA	NA	NA	NA	NA
	5702SB-19-06	3022705.47	632781.33	GP	01/29/2019	232.77	8	EOB	NA	NA	NA	NA	NA
	5702SB-19-07	3022842.00	632505.00	GP	01/28/2019	241.65	16	EOB	NA	NA	NA	NA	NA
	5703SB-19-01	3023010.28	633157.03	GP	01/28/2019	234.81	8	EOB	NA	NA	NA	NA	NA
	5703SB-19-02	3023109.00	633236.00	GP	01/28/2019	237.94	12	EOB	NA	NA	NA	NA	NA
	5703SB-19-03	3023140.96	633314.20	GP	01/28/2019	236.39	12	EOB	NA	NA	NA	NA	NA
	5703SB-19-04	3022986.00	633205.00	GP	01/28/2019	233.46	10	EOB	NA	NA	NA	NA	NA
Piezometer and Monitoring Well Installation													
Well and Piezometer Installation	5702MW-19-01	3023020.90	632237.00	RD	12/10/2019	247.9	160	EOB	NA	NA	NA	NA	NA
	5702MW-19-01A	3023025.66	632239.57	RD	12/16/2019	247.72	30	Well depth	247.37	20	30	227.72	217.72
	5702MW-19-01B	3023020.86	632237.00	RD	12/16/2019	247.86	50	Well depth	247.6	40	50	207.86	197.86
	5702MW-20-01	3022574.44	632761.63	W	01/3/2020	219.69	115	EOB	NA	NA	NA	NA	NA
	5702MW-20-01A	3022575.57	632765.18	W	01/2/2020	219.59	40.5	Well depth	222.23	30	40	189.59	179.59
	5702MW-20-01B	3022574.41	632761.63	W	01/10/2020	219.7	80	Well depth	222.27	70	80	149.7	139.7
	5702MW-20-02	3022839.99	632508.28	W	01/17/2020	241.65	40.5	EOB	NA	NA	NA	NA	NA
	5702MW-20-02A	3022839.99	632508.28	W	01/17/2020	241.65	40	Well depth	244.32	30	40	211.65	201.65
	5702MW-20-03	3022636.00	632530.26	RD	02/6/2020	234.78	150	EOB	NA	NA	NA	NA	NA
	5702MW-20-03A	3022636.00	632530.26	RD	02/10/2020	234.78	36	Well depth	237.7	26	36	208.78	198.78
	5702MW-20-04	3022723.53	632758.35	W	01/15/2020	232.69	80.5	EOB	NA	NA	NA	NA	NA
	5702MW-20-04A	3022723.53	632758.35	W	01/15/2020	232.69	80	Well depth	235.62	70	80	162.69	152.69
	5702MW-20-05	3022550.82	632575.52	RD	01/27/2020	223.29	140	EOB	NA	NA	NA	NA	NA
	5702MW-20-05A	3022545.98	632578.79	RD	02/5/2020	223.25	40	Well depth	226.09	30	40	193.25	183.25
	5702MW-20-05B	3022550.82	632575.52	RD	02/5/2020	223.29	80	Well depth	226.07	70	80	153.29	143.29
	5702MW-20-06	3022688.54	632671.44	W	01/14/2020	234.1	82.5	EOB	NA	NA	NA	NA	NA
	5702MW-20-06A	3022688.54	632671.44	W	01/14/2020	234.1	80	Well depth	236.52	70	80	164.1	154.1
	5702MW-20-07	3022514.57	632695.25	W	01/13/2020	219.42	40.5	EOB	NA	NA	NA	NA	NA
	5702MW-20-07A	3022514.57	632695.25	W	01/13/2020	219.42	40	Well depth	221.71	30	40	189.42	179.42
	5703MW-20-01	3022962.90	633315.55	W	01/22/2020	225.12	60.5	EOB	NA	NA	NA	NA	NA
	5703MW-20-01A	3022963.71	633310.05	W	01/23/2020	225.25	12	Well depth	228.18	2	12	223.25	213.25
	5703MW-20-01B	3022962.90	633315.55	W	01/22/2020	225.1	60	Well depth	228.1	50	60	175.1	165.1
	5703MW-20-02	3022994.58	633213.60	W	01/28/2020	233.46	84	Refusal	NA	NA	NA	NA	NA
	5703MW-20-02A	3022994.58	633213.60	W	01/31/2020	233.46	20	Well depth	235.75	10	20	223.46	213.46

Table 3-1
AOC 57 Field Activities
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

	Location	North Coordinate (ft NAD83)	East Coordinate (ft NAD83)	Construction Method	Establishing Date	Surface Elevation (ft NAVD88)	Total Depth (ft BGS)	Description of Total Depth	Top of Casing Elevation (ft NAVD88)	Depth to Top of Screen (ft BGS)	Depth to Bottom of Screen (ft BGS)	Elevation of Top of Screen (ft NAVD88)	Elevation of Bottom of Screen (ft NAVD88)
Well and Piezometer Installation	5703MW-20-03	3022909.33	633168.54	W	01/20/2020	222.95	61	EOB	NA	NA	NA	NA	NA
	5703MW-20-03A	3022909.33	633168.54	W	01/20/2020	222.95	60	Well depth	225.8	50	60	172.95	162.95
	5703MW-20-04	3022990.40	633265.61	W	01/24/2020	229.21	70.5	EOB	NA	NA	NA	NA	NA
	5703MW-20-04A	3022990.40	633265.61	W	01/24/2020	229.21	70	Well depth	231.74	60	70	169.21	159.21
	5703PZ-19-01	3022896.59	633266.60	GP	02/19/2020	220.16	67.5	Well depth	222.93	62.5	67.5	157.66	152.66

BGS = below ground surface
EOB = end of boring
ft = feet
GP = Geoprobe
NA = not applicable
RD = rotosonic
SB = soil boring
UKN = unknown

VP = vertical profile
W = drive and wash
NAD83 = North American Datum 1983.
NAVD88 = North American Vertical Datum 1988

Table 3-2
AOC 57 Summary of Groundwater Results from Vertical Profile Samples
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Parameter	Sample Count with Detected Concentrations	Number of Samples Exceeding EPA LHA	Number of Samples Exceeding MassDEP GW-1	Maximum Detected Concentration (ng/L)	Minimum Detected Concentration (ng/L)	Location of Maximum Detected Concentration
6:2 Fluorotelomer sulfonate (6:2 FTS)	5/245	---	---	17.0 J	8.40 J	5702VP-18-08
8:2 Fluorotelomer sulfonate (8:2 FTS)	3/245	---	---	43.0	7.00 J	5702VP-19-01
N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	0/245	---	---	---	---	---
N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	0/245	---	---	---	---	---
Perfluorobutanesulfonic acid (PFBS)	174/245	---	---	88.0	0.470 J	5703VP-18-04
Perfluorodecanoic acid (PFDA)	45/245	---	2	82.0	0.450 J	5702VP-19-01
Perfluorododecanoic acid (PFDoA)	6/245	---	---	19.0	0.640 J	5702VP-19-01
Perfluoroheptanoic acid (PFHpA)	150/245	---	60	1600	0.590 J	5702VP-18-01
Perfluorohexanesulfonic acid (PFHxS)	209/245	---	58	4100	0.370 J	5702VP-18-08
Perfluorohexanoic acid (PFHxA)	184/245	---	---	1500	0.510 J	5702VP-18-08
Perfluorononanoic acid (PFNA)	75/245	---	2	65.0	0.510 J	5702VP-19-03
Perfluorooctanesulfonic acid (PFOS)	124/245	7	21	1100	1.00 J	5702VP-19-01
Perfluorooctanoic acid (PFOA)	178/245	36	64	3900	0.470 J	5702VP-18-08
Perfluorotetradecanoic acid (PFTA)	2/245	---	---	3.10 J	2.80 J	5702VP-19-01
Perfluorotridecanoic acid (PFTrDA)	2/245	---	---	4.80	2.70 J	5702VP-19-07
Perfluoroundecanoic acid (PFUnA)	6/245	---	---	32.0	1.10 J	5702VP-19-01
EPA LHA	---	41	---	4390	1.54	5702VP-18-08
MassDEP GW-1	---	---	124	8760	2.10	5702VP-18-08

ng/L = nanograms per liter

EPA Life-time Health Advisory (LHA) is the individual or sum of PFOS and PFOA = 70 ng/L.

MassDEP GW-1 is the individual concentration or sum of PFOA, PFOS, PFHpA, PFHxS, PFNA, PFDA = 20 ng/L.

Table 3-3
AOC 57 Summary of Groundwater Results from Monitoring Wells
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Parameter	Sample Count with Detected Concentrations	Number of Samples Exceeding EPA LHA	Number of Samples Exceeding MassDEP GW-1	Maximum Detected Concentration (ng/L)	Minimum Detected Concentration (ng/L)	Location of Maximum Detected Concentration
6:2 Fluorotelomer sulfonate (6:2 FTS)	3/37	---	---	39.0 J	7.50 J	57WP-06-02
8:2 Fluorotelomer sulfonate (8:2 FTS)	1/37	---	---	14.0 J	14.0 J	5702MW-19-01A
N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	0/37	---	---	---	---	---
N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	0/37	---	---	---	---	---
Perfluorobutanesulfonic acid (PFBS)	35/37	---	---	82.0	0.610 J	57M-96-13X
Perfluorodecanoic acid (PFDA)	9/37	---	---	6.80	0.460 J	57WP-06-02
Perfluorododecanoic acid (PFDoA)	0/37	---	---	---	---	---
Perfluoroheptanoic acid (PFHpA)	35/37	---	24	760	1.20 J	5702MW-20-02A
Perfluorohexanesulfonic acid (PFHxS)	37/37	---	19	1500	0.510 J	5702MW-20-05A
Perfluorohexanoic acid (PFHxA)	35/37	---	---	600	1.70	57M-96-12X
Perfluorononanoic acid (PFNA)	23/37	---	---	10.0	0.490 J	57WP-06-02
Perfluorooctanesulfonic acid (PFOS)	27/37	3	9	190	1.30 J	5702MW-20-02A
Perfluorooctanoic acid (PFOA)	35/37	19	26	2400	1.70 J	5702MW-20-05A
Perfluorotetradecanoic acid (PFTA)	0/37	---	---	---	---	---
Perfluorotridecanoic acid (PFTrDA)	1/37	---	---	1.20 J	1.20 J	5702MW-19-01A
Perfluoroundecanoic acid (PFUnA)	0/37	---	---	---	---	---
EPA LHA	---	20	---	2480	2.90	5702MW-20-05A
MassDEP GW-1	---	---	31	4150	6.60	5702MW-20-05A

ng/L = nanograms per liter
EPA Life-time Health Advisory (LHA) is the individual or sum of PFOS and PFOA = 70 ng/L.
MassDEP GW-1 is the individual concentration or sum of PFOA, PFOS, PFHpA, PFHxS, PFNA, PFDA = 20 ng/L.

Table 4-1
AOC 74 Field Activities
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

	Location	North Coordinate (ft NAD83)	East Coordinate (ft NAD83)	Construction Method	Establishing Date	Surface Elevation (ft NAVD88)	Total Depth (ft BGS)	Description of Total Depth	Top of Casing Elevation (ft NAVD88)	Depth to Top of Screen (ft BGS)	Depth to Bottom of Screen (ft BGS)	Elevation of Top of Screen (ft NAVD88)	Elevation of Bottom of Screen (ft NAVD88)
Existing Irrigation Well Sampling													
	74IG-01	3024085.92	633412.84	NA	UKN	UKN	505	UKN	UKN	UKN	UKN	UKN	UKN
Suface Water and Sediment Sampling													
First Set of Samples	CSB-18-06	3023671.96	633972.07	NA	09/27/2018	NA	NA	NA	NA	NA	NA	NA	NA
	CSB-18-07	3024023.65	634345.64	NA	09/26/2018	NA	NA	NA	NA	NA	NA	NA	NA
	CSB-18-08	3024816.25	634801.52	NA	09/26/2018	NA	NA	NA	NA	NA	NA	NA	NA
Second Set of Samples	CSB-20-06	3023863.16	634270.73	NA	03/26/2020	NA	NA	NA	NA	NA	NA	NA	NA
Vertical Profiles													
Initial Vertical Profiles	74VP-18-01	3024093.5	633760.56	GP	10/10/2018	237.85	106	Refusal	NA	NA	NA	NA	NA
	74VP-18-02	3023875.13	634038.49	GP	12/5/2018	241.12	73	Refusal	NA	NA	NA	NA	NA
	74VP-18-03	3023897.8	633502.96	GP	10/12/2018	242.69	119.5	Refusal	NA	NA	NA	NA	NA
	74VP-18-04	3024257.72	633990.7	GP	12/10/2018	238.48	71	Refusal	NA	NA	NA	NA	NA
	74VP-18-04A	3024245.06	633996.44	GP	12/11/2018	238.36	85	Refusal	NA	NA	NA	NA	NA
	74VP-18-05	3024359.94	633819.7	GP	10/8/2018	242.87	114	Refusal	NA	NA	NA	NA	NA
	74VP-18-06	3023940.54	633800.45	GP	12/3/2018	227.82	85.5	Refusal	NA	NA	NA	NA	NA
	74VP-18-07	3024328.32	633464.18	GP	10/3/2018	244.72	121	EOB	NA	NA	NA	NA	NA
	74VP-18-08	3024483.67	633723.43	GP	10/5/2018	247.44	146	Refusal	NA	NA	NA	NA	NA
	74VP-18-09	3023959.35	634135.92	GP	12/4/2018	222.35	39.5	Refusal	NA	NA	NA	NA	NA
	74VP-18-10	3023801.51	633867.83	GP	12/4/2018	226.22	50	Refusal	NA	NA	NA	NA	NA
	74VP-18-11	3024179.62	633266.66	GP	10/1/2018	245.19	100	Refusal	NA	NA	NA	NA	NA
Second Set of Vertical Profiles	74VP-18-12	3024634.59	633907.92	GP	12/16/2018	247.94	102	Refusal	NA	NA	NA	NA	NA
	74VP-18-13	3024450.12	634201.21	GP	12/11/2018	241.53	82.5	Refusal	NA	NA	NA	NA	NA
Third Set of Vertical Profiles	74VP-19-01	3023830.68	633238.51	GP	02/20/2019	243.73	106	EOB	NA	NA	NA	NA	NA
	74VP-19-02	3024992.85	634477.49	GP	02/20/2019	246.05	101	EOB	NA	NA	NA	NA	NA
Fourth Set of Vertical Profiles	74VP-19-03	3024285.56	634403.9	GP	06/5/2019	230.46	41.5	Refusal	NA	NA	NA	NA	NA
	74VP-19-04	3024119.61	634318.93	GP	06/6/2019	236.49	54	Refusal	NA	NA	NA	NA	NA
Fifth Set of Vertical Profiles	74VP-20-01	3024085.21	633829.77	GP	02/4/2020	237.09	92	Refusal	NA	NA	NA	NA	NA

Table 4-1
AOC 74 Field Activities
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

	Location	North Coordinate (ft NAD83)	East Coordinate (ft NAD83)	Construction Method	Establishing Date	Surface Elevation (ft NAVD88)	Total Depth (ft BGS)	Description of Total Depth	Top of Casing Elevation (ft NAVD88)	Depth to Top of Screen (ft BGS)	Depth to Bottom of Screen (ft BGS)	Elevation of Top of Screen (ft NAVD88)	Elevation of Bottom of Screen (ft NAVD88)
Soil Borings													
Soil Borings	74SB-19-01	3024093	633760	GP	01/3/2019	239.35	14	EOB	NA	NA	NA	NA	NA
	74SB-19-02	3024024.64	633674.78	GP	01/3/2019	238.15	14	EOB	NA	NA	NA	NA	NA
	74SB-19-03	3024146.58	633834.37	GP	01/3/2019	238.38	13	EOB	NA	NA	NA	NA	NA
	74SB-19-04	3024257	633990	GP	01/4/2019	238.27	13	EOB	NA	NA	NA	NA	NA
	74SB-19-05	3024359	633819	GP	01/3/2019	242.87	18	EOB	NA	NA	NA	NA	NA
	74SB-19-06	3023940	633800	GP	01/4/2019	238.04	16	EOB	NA	NA	NA	NA	NA
	74SB-19-07	3024065.04	633950.39	GP	01/4/2019	236.47	13	EOB	NA	NA	NA	NA	NA
Piezometer and Monitoring Well Installation													
First Set of Piezometers	74PZ-19-01	3023395.6	633692.45	GP	02/25/2019	241.51	26	EOB	244.37	16	26	225.51	215.51
	74PZ-19-02	3023830.28	633310.6	GP	02/22/2019	244.67	28	EOB	244.41	18	28	226.67	216.67
	74PZ-19-03	3024181.02	633069.43	GP	03/6/2019	246.64	36	EOB	246.48	26	36	220.64	210.64
	74PZ-19-04	3023948.72	634144.94	GP	02/22/2019	222.70	16	EOB	246.48	6	16	216.7	206.7
	74PZ-19-05	3024351.21	633822.46	GP	02/25/2019	243.15	30	EOB	242.69	20	30	223.15	213.15
	74PZ-19-06	3024738.94	633401.05	GP	03/7/2019	249.51	42	EOB	249.1	32	42	217.51	207.51
	74PZ-19-07	3024827.51	633824.08	GP	03/8/2019	248.63	40	EOB	248.4	30	40	218.63	208.63
	74PZ-19-08	3024747.66	634083.73	GP	02/25/2019	249.04	35	EOB	248.89	25	35	224.04	214.04
	74PZ-19-09	3024557.03	634521.85	GP	02/25/2019	237.52	35	EOB	237.42	18	28	219.52	209.52
Second Set of Piezometers and Monitoring Wells	74PZ-19-10	3023949	634140.8	GP	11/6/2019	222.37	38	EOB	226.03	36	38	186.37	184.37
	74PZ-20-01	3024411.3	634446.6	GP	02/7/2020	235.93	27.5	EOB	238.62	17.5	27.5	218.43	208.43
	74PZ-20-02	3023988	633699	GP	02/3/2020	238.08	30.5	EOB	240.92	20.5	30.5	217.58	207.58
	74PZ-20-03	3024551.1	634138.7	GP	02/6/2020	243.24	26.2	EOB	243.04	16.2	26.2	227.04	217.04
	74PZ-20-04	3024308.95	633457.2	GP	02/3/2020	243.97	28.5	EOB	243.73	18.5	28.5	225.47	215.47
	74PZ-20-05	3024184.3	634092.9	GP	02/6/2020	237.89	23.5	EOB	237.64	13.5	23.5	224.39	214.39
	74MW-19-04	3023949.2	634137.2	GP	11/7/2019	222.06	30	EOB	NA	NA	NA	NA	NA
	74MW-19-04A	3023949.2	634137.2	GP	11/7/2019	222.07	28	EOB	225.48	18	28	204.07	194.07

BGS = below ground surface
EOB = end of boring
ft = feet
GP = Geoprobe
NA = not applicable
SB = soil boring
VP = vertical profile
NAD83 = North American Datum 1983.
NAVD88 = North American Vertical Datum 1988

Table 4-2
AOC 74 Summary of Groundwater Results from Vertical Profile Samples
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Parameter	Sample Count with Detected Concentrations	Number of Samples Exceeding EPA LHA	Number of Samples Exceeding MassDEP GW-1	Maximum Detected Concentration (ng/L)	Minimum Detected Concentration (ng/L)	Location of Maximum Detected Concentration
6:2 Fluorotelomer sulfonate (6:2 FTS)	4/133	---	---	32.0 J	10.6 J	74VP-20-01
8:2 Fluorotelomer sulfonate (8:2 FTS)	0/133	---	---	---	---	---
N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	0/133	---	---	---	---	---
N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	0/133	---	---	---	---	---
Perfluorobutanesulfonic acid (PFBS)	70/133	---	---	21.0	0.460 J	74VP-19-01
Perfluorodecanoic acid (PFDA)	29/133	---	5	113 J	0.580 J	74VP-18-05
Perfluorododecanoic acid (PFDoA)	0/133	---	---	---	---	---
Perfluoroheptanoic acid (PFHpA)	90/133	---	19	1360 J	0.590 J	74VP-18-05
Perfluorohexanesulfonic acid (PFHxS)	70/133	---	2	22.7 J	0.360 J	74VP-18-05
Perfluorohexanoic acid (PFHxA)	99/133	---	---	2020 J	0.640 J	74VP-18-05
Perfluorononanoic acid (PFNA)	51/133	---	7	128 J	0.560 J	74VP-18-05
Perfluorooctanesulfonic acid (PFOS)	60/133	2	15	505 J	1.08 J	74VP-18-05
Perfluorooctanoic acid (PFOA)	103/133	11	27	2270 J	0.540 J	74VP-18-05
Perfluorotetradecanoic acid (PFTA)	0/133	---	---	---	---	---
Perfluorotridecanoic acid (PFTrDA)	1/133	---	---	0.790 J	0.790 J	74VP-20-01
Perfluoroundecanoic acid (PFUnA)	10/133	---	---	6.39	0.930 J	74VP-18-03
EPA LHA	---	17	---	2270	2.00	74VP-18-05
MassDEP GW-1	---	---	48	3660	3.64	74VP-18-05

ng/L = nanograms per liter
EPA Life-time Health Advisory (LHA) is the individual or sum of PFOS and PFOA = 70 ng/L.
MassDEP GW-1 is the individual concentration or sum of PFOA, PFOS, PFHpA, PFHxS, PFNA, PFDA = 20 ng/L.

Table 4-3
AOC 74 Summary of Groundwater Results from Monitoring Wells
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Parameter	Sample Count with Detected Concentrations	Number of Samples Exceeding EPA LHA	Number of Samples Exceeding MassDEP GW-1	Maximum Detected Concentration (ng/L)	Minimum Detected Concentration (ng/L)	Location of Maximum Detected Concentration
6:2 Fluorotelomer sulfonate (6:2 FTS)	0/1	---	---	---	---	---
8:2 Fluorotelomer sulfonate (8:2 FTS)	0/1	---	---	---	---	---
N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	0/1	---	---	---	---	---
N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	0/1	---	---	---	---	---
Perfluorobutanesulfonic acid (PFBS)	0/1	---	---	---	---	---
Perfluorodecanoic acid (PFDA)	1/1	---	---	8.1 J	8.1 J	74MW-19-04A
Perfluorododecanoic acid (PFDoA)	0/1	---	---	---	---	---
Perfluoroheptanoic acid (PFHpA)	1/1	---	---	12 J	12 J	74MW-19-04A
Perfluorohexanesulfonic acid (PFHxS)	0/1	---	---	---	---	---
Perfluorohexanoic acid (PFHxA)	1/1	---	---	10 J	10 J	74MW-19-04A
Perfluorononanoic acid (PFNA)	1/1	---	---	7.9 J	7.9 J	74MW-19-04A
Perfluorooctanesulfonic acid (PFOS)	1/1	---	1	44	44	74MW-19-04A
Perfluorooctanoic acid (PFOA)	1/1	---	1	27	27	74MW-19-04A
Perfluorotetradecanoic acid (PFTA)	0/1	---	---	---	---	---
Perfluorotridecanoic acid (PFTrDA)	0/1	---	---	---	---	---
Perfluoroundecanoic acid (PFUnA)	0/1	---	---	---	---	---
EPA LHA	---	1	---	71.0	71.0	74MW-19-04A
MassDEP GW-1	---	---	1	99.0	99.0	74MW-19-04A

ng/L = nanograms per liter

EPA Life-time Health Advisory (LHA) is the individual or sum of PFOS and PFOA = 70 ng/L.

MassDEP GW-1 is the individual concentration or sum of PFOA, PFOS, PFHpA, PFHxS, PFNA, PFDA = 20 ng/L.

Table 5-1
AOC 75 Field Activities
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

	Location	North Coordinate (ft NAD83)	East Coordinate (ft NAD83)	Construction Method	Establishing Date	Surface Elevation (ft NAVD88)	Total Depth (ft BGS)	Description of Total Depth	Top of Casing Elevation (ft NAVD88)	Depth to Top of Screen (ft BGS)	Depth to Bottom of Screen (ft BGS)	Elevation of Top of Screen (ft NAVD88)	Elevation of Bottom of Screen (ft NAVD88)
Vertical Profiles													
Initial Vertical Profiles	75VP-18-01	3022466.17	630346.17	GP	10/24/2018	251.84	106	EOB	NA	NA	NA	NA	NA
	75VP-18-02	3022800.50	630545.97	GP	10/29/2018	250.63	106	EOB	NA	NA	NA	NA	NA
	75VP-18-03	3022470.42	631194.33	GP	10/17/2018	244.78	106	EOB	NA	NA	NA	NA	NA
	75VP-18-04	3022226.45	631088.24	GP	10/18/2018	241.52	106	EOB	NA	NA	NA	NA	NA
	75VP-18-05	3022771.83	630810.20	GP	10/26/2018	249.58	106	EOB	NA	NA	NA	NA	NA
	75VP-18-06	3022543.94	630803.42	GP	10/25/2018	243.25	76	EOB	NA	NA	NA	NA	NA
	75VP-18-06A	3022512.92	630796.57	GP	10/29/2018	243.17	86	EOB	NA	NA	NA	NA	NA
	75VP-18-07	3022266.62	630755.51	GP	10/23/2018	244.39	86	Refusal	NA	NA	NA	NA	NA
	75VP-18-08	3022677.30	631295.62	GP	10/10/2018	247.86	151	Refusal	NA	NA	NA	NA	NA
	75VP-18-09	3022736.34	631341.94	GP	10/16/2018	248.57	115	Refusal	NA	NA	NA	NA	NA
Second set of Vertical Profiles	75VP-18-10	3021835.14	630997.50	GP	12/17/2018	245.36	102	Refusal	NA	NA	NA	NA	NA
	75VP-18-11	3022032.26	631721.26	GP	12/17/2018	227.43	96	Refusal	NA	NA	NA	NA	NA
	75VP-18-12	3022571.40	631969.34	GP	12/12/2018	243.61	122.5	Refusal	NA	NA	NA	NA	NA
	75VP-18-13	3021710.55	631556.29	GP	12/18/2018	225.37	102	Refusal	NA	NA	NA	NA	NA
	75VP-19-01	3022307.80	630336.86	GP	01/8/2019	248.95	109	Refusal	NA	NA	NA	NA	NA
Third set of Vertical Profiles	75VP-19-02	3021943.47	630296.37	GP	02/11/2019	247.65	106	EOB	NA	NA	NA	NA	NA
	75VP-19-03	3022507.51	629633.92	GP	02/11/2019	252.4	48.5	Refusal	NA	NA	NA	NA	NA
	75VP-19-04	3022260.89	629582.86	GP	02/12/2019	250.23	45	Refusal	NA	NA	NA	NA	NA
Fourth set of Vertical Profiles	75VP-19-05	3021749.65	630301.10	GP	05/7/2019	248.39	106	EOB	NA	NA	NA	NA	NA
	75VP-19-06	3022003.80	629499.80	GP	05/6/2019	253.56	31.8	Refusal	NA	NA	NA	NA	NA
	75VP-19-07	3022255.47	629335.90	GP	05/6/2019	253.92	22.5	Refusal	NA	NA	NA	NA	NA
	75VP-19-08	3022520.54	629274.19	GP	05/9/2019	252.89	32	Refusal	NA	NA	NA	NA	NA
Fifth set of Vertical Profiles	75VP-19-09	3021588.41	629841.11	GP	06/20/2019	245.29	61	Refusal	NA	NA	NA	NA	NA
Sixth set of Vertical Profiles	75VP-20-01	3022310.31	631904.78	GP	02/11/2020	233.2	110	Refusal	NA	NA	NA	NA	NA

Table 5-1
AOC 75 Field Activities
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

	Location	North Coordinate (ft NAD83)	East Coordinate (ft NAD83)	Construction Method	Establishing Date	Surface Elevation (ft NAVD88)	Total Depth (ft BGS)	Description of Total Depth	Top of Casing Elevation (ft NAVD88)	Depth to Top of Screen (ft BGS)	Depth to Bottom of Screen (ft BGS)	Elevation of Top of Screen (ft NAVD88)	Elevation of Bottom of Screen (ft NAVD88)
Soil Borings													
Initial Soil Borings	75SB-19-01	3022466.00	630346.00	GP	01/8/2019	251.84	20	EOB	NA	NA	NA	NA	NA
	75SB-19-02	3022800.00	630545.00	GP	01/7/2019	250.63	20	EOB	NA	NA	NA	NA	NA
	75SB-19-03	3022571.27	630610.22	GP	01/4/2019	249.36	20	EOB	NA	NA	NA	NA	NA
	75SB-19-04	3022444.18	630708.23	GP	01/7/2019	247.31	15	EOB	NA	NA	NA	NA	NA
	75SB-19-05	3022771.00	630810.00	GP	01/7/2019	249.58	20	EOB	NA	NA	NA	NA	NA
	75SB-19-06	3022562.96	630772.91	GP	01/7/2019	243.25	15	EOB	NA	NA	NA	NA	NA
	75SB-19-07	3022266.00	630755.00	GP	01/7/2019	244.39	10	EOB	NA	NA	NA	NA	NA
Second set of Soil Borings	75SB-19-08	3022306.99	630340.02	GP	05/9/2019	248.79	16	EOB	NA	NA	NA	NA	NA
	75SB-19-09	3022152.79	630400.32	GP	05/9/2019	240.86	8	EOB	NA	NA	NA	NA	NA
	75SB-19-10	3022097.78	630367.68	GP	05/10/2019	239.99	7	EOB	NA	NA	NA	NA	NA
Piezometer and Monitoring Well Installation													
Well Installation, Piezometer Installation, and Last VP	75MW-19-01	3021955.16	628945.47	RD	02/13/2020	259.37	45	EOB	258.79	35	45	224.37	214.37
	75MW-19-01BR	3021955.16	628945.47	RD	02/13/2020	259.37	45	EOB	258.79	35	45	224.37	214.37
	75MW-19-02	3022542.59	630774.48	RD	12/18/2019	247.87	318	EOB	NA	NA	NA	NA	NA
	75MW-19-02A	3022532.69	630775.34	RD	01/22/2020	247.76	47.5	EOB	250.08	37.5	47.5	210.26	200.26
	75MW-19-02B	3022534.02	630766.92	RD	01/21/2020	247.86	80	EOB	250.47	70	80	177.86	167.86
	75MW-19-02C	3022561.92	630773.85	RD	02/12/2020	248.01	220	EOB	250.64	210	220	38.01	28.01
	75MW-19-02BR	3022530.02	630771.18	RD	02/13/2020	247.87	318	EOB	250.78	308	318	-60.13	-70.13
	75MW-19-04	3022035.06	631715.44	RD	12/16/2019	227.99	99.5	Bedrock	NA	NA	NA	NA	NA
	75MW-19-04A	3022035.06	631715.44	RD	12/17/2019	228.06	30	EOB	230.51	20	30	208.06	198.06
	75MW-19-04B	3022030.68	631713.03	RD	12/17/2019	227.99	60	EOB	230.57	50	60	177.99	167.99
	75PZ-19-01	3022028.20	631721.60	GP	12/9/2019	227.63	10.8	NA	230.47	0.8	10.8	226.83	216.83
	75PZ-19-02	3021645.30	630327.03	GP	12/6/2019	248.23	25.2	NA	247.94	15.2	25.2	233.03	223.03
	75PZ-19-03	3022129.20	630373.50	GP	12/6/2019	240.62	18.2	NA	240.39	8.2	18.2	232.42	222.42
	75PZ-19-04	3022269.70	629580.60	GP	12/5/2019	249.98	35	NA	249.70	24.6	34.6	225.38	215.38
	75PZ-20-01	3022301.20	631915.70	GP	02/14/2020	236.43	21.5	NA	236.21	11.5	21.5	224.93	214.93
	75PZ-20-02	3022659.40	631327.90	GP	02/19/2020	245.64	24.25	NA	245.44	14.25	24.25	231.39	221.39
	75PZ-20-03	3022208.90	631092.20	GP	02/14/2020	242.50	23	NA	245.82	13	23	229.50	219.50
	75PZ-20-04	3021622.30	630904.40	GP	02/13/2020	246.31	24	NA	246.17	14	24	232.31	222.31
	75PZ-20-05	3021245.40	629855.60	GP	03/3/2020	243.46	20	NA	243.20	10	20	233.46	223.46
	75PZ-20-06	3022430.80	630363.80	GP	02/18/2020	249.41	26	NA	249.11	16	26	233.41	223.41
	75PZ-20-07	3021697.10	631557.90	GP	02/13/2020	225.30	11	NA	228.63	1	11	224.30	214.30

Table 5-1
AOC 75 Field Activities
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

	Location	North Coordinate (ft NAD83)	East Coordinate (ft NAD83)	Construction Method	Establishing Date	Surface Elevation (ft NAVD88)	Total Depth (ft BGS)	Description of Total Depth	Top of Casing Elevation (ft NAVD88)	Depth to Top of Screen (ft BGS)	Depth to Bottom of Screen (ft BGS)	Elevation of Top of Screen (ft NAVD88)	Elevation of Bottom of Screen (ft NAVD88)
Surface Water and Sediment													
	CSB-20-02	3021877.48	631980.01	NA	03/27/2020	NA	NA	NA	NA	NA	NA	NA	NA
	CSB-20-03	3021961.28	632089.43	NA	03/26/2020	NA	NA	NA	NA	NA	NA	NA	NA

BGS = below ground surface
EOB = end of boring
ft = feet
GP = Geoprobe
NA = not applicable
RD = rotosonic
SB = soil boring
VP = vertical profile
NAD83 = North American Datum 1983.
NAVD88 = North American Vertical Datum 1988

Table 5-2
AOC 75 Summary of Groundwater Results from Vertical Profile Samples
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Parameter	Sample Count with Detected Concentrations	Number of Samples Exceeding EPA LHA	Number of Samples Exceeding MassDEP GW-1	Maximum Detected Concentration (ng/L)	Minimum Detected Concentration (ng/L)	Location of Maximum Detected Concentration
6:2 Fluorotelomer sulfonate (6:2 FTS)	0/194	---	---	---	---	---
8:2 Fluorotelomer sulfonate (8:2 FTS)	2/194	---	---	8.40 J	3.10 J	75VP-19-03
N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	0/194	---	---	---	---	---
N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	0/194	---	---	---	---	---
Perfluorobutanesulfonic acid (PFBS)	155/194	---	---	16.0	0.450 J	75VP-19-01
Perfluorodecanoic acid (PFDA)	2/194	---	---	0.73 J	0.630 J	75VP-19-09
Perfluorododecanoic acid (PFDoA)	0/194	---	---	---	---	---
Perfluoroheptanoic acid (PFHpA)	157/194	---	15	44.0	0.594 J	75VP-19-02
Perfluorohexanesulfonic acid (PFHxS)	174/194	---	72	1100	0.380 J	75VP-19-01
Perfluorohexanoic acid (PFHxA)	168/194	---	---	130	0.444 J	75VP-19-01
Perfluorononanoic acid (PFNA)	50/194	---	---	3.90	0.520 J	75VP-19-04
Perfluorooctanesulfonic acid (PFOS)	142/194	24	47	1160	0.981 J	75VP-18-07
Perfluorooctanoic acid (PFOA)	160/194	14	35	290	0.487 J	75VP-19-01
Perfluorotetradecanoic acid (PFTA)	0/194	---	---	---	---	---
Perfluorotridecanoic acid (PFTrDA)	0/194	---	---	---	---	---
Perfluoroundecanoic acid (PFUnA)	2/194	---	---	1.70 J	0.680 J	75VP-19-01
EPA LHA	---	33	---	1400	1.75	75VP-18-07
MassDEP GW-1	---	---	119	2050	2.10	75VP-19-01

ng/L = nanograms per liter
EPA Life-time Health Advisory (LHA) is the individual or sum of PFOS and PFOA = 70 ng/L.
MassDEP GW-1 is the individual concentration or sum of PFOA, PFOS, PFHpA, PFHxS, PFNA, PFDA = 20 ng/L.

Table 5-3
AOC 75 Summary of Groundwater Results from Monitoring Wells in Overburden
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Parameter	Sample Count with Detected Concentrations	Number of Samples Exceeding EPA LHA	Number of Samples Exceeding MassDEP GW-1	Maximum Detected Concentration (ng/L)	Minimum Detected Concentration (ng/L)	Location of Maximum Detected Concentration
6:2 Fluorotelomer sulfonate (6:2 FTS)	0/5	---	---	---	---	---
8:2 Fluorotelomer sulfonate (8:2 FTS)	0/5	---	---	---	---	---
N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	0/5	---	---	---	---	---
N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	0/5	---	---	---	---	---
Perfluorobutanesulfonic acid (PFBS)	5/5	---	---	9.10	0.630 J	75MW-19-04A
Perfluorodecanoic acid (PFDA)	0/5	---	---	---	---	---
Perfluorododecanoic acid (PFDoA)	0/5	---	---	---	---	---
Perfluoroheptanoic acid (PFHpA)	5/5	---	1	23.0	1.70 J	75MW-19-04A
Perfluorohexanesulfonic acid (PFHxS)	5/5	---	3	680	9.30	75MW-19-04A
Perfluorohexanoic acid (PFHxA)	5/5	---	---	71.0	2.30	75MW-19-04A
Perfluorononanoic acid (PFNA)	0/5	---	---	---	---	---
Perfluorooctanesulfonic acid (PFOS)	5/5	3	3	530	2.2 J	75MW-19-04A
Perfluorooctanoic acid (PFOA)	5/5	1	3	170	1.90	75MW-19-04A
Perfluorotetradecanoic acid (PFTA)	0/5	---	---	---	---	---
Perfluorotridecanoic acid (PFTrDA)	0/5	---	---	---	---	---
Perfluoroundecanoic acid (PFUnA)	0/5	---	---	---	---	---
EPA LHA	---	3	---	700	4.10	75MW-19-04A
MassDEP GW-1	---	---	4	1403	19.8	75MW-19-04A

ng/L = nanograms per liter
EPA Life-time Health Advisory (LHA) is the individual or sum of PFOS and PFOA = 70 ng/L.
MassDEP GW-1 is the individual concentration or sum of PFOA, PFOS, PFHpA, PFHxS, PFNA, PFDA = 20 ng/L.

Table 6-1
Grove Pond Area Field Activities
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

	Location	North Coordinate (ft NAD83)	East Coordinate (ft NAD83)	Construction Method	Establishing Date	Surface Elevation (ft NAVD88)	Total Depth (ft BGS)	Description of Total Depth	Top of Casing Elevation (ft NAVD88)	Depth to Top of Screen (ft BGS)	Depth to Bottom of Screen (ft BGS)	Elevation of Top of Screen (ft NAVD88)	Elevation of Bottom of Screen (ft NAVD88)
Existing Monitoring Well Sampling													
	92-1	3025938.38	634242.21	UKN	UKN	221.45	55	UKN	223.35	49	55	172.45	166.45
	92-2	3025954.21	634521.93	UKN	UKN	UKN	UKN	UKN	UKN	UKN	UKN	UKN	UKN
	92-3	3025909.38	634255.61	UKN	UKN	217.38	55	UKN	219.39	49	55	168.38	162.38
	92-4	3025767.67	634052.02	UKN	UKN	251.55	86	UKN	254.56	67	71	184.55	180.55
	92-5	3026858.17	633899.9	UKN	UKN	222.87	41	UKN	223.87	35	41	187.87	181.87
	CSMS-11-01	3025631.5	633877.76	UKN	UKN	250.7	UKN	UKN	253.6	30	40	220.7	210.7
	CSMS-11-02	3025614.14	634304.19	UKN	UKN	248.9	UKN	UKN	252.04	30	40	218.9	208.9
	GF-1	3026000.98	634311.61	UKN	UKN	221.04	UKN	UKN	223.65	116	121	105.04	100.04
	GF-2	3026015.88	634185.31	UKN	UKN	221.58	UKN	UKN	223.27	114	121	107.58	100.58
	GF-3A	3026080.08	634258.31	UKN	UKN	218.52	UKN	UKN	220.67	97	102	121.52	116.52
	GF-3B	3026074.23	634258.46	UKN	UKN	218.61	UKN	UKN	220.63	8	13	210.61	205.61
	GF-4	3026033.17	634009.51	UKN	UKN	224.29	UKN	UKN	225.93	79	84	145.29	140.29
	MNG-2R	3025606.64	633011.03	UKN	05/9/2014	233.5	26	UKN	236.08	14	24	219.5	209.5
	MNG-3R	3025615.73	634063.76	UKN	05/6/2014	251.5	66	UKN	254.36	55	65	196.5	186.5
	MNG-5R	3025390.28	633156.49	UKN	05/8/2014	233.5	21	UKN	235.91	10	20	223.5	213.5
	MNG-6R	3025321.19	633467.4	UKN	05/5/2014	249.7	41	UKN	252.39	30	40	219.7	209.7
Surface Water and Sediment Samples													
	BP-18-01	3027010.47	636075.03	NA	12/21/2018	NA	NA	NA	NA	NA	NA	NA	NA
	GP-18-01	3026180.5	636151.98	NA	10/4/2018	NA	NA	NA	NA	NA	NA	NA	NA
	GP-18-02	3026112.32	634283.84	NA	10/4/2018	NA	NA	NA	NA	NA	NA	NA	NA
	GP-18-03	3026815.57	633482.21	NA	10/3/2018	NA	NA	NA	NA	NA	NA	NA	NA
	GP-18-04	3025933.9	632723.62	NA	10/3/2018	NA	NA	NA	NA	NA	NA	NA	NA
	GP-18-05	3027020.14	632561.73	NA	10/3/2018	NA	NA	NA	NA	NA	NA	NA	NA
Vertical Profiles													
Initial Set of Vertical Profiles	GPVP-18-01	3026944.26	633523.97	GP	03/6/2019	229.44	26	Refusal	NA	NA	NA	NA	NA
	GPVP-18-02	3026775.09	634465.62	GP	02/28/2019	231.84	42	Refusal	NA	NA	NA	NA	NA
	GPVP-18-03	3026862.72	635021.12	GP	03/5/2019	241.67	46	Refusal	NA	NA	NA	NA	NA
	GPVP-18-04	3026424.94	635682.46	GP	02/28/2019	226.81	21	Refusal	NA	NA	NA	NA	NA
	GPVP-18-05	3025683.86	634879.86	GP	02/11/2019	244.17	101	Refusal	NA	NA	NA	NA	NA
	GPVP-18-06	3025456.71	634491.63	GP	12/10/2018	244.71	132	Refusal	NA	NA	NA	NA	NA
	GPVP-18-07	3025504.43	634247.71	GP	10/30/2018	249.14	115	Refusal	NA	NA	NA	NA	NA
	GPVP-18-08	3025523.94	634013.75	GP	11/1/2018	250.7	140	Refusal	NA	NA	NA	NA	NA
	GPVP-18-09	3025563.54	633757.01	GP	10/31/2018	250.2	146	Refusal	NA	NA	NA	NA	NA
	GPVP-18-10	3025555.89	633458.74	GP	11/6/2018	228.16	134.5	Refusal	NA	NA	NA	NA	NA
	GPVP-18-11	3025633.51	633154.97	GP	11/5/2018	233.82	124	Refusal	NA	NA	NA	NA	NA
	GPVP-18-12	3025799.18	632892.79	GP	12/3/2018	222.83	104	Refusal	NA	NA	NA	NA	NA

Table 6-1
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Second Set of Vertical Profiles	GPVP-19-01	3025337.49	632503.04	GP	01/23/2019	251.65	106	EOB	NA	NA	NA	NA	NA
	GPVP-19-02	3025149.35	632760.07	GP	01/22/2019	252.09	96	Refusal	NA	NA	NA	NA	NA
	GPVP-19-03	3025088.32	633181.86	GP	01/7/2019	249.12	138	Refusal	NA	NA	NA	NA	NA
	GPVP-19-04	3025047.16	633617.52	GP	01/17/2019	249.42	106	EOB	NA	NA	NA	NA	NA
	GPVP-19-05	3024941.07	633914.55	GP	01/11/2019	248.65	106	EOB	NA	NA	NA	NA	NA
	GPVP-19-06	3024725.06	632092	GP	01/15/2019	249.6	94	Refusal	NA	NA	NA	NA	NA
	GPVP-19-07	3024570.39	632282.44	GP	01/10/2019	251.01	101	EOB	NA	NA	NA	NA	NA
	GPVP-19-08	3024457.86	632522.78	GP	01/10/2019	251.1	106	EOB	NA	NA	NA	NA	NA
	GPVP-19-09	3024271.98	632853.02	GP	01/17/2019	248.23	101	EOB	NA	NA	NA	NA	NA
	GPVP-19-10	3025325.41	632104.79	GP	01/16/2019	243.71	98.8	Refusal	NA	NA	NA	NA	NA
Third Set of Vertical Profiles	GPVP-19-11	3024044	631993.37	GP	02/14/2019	249.48	106	EOB	NA	NA	NA	NA	NA
	GPVP-19-12	3023950.1	632105.7	GP	02/14/2019	250.16	101	EOB	NA	NA	NA	NA	NA
Fourth Set of Vertical Profiles	GPVP-19-13	3025637.86	632668.47	GP	04/29/2019	226.36	96	Refusal	NA	NA	NA	NA	NA
	GPVP-19-14	3025561.54	632898.81	GP	04/29/2019	234.34	92.5	Refusal	NA	NA	NA	NA	NA
	GPVP-19-15	3025731.59	633095.54	GP	05/1/2019	235.38	102.8	Refusal	NA	NA	NA	NA	NA
Soil Borings													
Soil Borings	GPSB-19-01	3024723.75	633221.53	GP	07/16/2019	248.03	24	EOB	NA	NA	NA	NA	NA
	GPSB-19-02	3025192.21	633346.68	GP	07/15/2019	249.37	28	EOB	NA	NA	NA	NA	NA
	GPSB-19-03	3024092.93	632212.33	GP	07/15/2019	249.29	15	EOB	NA	NA	NA	NA	NA
	GPSB-19-04	3024327.75	632404.13	GP	07/15/2019	267.51	24	EOB	NA	NA	NA	NA	NA
	GPSB-19-05	3025207.39	632401.47	GP	07/16/2019	250.89	17	EOB	NA	NA	NA	NA	NA
	GPSB-19-06	3025125.72	632780.29	GP	07/16/2019	252.39	33	EOB	NA	NA	NA	NA	NA
	GPSB-19-07	3024973.74	633228.87	GP	07/16/2019	247.79	27	EOB	NA	NA	NA	NA	NA
	GPSB-19-08	3024696.53	632805.41	GP	07/16/2019	250.5	28	EOB	NA	NA	NA	NA	NA
	GPSB-19-09	3025279.52	633614.47	GP	07/15/2019	251.49	38	EOB	NA	NA	NA	NA	NA
Piezometer and Monitoring Well Installation													
Piezometer and Monitoring Wells	GPMW-19-01	3025551.7	633756.2	RD	11/25/2019	250.83	185	EOB	NA	NA	NA	NA	NA
	GPMW-19-01A	3025549.93	633761.04	RD	12/10/2019	251.09	55	EOB	253.93	45	55	206.09	196.09
	GPMW-19-01BR	3025551.65	633756.22	RD	02/13/2020	250.83	185	EOB	253.75	175	185	75.83	65.83
	GPPZ-19-01	3025556.98	633757.59	RD	12/9/2019	250.72	110	EOB	253.63	105	110	145.72	140.72

BGS = below ground surface
EOB = end of boring
ft = feet

NA = not applicable
RD = rotosonic
SB = soil boring

GP = Geoprobe
UKN = unknown
VP = vertical profile

NAD83 = North American Datum 1983.
NAVD88 = North American Vertical Datum 1988

Table 6-2
Grove Pond Summary of Groundwater Results from Vertical Profile Samples
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Parameter	Sample Count with Detected Concentrations	Number of Samples Exceeding EPA LHA	Number of Samples Exceeding MassDEP GW-1	Maximum Detected Concentration (ng/L)	Minimum Detected Concentration (ng/L)	Location of Maximum Detected Concentration
6:2 Fluorotelomer sulfonate (6:2 FTS)	11/208	---	---	34.0 J	6.40 J	GPVP-19-11
8:2 Fluorotelomer sulfonate (8:2 FTS)	6/208	---	---	15.0 J	3.40 J	GPVP-19-12
N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	1/208	---	---	4.80 J	4.80 J	GPVP-18-09
N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	0/208	---	---	---	---	---
Perfluorobutanesulfonic acid (PFBS)	159/208	---	---	15.0	0.450 J	GPVP-18-02
Perfluorodecanoic acid (PFDA)	41/208	---	1	31.0	0.480 J	GPVP-19-01
Perfluorododecanoic acid (PFDoA)	2/208	---	---	1.60 J	0.780 J	GPVP-19-09
Perfluoroheptanoic acid (PFHpA)	154/208	---	61	420	0.670 J	GPVP-19-01
Perfluorohexanesulfonic acid (PFHxS)	167/208	---	28	190	0.440 J	GPVP-18-12
Perfluorohexanoic acid (PFHxA)	163/208	---	---	1200	0.460 J	GPVP-19-05
Perfluorononanoic acid (PFNA)	84/208	---	---	14.0	0.530 J	GPVP-19-01
Perfluorooctanesulfonic acid (PFOS)	142/208	12	28	880	1.00 J	GPVP-18-12
Perfluorooctanoic acid (PFOA)	163/208	29	53	200	0.510 J	GPVP-19-01
Perfluorotetradecanoic acid (PFTA)	0/208	---	---	---	---	---
Perfluorotridecanoic acid (PFTrDA)	0/208	---	---	---	---	---
Perfluoroundecanoic acid (PFUnA)	6/208	---	---	3.30	0.870 J	GPVP-19-01
EPA LHA	---	41	---	919	1.70	GPVP-18-12
MassDEP GW-1	---	---	129	1160	2.40	GPVP-18-12

ng/L = nanograms per liter
EPA Life-time Health Advisory (LHA) is the individual or sum of PFOS and PFOA = 70 ng/L.
MassDEP GW-1 is the individual concentration or sum of PFOA, PFOS, PFHpA, PFHxS, PFNA, PFDA = 20 ng/L.

Table 6-3
Grove Pond Summary of Groundwater Results from Monitoring Wells in Overburden
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Parameter	Sample Count with Detected Concentrations	Number of Samples Exceeding EPA LHA	Number of Samples Exceeding MassDEP GW-1	Maximum Detected Concentration (ng/L)	Minimum Detected Concentration (ng/L)	Location of Maximum Detected Concentration
6:2 Fluorotelomer sulfonate (6:2 FTS)	4/13	---	---	19 J	6.6 J	MNG-6R
8:2 Fluorotelomer sulfonate (8:2 FTS)	1/13	---	---	3 J	3 J	MNG-6R
N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	0/13	---	---	---	---	---
N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	0/13	---	---	---	---	---
Perfluorobutanesulfonic acid (PFBS)	13/13	---	---	8.40	0.920 J	MNG-2R
Perfluorodecanoic acid (PFDA)	7/13	---	---	13.0	0.470 J	MNG-6R
Perfluorododecanoic acid (PFDoA)	0/13	---	---	---	---	---
Perfluoroheptanoic acid (PFHpA)	12/13	---	7	480	1.50 J	MNG-2R
Perfluorohexanesulfonic acid (PFHxS)	13/13	---	3	65.0	3.10	MNG-2R
Perfluorohexanoic acid (PFHxA)	13/13	---	---	360	0.680 J	MNG-2R
Perfluorononanoic acid (PFNA)	8/13	---	---	11.0	0.670 J	MNG-6R
Perfluorooctanesulfonic acid (PFOS)	13/13	---	4	36.0	1.30 J	CSMS-11-01
Perfluorooctanoic acid (PFOA)	13/13	5	7	200	4.40	MNG-2R
Perfluorotetradecanoic acid (PFTA)	0/13	---	---	---	---	---
Perfluorotridecanoic acid (PFTrDA)	0/13	---	---	---	---	---
Perfluoroundecanoic acid (PFUnA)	1/13	---	---	1.40 J	1.40 J	MNG-6R
EPA LHA	---	6	---	212	3.56	GPMW-19-01A
MassDEP GW-1	---	---	9	749	7.58	MNG-2R

ng/L = nanograms per liter
EPA Life-time Health Advisory (LHA) is the individual or sum of PFOS and PFOA = 70 ng/L.
MassDEP GW-1 is the individual concentration or sum of PFOA, PFOS, PFHpA, PFHxS, PFNA, PFDA = 20 ng/L.

Table 7-1
Patton Well Area/AOC 40 Field Activities
Area 1 Preliminary Site Characterization
Devens PFAS Remedial Investigation

	Location	North Coordinate (ft NAD83)	East Coordinate (ft NAD83)	Construction Method	Establishing Date	Surface Elevation (ft NAVD88)	Total Depth (ft BGS)	Description of Total Depth	Top of Casing Elevation (ft NAVD88)	Depth to Top of Screen (ft BGS)	Depth to Bottom of Screen (ft BGS)	Elevation of Top of Screen (ft NAVD88)	Elevation of Bottom of Screen (ft NAVD88)
Vertical Profiles													
Initial Set of Vertical Profiles	PWVP-19-01	3020037.83	626699.4	GP	05/24/2019	263.29	27	Refusal	NA	NA	NA	NA	NA
	PWVP-19-02	3018047.62	627010.55	GP	05/28/2019	287.19	101	EOB	NA	NA	NA	NA	NA
	PWVP-19-03	3019038.18	627604	GP	06/4/2019	251.96	69	Refusal	NA	NA	NA	NA	NA
	PWVP-19-04	3018282.39	628186.07	GP	05/28/2019	259.9	106	EOB	NA	NA	NA	NA	NA
	PWVP-19-05	3018548.45	626877.05	GP	05/31/2019	249.45	56.5	Refusal	NA	NA	NA	NA	NA
	PWVP-19-06	3018991.14	629350.01	GP	06/24/2019	247.03	88	Refusal	NA	NA	NA	NA	NA
	PWVP-19-07	3017800.39	629411.02	GP	06/20/2019	260.19	69	Refusal	NA	NA	NA	NA	NA
	PWVP-19-08	3019328.79	626466.48	GP	06/26/2019	264.88	27	Refusal	NA	NA	NA	NA	NA
Second Set of Vertical Profiles	PWVP-19-09	3019177	628836.7	GP	10/29/2019	305.36	135.75	Refusal	NA	NA	NA	NA	NA
	PWVP-19-10	3019425	629733.7	GP	11/4/2019	249.06	85	Refusal	NA	NA	NA	NA	NA
	PWVP-19-11	3019103.36	630177.38	GP	11/20/2019	237.2	34.5	Refusal	NA	NA	NA	NA	NA
	PWVP-19-12	3018441	630045	GP	11/15/2019	253.61	24.5	Refusal	NA	NA	NA	NA	NA
	PWVP-19-13	3018113.4	627859.82	GP	10/23/2019	266.2	106	Refusal	NA	NA	NA	NA	NA
Third Set of Vertical Profiles	PWVP-20-01	3017415.4	627565.95	GP	02/26/2020	278.2	123.5	Refusal	NA	NA	NA	NA	NA
Soil Borings													
Soil Boring	PWSB-19-01	3018289.04	628193.36	GP	11/26/2019	259.53	20	EOB	NA	NA	NA	NA	NA
	PWSB-19-02	3018462.74	629075.64	GP	03/10/2020	242.22	0.5	EOB	NA	NA	NA	NA	NA
	PWSB-19-03	3018519.22	629087.71	GP	03/10/2020	242.19	0.5	EOB	NA	NA	NA	NA	NA
	PWSB-19-04	3018370.44	628122.22	GP	11/26/2019	261.76	25	EOB	NA	NA	NA	NA	NA
Piezometers													
Piezometers	PWPZ-19-01	3019177.4	628836.7	GP	11/1/2019	305.36	70	EOB	304.94	60	70	245.36	235.36
	PWPZ-19-02	3019425.1	629733.7	GP	11/6/2019	249.06	22	EOB	251.52	12	22	237.06	227.06
	PWPZ-19-03	3018441	630045.3	GP	11/18/2019	253.61	23	EOB	256.02	13	23	240.61	230.61
	PWPZ-19-04-F1*	3016816.68	629767.37	GP	11/8/2019	296.173	45	Refusal	NA	NA	NA	NA	NA
	PWPZ-19-04-F2*	3016928.42	629238.35	GP	11/22/2019	300.674	81	Refusal	NA	NA	NA	NA	NA
	PWPZ-19-04	3017203.4	629277.9	GP	12/9/2019	284.58	46.2	EOB	288.00	36.2	46.2	248.38	238.38
	PWPZ-19-05	3017150.1	628514.8	GP	11/12/2019	312.69	80	EOB	312.43	70	80	242.69	232.69
	PWPZ-19-06	3018162.8	628252.4	GP	10/28/2019	266.56	30	EOB	266.22	20	30	246.56	236.56
	PWPZ-19-07	3017814.9	629411.3	GP	10/11/2019	260.65	26	EOB	260.29	16	25.9	244.65	234.75
	PWPZ-19-08	3018358.7	628023.5	GP	12/3/2019	253.18	19.3	EOB	256.53	9.3	19.3	243.88	233.88

Table 7-1
Patton Well Area/AOC 40 Field Activities
Area 1 Preliminary Site Characterization
Devens PFAS Remedial Investigation

	Location	North Coordinate (ft NAD83)	East Coordinate (ft NAD83)	Construction Method	Establishing Date	Surface Elevation (ft NAVD88)	Total Depth (ft BGS)	Description of Total Depth	Top of Casing Elevation (ft NAVD88)	Depth to Top of Screen (ft BGS)	Depth to Bottom of Screen (ft BGS)	Elevation of Top of Screen (ft NAVD88)	Elevation of Bottom of Screen (ft NAVD88)
Piezometers	PWPZ-19-09	3018422.6	627777.7	GP	12/3/2019	250.12	15.6	EOB	253.09	5.6	15.6	244.52	234.52
	PWPZ-19-10	3018039.3	627087.5	GP	12/4/2019	285.99	53.5	EOB	288.42	43.5	53.5	242.49	232.49
	PWPZ-20-01	3017415.45	627565.95	GP	03/3/2020	278.20	68	EOB	0	58	68	220.20	210.20
Surface Water and Sediment													
Surface Water and Sediment	CP-20-01	3018507.9	628163.59	NA	03/27/2020	243.12	NA	NA	NA	NA	NA	NA	NA
	CP-20-02	3018837.07	629335.59	NA	03/27/2020	241.48	NA	NA	NA	NA	NA	NA	NA
	CP-20-03	3018750.88	628608.29	NA	03/27/2020	241.84	NA	NA	NA	NA	NA	NA	NA
	CSB-20-01	3019412.37	630027.31	NA	03/27/2020	233.69	NA	NA	NA	NA	NA	NA	NA
	ML-20-01	3016630.87	625625.03	NA	03/30/2020	241.42	NA	NA	NA	NA	NA	NA	NA
Staff Gauges													
Staff Gauges	CPSG-01	3018744.8	627621.7	V	12/12/2019	247.28	NA	NA	NA	NA	NA	NA	NA
	CPSG-02	3018918.8	629358.3	V	12/12/2019	244.09	NA	NA	NA	NA	NA	NA	NA
	CSBSG-01	3019399	630022.5	V	12/12/2019	236.8	NA	NA	NA	NA	NA	NA	NA
	MLSG-01	3016884.81	625779.1	V	03/18/2020	243.59	NA	NA	NA	NA	NA	NA	NA
Irrigation Well													
Irrigation Well	RTG-IG01	3019614.9	628650.3	NA	08/23/2000	268.00	72	EOB	NA	56	66	212.00	202.00

BGS = below ground surface
EOB = end of boring
ft = feet
GP = Geoprobe
NA = not applicable
SB = soil boring
V = driven
VP = vertical profile
NAD83 = North American Datum 1983.
NAVD88 = North American Vertical Datum 1988
* = water was not encountered during drilling

Table 7-2
Patton Well Area/AOC 40 Summary of PFAS Exceedances from Vertical Profile Samples
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Parameter	Sample Count with Detected Concentrations	Number of Samples Exceeding EPA LHA	Number of Samples Exceeding MassDEP GW-1	Maximum Detected Concentration (ng/L)	Minimum Detected Concentration (ng/L)	Location of Maximum Detected Concentration
6:2 Fluorotelomer sulfonate (6:2 FTS)	0/84	---	---	---	---	---
8:2 Fluorotelomer sulfonate (8:2 FTS)	0/84	---	---	---	---	---
N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	0/84	---	---	---	---	---
N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	0/84	---	---	---	---	---
Perfluorobutanesulfonic acid (PFBS)	69/84	---	---	30.0	0.430 J	PWVP-19-05
Perfluorodecanoic acid (PFDA)	13/84	---	---	1.80 J	0.580 J	PWVP-19-04
Perfluorododecanoic acid (PFDoA)	3/84	---	---	3.70	0.790 J	PWVP-19-04
Perfluoroheptanoic acid (PFHpA)	53/84	---	9	200	0.630 J	PWVP-19-04
Perfluorohexanesulfonic acid (PFHxS)	77/84	---	2	22.0	0.410 J	PWVP-19-10
Perfluorohexanoic acid (PFHxA)	59/84	---	---	180	0.520 J	PWVP-19-04
Perfluorononanoic acid (PFNA)	33/84	---	---	3.50 J	0.520 J	PWVP-19-13
Perfluorooctanesulfonic acid (PFOS)	55/84	---	6	28.0	1.10 J	PWVP-19-08
Perfluorooctanoic acid (PFOA)	67/84	5	21	380	0.590 J	PWVP-19-04
Perfluorotetradecanoic acid (PFTA)	0/84	---	---	---	---	---
Perfluorotridecanoic acid (PFTrDA)	2/84	---	---	1.70 J	1.40 J	PWVP-19-04
Perfluoroundecanoic acid (PFUnA)	1/84	---	---	0.700 J	0.700 J	PWVP-19-03
EPA LHA	---	8	---	394	1.80	PWVP-19-04
MassDEP GW-1	---	---	42	607	2.50	PWVP-19-04

ng/L = nanograms per liter
EPA Life-time Health Advisory (LHA) is the individual or sum of PFOS and PFOA = 70 ng/L.
MassDEP GW-1 is the individual concentration or sum of PFOA, PFOS, PFHpA, PFHxS, PFNA, PFDA = 20 ng/L.

Table 8-1
Shabokin Well Area Field Activities
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

	Location	North Coordinate (ft NAD83)	East Coordinate (ft NAD83)	Construction Method	Establishing Date	Surface Elevation (ft NAVD88)	Total Depth (ft BGS)	Description of Total Depth	Top of Casing Elevation (ft NAVD88)	Depth to Top of Screen (ft BGS)	Depth to Bottom of Screen (ft BGS)	Elevation of Top of Screen (ft NAVD88)	Elevation of Bottom of Screen (ft NAVD88)
Vertical Profiles													
Initial Set of Vertical Profiles	SWVP-19-01	3015815.08	625598.71	GP	05/17/2019	244.64	89	Refusal	NA	NA	NA	NA	NA
	SWVP-19-02	3014740.64	626755.38	GP	05/20/2019	359.58	73	Refusal	NA	NA	NA	NA	NA
	SWVP-19-03	3014012.64	626152.94	GP	05/21/2019	278.50	93	Refusal	NA	NA	NA	NA	NA
	SWVP-19-04	3014479.3	625367.56	GP	05/22/2019	247.31	95.75	Refusal	NA	NA	NA	NA	NA
	SWVP-19-05	3014706.75	626143.02	GP	06/26/2019	243.70	101	EOB	NA	NA	NA	NA	NA
Second Set of Vertical Profiles	SWVP-19-06	3015572.51	623923.55	GP	10/9/2019	240.20	44	Refusal	NA	NA	NA	NA	NA
	SWVP-20-01	3016220.83	624504.24	GP	02/21/2020	357.65	91	Refusal	NA	NA	NA	NA	NA
	SWVP-20-02	3017851.89	623791.15	GP	02/19/2020	363.20	22.5	Refusal	NA	NA	NA	NA	NA
	SWVP-20-03	3017046.56	623481.11	GP	02/20/2020	333.30	23.5	Refusal	NA	NA	NA	NA	NA
	SWVP-20-04	3016882.03	625453.27	GP	02/21/2020	269.20	97	Refusal	NA	NA	NA	NA	NA
Piezometers and Monitoring Well													
Piezometers	SWPZ-19-01	3014476.89	625364.58	GP	10/10/2019	247.47	26.50	EOB	250.62	16.5	26.5	230.97	220.97
	SWPZ-19-02*	3017684.34	625630.18	GP	10/11/2019	292.58	37	Refusal	NA	NA	NA	NA	NA
	SWPZ-19-03	3015861.33	625580.68	GP	10/17/2019	245.39	13	EOB	245.26	3	13	242.39	232.39
	SWPZ-19-04	3015553.23	623974.71	GP	10/10/2019	237.86	14	EOB	240.63	4	14	233.86	223.86
	SWPZ-20-01	3017049.19	623460.84	GP	02/20/2019	333.58	20	EOB	333.38	10	20	323.58	313.58
	SWPZ-20-02	3016909.36	625457.38	GP	02/20/2019	267.48	33	EOB	267.19	23	33	244.48	234.48
Monitoring Wells	SWMW-20-01	3017855.05	623813.13	W	03/6/2020	362.96	27	EOB	NA	NA	NA	NA	NA
	SWMW-20-01A	3017855.05	623813.13	W	03/6/2020	362.96	27	EOB	362.55	5	15	357.96	347.96
Suface Water and Sediment Sampling													
Surface Water and Sediment Sample	ML-20-01	3016630.87	625625.03	NA	03/30/2020	NA	NA	NA	NA	NA	NA	NA	NA
Staff Gague													
Staff Gauge	MLSG-01	3016884.81	625779.1	V	03/18/2020	243.59	0.00	NA	NA	NA	NA	NA	NA

BGS = below ground surface
EOB = end of boring
ft = feet
GP = Geoprobe
NA = not applicable
V = driven
VP = vertical profile
NAD83 = North American Datum 1983.

NAVD88 = North American Vertical Datum 1988
* = water was not encountered during drilling and a piezometer was not installed

Table 8-2
Shabokin Well Area Summary of PFAS Exceedances from Vetical Profiles
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Parameter	Sample Count with Detected Concentrations	Number of Samples Exceeding EPA LHA	Number of Samples Exceeding MassDEP GW-1	Maximum Detected Concentration (ng/L)	Minimum Detected Concentration (ng/L)	Location of Maximum Detected Concentration
6:2 Fluorotelomer sulfonate (6:2 FTS)	0/46	---	---	---	---	---
8:2 Fluorotelomer sulfonate (8:2 FTS)	0/46	---	---	---	---	---
N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	0/46	---	---	---	---	---
N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	0/46	---	---	---	---	---
Perfluorobutanesulfonic acid (PFBS)	36/46	---	---	2.40	0.45 J	SWVP-20-03
Perfluorodecanoic acid (PFDA)	0/46	---	---	---	---	---
Perfluorododecanoic acid (PFDoA)	0/46	---	---	---	---	---
Perfluoroheptanoic acid (PFHpA)	34/46	---	---	14.0	0.58 J	SWVP-19-06
Perfluorohexanesulfonic acid (PFHxS)	45/46	---	1	23.0	0.65 J	SWVP-19-01
Perfluorohexanoic acid (PFHxA)	40/46	---	---	17.0	0.46 J	SWVP-19-06
Perfluorononanoic acid (PFNA)	11/46	---	---	1.3 J	0.65 J	SWVP-20-04
Perfluorooctanesulfonic acid (PFOS)	34/46	---	1	28.0	1.3 J	SWVP-19-05
Perfluorooctanoic acid (PFOA)	45/46	---	3	23.0	0.53 J	SWVP-19-06
Perfluorotetradecanoic acid (PFTA)	0/46	---	---	---	---	---
Perfluorotridecanoic acid (PFTrDA)	0/46	---	---	---	---	---
Perfluoroundecanoic acid (PFUnA)	0/46	---	---	---	---	---
EPA LHA	---	---	---	38.0	1.95	SWVP-20-04
MassDEP GW-1	---	---	19	48.3	3.39	SWVP-20-04

ng/L = nanograms per liter

EPA Life-time Health Advisory (LHA) is the individual or sum of PFOS and PFOA = 70 ng/L.

MassDEP GW-1 is the individual concentration or sum of PFOA, PFOS, PFHpA, PFHxS, PFNA, PFDA = 20 ng/L.

Table 8-3
Shabokin Well Field Summary of Groundwater Results from Monitoring Wells
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Parameter	Sample Count with Detected Concentrations	Number of Samples Exceeding EPA LHA	Number of Samples Exceeding MassDEP GW-1	Maximum Detected Concentration (ng/L)	Minimum Detected Concentration (ng/L)	Location of Maximum Detected Concentration
6:2 Fluorotelomer sulfonate (6:2 FTS)	0/1	---	---	---	---	---
8:2 Fluorotelomer sulfonate (8:2 FTS)	0/1	---	---	---	---	---
N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	0/1	---	---	---	---	---
N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	0/1	---	---	---	---	---
Perfluorobutanesulfonic acid (PFBS)	1/1	---	---	0.82 J	0.82 J	SWMW-20-01A
Perfluorodecanoic acid (PFDA)	0/1	---	---	---	---	---
Perfluorododecanoic acid (PFDoA)	0/1	---	---	---	---	---
Perfluoroheptanoic acid (PFHpA)	1/1	---	---	3.7	3.7	SWMW-20-01A
Perfluorohexanesulfonic acid (PFHxS)	1/1	---	1	1.7 J	1.7 J	SWMW-20-01A
Perfluorohexanoic acid (PFHxA)	1/1	---	---	3.2	3.2	SWMW-20-01A
Perfluorononanoic acid (PFNA)	1/1	---	---	1.4 J	1.4 J	SWMW-20-01A
Perfluorooctanesulfonic acid (PFOS)	1/1	---	1	19	19	SWMW-20-01A
Perfluorooctanoic acid (PFOA)	1/1	---	3	9.5	9.5	SWMW-20-01A
Perfluorotetradecanoic acid (PFTA)	0/1	---	---	---	---	---
Perfluorotridecanoic acid (PFTrDA)	0/1	---	---	---	---	---
Perfluoroundecanoic acid (PFUnA)	0/1	---	---	---	---	---
EPA LHA	---	---	---	28.5	28.5	SWMW-20-01A
MassDEP GW-1	---	---	1	35.3	35.3	SWMW-20-01A

ng/L = nanograms per liter
EPA Life-time Health Advisory (LHA) is the individual or sum of PFOS and PFOA = 70 ng/L.
MassDEP GW-1 is the individual concentration or sum of PFOA, PFOS, PFHpA, PFHxS, PFNA, PFDA = 20 ng/L.

Table 9-1
AOC 43J Field Activities
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

	Location	North Coordinate (ft NAD83)	East Coordinate (ft NAD83)	Construction Method	Establishing Date	Surface Elevation (ft NAVD88)	Total Depth (ft BGS)	Description of Total Depth	Top of Casing Elevation (ft NAVD88)	Depth to Top of Screen (ft BGS)	Depth to Bottom of Screen (ft BGS)	Elevation of Top of Screen (ft NAVD88)	Elevation of Bottom of Screen (ft NAVD88)
Existing Wells													
First Round of Sampling	2446-03	3018185.36	623519.52	UKN	UKN	368.7	UKN	UKN	368.36	8	18	360.7	350.7
	HA-1B	3018026.98	623550.04	UKN	UKN	365.5	UKN	UKN	370.7	21	31	344.5	334.5
	HA-1S	3018024.81	623546.78	UKN	UKN	365.6	UKN	UKN	370.6	3.5	16.5	362.1	349.1
	HA-2B	3018078.41	623648.13	UKN	UKN	365.6	UKN	UKN	365.3	31	39	334.6	326.6
	HA-4B	3018170.43	623729.51	UKN	UKN	365.6	UKN	UKN	365.3	35.8	43.8	329.8	321.8
	HA-4S	3018172.16	623724.52	UKN	UKN	365.8	UKN	UKN	365.5	4	17	361.8	348.8
	HA-5S	3018140.12	623478.15	UKN	UKN	UKN	UKN	UKN	368	5.5	15.5	UKN	UKN
	XJM-93-01X	3018256.15	623416.31	UKN	UKN	368.4	UKN	UKN	370.6	6.5	16.5	361.9	351.9
	XJM-93-04X	3018150.54	623399.7	UKN	UKN	367.9	UKN	UKN	370.37	4.5	14.5	363.4	353.4
	XJM-94-07X	3018055.81	623743.83	UKN	UKN	361.4	UKN	UKN	364.24	3.7	13.7	357.7	347.7
	XJM-97-12X	3018120.6	623496.13	UKN	UKN	368.0	UKN	UKN	367.6	20	30	348	338
Second Round of Sampling	HA-2S	3018082.06	623652.13	UKN	UKN	365.6	14	UKN	UKN	4	14	361.6	351.6
	XJM-94-08X	3017979.67	623635.64	UKN	UKN	365.9	14	UKN	368.5	7.6	17.6	358.3	348.3
	XJM-97-13X	3017979.53	623640.48	NA	UKN	365.8	UKN	UKN	368.5	41.5	51.5	324.3	314.3

BGS = below ground surface
ft = feet
NA = not applicable
UKN = unknown
NAD83 = North American Datum 1983.
NAVD88 = North American Vertical Datum 1988

Table 9-2
AOC 43J Summary of PFAS Exceedances from Monitoring Wells
Area 1 Preliminary Site Characterization Summary
Devens PFAS Remedial Investigation

Parameter	Sample Count with Detected Concentrations	Number of Samples Exceeding EPA LHA	Number of Samples Exceeding MassDEP GW-1	Maximum Detected Concentration (ng/L)	Minimum Detected Concentration (ng/L)	Location of Maximum Detected Concentration
6:2 Fluorotelomer sulfonate (6:2 FTS)	1/14	---	---	8.9 J	8.9 J	XJM-93-04X
8:2 Fluorotelomer sulfonate (8:2 FTS)	0/14	---	---	---	---	---
N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	0/14	---	---	---	---	---
N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	0/14	---	---	---	---	---
Perfluorobutanesulfonic acid (PFBS)	7/14	---	---	3.30	0.57 J	XJM-94-07X
Perfluorodecanoic acid (PFDA)	5/14	---	---	2.20	0.44 J	XJM-93-04X
Perfluorododecanoic acid (PFDoA)	0/14	---	---	---	---	---
Perfluoroheptanoic acid (PFHpA)	12/14	---	---	9.80	0.69 J	XJM-94-07X
Perfluorohexanesulfonic acid (PFHxS)	11/14	---	---	2.80	0.41 J	XJM-94-07X
Perfluorohexanoic acid (PFHxA)	11/14	---	---	5.70	0.50 J	XJM-94-07X
Perfluorononanoic acid (PFNA)	11/14	---	---	1.9 J	0.48 J	XJM-93-01X
Perfluorooctanesulfonic acid (PFOS)	10/14	---	---	7.60	1.0 J	XJM-94-07X
Perfluorooctanoic acid (PFOA)	12/14	---	1	29.0	1.4 J	XJM-94-07X
Perfluorotetradecanoic acid (PFTA)	0/14	---	---	---	---	---
Perfluorotridecanoic acid (PFTrDA)	0/14	---	---	---	---	---
Perfluoroundecanoic acid (PFUnA)	0/14	---	---	---	---	---
EPA LHA	---	---	---	36.6	2.90	XJM-94-07X
MassDEP GW-1	---	---	1	51.0	4.77	XJM-94-07X

ng/L = nanograms per liter

EPA Life-time Health Advisory (LHA) is the individual or sum of PFOS and PFOA = 70 ng/L.

MassDEP GW-1 is the individual concentration or sum of PFOA, PFOS, PFHpA, PFHxS, PFNA, PFDA = 20 ng/L.

Appendix C

Detailed Site Histories

C Area 1 PFAS Site Histories

C.1 AOC 43G Historical Gas Station G

C.1.1 Site Location and Historical Use

AOC 43G – Historical Gas Station G is located in the central portion of the former Main Post of Fort Devens at the southwestern corner of Feinburg Road and Queenstown Street (**Figure C-1**). The reported location of Gas Station G was southwest of the former Army Air Force Exchange Service (AAFES) gasoline station (Building 2008) and southwest of Building 2009. Historical Gas Station G was used during World War II as a vehicle motor pool to support military operations and was one of 18 historical gas station sites at Fort Devens. The structures of gas station G consisted of a pump island and a small gasoline pumphouse. Reportedly, the gas station had one 5,000-gallon (or possibly 5,140-gallon) underground storage tank (UST) located between the gasoline pumphouse and the pump island (ABB 1996d). The motor pool operations were discontinued during the late 1940s or early 1950s. No records are available on the decommissioning of the motor pool, the exact location of Gas Station G, or the location or ultimate disposition of the station's UST (ABB 1996d).

C.1.2 CERCLA Previous Investigations

In 1991, SIs were conducted at SAs at Fort Devens including historical gas stations (ABB 1993a). Based on the results of the SIs, the Army decided to conduct Supplemental Site Inspections (SSIs) at 14 of the original 32 SAs (ABB 1996b). Upon completion of the SSIs, three SAs (SA 41, 43G, and 43J) were recommended to progress to the RI and FS phase. The name designations for each of these SAs were administratively changed to AOCs (i.e., AOC 43G; ABB 1996d, H&S Environmental [H&S] 2015).

Originally, AOC 43G consisted solely of Historical Gas Station G; however, after completion of the SI, AOC 43G was expanded to include the former AAFES gas station located approximately 120 feet northeast of Historical Gas Station G. The AAFES gas station was added to further define the distribution of contamination detected during the past gasoline UST removals (completed in 1990), as well as the contaminants detected during a waste oil UST removal completed in 1992 (ABB 1996d).

At the time of the SI and SSI, the AAFES gas station consisted of a service station (Building 2008), which housed three vehicle service bays and the AAFES store. It also included three 10,000-gallon USTs, associated pump islands, and a sand and gas trap (H&S 2015). The 10,000-gallon gasoline USTs and associated piping were removed in July/August 1996. The sand and gas trap and residual soil contamination were also removed at that time (ABB 1996d).

Based on the results of the SI and SSI, no further action was recommended for AOC43G (ABB 1996a). After completion of an RI/FS and Proposed Plan (PP), the Army and USEPA signed a Record of Decision (ROD) for AOC 43G in 1996 documenting the selection of intrinsic remediation with LTM as the selected remedy. The major components of the selected remedy included intrinsic bioremediation, intrinsic bioremediation assessment data collection and groundwater modeling, installing additional monitoring wells, groundwater LTM, annual data reports to USEPA and MassDEP, and 5-year reviews. Intrinsic bioremediation is the principal technology proposed to prevent constituents of concern (COCs) present at concentrations that exceed groundwater cleanup levels from potentially migrating off Army property (ABB 1996d, Sovereign/HGL 2015).

C.1.3 PFAS Previous Investigations

No historical source of PFAS was identified at AOC 43G during the PA; rather, AOC 43G was identified for sampling to provide more information about the overall extent of PFAS at the former Fort Devens and to support the RI (KGS 2018b).

C.2 AOC 43J Historical Gas Station J

C.2.1 Site Location and Historical Use

AOC 43J - Historical Gas Station J is located in the northwest quadrant of the Queenstown Street and Patton Road intersection (**Figure C-2**). Historical Gas Station J was used during World War II as a vehicle motor pool to support military operations. The structures of this historical gas station consisted of a pump island and a small gasoline pump house. This gas station was reported to be a Type A station, with one 5,000-gallon UST located between the gasoline pump house and pump island. The motor pool operations were discontinued during the late 1940s or early 1950s. No records were available on the decommissioning of this motor pool or the removal of the associated UST (Haley and Aldrich 2017).

The Army subsequently used AOC 43J as a vehicle storage yard and maintenance facility for Fort Devens. The property at AOC 43J was transferred to MassDevelopment in 2006 as a condition of Bristol Myers Squibb’s commitment to develop facilities at Fort Devens. USEPA and the MassDEP currently administer AOC 43J jointly (Haley and Aldrich 2017).

C.2.2 CERCLA Previous Investigations

AOC 43J was first identified as a possible source of contamination in 1988 (Argonne National Laboratory [ANL] 1992). The Army identified several leaking USTs that held gasoline, waste oil, and diesel. At the time of base closure in 1996, the area surrounding AOC 43J was used as a vehicle storage yard and maintenance facility (former Buildings T-2446 and T-2479) for a Special Forces Unit of the Army. The former maintenance facility used a 1,000-gallon UST for storage of maintenance wastes. This UST was located just south of former Building T-2446 (Haley and Aldrich 2017).

During the 1992 SI conducted at the site, an abandoned 5,000-gallon UST was found in the area of the Historical Gas Station J. This UST was added to the Fort Devens UST removal program and removed in August 1992. The former waste oil UST was also removed during May of the same year. During both UST removals, the Army removed and disposed of contaminated impacted soil. Based on the data and the findings of the 1992 SI, additional investigation was recommended (ABB 1996c).

After completion of an RI, FS, and PP, the Army and USEPA signed a ROD for AOC 43J in 1996 documenting the selection of intrinsic bioremediation (i.e., monitored natural attenuation [MNA]), as the selected remedy. (ABB 1996d).

In 2006, an Explanation of Significant Differences (ESD) (U.S. Department of Army 2006), completed following a Finding of Suitability for Early Transfer (FOSET), addressed the changes necessary for the remedy to remain protective of human health and the environment. The purpose of the ESD was to allow land use controls to be implemented to allow property to be transferred from Army to MassDevelopment. AOC 43J property was transferred from the Army to MassDevelopment in June 2006. The land use controls were detailed in a June 2006 Grant of Environmental Restriction and Easement (GERE) issued by MassDEP.

During a 5-year review, it was noted that MNA would not reach the ROD goals within the required 30-year performance period (H&S 2015). Subsequently, in 2010 and 2011, pilot testing of remedial-amendment injections was performed during two separate pilot tests (Haley and Aldrich 2015). These tests concluded that sodium persulfate/calcium peroxide would provide short-term oxidation and long-term reduction processes to augment MNA to reduce petroleum-related contaminant concentrations remaining at the site. Remedial-amendment injections of sodium persulfate/calcium peroxide were performed during 2012, and subsequent groundwater sampling conducted in 2013 and 2014 indicated that benzene, toluene, ethylbenzene, and xylene (BTEX) concentrations had generally decreased over time in most monitoring wells; however, continued monitoring was recommended (Haley and Aldrich 2015 and 2017).

C.2.3 PFAS Previous Investigations

No historical source of PFAS was identified at AOC 43J during the PA; rather, AOC 43J was identified for sampling to provide more information about the overall extent of PFAS at the former Fort Devens and to support the RI (KGS 2018c).

C.3 AOC 57 Former Vehicle Storage and Motor Repair Shops

C.3.1 Site Location and Historical Use

AOC 57 is located between Barnum Road and Cold Spring Brook (**Figure C-3**). The portion of Fort Devens that includes AOC 57 was used primarily as a storage and maintenance area for military vehicles.

AOC 57 consists of three sub-areas (Area 1, Area 2, and Area 3) located south to southeast of Building 3713 and former Buildings 3756, 3757, and 3758 (**Figure C-3**; KGS 2018c). Area 1 is a stormwater drain that collects rainfall from the paved areas around Building 3713. The runoff from the stormwater drain flows to the outfall at Area 57-1 and eventually into Cold Spring Brook (Harding Lawson Associates [HLA] 2000). Area 2 is located 800 feet northeast of Area I, adjacent to a vehicle storage yard associated with the former motor repair shops located in former Building 3757 and 3758 (**Figure C-4**). The nearby former Building 3756 served as a mess hall and was later converted to a general storehouse. This area formerly consisted of an eroded drainage ditch created by periodic rain runoff. Area 3 is located approximately 600 feet to the northeast of Area 2, south of former vehicle maintenance motor pools and north of the Cold Spring Brook floodplain (**Figure C-5**), and is characterized by a historical garage and vehicle waste disposal area (HLA 2000). Area 3 was identified in 1995 after test pits were excavated east of Area 2 in locations where historical photographs indicated soil staining and showed soil samples confirmed the presence of total petroleum hydrocarbons (TPH) and chlorinated volatile organic compounds (CVOCs; Harding 2001).

In 1977, an estimated 50- to 100-gallon spill of No. 4 fuel oil was discharged through the Area 1 outfall (Harding 2001). The fuel oil spill occurred from an overfilled UST at Building 3713 into a nearby storm drain (HLA 2000). Approximately 3,000 gallons of mixed soil and water were recovered using containment dikes and absorbent booms set up across Cold Spring Brook adjacent to Area 2 (Harding 2001).

Evergreen Solar constructed a manufacturing facility between Areas 2 and 3 and Barnum Road (112 Barnum Road) in 2008/2009 to manufacture silicon wafers used in solar power systems. The building was constructed with oversized/complex air handling and humidification, air and process cooling, power supply and distribution, compressed air production and distribution, specialty gas distribution, and wastewater and hazardous material treatment systems. Evergreen Solar went bankrupt in 2011, and the property was sold to Calare Properties/Hackman Capital Properties. In 2012, Calare leased half the facility to Saint-Gobain Ceramics & Plastics. Saint-Gobain upgraded the facility for the manufacture of components used in light-emitting diode (LED) lights (using sapphire substrates in LED bulbs for backlighting smartphones, tablets, and other devices). In 2013, Calare leased the other half of the building to Nypro Healthcare. In 2014, Nypro started its manufacturing of precision plastic products for customers in the healthcare, packaging, and consumer electronics industries (e.g., medical device manufacturing). In August 2014, Saint-Gobain ceased operations, and Nypro moved into their space. In May 2015, Calare sold the property to an LLC/institutional buyer (KGS 2018c). The property is now occupied by Jabil Corporation.

The Army retained the property at former Building 3713 during the base closure process. Building 3713 was demolished, and the Major David S. Connolly Armed Forces Reserve Center was constructed on the property between 2008 and 2010 (KGS 2020a). The area adjacent to Building 3713 to the north includes AOC44 – Maintenance Yards. Through early 2009, the maintenance yards were fenced, paved, and used for military vehicle parking. The soils of the site have been exposed to possible vehicle crankcase releases over a long duration. Gasoline, motor oil, and other automotive fluids have also likely been released during vehicle dismantling operations. The former maintenance yards were removed during reconstruction activities (KGS 2020b).

The historical storm sewer system drained paved areas, unpaved areas, and a discharge point to Cold Spring Brook near AOC 57 Area 1. The system was revised, and there are now numerous detention pond areas across the area (KGS 2020a).

C.3.2 CERCLA Previous Investigations

In September 1992, an investigation was performed at Areas 1 and 2 to determine the presence or absence of environmental contamination at AOC 57 resulting from the 1977 fuel oil spill. Polycyclic aromatic hydrocarbons (PAHs) and total petroleum hydrocarbon content (TPHC), possibly associated with fuel oil, were detected at Area 1; however, a preliminary risk evaluation indicated that there was no unacceptable risk for presumed commercial/industrial site reuse (HLA 2000). At Area 2, naphthalene and TPHC were detected in surface soils. Fingerprint analysis of soil indicated that contaminated soil was most likely derived from lubricating oil, possibly from the release of vehicle crank case oil and not likely related to the No. 4 fuel oil release.

In 1994, a soil removal action was conducted at Area 2 in response to newly promulgated MCP standards (**Figure C-4;** Harding 2001). During the removal action, it was discovered that the soil and groundwater contamination were more widespread than expected. The soil removal was suspended after 1,300 cubic yards of soil were excavated, and AOC 57 Area 2 was administratively transferred to the RI/FS process. Following the soil removal action, the area was re-graded, and a stone drainage swale was installed that discharges into Cold Spring Brook (HLA 2000).

In 1997, Area 1 outfall soil was excavated to address soil contamination resulting from releases of petroleum oil in response to newly promulgated MCP standards (HLA 2000). The time-critical removal action (TCRA) included excavation of a 22-foot by 22.5-foot area to a maximum depth of 3 feet below ground surface (bgs) at the outfall location; approximately 25 cubic yards of contaminated soil were removed (Harding 2001).

In the spring of 1999, a total of 1,860 cubic yards of soil was removed from Area 3, focusing on polychlorinated biphenyls (PCBs) and extractable petroleum hydrocarbons (EPH; **Figure C-5**; HLA 2000). In June 2000, the Army completed an RI at AOC 57 Areas 2 and 3 (57-2 and 57-3) that revealed the presence of residual contamination at both sites (HLA 2000). The ROD selected no further action for Area 1, Excavation (For Possible Future Use) and land use controls (LUCs) for Area 2, and Excavation (To Accelerate Groundwater Cleanup) and LUCs for Area 3 (Harding 2001). The remedies for Area 2 and 3 also included LTM of groundwater and surface water.

The soil excavations in Area 2 and 3 were initiated in January 2002 and completed in February 2003 (H&S 2015). At Area 2, the contamination extended beyond the assumed limits, and petroleum waste seeped into the excavation. A petroleum product recovery system was operated while additional sampling was conducted. In 2003, the remaining contaminated soil was removed. A total of 4,361 tons of contaminated material was excavated from Area 2 (H&S 2015). At Area 3, the excavation was completed to the target limits, and the planned volume of soil was removed within these limits to depths ranging between 2 and 4 feet, resulting in the removal of 197 tons of soil. The confirmatory samples met the ROD cleanup criteria, and the area was backfilled (H&S 2015).

Data obtained and observations made at Area 2 between 2002 and 2003 (during the soil excavation and subsequent investigations) prompted the submittal of an ESD in March 2004. The ESD expanded the Area 2 LTM to include EPH C11-C22 aromatics and PCB Aroclors (BRAC 2004). Per the ROD and ESD, LTM has continued at AOC 57 Area 2 and Area 3 (KGS 2020a).

C.3.3 PFAS Previous Investigations

AOC 57 was not identified during the PA (KGS 2017b) as an area of known AFFF use or releases and was not sampled for PFAS during the SI (BERS-Weston 2018a). However, select monitoring wells at this AOC were sampled in early 2018 at the request of the USEPA in order to help delineate PFAS concentrations across Fort Devens (KGS 2018c). Four LTM groundwater monitoring wells sampled for PFAS at AOC 57 exhibited combined concentrations of PFOA and PFOS that exceeded the LHA for drinking water of 70 ng/L (57M-03-01X, 57M-03-03X, 57M-03-04X, and 57M-03-06X; KGS 2018b). No soil sampling for PFAS analysis was conducted at AOC 57. PFAS was detected in Cold Spring Brook at AOC 57 Area 3 during the LTM sampling (KGS 2018b).

The Phase 1 RI field investigations conducted between 2018 and 2020 at AOC 57 included collecting groundwater and soil samples from vertical profiling borings (VPBs), sampling existing monitoring wells, collecting surface water and sediment samples in Cold Spring Brook, and collecting synoptic water level measurements.

- A total of 245 groundwater samples were collected from 31 VPBs and 37 groundwater samples from monitoring wells. Of the groundwater samples, results from 61 exceeded USEPA LHA of 70 ng/L and 155 exceeded MassDEP GW-1 criteria. The highest PFAS concentrations were detected at 5702VP-18-08 (PFOA + PFOS = 4,390 ng/L and 8,760 ng/L, sum of six GW-1 compounds), which is slightly cross-gradient from the south of the center of the historical AOC 57 Area 2 contamination (KGS 2020a).
- Seven soil borings were advanced at AOC 57 Area 2 to a maximum depth of 16 feet bgs. One or more sample intervals at six locations exhibited detections of PFAS greater than the MCP S-1/GW-1 standard. At AOC 57 Area 3, four soil borings were advanced to a maximum depth of 12 feet bgs. Two soil borings exhibited one or more sample intervals with detections of PFAS compounds greater than screening criteria. As part of previous removal activities, soil was removed from AOC 57 Area 2 and Area 3. The highest PFAS concentrations in both areas are on the edges or outside of the estimated areas from which soil was removed (KGS 2020a).
- Five surface water and sediment samples were collected in Cold Spring Brook near AOC 57 Area 2 and Area 3. All of the PFAS detections in surface water and sediment were below the USEPA site-specific SLs for PFAS at Fort Devens.

C.4 AOC 74 Barnum Road Firefighting Exercise Site

C.4.1 Site Location and Historical Use

The AOC 74 - Barnum Road Firefighting Exercise Site is located at 78 Barnum Road (**Figure C-6**) and consists of the site of former Building 3773 and former Building 3774. Building 3773 was used as an administrative building for the Army Reserve Center and Building 3774 was used as storage. Firefighting equipment was stored at this location during the closure of the former MAAF (KGS 2017b). Firefighting training exercises with AFFF are believed to have been conducted behind Building 3773 (BERS-Weston 2018a).

The portion of the property near Barnum Road, the buildings, and parking lots are fairly flat, with little change in ground surface elevations. Behind the main building, the topography has been altered by the installation of two storm water detention ponds. Between the storm water detention ponds, the land slopes down to a drainage swale that discharges to Cold Spring Brook. Historically, the storm sewer system drained paved and unpaved areas and had numerous discharge points to Cold Spring Brook behind former Building 3773.

.4.1.1 Previous Investigations

The Barnum Road Firefighting Exercise Site was first identified for investigation based on interviews conducted as part of the 2016 Fort Devens PFAS PA, which identified the site as SA 74. No previous environmental investigations were found during historical document review (KGS 2017b).

During the SI, shallow soil (0 to 5 feet bgs) samples were collected from three locations and water table groundwater samples were collected from five locations behind former Building 3773 (BERS-Weston 2018a). Relatively low concentrations of PFOS (non-detect to 0.36 estimated value [J] micrograms per kilogram [µg/kg]) and PFOA (0.21 µg/kg to 0.77 µg/kg) were detected in the shallow soil sampled behind former Building 3773. PFOS and PFOA were detected in groundwater at concentrations that exceed the USEPA LHA of 70 ng/L. A maximum combined concentration of PFOS and PFOA of 490 ng/L was detected in shallow groundwater at AOC 74 (BERS-Weston 2018a).

The Phase I RI field investigations conducted between 2018 and 2020 at AOC 74 included collecting groundwater and soil samples from VPBs, sampling an existing irrigation well, sampling a new monitoring well, collecting surface water and sediment samples in Cold Spring Brook, and synoptic water level measurements.

- A total of 133 groundwater samples were collected from 18 VPBs and one groundwater sample from a new monitoring well. Of the groundwater samples, results from 17 exceeded USEPA LHA of 70 ng/L, and results from 49 exceeded MassDEP GW-1 criteria. The highest PFAS concentrations were detected at 74VP-18-05 at 52 to 56 feet bgs (PFOA + PFOS = 2,270 ng/L and 3,660 ng/L, for the sum of the six GW-1 compounds; KGS 2020a). Groundwater level contours indicated that some of the groundwater from behind former Building 3773 flows to the southeast toward Cold Spring Brook, and some flows to the north toward 74VP-18-05 and then north towards Grove Pond. The downgradient extent of the AOC 74 plume flowing toward Grove Pond is not clearly defined and may be commingling with PFAS-impacted groundwater in the Grove Pond area as the groundwater migrates north toward Grove Pond and the Town of Ayer Grove Pond wellfield.
- One groundwater sample was collected from the irrigation well (505 feet deep) off the southeast corner of former Building 3773. The sample was collected from the output of the existing pump within the well. The sample result was non-detect for all PFAS compounds.

- Seven soil borings were advanced at AOC 74 to a maximum depth of 16 feet bgs. Four locations exhibited one or more sample intervals with detections of PFAS greater than the MCP S-1/GW-1 standard (KGS 2020a). The soil data from the SI and the Phase 1 RI field investigations suggest that the greatest impact of firefighting training exercises was directly behind former Building 3773, with lesser impacts to the south, east, and north.
- Three surface water and sediment samples were collected in 2018 and 2020 in Cold Spring Brook east of former Building 3773, and one surface water and sediment sample pair was collected downstream in 2018. All of the PFAS detections in surface water and sediment were below the USEPA site-specific SLs for PFAS at Fort Devens.

C.5 AOC 75 Former Building T-1445 Warehouse Fire

C.5.1 Site Location and Historical Use

AOC 75 - Former Building T-1445 Warehouse Fire is located at 18 Saratoga Street (**Figure C-7**). Building T-1445 was reportedly used for storage of lumber and pipe (Arthur D. Little [ADL] 1994). A large warehouse fire occurred at Building T-1445 sometime during the late 1980s/early 1990s. Reportedly, due to the storage of flammable substances, the nature of the fire, and for purposes of firefighter safety, any available firefighting foam at that time was used to suppress the fire. Remnants from the fire were transported to and disposed at AOC 5 and AOC 50 (BERS-Weston 2018a).

The current building at 18 Saratoga Street was constructed between 2001 and 2003. Currently, the building is occupied by Peak Manufacturing which is a manufacturer and assembler of machined components. Overall, the area is generally flat with little change in ground surface elevation. There is a gentle slope from 18 Saratoga Street toward Cold Spring Brook. Historically, the storm water system drained south along Saratoga Street and discharged into Cold Spring Brook at the junction of Saratoga Street and Barnum Road.

C.5.2 Previous PFAS Investigations

AOC 75 was first identified for investigation based on interviews conducted as part of the 2016 Fort Devens PFAS PA, which identified the site as SA 75. No previous environmental investigations were found during historical document review (KGS 2017b).

The detections of PFOS and PFOA in groundwater at AOC 75 were below the LHA during sampling completed at four temporary water table wells for the SI (BERS-Weston 2018a). PFOS and PFOA were detected in shallow soils at AOC 75 at concentrations ranging from 0.17 to 1.2 µg/kg for PFOA and non-detect to 0.25 µg/kg for PFOS.

The Phase 1 RI field investigations conducted between 2018 and 2020 at AOC 75 included collecting groundwater and soil samples from VPBs, sampling new monitoring wells, collecting surface water and sediment samples in Cold Spring Brook, and synoptic water level measurements.

- A total of 194 groundwater samples were collected from 24 VPBs and five groundwater samples from new monitoring wells. Of the groundwater samples, results from 36 exceeded USEPA LHA of 70 ng/L, and 123 exceeded MassDEP GW-1 criteria. The maximum concentrations were detected at 75VP-18-07 (PFOA + PFOS = 1,400 ng/L, 62 to 66 feet bgs) and 75VP-19-01 at 27-31 feet bgs (2,050 ng/L, for the sum of the six GW-1 compounds). The high PFAS concentrations at 75VP-19-01 and shallow depth, combined with the proximity to the former warehouse fire, suggest that 75VP-19-01 is within the source area caused by AFFF used to extinguish the warehouse fire (KGS 2020a).

- Ten soil borings were advanced at AOC 75 to a maximum depth of 16 feet bgs. One location (75SB-19-09) exhibited a detection of PFAS greater than screening criteria in the shallowest sample (0 to 0.5 foot bgs). The low concentrations of PFAS in the soil data from the SI and the Phase 1 RI field investigations suggest that, during the fire, instead of penetrating the site soil, much of the AFFF may have flowed into the storm drains at the site and either discharged to the groundwater via breaks in the storm drain or directly into Cold Spring Brook (KGS 2020a).
- Two surface water and sediment samples were collected in 2020 where AOC 75 groundwater discharges to Cold Spring Brook. All of the PFAS detections in surface water and sediment were below the USEPA site-specific SLs for PFAS at Fort Devens.

C.6 Grove Pond Wellfield

C.6.1 Site Location and Historical Use

The Grove Pond Area includes the Town of Ayer Grove Pond wellfield and areas upgradient of the wellfield. The Town of Ayer operates a wellfield of five supply wells on the south shore of Grove Pond as part of the town municipal water supply (**Figure C-6**) with the combined flow from the wells treated at a facility to reduce concentrations of metals (KGS 2018c).

Upgradient of the Town of Ayer property is Massachusetts Army National Guard (MAARNG) property (outside of the Fort Devens boundary), and the Army retains property south of the MAARNG property. Most of the area is developed. MassDevelopment retains a small portion of property in the area zoned Open Space/Recreational. The MAARNG property is home to the Consolidated Support Maintenance Shop (CSMS), the Annex, and a recruiting office. The MAARNG CSMS facility functions as a motor vehicle maintenance, repair, rebuilding, and cannibalization facility. Overall, the MAARNG property and Army property west of MAARNG property is generally flat with little change in ground surface elevation. East of the developed portion of the MAARNG property, the land is sloped downward to Grove Pond (KGS 2020a).

C.6.2 Previous PFAS Investigations

In September 2016, the Town of Ayer first sampled the on-line Grove Pond supply wells and the post-treatment combined flow for PFAS. The results indicated that PFAS were present in the flow from all three wells, with the highest concentrations from Well 8. The sum of the PFOS and PFOA concentrations from Well 8 (103 ng/L) exceeded the USEPA LHA of 70 ng/L. The supply wells and the combined flow after treatment have been sampled quarterly since September 2016.

On February 26, 2018, the Town of Ayer discontinued use of Well 8 as a water supply well after notice that MassDEP was considering adopting a screening criterion of 70 ng/L for the sum of five PFAS constituents (PFOS, PFOA, PFNA, PFHxS, and PFHpA). Well 8 was pumped at a reduced rate of 150 to 200 gallons per minute (gpm), and the water was discharged to Grove Pond rather than contributing to the town drinking water supply. The Town of Ayer supplemented the water supply by reinitiating use of Well 1 (Town of Ayer 2018).

To address PFAS impacts from operations associated with Fort Devens to the Town of Ayers public supply wells at Grove Pond, the Army conducted a TCRA (USACE 2019). The objective for the TCRA was to remove PFOA/PFOS from water pumped by the Town of Ayer Grove Pond public water supply wells to prevent unacceptable risk to human health. The TCRA included:

- Elimination of the current discharge of Well 8 extracted groundwater impacted by PFOS/PFOA into Grove Pond by installing a temporary treatment system that will reduce PFOS/PFOA from the extracted water. The treated water from Grove Pond Well 8 will then be returned to the Town of Ayer Grove Pond water treatment plant.

- Installation of a permanent drinking water treatment system to address PFOS/PFOA in Grove Pond public drinking water supply wells to ensure that combined PFOS/PFOA levels in drinking water are below 70 ng/L.

The Well 8 temporary treatment system was installed in June 2019. The permanent upgrade to the Grove Pond water treatment plant to address PFOS/PFOA was completed in Fall 2020 and the temporary treatment system has been removed.

The Massachusetts wellhead protection Zones I and II from the public water supplies in the vicinity of Fort Devens are shown on **Figure C-8.** The Phase I RI field investigations conducted between 2018 and 2020 at the Grove Pond wellfield area included collecting groundwater and soil samples from VPBs, sampling new monitoring wells, collecting surface water and sediment samples in Grove Pond, and synoptic water level measurements.

- A total of 221 groundwater samples were collected from 28 VPBs and 13 groundwater samples from new and existing monitoring wells. Of the groundwater samples, results from 47 exceeded USEPA LHA of 70 ng/L and 138 exceeded MassDEP GW-1 criteria. The highest PFAS concentrations in this area were detected at GPVP-18-12 (PFOA + PFOS = 919 ng/L and 1,160 ng/L, sum of six GW-1 compounds). The distribution of PFAS in the Grove Pond Area covers a broad area, and specific source areas have not been identified (KGS 2020b). AOC 74 PFAS contamination appears to cross the MAARNG property on the east side as groundwater migrates toward Grove Pond and the Town of Ayer Grove Pond wellfield. The downgradient extent is undefined as the groundwater migrates toward Grove Pond and the Town of Ayer Grove Pond wellfield. PFAS was not detected at concentrations greater than the USEPA LHA on the north side of Grove Pond. In addition, it appears that a broad portion of the shallow to mid-portion of the aquifer has been impacted by activities on the MAARNG property and legacy Army activities that may have occurred on the Army property to the south. The data from wells installed in bedrock do not suggest a significant impact from PFAS to the groundwater in bedrock at these locations (KGS 2020a).
- Nine soil borings were advanced at the Grove Pond Area to a maximum depth of 38 feet bgs. PFAS were detected at all nine locations sampled. Five of the locations (GPSB-19-01, -02, -05, -07, and -08) exhibited one or more sample intervals with detections of PFAS compounds greater than the S-1/GW-1 standards. Three locations (GPSB-19-01, -05, and -08) exhibited PFAS detected at concentrations greater than the S-1/GW-1 standards in all samples collected from each location with exceedances as deep as 28 feet bgs. All of the samples with PFAS concentrations greater than the S-1/GW-1 standards were collected on MAARNG property at five different locations. These data suggest potential sources of PFAS in the soil within the MAARNG property (KGS 2020a).
- Six surface water and sediment samples were collected in 2018 in Balch and Grove Ponds. All of the PFAS detections in surface water and sediment were below the USEPA site-specific SLs for PFAS at Fort Devens. None of the PFAS compounds in the USEPA site-specific SLs were detected in sediment samples collected from Grove Pond. In Balch Pond, PFOA and PFOS concentrations in the surface water were slightly higher than surface water concentrations in Grove Pond. Also, while no PFAS were detected in Grove Pond sediment samples, PFOA was detected in the sediment sample from Balch Pond. Balch Pond is hydraulically upgradient from Fort Devens (not affected by conditions at Fort Devens) and drains into Grove Pond from the north (KGS 2020a).

C.7 Patton Water Supply Well/AOC 40 Cold Spring Brook Landfill/AREE 61I/61H

C.7.1 Site Location and Historical Use

The Patton water supply well is located in the former North Post (**Figure C-9**) and operated by MassDevelopment as part of the Devens municipal water supply. Patton well is located on property owned by MassDevelopment. North of Patton Road, the land is owned by the Red Tail Golf Course and is undeveloped. To the east of Patton well, the land is sloped steeply upward to portions of the Red Tail Golf Course. To the south and west of Patton well, the land is owned by MassDevelopment, it is undeveloped, and there are steep hills between the well and Mirror Lake to the south. All of the land surrounding Patton well and AOC 40 is zoned as Open Space/Recreational (KGS 2020a).

AOC 40 - Cold Spring Brook Landfill is located along the edge of Patton Road just east of the Patton water supply well (**Figure C-9**). AOC 40 consists of an abandoned 4-acre landfill that was used for the disposal of construction debris (masonry, asphalt, wire and metal), ash, stumps, and logs and that was remediated in 2000 through the removal of debris, contaminated soil, and contaminated sediment (KGS 2019). Portions of the landfill area were situated in a wetland and were subsequently submerged under Cold Spring Brook Pond. North of the pond is a steep wooded slope, on top of which is a portion of Red Tail Golf Course. South of AOC 40 is Patton Road, and further south is another steep wooded slope up to another portion of the Red Tail Golf Course. To the east, Cold Spring Brook Pond empties to Cold Spring Brook under Patton Road. Cold Spring Brook continues to flow to the north. West of AOC 40, the land is owned by the Red Tail Golf Course and is currently undeveloped (KGS 2020a).

Located northwest of the Patton supply well, AREE 61I and AREE 61H were both Reserves Motor Pool facilities initially investigated in 1994. AREE 61H was determined to require no further action (ADL 1995a). A UST at the site was subsequently removed (ADL 1995b). AREE 61I was investigated further (ADL 1995a). Because PFAS have been detected at similar vehicle maintenance or storage areas on Fort Devens, AREE 61I and 61H were included in the PFAS investigation (KGS 2020b).

C.7.2 Previous CERCLA Investigations

The abandoned landfill was discovered in November 1987 when 14 55-gallon drums were uncovered along Cold Spring Brook. An identification number on the drums indicated that the original contents had been antifreeze manufactured by Union Carbide and that they were 15 to 20 years old. In March 1988, the drums were examined by a response team from Union Carbide, New Hampshire. Apparently, the drums had been painted yellow and reused. An RI was completed in 1993 (E&E 1993).

A ROD was issued in July 1999 (HLA 1999) requiring full excavation of AOC 40. Excavated debris, soil, and sediment were consolidated in an on-site landfill built at the former golf course driving range on Patton Road (S&W 2000). Excavation at AOC 40 began in November 2000 and was completed in September 2002. A total of 148,450 cubic yards of debris was removed from AOC 40.

C.7.3 Previous PFAS Investigations

MassDevelopment first sampled the Patton well for PFAS in July 2016. The well was taken out of service in August 2019 after notice that MassDEP was considering adopting a drinking water standard of 20 ng/L for the sum of six PFAS (PFOS, PFOA, PFNA, PFHxS, PFHpA, and PFDA; KGS 2020a).

MassDevelopment installed temporary treatment for PFAS at the Patton well and brought the well back into service in March 2020. MassDevelopment plans to build a permanent treatment system of granular activated carbon (GAC) followed by ion exchange to treat water from Patton and Shabokin water supply wells. MassDevelopment is also planning permanent treatment for iron and manganese using green sand filters. The permanent treatment plant for Patton and Shabokin water supply wells is planned to be online in early 2022 (KGS 2020a).

The Phase 1 RI field investigations conducted between 2018 and 2020 at Patton water supply well/AOC 40/AREE61I/61H included collecting groundwater and soil samples from VPBs, sampling one irrigation well, collecting surface water and sediment samples in Cold Spring Brook, and synoptic water level measurements.

- A total of 84 groundwater samples were collected from 18 VPBs. Of the groundwater samples, results from eight exceeded the USEPA LHA of 70 ng/L, and 42 exceeded MassDEP GW-1 criteria. The maximum concentrations were detected at PWVP-19-04 at the water table (PFOA + PFOS = 394 ng/L, sum of the six GW-1 compounds + 607 ng/L, 22-26 feet bgs; KGS 2020a). Based on the AOC 40 RI, groundwater on the west side of Cold Spring Brook Pond is flowing west toward Patton well, and groundwater on the east side of Cold Spring Brook Pond is flowing to the east toward Cold Spring Brook (E&E 1993). This flow seems to be confirmed, as the highest PFAS concentrations were detected at PWPV-19-04 and -13, west of Cold Spring Brook Pond, and at PWVP-19-06 and -11, east of Cold Spring Brook Pond. Results from locations to the north and south of the highest concentrations were less than the USEPA LHA (KGS 2020a).
- Four soil borings were advanced at AOC 40 to a maximum depth of 21.5 feet bgs. Three of the locations exhibited one or more sample intervals with detections of PFAS compounds greater than the S-1/GW-1 standards. The locations west of the debris removal area at AOC 40 exhibited lower PFAS concentrations, and only one sample exhibited PFDA at a concentration that was greater than the MassDEP S-1/GW-1 standards. These data suggest potential sources of PFAS in the soil east of the debris removal area at AOC 40 (KGS 2020a).
- Five surface water and sediment sample pairs were collected in 2020 associated with Patton well/AOC 40: three in Cold Spring Brook Pond, one in the upper reaches of Cold Spring Brook, and one in Mirror Lake. All of the PFAS detections in surface water and sediment were below the USEPA site-specific SLs for PFAS at Fort Devens. In Cold Spring Brook Pond, PFOA and PFOS concentrations in the surface water and sediment were slightly higher than concentrations in Cold Spring Brook, suggesting a potential source of PFAS in the vicinity of Cold Spring Brook Pond. In Mirror Lake, the PFAS concentrations for the surface water sample were PFOA = 12.0 ng/L, PFOS = 11.0 ng/L, PFBS = 1.10J ng/L, and there were no detections of PFAS in the sediment sample (KGS 2020a).

C.8 Shabokin Water Supply Well

C.8.1 Site Location and Historical Use

The Shabokin water supply well is located in the former North Post (**Figure C-10**) and operated by MassDevelopment as part of the Devens municipal water supply.

C.8.2 Previous PFAS Investigations

MassDevelopment first sampled the Shabokin water supply well for PFAS in July 2016. MassDevelopment installed a GAC treatment system at the Shabokin well to remove PFAS in September 2019. As discussed above, MassDevelopment plans to build a permanent treatment system using GAC followed by ion exchange to treat water from Patton and Shabokin water supply wells. The permanent treatment plant for Patton and Shabokin water supply wells is planned to be online in early 2022.

The Phase 1 RI field investigations conducted between 2018 and 2020 at the Shabokin water supply well included collecting groundwater samples from VPBs, sampling of a new monitoring well, and synoptic water level measurements.

- A total of 47 groundwater samples were collected from seven VPBs and one new monitoring well. Of the groundwater samples, no sample results exceeded the USEPA LHA of 70 ng/L, and 20 exceeded MassDEP GW-1 criteria. The maximum concentrations were detected at SWVP-20-04 (48.3 ng/L, sum of the six GW-1 compounds, 64 to 68 feet bgs). Based on the lack of any knowledge of historical AFFF use, storage, disposal in areas around the Shabokin well, and the broad occurrence of lower PFAS concentrations (below the USEPA LHA and below 50 ng/L for the sum of the six GW-1 compounds) around the Shabokin well, a primary source of the PFAS impact to the Shabokin well has not been identified (KGS 2020a).

Appendix D

USEPA Region 1 Site-Specific Screening Levels (2023)

Site-specific Screening Levels for PFOA, PFOS, PFBS, PFNA, PFHxS, HFPO-DA, PFBA, and PFHxA for the Fort Devens NPL Site, June 2023, calculated using USEPA Regional Screening Level (RSL) Calculator based on May 2023 USEPA RSLs.

Included with USEPA comments on the Draft Final Devens Area 1 Phase II PFAS Remedial Investigation Work Plan.

Summary of Updated PFAS Site-Specific Screening Levels for Ft. Devens based on EPA's latest toxicity values availablefor PFAS

Receptor [Exposure Route & Medium]	Adult								Child							
	PFOA	**PFOS**	**PFBS**	**PFNA**	**PFHxS**	**HFPO-DA (GenX)**	**PFBA**	**PFHxA**	**PFOA**	**PFOS**	**PFBS**	**PFNA**	**PFHxS**	**HFPO-DA (GenX)**	**PFBA**	**PFHxA**
Child Resident [dermal + ingestion, soil] (mg/kg)									**1.90E-02**	**1.26E-02**	**1.90E+00**	**1.90E-02**	**1.26E-01**	2.35E-02	7.82E+00	**3.16E+00**
Child Resident [ingestion, groundwater] (ug/L)									6.02E-03	4.01E-03	6.01E-01	5.89E-03	3.94E-02	6.02E-03	1.85E+00	9.92E-01
Child Recreator [dermal + ingestion, sediment] (mg/kg)									**9.14E-02**	**6.09E-02**	**9.14E+00**	**9.14E-02**	**6.09E-01**	1.10E-01	3.65E+01	**1.52E+01**
Child Recreator [ingestion + dermal, surface water] (ug/L)									**3.04E-01**	**2.03E-01**	**3.04E+01**	**2.87E-01**	**1.93E+00**	3.04E-01	1.01E+02	**4.92E+01**
Commercial Worker [ingestion + dermal, soil] (mg/kg)	**2.46E-01**	**1.64E-01**	**2.46E+01**	**2.46E-01**	**1.64E+00**	3.50E-01	1.17E+02	**4.10E+01**								
Commercial Worker [ingestion, groundwater] (ug/L)	3.50E-02	3.50E-02	3.50E+00	3.50E-02	2.34E-01	3.50E-02	1.17E+01	5.84E+00								
Fish Consumption [in fish tissue] (mg/kg)	1.19E-03	7.95E-04	1.19E-01	1.19E-03	7.95E-03	1.19E-03	3.97E-01	1.99E-01	9.20E-04	6.13E-04	9.20E-02	9.20E-04	6.13E-03	9.20E-04	3.07E-01	1.53E-01
Construction Worker [ingestion + dermal, soil] (mg/kg)	**8.04E-02**	**5.36E-02**	**8.04E+00**	**8.04E-02**	**5.36E-01**	1.06E-01	3.54E+01	**1.34E+01**								

* **BOLD** values indicates SL for combined dermal and ingestion route.

PD Updated June 13, 2023

Table 1. Screening Levels for PFOA, PFOS, PFBS, PFNA, PFHxS, and HFPO-DA(GenX) in soil and groundwater for Residential Child

		Exposure	PFOA	PFOS	PFBS	PFNA	PFHxS	PO-DA (Ge	Units	THQ	EF	ED	SA	BW	IRW	IRS	AT-N	CFS	CFW	RfD (mg/kg-d)						GIABS	ABS	AF
Receptor	**Exposure Route**	**Medium**	**SL**	**SL**	**SL**	**Sl**	**SL**	**SL**		**(unitless)**	**(d/yr)**	**(yr)**	**(cm^2)**	**(kg)**	**(L/d)**	**(mg/d)**	**(days)**	**(kg/mg)**	**(µg/mg)**	**PFOA**	**PFOS**	**PFBS**	**PFNA**	**PFHxS**	**O-DA (Ge**	**(unitless)**	**(unitless)**	**(mg/cm^2)**
Child Resident	ingestion	soil	2.35E-02	1.56E-02	2.35E+00	2.35E-02	1.56E-01	2.35E-02	mg/kg	0.1	350	6		15		200	2190	1.0E-06		3.0E-06	2.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06	1	0.1	
Child Resident	dermal	soil	9.89E-02	6.59E-02	9.89E+00	9.89E-02	6.59E-01	-	mg/kg	0.1	350	6	2373	15			2190	1.0E-06		3.0E-06	2.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06	1	0.1	0.2
Child Resident	ingestion + dermal	soil	**1.90E-02**	**1.26E-02**	**1.90E+00**	**1.90E-02**	**1.26E-01**	**2.35E-02**	mg/kg	0.1	350	6	2373	15		200	2190	1.0E-06		3.0E-06	2.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06	1	0.1	0.2
Child Resident	ingestion	groundwater	**6.02E-03**	**4.01E-03**	**6.02E-01**	**6.02E-03**	**4.01E-02**	**6.02E-03**	µg/L	0.1	350	6		15	0.78		2190		1.0E+03	3.0E-06	2.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06			

**Screening levels are calculated using the EPA RSL calculator.*

Bold SL=Selected Screening Levels for Use

PFOA = Perfluorooctanoic acid

PFOS = Perfluorooctanesulfonic acid

PFBS = Perfluorobutanesulfonic acid

PFNA = Perfluorononanoic acid

PFHxS = Perfluorohexanesulfonic acid

HFPO-DA = Hexafluoropropylene oxide dimer acid (and its ammonium salt), (also sometimes referred to as GenX chemicals)

SL	Screening Level
THQ	Target Hazard Quotient
EF	Exposure Frequency
ED	Exposure Duration
SA	Skin Surface Area
BW	Body Weight
IRW	Drinking Water Ingestion Rate
IRS	Soil Ingestion Rate
AT-N	Non-Cancer Averaging Time
CFS	Soil Conversion Factor
CFW	Water Conversion Factor
RfD	Reference Dose
AF	Adherence Factor
GIABS	GI Absorption Factor

Table 2. Screening Levels for PFOA, PFOS, PFBS, PFNA, PFHxS, and HFPO-DA(GenX) in Sediment and Surface Water for Child Recreator

Receptor	**Exposure Route**	**Exposure Medium**	**PFOA SL**	**PFOS SL**	**PFBS SL**	**PFNA SL**	**PFHxS SL**	**HFPO-DA (GenX) SL**	**Units**	**THQ (unitless)**	**EF (d/yr)**	**ED (yr)**	**SA (cm^2)**	**BW (kg)**	**IRW (L/d)**	**IRS (mg/d)**	**AT-N (days)**	**CFS (kg/mg)**	**CFW (mg/µg)**	**RfD (mg/kg-d**						**AF (mg/cm^2)**	**ABS (unitless)**	**GIABS (unitless)**
																				PFOA	**PFOS**	**PFBS**	**PFNA**	**PFHxS**	**PO-DA(Ger**			
Child Recreator	ingestion	sediment	1.10E-01	7.30E-02	1.10E+01	1.10E-01	7.30E-01	1.10E-01	mg/kg	0.1	75	6		15		200	2190	1.0E-06		3.0E-06	2.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06	0.2	0.1	0.2
Child Recreator	dermal	sediment	5.53E-01	3.69E-01	5.53E+01	5.53E-01	3.69E+00	-	mg/kg	0.1	75	6	1978.61	15		200	2190	1.0E-06		3.0E-06	2.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06	0.2	0.1	0.2
Child Recreator	ingestion + dermal	sediment	**9.14E-02**	**6.09E-02**	**9.14E+00**	**9.14E-02**	**6.09E-01**	**1.10E-01**	mg/kg	0.1	75	6	1978.61	15		200	2190	1.0E-06		3.0E-06	2.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06	0.2	0.1	0.2
Child Recreator	ingestion	surface water	3.04E-01	2.03E-01	3.04E+01	3.04E-01	2.03E+00	3.04E-01		0.1	45	6		15	0.12		2190		1.0E-03	3.0E-06	2.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06			
Child Recreator	dermal	surface water	-	-	1.54E+04	5.19E+00	4.03E+01	-		0.1	45	6		15	0.12		2190		1.0E-03	3.0E-06	2.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06			
Child Recreator	ingestion+dermal	surface water	**3.04E-01**	**2.03E-01**	**3.04E+01**	**2.87E-01**	**1.93E+00**	**3.04E-01**	µg/L	0.1	45	6		15	0.12		2190		1.0E-03	3.0E-06	2.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06			

**Screening levels are calculated using the EPA RSL calculator.*

**SA was modified to 1978.61 cm^2 to reflect wading child, calculated as a time-weighted average of the surface area of legs and feet for children ages 0 to 6.*

**Defaults for EF obtained from RAIS Tool*

Bold SL= Selected Screening Levels for Use
PFOA = Perfluorooctanoic acid
PFOS = Perfluorooctanesulfonic acid
PFBS = Perfluorobutanesulfonic acid
PFNA = Perfluorononanoic acid
PFHxS = Perfluorohexanesulfonic acid
HFPO-DA = Hexafluoropropylene oxide dimer acid (and its ammonium salt), (also sometimes referred to as GenX chemicals)

SL	Screening Level
THQ	Target Hazard Quotient
EF	Exposure Frequency
ED	Exposure Duration
SA	Skin Surface Area
BW	Body Weight
IRW	Drinking Water Ingestion Rate
IRS	Soil Ingestion Rate
AT-N	Non-Cancer Averaging Time
CFS	Soil Conversion Factor
CFW	Water Conversion Factor
RfD	Reference Dose
AF	Adherence Factor

Table 3. Screening Levels for PFOA, PFOS, PFBS, PFNA, PFHxS and HFPO-DA (GenX) in Soil and Groundwater for Commercial Worker

		Exposure	PFOA	PFOS	PFBS	PFNA	PFHxS	HFPO-DA (GenX)	Units	THQ	EF	ED	SA	BW	IRS	IRW	AT-N	CFS	CFW		RfD (mg/kg-d					ABS	GIABS	AF
Receptor	**Exposure Route**	**Medium**	**SL**	**SL**	**SL**	**SL**	**SL**	**SL**		**(unitless)**	**(d/yr)**	**(yr)**	**(cm^2)**	**(kg)**	**(mg/d)**	**(L/d)**	**(days)**	**(kg/mg)**	**(µg/mg)**	**PFOA**	**PFOS**	**PFBS**	**PFNA**	**PFHxS**	**HFPO-DA (G**	**(unitless)**	**(unitless)**	**(mg/cm^2)**
Commercial Worker	ingestion	soil	3.50E-01	2.34E-01	3.50E+01	3.50E-01	2.34E+00	3.50E-01	mg/kg	0.1	250	25		80	100		9125	1.0E-06		3.0E-06	2.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06		1	
Commercial Worker	dermal	soil	8.28E-01	5.52E-01	8.28E+01	8.28E-01	5.52E+00	-	mg/kg	0.1	250	25	3527	80			9125	1.0E-06		3.0E-06	2.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06	0.1	1	0.12
Commercial Worker	ingestion + dermal	soil	**2.46E-01**	**1.64E-01**	**2.46E+01**	**2.46E-01**	**1.64E+00**	**3.50E-01**	mg/kg	0.1	250	25	3527	80	100		9125	1.0E-06		3.0E-06	3.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06	0.1	1	0.12
Commercial Worker	ingestion	groundwater	**3.50E-02**	**3.50E-02**	**3.50E+00**	**3.50E-02**	**2.34E-01**	**3.50E-02**	µg/L	0.1	250	25		80		1	9125		1.0E+03	3.0E-06	3.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06			

**Screening Levels calculated using formulas below, equations are from the RSL Calculator. Expsoure default parameters used for commercial worker.*

Soil Ingestion SL = (THQ*AT*BW)/(EF*ED*(1/RfD)*IRS*CFS)

Soil Dermal SL = (THQ*AT*BW)/(EF*ED*((1/RfD)*GIABS)*SA*AF*ABS*CFS))

Soil Ingestion + Dermal S 1/((1/Ingestion SL)+(1/Dermal SL))

Groundwater Ingestion S (THQ*AT*BW*CFW)/(EF*ED*(1/RfD)*IRW)

Bold SL = Selected Screening Levels for Use
PFOA = Perfluorooctanoic acid
PFOS = Perfluorooctanesulfonic acid
PFBS = Perfluorobutanesulfonic acid
PFNA = Perfluorononanoic acid
PFHxS = Perfluorohexanesulfonic acid
HFPO-DA = Hexafluoropropylene oxide dimer acid (and its ammonium salt), (also sometimes referred to as GenX chemicals)

SL	Screening Level
THQ	Target Hazard Quotient
EF	Exposure Frequency
ED	Exposure Duration
SA	Skin Surface Area
BW	Body Weight
IRW	Drinking Water Ingestion Rate
IRS	Soil Ingestion Rate
AT-N	Non-Cancer Averaging Time
CFS	Soil Conversion Factor
CFW	Water Conversion Factor
RfD	Reference Dose
AF	Adherence Factor

Table 4. Screening Levels for PFOA, PFOS, PFNA, PFHxS, HFPO-DA and PFBS in fish using HQ 0.1

Chemical	**SL Adult Fish Consumption¹ (mg/kg) IRF = 21,000 mg/d**	**SL Child Fish Consumption¹ (mg/kg) IRF = 5,100 mg/c**	**THQ (unitless)**	**AT-N (days)**	**BW Adult (kg)**	**BW Child (kg)**	**EF (d/yr)**	**ED Adult (yr)**	**ED Child (yr)**	**RfD (mg/kg-d)**
PFOA	1.19E-03	9.20E-04	0.1	365	80	15	350	20	6	3.0E-06
PFOS	7.95E-04	6.13E-04	0.1	365	80	15	350	20	6	2.0E-06
PFBS	1.19E-01	9.20E-02	0.1	365	80	15	350	20	6	3.0E-04
PFNA	1.19E-03	9.20E-04	0.1	365	80	15	350	20	6	3.0E-06
PFHxS	7.95E-03	6.13E-03	0.1	365	80	15	350	20	6	2.0E-05
HFPO-DA (GenX)	1.19E-03	9.20E-04	0.1	365	80	15	350	20	6	3.0E-06

**Screening levels are calculated using fish ingestion rates from NHANES and the EPA RSL calculator.*

Bold SL=Selected Screening Levels for Use (HQ=0.1)
PFOA = Perfluorooctanoic acid
PFOS = Perfluorooctanesulfonic acid
PFBS = Perfluorobutanesulfonic acid
PFNA = Perfluorononanoic acid
PFHxS = Perfluorohexanesulfonic acid
HFPO-DA = Hexafluoropropylene oxide dimer acid (and its ammonium salt), (also sometimes referred to as GenX chemicals)

SL	Screening Level
IRF	Fish ingestion rate
THQ	Target Hazard Quotient
AT-N	Non-cancer averaging time
BW	Body weight
EF	Exposure Frequency
ED	Exposure Duration
RfD	Reference Dose

[1] EPA (April 2014) Estimated Fish Consumption Rates for the U.S. Population and Selected Subpopulations (NHANES 2003-2010) Final Report

Table 5. Screening Levels for PFOA, PFOS, PFBS, PFNA, PFHxS and HFPO-DA (GenX) in Soil Construction Worker

		Exposure	**PFOA**	**PFOS**	**PFBS**	**PFNA**	**PFHxS**	**HFPO-DA (GenX)**	**Units**	**THQ**	**EF**	**ED**	**SA**	**BW**	**IRS**	**AT-N**	**CFS**	**RfD (mg/kg-d)**						**ABS**	**GIABS**	**AF**
Receptor	**Exposure Route**	**Medium**	**SL**	**SL**	**SL**	**SL**	**SL**	**SL**		**(unitless)**	**(d/yr)**	**(yr)**	**(cm^2)**	**(kg)**	**(mg/d)**	**(days)**	**(kg/mg)**	**PFOA**	**PFOS**	**PFBS**	**PFNA**	**PFHxS**	**HFPO-DA**	**(unitless)**	**(unitless)**	**(mg/cm^2)**
Construction Worker	ingestion	soil	1.06E-01	7.08E-02	1.06E+01	1.06E-01	7.08E-01	1.06E-01	mg/kg	0.1	**250**	1		80	**330**	**365**	1.0E-06	3.0E-06	2.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06		1	
Construction Worker	dermal	soil	3.31E-01	2.21E-01	3.31E+01	3.31E-01	2.21E+00	3.31E-01	mg/kg	0.1	**250**	1	3527	80		**365**	1.0E-06	3.0E-06	2.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06	0.1	1	0.3
Construction Worker	ingestion + dermal	soil	**8.04E-02**	**5.36E-02**	**8.04E+00**	**8.04E-02**	**5.36E-01**	**8.04E-02**	mg/kg	0.1	**250**	1	3527	80	**330**	**365**	1.0E-06	3.0E-06	2.0E-06	3.0E-04	3.0E-06	2.0E-05	3.0E-06	0.1	1	0.3

**Screening Levels calculated using formulas below, equations are from the RSL Calculator. Expsoure default parameters used for consturction worker.*

Bold SL	Selected Screening Levels for Use

Soil Ingestion SL = (THQ*AT*BW)/(EF*ED*(1/RfD)*IRS*CFS)

Soil Dermal SL = (THQ*AT*BW)/(EF*ED*((1/RfD)*GIABS)*SA*AF*ABS*CFS))

Soil Ingestion + Derma 1/((1/Ingestion SL)+(1/Dermal SL))

PFOA = Perfluorooctanoic acid
PFOS = Perfluorooctanesulfonic acid
PFBS = Perfluorobutanesulfonic acid
PFNA = Perfluorononanoic acid
PFHxS = Perfluorohexanesulfonic acid
HFPO-DA = Hexafluoropropylene oxide dimer acid (and its ammonium salt), (also sometimes referred to as GenX chemicals)

SL	Screening Level
THQ	Target Hazard Quotient
EF	Exposure Frequency
ED	Exposure Duration
SA	Skin Surface Area
BW	Body Weight
IRS	Soil Ingestion Rate
AT-N	Non-Cancer Averaging Time
CFS	Soil Conversion Factor
RfD	Reference Dose
AF	Adherence Factor

Appendix E

Regional Groundwater Flow Model of the Former Fort Devens, Massachusetts

Regional Groundwater Flow Model of the Former Fort Devens, Massachusetts

S.S. PAPADOPULOS & ASSOCIATES, INC.
Environmental & Water-Resource Consultants

SERES
Engineering & Services, LLC
ARCADIS
a joint venture

November 22, 2022

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List of Acronyms

AOC	Area of Concern
CHD	Constant-Head (package - MODFLOW)
CLN	Connected Linear Network (package - MODFLOW)
DRN	Drain (package - MODFLOW)
ETA	Engineering Technologies Associates, Inc.
GWF	Groundwater Flow (process)
HSU	hydrostratigraphic unit
HUF	Hydrogeologic-Unit Flow (package - MODFLOW)
LAK	Lake (package - MODFLOW)
LHA	lifetime health advisory
MNW	Multi-Node Well (package)
PVC	polyvinyl chloride
RIV	River (package - MODFLOW)
S-A JV	SERES-Arcadis 8(a) Joint Venture 2, LLC
SFR	Streamflow-Routing (package - MODFLOW)
SHL	Shepley's Hill Landfill
SSP&A	S.S. Papadopulos & Associates, Inc.
PFAS	per- and polyfluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WEL	Well (package - MODFLOW)
WWTP	wastewater treatment plant

REPORT

Section 1
Introduction

S.S. Papadopulos and Associates, Inc. (SSP&A), as a subcontractor to SERES-Arcadis 8(a) Joint Venture 2, LLC (S-A JV), prepared this report on behalf of the United States Army Corps of Engineers, New England District to document a regional numerical groundwater model of the former Fort Devens U.S. Army post in Worcester and Middlesex counties in central Massachusetts (Figure 1). The model was developed to (a) combine conceptual and structural details from existing regional and local models encompassing the area within, and extending beyond, the former Fort Devens U.S. Army post footprint; and (b) calculate groundwater flow paths within the overburden sands throughout the facilities. Areas identified as being contaminated with per- and polyfluoroalkyl substances (PFAS) on the Former Fort Devens were grouped into three focus areas (Figure 2). However, flow-path analyses were conducted on areas with perfluorooctane sulfonate/ perfluorooctanoic acid (PFOS/PFOA) contamination in Focus Area 1, on the former Main Post.

The model was constructed using USG-Transport (Panday, 2020) to take advantage of its unstructured grid capabilities, specifically a quad-tree grid type for targeted grid refinement, and the Connected Linear Network (CLN) package to simulate surface water features. The model was calibrated using PEST_HP (Watermark Numerical Computing, 2020a) and pilot-point techniques. Flow paths were calculated using mod-PATH3DU (SSP&A, 2020). The model domain for this groundwater model encompasses approximately 60 square miles centered about the former Fort Devens as shown on Figure 2.

The foundation for the models currently in use for groundwater investigations throughout the former Fort Devens is a regional groundwater flow model developed in 1993 by Engineering Technologies Associates, Inc. (ETA). The purpose of this model was to calculate directions and velocities of groundwater flow to assist in the evaluation of impacts to groundwater quality from contaminated areas (ETA, 1993). Subsequently, models of the former South Post (1994) and Main and North Posts (1995) were developed by ETA. The purpose of these models was the same, but with a focus on their respective areas (ETA, 1994 and 1995). Arcadis (2002) developed a local-scale groundwater flow and transport model of the former North Post, focusing on the Area of Concern 50 (AOC 50) area, that was used to assist in the development and evaluation of alternative remedies to address contaminated groundwater. In 2013 Sovereign Consulting Inc. modified a groundwater model developed in the mid-1990's of the area around the Shepley's Hill Landfill (SHL). The purpose of this model was to evaluate arsenic migration in groundwater (Sovereign, 2013). Since 2016, Geosyntec Consultants have maintained and updated this model to support and evaluate existing and proposed remedies at the Shepley's Hill Landfill (Geosyntec, 2016 and 2020). The extent of each of these models is shown in Figure 2. The current model domain is similar to the area of the 1993 Regional Model but extends further to the east, to include the Bowers Brook watershed, and to the north, to include Flannagan Pond and Lower Long Pond.

The hydrogeology of the model domain and conceptualization of groundwater flow are well documented in the previous modeling studies and formed the foundation of the development of this model. In particular, ETA (1993) and ETA (1995) were the two models that the current model primarily relied upon because they contain excellent summaries of regional groundwater flow characteristics.

Section 2
Hydrogeologic Setting

2.1 Surface Water and Drainage

The former Fort Devens is in the watershed of the Nashua River, which is a tributary of the Merrimack River. The North Nashua River is in the western extent of the former South Post, it flows southeast into the Nashua River, which flows north and is the eastern extent of the former South Post and the western extent of the former Main and North Posts (Figure 3a). The model domain, on the eastern side, also includes a portion of the Bennett's Brook watershed, which is outside of the Nashua River watershed. The Nashua River watershed in the model domain is punctuated throughout by small drainages consisting of creeks, ponds, lakes, and wetlands. Approximately 125 miles of river and creeks, 1,000 acres of ponds and lakes, and 4,000 acres of wetlands, have been mapped within the extent of the model, these features are shown on Figure 3b. Representation of these features in a groundwater model is important because, conceptually, the flow of groundwater is from recharged upland areas to these surface-water bodies (ETA, 1993).

2.2 Hydrostratigraphy

The geologic setting of the model area consists of glacial-derived overburden materials, overlying glacial till and igneous and metamorphic bedrock. The bedrock surface is an eroded and irregular surface. It includes elevated upland areas with exposed or nearly-exposed bedrock, and lowland areas where the bedrock surface has been eroded and overlain by fluvial, glaciofluvial, and glacial sediments. A map of the bedrock surface was developed by S-A JV (2020a) and is shown in Appendix H, Figure H.1. The glacial deposits include Pleistocene-age glacial till that was deposited on the bedrock surface and overburden material, which includes glaciofluvial and ice-contact deposits that were deposited above the till and bedrock (Jahns, 1953, and Stone et al., 2018).

The eastern portion of the model domain consists of an upland bedrock area with a veneer of glacial till. In most upland areas, the till is thin but isolated pockets of thick till occur and are associated with glacial drumlins (Jahns, 1953). The western part of the model area is underlain predominantly by coarse-grained glaciofluvial overburden deposits, filling in ancestral bedrock valleys (Stone et al., 2018). Till underlies the overburden throughout much of the model area. A geologic map of surficial deposits is shown in Figure 7.

The conceptualization of the regional hydrostratigraphy is the same as in the previous models: a coarse-grained glacial outwash (overburden) aquifer of variable thickness underlain by a till of nominal thickness (in most areas), both of which overly bedrock, the upper 50 feet of which is weathered. Groundwater flow occurs primarily in the overburden materials with flow limited in the underlying bedrock. The uppermost bedrock is weathered, based on log descriptions, and some groundwater flow likely occurs within the weathered bedrock zone, but groundwater flow in the underlying crystalline bedrock is limited to non-existent.

Both the 1993 regional and 1994 South Post models had two layers; the first layer represented the glacial outwash aquifer and the second the weathered bedrock. The 1995 model of the Main and North Posts had 3 layers; the glacial outwash aquifer was represented by two model layers to account for localized areas where deeper and thicker gravel deposits were present, while the third layer represented the weathered bedrock. The till was represented implicitly in these three models as an aquitard. Arcadis (2002) had five model layers. The first three represented the overburden sands, the fourth explicitly represented the till deposits as they were mapped to be thicker here, and the fifth represented the weathered bedrock. The Geosyntec (2020) model of the Shepley's Hill Landfill area has six model layers. The first five layers are consistent with the layering in Arcadis (2002), while the sixth explicitly represented 200 feet of competent bedrock.

Section 3
Model Structure

The groundwater flow model was implemented using USG-Transport v.1.5.0, a finite difference flow simulation code originally developed by the U.S. Geological Survey (USGS) as MODFLOW-USG, but is currently maintained by its author, Sorab Panday, for GSI Environmental Inc. (Panday et al., 2017; Panday, 2020). Only standard features in USG-Transport were implemented and are discussed in the following sections. The structure of the groundwater flow model is described in this section. A steady-state model was developed to be representative of average flow conditions.

3.1 Grid

The finite-difference model grid encompasses an area of approximately 60 square miles as shown on Figure 2. The extents of the model correspond to natural barriers to groundwater flow where the regional bedrock is at or near the surface; thus, the model is bounded by implicit no-flow boundaries. The model domain is similar to the area of the 1993 Regional Model but extends further to the east, to include the Bowers Brook watershed, and to the north, to include Flannagan Pond and Lower Long Pond.

The model was developed based upon the Massachusetts (Mainland) State Plane coordinate system in US feet, referenced to the North American Datum of 1983 (NAD83). The offset for the lower-left corner of the model grid is 594440.0 feet in the x-direction and 2981380.0 in the y-direction. There is no rotation.

3.1.1 Discretization

A quadtree grid[1] was used to focus cell refinement along surface water features, near pumping and monitoring wells, and around other features in key areas of the model domain like bedrock outcrops and the barrier wall installed as part of the SHL remediation system. The USGS quadtree grid generation program, GRIDGEN (Lien et al., 2015), was used to create the grid. The model grid is shown in Figures 4a and 4b. All grid cells are square and range in width from 2.5 feet along the SHL barrier wall to a maximum of 640 feet in areas off-base. On the former South and North Posts (Insets A, B, and C of Figure 4b), the largest cell is 320 feet wide, with refinement to 160 feet along the Nashua River and 80 feet along tributaries on the former North Post. Cells are refined to 40 feet around ponds and lakes, and 10 feet around pumping and monitoring wells. On the former Main Post, the largest cell size is 320 feet, with the southern portion within Focus Area 1 refined to 160 feet (Inset D of Figure 4b). Cells along and around surface water features are, at most, 40 feet and are 10 feet around pumping and monitoring wells.

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[1] A quadtree grid is comprised of square or rectangular cells in which a quadrant can be recursively subdivided.

3.1.2 Layering

There are 8 model layers. The upper 7 correspond to one or a combination of the overburden sands, till or bedrock, while layer 8 represents at least 200 feet of lower (competent) bedrock.

The existing models were developed using a terrain following grid concept in which layers represent a dominant hydrostratigraphic unit (HSU) and their respective elevations follow those mapped for that unit. An alternative approach is described by Anderman and Hill (2000) for the MODFLOW Hydrogeologic-Unit Flow (HUF) package[2]. In this package, the properties of the HSUs are apportioned to different layers based on their relative thickness. Here, a hybrid approach is used in which the available thickness between the ground surface and top of competent bedrock is distributed equally between the first 6 model layers; thus, layer thickness varies spatially, but for a given point, the first 6 layers have the same thickness. The aquifer properties in each cell are determined by the relative thickness of overburden, till, or upper bedrock within the cell using the approach described by Anderman and Hill (2000).

This HUF approach was used here primarily because both unit thickness and hydraulic conductivity can be parameterized to calibrate aquifer transmissivity. When using a terrain following grid, structure thickness is fixed, and hydraulic conductivity can take on a surrogate role accounting for both hydraulic conductivity and unit thickness. Further, because HSUs are not represented by a fixed number of layers, the principal unit in an area is represented by the most layers: where overburden is the dominant unit along the deeper river and creek corridors it is represented by up to 6 layers (layer 7 being upper bedrock and layer 8 being lower bedrock, both of which, conceptually, are present everywhere), and on the east side of Bowers Brook where there is little to no overburden, the available till and bedrock are represented by up to 7 layers (layer 8 being lower bedrock). The percent bedrock in each model layer are shown in Appendix A. The maps in Appendix A were generated by calculating the relative proportion of bedrock in each model cell, based on its top and bottom elevation and the bedrock surface elevation (if present) and the assumed thickness.

A map of till thickness was produced by combining data from a variety of sources. Till thickness was previously mapped by Arcadis (2002) for the former North Post, and by Geosyntec (2020) for the model of the SHL. A point data set of till thickness was developed from the following sources:

- Till thickness at the cell centers of the Arcadis (2002) model,
- Till thickness picks identified by Geosyntec (2020) and shown on Figure 5-3 of that report,

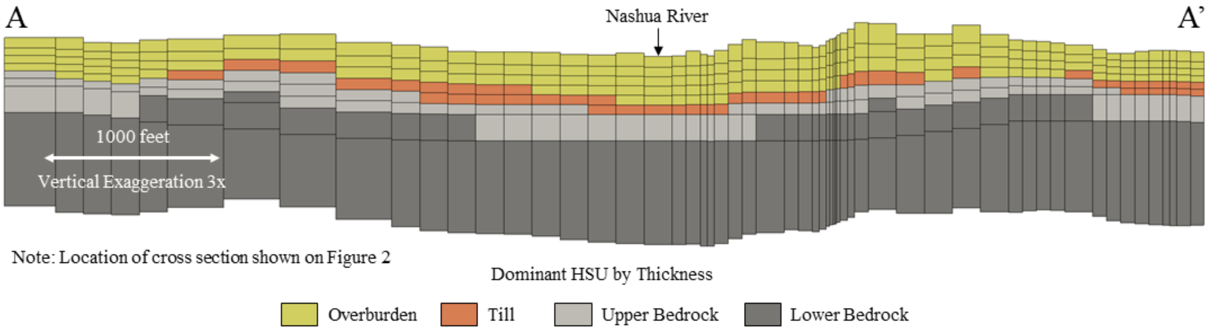
---

[2] The HUF package is not available for USG-Transport. A pre-processing script was developed to implement the necessary features of the package for use here.

- Point data from lithologic borehole logs[3] where a compact till[4] above the bedrock was identified.

This point data set was interpolated to a fine, regular grid, using simple kriging with a mean of 5 feet[5], and then augmented in areas mapped as surficial till with the thickness calculated by subtracting the bedrock surface from the LIDAR surface provided by S-A JV (2020b). The resulting thickness map is shown on Figure 5. The thickness of the overburden was calculated by subtracting the till thickness from the difference between the LIDAR and bedrock surfaces and is shown on Figure 6.

The elevations for each model layer were calculated as follows. The ground surface elevation, top of model layer 1, was derived from a LIDAR surface developed for the model extent by S-A JV (2020b) and is shown in Appendix H, Figure H.2. The bedrock surface map developed by S-A JV (2020a) represents the top of the upper (weathered) bedrock. The upper bedrock is 50 feet thick everywhere, as such, the bottom of the competent bedrock was calculated by subtracting 250 feet from the top of the upper bedrock surface; this surface was assigned to the bottom of model layer 8. The elevations of layers 2 through 6 were calculated by equally distributing the available thickness between the ground surface and top of bedrock after lightly smoothing[6] each. The top of layer 7 corresponds to the smoothed top of bedrock surface, while the bottom of layer 7 is 50 feet below that. An example cross section through the former North Post showing model layers and the corresponding dominant HSU in each model cell is shown on the figure below.



3.2 Boundary Conditions

3.2.1 Surface Water Features

The myriad surface water features identified within the model domain are all simulated using the CLN package (Figures 4a and 4b). As the name suggests, this package provides a generic framework to represent connected features. It is a separate flow process that is solved

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[3] Source: Arcadis (email July 29, 2020); Area 1 Geology Workbook rev3.xlsx, Area 2 Geology Workbook_rev1.xlsx, and Area 3 Geology Workbook_rev1.xlsx.

[4] Two types of till are described in Jahns (1953) – one a hard compacted till and the other a loose poorly-compacted till.

[5] The assumed till thickness specified in ETA (1993).

[6] Arcmap tool – Focal Statistics

simultaneously with the Groundwater Flow (GWF) process. Different CLN to GWF connectivity options give the CLN package the flexibility to simulate a variety of features like multi-aquifer pumping wells[7], rivers, lakes, or wetlands. The Thiem equation can be used for wells or a leakance term for rivers and lakes (Panday, 2020). Further, because it is a separate flow system, boundary conditions can be applied to it, independent of the GWF system. The well (WEL) package was used to represent the net of precipitation and potential evapotranspiration, and the Constant-Head (CHD) package was used to represent the stages of the Nashua River and Bennett's Brook where they intersect the boundary of the model domain. The outlet stages were estimated from the LIDAR surface and are 198.5 feet for the Nashua River, and 261 feet for Bennett's Brook (Figure 4a).

The interconnectivity of CLN cells (or nodes) is specified using the same approach as the unstructured discretization package for the GWF system, namely, for each CLN cell, there is a listing of those cells to which it is connected. This flexibility allows for a surface water network that can better represent the interconnectivity of rivers, creeks, ponds, lakes, and wetlands than is possible with the boundary packages commonly used with other MODFLOW versions, like the River (RIV), Drain (DRN), Streamflow-Routing (SFR) or Lake (LAK) packages. Specifically, here, much of the Nashua River and its tributaries flow through low-lying wetland areas that can be significant groundwater discharge areas. Simulating this interaction is cumbersome using other boundary packages because they only allow for a single inlet and outlet for a given length of river. With the CLN package, for example, a river CLN cell flowing through a low-lying area can be connected to wetland CLN cells on either side. Further, the CLN package is flow conserved and can simulate flow-through features like ponds and lakes, for which the net exchange of groundwater is zero.

For surface water features, the input parameters for the CLN package are consistent with the RIV, DRN, SFR and LAK packages. These parameters are GWF cell (location), river or lakebed elevation, and conductance (C) terms: bed length (L), width (wetted perimeter, P_w), thickness (b), and vertical hydraulic conductivity (k). A schematic illustrating these conductance terms is shown on the next page. Use of the CLN package to represent different surface water feature types is detailed in Muffels et al. (2022). GIS shapefiles delineating each surface water feature were obtained from MassGIS[8] and augmented manually using satellite imagery. CLN cells were structured to corresponded to GWF cells. The final delineations were apportioned to CLN cells using GIS intersection tools and the model grid. A feature was included if it covered at least 2% of the cell area for ponds and lakes, and 10% for wetlands. The following sections detail the source of the initial values and process by which the values are assigned to the different surface water features for each input parameter type.

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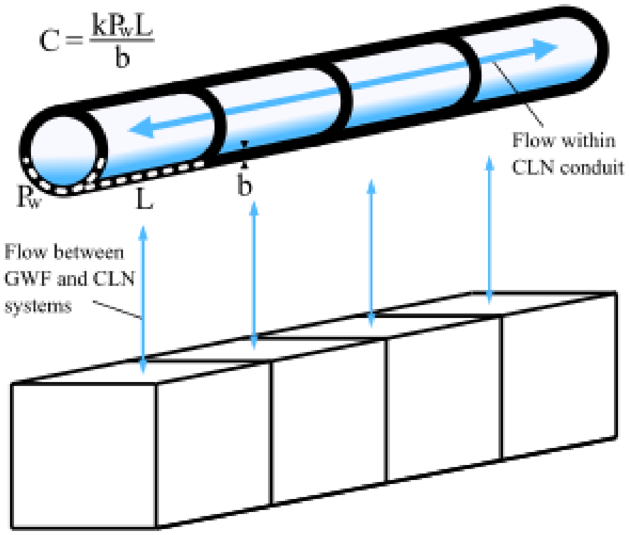
[7] Wells whose screened interval spans multiple model layers.

[8] https://www.mass.gov/orgs/massgis-bureau-of-geographic-information.



3.2.1.1 Bed Elevation

*3.2.1.1.1 **Rivers and Creeks***

River and creek bed elevations were determined by subtracting an offset (or depth) from an initial estimate of the stage in each model cell that was determined from available staff gages and the LIDAR surface. The LIDAR surface was contoured at 10-foot intervals and intersected with the river and creek delineations. The stage estimate in each CLN cell was calculated by linearly interpolating from the staff gage and intersection points to the mid-point of each feature segment within a cell. Initially, an offset (or depth) of 2.5 feet was assigned to the Nashua and North Nashua rivers, and 1 foot for each creek. These values are consistent with the depths used in the ETA (1995) model of the former Main and North posts. The offset assigned to each CLN cell was calculated by linearly interpolating from control-points to the mid-point of a feature segment within that cell. The staff gage and control-point locations are shown on Figure 3b.

*3.2.1.1.2 **Ponds and Lakes***

Bathymetry maps were available for Plow Shop and Grove ponds from a study by Mercadante et. al (1999) and for Robbins Pond and Bare Hill Lake from MassGIS. The bathymetry contours were digitized and the corresponding depth calculated using the reported stage of 216.9 feet for Plow Shop and Grove ponds, and the average LIDAR value for Robbins Pond and Bare Hill Lake. The depth contours were interpolated to a fine and regular grid using simple kriging[9], from which the average depth within each CLN cell was calculated. Initial bed elevations for all other lakes and ponds were calculated as an offset from the available LIDAR; smaller ponds (mostly unnamed) were assumed to be one-foot deep, larger features like Mirror Lake and Cranberry Pond were assumed to be 5 feet deep, while Little Mirror Lake was assumed to be 3 feet deep.

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[9] Mean depth of zero.

3.2.1.1.3 Wetlands

For connected wetlands, those through which a river or creek flows, their elevation was taken from the nearest river or creek CLN cell and adjusted depending on the slope[10] of the LIDAR surface within that cell. Conceptually, these connected wetlands are expected to be deeper along the river or creek flowing through it, getting shallower moving away from it. For shallow slopes, between 0 and 1 feet per foot, which are indicative of a flat surface, a CLN cell is predominantly wetland and is expected to have the same depth as the nearby river or creek cell. At the other end of the spectrum, for slopes greater than 5, which reflect more the topography outside the wetland, the river or creek depth is scaled by 0.01. For slopes between 1 and 3, and 3 and 5, the river or creek depth is scaled by 0.50 and 0.25, respectively. Flow-through wetlands were assumed to be 1 foot deep. The elevation of each wetland CLN cell was calculated as the average LIDAR elevation within it minus the corresponding depth.

3.2.1.2 Bed Vertical Hydraulic Conductivity

3.2.1.2.1 Rivers and Creeks

The vertical hydraulic conductivity initially assigned to river and creek CLN cells was 13 feet/day and 3 feet/day, respectively. The normalized vertical hydraulic conductivity of river and creek beds (K_n, feet/day) is defined here as the product of vertical hydraulic conductivity (K, feet/day), width (W, feet), and 1/thickness (M, feet):

$$K_n = \frac{KW}{M}$$

Bed conductance (C, feet^2/day), is then:

$$C = K_n L$$

where L is the length (feet) of the river or creek within a model cell.

The riverbed normalized vertical hydraulic conductivity is 130 feet/day, which is consistent with the 1993 and 1995 ETA models, which used normalized vertical hydraulic conductivities of 213 and 100 feet/day, respectively. For creek beds, the normalized vertical hydraulic conductivity is 30 feet/day, again consistent with the 1993 and 1995 ETA models, which had values of 50 and 10 feet/day, respectively.

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[10] Calculated using GIS tools.

3.2.1.2.2 Ponds, Lakes, and Wetlands

The 1995 ETA model specified a bed leakance of 0.5 feet^2/day for ponds, lakes, and wetlands. Leakance is the product of bed vertical hydraulic conductivity and thickness. Assuming a uniform bed thickness of 1 foot for these surface water features[11], and the constant value of 0.5 feet^2/day for bed leakance, the initial vertical hydraulic conductivity is 0.5 feet/day for ponds, lakes, and wetlands. Bed conductance (C, feet^2/day) for a model cell is calculated as the product of vertical hydraulic conductivity (K, feet/day), area (A, feet^2) of the feature within the model cell, and 1/thickness (M, feet):

$$C = \frac{KA}{M}$$

Vertical hydraulic conductivity was calculated for each CLN cell using the control-points and linear interpolation scheme developed for elevation.

3.2.1.3 Bed Length, Width and Thickness

3.2.1.3.1 Rivers and Creeks

The length of each river and creek in a CLN cell was calculated using GIS intersection tools. For all rivers and creeks bed thickness and width were uniform, 1 foot thick and 10 feet wide, for numerical stability. As discussed in the previous subsection, bed conductance is the ratio of the product of length, width, and vertical hydraulic conductivity to thickness. Although bed width is an important property in calculating stream stage within the CLN network, the modeling focus here is on groundwater flow paths for which the flow exchange between the stream and the aquifer is important, including where this exchange occurs, which is determined by the bed elevation. Therefore, the width and thickness terms were integrated into the normalized vertical hydraulic conductivity for rivers and creeks, which are 130 and 30 feet/day, respectively, and hence the effective width and thickness of the riverbeds is greater than that of the creek beds.

3.2.1.3.2 Ponds, Lakes, and Wetlands

Bed area for each CLN cell was calculated using GIS intersection tools. Mercadante et. al (1999) mapped bed thickness for Plow Shop and Grove ponds. These contours were digitized and incorporated into the model using the same approach as the bathymetry contours. For all other ponds, lakes and wetlands, a bed thickness of 1 foot was specified.

3.2.2 Domestic and Water Supply Pumping

Within the modeled domain there are several municipal supply wells, smaller community supply wells and open hole residential wells; all of which were simulated using the CLN package[12].

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[11] Excepting Plow Shop and Grove ponds, for which bed thickness was mapped by Mercadante et al. (1999). Therefore, leakance is variable for these ponds, and ranges between approximately 0.03 and 0.5 feet^2/day.

[12] The CLN package is the only boundary package in USG-Transport that supports multi-aquifer or multi-layer wells and is comparable in functionality to the Multi-Node Well (MNW) package available with previous MODFLOW releases.

Details for the supply wells, including the annual volume pumped from 2016 for the municipal wells and 2015 for the smaller community wells, through 2019, were compiled by S-A JV (2020c). These wells were simulated in the model using the CLN package and pumped at the average volumetric pumping rate for their available time frame. Representative pumping rates for the residential wells were not available and were specified as zero in the model as these pumping rates are likely very small with negligible impact on groundwater flow directions.

The municipal and community wells, and pertinent details about each, including the average pumping rate applied in the model, are listed in Appendix B, Tables B.1a and B.1b. Details for each residential well are provided in Appendix B, Table B.2.

3.2.3 Recharge

Groundwater recharge was specified using the approach developed by ETA (1995) for the model of the Main and North Posts, and similar rates were calculated. The approach employed by ETA (1995) involved estimating a maximum rate for the region and adjusting it spatially by the surficial geology and land cover.

ETA (1995) estimated the maximum regional recharge rate to be 20.5 inches/year by subtracting an estimate of the actual annual evapotranspiration, 22.14 inches, from the annual average precipitation of 42.64 inches in 1993[13]. This maximum rate applies to flat sandy overburden soils and a corresponding maximum rate for flat surficial till and bedrock of 9.5 inches/year was used (ETA, 1995). The extent of the area modeled in 1995 included little surficial till, while here, it is the dominant type in the eastern portion of the domain. Here, because the till is more permeable than the bedrock, a maximum recharge rate of 11.5 inches/year was used. The surficial geology for the area of the model was taken from Stone et al. (2018) and is shown in Figure 7.

The most recent land cover available for the modeled area, 2016, was obtained from the MassGIS website and is shown in Figure 8. The cover types were generalized into five categories, consistent with those used by ETA (1995):

- Impervious, commercial, and industrial;
- Open space, forest, and agriculture;
- Residential and recreational;
- Open water, and wetlands; and
- Landfill cap.

The landfill cap category is introduced here because the 2016 cover-type for the SHL Landfill is "grassland", however, underlying this grass cover is a 30 to 40 mil thick polyvinyl chloride (PVC) membrane cap (Geosyntec, 2016). Each of the land cover categories was assigned a factor, listed in the table below, that was used to scale the maximum recharge rate for each surficial geology type.

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[13] The average annual precipitation at Fitchburg Municipal Airport, Fitchburg, Massachusetts (Station: USW00004780) for the period 1998 – 2020 is 43 inches.

Land Cover Group	2016 Land Cover Name	Recharge Factor	Model Area
Impervious, commercial, and industrial	Impervious	0.35	8%
Open space, forest, and agriculture	Bare land, cultivated, forest, grassland, pasture/hay, and scrub	1.00	62%
Residential and recreational	Developed open space	0.75	11%
Open water and wetlands	Water and wetland	0.00[14]	18%
Landfill cap	-	0.00	0.2%

The surficial geology and land cover maps were intersected with the model grid using GIS tools to get the relative amount of each map's categories in a model cell. The recharge rate for each model cell was calculated from these fractions and the rate adjustments outlined above, as the product of the area weighted average surficial geology rate and the area weighted average land cover factor. The calculated recharge rates for the model domain are shown in Figure 9. The average recharge rate for the entire model domain is 11.8 inches/year. Within the domains of the 1993 regional, 1994 South Post, and 1995 Main and North Post models developed by ETA, the average recharge is 13.3, 14.2, and 13.3 inches/year, respectively. These rates compare well with the average rate of 13.7 inches/year in the ETA (1995) model. Over the predominantly till and bedrock areas (approximately 40% of the model domain) the average recharge rate is 9.5 inches/year.

Two infiltration basins were represented in one or more of the previous models as a zone of higher recharge: the rapid infiltration basin associated with the wastewater treatment plant (WWTP) on the former North Post (ETA, 1995; Arcadis, 2002), and the storm water collection basins located south of the SHL (Geosyntec, 2020). Both basins are represented in the CLN package, and their respective recharge applied using the WEL package. The rate used by Arcadis (2002), 215 inches/year, was applied uniformly over the WWTP infiltration basin. The recharge zone used by Geosyntec (2020) to represent the stormwater collection basin corresponded to a mapped wetland. The same volumetric rate of water, 3.3 acre-feet/year, was applied to this feature; corrected for the relative area difference between the recharge zone and wetland, this volume is an equivalent recharge rate of 360 inches/year.

ETA (1995) estimated the annual potential evapotranspiration to be 40.9 inches in 1993. This estimate was derived using the average estimate from five different techniques using average climatic data – these calculations made by ETA are reproduced in Appendix I. At open surface water features like ponds, lakes, and wetlands, the net difference of 1.8 inches between the average annual precipitation and potential evapotranspiration was applied to the corresponding CLN cells using the WEL package.

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[14] Represented as the net of precipitation and potential evapotranspiration and simulated using the WEL and CLN packages.

3.3 Hydraulic Properties

The initial horizontal and vertical hydraulic conductivity distributions in the overburden, till, and bedrock were derived from the existing models. Where there is overlap in the extents of these models, the hydraulic conductivity of the most recently developed model was used. However, because of updates to the bedrock surface in areas on the former Main and North posts since these models were last calibrated, uniform horizontal hydraulic conductivities were used for the overburden throughout the respective former posts. For the former Main Post, a horizontal hydraulic conductivity of 30 feet/day was specified, while the initial vertical hydraulic conductivity was specified to be 1/10th of the horizontal hydraulic conductivity in the ETA (1995) model. For the former North Post, uniform horizontal and vertical hydraulic conductivities of 38 and 3.8 feet/day, respectively, were specified, consistent with the dominant overburden zone calibrated by Arcadis (2002). Uniform horizontal and vertical hydraulic conductivities of 5 and 0.5 feet/day, respectively, were specified for the till, consistent with the 2020 SHL Model (Geosyntec, 2020). Initial horizontal hydraulic conductivity for the upper bedrock was specified based on the previous models and ranged between 0.2 and 2 feet/day. The initial vertical hydraulic conductivity of the upper bedrock was specified to be 1.7 feet/day, based on the value used most recently for the SHL model (GeoSyntec, 2020). For the deeper bedrock, the initial horizontal and vertical hydraulic conductivities were specified as 0.005 and 0.0005 feet/day, respectively.

The barrier wall installed as part of the SHL remedial system was simulated as low horizontal hydraulic conductivity cells – the spacing of these cells is 2.5 feet to reflect the excavation width (Sovereign, 2013). The hydraulic conductivity was assigned the value calibrated by Geosyntec (2020), 1.1e-4 feet/day, for the SHL model and assigned to all cells within the overburden.

Section 4
Model Calibration

The development of an appropriate inverse[15] model is a critical step in any groundwater model development exercise. The inverse model serves two important, but distinct functions – the first is to calibrate the parameters and other inputs of the model, and the second is to help identify and, to the extent possible, quantify sources of uncertainty in predictions made by the calibrated model. Here, the focus is on the calibration component of the inverse model and the discussion in this section details that development.

4.1 Procedure

Calibration of a groundwater model involves adjusting the initial estimates of model parameters to improve the correspondence between model calculated outputs and field observations ("calibration targets"). Calibration is a necessary process because initial estimates of model parameter values are generally not well constrained. Calibration of the parameters of the groundwater flow model is based upon a combination of (a) manual and principally qualitative adjustments, plus (b) automated and more quantitative procedures, each facilitated using the inverse modeling code PEST_HP v.17.1 (Watermark Numerical Computing, 2020a).

Manual and automated calibration are iterative processes that estimate parameter values by minimizing the differences between model outputs and targets in the weighted least-squares sense (i.e., the sum of the squared differences between model outputs and measurements, termed the objective function). Parameter values are determined according to their sensitivity to observed or measured values. The resulting parameter values are considered optimal with respect to the measured data set and any underlying assumptions and may then be used to make predictions under conditions comparable to calibration conditions.

Formulation of a well-posed inverse model is important to effective model calibration. The following sections describe the basic components of the inverse model, including the target and parameter definitions.

For this model, calibration was undertaken in steps, with each step focusing on a different post (i.e., South Post, the Former Main Post, and the Former North Post). This approach was implemented because model calibration within each post was not expected to be impacted by targets in other posts. Model calibration results, presented in Section 4.5 illustrate the validity of this approach.

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[15] The groundwater flow model is termed the forward model because hydraulic heads, base flows, etc., are calculated by the model from the specified parameter values input to it. Conversely, the inverse model determines parameter values from field observations.

4.2 Multi-Component Objective Function

4.2.1 Water Levels

Historical water levels were downloaded for the Main and North Posts from the Former Fort Devens database[16] and for the South Post, as a series of document and spreadsheet tables. These water levels are provided in Table E.1. Nearly 1700 locations, including monitoring wells, pumping wells, residential wells, and staff gages were identified in these sources. Of these, 662 had measured levels. Excluding duplicates, pumping wells, staff gages, and monitoring wells without screen information, a total of 559 target locations were identified and used in the model calibration – 62 on the South Post, 108 on the former North Post, and 389 on or near the former Main Post. These target locations are shown on Figures 10a, 10b, and 10c, respectively. The historical average, regardless of time frame, was used as the target value to support the calibration of a groundwater model that simulates steady-state, average conditions. The target water levels are provided in Table E.2. Target water levels ranged between 201 and 365 feet. Because the purpose is to calibrate a regional model to average water levels it is important that all areas are represented in the composite objective function (Moore and Doherty, 2005). For this reason, observation weights were not developed on the basis of presumed measurement accuracy but rather were developed using professional judgement as part of the process of developing the inverse model. Weights were 1.0 for target locations in most areas. However, in areas with fewer target locations on the South Post and former North Post, weights were ascribed 1.5 or 2.0 such that the magnitude of their contribution to the measurement objective function was consistent with other areas with more target locations. Monitoring wells were represented in the model using the CLN package and the calculated water level for each was extracted from the CLN head-save file written by USG-Transport.

These average water levels formed the primary basis of the multi-component objective function that was used for model calibration. Additional target types in the objective function include gradient magnitude and direction calculated using a three-point approach, and horizontal head differences between piezometer pairs installed on either side of the barrier wall. These target types effectively supplement the weights on the corresponding water levels to focus calibration on the information that affects flow directions, rather than the water level itself.

4.2.2 Three-point Gradient Method - Magnitudes and Directions

The magnitude and direction of horizontal gradients calculated using the three-point method (described by Pinder et al., 1981; Silliman and Frost, 1998) for 160 triangles were included as calibration targets. Fifteen triangles were identified on the South Post, 122 on the former Main Post, and 23 on the former North Post – these triangles are shown on Figures 10a, 10b, and 10c, respectively. Table E.3 lists the monitoring well triad used for each triangle as well as the corresponding target gradient direction and magnitude.

A custom program was used to calculate the observed and corresponding simulated equivalents of gradient magnitude and direction for each triangle. The program internally

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[16] Former Fort Devens EDMS Portal: ftdevens.org

calculates the direction residual[17] to account for the relative position of the reference angle (which is both 0 and 360 degrees) aligned along the positive y-axis; thus, the target value for direction is zero for all triangles. The magnitude and direction calculated for an example well triad (SHL-12, SHL-17, 32Z-99-02X), using the USEPA (2014) 3PE tool, is shown on Figure E.1. The 3PE calculated magnitudes of 0.0161 and 0.0138 based on the target and simulated water levels, respectively, are the same as those calculated by the custom program (Table E.3). The same is true for the calculated 3PE target and simulated directions of 349.31 and 359.89, respectively. Both the 3PE tool and the custom program use the equations from Silliman and Frost (1998) for their respective calculations. Simulated equivalents were calculated as the square root of the absolute value of the azimuth difference. Weights ascribed were either 0.25 or 0.50 to reflect their desired relative contribution to the total objective function and their respective density in different areas of the model domain.

Observed gradient magnitudes ranged over three orders of magnitude, between 1×10^{-4} and 1×10^{-1}, while target water levels are on the order of several hundred feet. The relative magnitude differences between these two target types can be problematic for model calibration. By transforming the gradient magnitude values as the square root of their reciprocal, the resultant magnitude values ranged between 3 and 51, a range more in line with water level values. Again, weights were 0.25 or 0.50 to reflect their desired relative contribution to the total objective function.

4.2.3 Head Differences Across the Barrier Wall

Five sets of piezometer pairs were installed along the SHL barrier wall, one on either side, to measure the water level change across it (Sovereign, 2013). The average change[18] between each pair was included as a calibration target and assigned a weight of 10.0 to reflect their desired relative contribution to the total objective function. The locations of the piezometer pairs are shown on Figure 10b and their respective target differences are provided in Table E.4.

4.2.4 Soft Target Types

Calibration targets that are based upon quantitative measurements made in the field and that correspond to a model-calculated output are often referred to as “hard” targets. In addition to these hard targets, “soft” targets can be used to help condition the inverse model by providing independent information on a model parameter such as hydraulic conductivity. The following sections describe several soft target types that were incorporated to condition the model calibration in areas for which hard targets were either unavailable or for which the available observation data were insufficient to constrain parameter estimates. The weights assigned to these target types reflect their desired relative contribution to the total objective function.

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[17] Observed minus model calculated.

[18] Calculated as the historical average water level of the upgradient piezometer minus that of the downgradient piezometer.

4.2.4.1 Surface Water Levels – Staff Gages and LIDAR Based

Thirty-nine staff gages were identified in the provided water-level data sources discussed previously. The historical average stage elevations for 24 of these were consistent with the average water levels in nearby monitoring wells and therefore were included in the calibration. These values were not considered hard targets because (a) the corresponding stage calculated by the model is based primarily on baseflow (i.e., exchange between surface water and groundwater), not the complete surface water budget, and (b) some simplifying assumptions are necessary regarding the geometry of each surface water feature (although it is noted that the gage data included in the calibration correspond to ponds, lakes, or wetlands, for which the spatial extent of the feature is better delineated and for which groundwater baseflow is the primary component of streamflow). The locations of gages included in the calibration are shown in Figure 11 and listed in Table E.5a with their corresponding target stage. Weights of 1.0 or 2.0 were assigned to these surface water targets to reflect their desired relative contribution to the total objective function.

Some surface water features – especially ponds, lakes, and wetlands, occurring along the creeks, rivers, and their floodplain corridors – are surficial expressions of the water table. Additional stage soft target values were developed for select features by inspecting aerial imagery[19] for features that are visibly open water and calculating the corresponding average LIDAR elevation. These locations are shown on Figure 11 and listed in Table E.5a with their corresponding target stage. These soft calibration targets were assigned a weight of 1.0 to reflect their desired relative contribution to the total objective function.

In each case, the weights selected resulted in these targets providing sufficient contribution to the objective function to help condition the calibration without compromising the fit to the hard targets.

4.2.4.2 Transmissivity and Pumping Rate Constraints

Two additional soft-target types were used to constrain estimates of hydraulic conductivity that can occur when using the automatic pumping rate reduction capabilities of USG-Transport as described in the following paragraphs.

The “AUTOFLOWREDUCE” option available with the USG-Transport WEL package was used for pumping wells. This option provides a constraint that ensures the desired pumping rate does not exceed the maximum rate supported by the well and aquifer properties by reducing the specified pumping rate if the calculated water level in the well falls below its bottom elevation. Any rates that are adjusted by this option during the course of a simulation are recorded in output to a text file.

Use of “AUTOFLOWREDUCE” can be problematic when calibrating a model for which there are target water levels near a pumping well. The expectation is that these historical average water levels reflect the long-term drawdown due to specified average pumping rates at any nearby pumping wells. Drawdown is theoretically proportional to the ratio of pumping rate and aquifer transmissivity, and this relationship is important to the parameter estimation process – however,

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[19] World Imagery (Clarity) - Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

when the "AUTOFLOWREDUCE" option is used, the pumping rate is not necessarily fixed, and as a consequence the transmissivity is not well constrained because a particular water level can be simulated using any number of pumping rate-to-transmissivity ratios. For example: if the initial hydraulic conductivity is too low, and the specified pumping rate causes a well to go dry, its rate is reduced, and sensitivities calculated by PEST_HP will reflect a combination of the change in hydraulic conductivity and corresponding change in pumping rate.

The two soft target types used to mitigate this issue were:

1. Estimates of transmissivity in the vicinity of several of the large community well systems, that were compiled by Vanasse Hangen Brustlin, Inc. (1994). Using the average water level from a nearby monitoring well and an estimate of the bedrock elevation at that location, a corresponding hydraulic conductivity was estimated at 11 of these wells and included as a soft target in the model calibration[20]. The hydraulic conductivity in the model was extracted at the location of the monitoring well used to estimate the saturated thickness. Table B.1c in Appendix B summarizes the calculation parameters and the resulting hydraulic conductivity estimate for these wells.
2. Estimates of the flow reduction at each pumping well. A soft target value of 0 was specified for the total calculated flow reduction at pumping wells. The simulated equivalent was calculated by taking the square root of the total flow reduction reported in the USG-Transport output file in gallons/minute. These soft targets were assigned a weight of 2.0.

The targets associated with these two soft-target types are provided in Table E.5b of Appendix E.

4.3 Parameterization

Flow paths in the overburden are largely controlled by the properties of the overburden aquifer and by the distribution of surface water features.

Aquifer parameterization focused on the overburden materials but did also estimate values for the underlying weathered bedrock. Aquifer properties were parameterized using pilot-points – a parameterization device that enables the distribution and magnitude of parameter values to be calibrated without enforcing *a-priori* zones of parameter constancy (Doherty, 2003). The pilot-points for aquifer properties were defined as scalars on the initial model properties and interpolated to the model grid using a kriging approach[21] available with PLPROC, a program in the PEST suite (Watermark Numerical Computing, 2020b). Parameters estimated for the overburden material included horizontal and vertical hydraulic conductivity and competent bedrock thickness[22]. Horizontal and vertical hydraulic conductivity were also calibrated for the upper bedrock. For both

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[20] The target value was the square root of the estimated hydraulic conductivity.

[21] The principal anisotropy direction is defined by a series of lines representing the river and creek delineations to provide a basis for spatial interpolation that follows the alluvial system.

[22] The parameter was defined as a scalar on the lower bedrock thickness, a surrogate for overburden thickness; [Overburden thickness] = [Model top] – [Till thickness] – [Upper bedrock thickness (50 feet)] – [Lower bedrock thickness * thickness scalar].

the overburden and upper bedrock, the vertical hydraulic conductivity parameter was defined as a scalar on the initial ratio of horizontal to vertical hydraulic conductivity. The same set of 1378 pilot-point locations was used to represent the five unit properties – 228 for the South Post, 873 for the former Main Post, 125 for the former North Post, and 152 for the off-facility area.

Pilot-points were also used as the parameterization device for the surface water properties[23]. In this case, the property values at each CLN cell were calculated by linearly interpolating between pilot points along the corresponding feature. Estimated surface water feature parameters included bed elevation through an offset term[24], and (normalized) vertical hydraulic conductivity. For the surface water features, the same set of 84 pilot-points were used to represent both the bed elevation change and vertical hydraulic conductivity. Pilot-point locations are shown on Figure 12.

4.4 Regularization

Tikhonov regularization (Doherty, 2015) was employed to constrain calibrated parameter values. With Tikhonov regularization, the objective function is augmented with a model misfit term whereby the total objective function minimized during calibration is the sum of the measurement and regularization terms. The model misfit term is a measure of how different the calibrated parameter set is from a preferred condition. With regularized inversion, the role of calibration becomes a trade-off, between fitting the data and honoring the parameter value constraints; as a consequence this approach is often referred to as “penalized least squares” because deviation from the preferred condition incurs a penalty in the calibration. One end member of this trade-off (especially when using highly parameterized inversion as undertaken here) is over-fitting the data where the data misfit is small and the model misfit is large. The other end member is under-fitting the data, where the data misfit is large and the model misfit is small. In this calibration, an approach for optimizing the level of fit that follows the guidelines in Doherty (2015) was used. First, the model was calibrated with a target data misfit of zero to establish the over-fitting end member[25], at the conclusion of which the (relative) contributions to the total objective function by the measurement and regularization[26] components were reviewed. The optimal level of model-to-measurement fit was established as the calibration iteration for which the change in both the measurement and model misfit terms were small. An example of this procedure is provided in Appendix C. The parameter set corresponding to this iteration was then used, or the calibration was repeated using this updated target objective function.

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[23] Except for flow-through features, whose properties were uniform over the feature and represented as zones.

[24] The depth relative to the estimated stage derived from staff gages and LIDAR as discussed in Section 3.2.1.1.1.

[25] The under-fitting end member corresponds to the initial parameter set.

[26] The regularization contribution is calculated here as the parameter variance, var, relative to the initial parameter value; $var = E[(X_{calib} - X_{init})^2]$

Tikhonov regularization constraints are commonly expressed as either preferred-value[27] or preferred-difference[28]. A combination of approaches was used in different areas of the model. Generally, for the overburden and upper bedrock parameters, a preferred-difference constraint was used. For the former Main and North Posts, the initial aquifer properties were homogeneous, however, calibration of the previous models resulted in heterogeneous zones. A preferred-difference regularization scheme was used for these two posts because targets are clustered in localized areas and this regularization device constrains the calibrated values for pilot-points in less sensitive areas to be consistent with the values determined for the more sensitive areas nearer to targets.

4.5 Results

As mentioned earlier, calibration was undertaken in steps, each step focusing on a different post (i.e., South Post, the Former Main Post, and the Former North Post). This approach was implemented because model calibration within each post was not expected to be impacted by targets in other posts. Figure J.1 in Appendix J shows the composite sensitivity of each horizontal hydraulic conductivity pilot point in the overburden to water-level targets at AOC-41. This AOC is located at the north end of New Cranberry Pond on South Post. Figure J.1 illustrates that overburden horizontal hydraulic conductivity pilot points on the Former Main and Former North Posts are insensitive to AOC-41 water levels, and therefore, each post could be calibrated independently of one another.

Surface water parameter values were generally manually calibrated, except along the Nashua River and an unnamed tributary on the North Post, and the bed vertical hydraulic conductivity for a portion of Plow Shop Pond. Contour maps of the calculated steady state water table for the regional domain and each post are depicted in Appendix D.

The model fit for each post was evaluated graphically following guidelines by Hill and Tiedeman (2007). Plots of the measured versus simulated water levels, the measured water levels versus residuals, and the cumulative frequency of water level residuals for South Post, the Former Main Post, and Former North Post are shown on Figures 13a-13c, respectively. Classed post maps of the water level residuals are posted on figures in Appendix D, as are the estimated and calculated three-point gradients. Together, these figures indicate good correspondence between observed and calculated water levels and demonstrate little systematic bias throughout the posts. Calibration targets, corresponding simulated values and residuals are tabulated in Appendix E. Graphical summaries of the estimated parameter values for the overburden and upper bedrock units are shown on Figure 14a, and 14b, respectively. These figures summarize the pre- and post-calibration distribution of hydraulic conductivity values, as a percentage of the area, for each post. Confidence intervals cannot be calculated when regularized inversion is used (Doherty, 2015). Moreover, because recharge and hydraulic conductivity are highly correlated and recharge was not calibrated as part of this effort, estimates of parameter value confidence intervals would not include the contribution from this parameter type. For this reason, the appropriateness of the calibrated values

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[27] The preferred-value being a parameter's initial value, here a scalar of 1.

[28] Referred to as a preferred homogeneity condition where the difference between neighboring pilot-point values is specified to be zero.

for hydraulic conductivity are assessed qualitatively against the expected values determined from the previous modeling efforts and encapsulated in the model inversion as prior information. The comparison with expected values is shown in Figures 14a and 14b. Appendix F contains maps depicting the spatial distribution of horizontal and vertical hydraulic conductivity for the overburden and upper bedrock units, and the bedrock thickness scalar. Appendix G contains maps depicting the spatial distribution of surface water properties. Appendix J contains classed post maps showing the sensitivity of each pilot point for the different parameter types. The calculated groundwater budget per HSU is provided in Table 1.

4.5.1 South Post

On the South Post, water levels are bimodal, reflecting the divide between those near AOC 41 and New Cranberry Pond, and an unnamed creek near AOCs 25, 26 and 27. The median water level residual value is -0.20 feet, the mean water level residual is +0.01 feet, and the standard deviation is 1.5 feet, which may suggest some bias towards overestimation of water levels. However, the bias is small and does not appear systematic based on Figures 13a and D.2. From Figure 13a, the range in measured water levels spanned by residuals between +/-1 feet, is about 1 standard deviation, or 68% of the water levels, which covers water levels on both sides of the divide. The only area of probable estimation bias appears to be in water levels near AOC 27.

Triangles for three-point gradient calculations for the South Post are focused near AOCs 25 and 26. The median direction residual is -2.7 degrees, the mean is -1.0 degrees, and the standard deviation is 6.5 degrees. Generally, the calculated gradient magnitudes correspond well (Figure 13d) to values estimated using the three-point gradient approach. However, there is some tendency to overestimate the magnitude of the gradient, although this apparent bias does not appear to be large, and average long term flow gradients in this area are well represented by the model. The calibrated horizontal hydraulic conductivity of the overburden within this post ranges between 0.1 and 128 feet/day, with 82% of the area between 5 and 35 feet/day, and 60% of the area between 25 and 35 feet/day (Figure 14a). The vertical hydraulic conductivity of the overburden ranges between 0.01 feet/day and 16.6 feet/day, with 88% of the area between 1 and 10 feet/day (Figure 14a). The calibrated horizontal hydraulic conductivity of the upper bedrock within this post ranges between 0.6 and 1.3 feet/day (Figure 14b). The vertical hydraulic conductivity of the upper bedrock ranges between 1.5 and 2.2 feet/day (Figure 14b).

4.5.2 Former Main Post

On the former Main Post measured water levels range between 205 and 365 feet. The median water level residual is +0.13 feet, the mean water level residual is +0.24 feet, and the standard deviation is 1.3 feet, which may suggest some bias towards underestimating water levels. However, from Figure 13b, the range in measured water levels spanned by residuals between +/-2 feet (94% of the target locations) is 157.5 feet, and the simulated range is comparable at 157.0 feet, which indicates the bias is likely not systematic. From Figure D.3 in Appendix D, it can be seen the bias is due to target locations that are mostly on the periphery of mapped bedrock outcrops near SHL. It is likely the weathered bedrock is more variable in these areas than what is represented in the model.

The median gradient direction residual is -0.0, the mean is +1.3 degrees, and the standard deviation is 20.6 degrees. The largest direction residuals are predominantly along the northwest shoreline of Plow Shop Pond (Figure D.5b, in Appendix D). Likely, the localized interaction between that part of the pond and the mapped wetlands impacts model calibration in that area. From Figure 13d, the calculated gradient magnitudes correspond well to the values estimated using the three-point approach. Flow gradients throughout the post are well represented by the model.

Head differences across the barrier wall calculated by the model correspond well to the average measured values for each piezometer pair as shown on Figure 13e. These differences range between 0.4 and 1.7 feet. The median difference residual is +0.10 feet, the mean is +0.05 feet, and the standard deviation is 0.1 feet.

The calibrated horizontal hydraulic conductivity of the overburden within this post ranges between 0.1 and 401 feet/day, with 66% of the area between 5 and 35 feet/day (Figure 14a). The vertical hydraulic conductivity of the overburden ranges between 0.0006 feet/day and 92 feet/day, with 82% of the area between 0.1 and 10 feet/day (Figure 14a). The calibrated horizontal hydraulic conductivity of the upper bedrock within this post ranges between 0.02 and 10.2 feet/day, with 75% of the area between 0.5 and 1 feet/day (Figure 14b). The vertical hydraulic conductivity of the upper bedrock ranges between 0.03 and 9 feet/day, with 87% of the area between 1 and 2 feet/day (Figure 14b).

4.5.3 Former North Post

On the former North Post measured water levels generally range between 201 and 214 feet, except for MW-06 and MW-07 west of the WWTP, which have measured water levels of 222.1 and 219.8, respectively. The median water level residual is +0.02 feet, the mean water level residual is -0.06 feet, and the standard deviation is 0.9 feet. From Figure 13c there is little systematic bias in the calculated water levels as the positive and negative residuals are well balanced throughout the range in water levels.

The median gradient direction residual is +0.9 degrees, the mean is +5.1 degrees, and the standard deviation is 21.3 degrees. From Figure 13d, the calculated gradient magnitudes correspond well to the values estimated using the three-point gradient approach. Flow gradients in this area are well represented by the model. The largest gradient residuals are along the narrow corridor of wells installed as part of the AOC 50 investigation (Figure D.5b in Appendix D). The wells used to define the triangles in this area are close together with a small range in water levels. As a result, the gradient calculation is sensitive to small changes in water levels. A better fit to these estimates of gradients would likely involve overfitting of the average water levels.

The calibrated horizontal hydraulic conductivity of the overburden within this post ranges between 4.4 and 413 feet/day, with 81% of the area between 15 and 75 feet/day, and 47% of the area between 25 and 45 feet/day (Figure 14a). The vertical hydraulic conductivity of the overburden ranges between 0.4 feet/day and 55 feet/day, with 89% of the area between 1 and 10 feet/day (Figure 14a). The calibrated horizontal hydraulic conductivity of the upper bedrock within this post ranges between 0.4 and 1.2 feet/day (Figure 14b). The vertical hydraulic conductivity of the upper bedrock ranges between 1 and 3 feet/day (Figure 14b).

Section 5
Flow Path Analysis – Focus Area 1

Particle tracking analyses were used to evaluate flow paths and travel times within Focus Area 1 to and from areas and receptors of interest identified by S-A JV. These analyses are described below and the calculated pathlines presented in Figures 15b-d, for which Figure 15a is a reference map showing their relative extents.

Flow paths were calculated for areas of PFOS/PFOA contamination delineated by S-A JV (2020d) to U.S. Environmental Protection Agency's (USEPA's) lifetime health advisory (LHA) of 70 parts per trillion (USEPA, 2016) within Focus Area 1. The mapped contamination includes a small area on the eastern edge of Robbins Pond, an area near AOC 43G to the west of Robbins Pond, an area south of AOC 75, an area between the Patton Well and the headwaters of Cold Spring Brook near AOC 40, and an area south of the Grove Pond well field to AOC 57 along Bowers Brook (Figure 15b).

The base estimates of effective porosity specified for the particle tracking analyses were taken from Geosyntec (2020) for the SHL model – 30% for the overburden, 25% for the till, and 0.1% for the bedrock units. Like what was done for other aquifer properties, the effective porosity in each model cell was calculated as the thickness weighted average of the effective porosities of each HSU within it. Effective porosity is a scalar on particle travel time. A range in potential travel times for each area was calculated by using an alternate set of effective porosities: 15% for the overburden and till units, 10% in the upper bedrock, and 2% in the competent bedrock. This alternate set of effective porosities reflect our professional judgement of the best estimate based on our experience and is consistent with differences between effective porosity estimated from textural data (e.g., grain size and moisture retention) and field calibrated values to a tracer test reported by Stephens et al. (1998). Stephens et al. (1998) concluded that porosities derived from textural data resulted in effective porosity estimates that were between 50 and 90% larger than an estimate resulting from a calibration to a field tracer test for a sand and gravel aquifer. The base overburden effective porosity is 90% larger than the alternate value, and 67% larger for the till. The alternate porosities for the bedrock units are consistent with values discussed by Fetter (2001) for fractured crystalline bedrock. Retardation was assumed to be negligible, and thus specified as 1.

Particles were released throughout the overburden[29] at regular intervals[30] within the identified PFOS/PFOA contamination areas. Forward paths were calculated to identify potential discharge areas, while backwards paths were calculated to identify potential recharge areas. Particle paths were calculated using mod-PATH3DU v.2.1.5 (SSP&A, 2020). The resulting flow paths are shown on Figures 15b and 15c.

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[29] The middle of any layer for model cells in which the overburden constitutes at least 30% of the layer thickness.

[30] One-hundred foot spacing in each area except for the smaller one east of Robbins Pond in which particles were released at 50-foot intervals.

The forward particle paths indicate that discharge from these PFOS/PFOA contamination areas are primarily to nearby creeks or rivers. Particles released east of Robbins Pond discharge to gaining portions of Willow Branch or for deeper releases, follow the brook ultimately discharging to a bend in the Nashua River just west of a reach of Willow Branch calculated to be losing water to the groundwater system. Particles released from the area west of Robbins Pond discharge to Robbins Pond or Willow Branch. Particles released from the area south of AOC 75 discharge to Cold Spring Brook or the low-lying wetland areas through which it flows. Particles released near AOC 40 discharge to either the Patton Well or Cold Spring Brook depending on which side of the groundwater divide in this area they originate. Particles released from the area between the Grove Pond well field and AOC 57 discharge to Bowers Brook or the wetlands through which it runs, Grove Pond or the Grove Pond well field. Particle travel times, in years, are summarized in Table 2 for the base and alternate set of effective porosities. Generally, travel times for the alternate effective porosity scenario are half those of the base effective porosity, as expected given effective porosity in the overburden for the alternate scenario is half of the base value. This result is made evident by comparing the median travel times. For two areas, the one east of Robbins Pond, and the one south of AOC 75, the maximum travel time is longer for the alternate scenario as the effective porosity in the upper bedrock is 100 times higher than the base scenario. This result indicates that for these two scenarios some particles travel through cells that are comprised mainly of bedrock. However, the longest travel time for these areas is, at most, twice that of the base scenario, which indicates the particles, regardless of area, are predominantly travelling through the overburden and that particle paths in the bedrock are shallow and largely confined to the upper bedrock.

Backward particle paths indicate the calculated recharge areas for the groundwater in the identified PFOS/PFOA contaminated areas generally extend to groundwater divides at topographic highs. For the contaminated area just east of Robbins Pond, the recharge area extends west, below Robbins Pond, through AOC 43G, to the groundwater divide at a topographic high. The recharge area also includes a portion on the northeast side of Robbins Pond where it is calculated to be losing to the groundwater system. For the contaminated area west of Robbins Pond, the recharge area extends further west to the groundwater divide at a topographic high. For the area south of AOC 75, the calculated recharge area extends to the ridge of bedrock outcrops just east of Robbins Pond that is the calculated groundwater divide between the Willow Branch and Cold Spring Brook watersheds. The calculated recharge area for the contaminated area between the Patton Well and the headwaters of Cold Spring Brook extends predominantly to the bedrock hill to the southeast with a small area towards the hill to the west. The recharge area of the PFOS/PFOA contamination area identified between the Grove Pond well field and AOC 57 extends to the bedrock ridge to the west that is the calculated groundwater divide between the Willow Branch and Cold Spring Brook watersheds. Particle travel times are summarized in Table 2 for the base and alternate set of effective porosities. Generally, travel times for the alternate effective porosity scenario are half those of the base effective porosity, as expected given effective porosity in the overburden for the alternate scenario is half of the base value. This result is made evident by comparing the median travel times. Largely the maximum travel time for each area is less for the alternative scenario compared to the base one, which indicates that particles are predominantly travelling through the overburden from their recharge areas. The exception is for the area south of AOC 75, which has a maximum travel time 24% longer for the alternate scenario compared to the base one. This result indicates that the reverse particle paths are still predominantly through the overburden for this area, but a small portion of some pathways travel through cells that are comprised mostly of upper bedrock.

The 5-, 25-, and 50-year capture zones for the Patton and Shabokin wells, and the Grove Pond Well Field were calculated using backward particle tracking analysis. The model cells from which these wells are pumping are 10x10 square feet. For the backward tracking analysis, a circle of particles was released around each well at a radius of 7 feet from the cell center. Particles were released at one-degree intervals (1.2 feet between particles) at 9 vertical release points per layer in which a well was screened. These vertical release points corresponded to 10% intervals of a cell's thickness, from 10% through 90%. At these intervals, 3240 particles are released per model layer that a well is screened within.

The Shabokin Well is screened in model layers 4 and 5, thus 6480 particles were used to delineate its capture zone, while Patton Well is screened in model layer 3 and its capture zone was delineated using 3240 particles. Particles were also released at the water table from the gaining areas of any pond, lake, or wetland, within a capture zone of the Patton and Shabokin Wells as these are small flow-through features. The resulting capture zones are shown on Figures 15d and 15e for the base and alternate set of effective porosities, respectively. The recharge areas for these wells extend to the topographic highs to the west and east. Figures K.1 and K.2 show the extent of capture within each HSU[31], for the base and alternate effective porosity sets, respectively. Wells 1 and 6 in the Grove Pond Well Field are screened in model layers 2 and 3, while wells 7 and 8 are screened in model layer 3. As such, 6480 particles were used to delineate Grove Pond Wells 1 and 6, and 3240 particles were used to delineate Grove Pond Wells 6 and 7. The resulting capture zones are shown on Figures 15f and 15g for the base and alternate set of effective porosities, respectively, while Appendix K, Figures K.3 and K.4 show the extent of capture within each HSU for the base and alternate effective porosity sets, respectively.

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[31] A particle pathway is shown if at least 50% of a cell's thickness is comprised of the designated HSU.

Section 6
Summary and Conclusions

This report documents the development and calibration of a regional steady-state groundwater flow model of the former Fort Devens U.S. Army post. The groundwater model was developed to (a) combine conceptual and structural details from existing regional and local models encompassing the area within, and extending beyond, the former Fort Devens U.S. Army post footprint; and (b) calculate groundwater flow paths within the overburden sands throughout the facilities. The groundwater model was constructed using USG-Transport.

Conceptually, the regional flow of groundwater is from recharged upland areas to the myriad surface water features, including the Nashua River, contributing creeks, ponds, lakes, and wetlands, that punctuate the area. The hydrostratigraphy of the region consists of a coarse-grained glacial outwash aquifer of variable thickness underlain by a till of nominal thickness (in most areas), both of which overly bedrock. The uppermost bedrock is weathered based on log descriptions. Groundwater flow occurs primarily in the overburden materials with some flow likely occurring in the weathered portion of the bedrock. Flow in the underlying crystalline bedrock is limited to non-existent.

The inverse model was developed for calibrating the groundwater model, using pilot-points to represent both aquifer and surface water properties. The inverse model includes a multi-component objective function comprising historical average water levels, gradient magnitude and direction calculated using a three-point approach, and horizontal hydraulic-head differences between piezometer pairs installed on either side of the SHL barrier wall. Additional soft target constraints, incorporated into the objective function, included surface water levels derived from staff gages and LIDAR elevations, and estimates of hydraulic conductivity at several pumping wells. Tikhonov regularization was employed to constrain the parameter values estimated during the calibration process. The inverse model was constructed using PEST_HP.

Following groundwater model development and calibration, the potential discharge and recharge areas for PFOS/PFOA contaminated regions identified by the S-A JV within Focus Area 1 were calculated. The S-A JV identified five (5) contaminated areas. Particles were released throughout the overburden in these areas and were tracked forward and backward using the particle tracking program mod-PATH3DU. The discharge areas for each of these locations were calculated to be downgradient surface water features, or nearby supply wells, and the calculated recharge areas are groundwater divides that correspond to upgradient topographic highs. In addition, the 5-, 25-, and 50-year capture zones for the Patton and Shabokin supply wells were calculated using a backward tracking analysis.

Section 7
Model Usefulness and Limitations

Calibrating regional models poses unique challenges – typically, the model is not expected to answer a specific question for a particular area, rather the purpose, as it is here, is to provide a vehicle to understand optimized flow directions given the available monitoring data. As was the case for the ETA (1993) regional model, the model presented herein was developed to be the foundation for future investigations requiring groundwater modeling. However, owing to current best practices for groundwater model development and calibration that are employed here, this model can be used directly to answer questions specific to different areas, as needed.

As built, the groundwater flow model is a useful tool to understand potential recharge and discharge areas of mapped PFOS/PFOA contamination under historically average conditions described by the available water level data and best estimate of recharge. The discharge areas are largely controlled by the elevation, and to a lesser degree, the conductance of the surface water features. The recharge areas are controlled by the upstream recharge and hydraulic conductivity distribution, and the ratio of the two is reasonably constrained by the available water-level data. However, travel time is not well constrained, as it is controlled by the hydraulic conductivity and porosity of the overburden, neither of which are uniquely identifiable through calibration of water levels alone.

Baseflow estimated from surface water flow measurements provide a direct measure of the bulk average recharge to the contributing watershed area. This type of data would help to better inform recharge estimation or calibration and as a result better constrain the hydraulic conductivity. Incorporating data types related to contaminant migration are important to constraining travel time and the transport parameters controlling it, especially the product of retardation and the ratio of hydraulic conductivity to effective porosity. This data type would also bolster flow direction information and can be used to supplant estimates based on a three-point gradient analysis.

The inverse model developed here is a useful tool to test hypotheses about the flow of groundwater in the overburden. The use of pilot-points to represent both aquifer and surface water properties provides a robust mechanism to evaluate sensitivity throughout the model domain. If the model is used to make more specific predictions in the future, this inverse model is a useful tool to evaluate the uncertainty of such a prediction. Further, the framework developed here is readily extendable to other parameter types as needed.

The geometry and properties of the different surface water features were developed for the purposes of a regional model, and therefore the interaction between these features in the model reflects this assumption.

Section 8
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FIGURES

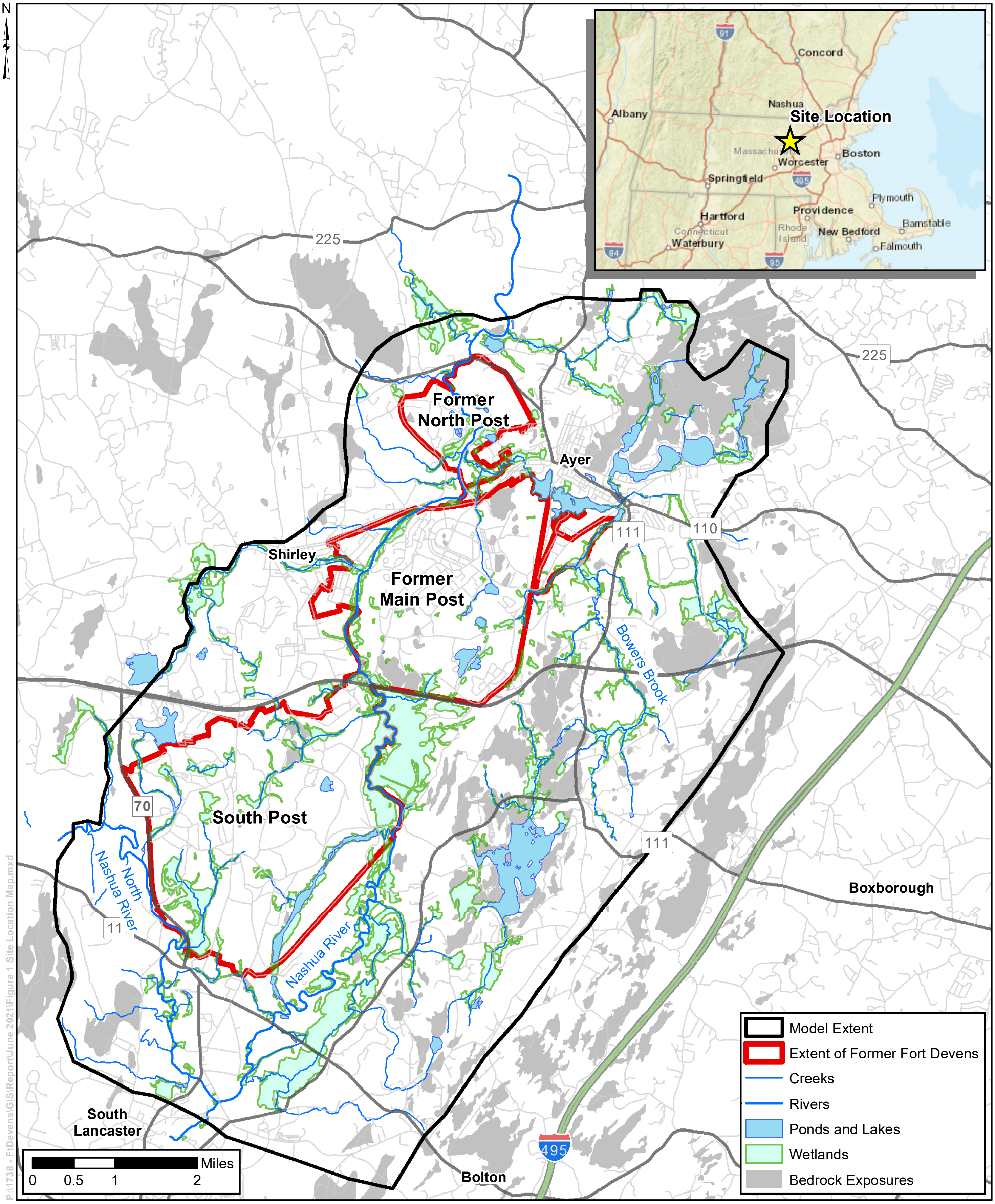
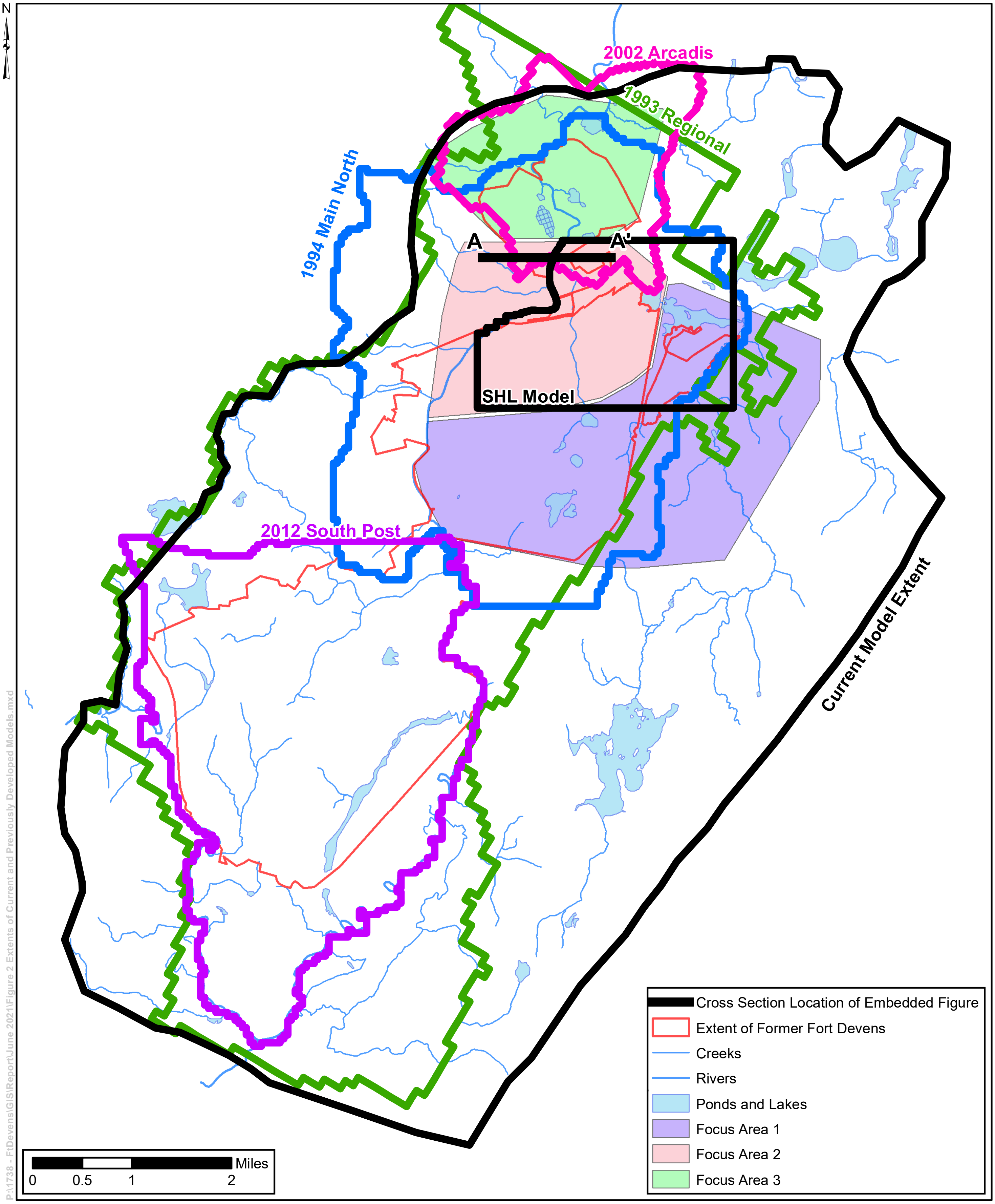


Figure 1 Site Location Map



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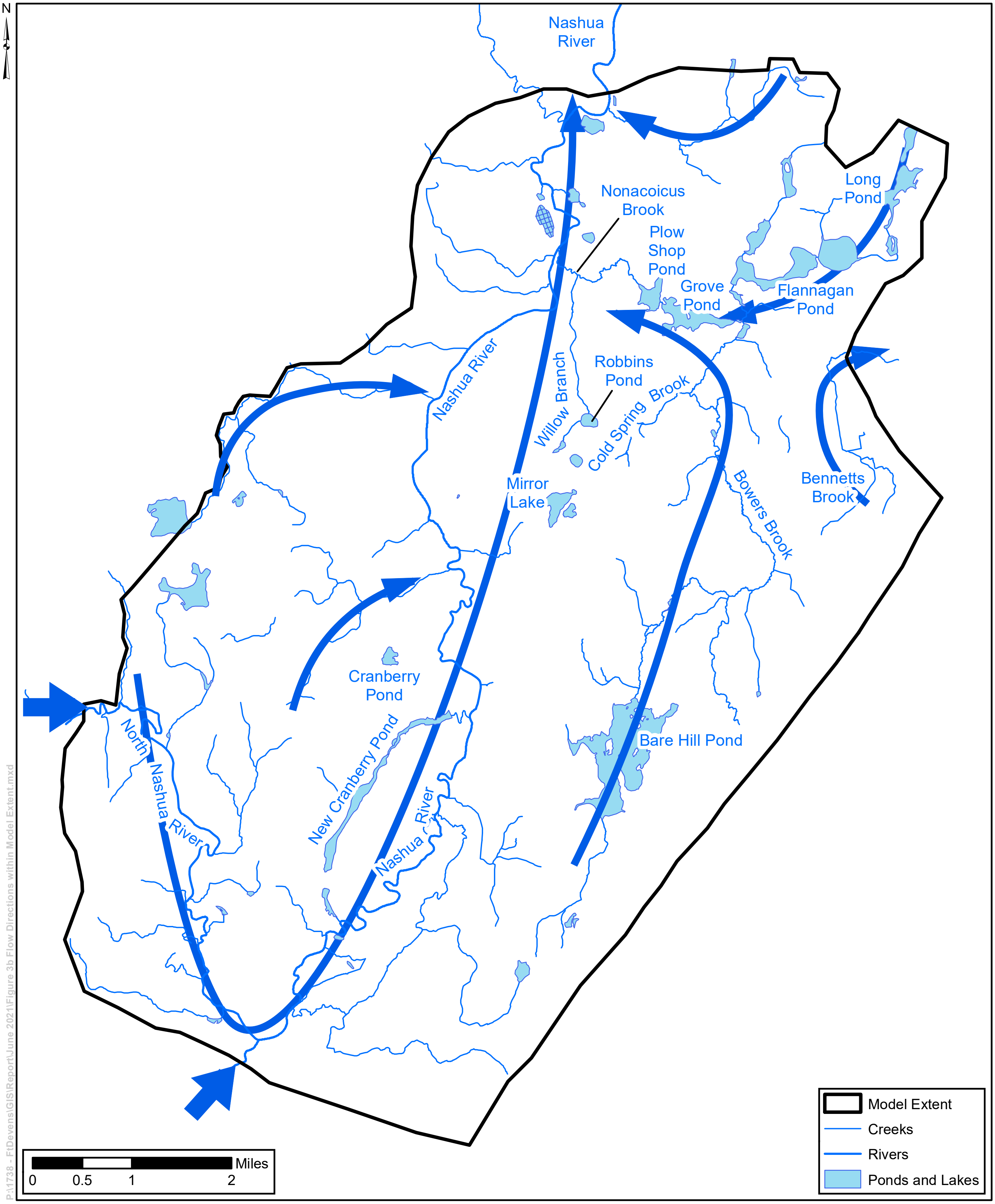

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Figure 3a Surface Water Flow Directions

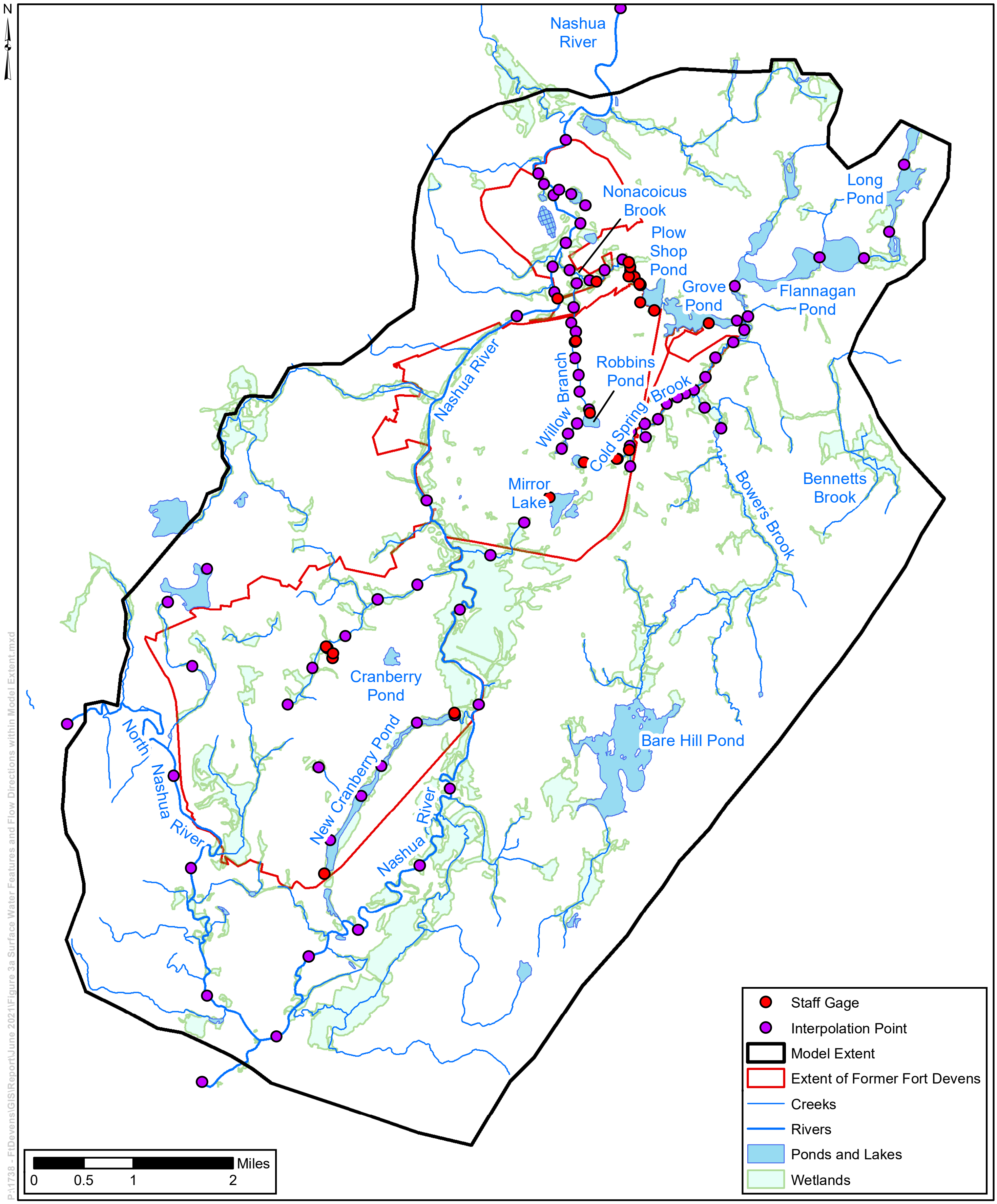

Figure 3b Surface Water Features within Model Domain

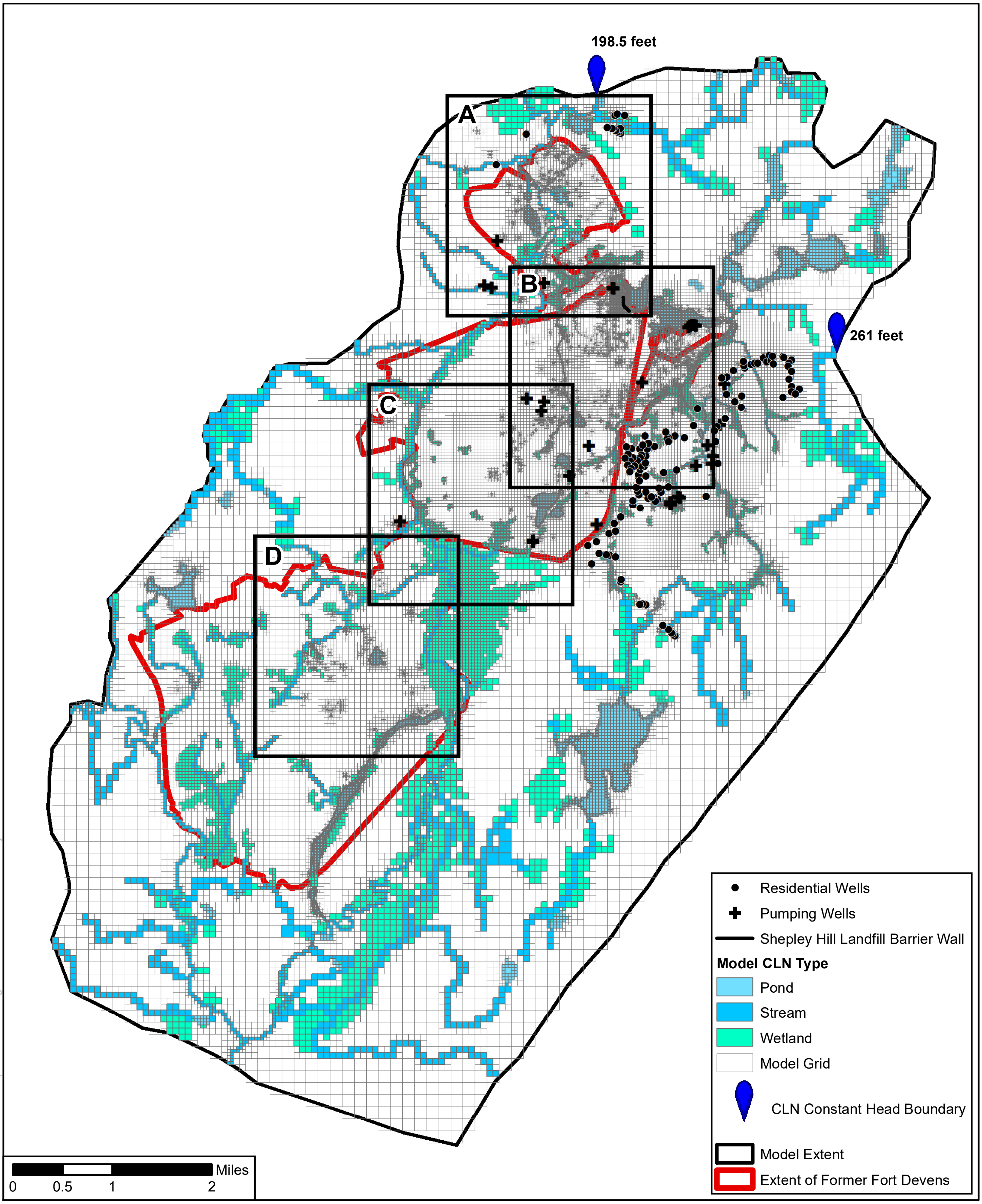

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Figure 4a Model Grid and Boundary Conditions

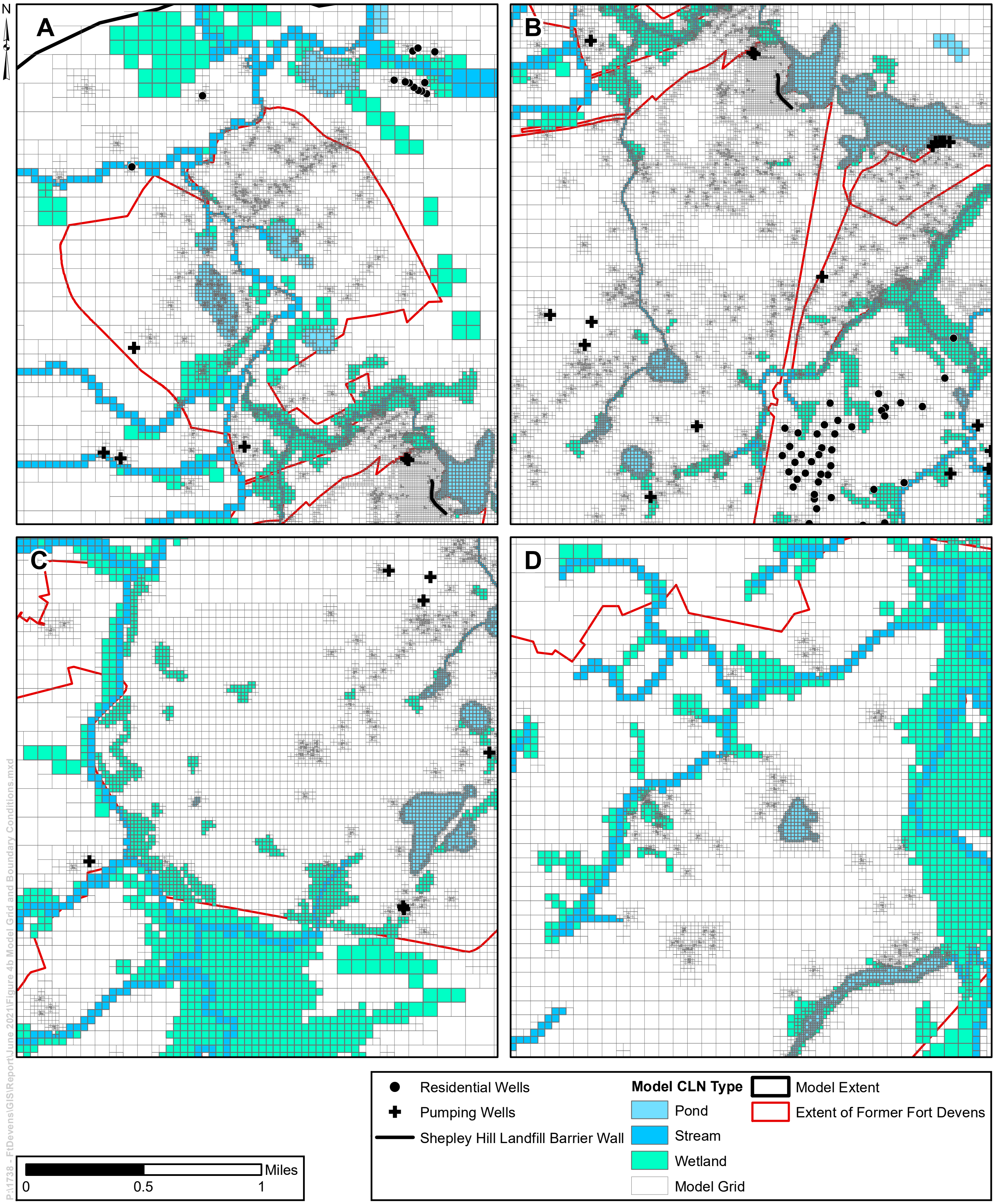

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Figure 4b Model Grid and Boundary Conditions - Insets A-D

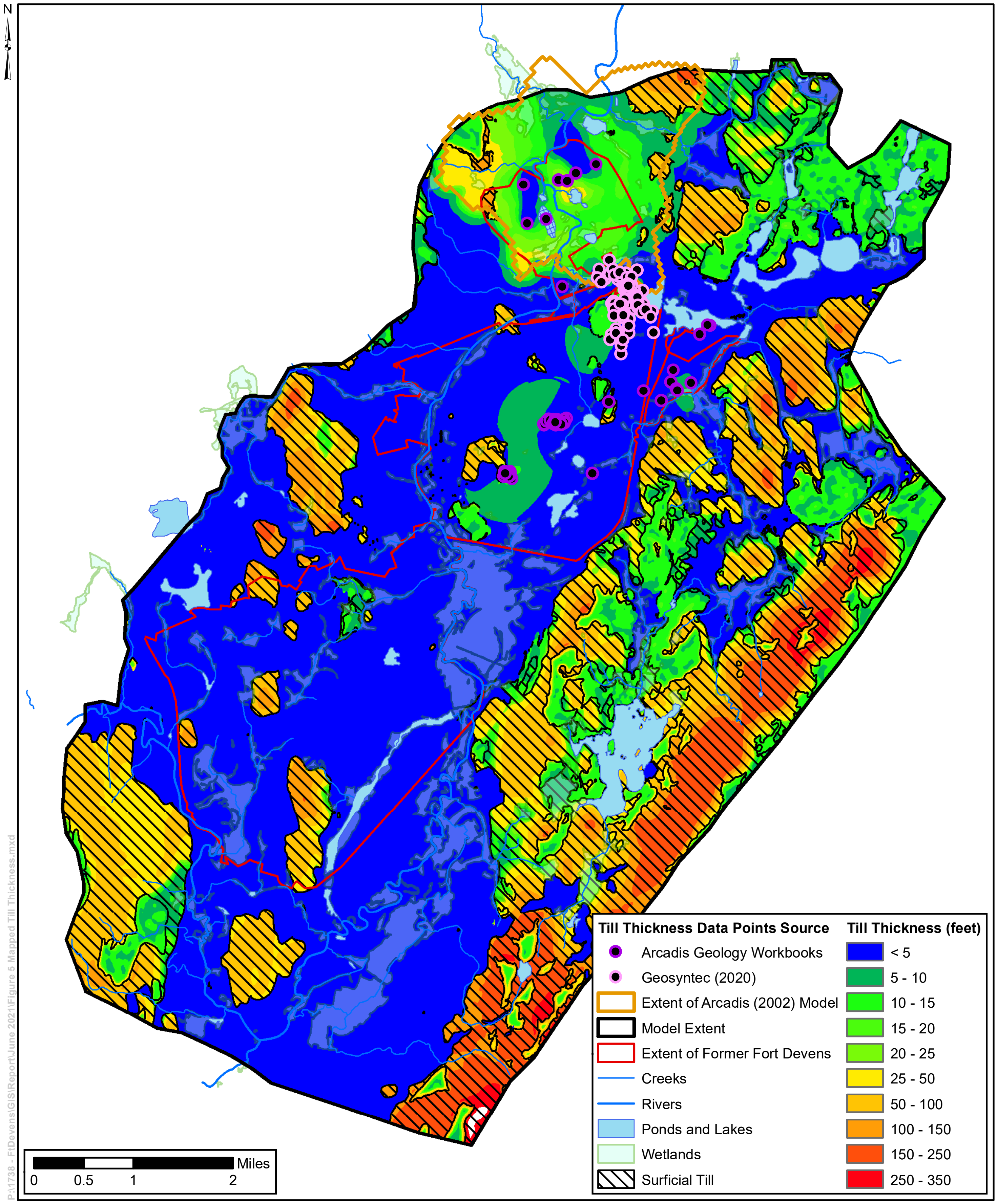

Figure 5 Mapped Till Thickness

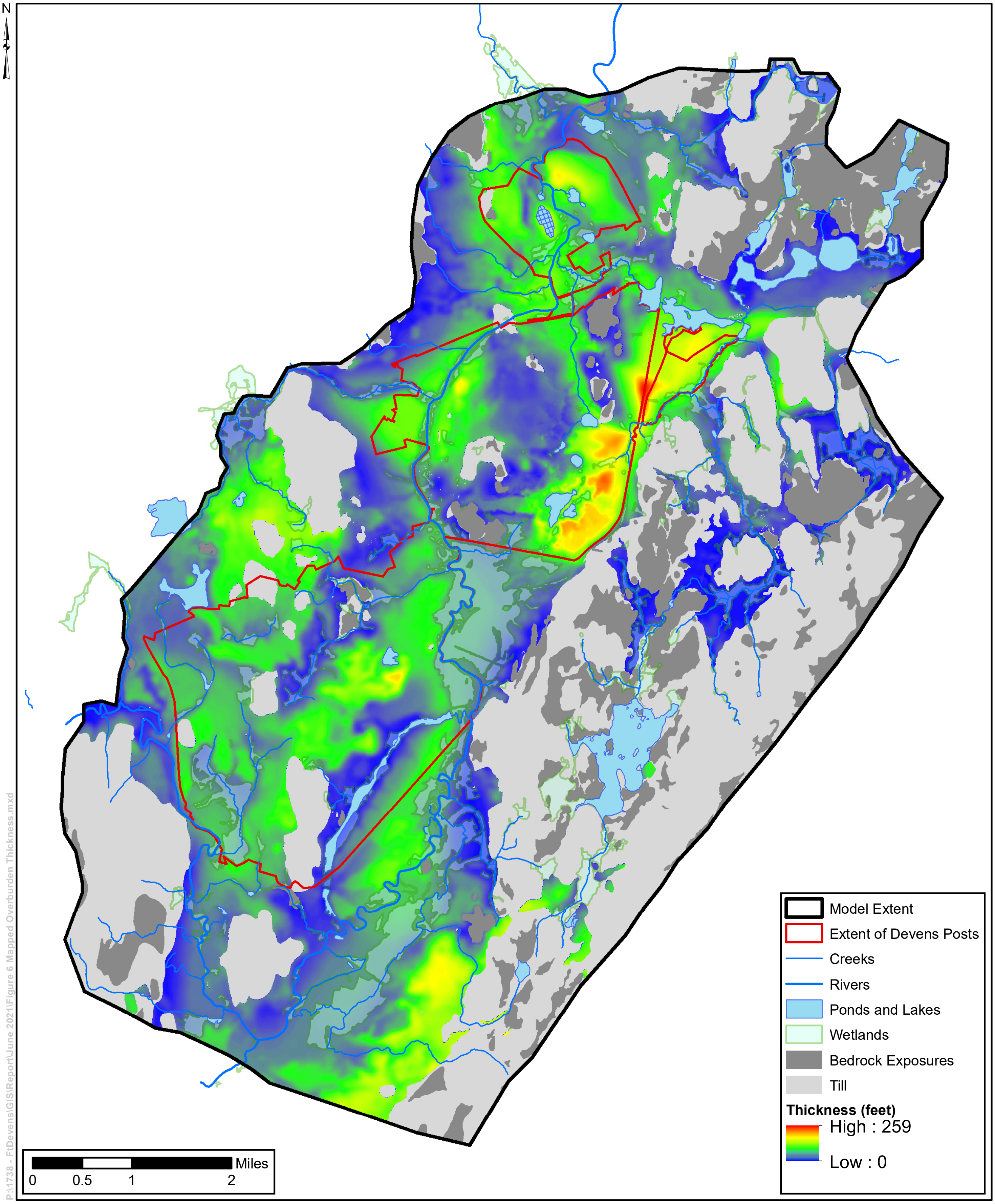

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Figure 6 Mapped Overburden Thickness

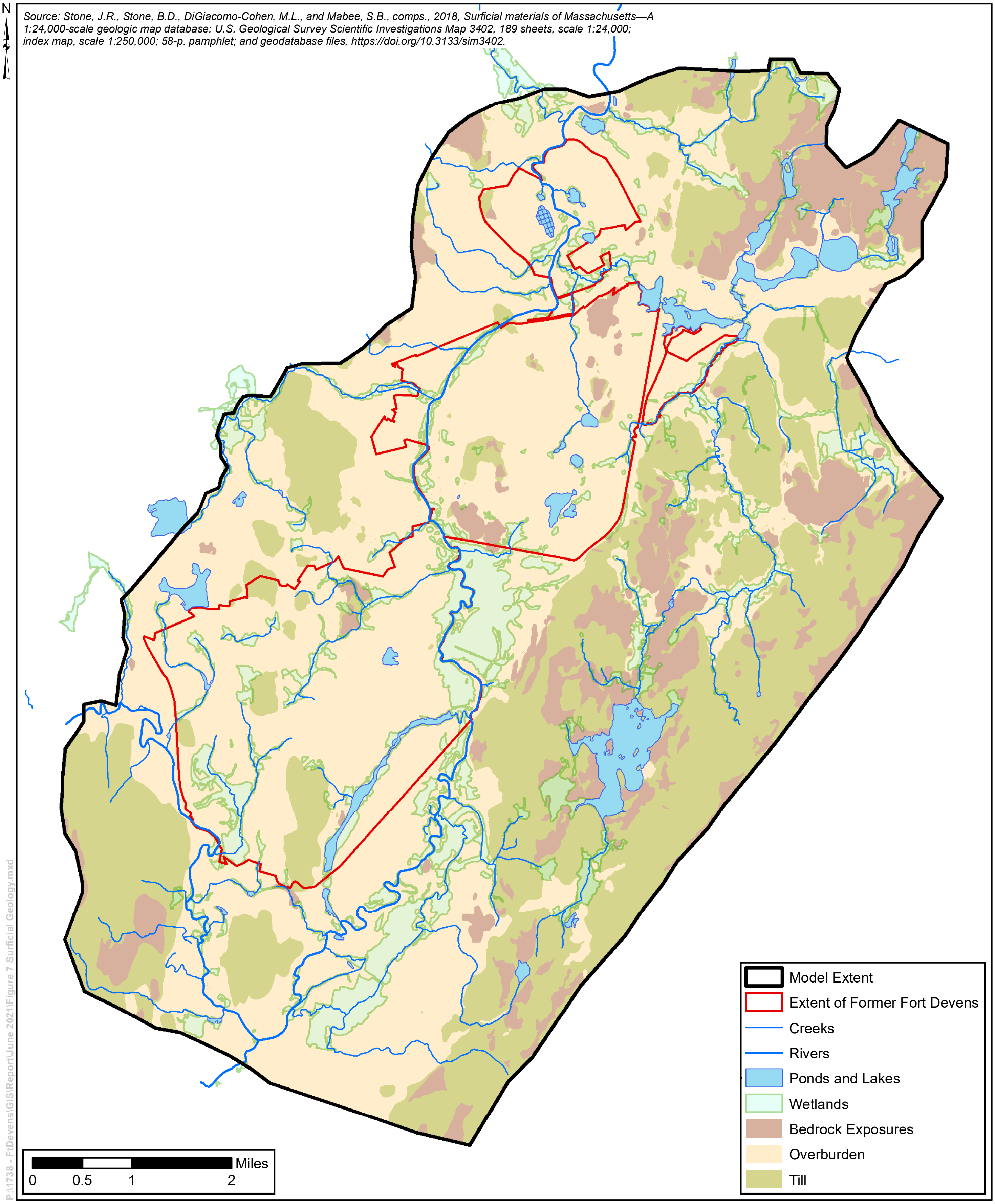

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Figure 7 Surficial Geology

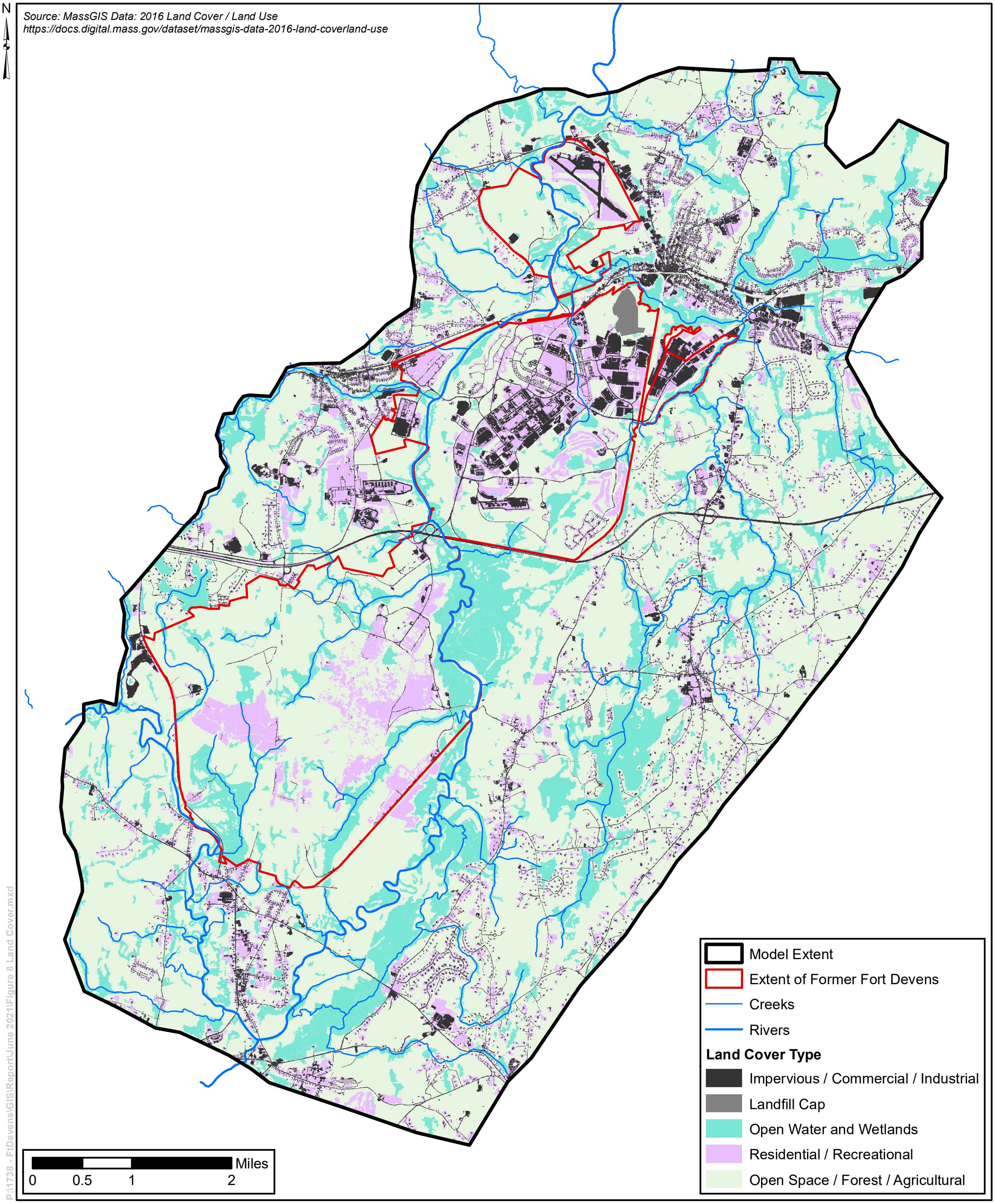


Figure 8 Land Cover

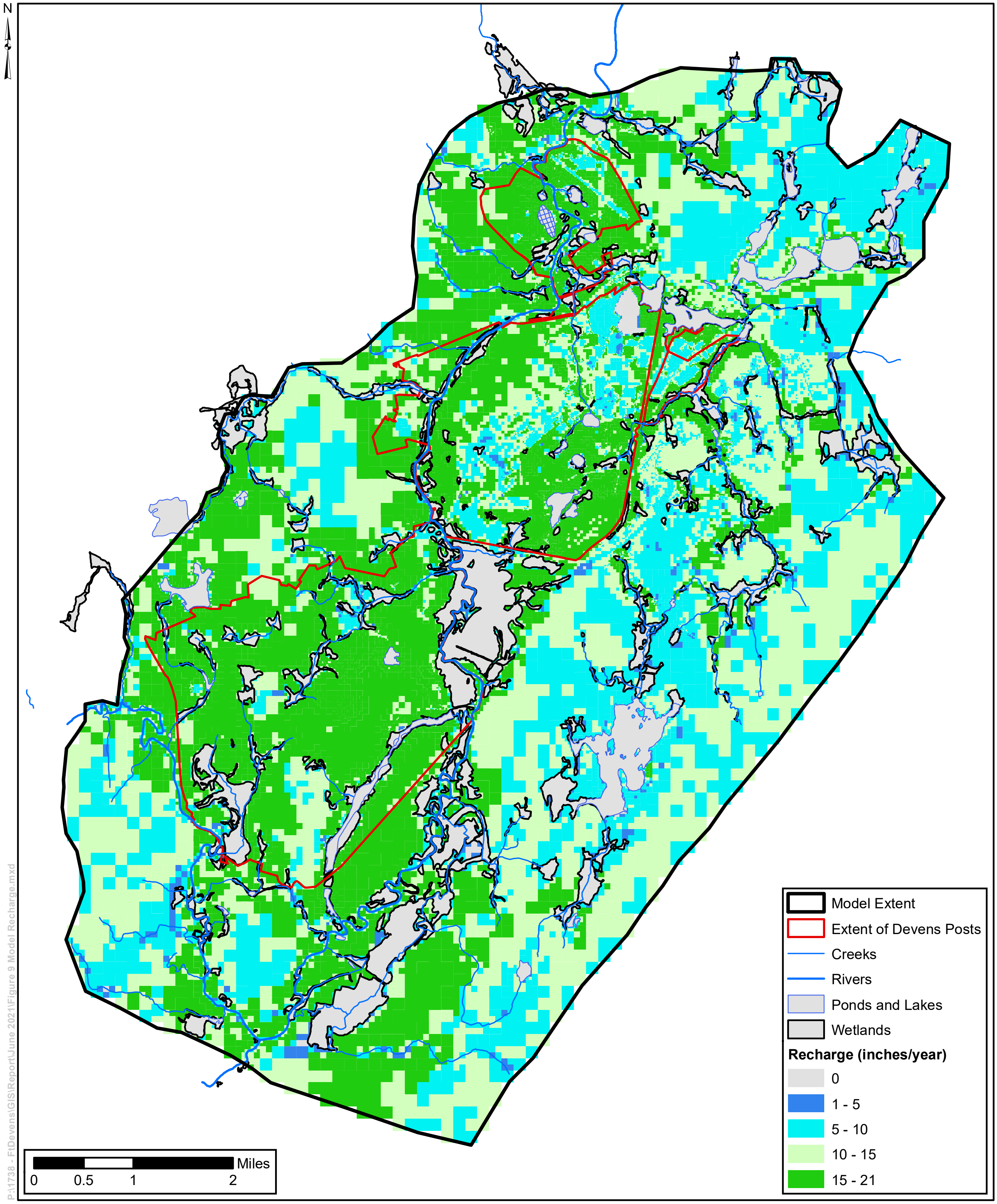
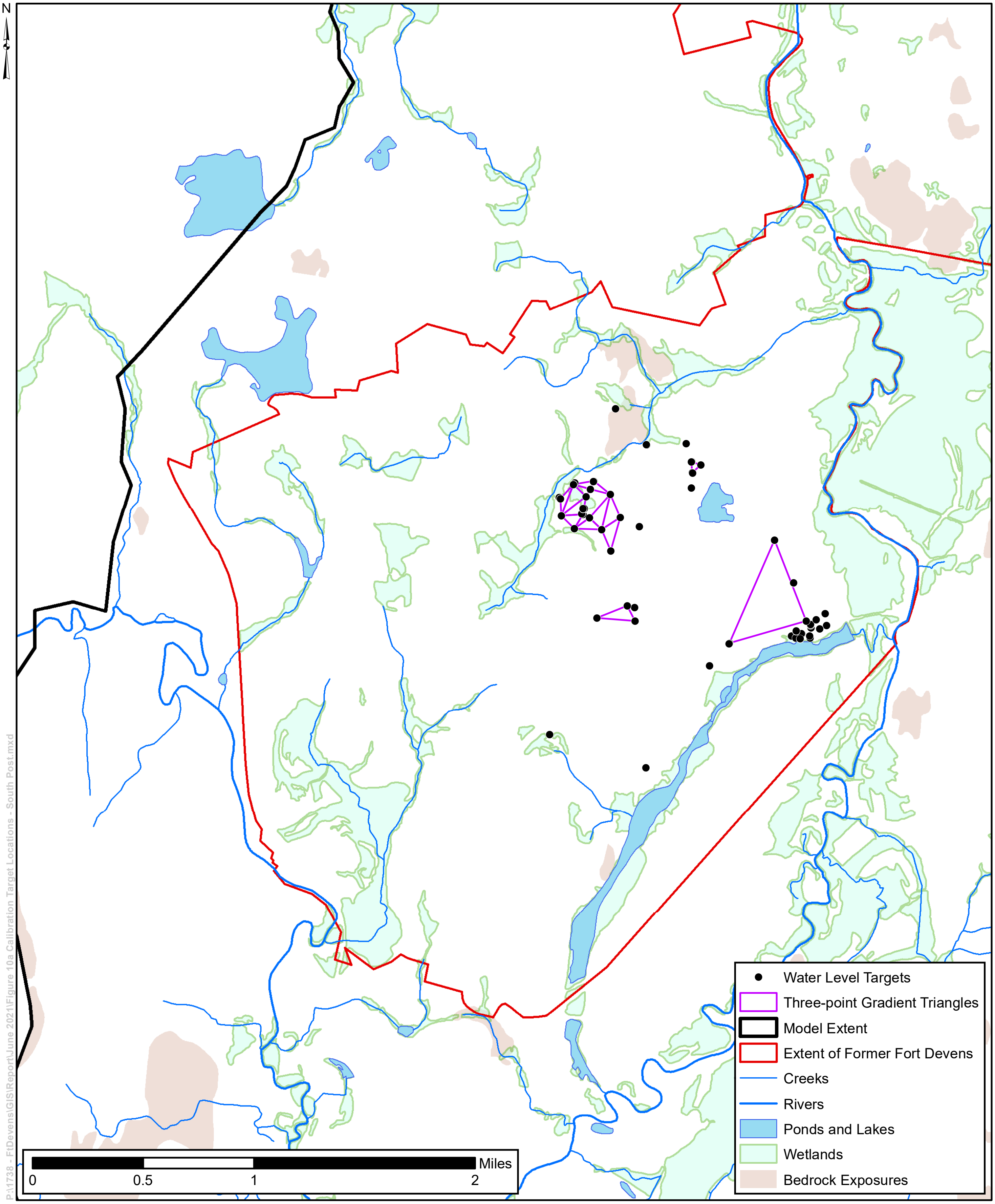


Figure 9 Model Recharge



P:\1738 - FtDevens\GIS\Report\June 2021\Figure 10a Calibration Target Locations - South Post.mxd

Figure 10a Calibration Target Locations - South Post

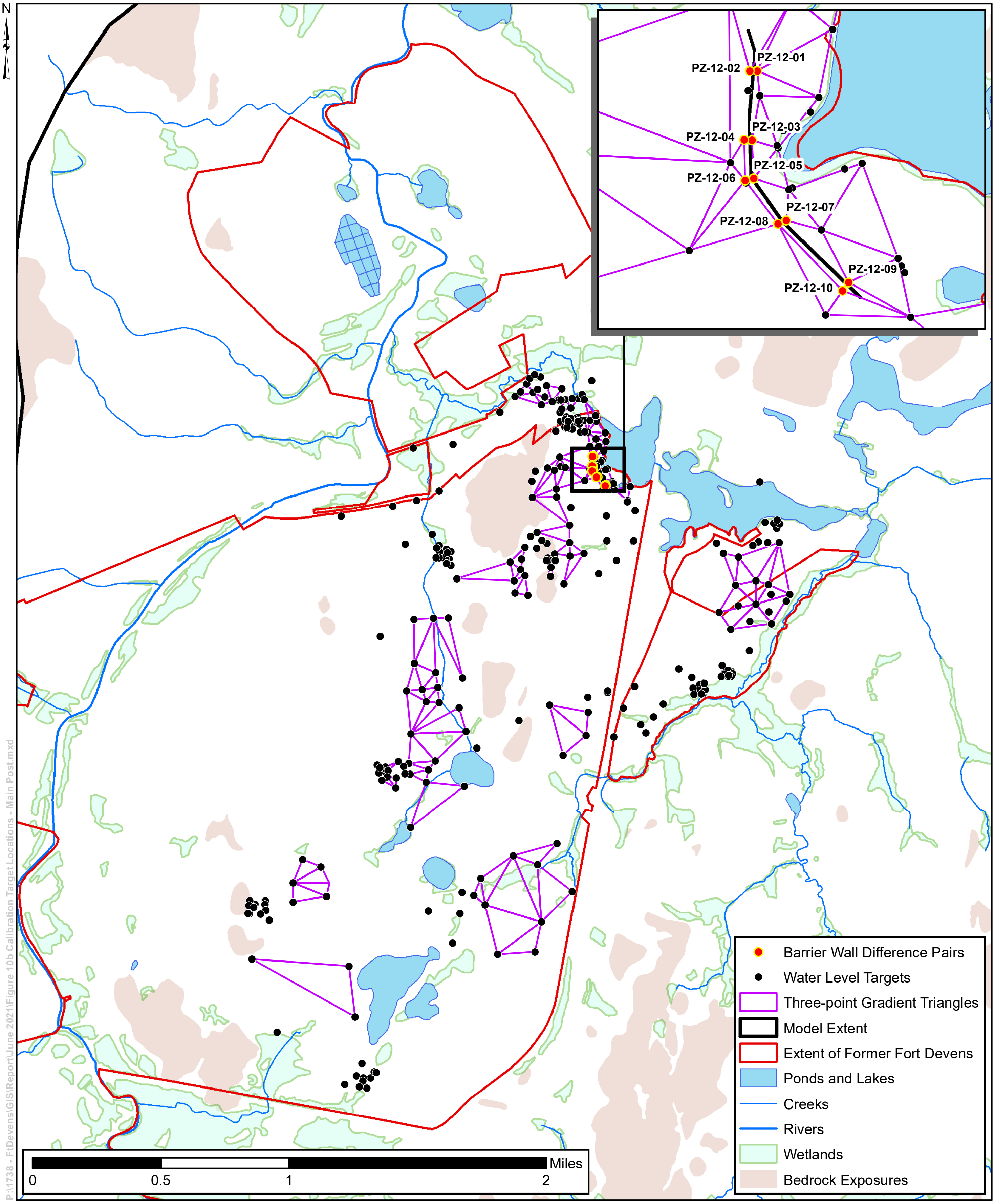


Figure 10b Calibration Target Locations - Former Main Post

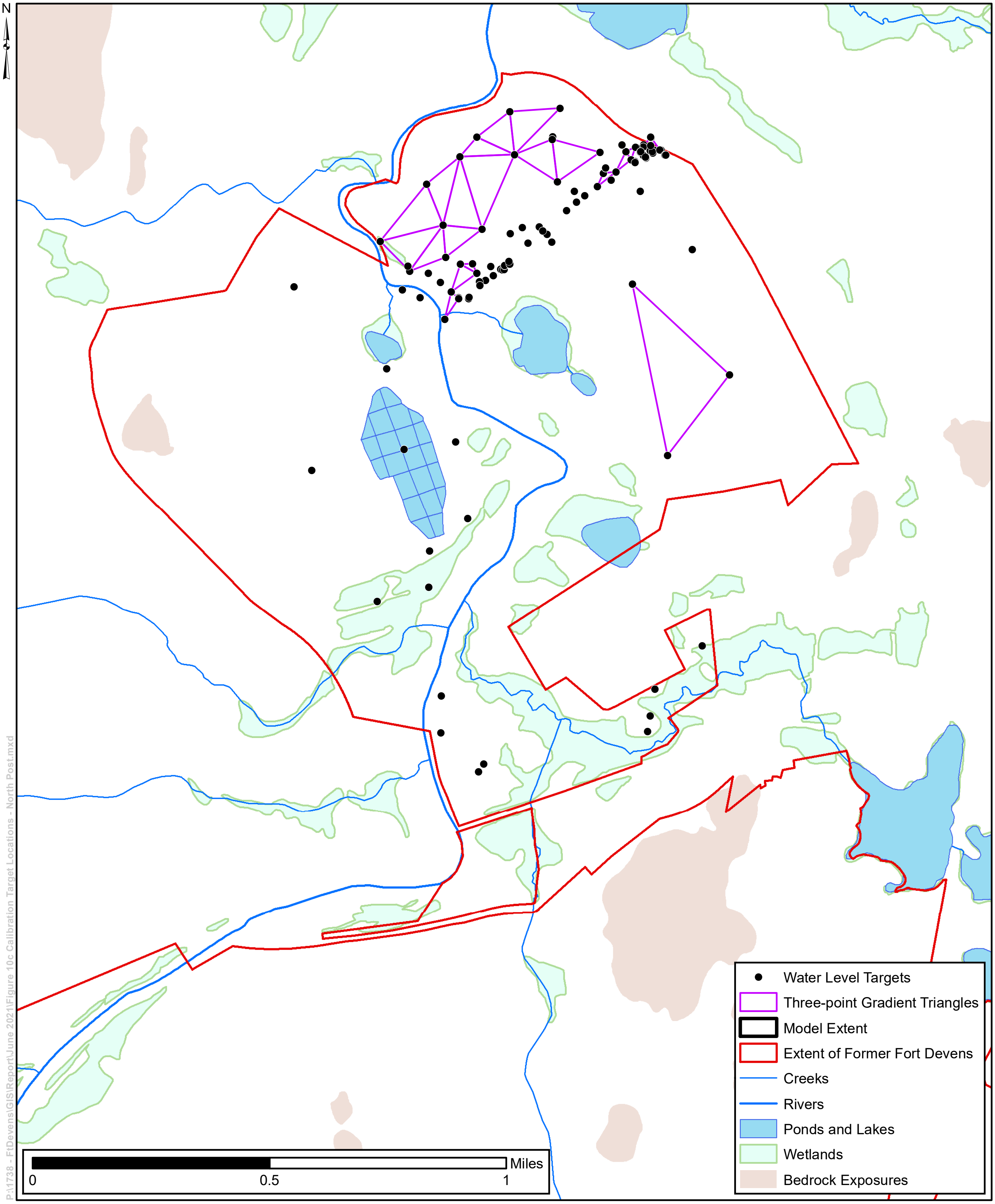


Figure 10c Calibration Target Locations - Former North Post

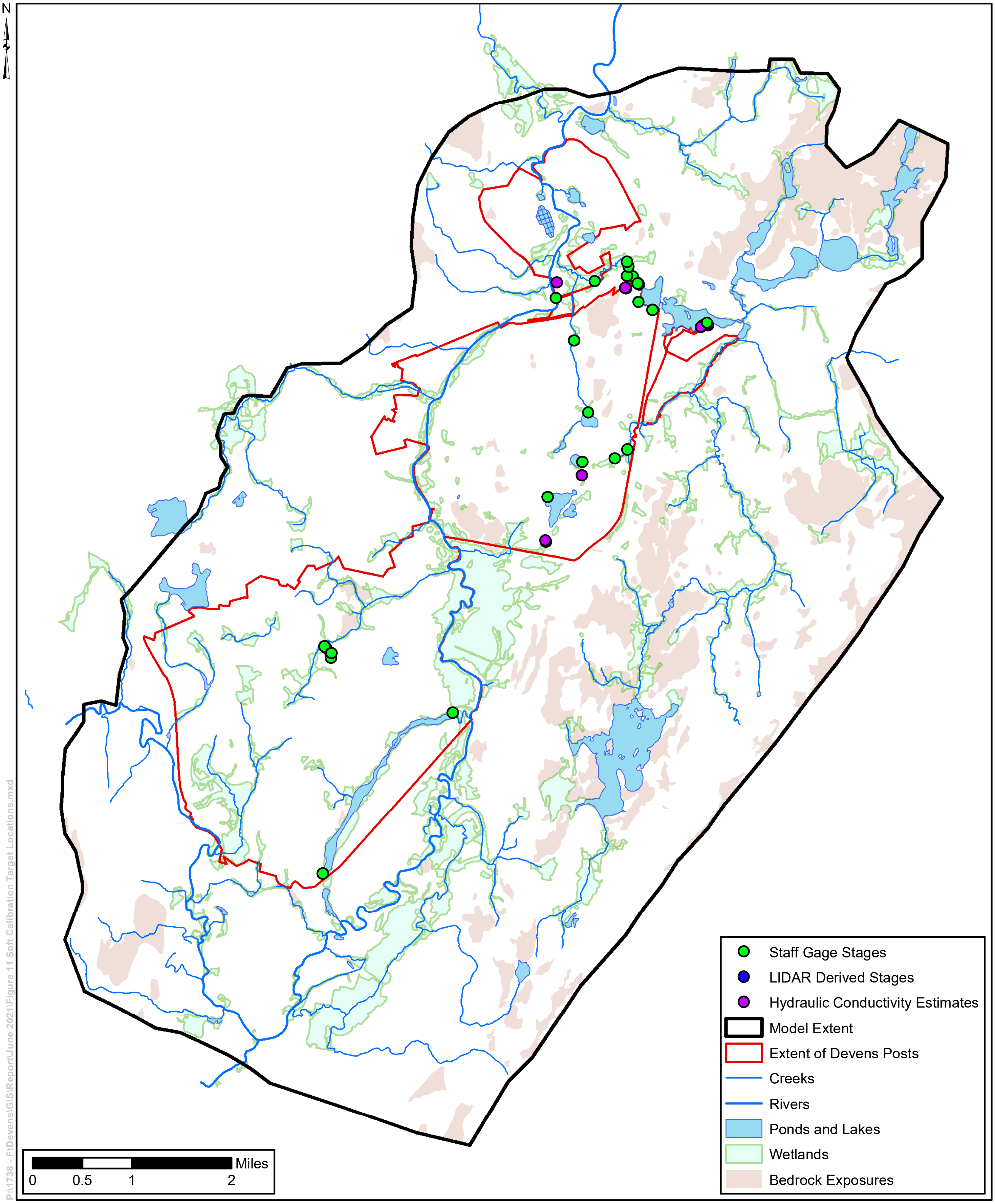


Figure 11 Soft Calibration Target Locations

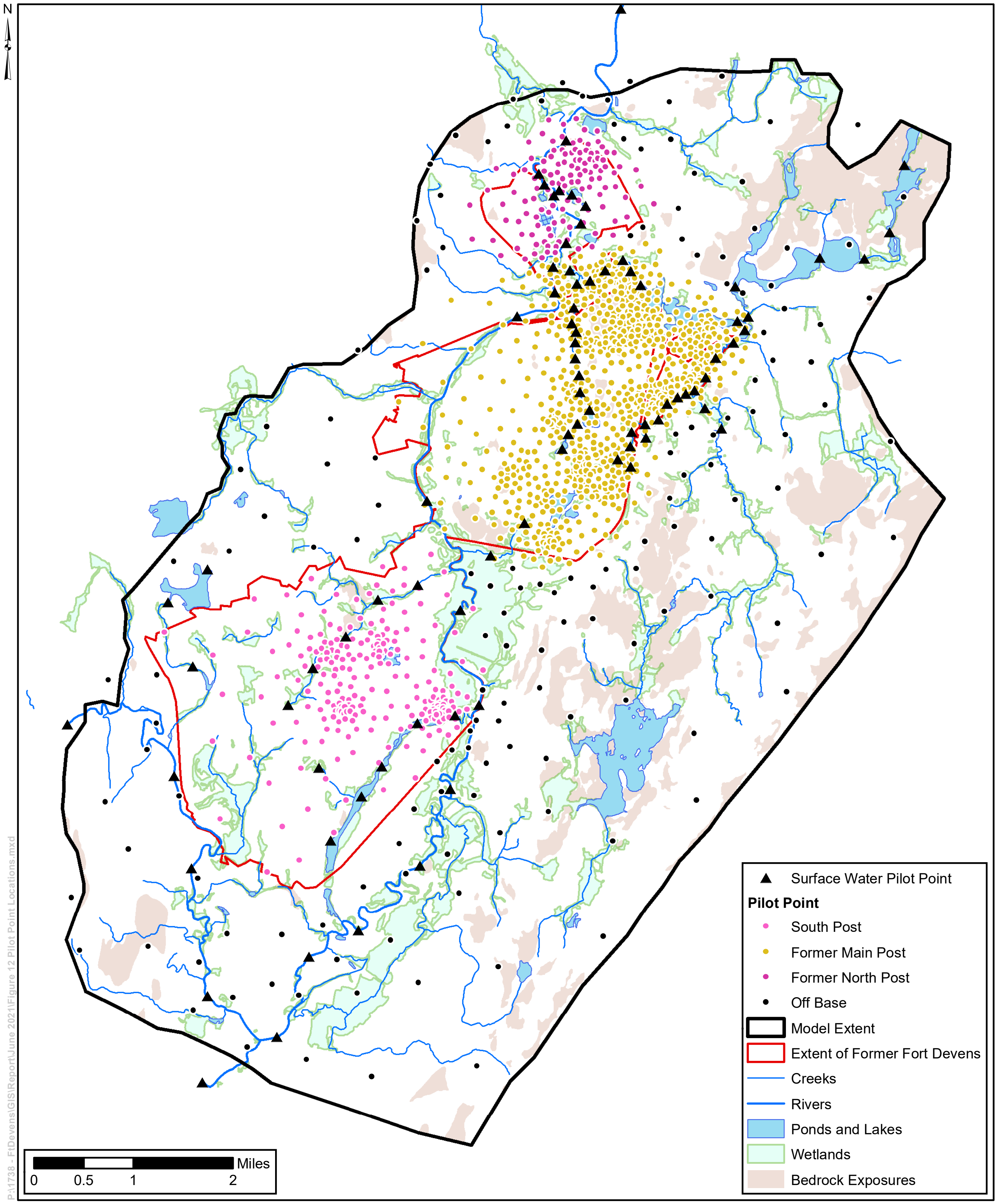


Figure 12 Pilot Point Locations

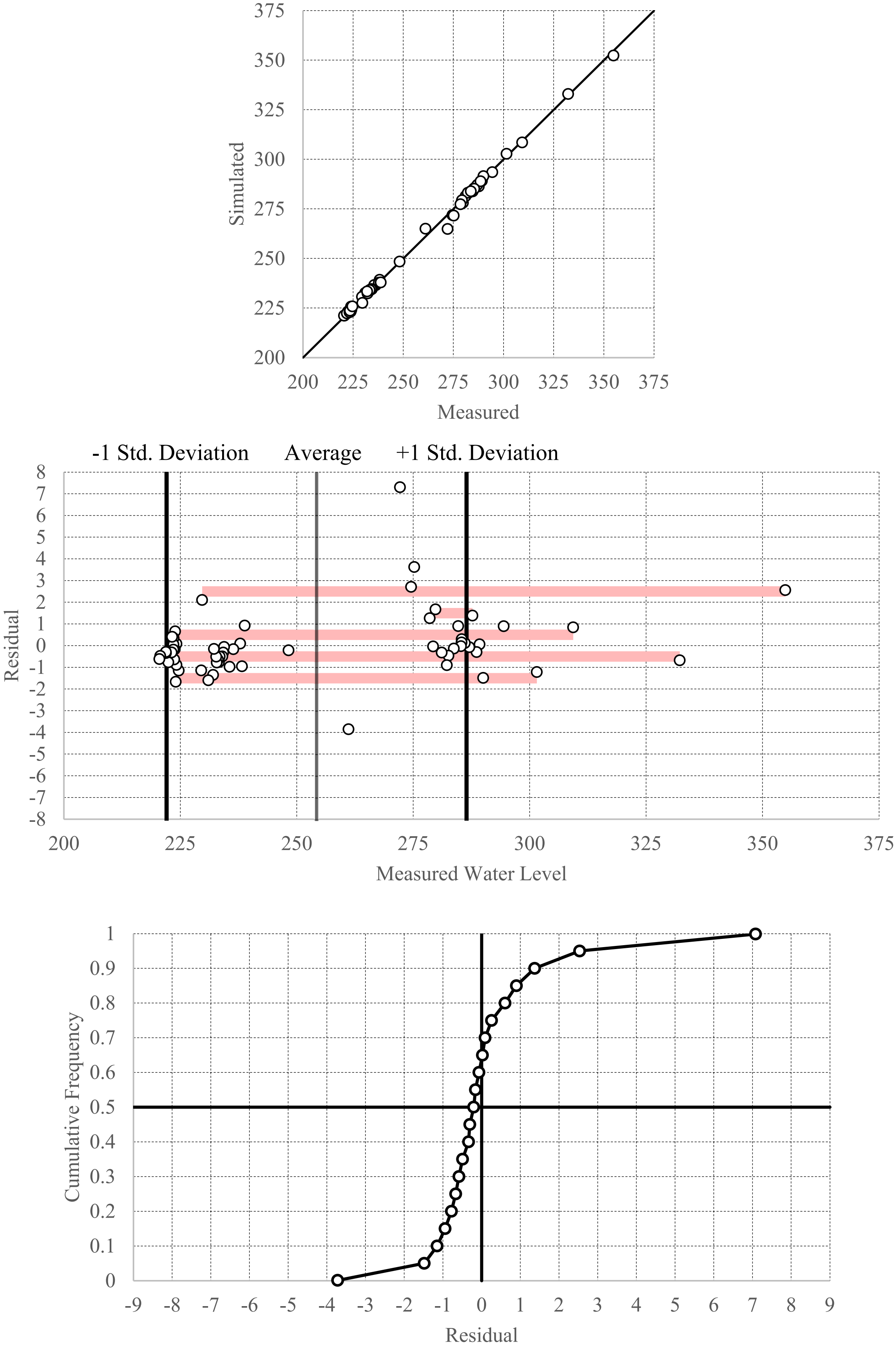


Figure 13a Graphical Summary of Water Level Residuals – South Post

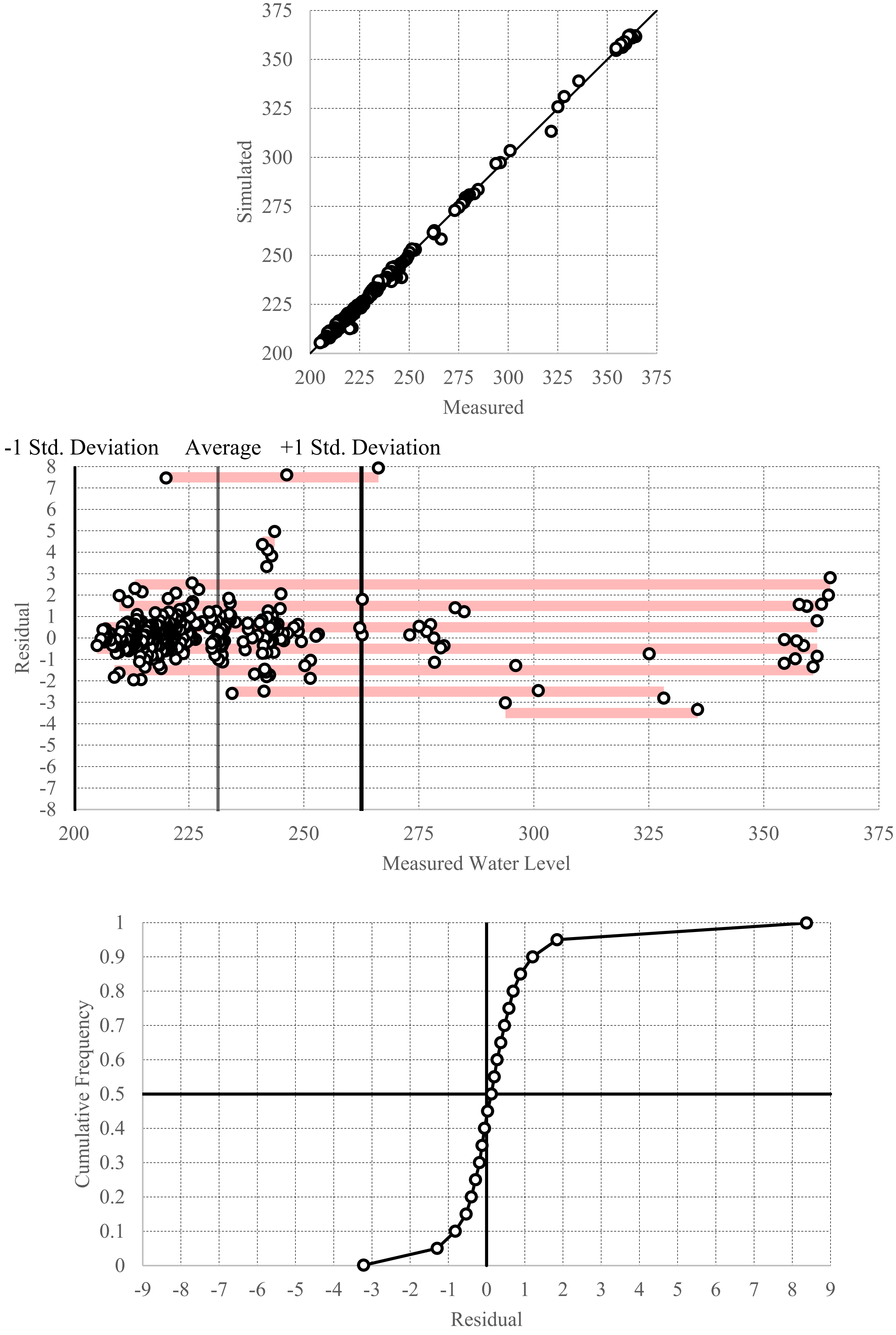


Figure 13b Graphical Summary of Water Level Residuals – Former Main Post

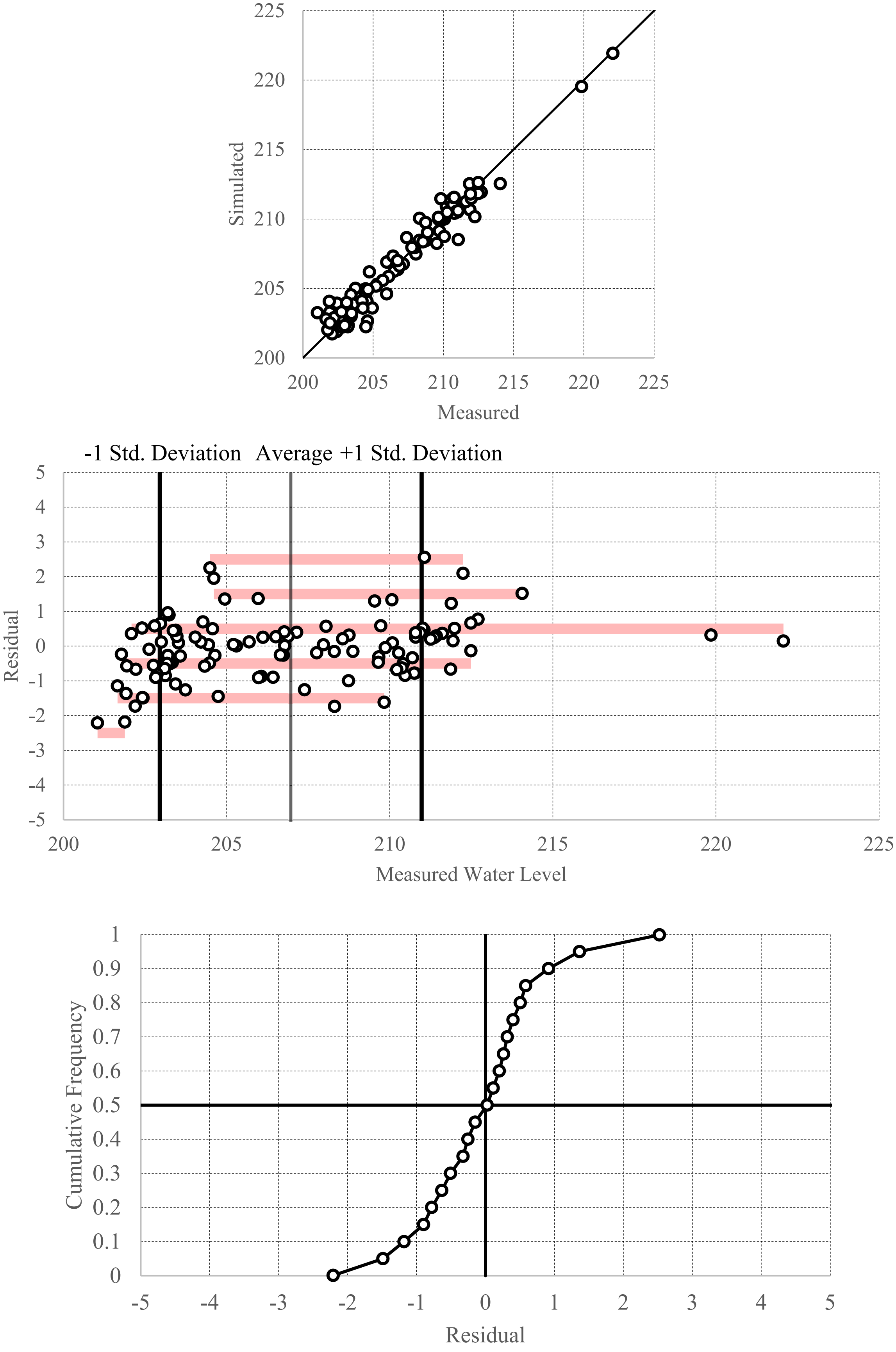
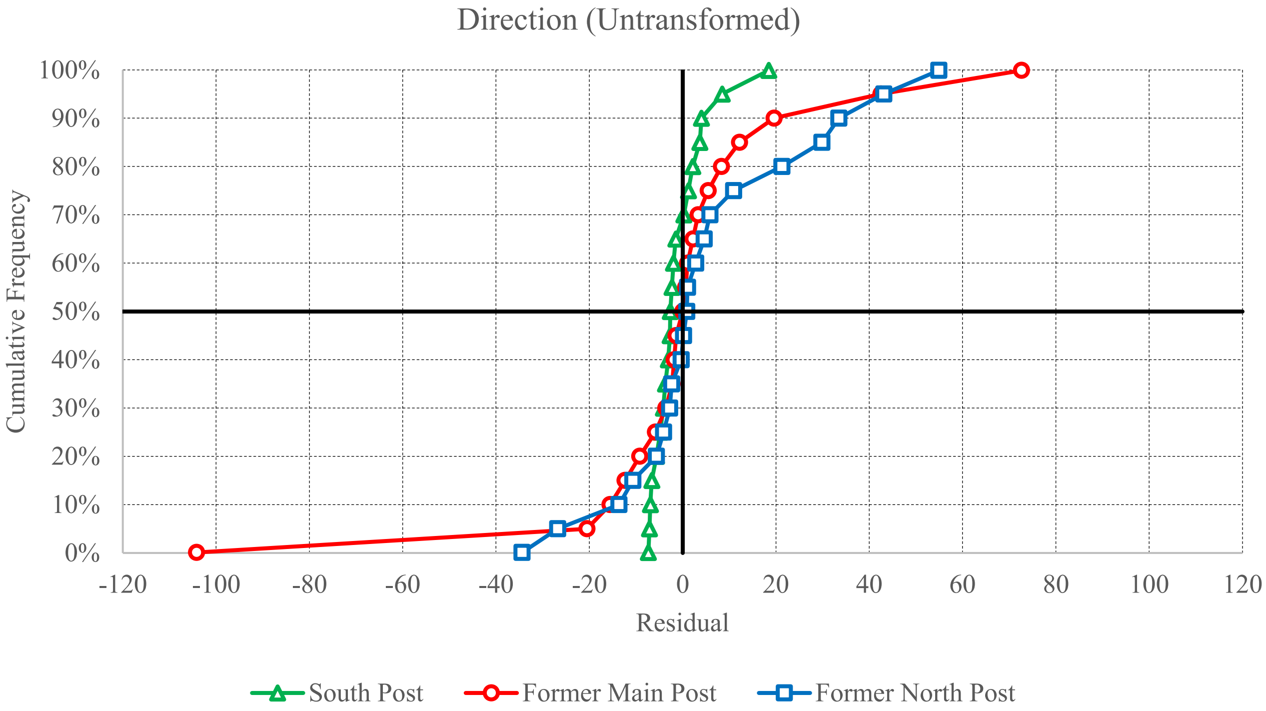


Figure 13c Graphical Summary of Water Level Residuals – Former North Post



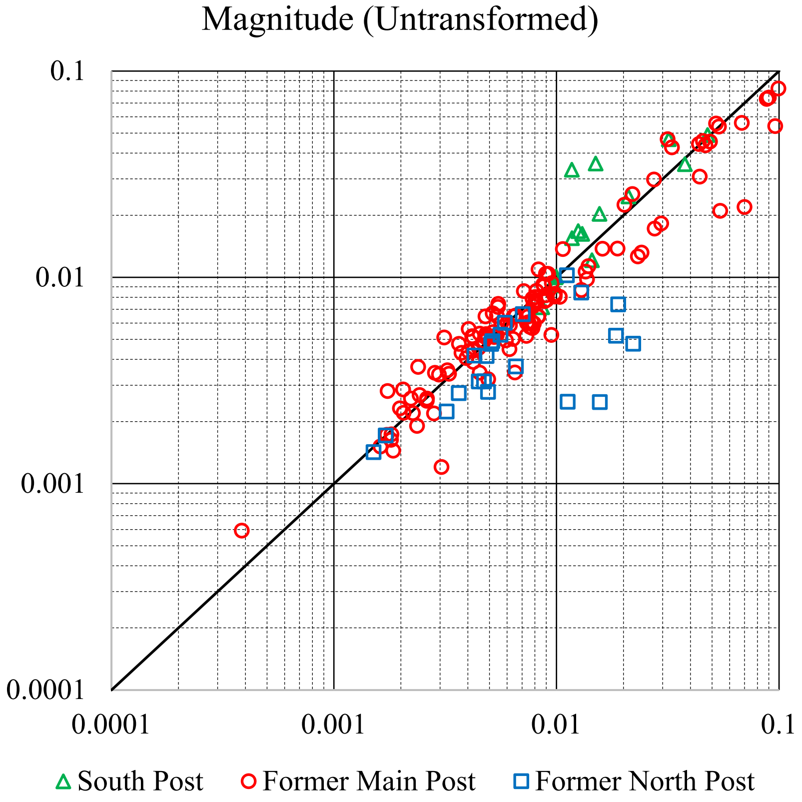


Figure 13d Graphical Summary of Three-Point Gradient Residuals

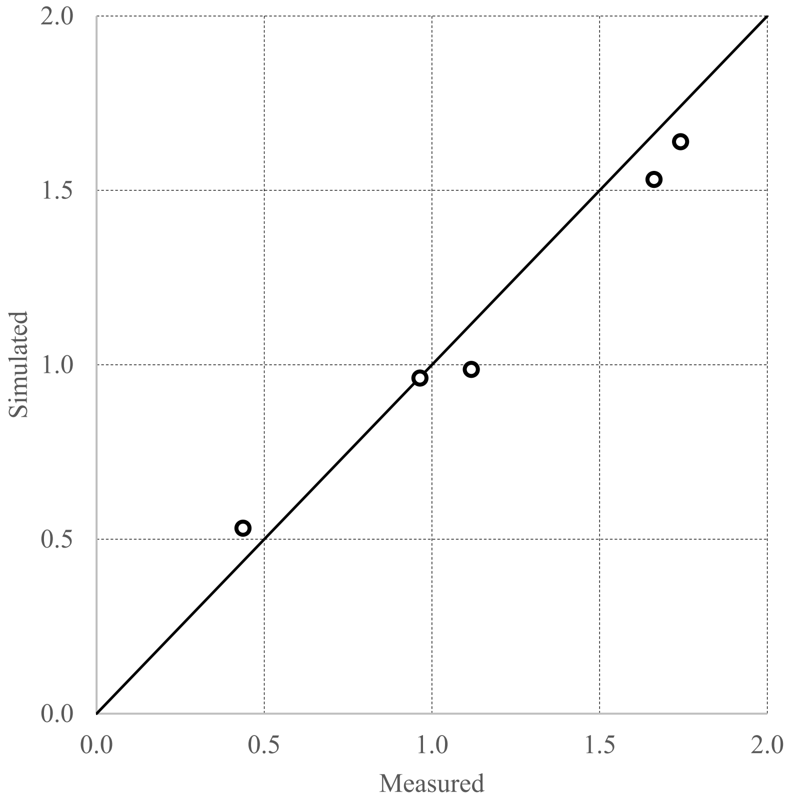


Figure 13e Graphical Summary of Barrier Wall Difference Residuals

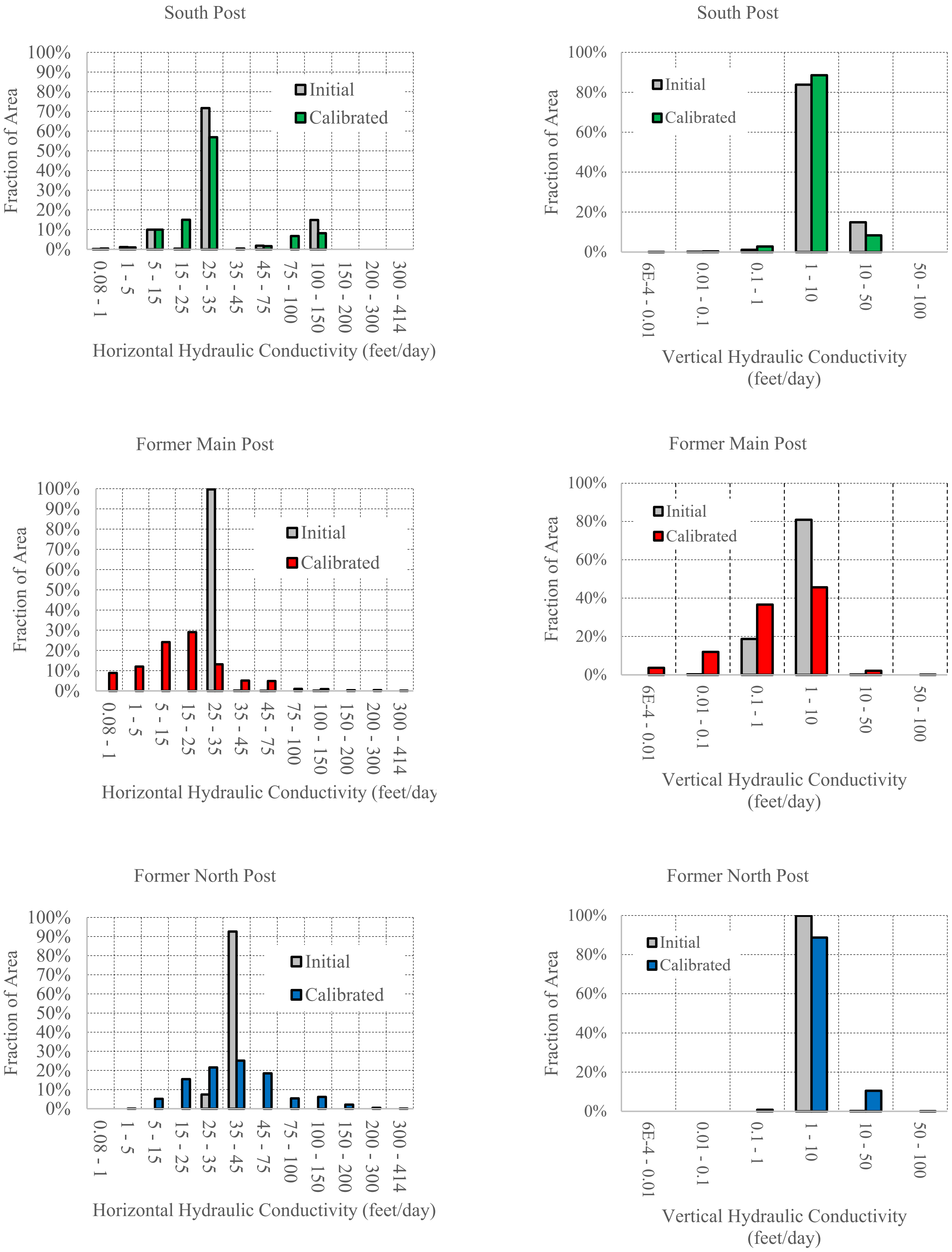


Figure 14a Summary of Overburden Hydraulic Conductivity

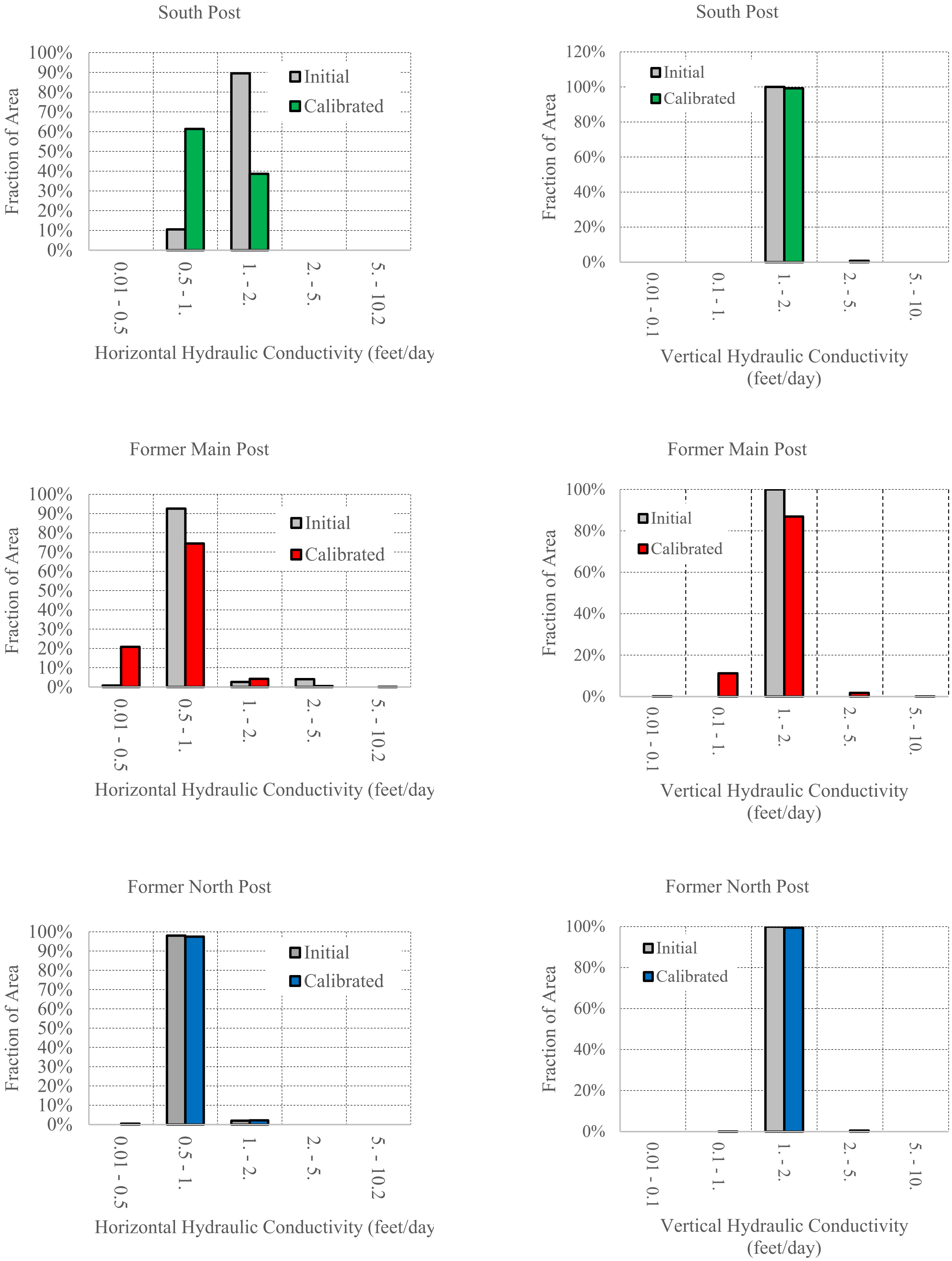


Figure 14b Summary of Upper Bedrock Hydraulic Conductivity

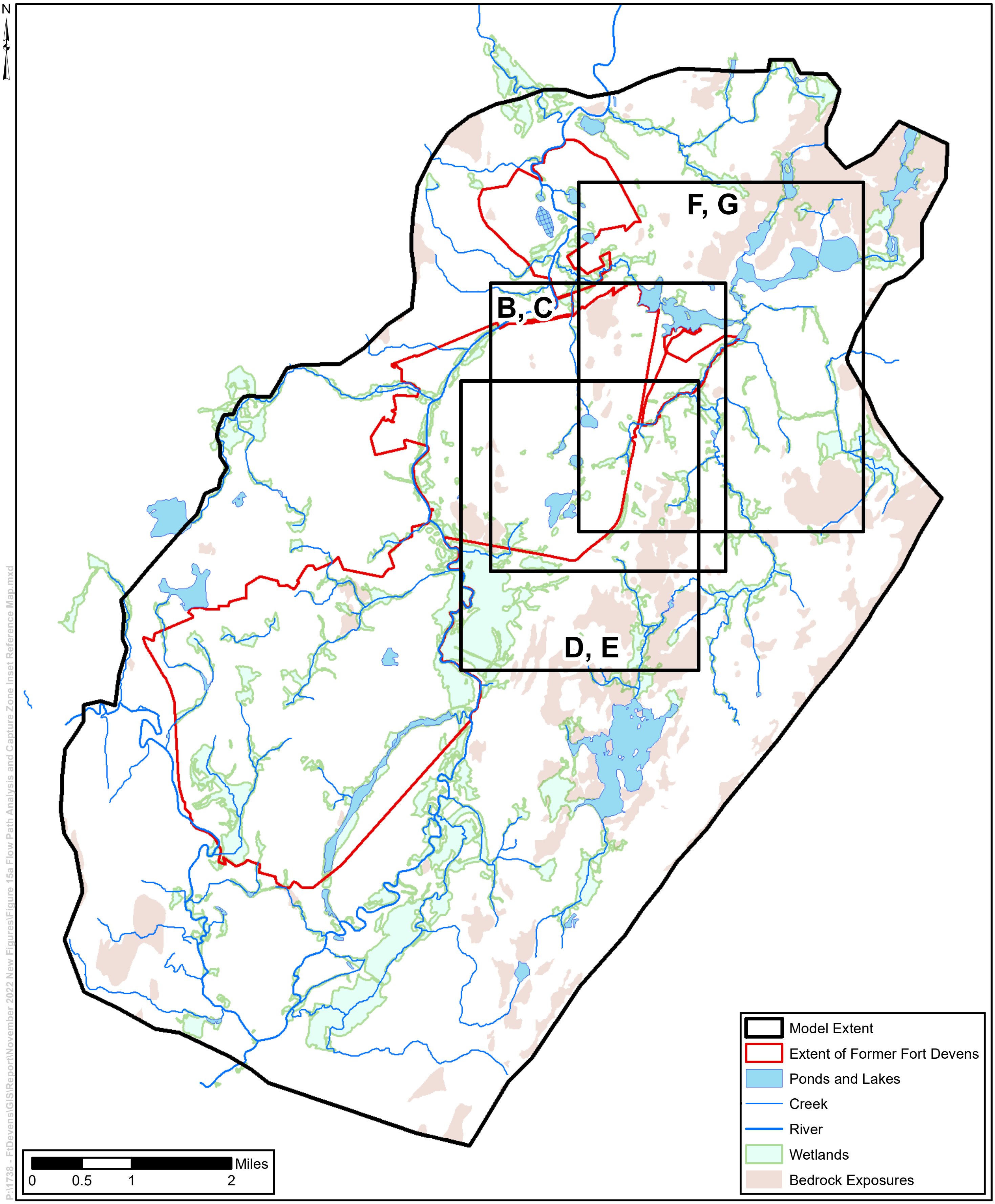


Figure 15a Flow Path Analysis and Capture Zone - Inset Reference Map

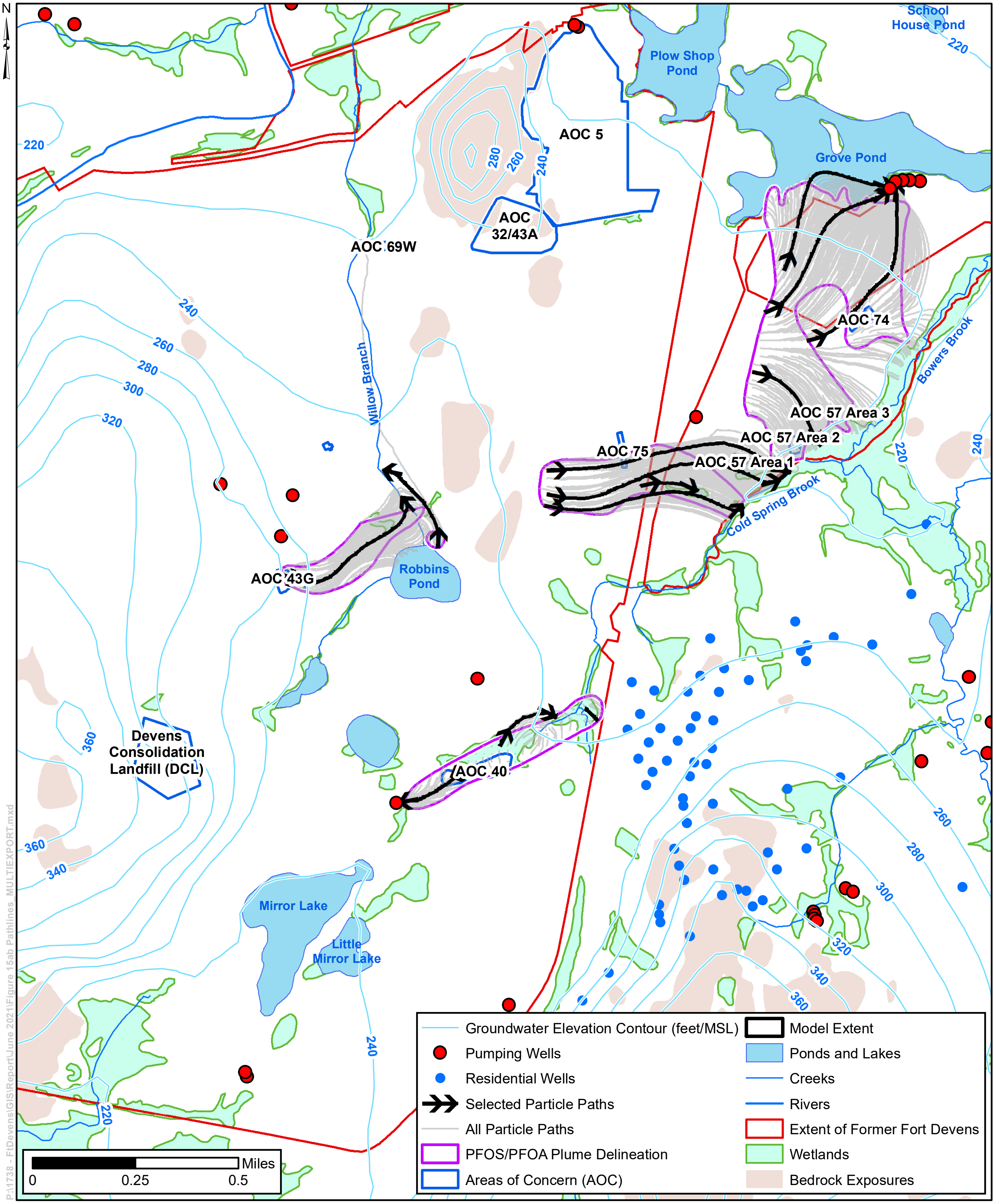


Figure 15b Flow Path Analysis, Focus Area 1 - Forward Particle Paths

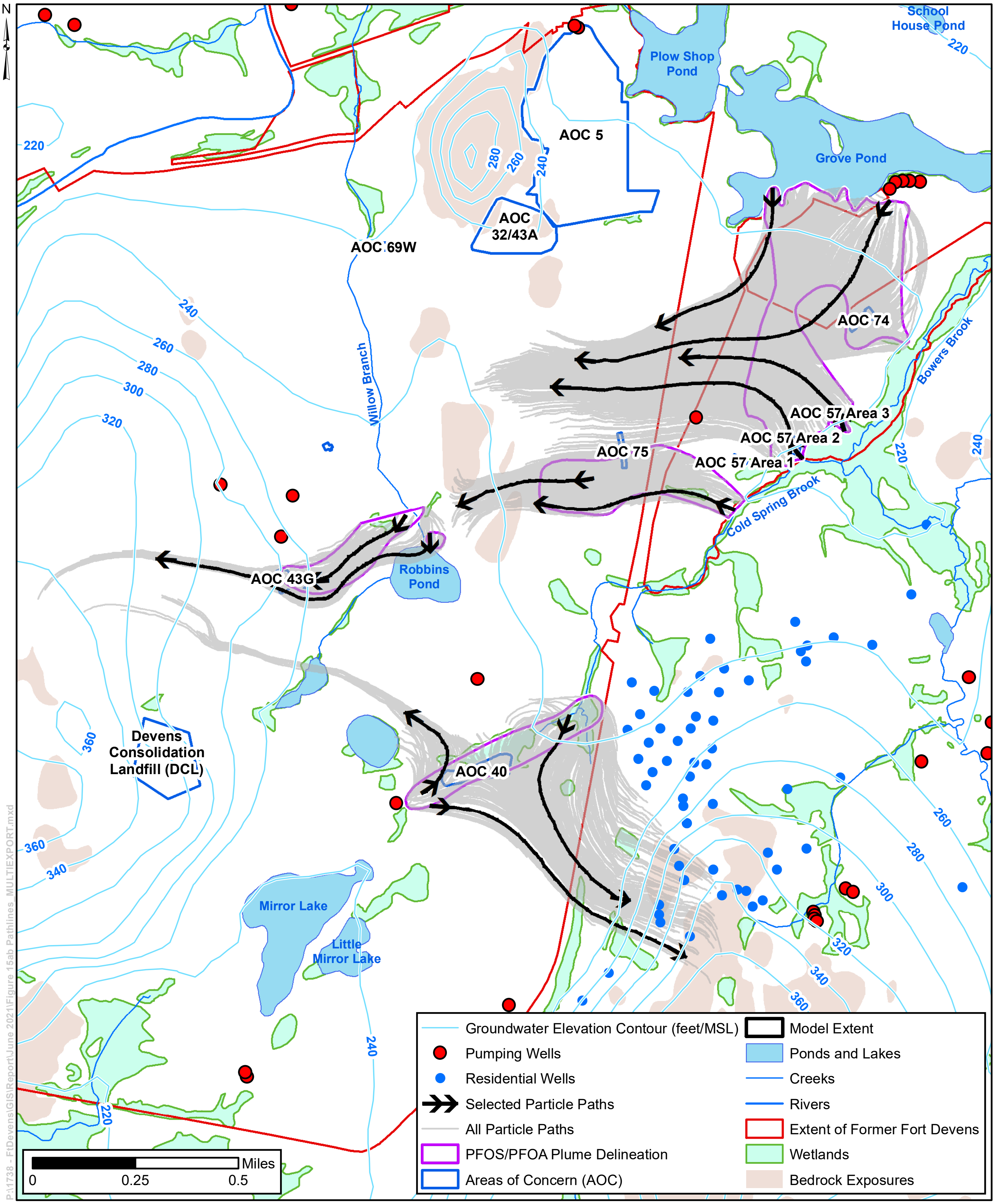


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Figure 15c Flow Path Analysis, Focus Area 1 - Backward Particle Paths

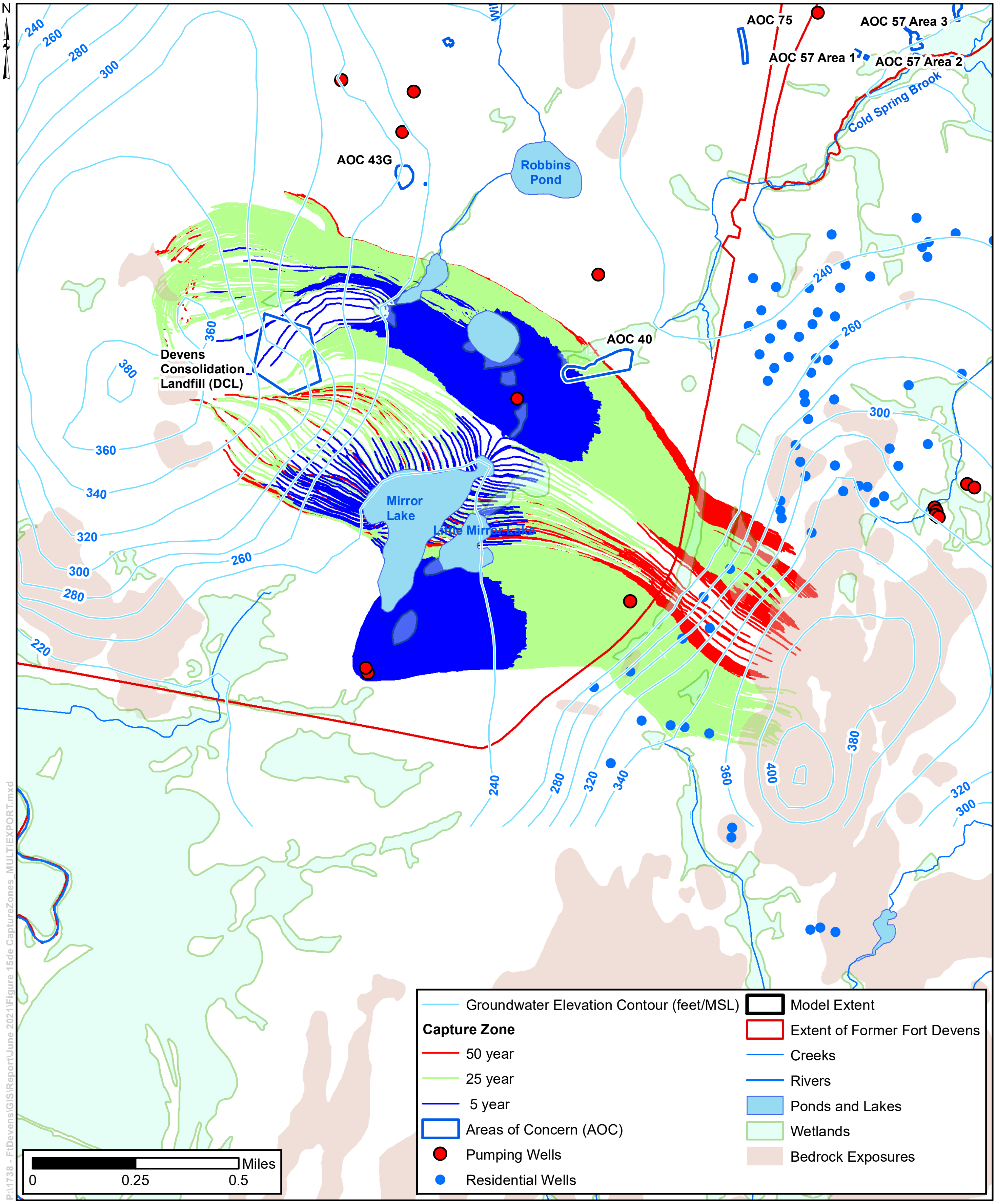

Figure 15d Five-, Twenty-five-, and Fifty-year Capture Zones for Patton and Shabokin Wells – Base Effective Porosity

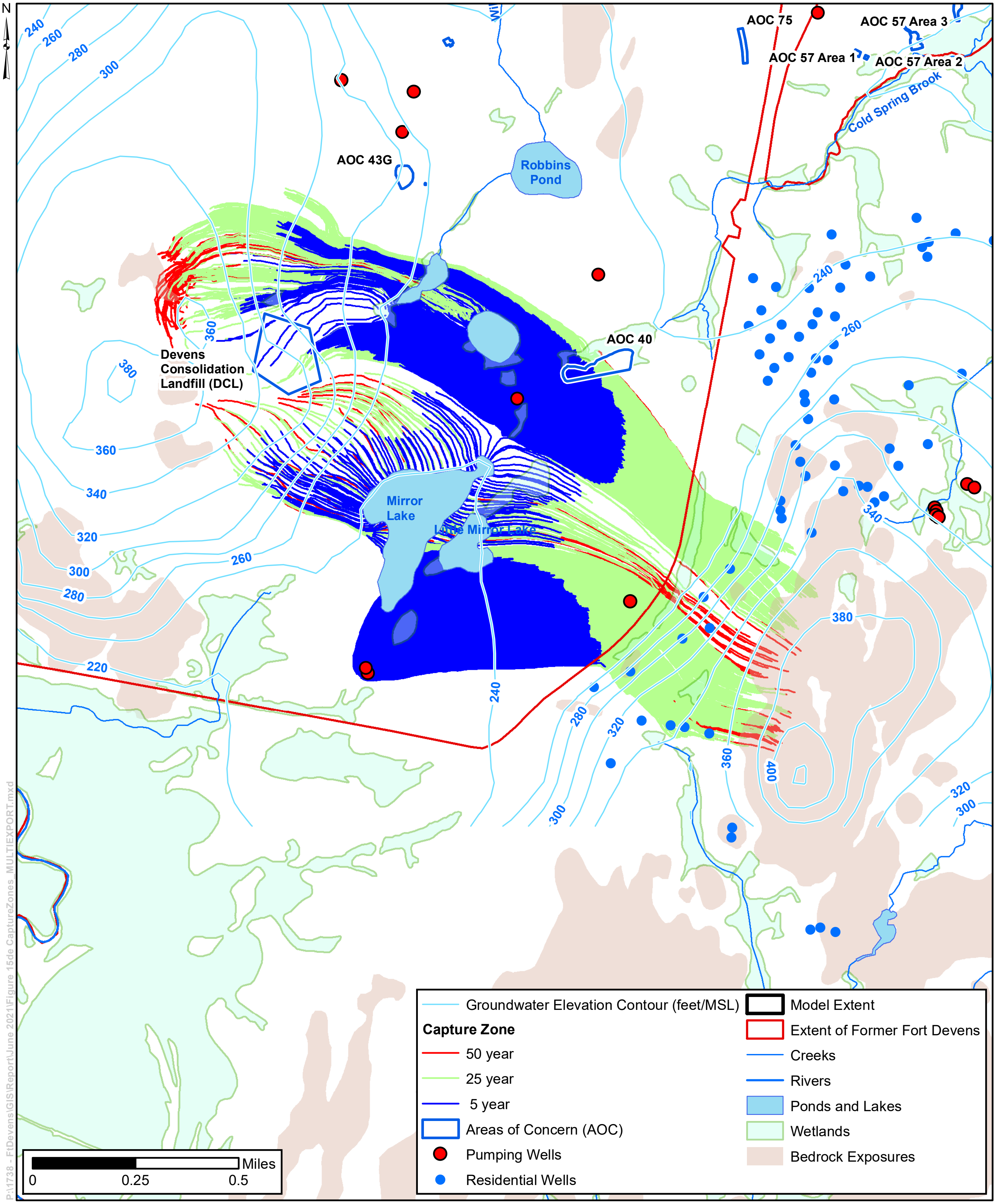

Figure 15e Five-, Twenty-five-, and Fifty-year Capture Zones for Patton and Shabokin Wells – Alternate Effective Porosity

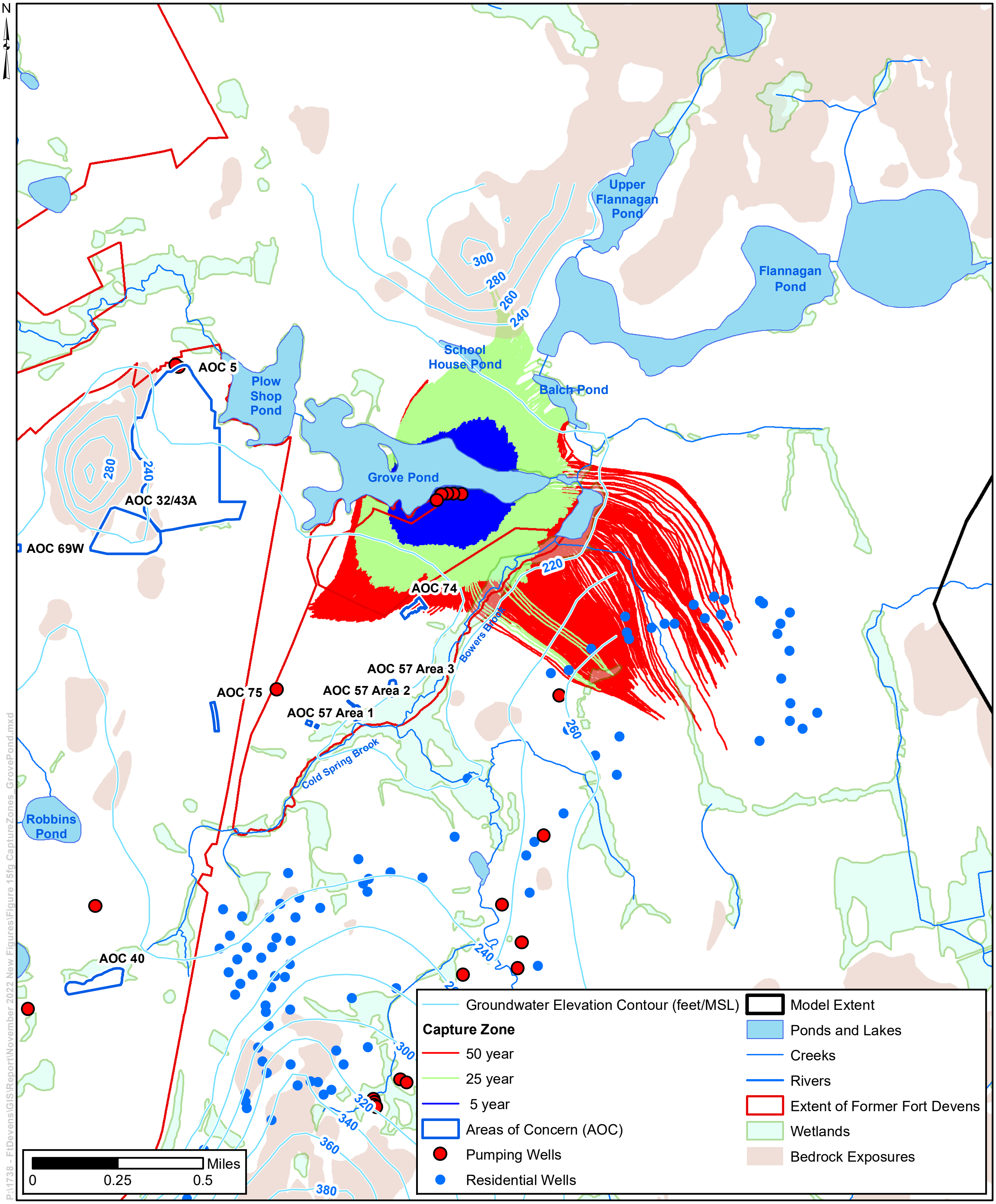

Figure 15f Five-, Twenty-five-, and Fifty-year Capture Zones for the Grove Pond Well Field – Base Effective Porosity

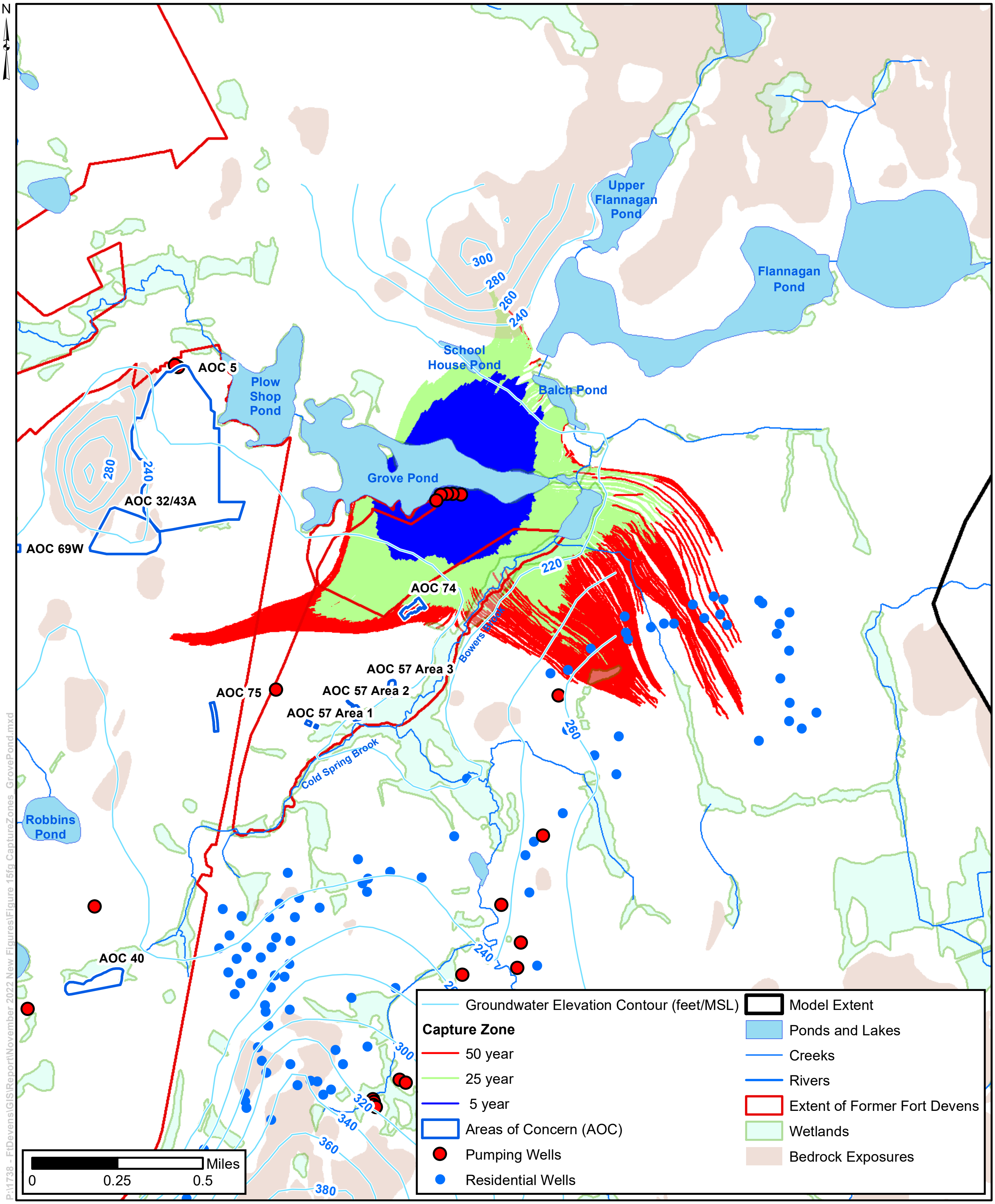

Figure 15g Five-, Twenty-five-, and Fifty-year Capture Zones for the Grove Pond Well Field – Alternate Effective Porosity

TABLES

Table 1

Groundwater Budget Per Hydrostratigraphic Unit
(acre-ft/year)

		In (from)						Out (to)						In	Out
HSU	HSU Code	CLN[1]	RCH[2]	OBD	TIL	UPR	LWR	CLN[1]	RCH[2]	OBD	TIL	UPR	LWR	Total	Total
Overburden	OBD	7,507	24,625	-	13,168	8,372	2	35,448	-	-	9,832	8,392	0	53,674	53,672
Till	TIL	818	12,043	9,832	-	11,082	110	9,906	-	13,168	-	10,788	21	33,885	33,883
Weathered Bedrock	UPR	93	827	8,392	10,788	-	1,379	550	-	8,372	11,082	-	1,474	21,479	21,479
Competent Bedrock	LWR	4	-	0	21	1,474	-	7	-	2	110	1,379	-	1,498	1,498

Notes:

[1] Includes discharge to / flow through surface water features, flow through monitoring wells screened across multiple layers, and pumping wells

[2] Recharge

Table 2

Flow Path Analysis, Focus Area 1 - Summary of Particle Travel Time

Forward Tracking Analysis								
	Particle Travel Time (years)							
	Base Effective Porosity[1]				Alternate Effective Porosity[2]			
PFOS/PFOA Contaminated Zone	Min	Max	Average	Median	Min	Max	Average	Median
Small area east side of Robbins Pond	1.9	146	65	57	1.0	308	43	29
Area near AOC 43G to the west of Robbins Pond	0.2	65	11	9	0.1	35	6	4
Area south of AOC 75	0.03	82	29	27	0.02	187	18	15
Area between the Patton Well and the headwaters of Cold Spring Brook near AOC 40	0.03	94	16	6	0.02	53	8	3
Area south of the Grove Pond well field to AOC 57 along Bowers Brook	0.03	195	24	16	0.01	136	13	8

Backward Tracking Analysis								
	Particle Travel Time (years)							
	Base Effective Porosity[1]				Alternate Effective Porosity[2]			
PFOS/PFOA Contaminated Zone	Min	Max	Average	Median	Min	Max	Average	Median
Small area east side of Robbins Pond	2.1	194	41	35	1.1	160	31	18
Area near AOC 43G to the west of Robbins Pond	0.2	115	8	4	0.1	68	5	2
Area south of AOC 75	0.23	91	21	17	0.1	113	12	9
Area between the Patton Well and the headwaters of Cold Spring Brook near AOC 40	0.11	82	27	27	0.1	67	15	14
Area south of the Grove Pond well field to AOC 57 along Bowers Brook	0.01	219	34	29	0.004	203	18	14

Notes:

[1] Overburden: 30%, Till: 25%, Upper and Lower Bedrock: 0.1%

[2] Overburden: 15%, Till: 15%, Upper Bedrock: 10%, Lower Bedrock 2%

APPENDICES

Appendix A

Percent Bedrock in Each Model Layer

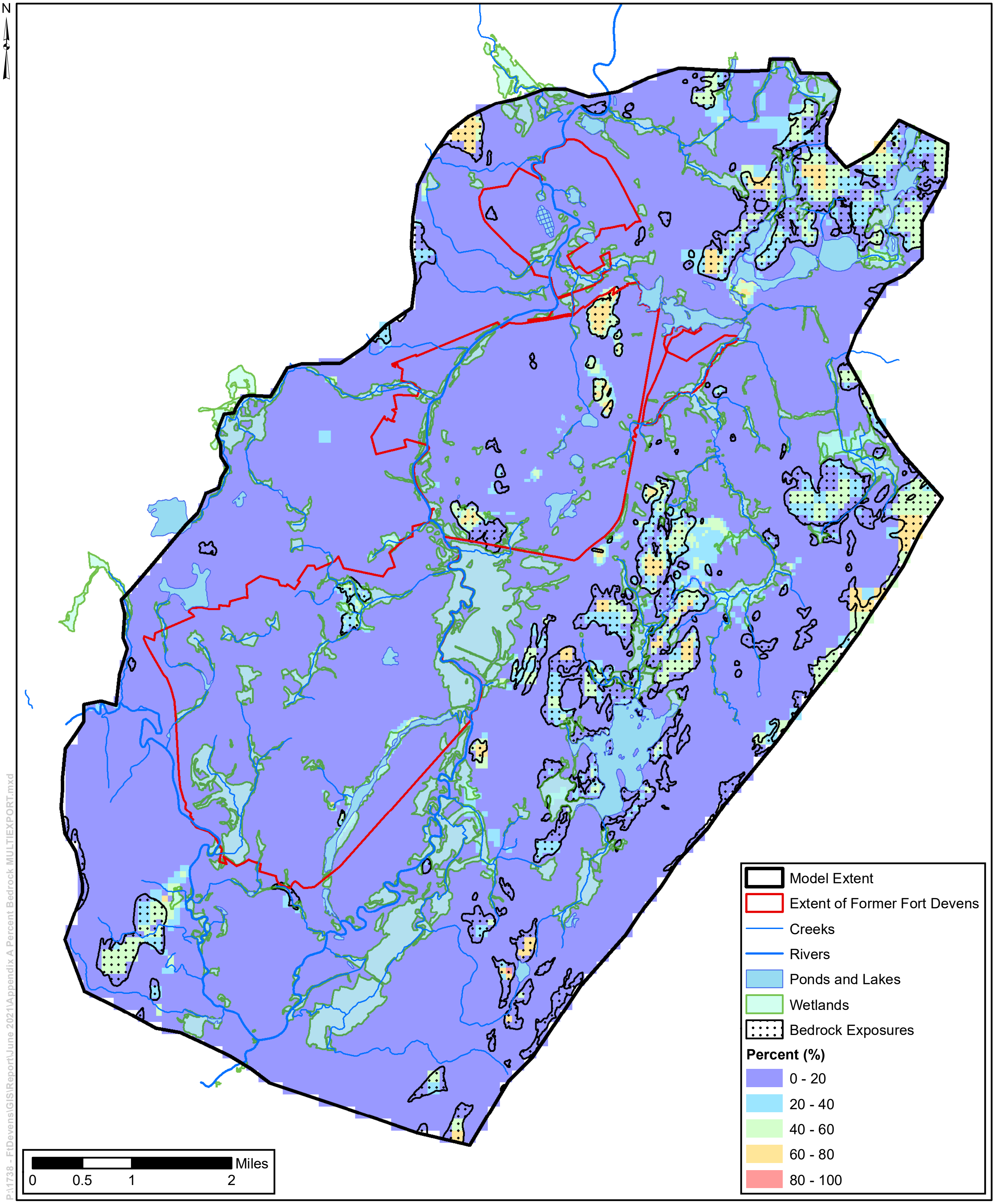

Figure A.1 Percent Bedrock Model Layer 1

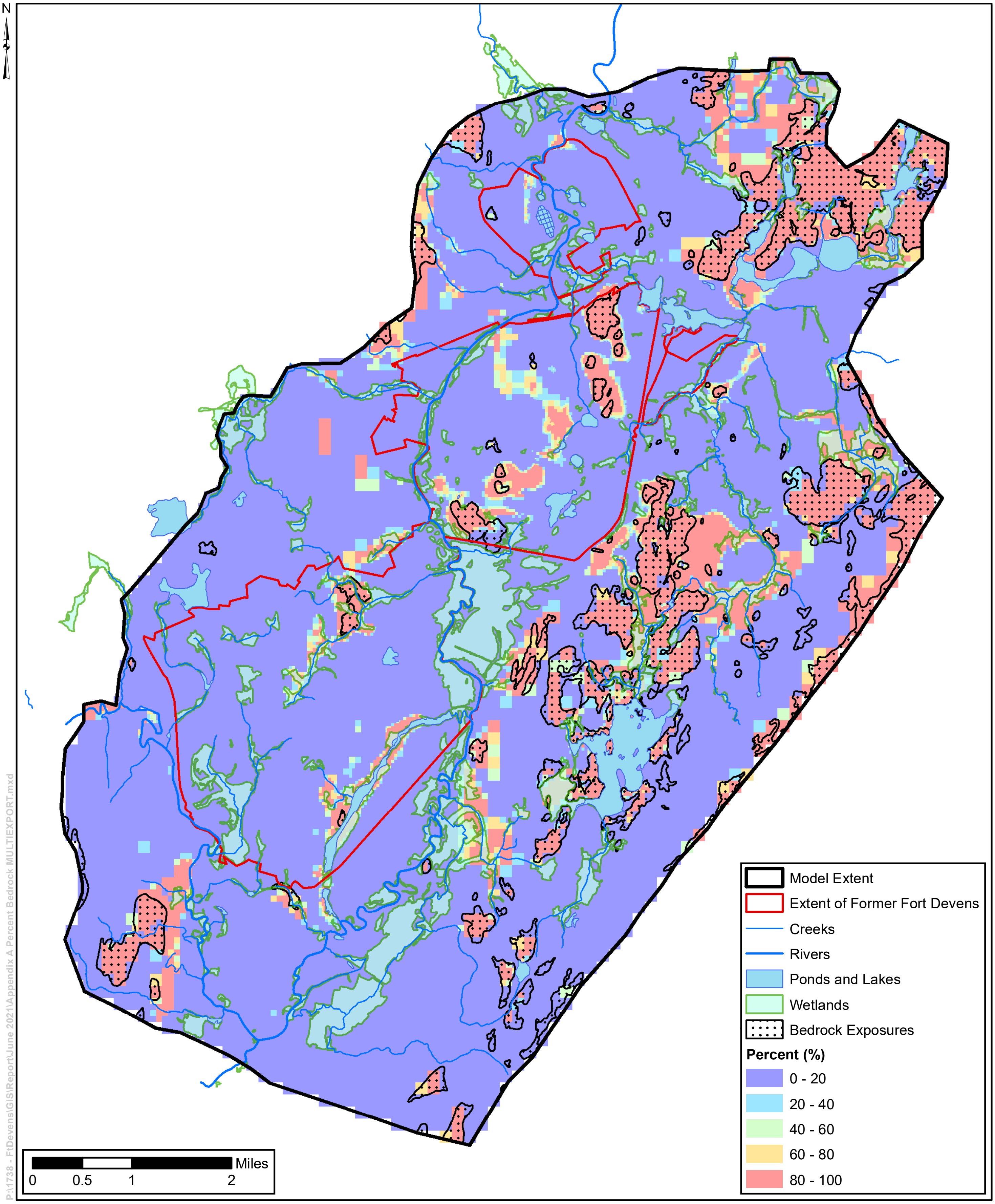

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Figure A.2 Percent Bedrock Model Layer 2

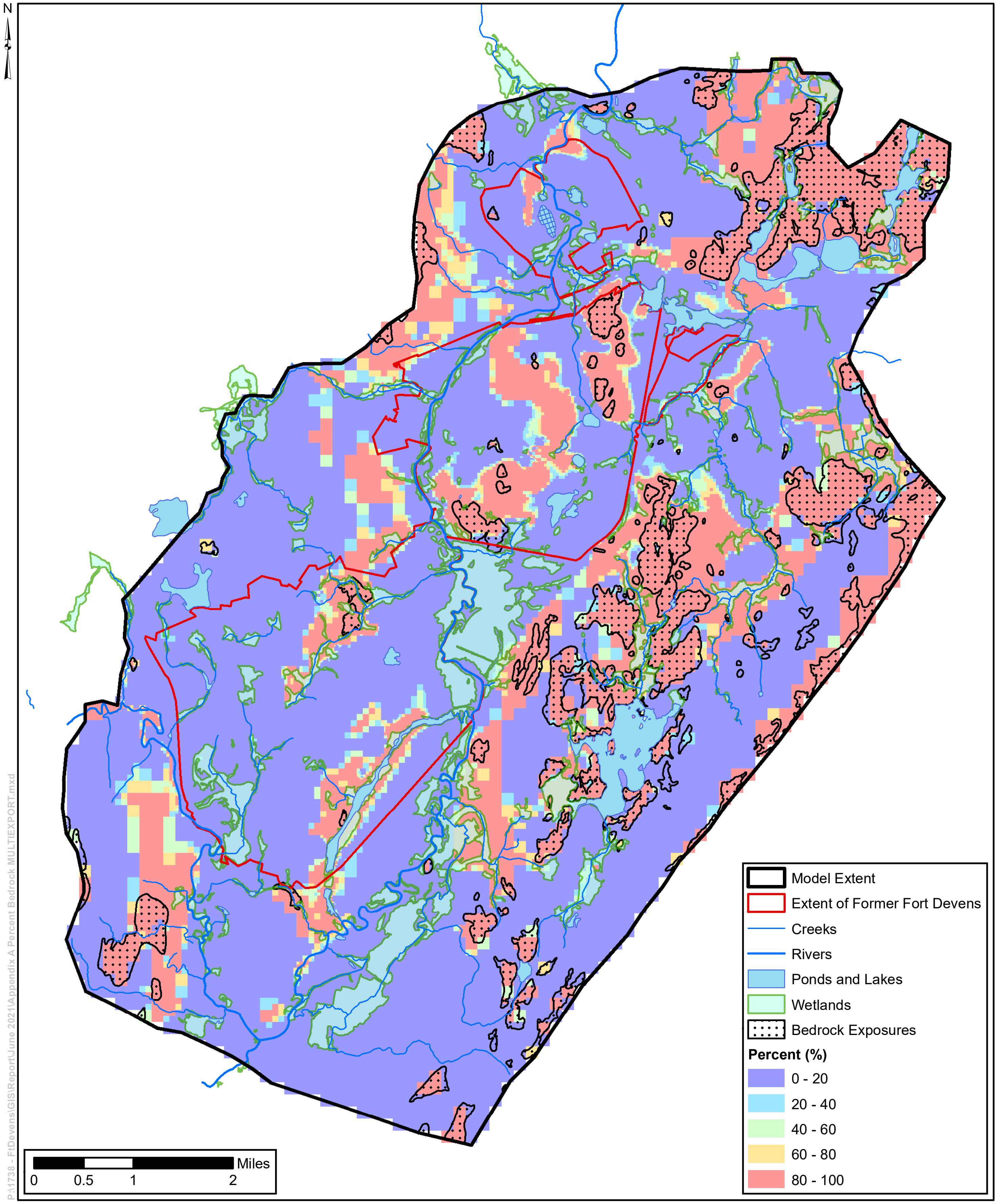

Figure A.3 Percent Bedrock Model Layer 3

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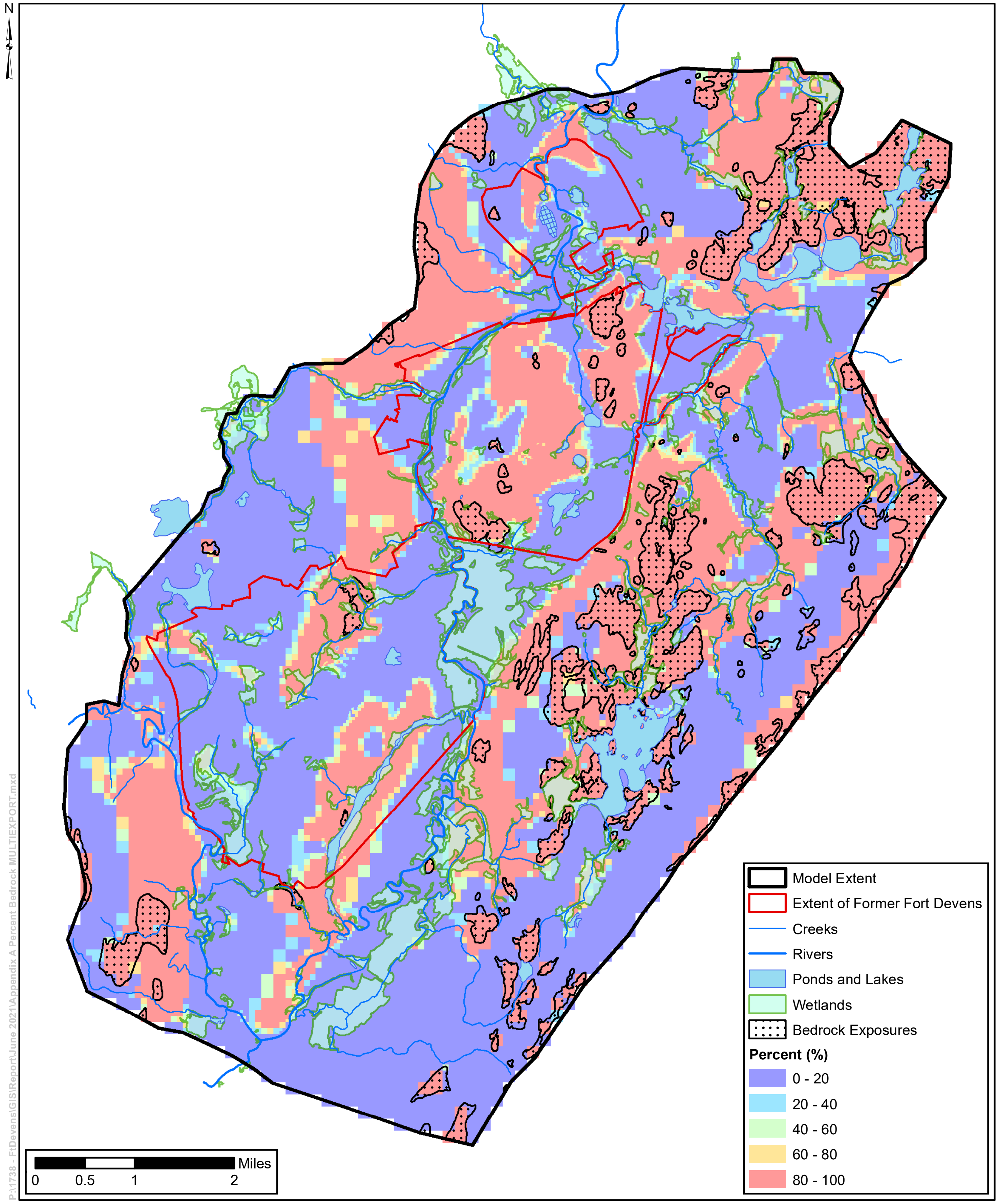

Figure A.4 Percent Bedrock Model Layer 4

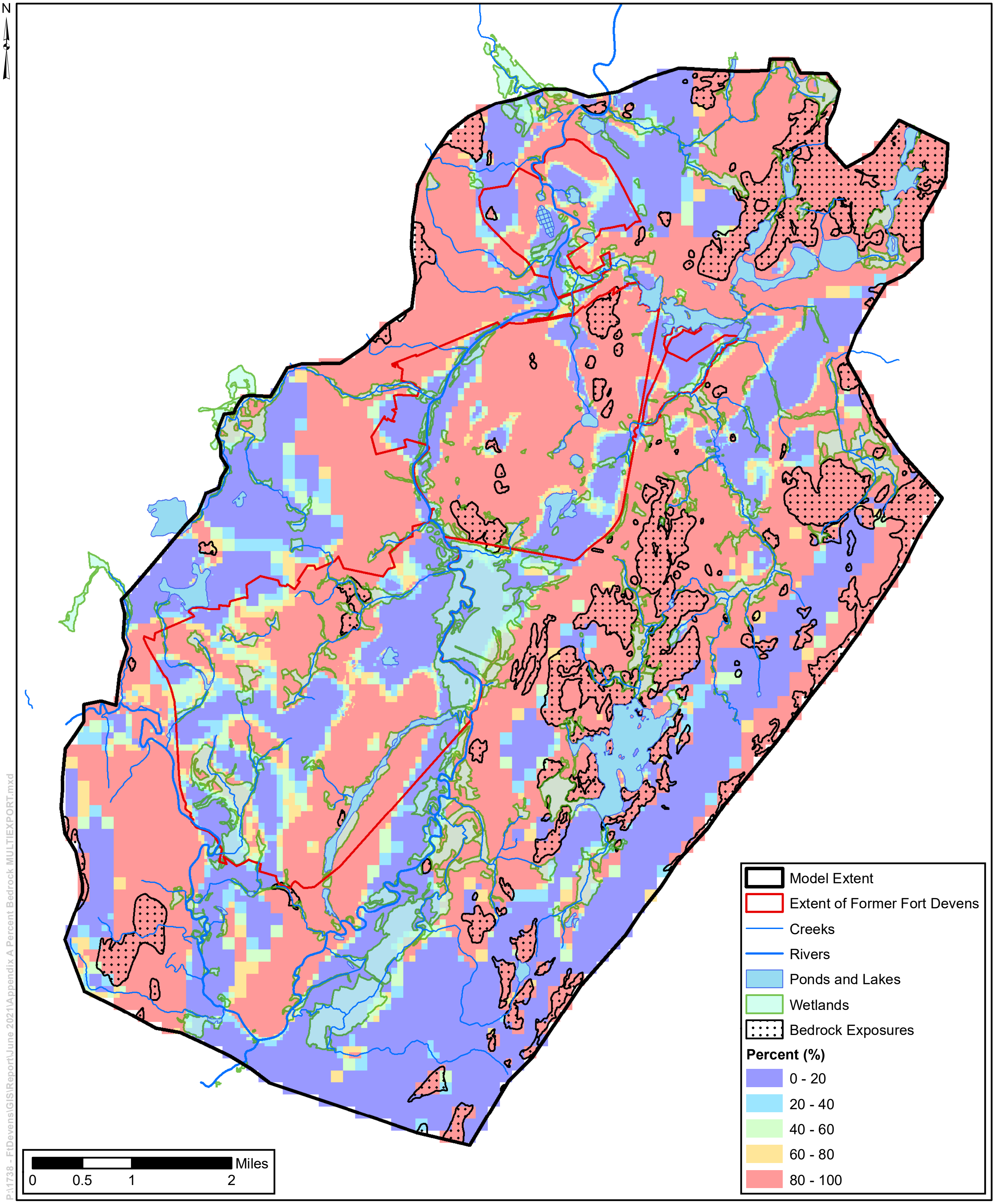

Figure A.5 Percent Bedrock Model Layer 5

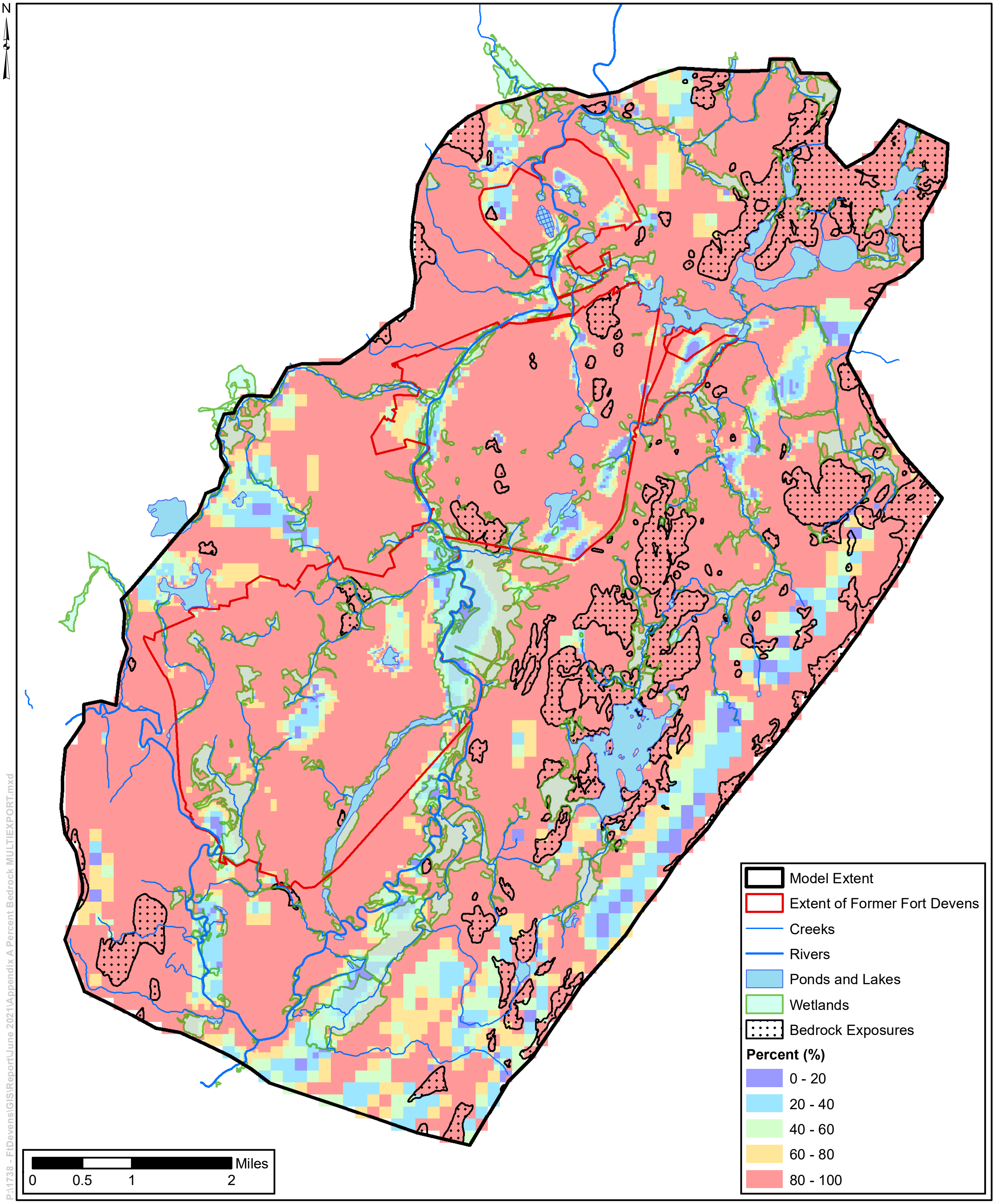

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Figure A.6 Percent Bedrock Model Layer 6

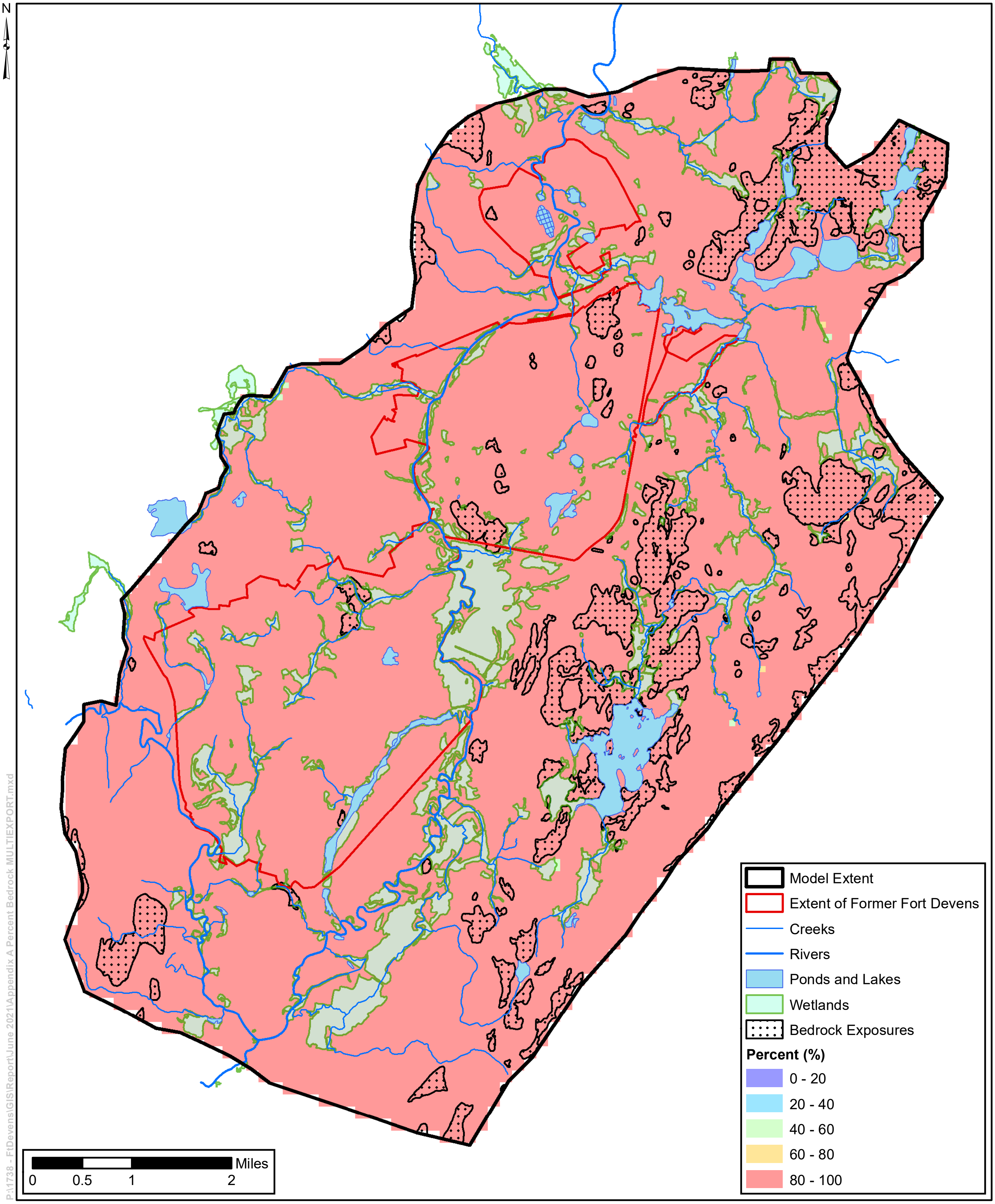

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Figure A.7 Percent Bedrock Model Layer 7

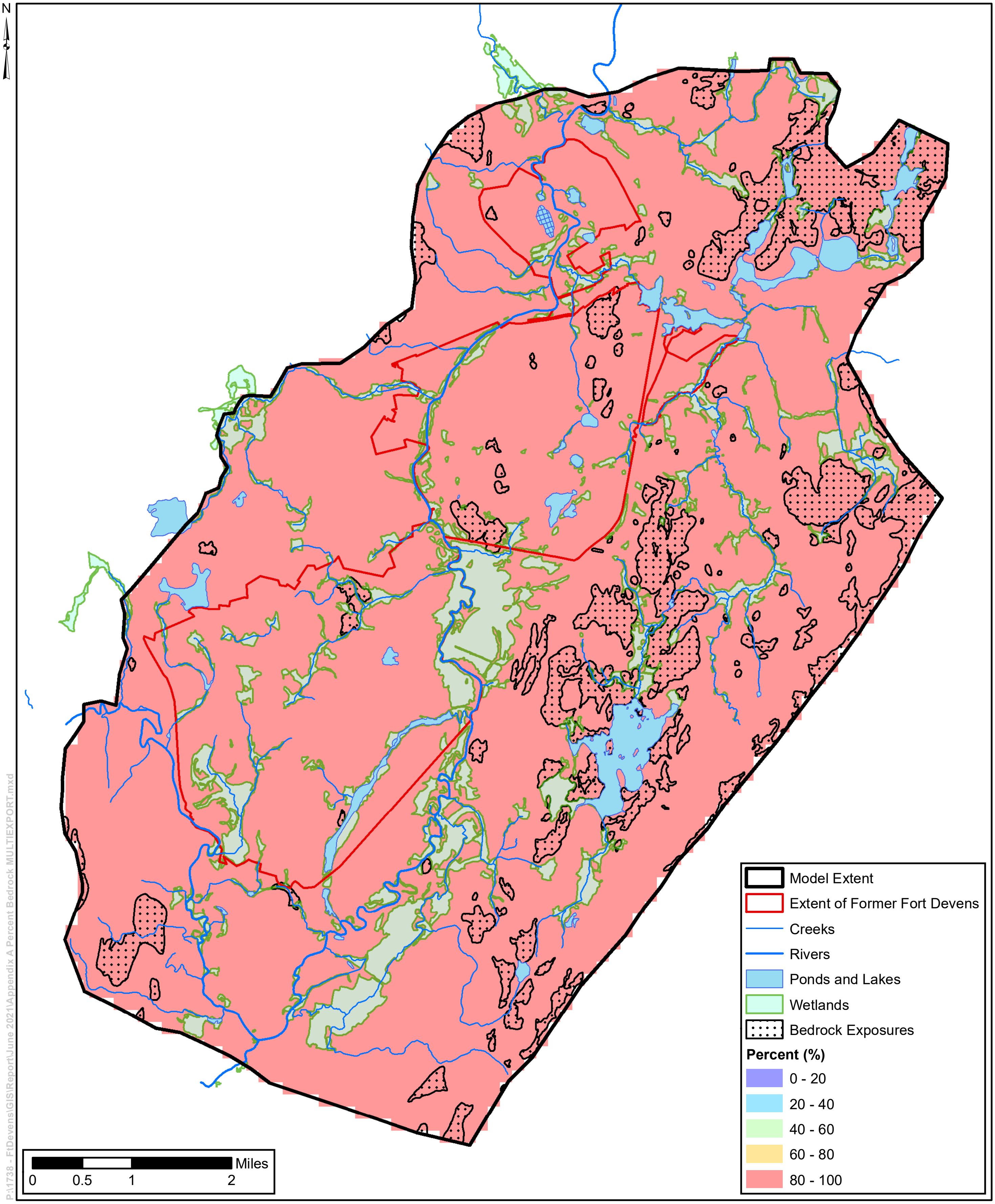

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Figure A.8 Percent Bedrock Model Layer 8

Appendix B

Municipal, Community, and Residential Well Details

Table B.1a

Municipal and Community Well Details

PWS Name	Source Name	Short Name	Type of Well	Easting	Northing	LIDAR Elevation[1] (feet/MSL)	Top of Bedrock[2] (feet/MSL)	Well Depth (feet/BGS[3])	Screen / Open Interval (feet/BGS[3])	Screen / Open Interval (feet/MSL)
Devens MASSDevelopment	Shabokin Gravel Packed Well	Shabokin_Inactive	Gravel-Packed	625695.1	3014510.0	243.6	141.0	77.5	unknown	196 - 166
Devens MASSDevelopment	Shabokin Replacement Well	Shabokin Well	Gravel-Packed	625672.8	3014574.2	243.1	138.5	85.0	55 - 85	188 - 158
Devens MASSDevelopment	MacPherson NaturallyDeveloped Well	MacPherson Well	Gravel-Packed	626266.5	3028262.9	217.2	105.1	93.0	unknown	144 - 124
Devens MASSDevelopment	Patton Replacement Well	Patton Well	Gravel-Packed	627610.6	3018025.9	257.6	154.3	86.5	61 - 83	197 - 175
Ayer DPW Water Division	Grove Pond Well #1	Grove Pond Well #1	Gravel-Packed	634322.1	3025990.7	221.1	103.5	62.0	42 - 62	179 - 159
Ayer DPW Water Division	Grove Pond Well #2	Grove Pond Well #2	Gravel-Packed	634192.5	3026001.7	221.3	102.9	60.5	42 - 62	179 - 159
Ayer DPW Water Division	Well 6	Grove Pond Well #6	Gravel-Packed	634103.6	3026000.4	223.8	103.9	57.0	47 - 57	177 - 167
Ayer DPW Water Division	Well 7	Grove Pond Well #7	Gravel-Packed	634010.9	3025986.2	226.5	105.3	71.0	56 - 71	170 - 155
Ayer DPW Water Division	Well 8	Grove Pond Well #8	Gravel-Packed	633937.5	3025897.4	235.8	103.8	73.0	60 - 73	176 - 163
Shirley Water District	Patterson Well	Patterson Well	Gravel-Packed	623106.7	3028127.0	225.5	180.0	53.0	unknown	195 - 185
Shirley Water District	Walker Well	Walker Well	Gravel-Packed	623485.8	3028002.5	240.6	179.9	70.5	60.5 - 70.5	195 - 185
MCI Shirley	GP Well 1	MCI Shirley GP Well 1	Gravel-Packed	629054.7	3015433.3	354.0	203.5	60.0	unknown	304 - 294
MCI Shirley	GP Well 2	MCI Shirley GP Well 2	Gravel-Packed	618637.9	3015579.9	247.6	194.6	40.0	unknown	218 - 208
The Appleworks	Well 1	The Appleworks	Bedrock	635832.3	3022877.4	282.7	245.2	450.0	-	240 - -167
Harvard Plaza	Well 1	Harvard Plaza	Bedrock	635589.7	3020712.1	283.2	211.3	unknown	-	206 - -31
Lancaster County Road LLC	Rock Well	Rock Well 1	Bedrock	634343.5	3018557.3	262.6	226.0	365.0	-	221 - -102
Foxglove Apartments	6" BEDROCK DW WELL	Foxglove Apartments	Bedrock	634948.3	3019636.5	260.8	213.3	240.0	-	208 - 21
Harvard Green Condominiums	Well 1	Harvard Green Well 1	Bedrock	633371.8	3016931.4	321.2	286.2	300.0	-	281 - 21
Harvard Green Condominiums	Well 2	Harvard Green Well 2	Bedrock	633468.2	3016883.9	320.5	285.8	400.0	-	281 - -80
Shaker Place Offices	Well #1	Shaker Place Offices	Bedrock	635246.9	3019055.7	269.1	208.6	200.0	-	204 - 69
Ayer Road Properties LLC	Well 1	Ayer Road Well 1	Bedrock	632957.1	3016629.7	332.7	302.7	245.0	-	298 - 88
Ayer Road Properties LLC	Well 2	Ayer Road Well 2	Bedrock	632975.4	3016587.0	332.8	305.4	360.0	-	300 - -27
Ayer Road Properties LLC	Well 3	Ayer Road Well 3	Bedrock	632965.1	3016537.4	333.4	309.1	360.0	-	304 - -27
Ayer Road Properties LLC	Well 4	Ayer Road Well 4	Bedrock	633002.3	3016507.2	332.4	309.8	300.0	-	305 - 32
School House 1870 Trust	Rock Well	Rock Well 2	Bedrock	635190.8	3018660.3	258.5	207.4	235.0	-	202 - 24
SHL Extraction Well EW-1	Shepley Hill Landfill	EW-01	Overburden	629942.8	3027960.2	226.5	130.9	85.0	60 - 85	167 - 142
SHL Extraction Well EW-4	Shepley Hill Landfill	EW-04	Overburden	629895.3	3027991.0	228.6	130.2	95.0	70 - 95	159 - 137
Red Tail GC Irrigation Well	Red Tail Golf Course	Red Tail Golf Course	Overburden	628650.3	3019614.9	273.0	95.3	72.0	56 - 66	217 - 207
LLFARM-SHI	105 Walker Rd, Shirley	LLFARM-SHI	Overburden	623789.5	3030476.1	267.3	166.5	unknown	50 - 60	217 - 207
Hilton Garden Inn	59 Andrews Parkway, Harvard	Hilton Garden Inn	Bedrock	626136.8	3021440.8	299.1	270.1	920.0	20 - 920	265 - -621

Table B.1a

Municipal and Community Well Details

PWS Name	Source Name	Short Name	Type of Well	Easting	Northing	LIDAR Elevation[1] (feet/MSL)	Top of Bedrock[2] (feet/MSL)	Well Depth (feet/BGS[3])	Screen / Open Interval (feet/BGS[3])	Screen / Open Interval (feet/MSL)
Springhill Suites - Marriot Hotel	27 Andrews Parkway, Harvard	Springhill Suites	Bedrock	626284.1	3021960.6	289.3	250.4	600.0	31 - 600	245 - -311
Primrose Car Wash	2 Andrews Parkway, Ayer	Primrose Car Wash	Bedrock	625355.6	3022108.0	316.4	284.2	420.0	20 - 420	279 - -104
Devens Irrigation Well	78 Barnum Road, Devens	Devens Irrigation Well	Bedrock	631458.4	3022970.3	249.8	55.1	505.0	-	50 - -255

Notes:

Original source: Seres-Arcadis (2020c); Devens Community Wells 9_Updated(1).xlsx

[1] Source: LIDAR Surface Map developed by Seres-Arcadis (2020b)

[2] Source: Bedrock Surface Map developed by Seres-Arcadis (2020a)

[3] Reference elevation unknown. Screen / open interval elevation calculated from LIDAR

Screen / Open Interval Assumptions:

Assumed same screen length as replacement.	Assumed top of screen is 5 feet below bedrock surface.
53 foot depth puts well just below top of bedrock, assuming it is 5 feet above bedrock surface with a 10 foot screen.	Adjusted bottom of screen elevation to just above bedrock surface.
Assumed 20 foot screen.	Assumed shallow well, screened interval 50 - 60 feet below LIDAR surface.
Assumed 10 foot screen.	The provided top of screen is just above top of bedrock, adjusted to be 5 feet below bedrock surface.
Assumed well depth was average of other Small Community Wells, and top-of-screen is 5 feet below bedrock surface.	

Table B.1b

Municipal and Community Well Pumping Rates

Short Name	2015 Volume (Mgal)	2016 Volume (Mgal)	2017 Volume (Mgal)	2018 Volume (Mgal)	2019 Volume (Mgal)	Average Pumping Rate (gpm)
Shabokin_Inactive		-	-	-	-	-
Shabokin Well		135.3	132.1	153.6	158.4	275.4
MacPherson Well		63.2	65.5	5.0	65.8	94.8
Patton Well		139.0	120.9	148.3	103.4	243.2
Grove Pond Well #1		0.0	0.0	30.1	58.3	42.0
Grove Pond Well #2		0.0	0.0	0.0	0.0	0.0
Grove Pond Well #6		88.7	124.4	122.6	114.8	214.1
Grove Pond Well #7		103.5	107.5	116.8	88.5	197.8
Grove Pond Well #8		117.7	83.4	15.8	27.4	116.1
Patterson Well		87.9	26.2	90.4	61.8	126.6
Walker Well		30.0	109.1	27.4	31.6	94.1
MCI Shirley GP Well 1		40.7	49.1	76.6	32.9	94.7
MCI Shirley GP Well 2		20.4	47.7	32.4	39.6	66.6
The Appleworks	0.2	0.2	0.2	0.2	0.1	0.4
Harvard Plaza	0.3	0.4	0.4	0.3	0.3	0.6
Rock Well 1	0.6	0.6	0.5	0.4	0.4	1.0
Foxglove Apartments	0.6	0.5	0.5	0.5	0.5	1.0
Harvard Green Well 1	0.6	0.8	0.6	0.6	0.7	1.2
Harvard Green Well 2	0.6	0.9	0.6	0.6	0.6	1.2
Shaker Place Offices	0.0	0.0	0.0	0.0	0.0	0.1
Ayer Road Well 1	0.4	0.3	0.6	0.2	0.1	0.6
Ayer Road Well 2	0.3	0.3	0.6	0.4	0.3	0.7
Ayer Road Well 3	0.3	0.3	0.6	0.3	0.3	0.7
Ayer Road Well 4	0.3	0.2	0.6	0.4	0.4	0.7
Rock Well 2	0.0	0.0	0.0	0.1	0.1	0.1
EW-01	14.0	17.0	16.7	16.0	16.2	30.4
EW-04	11.5	10.9	9.9	8.9	8.8	19.0
Red Tail Golf Course	25.0	25.0	25.0	25.0	25.0	47.5
LLFARM-SHI	0.0	0.0	0.0	0.0	0.0	0.0
Hilton Garden Inn					5.3	10.0
Springhill Suites					7.9	15.0
Primrose Car Wash					21.0	40.0
Devens Irrigation Well					7.9	15.0

Notes:

Original source: Seres-Arcadis (2002c); Devens Community Wells 9_Updated(1).xlsx

Source: SHL Extraction Well Flow Data 081720.xlsx, received 08/18/2020 from Michael Kulbersh

Table B.1c

Estimates of Hydraulic Conductivity at Select Municipal and Community Pumping Wells

Short Name	Top of Bedrock[1] (feet/MSL)	Estimated Transmissivity (feet^2/day)	Transmissivity Constraint[2] (feet^2/day)	Reference Monitoring Well	Reference Water Level[3] (feet/MSL)	Estimated Hydraulic Conductivity[4] (feet/day)
Shabokin_Inactive	141.0	24,600*	24,600	Estimated from Nearby Bedrock Wells	230.5	275
Shabokin Well	138.5	24,600*	24,600	Estimated from Nearby Bedrock Wells	230.5	267
MacPherson Well	105.1	40,291*	40,291	McPh-Sentinel	204.3	406
Patton Well	154.3	23,900*	23,900	PTW-A	242.2	272
Grove Pond Well #1	103.5	21,000 - 51,600*	36,300	GF-2	214.5	327
Grove Pond Well #2	102.9	21,000 - 51,600*	36,300	GF-2	214.5	325
Grove Pond Well #6	103.9	21,000 - 51,600*	36,300	GF-2	214.5	328
Grove Pond Well #7	105.3	21,000 - 51,600*	36,300	GF-2	214.5	333
Grove Pond Well #8	103.8	21,000 - 51,600*	36,300	GF-2	214.5	328
Patterson Well	180.0					
Walker Well	179.9					
MCI Shirley GP Well 1	203.5	28,650 - 57,300*	42,975	No wells nearby		
MCI Shirley GP Well 2	194.6	28,650 - 57,300*	42,975	No wells nearby		
The Appleworks	245.2					
Harvard Plaza	211.3					
Rock Well 1	226.0					
Foxglove Apartments	213.3					
Harvard Green Well 1	286.2					
Harvard Green Well 2	285.8					
Shaker Place Offices	208.6					
Ayer Road Well 1	302.7					
Ayer Road Well 2	305.4					
Ayer Road Well 3	309.1					
Ayer Road Well 4	309.8					
Rock Well 2	207.4					
EW-01	130.9	1,150 - 3,500	2,325	SHP-2016-1A	212.5	28
EW-04	130.2	1,300 - 4,000	2,650	SHP-2016-1A	212.5	32

Table B.1c

Estimates of Hydraulic Conductivity at Select Municipal and Community Pumping Wells

Short Name	Top of Bedrock[1] (feet/MSL)	Estimated Transmissivity (feet^2/day)	Transmissivity Constraint[2] (feet^2/day)	Reference Monitoring Well	Reference Water Level[3] (feet/MSL)	Estimated Hydraulic Conductivity[4] (feet/day)
Red Tail Golf Course	95.3	4,205 - 6,800	5,503	No wells nearby		
LLFARM-SHI	166.5					
Hilton Garden Inn	270.1					
Springhill Suites	250.4					
Primrose Car Wash	284.2					
Devens Irrigation Well	55.1					

Notes:

Original source: Seres-Arcadis (2002c); Devens Community Wells 9_Updated(1).xlsx

[1] Source: LIDAR Surface Map developed by Seres-Arcadis (2020b).

[2] Average of estimated range

[3] Historical average water level

[4] Calculated as Estimated Transmissivity / (Reference Water Level - Top of Bedrock)

* Transmissivities reported in Devens Water Resource Protection Report by Vanasse Hangen Brustlin Inc. and Haley and Aldrich, Inc., November, 1994.

Table B.2

Residential Well Details

Street Address	Town	Location in Database[1]	Easting	Northing	Well Depth (feet)	Reference Elevation[2] (feet/MSL)	Top of Bedrock[3] (feet/MSL)	Open Interval[4,5] (feet/MSL)
202 Ayer Road	Harvard, MA	202-AR	634864.8	3016949.9	365	277.9	251.6	247 - -87
232 Ayer Road	Harvard, MA	232-AR	635496.6	3018697.0	unknown	283.5	205.4	200 - 0
259 Ayer Road	Harvard, MA	259-AR	635372.9	3019831.6	unknown	278.8	220.7	216 - 16
276 Ayer Road	Harvard, MA	276-AR	635443.4	3020619.3	unknown	284.2	217.7	213 - 13
284 Ayer Road	Harvard, MA	284-AR	635891.8	3021057.5	unknown	281.4	208.9	204 - 4
292 Ayer Road	Harvard, MA	292-AR	636721.0	3021658.5	unknown	330.5	195.8	191 - -9
294 Ayer Road	Harvard, MA	294-AR	634408.3	3021595.1	~100 (owner) 245 (driller)	272.9	205.5	201 - 1
304 Ayer Road	Harvard, MA	304-AR	636380.6	3021952.1	unknown	272.4	201.8	197 - -3
306 Ayer Road	Harvard, MA	306-AR	636760.5	3022251.0	276	323.4	200.7	196 - 47
310 Ayer Road	Harvard, MA	310-AR	635959.6	3022352.2	unknown	280.6	227.2	222 - 22
327 Ayer Road	Harvard, MA	327-AYR-S	635973.2	3023277.3	unknown	286.0	255.9	251 - 51
327 Ayer Road	Harvard, MA	327-AYR-D	635700.5	3023227.2	365	289.0	256.4	251 - -76
335 Ayer Road	Harvard, MA	335-AR	636323.1	3023606.3	600	272.3	250.0	245 - -328
344 Ayer Road	Harvard, MA	344-AR	636905.7	3023757.1	600	277.5	219.1	214 - -322
345 Ayer Road	Harvard, MA	345-AR	636870.6	3023856.9	unknown	266.9	224.0	219 - 19
346 Ayer Road	Harvard, MA	346-AR	636870.6	3023856.9	~40	257.2	224.0	219 - 179
350 Ayer Road	Harvard, MA	350-AR	636846.6	3024106.4	unknown	268.7	235.3	230 - 30
1 Blanchard Road	Harvard, MA	01-BLR	631375.3	3016315.4	~120 ft	379.7	365.7	361 - 260
2 Blanchard Road	Harvard, MA	2-BLR	631783.6	3016847.3	245	376.5	372.0	367 - 132
14 Blanchard Road	Harvard, MA	14-BLR	631675.2	3017172.9	unknown	375.5	366.3	361 - 161
15 Blanchard Road	Harvard, MA	15-BLR	631301.6	3017041.3	unknown	367.3	357.8	353 - 153
17 Blanchard Road	Harvard, MA	17-BLR	631234.1	3017224.5	~80	363.1	350.7	346 - 266
19 Blanchard Road	Harvard, MA	19-BLR	631172.6	3017437.6	unknown	351.9	336.3	331 - 131
21 Blanchard Road	Harvard, MA	21-BLR	631332.2	3017769.2	320	344.9	307.7	303 - 25
31 Blanchard Road	Harvard, MA	31-BLR	631290.8	3017988.6	400	334.6	280.3	275 - -65
33 Blanchard Road	Harvard, MA	33-BLR	631281.7	3018084.9	unknown	332.5	273.3	268 - 68
34 Blanchard Road	Harvard, MA	34-BLR	631665.8	3018017.1	66	331.4	303.9	299 - 233
37 Blanchard Road	Harvard, MA	37-BLR	631373.9	3018366.5	230	328.4	269.2	264 - 98
40 Blanchard Road	Harvard, MA	40-BLR	631584.1	3018523.0	unknown	332.0	275.5	271 - 71
42 Blanchard Road	Harvard, MA	42-BLR	631430.6	3018546.8	155	328.3	265.7	261 - 173

Table B.2

Residential Well Details

Street Address	Town	Location in Database[1]	Easting	Northing	Well Depth (feet)	Reference Elevation[2] (feet/MSL)	Top of Bedrock[3] (feet/MSL)	Open Interval[4,5] (feet/MSL)
48 Blanchard Road	Harvard, MA	48-BLR	631658.4	3018728.1	~120	330.7	265.7	261 - 211
56 Blanchard Road	Harvard, MA	56-BLR	631674.7	3019085.3	220	319.4	240.3	235 - 99
62 Blanchard Road	Harvard, MA	62-BLR	631746.1	3019450.5	unknown	309.7	219.7	215 - 15
4 Cedar Ledge Road	Harvard, MA	04-CLR	632489.6	3017171.9	~100	351.5	298.7	294 - 194
8 Cedar Ledge Road	Harvard, MA	08-CLR	632375.5	3017392.8	unknown	362.0	330.1	325 - 125
2 Depot Road	Harvard, MA	02-DPR	633225.0	3009539.6	705	392.6	374.2	369 - -312
6 Depot Road	Harvard, MA	06-DPR	633107.1	3009634.6	500	390.8	333.3	328 - -109
8 Depot Road	Harvard, MA	08-DPR	633032.3	3009710.6	8	389.8	303.6	299 - 291
14 Depot Road	Harvard, MA	14-DPR	632872.1	3009889.5	140	383.3	303.6	299 - 243
20 Depot Road	Harvard, MA	20-DPR	632569.4	3010096.0	505	397.4	365.5	360 - -108
21 Depot Road	Harvard, MA	21-DPR	631332.2	3017769.2	unknown	395.5	307.7	303 - 103
56 Depot Road	Harvard, MA	56-DPR	631679.8	3011198.8	245	359.0	342.2	337 - 114
58 Depot Road	Harvard, MA	58-DPR	631487.6	3011253.8	unknown	351.8	338.6	334 - 134
61 Depot Road	Harvard, MA	61-DPR	631359.2	3011231.8	120	352.5	341.1	336 - 233
89 Depot Road	Harvard, MA	89-DPR	630350.7	3012409.4	~110	359.8	352.1	347 - 250
100 Depot Road	Harvard, MA	100-DPR	630359.1	3012535.6	~350-375	367.7	358.7	354 - 18
124 Depot Road	Harvard, MA	124-DPR	629747.5	3013825.8	unknown	351.3	335.8	331 - 131
140 Depot Road	Harvard, MA	140-DPR	629719.4	3014958.5	unknown	328.0	306.7	302 - 102
141 Depot Road	Harvard, MA	141-DPR	629054.0	3014533.5	unknown	315.6	300.4	295 - 95
143 Depot Road	Harvard, MA	143-DPR	628589.8	3014337.7	550	307.6	286.4	281 - -242
144 Depot Road	Harvard, MA	144-DPR	630069.9	3015092.6	unknown	348.2	315.8	311 - 111
152 Depot Road	Harvard, MA	152-DPR	630334.0	3015852.5	unknown	345.6	294.4	289 - 89
156 Depot Road	Harvard, MA	156-DPR	629996.1	3015493.2	unknown	335.9	291.3	286 - 86
38 Lancaster County Road	Harvard, MA	38-LCR	633300.5	3018354.2	unknown	305.7	262.6	258 - 58
52 Lancaster County Road	Harvard, MA	52-LCR	632621.6	3018204.2	~100	321.2	280.7	276 - 176
52 Lancaster County Road	Harvard, MA	52B-LCR	632865.2	3017445.8	~100	321.2	281.9	277 - 177
65 Lancaster County Road	Harvard, MA	65-LCR	632304.1	3016780.8	unknown	364.4	320.1	315 - 115
68 Lancaster County Road	Harvard, MA	68-LCR	632094.1	3016902.3	unknown	378.9	359.0	354 - 154
71 Lancaster County Road	Harvard, MA	71-LCR	632180.7	3016701.8	unknown	368.1	334.8	330 - 130
74 Lancaster County Road	Harvard, MA	74-LCR	631984.4	3016915.2	205	382.5	369.9	365 - 177

Table B.2

Residential Well Details

Street Address	Town	Location in Database[1]	Easting	Northing	Well Depth (feet)	Reference Elevation[2] (feet/MSL)	Top of Bedrock[3] (feet/MSL)	Open Interval[4,5] (feet/MSL)
81 Lancaster County Road	Harvard, MA	81-LCR	630975.9	3016597.6	425	346.7	322.0	317 - -78
83 Lancaster County Road	Harvard, MA	83-LCR	630995.9	3016495.9	unknown	348.4	321.4	316 - 116
87 Lancaster County Road	Harvard, MA	87-LCR	630976.2	3016722.4	~200-400	344.3	326.8	322 - 44
15 Myrick Lane	Harvard, MA	15-MYR	637254.3	3023934.7	unknown	263.0	205.9	201 - 1
19 Myrick Lane	Harvard, MA	19-MYR	637455.3	3023994.1	unknown	271.5	206.8	202 - 2
22 Myrick Lane	Harvard, MA	22-MYR	637614.5	3023994.1	~200-250	277.6	204.6	200 - 53
29 Myrick Lane	Harvard, MA	29-MYR	637904.2	3024287.0	~450	290.5	203.6	199 - -159
32 Myrick Lane	Harvard, MA	32-MYR	638080.7	3024078.9	unknown	308.0	202.6	198 - -2
33 Myrick Lane	Harvard, MA	33-MYR	638225.9	3024415.5	~200	313.7	204.0	199 - 114
36 Myrick Lane	Harvard, MA	36-MYR	638328.4	3024136.4	unknown	317.4	199.3	194 - -6
39 Myrick Lane	Harvard, MA	39-MYR	638380.6	3024370.3	200	319.4	203.4	198 - 119
40 Myrick Lane	Harvard, MA	40-MYR	638434.9	3023968.8	unknown	323.0	199.2	194 - -6
47 Myrick Lane	Harvard, MA	47-MYR	638934.2	3024349.7	300	319.3	199.3	194 - 19
51 Myrick Lane	Harvard, MA	51-MYR	638982.7	3024307.7	unknown	318.3	198.2	193 - -7
52 Myrick Lane	Harvard, MA	52-MYR	638929.3	3022180.1	420	327.3	192.4	187 - -93
53 Myrick Lane	Harvard, MA	53-MYR	639400.0	3024165.8	unknown	307.8	198.9	194 - -6
55 Myrick Lane	Harvard, MA	55-MYR	639250.9	3023993.6	500	316.1	198.1	193 - -184
57 Myrick Lane	Harvard, MA	57-MYR	639204.5	3023836.1	~300-600	316.3	194.6	190 - -84
63 Myrick Lane	Harvard, MA	63-MYR	639393.4	3023574.3	unknown	320.8	197.9	193 - -7
70 Myrick Lane	Harvard, MA	70-MYR	639261.1	3023145.6	~250	324.2	194.2	189 - 74
80 Myrick Lane	Harvard, MA	80-MYR	639403.0	3022768.0	unknown	323.6	199.1	194 - -6
82 Myrick Lane	Harvard, MA	82-MYR	639395.2	3022487.2	unknown	316.5	198.8	194 - -6
85 Myrick Lane	Harvard, MA	85-MYR	639819.7	3022616.0	~100-300	329.5	221.9	217 - 129
86 Myrick Lane	Harvard, MA	86-MYR	639593.9	3022369.9	unknown	318.9	210.6	206 - 6
6 Old Mill Road	Harvard, MA	06-OMR	635316.0	3020409.0	unknown	272.8	221.0	216 - 16
22 Old Mill Road	Harvard, MA	22-OMR	634211.6	3020699.3	unknown	237.2	200.8	196 - -4
41 Old Mill Road	Harvard, MA	41-OMR	633710.1	3020058.4	unknown	268.1	201.7	197 - -3
48 Old Mill Road	Harvard, MA	48-OMR	633218.8	3020148.7	~30	275.9	221.3	216 - 186
54 Old Mill Road	Harvard, MA	54-OMR	632879.4	3020044.3	unknown	288.3	218.0	213 - 13
56 Old Mill Road	Harvard, MA	56-OMR	632793.9	3019974.8	unknown	292.3	219.9	215 - 15

Table B.2

Residential Well Details

Street Address	Town	Location in Database[1]	Easting	Northing	Well Depth (feet)	Reference Elevation[2] (feet/MSL)	Top of Bedrock[3] (feet/MSL)	Open Interval[4,5] (feet/MSL)
57 Old Mill Road	Harvard, MA	57-OMR	632862.2	3019845.7	505	294.9	231.3	226 - -210
58 Old Mill Road	Harvard, MA	58-OMR	632723.0	3020348.8	600	279.6	184.7	180 - -320
71 Old Mill Road	Harvard, MA	71-OMR	632126.4	3019599.6	~100-125	301.0	222.0	217 - 117
76 Old Mill Road	Harvard, MA	76-OMR	631634.4	3020135.6	200	275.6	170.5	166 - 76
80 Old Mill Road	Harvard, MA	80-OMR	631809.9	3019748.5	~100	297.9	203.4	198 - 98
88 Old Mill Road	Harvard, MA	88-OMR	631345.2	3019449.0	unknown	294.1	201.5	197 - -3
91 Old Mill Road	Harvard, MA	91-OMR	631451.8	3019133.6	unknown	310.9	229.9	225 - 25
92 Old Mill Road	Harvard, MA	92-OMR	631508.7	3019656.9	unknown	290.9	194.6	190 - -10
94 Old Mill Road	Harvard, MA	94-OMR	630919.6	3019466.3	~420	274.0	174.2	169 - -146
95 Old Mill Road	Harvard, MA	95-OMR	631385.1	3018983.5	unknown	314.0	235.9	231 - 31
96 Old Mill Road	Harvard, MA	96-OMR	630629.2	3019574.9	> 100	260.5	135.6	131 - -69
97 Old Mill Road	Harvard, MA	97-OMR	631218.2	3018824.3	unknown	308.0	232.7	228 - 28
100 Old Mill Road	Harvard, MA	100-OMR	630992.7	3018982.5	180	291.8	209.3	204 - 112
102 Old Mill Road	Harvard, MA	102-OMR	630734.7	3019166.5	287	272.6	171.6	167 - -14
104 Old Mill Road	Harvard, MA	104-OMR	630845.8	3018801.5	unknown	289.6	207.4	202 - 2
106 Old Mill Road	Harvard, MA	106-OMR	630570.8	3018966.2	~500-600	268.7	166.3	161 - -231
107 Old Mill Road	Harvard, MA	107-OMR	631081.0	3018566.1	unknown	311.7	232.4	227 - 27
108 Old Mill Road	Harvard, MA	108-OMR	630712.7	3018595.0	unknown	287.2	201.7	197 - -3
109 Old Mill Road	Harvard, MA	109-OMR	630897.7	3018422.8	unknown	306.2	218.5	213 - 13
113 Old Mill Road	Harvard, MA	113-OMR	630812.9	3018256.7	300	304.2	212.4	207 - 4
112 Old Shirley Road	Harvard, MA	112-OSR	630064.3	3013739.4	unknown	365.8	343.1	338 - 138
4 Prospect Hill Road	Harvard, MA	04-PHR	629571.6	3013845.5	unknown	350.6	332.8	328 - 128
10 Prospect Hill Road	Harvard, MA	10-PHR	629199.3	3013908.2	unknown	349.7	327.6	323 - 123
20 Prospect Hill Road	Harvard, MA	20-PHR	628803.4	3013357.8	500	357.1	337.4	332 - -143
13 James Brook Way	Ayer, MA	13-JBW	630041.6	3037137.1	~300	222.1	191.5	187 - -78
15 James Brook Way	Ayer, MA	15-JBW	630156.8	3037203.9	unknown	227.9	178.2	173 - -27
17 James Brook Way	Ayer, MA	17-JBW	630538.9	3037130.8	415	217.9	165.4	160 - -197
31 Groton Shirley Road	Ayer, MA	31-GSR	630349.1	3036188.7	unknown	222.3	170.8	166 - -34
33 Groton Shirley Road	Ayer, MA	33-GSR	630244.1	3036247.3	25	221.8	169.7	165 - 140
35 Groton Shirley Road	Ayer, MA	35-GSR	630162.2	3036266.4	unknown	222.0	169.4	164 - -36

Table B.2

Residential Well Details

Street Address	Town	Location in Database[1]	Easting	Northing	Well Depth (feet)	Reference Elevation[2] (feet/MSL)	Top of Bedrock[3] (feet/MSL)	Open Interval[4,5] (feet/MSL)
37 Groton Shirley Road	Ayer, MA	37-GSR	630314.0	3036436.1	320	219.2	172.0	167 - -101
39 Groton Shirley Road	Ayer, MA	39-GSR	630066.7	3036329.9	~125	220.2	168.4	163 - 95
41 Groton Shirley Road	Ayer, MA	41-GSR	629959.4	3036429.0	unknown	216.4	166.6	162 - -38
43 Groton Shirley Road	Ayer, MA	43-GSR	629872.5	3036443.8	unknown	216.1	167.1	162 - -38
49 Groton Shirley Road	Ayer, MA	49-GSR	629619.1	3036481.9	500	218.7	167.5	163 - -281
9 Great Road	Shirley, MA	9-GR	623739.4	3034539.4	10	233.2	145.4	140 - 130
66 Great Road	Shirley, MA	66-GR	625322.2	3036139.4	unknown	246.0	168.0	163 - -37

Notes:

[1] Former Fort Devens EDMS Portal Database (ftdevens.org)

[2] Source: Former Fort Devens Database when available, Seres-Arcadis (2020) LIDAR surface otherwise

[3] Source: Bedrock Surface Map developed by Seres-Arcadis (2020)

[4] Open interval top was assumed to be 5 feet below Top of Bedrock

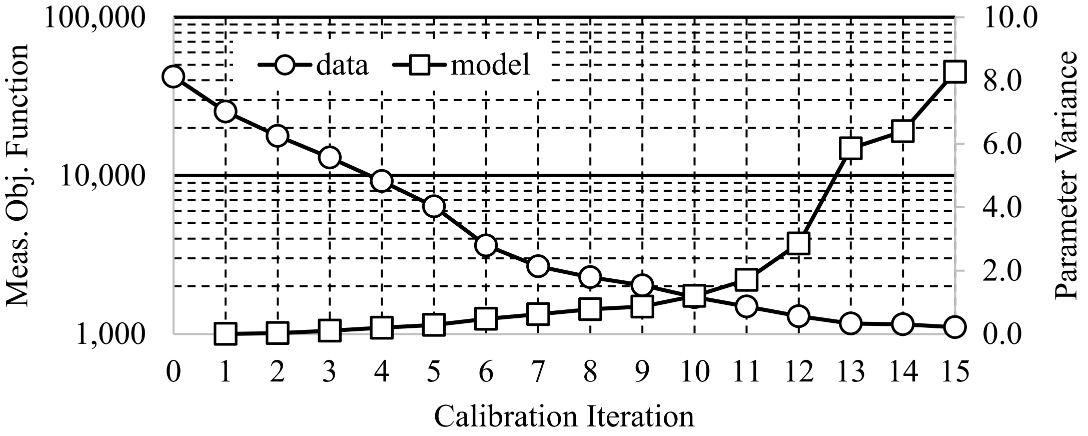
[5] Open interval bottom was calculated as: Reference Elevation - Well Depth (open interval assumed to be 200 feet long if depth unknown)

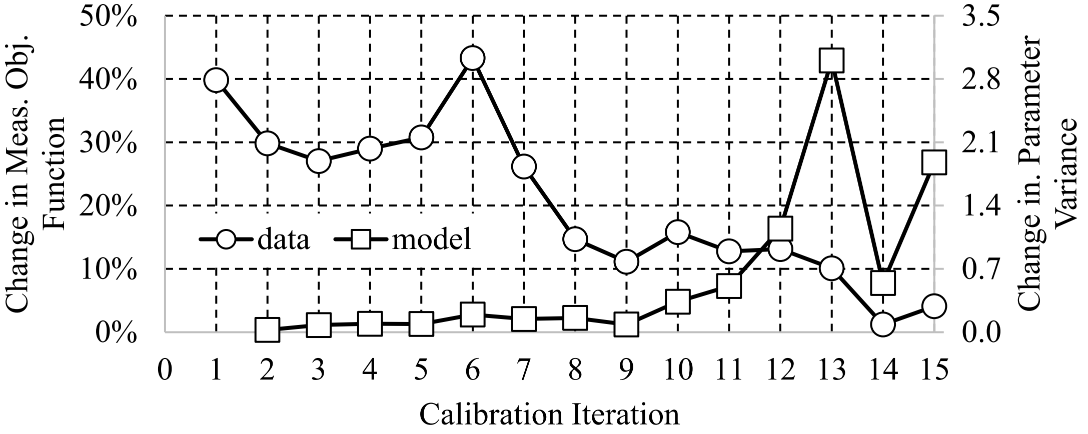
Appendix C

Optimal Level of Measurement-to-Model Misfit Procedure

Appendix C

An example of the regularized inversion procedure is presented here for the primary calibration step of the Main Post. In the first figure below, the measurement and regularization objective function contributions are plotted for each PEST_HP calibration iteration. The initial measurement objective function is approximately 42,000 and after 15 iterations it is reduced to about 1,100, while parameter variance increases from 0 to approximately 8. In the second figure, the relative improvement in the measurement objective function from the previous iteration is shown, as is the relative change in parameter variance. The relative improvement in the measurement objective function for the first 7 iterations is between 25% and 45%, and 1% and 15% for iterations 8 through 15. The change in parameter variance is small for the first 9 iterations but begins to change more rapidly from iteration 10. For this reason, an appropriate trade-off is at iteration 9, which is a measurement objective function of approximately 2,000, about twice the minimum.





Appendix D

Calculated Steady State Water Levels and Residuals

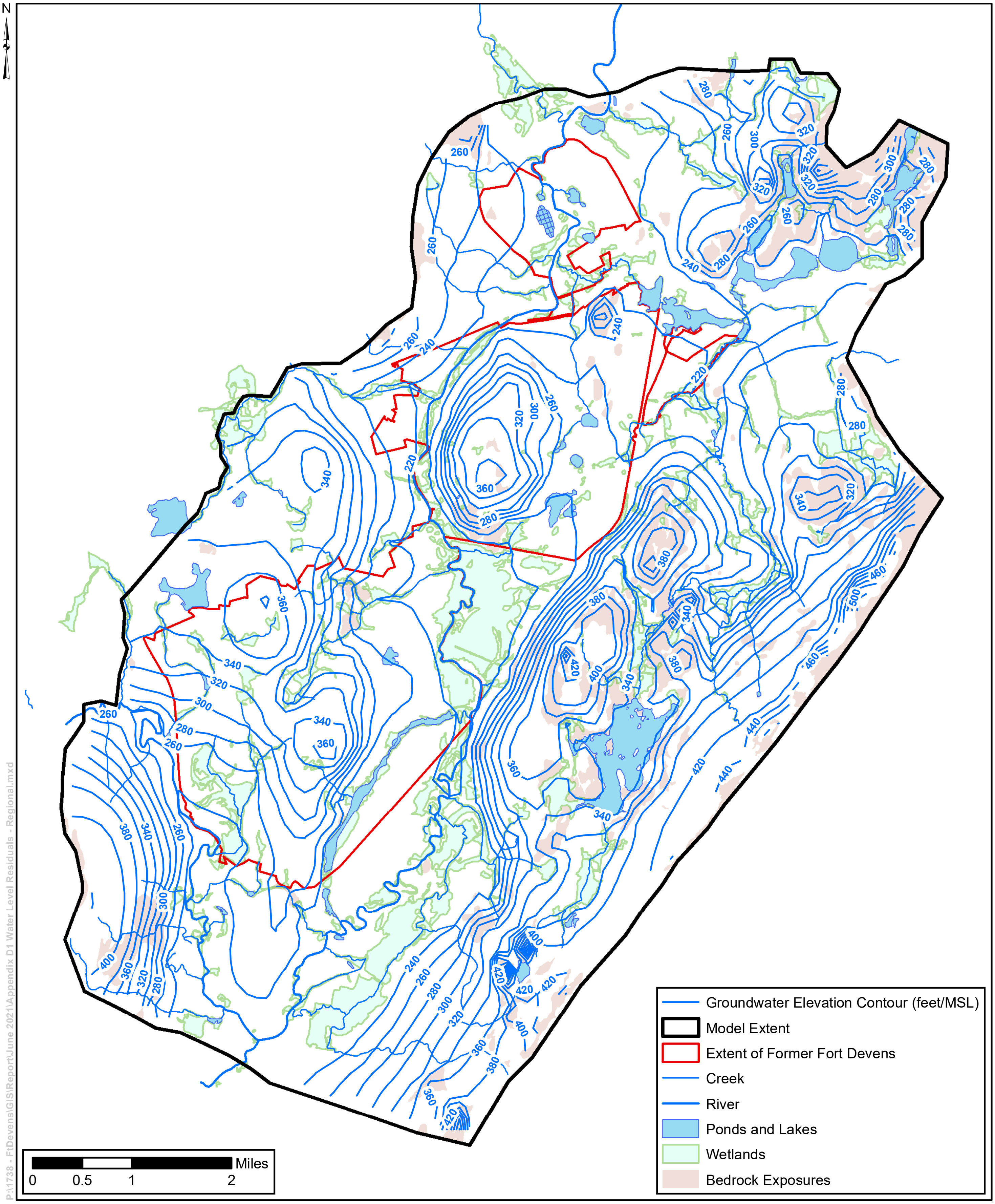


Figure D.1 Calculated Steady State Water Levels – Regional Domain

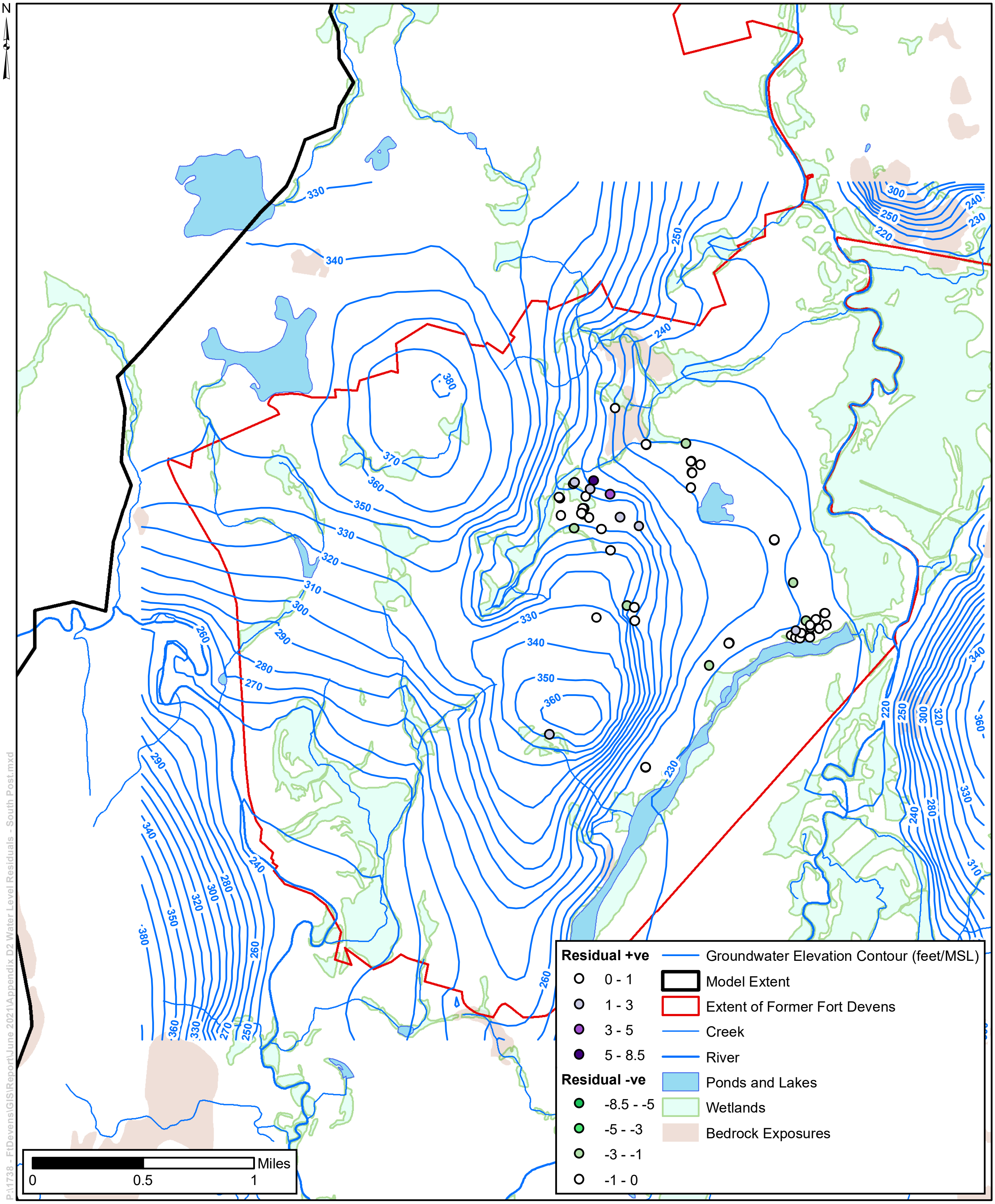


Figure D.2 Calculated Steady State Water Levels with Residuals – South Post

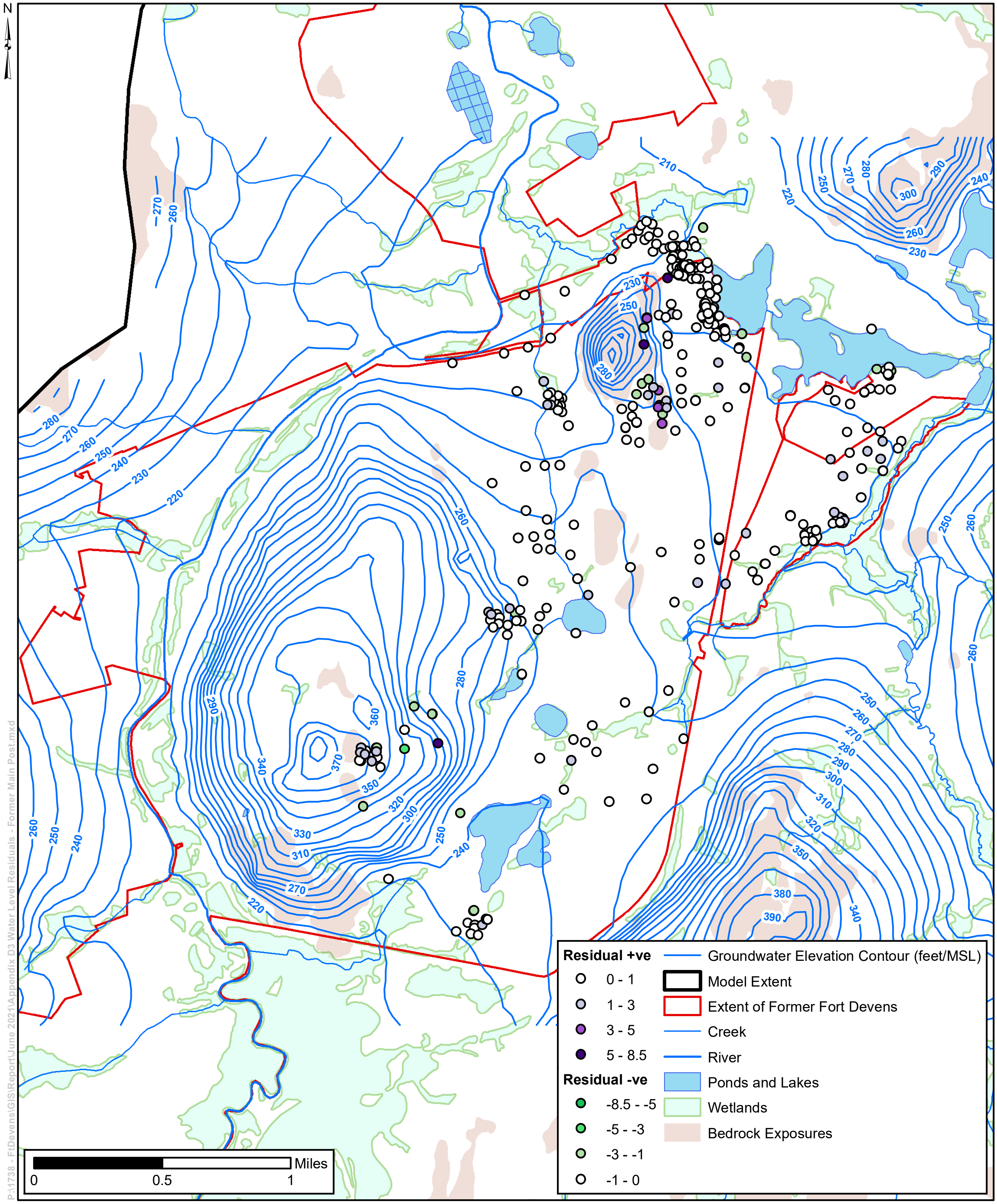


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Figure D.3 Calculated Steady State Water Levels with Residuals – Former Main Post

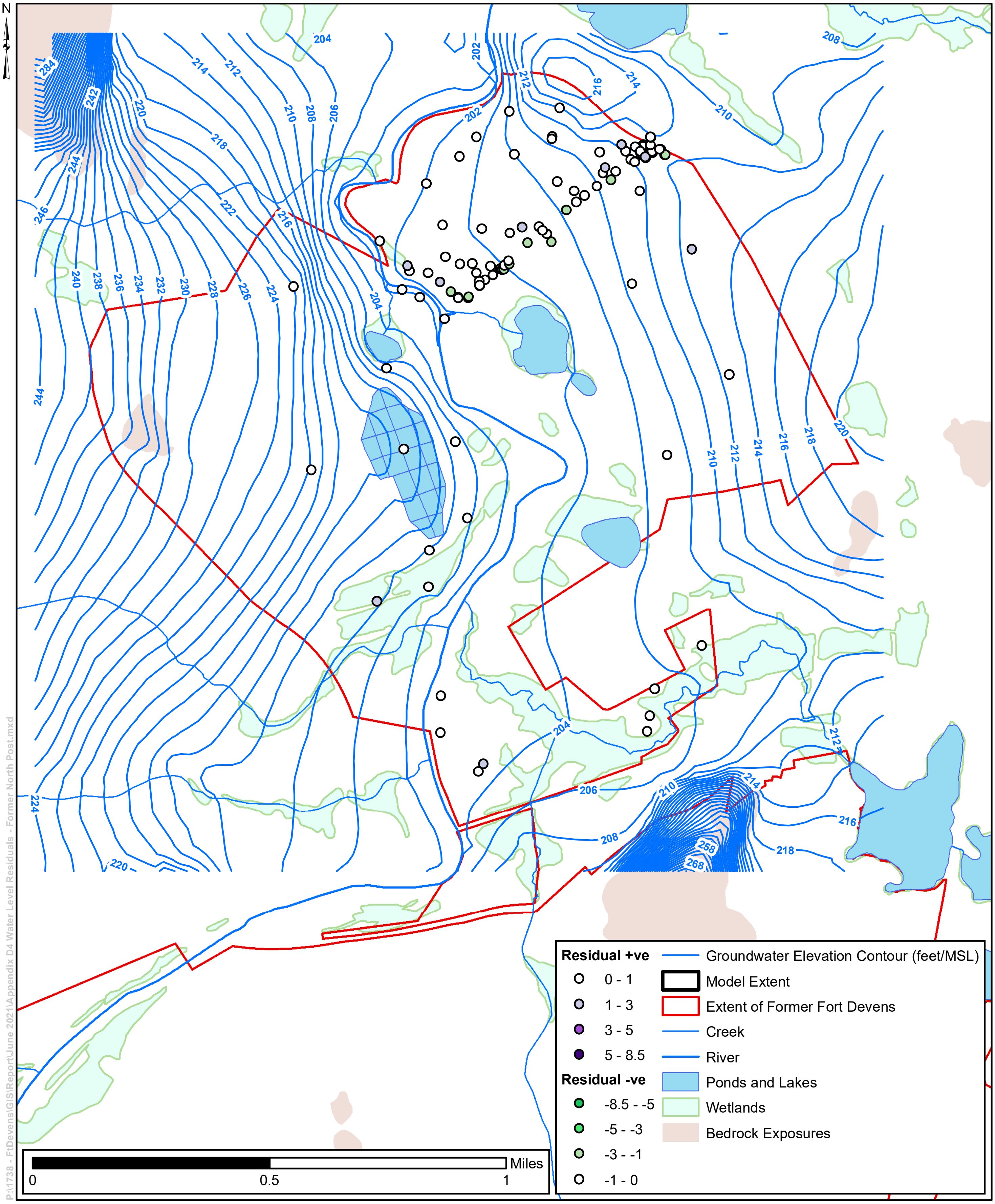

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Figure D.4 Calculated Steady State Water Levels with Residuals – Former North Post

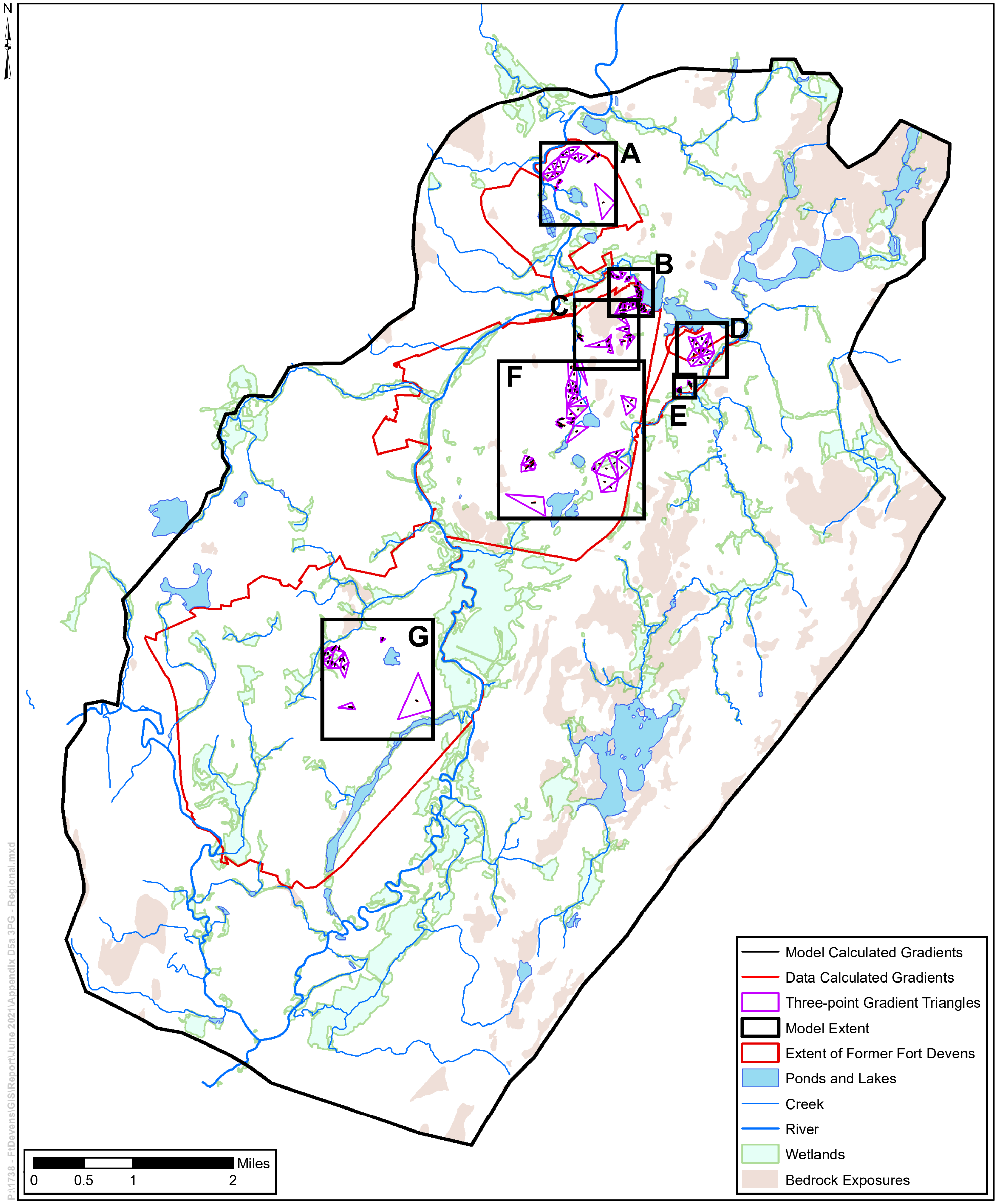

Figure D.5a Three-point Gradient Estimates and Simulated Equivalents - Inset Reference Map

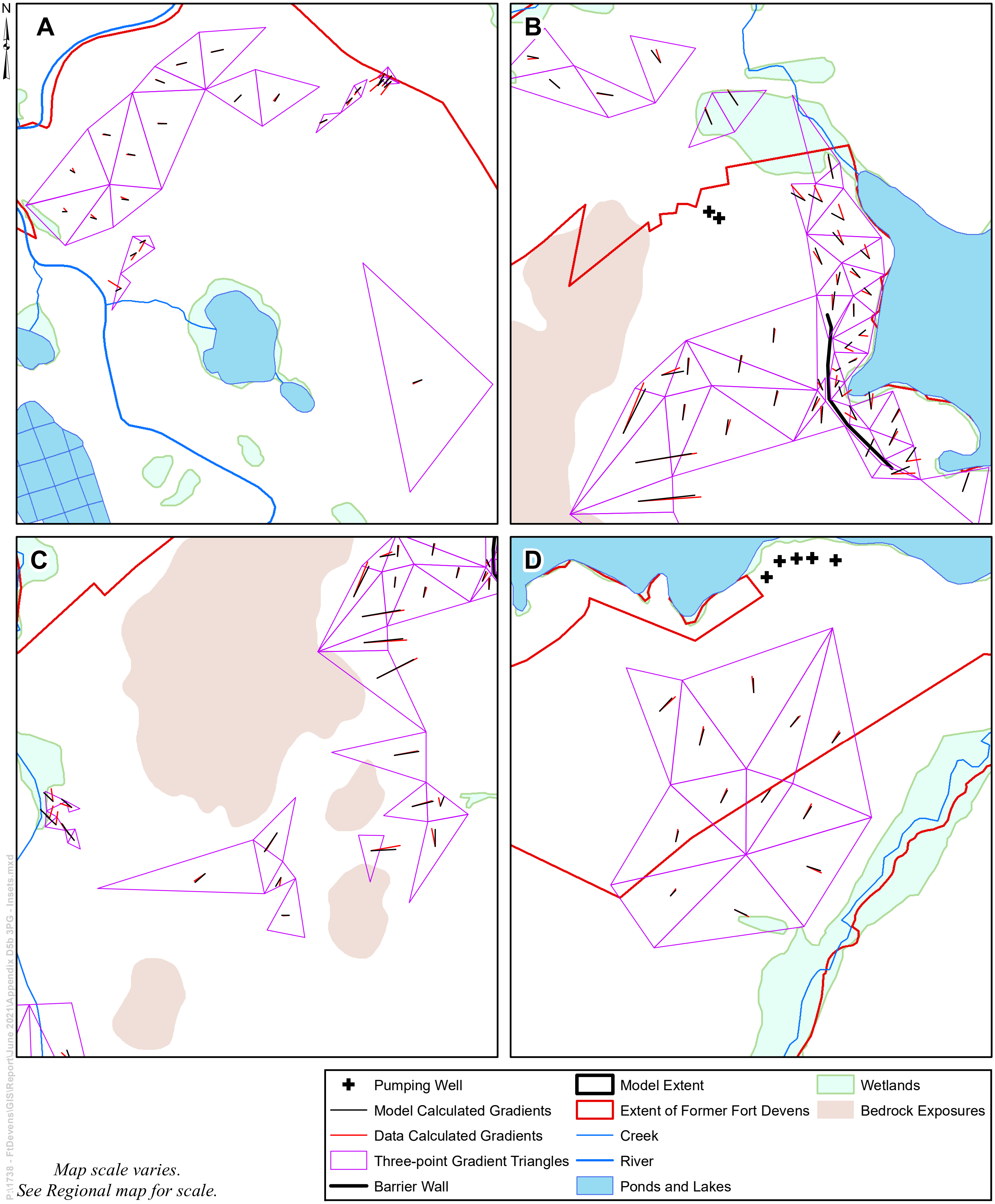

Figure D.5b Three-point Gradient Estimates and Simulated Equivalents - Insets A-D

Map scale varies.
See Regional map for scale.

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Figure D.5c Three-point Gradient Estimates and Simulated Equivalents - Insets E-G

Appendix E

Calibration Targets, Simulated Equivalents, and Residuals

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_20	MW-01A	4/27/2020	206.8	
AOC_20	MW-02A	4/27/2020	206.7	
AOC_20	MW-04	4/27/2020	208.1	
AOC_20	MW-06	4/27/2020	222.1	
AOC_20	MW-07	4/27/2020	219.9	
AOC_20	MW-WC1A	4/27/2020	207.2	
AOC_20	MW-WC2	4/27/2020	209.5	
AOC_20	PZ-1	4/27/2020	211.9	
AOC_20	PZ-2	4/27/2020		
AOC_20	PZ-5	4/27/2020	208.0	
AOC_20	PZ-6	4/27/2020	203.9	
AOC_25	25M-92-05X	1/15/1997	333.4	
AOC_25	25M-92-05X	6/2/1997	332.9	
AOC_25	25M-92-05X	4/23/1998	334.0	
AOC_25	25M-92-05X	12/6/1999	328.6	
AOC_25	25M-92-06X	1/15/1997	294.9	
AOC_25	25M-92-06X	6/2/1997	294.7	
AOC_25	25M-92-06X	10/27/1997	287.5	
AOC_25	25M-92-06X	4/23/1998	294.8	
AOC_25	25M-92-06X	10/14/1998	290.0	
AOC_25	25M-92-06X	10/21/1998	289.6	
AOC_25	25M-92-06X	10/18/1999	285.6	
AOC_25	25M-92-06X	12/6/1999	286.0	
AOC_25	25M-92-06X	10/25/2000	288.4	
AOC_25	25M-92-06X	10/15/2001	287.6	
AOC_25	25M-92-06X	10/21/2002	285.3	
AOC_25	25M-92-06X	10/28/2003	288.3	
AOC_25	25M-92-06X	11/1/2004	287.4	
AOC_25	25M-92-07X	1/15/1997	297.8	
AOC_25	25M-92-07X	6/2/1997	297.7	
AOC_25	25M-92-07X	4/23/1998	297.9	
AOC_25	25M-92-07X	10/14/1998	291.9	
AOC_25	25M-92-07X	12/6/1999	286.9	
AOC_25	25M-92-08X	1/15/1997	305.9	
AOC_25	25M-92-08X	6/2/1997	305.9	
AOC_25	25M-92-08X	4/23/1998	305.9	
AOC_25	25M-92-08X	10/14/1998	298.4	
AOC_25	25M-92-08X	12/6/1999	291.6	
AOC_25	26M-10-09X	10/25/2010	274.5	
AOC_25	26M-10-09X	10/18/2011	274.8	
AOC_25	26M-10-09X	11/13/2012	274.6	
AOC_25	26M-10-09X	11/12/2013	274.4	
AOC_25	26M-10-09X	11/24/2014	274.6	
AOC_25	26M-10-09X	12/10/2015	274.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_25	26M-10-09X	11/1/2016	274.4	
AOC_25	26M-10-09X	3/13/2017	274.8	
AOC_25	26M-10-09X	5/22/2017	273.8	
AOC_25	26M-10-09X	8/21/2017	274.4	
AOC_25	26M-10-09X	11/27/2017	274.5	
AOC_25	26M-10-09X	11/27/2018	275.2	
AOC_25	26M-10-09X	5/20/2019	274.9	
AOC_25	26M-10-09X	11/21/2019	274.5	
AOC_25	26M-14-10X	11/24/2014	273.7	
AOC_25	26M-14-10X	12/9/2015	273.5	
AOC_25	26M-14-10X	11/1/2016	273.3	
AOC_25	26M-14-10X	3/13/2017	273.4	
AOC_25	26M-14-10X	5/22/2017	275.5	
AOC_25	26M-14-10X	8/21/2017	280.2	
AOC_25	26M-14-10X	11/27/2017	274.2	
AOC_25	26M-14-10X	11/27/2018	276.6	
AOC_25	26M-14-10X	5/20/2019	277.6	
AOC_25	26M-14-10X	11/21/2019	274.2	
AOC_25	26M-14-11X	11/24/2014	286.6	
AOC_25	26M-14-11X	12/9/2015	286.3	
AOC_25	26M-14-11X	11/1/2016		
AOC_25	26M-14-11X	3/13/2017	286.6	
AOC_25	26M-14-11X	5/22/2017	288.2	
AOC_25	26M-14-11X	8/21/2017	288.5	
AOC_25	26M-14-11X	11/27/2017	287.2	
AOC_25	26M-14-11X	11/27/2018	289.4	
AOC_25	26M-14-11X	5/20/2019	289.8	
AOC_25	26M-14-11X	11/21/2019	287.0	
AOC_25	26M-92-01X	6/2/1997	311.4	
AOC_25	26M-92-01X	10/14/1998	307.2	
AOC_25	26M-92-01X	12/6/1999	308.3	
AOC_25	26M-92-01X	10/22/2008	310.0	
AOC_25	26M-92-01X	11/13/2009	306.3	
AOC_25	26M-92-01X	10/25/2010		
AOC_25	26M-92-01X	10/18/2011	310.6	
AOC_25	26M-92-01X	11/13/2012	307.6	
AOC_25	26M-92-01X	11/12/2013		
AOC_25	26M-92-01X	11/24/2014	306.3	
AOC_25	26M-92-01X	12/10/2015		
AOC_25	26M-92-01X	11/1/2016	305.3	
AOC_25	26M-92-01X	3/13/2017	311.2	
AOC_25	26M-92-01X	5/22/2017	315.5	
AOC_25	26M-92-01X	8/21/2017	307.7	
AOC_25	26M-92-01X	11/27/2017	307.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_25	26M-92-01X	11/27/2018	313.1	
AOC_25	26M-92-01X	5/20/2019	312.0	
AOC_25	26M-92-01X	11/21/2019		
AOC_25	26M-92-02X	1/15/1997	285.9	
AOC_25	26M-92-02X	6/2/1997	286.0	
AOC_25	26M-92-02X	10/27/1997	284.7	
AOC_25	26M-92-02X	4/23/1998	286.4	
AOC_25	26M-92-02X	10/14/1998	285.6	
AOC_25	26M-92-02X	10/21/1998	285.7	
AOC_25	26M-92-02X	10/18/1999	284.7	
AOC_25	26M-92-02X	12/6/1999	284.8	
AOC_25	26M-92-02X	10/25/2000	285.4	
AOC_25	26M-92-02X	10/15/2001	284.8	
AOC_25	26M-92-02X	10/21/2002	284.0	
AOC_25	26M-92-02X	10/28/2003	285.7	
AOC_25	26M-92-02X	11/1/2004	285.4	
AOC_25	26M-92-02X	11/14/2005	286.6	
AOC_25	26M-92-02X	10/23/2006	286.1	
AOC_25	26M-92-02X	10/22/2007	285.9	
AOC_25	26M-92-02X	10/22/2008	286.1	
AOC_25	26M-92-02X	11/13/2009	286.1	
AOC_25	26M-92-02X	10/21/2010	285.3	
AOC_25	26M-92-02X	10/18/2011	286.1	
AOC_25	26M-92-02X	11/13/2012	285.2	
AOC_25	26M-92-02X	11/12/2013	285.1	
AOC_25	26M-92-02X	11/24/2014	284.5	
AOC_25	26M-92-02X	12/9/2015	284.1	
AOC_25	26M-92-02X	11/1/2016	283.9	
AOC_25	26M-92-02X	3/13/2017	284.6	
AOC_25	26M-92-02X	5/22/2017	286.5	
AOC_25	26M-92-02X	8/21/2017	285.5	
AOC_25	26M-92-02X	11/27/2017	284.9	
AOC_25	26M-92-02X	11/27/2018	286.1	
AOC_25	26M-92-02X	5/20/2019	286.5	
AOC_25	26M-92-02X	11/21/2019	284.9	
AOC_25	26M-92-03X	1/15/1997	286.0	
AOC_25	26M-92-03X	6/2/1997	286.4	
AOC_25	26M-92-03X	10/27/1997	284.5	
AOC_25	26M-92-03X	4/23/1998	286.5	
AOC_25	26M-92-03X	10/14/1998	285.6	
AOC_25	26M-92-03X	10/21/1998	285.5	
AOC_25	26M-92-03X	10/18/1999	284.9	
AOC_25	26M-92-03X	12/6/1999	284.6	
AOC_25	26M-92-03X	10/25/2000	285.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_25	26M-92-03X	10/15/2001	284.7	
AOC_25	26M-92-03X	10/21/2002	283.9	
AOC_25	26M-92-03X	10/28/2003	285.4	
AOC_25	26M-92-03X	11/1/2004	285.2	
AOC_25	26M-92-03X	11/14/2005	286.5	
AOC_25	26M-92-03X	10/23/2006	285.9	
AOC_25	26M-92-03X	10/22/2007	285.6	
AOC_25	26M-92-03X	10/22/2008	285.9	
AOC_25	26M-92-03X	11/13/2009	285.9	
AOC_25	26M-92-03X	10/21/2010	285.1	
AOC_25	26M-92-03X	10/18/2011	286.0	
AOC_25	26M-92-03X	11/13/2012	284.0	
AOC_25	26M-92-03X	11/12/2013	285.0	
AOC_25	26M-92-03X	11/24/2014	284.4	
AOC_25	26M-92-03X	12/8/2015	284.8	
AOC_25	26M-92-03X	11/1/2016	283.9	
AOC_25	26M-92-03X	3/13/2017	284.5	
AOC_25	26M-92-03X	5/22/2017	285.4	
AOC_25	26M-92-03X	8/22/2017	285.3	
AOC_25	26M-92-03X	11/27/2017	284.8	
AOC_25	26M-92-03X	11/27/2018	286.0	
AOC_25	26M-92-03X	5/20/2019	286.4	
AOC_25	26M-92-03X	11/21/2019	284.8	
AOC_25	26M-92-04X	6/2/1997	287.4	
AOC_25	26M-92-04X	4/23/1998	287.1	
AOC_25	26M-92-04X	10/14/1998	286.6	
AOC_25	26M-92-04X	10/21/1998	286.8	
AOC_25	26M-92-04X	10/18/1999	285.5	
AOC_25	26M-92-04X	12/6/1999	285.1	
AOC_25	26M-92-04X	10/25/2000	286.2	
AOC_25	26M-92-04X	10/15/2001	285.6	
AOC_25	26M-92-04X	10/21/2002	284.7	
AOC_25	26M-92-04X	10/28/2003	286.3	
AOC_25	26M-92-04X	11/1/2004	286.0	
AOC_25	26M-92-04X	11/14/2005	287.3	
AOC_25	26M-92-04X	10/23/2006	286.8	
AOC_25	26M-92-04X	10/22/2007	286.4	
AOC_25	26M-92-04X	10/22/2008	286.8	
AOC_25	26M-92-04X	11/13/2009	286.7	
AOC_25	26M-92-04X	10/21/2010	285.9	
AOC_25	26M-92-04X	10/18/2011	286.8	
AOC_25	26M-92-04X	11/13/2012	285.8	
AOC_25	26M-92-04X	11/12/2013	285.8	
AOC_25	26M-92-04X	11/24/2014	285.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_25	26M-92-04X	12/8/2015	284.8	
AOC_25	26M-92-04X	11/1/2016	284.5	
AOC_25	26M-92-04X	3/13/2017	285.1	
AOC_25	26M-92-04X	5/22/2017	286.1	
AOC_25	26M-92-04X	8/22/2017	286.3	
AOC_25	26M-92-04X	11/27/2017	285.5	
AOC_25	26M-92-04X	11/27/2018	286.9	
AOC_25	26M-92-04X	5/20/2019	287.5	
AOC_25	26M-92-04X	11/21/2019	285.6	
AOC_25	26M-92-05X	1/15/1997	288.3	
AOC_25	26M-92-05X	6/2/1997	288.1	
AOC_25	26M-92-05X	4/23/1998	288.5	
AOC_25	26M-92-05X	12/6/1999	286.8	
AOC_25	26M-92-05X	10/22/2008	288.4	
AOC_25	26M-92-05X	11/13/2009	289.0	
AOC_25	26M-92-05X	10/25/2010	288.0	
AOC_25	26M-92-05X	10/18/2011	288.3	
AOC_25	26M-92-05X	11/13/2012	286.6	
AOC_25	26M-92-05X	11/12/2013	278.3	
AOC_25	26M-92-05X	10/25/2014	287.5	
AOC_25	26M-92-05X	11/24/2014	285.6	
AOC_25	26M-92-05X	12/10/2015	284.8	
AOC_25	26M-92-05X	11/1/2016	285.1	
AOC_25	26M-92-05X	3/13/2017	287.5	
AOC_25	26M-92-05X	5/22/2017	288.6	
AOC_25	26M-92-05X	8/21/2017	287.4	
AOC_25	26M-92-05X	11/27/2017	287.8	
AOC_25	26M-92-05X	11/27/2018	289.1	
AOC_25	26M-92-05X	5/20/2019	288.4	
AOC_25	26M-92-05X	11/21/2019	286.1	
AOC_25	26M-92-06X	1/15/1997	291.5	
AOC_25	26M-92-06X	6/2/1997	291.8	
AOC_25	26M-92-06X	4/23/1998	292.3	
AOC_25	26M-92-06X	10/14/1998	290.8	
AOC_25	26M-92-06X	12/6/1999	288.6	
AOC_25	26M-92-06X	10/22/2008	291.1	
AOC_25	26M-92-06X	11/13/2009	290.8	
AOC_25	26M-92-06X	10/25/2010	289.2	
AOC_25	26M-92-06X	10/18/2011	291.2	
AOC_25	26M-92-06X	11/13/2012	289.6	
AOC_25	26M-92-06X	11/12/2013	288.5	
AOC_25	26M-92-06X	11/24/2014	288.4	
AOC_25	26M-92-06X	12/10/2015	287.3	
AOC_25	26M-92-06X	11/1/2016	286.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_25	26M-92-06X	3/13/2017	290.4	
AOC_25	26M-92-06X	5/22/2017	291.1	
AOC_25	26M-92-06X	8/21/2017	288.8	
AOC_25	26M-92-06X	11/27/2017	289.5	
AOC_25	26M-92-06X	11/27/2018	292.1	
AOC_25	26M-92-06X	5/20/2019	292.0	
AOC_25	26M-92-06X	11/21/2019	289.2	
AOC_25	26M-92-07X	6/2/1997	291.7	
AOC_25	26M-92-07X	4/23/1998	291.4	
AOC_25	26M-92-07X	10/14/1998	289.9	
AOC_25	26M-92-07X	12/6/1999	287.2	
AOC_25	26M-92-07X	10/22/2008	290.2	
AOC_25	26M-92-07X	11/13/2009	280.3	
AOC_25	26M-92-07X	10/25/2010	288.5	
AOC_25	26M-92-07X	10/18/2011	290.0	
AOC_25	26M-92-07X	11/13/2012	288.3	
AOC_25	26M-92-07X	11/12/2013	288.5	
AOC_25	26M-92-07X	11/24/2014	287.6	
AOC_25	26M-92-07X	12/10/2015	287.1	
AOC_25	26M-92-07X	11/1/2016	286.6	
AOC_25	26M-92-07X	3/13/2017	287.2	
AOC_25	26M-92-07X	5/22/2017	289.3	
AOC_25	26M-92-07X	8/21/2017	289.6	
AOC_25	26M-92-07X	11/27/2017	289.1	
AOC_25	26M-92-07X	11/27/2018	290.7	
AOC_25	26M-92-07X	5/20/2019	290.6	
AOC_25	26M-92-07X	11/21/2019	288.2	
AOC_25	26WP-06-01R	3/13/2017	282.4	
AOC_25	26WP-06-01R	5/22/2017	282.5	
AOC_25	26WP-06-01R	8/21/2017	282.6	
AOC_25	26WP-06-01R	11/27/2017	282.4	
AOC_25	26WP-06-01R	11/27/2018	282.3	
AOC_25	26WP-06-01R	5/20/2019	283.0	
AOC_25	26WP-06-01R	11/21/2019	282.8	
AOC_25	26WP-08-02R	3/13/2017	279.4	
AOC_25	26WP-08-02R	5/22/2017	279.0	
AOC_25	26WP-08-02R	8/21/2017	279.8	
AOC_25	26WP-08-02R	11/27/2017	279.8	
AOC_25	26WP-08-02R	11/27/2018	279.8	
AOC_25	26WP-08-02R	5/20/2019	280.7	
AOC_25	26WP-08-02R	11/21/2019	280.0	
AOC_25	26WP-09-01R	3/13/2017	281.0	
AOC_25	26WP-09-01R	5/22/2017	281.0	
AOC_25	26WP-09-01R	8/21/2017	281.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_25	26WP-09-01R	11/27/2017	280.8	
AOC_25	26WP-09-01R	11/27/2018	281.3	
AOC_25	26WP-09-01R	5/20/2019	281.7	
AOC_25	26WP-09-01R	11/21/2019	281.2	
AOC_25	26WP-09-02R	3/13/2017	271.5	
AOC_25	26WP-09-02R	5/22/2017	273.5	
AOC_25	26WP-09-02R	8/21/2017	270.4	
AOC_25	26WP-09-02R	11/27/2017	271.0	
AOC_25	26WP-09-02R	11/27/2018	272.6	
AOC_25	26WP-09-02R	5/20/2019	275.3	
AOC_25	26WP-09-02R	11/21/2019	270.9	
AOC_25	26WP-09-03R	3/13/2017	284.2	
AOC_25	26WP-09-03R	5/22/2017	284.4	
AOC_25	26WP-09-03R	8/21/2017		
AOC_25	26WP-09-03R	11/27/2017		
AOC_25	26WP-09-03R	11/27/2018	286.1	
AOC_25	26WP-09-03R	5/20/2019	284.0	
AOC_25	26WP-09-03R	11/21/2019		
AOC_25	27M-93-07X	10/21/2008	236.8	
AOC_25	27M-93-07X	10/25/2010	236.0	
AOC_25	27M-93-07X	11/13/2012	233.8	
AOC_25	27M-93-07X	11/25/2014		
AOC_25	27M-93-07X	11/2/2016		
AOC_25	27M-93-07X	11/26/2018	236.2	
AOC_25	27M-93-07X	11/25/2019	234.4	
AOC_25	27M-93-07X		252.3	
AOC_25	27M-93-09X	10/21/2008	235.3	
AOC_25	27M-93-09X	10/25/2010	234.4	
AOC_25	27M-93-09X	11/13/2012	232.5	
AOC_25	27M-93-09X	11/25/2014		
AOC_25	27M-93-09X	11/2/2016		
AOC_25	27M-93-09X	11/26/2018	234.0	
AOC_25	27M-93-09X	11/25/2019	233.1	
AOC_25	27M-93-09X		249.0	
AOC_25	27M-93-10X	10/21/2008	235.4	
AOC_25	27M-93-10X	10/25/2010	234.5	
AOC_25	27M-93-10X	11/13/2012	232.6	
AOC_25	27M-93-10X	11/25/2014	231.4	
AOC_25	27M-93-10X	11/2/2016	233.6	
AOC_25	27M-93-10X	11/26/2018	235.2	
AOC_25	27M-93-10X	11/25/2019	233.3	
AOC_25	27M-93-10X		248.6	
AOC_25	EOD-1	1/15/1997	331.9	
AOC_25	EOD-1	6/2/1997	331.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_25	EOD-1	4/23/1998	332.3	
AOC_25	EOD-1	12/6/1999	330.1	
AOC_25	EOD-2	1/15/1997	325.5	
AOC_25	EOD-2	6/2/1997	325.3	
AOC_25	EOD-2	4/23/1998	325.5	
AOC_25	EOD-2	12/6/1999	324.6	
AOC_25	EOD-3	7/23/1996	316.9	
AOC_25	EOD-3	1/15/1997	322.1	
AOC_25	EOD-3	6/2/1997	321.8	
AOC_25	EOD-3	4/23/1998	323.2	
AOC_25	EOD-3	12/6/1999	314.0	
AOC_25	EOD-4	7/23/1996	322.0	
AOC_25	EOD-4	1/15/1997	323.1	
AOC_25	EOD-4	6/2/1997	323.5	
AOC_25	EOD-4	4/23/1998	323.6	
AOC_25	EOD-4	12/6/1999	316.2	
AOC_25	SPM-93-06X	7/23/1996	231.1	
AOC_25	SPM-93-06X	1/15/1997	232.0	
AOC_25	SPM-93-06X	6/2/1997	232.1	
AOC_25	SPM-93-06X	10/27/1997	230.9	
AOC_25	SPM-93-06X	4/23/1998	231.9	
AOC_25	SPM-93-06X	10/14/1998	231.2	
AOC_25	SPM-93-06X	10/21/1998	231.3	
AOC_25	SPM-93-06X	10/18/1999	230.8	
AOC_25	SPM-93-06X	12/6/1999	230.7	
AOC_25	SPM-93-06X	10/25/2000	230.9	
AOC_25	SPM-93-06X	10/15/2001	230.7	
AOC_25	SPM-93-06X	10/21/2002	230.2	
AOC_25	SPM-93-06X	10/28/2003	231.2	
AOC_25	SPM-93-06X	11/1/2004	230.8	
AOC_25	SPM-93-06X	11/14/2005	231.9	
AOC_25	SPM-93-06X	10/23/2006	231.4	
AOC_25	SPM-93-06X	10/22/2007	224.7	
AOC_25	SPM-93-06X	10/21/2008	231.5	
AOC_25	SPM-93-06X	11/12/2009	231.6	
AOC_25	SPM-93-06X	10/26/2010	231.4	
AOC_25	SPM-93-06X	10/17/2011	231.7	
AOC_25	SPM-93-06X	11/13/2012	231.3	
AOC_25	SPM-93-06X	11/13/2013	230.9	
AOC_25	SPM-93-06X	11/25/2014	231.4	
AOC_25	SPM-93-06X	12/8/2015	230.6	
AOC_25	SPM-93-06X	8/22/2016	230.3	
AOC_25	SPM-93-06X	11/2/2016	230.5	
AOC_25	SPM-93-06X	11/13/2017	232.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_25	SPM-93-06X	11/19/2018	233.3	
AOC_25	SPM-93-06X	11/25/2019	230.2	
AOC_25	SPM-97-23X	6/2/1997	231.4	
AOC_25	SPM-97-23X	10/27/1997	229.5	
AOC_25	SPM-97-23X	10/21/1998	231.2	
AOC_25	SPM-97-23X	10/18/1999	228.7	
AOC_25	SPM-97-23X	10/25/2000	229.6	
AOC_25	SPM-97-23X	10/15/2001	229.1	
AOC_25	SPM-97-23X	10/21/2002	227.7	
AOC_25	SPM-97-23X	10/28/2003	229.9	
AOC_25	SPM-97-23X	11/1/2004	229.1	
AOC_25	SPM-97-23X	11/14/2005	231.3	
AOC_25	SPM-97-23X	10/23/2006		
AOC_25	SPM-97-23X	10/24/2007	230.7	
AOC_25	SPM-97-23X	10/21/2008		
AOC_25	SPM-97-23X	10/26/2010		
AOC_25	SPM-97-23X	10/17/2011		
AOC_25	SPM-97-23X	11/13/2012		
AOC_25	SPM-97-23X	11/13/2013	228.9	
AOC_25	SPM-97-23X	11/25/2014	228.7	
AOC_25	SPM-97-23X	12/8/2015	228.0	
AOC_25	SPM-97-23X	11/2/2016	227.3	
AOC_25	SPM-97-23X	11/13/2017	228.4	
AOC_25	SPM-97-23X	11/19/2018	231.6	
AOC_25	SPM-97-23X	11/25/2019	230.0	
AOC_25	SPM-97-23X			
AOC_26	26M-97-08X	10/27/1997	282.4	
AOC_26	26M-97-08X	10/21/1998	283.8	
AOC_26	26M-97-08X	10/18/1999	282.9	
AOC_26	26M-97-08X	12/6/1999	282.9	
AOC_26	26M-97-08X	10/25/2000	312.0	
AOC_26	26M-97-08X	10/15/2001	283.3	
AOC_26	26M-97-08X	10/21/2002	282.2	
AOC_26	26M-97-08X	10/28/2003	283.7	
AOC_26	26M-97-08X	11/1/2004	283.5	
AOC_26	26M-97-08X	11/14/2005	284.7	
AOC_26	26M-97-08X	10/23/2006	284.2	
AOC_26	26M-97-08X	10/22/2007	283.9	
AOC_26	26M-97-08X	10/22/2008	284.1	
AOC_26	26M-97-08X	11/13/2009	284.3	
AOC_26	26M-97-08X	10/21/2010	285.0	
AOC_26	26M-97-08X	10/18/2011	285.9	
AOC_26	26M-97-08X	11/14/2012	284.9	
AOC_26	26M-97-08X	11/12/2013	284.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_26	26M-97-08X	11/24/2014	284.3	
AOC_26	26M-97-08X	12/9/2015	284.0	
AOC_26	26M-97-08X	11/1/2016	288.8	
AOC_26	26M-97-08X	3/13/2017	284.4	
AOC_26	26M-97-08X	5/22/2017	285.4	
AOC_26	26M-97-08X	8/21/2017	285.3	
AOC_26	26M-97-08X	11/27/2017	284.4	
AOC_26	26M-97-08X	11/27/2018	285.8	
AOC_26	26M-97-08X	5/20/2019	286.2	
AOC_26	26M-97-08X	11/21/2019	284.7	
AOC_26	26WP-06-01	10/22/2007		
AOC_26	26WP-06-01	10/22/2008	282.2	
AOC_26	26WP-06-01	11/13/2009	282.5	
AOC_26	26WP-06-01	10/21/2010	282.5	
AOC_26	26WP-06-01	10/18/2011	282.7	
AOC_26	26WP-06-01	11/13/2012	282.5	
AOC_26	26WP-06-01	11/12/2013	282.3	
AOC_26	26WP-06-01	11/24/2014	281.7	
AOC_26	26WP-06-01	12/9/2015	281.6	
AOC_26	26WP-06-01	11/1/2016	282.0	
AOC_26	26WP-06-01			
AOC_26	26WP-08-02	10/22/2008	279.9	
AOC_26	26WP-08-02	11/13/2009	279.9	
AOC_26	26WP-08-02	10/21/2010	276.3	
AOC_26	26WP-08-02	10/18/2011	280.0	
AOC_26	26WP-08-02	11/14/2012	279.5	
AOC_26	26WP-08-02	11/12/2013	279.4	
AOC_26	26WP-08-02	11/24/2014	279.5	
AOC_26	26WP-08-02	12/9/2015	279.4	
AOC_26	26WP-08-02	11/1/2016	279.6	
AOC_26	26WP-08-02			
AOC_26	26WP-09-01	11/13/2009	270.9	
AOC_26	26WP-09-01	10/25/2010		
AOC_26	26WP-09-01	10/18/2011		
AOC_26	26WP-09-01	11/14/2012		
AOC_26	26WP-09-01	11/12/2013		
AOC_26	26WP-09-01	11/24/2014		
AOC_26	26WP-09-01	12/9/2015		
AOC_26	26WP-09-01	8/22/2016		
AOC_26	26WP-09-01	11/1/2016		
AOC_26	26WP-09-02	11/13/2009	261.1	
AOC_26	26WP-09-02	10/25/2010		
AOC_26	26WP-09-02	10/18/2011		
AOC_26	26WP-09-02	11/14/2012		

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_26	26WP-09-02	11/12/2013		
AOC_26	26WP-09-02	11/24/2014		
AOC_26	26WP-09-02	12/10/2015		
AOC_26	26WP-09-02	8/22/2016		
AOC_26	26WP-09-02	11/1/2016		
AOC_26	26WP-09-03	11/13/2009	284.9	
AOC_26	26WP-09-03	10/25/2010	284.6	
AOC_26	26WP-09-03	10/18/2011	284.4	
AOC_26	26WP-09-03	11/14/2012	283.3	
AOC_26	26WP-09-03	11/12/2013	283.3	
AOC_26	26WP-09-03	11/24/2014	282.9	
AOC_26	26WP-09-03	12/10/2015		
AOC_26	26WP-09-03	11/1/2016	282.7	
AOC_26	26WP-09-03			
AOC_27	27M-92-01X	9/5/1992	232.4	
AOC_27	27M-92-01X	6/2/1997	236.5	
AOC_27	27M-92-01X	10/27/1997	232.9	
AOC_27	27M-92-01X	4/23/1998	235.2	
AOC_27	27M-92-01X	10/14/1998	234.1	
AOC_27	27M-92-01X	10/21/1998	234.3	
AOC_27	27M-92-01X	10/18/1999	231.1	
AOC_27	27M-92-01X	12/6/1999	230.9	
AOC_27	27M-92-01X	10/25/2000	232.4	
AOC_27	27M-92-01X	10/15/2001	231.9	
AOC_27	27M-92-01X	10/21/2002	229.9	
AOC_27	27M-92-01X	10/28/2003	232.5	
AOC_27	27M-92-01X	11/1/2004	231.7	
AOC_27	27M-92-01X	11/14/2005	235.2	
AOC_27	27M-92-01X	10/23/2006	234.8	
AOC_27	27M-92-01X	10/21/2008	234.8	
AOC_27	27M-92-01X	10/25/2010	233.6	
AOC_27	27M-92-01X	11/13/2012	232.1	
AOC_27	27M-92-01X	11/25/2014	231.1	
AOC_27	27M-92-01X	11/2/2016	229.5	
AOC_27	27M-92-01X	11/26/2018	234.8	
AOC_27	27M-92-01X	11/25/2019	232.9	
AOC_27	27M-92-01X		245.1	
AOC_27	27M-92-02X	9/5/1992	234.5	
AOC_27	27M-92-02X	7/23/1996	237.2	
AOC_27	27M-92-02X	6/2/1997	239.4	
AOC_27	27M-92-02X	4/23/1998	237.7	
AOC_27	27M-92-02X	10/14/1998	236.5	
AOC_27	27M-92-02X	12/6/1999	232.0	
AOC_27	27M-92-02X	10/21/2008	237.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_27	27M-92-02X	10/25/2010	236.3	
AOC_27	27M-92-02X	11/13/2012	234.1	
AOC_27	27M-92-02X	11/25/2014	232.5	
AOC_27	27M-92-02X	11/2/2016	230.7	
AOC_27	27M-92-02X	11/26/2018	236.8	
AOC_27	27M-92-02X	11/25/2019	237.9	
AOC_27	27M-92-02X		252.2	
AOC_27	27M-92-03X	9/5/1992	235.7	
AOC_27	27M-92-03X	7/23/1996	238.3	
AOC_27	27M-92-03X	6/2/1997	240.5	
AOC_27	27M-92-03X	4/23/1998	238.7	
AOC_27	27M-92-03X	10/14/1998	237.4	
AOC_27	27M-92-03X	12/6/1999	232.7	
AOC_27	27M-92-03X	10/21/2008	238.1	
AOC_27	27M-92-03X	10/25/2010	237.1	
AOC_27	27M-92-03X	11/13/2012	234.9	
AOC_27	27M-92-03X	11/25/2014	233.3	
AOC_27	27M-92-03X	11/2/2016	231.4	
AOC_27	27M-92-03X	11/26/2018	237.8	
AOC_27	27M-92-03X	11/25/2019	235.9	
AOC_27	27M-92-03X		255.2	
AOC_27	27M-92-04X	9/5/1992	234.7	
AOC_27	27M-92-04X	7/23/1996	237.4	
AOC_27	27M-92-04X	10/14/1998	236.6	
AOC_27	27M-92-04X	10/21/2008		
AOC_27	27M-92-04X	10/25/2010		
AOC_27	27M-92-04X	11/13/2012		
AOC_27	27M-92-04X	11/25/2014		
AOC_27	27M-92-04X	11/2/2016		
AOC_27	27M-92-04X	11/25/2019		
AOC_27	27M-92-04X			
AOC_27	27M-93-05X	6/2/1997	235.8	
AOC_27	27M-93-05X	10/27/1997	232.2	
AOC_27	27M-93-05X	4/23/1998	234.6	
AOC_27	27M-93-05X	10/14/1998	233.5	
AOC_27	27M-93-05X	10/21/1998	233.6	
AOC_27	27M-93-05X	10/18/1999	230.5	
AOC_27	27M-93-05X	12/6/1999	230.2	
AOC_27	27M-93-05X	10/25/2000	231.8	
AOC_27	27M-93-05X	10/15/2001	231.2	
AOC_27	27M-93-05X	10/21/2002	229.4	
AOC_27	27M-93-05X	10/28/2003	231.8	
AOC_27	27M-93-05X	11/1/2004	231.0	
AOC_27	27M-93-05X	11/14/2005	234.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_27	27M-93-05X	10/23/2006	234.0	
AOC_27	27M-93-05X	10/21/2008	233.9	
AOC_27	27M-93-05X	10/25/2010	230.8	
AOC_27	27M-93-05X	11/13/2012	231.4	
AOC_27	27M-93-05X	11/25/2014	230.4	
AOC_27	27M-93-05X	11/2/2016	228.9	
AOC_27	27M-93-05X	11/26/2018	233.9	
AOC_27	27M-93-05X	11/25/2019	232.0	
AOC_27	27M-93-05X		244.7	
AOC_27	27M-93-06X	6/2/1997	235.7	
AOC_27	27M-93-06X	10/27/1997	232.2	
AOC_27	27M-93-06X	4/23/1998	234.5	
AOC_27	27M-93-06X	10/14/1998	233.4	
AOC_27	27M-93-06X	10/21/1998	234.0	
AOC_27	27M-93-06X	10/18/1999	230.7	
AOC_27	27M-93-06X	12/6/1999	230.6	
AOC_27	27M-93-06X	10/25/2000	232.1	
AOC_27	27M-93-06X	10/15/2001	231.6	
AOC_27	27M-93-06X	10/21/2002	229.6	
AOC_27	27M-93-06X	10/28/2003	232.2	
AOC_27	27M-93-06X	11/1/2004	231.3	
AOC_27	27M-93-06X	11/14/2005	234.3	
AOC_27	27M-93-06X	10/23/2006	234.5	
AOC_27	27M-93-06X	10/21/2008	234.4	
AOC_27	27M-93-06X	10/25/2010	233.5	
AOC_27	27M-93-06X	11/13/2012	231.8	
AOC_27	27M-93-06X	11/25/2014	230.7	
AOC_27	27M-93-06X	11/2/2016	229.2	
AOC_27	27M-93-06X	11/26/2018	234.1	
AOC_27	27M-93-06X	11/25/2019	232.4	
AOC_27	27M-93-06X		245.2	
AOC_27	27M-93-08X	7/23/1996	233.8	
AOC_27	27M-93-08X	6/2/1997	235.6	
AOC_27	27M-93-08X	10/27/1997	232.4	
AOC_27	27M-93-08X	4/23/1998	234.4	
AOC_27	27M-93-08X	10/14/1998	233.4	
AOC_27	27M-93-08X	10/21/1998	233.8	
AOC_27	27M-93-08X	10/18/1999	230.7	
AOC_27	27M-93-08X	12/6/1999	230.4	
AOC_27	27M-93-08X	10/25/2000	231.9	
AOC_27	27M-93-08X	10/15/2001	231.4	
AOC_27	27M-93-08X	10/21/2002	229.6	
AOC_27	27M-93-08X	10/28/2003	232.0	
AOC_27	27M-93-08X	11/1/2004	231.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_27	27M-93-08X	11/14/2005	234.7	
AOC_27	27M-93-08X	10/23/2006	234.3	
AOC_27	27M-93-08X	10/21/2008	234.1	
AOC_27	27M-93-08X	10/25/2010	233.3	
AOC_27	27M-93-08X	11/13/2012	231.6	
AOC_27	27M-93-08X	11/25/2014	230.6	
AOC_27	27M-93-08X	11/2/2016	225.2	
AOC_27	27M-93-08X	11/26/2018	234.1	
AOC_27	27M-93-08X	11/25/2019	232.3	
AOC_27	27M-93-08X		244.1	
AOC_30	30PZ-19-01	8/14/2019	207.0	
AOC_30	30PZ-19-01	10/7/2019	203.5	
AOC_30	30PZ-19-01	4/27/2020	209.1	
AOC_30	30PZ-19-02	8/14/2019	206.2	
AOC_30	30PZ-19-02	10/7/2019	205.1	
AOC_30	30PZ-19-02	4/27/2020	207.0	
AOC_30	30PZ-19-03	8/14/2019	203.3	
AOC_30	30PZ-19-03	10/7/2019	202.2	
AOC_30	30PZ-19-03	4/27/2020	205.1	
AOC_30	30PZ-19-04	8/14/2019	202.6	
AOC_30	30PZ-19-04	10/7/2019	201.7	
AOC_30	30PZ-19-04	4/27/2020	204.8	
AOC_30	30PZ-19-05	8/14/2019	212.7	
AOC_30	30PZ-19-05	10/7/2019	211.5	
AOC_30	30PZ-19-05	4/27/2020	214.0	
AOC_31	31PZ-19-01	8/14/2019	202.5	
AOC_31	31PZ-19-01	10/7/2019	200.7	
AOC_31	31PZ-19-01	4/27/2020	204.7	
AOC_31	31PZ-19-02D	10/7/2019	200.9	
AOC_31	31PZ-19-02D	4/27/2020	203.9	
AOC_31	31PZ-19-02S	10/7/2019	200.6	
AOC_31	31PZ-19-02S	4/27/2020	203.5	
AOC_32	32M-01-13XBR	6/5/2006	243.3	
AOC_32	32M-01-13XBR	6/7/2006	244.0	
AOC_32	32M-01-13XBR	10/17/2006	240.0	
AOC_32	32M-01-13XBR	10/19/2006	239.2	
AOC_32	32M-01-13XBR	5/22/2007	245.0	
AOC_32	32M-01-13XBR	5/23/2007	244.2	
AOC_32	32M-01-13XBR	10/15/2007	238.2	
AOC_32	32M-01-13XBR	10/16/2007	239.0	
AOC_32	32M-01-13XBR	6/25/2008	240.3	
AOC_32	32M-01-13XBR	6/26/2008	241.1	
AOC_32	32M-01-13XBR	10/28/2008	240.7	
AOC_32	32M-01-13XBR	10/29/2008	241.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32M-01-13XBR	5/8/2009	244.6	
AOC_32	32M-01-13XBR	5/11/2009	245.4	
AOC_32	32M-01-13XBR	10/26/2009	241.9	
AOC_32	32M-01-13XBR	11/9/2009	242.7	
AOC_32	32M-01-13XBR	5/18/2010	243.6	
AOC_32	32M-01-13XBR	5/20/2010	242.8	
AOC_32	32M-01-13XBR	10/7/2010	243.7	
AOC_32	32M-01-13XBR	10/19/2010	244.4	
AOC_32	32M-01-13XBR	6/30/2011	244.5	
AOC_32	32M-01-13XBR	10/13/2011	244.2	
AOC_32	32M-01-13XBR	5/15/2012	242.9	
AOC_32	32M-01-13XBR	10/22/2012	240.9	
AOC_32	32M-01-13XBR	6/11/2013	247.5	
AOC_32	32M-01-13XBR	10/23/2013	238.2	
AOC_32	32M-01-13XBR	6/17/2014	240.6	
AOC_32	32M-01-13XBR	6/28/2015	237.9	
AOC_32	32M-01-13XBR	10/8/2015	237.4	
AOC_32	32M-01-13XBR	5/17/2016	240.5	
AOC_32	32M-01-13XBR	7/7/2017	240.2	
AOC_32	32M-01-13XBR	4/9/2018	243.9	
AOC_32	32M-01-13XBR	12/5/2018	244.6	
AOC_32	32M-01-13XBR	4/8/2019	241.4	
AOC_32	32M-01-13XBR	4/29/2020	243.7	
AOC_32	32M-01-13XBR	5/14/2020	242.9	
AOC_32	32M-01-14XBR	1/30/2002	229.0	
AOC_32	32M-01-14XBR	4/11/2002	233.8	
AOC_32	32M-01-14XBR	7/10/2002	232.8	
AOC_32	32M-01-14XBR	10/1/2002	231.6	
AOC_32	32M-01-14XBR	3/27/2003	237.0	
AOC_32	32M-01-14XBR	6/19/2003	234.6	
AOC_32	32M-01-14XBR	9/23/2003	232.5	
AOC_32	32M-01-14XBR	12/1/2003	233.0	
AOC_32	32M-01-14XBR	5/25/2004	235.3	
AOC_32	32M-01-14XBR	10/7/2004	233.1	
AOC_32	32M-01-14XBR	6/13/2005	235.3	
AOC_32	32M-01-14XBR	10/3/2005	231.7	
AOC_32	32M-01-14XBR	6/5/2006	241.4	
AOC_32	32M-01-14XBR	6/7/2006	236.4	
AOC_32	32M-01-14XBR	10/17/2006	233.0	
AOC_32	32M-01-14XBR	10/19/2006	232.1	
AOC_32	32M-01-14XBR	5/22/2007	236.4	
AOC_32	32M-01-14XBR	5/23/2007	235.6	
AOC_32	32M-01-14XBR	10/15/2007	230.2	
AOC_32	32M-01-14XBR	10/16/2007	231.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32M-01-14XBR	6/25/2008	233.3	
AOC_32	32M-01-14XBR	6/26/2008	234.2	
AOC_32	32M-01-14XBR	10/28/2008	233.5	
AOC_32	32M-01-14XBR	10/29/2008	234.3	
AOC_32	32M-01-14XBR	5/8/2009	235.5	
AOC_32	32M-01-14XBR	5/11/2009	236.4	
AOC_32	32M-01-14XBR	10/26/2009	233.4	
AOC_32	32M-01-14XBR	11/9/2009	234.3	
AOC_32	32M-01-14XBR	5/18/2010	236.3	
AOC_32	32M-01-14XBR	5/20/2010	235.4	
AOC_32	32M-01-14XBR	10/7/2010	233.3	
AOC_32	32M-01-14XBR	10/19/2010	234.1	
AOC_32	32M-01-14XBR	6/30/2011	235.0	
AOC_32	32M-01-14XBR	10/13/2011	235.6	
AOC_32	32M-01-14XBR	5/15/2012	234.1	
AOC_32	32M-01-14XBR	10/22/2012	231.8	
AOC_32	32M-01-14XBR	6/11/2013	235.5	
AOC_32	32M-01-14XBR	10/23/2013	231.3	
AOC_32	32M-01-14XBR	6/17/2014	228.3	
AOC_32	32M-01-14XBR	5/17/2016	233.4	
AOC_32	32M-01-14XBR	7/7/2017	234.3	
AOC_32	32M-01-14XBR	4/9/2018	234.4	
AOC_32	32M-01-14XBR	12/5/2018	236.8	
AOC_32	32M-01-14XBR	4/8/2019	234.3	
AOC_32	32M-01-14XBR	4/29/2020	234.7	
AOC_32	32M-01-14XBR	5/14/2020	235.5	
AOC_32	32M-01-14XOB	1/30/2002	228.9	
AOC_32	32M-01-14XOB	4/11/2002	231.4	
AOC_32	32M-01-14XOB	7/10/2002	231.4	
AOC_32	32M-01-14XOB	10/1/2002	229.8	
AOC_32	32M-01-14XOB	3/27/2003	233.6	
AOC_32	32M-01-14XOB	6/19/2003	232.4	
AOC_32	32M-01-14XOB	9/23/2003	231.2	
AOC_32	32M-01-14XOB	12/1/2003	231.1	
AOC_32	32M-01-14XOB	5/25/2004	232.6	
AOC_32	32M-01-14XOB	10/7/2004	230.9	
AOC_32	32M-01-14XOB	6/13/2005	233.6	
AOC_32	32M-01-14XOB	10/3/2005	230.7	
AOC_32	32M-01-14XOB	6/5/2006	233.6	
AOC_32	32M-01-14XOB	6/7/2006	234.4	
AOC_32	32M-01-14XOB	10/17/2006	231.7	
AOC_32	32M-01-14XOB	10/19/2006	230.8	
AOC_32	32M-01-14XOB	5/22/2007	234.3	
AOC_32	32M-01-14XOB	5/23/2007	233.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32M-01-14XOB	10/15/2007	230.3	
AOC_32	32M-01-14XOB	10/16/2007	231.1	
AOC_32	32M-01-14XOB	6/25/2008	231.9	
AOC_32	32M-01-14XOB	6/26/2008	232.8	
AOC_32	32M-01-14XOB	10/28/2008	232.1	
AOC_32	32M-01-14XOB	10/29/2008	233.0	
AOC_32	32M-01-14XOB	5/8/2009	233.3	
AOC_32	32M-01-14XOB	5/11/2009	234.1	
AOC_32	32M-01-14XOB	10/26/2009	231.9	
AOC_32	32M-01-14XOB	11/9/2009	232.7	
AOC_32	32M-01-14XOB	5/18/2010	234.7	
AOC_32	32M-01-14XOB	5/20/2010	233.9	
AOC_32	32M-01-14XOB	10/7/2010	231.1	
AOC_32	32M-01-14XOB	10/19/2010	231.9	
AOC_32	32M-01-14XOB	6/30/2011	232.8	
AOC_32	32M-01-14XOB	10/13/2011	233.8	
AOC_32	32M-01-14XOB	5/15/2012	231.9	
AOC_32	32M-01-14XOB	10/22/2012	230.3	
AOC_32	32M-01-14XOB	6/11/2013	232.6	
AOC_32	32M-01-14XOB	10/23/2013	230.3	
AOC_32	32M-01-14XOB	6/17/2014	231.9	
AOC_32	32M-01-14XOB	6/28/2015	231.8	
AOC_32	32M-01-14XOB	10/8/2015	231.6	
AOC_32	32M-01-14XOB	5/17/2016	231.9	
AOC_32	32M-01-14XOB	6/24/2016	232.6	
AOC_32	32M-01-14XOB	11/15/2016	229.9	
AOC_32	32M-01-14XOB	5/22/2017	235.4	
AOC_32	32M-01-14XOB	7/7/2017	232.7	
AOC_32	32M-01-14XOB	4/9/2018	233.1	
AOC_32	32M-01-14XOB	11/1/2018	232.3	
AOC_32	32M-01-14XOB	12/5/2018	234.5	
AOC_32	32M-01-14XOB	4/8/2019	233.3	
AOC_32	32M-01-14XOB	10/22/2019	230.2	
AOC_32	32M-01-14XOB	4/29/2020	233.4	
AOC_32	32M-01-14XOB	5/14/2020	233.7	
AOC_32	32M-01-15XBR	1/30/2002	235.2	
AOC_32	32M-01-15XBR	4/11/2002	237.4	
AOC_32	32M-01-15XBR	7/10/2002	237.0	
AOC_32	32M-01-15XBR	10/1/2002	237.0	
AOC_32	32M-01-15XBR	3/27/2003	241.8	
AOC_32	32M-01-15XBR	6/19/2003	238.5	
AOC_32	32M-01-15XBR	9/23/2003	236.9	
AOC_32	32M-01-15XBR	12/1/2003	236.5	
AOC_32	32M-01-15XBR	5/25/2004	237.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32M-01-15XBR	10/7/2004	237.3	
AOC_32	32M-01-15XBR	6/13/2005	239.0	
AOC_32	32M-01-15XBR	10/3/2005	235.7	
AOC_32	32M-01-15XBR	6/5/2006	238.9	
AOC_32	32M-01-15XBR	6/7/2006	239.6	
AOC_32	32M-01-15XBR	10/17/2006	236.6	
AOC_32	32M-01-15XBR	10/19/2006	236.0	
AOC_32	32M-01-15XBR	5/22/2007	238.3	
AOC_32	32M-01-15XBR	5/23/2007	237.7	
AOC_32	32M-01-15XBR	10/15/2007	235.7	
AOC_32	32M-01-15XBR	10/16/2007	236.3	
AOC_32	32M-01-15XBR	6/25/2008	236.8	
AOC_32	32M-01-15XBR	6/26/2008	237.4	
AOC_32	32M-01-15XBR	10/28/2008	237.3	
AOC_32	32M-01-15XBR	10/29/2008	237.9	
AOC_32	32M-01-15XBR	5/8/2009	239.4	
AOC_32	32M-01-15XBR	5/11/2009	240.1	
AOC_32	32M-01-15XBR	10/26/2009	238.0	
AOC_32	32M-01-15XBR	11/9/2009	238.6	
AOC_32	32M-01-15XBR	5/18/2010	239.5	
AOC_32	32M-01-15XBR	5/20/2010	238.9	
AOC_32	32M-01-15XBR	10/7/2010	238.4	
AOC_32	32M-01-15XBR	10/19/2010	239.1	
AOC_32	32M-01-15XBR	6/30/2011	240.3	
AOC_32	32M-01-15XBR	10/13/2011	240.1	
AOC_32	32M-01-15XBR	5/15/2012	238.2	
AOC_32	32M-01-15XBR	10/22/2012	236.5	
AOC_32	32M-01-15XBR	6/11/2013	240.9	
AOC_32	32M-01-15XBR	10/23/2013	234.9	
AOC_32	32M-01-15XBR	6/17/2014	236.6	
AOC_32	32M-01-15XBR	10/8/2015	233.6	
AOC_32	32M-01-15XBR	5/17/2016	236.7	
AOC_32	32M-01-15XBR	7/7/2017	237.8	
AOC_32	32M-01-15XBR	4/9/2018	238.5	
AOC_32	32M-01-15XBR	12/5/2018	242.4	
AOC_32	32M-01-15XBR	4/8/2019	238.0	
AOC_32	32M-01-15XBR	4/29/2020	239.2	
AOC_32	32M-01-15XBR	5/14/2020	238.8	
AOC_32	32M-01-16XBR	1/30/2002	230.7	
AOC_32	32M-01-16XBR	4/11/2002	233.6	
AOC_32	32M-01-16XBR	7/10/2002	233.9	
AOC_32	32M-01-16XBR	10/1/2002	232.1	
AOC_32	32M-01-16XBR	3/27/2003	236.6	
AOC_32	32M-01-16XBR	6/19/2003	234.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32M-01-16XBR	9/23/2003	233.1	
AOC_32	32M-01-16XBR	12/1/2003	232.8	
AOC_32	32M-01-16XBR	5/25/2004	234.1	
AOC_32	32M-01-16XBR	10/7/2004	232.9	
AOC_32	32M-01-16XBR	6/13/2005	235.4	
AOC_32	32M-01-16XBR	10/3/2005	231.8	
AOC_32	32M-01-16XBR	6/5/2006	235.0	
AOC_32	32M-01-16XBR	6/7/2006	235.8	
AOC_32	32M-01-16XBR	10/17/2006	232.8	
AOC_32	32M-01-16XBR	10/19/2006	232.0	
AOC_32	32M-01-16XBR	5/22/2007	236.1	
AOC_32	32M-01-16XBR	5/23/2007	235.3	
AOC_32	32M-01-16XBR	10/15/2007	231.7	
AOC_32	32M-01-16XBR	10/16/2007	232.5	
AOC_32	32M-01-16XBR	6/25/2008	232.4	
AOC_32	32M-01-16XBR	6/26/2008	233.1	
AOC_32	32M-01-16XBR	10/28/2008	233.8	
AOC_32	32M-01-16XBR	10/29/2008	234.5	
AOC_32	32M-01-16XBR	5/8/2009	235.6	
AOC_32	32M-01-16XBR	5/11/2009	236.4	
AOC_32	32M-01-16XBR	10/26/2009	234.3	
AOC_32	32M-01-16XBR	11/9/2009	235.0	
AOC_32	32M-01-16XBR	5/18/2010	236.7	
AOC_32	32M-01-16XBR	5/20/2010	235.9	
AOC_32	32M-01-16XBR	10/7/2010	233.9	
AOC_32	32M-01-16XBR	10/19/2010	234.7	
AOC_32	32M-01-16XBR	6/30/2011	235.6	
AOC_32	32M-01-16XBR	10/13/2011	236.6	
AOC_32	32M-01-16XBR	5/15/2012	234.0	
AOC_32	32M-01-16XBR	10/22/2012	232.3	
AOC_32	32M-01-16XBR	6/11/2013	235.7	
AOC_32	32M-01-16XBR	10/23/2013	231.5	
AOC_32	32M-01-16XBR	6/17/2014	233.1	
AOC_32	32M-01-16XBR	10/8/2015	231.8	
AOC_32	32M-01-16XBR	5/17/2016	234.6	
AOC_32	32M-01-16XBR	7/7/2017	236.2	
AOC_32	32M-01-16XBR	4/9/2018	237.1	
AOC_32	32M-01-16XBR	12/5/2018	238.3	
AOC_32	32M-01-16XBR	4/8/2019	236.9	
AOC_32	32M-01-16XBR	4/29/2020	237.4	
AOC_32	32M-01-16XBR	5/14/2020	237.3	
AOC_32	32M-01-17X	1/30/2002	230.7	
AOC_32	32M-01-17X	4/11/2002	233.0	
AOC_32	32M-01-17X	7/10/2002	229.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32M-01-17X	10/1/2002	232.3	
AOC_32	32M-01-17X	3/27/2003	236.0	
AOC_32	32M-01-17X	6/19/2003	234.4	
AOC_32	32M-01-17X	9/23/2003	233.2	
AOC_32	32M-01-17X	12/1/2003	233.0	
AOC_32	32M-01-17X	5/25/2004	234.3	
AOC_32	32M-01-17X	10/7/2004	233.0	
AOC_32	32M-01-17X	6/13/2005	235.6	
AOC_32	32M-01-17X	10/3/2005	232.1	
AOC_32	32M-01-17X	6/5/2006	234.3	
AOC_32	32M-01-17X	10/19/2006	232.3	
AOC_32	32M-01-17X	5/23/2007	235.5	
AOC_32	32M-01-17X	10/15/2007	232.0	
AOC_32	32M-01-17X	6/25/2008	233.6	
AOC_32	32M-01-17X	10/28/2008	234.0	
AOC_32	32M-01-17X	5/8/2009	235.7	
AOC_32	32M-01-17X	10/26/2009	234.3	
AOC_32	32M-01-17X	5/20/2010	236.0	
AOC_32	32M-01-17X	10/7/2010	234.0	
AOC_32	32M-01-17X	6/30/2011	235.6	
AOC_32	32M-01-17X	10/13/2011	236.4	
AOC_32	32M-01-17X	5/15/2012	234.1	
AOC_32	32M-01-17X	10/22/2012	232.5	
AOC_32	32M-01-17XBR	1/30/2002	230.7	
AOC_32	32M-01-17XBR	4/11/2002	233.0	
AOC_32	32M-01-17XBR	7/10/2002	229.7	
AOC_32	32M-01-17XBR	10/1/2002	232.3	
AOC_32	32M-01-17XBR	3/27/2003	236.0	
AOC_32	32M-01-17XBR	6/19/2003	234.4	
AOC_32	32M-01-17XBR	9/23/2003	233.2	
AOC_32	32M-01-17XBR	12/1/2003	233.0	
AOC_32	32M-01-17XBR	5/25/2004	234.3	
AOC_32	32M-01-17XBR	10/7/2004	233.0	
AOC_32	32M-01-17XBR	6/13/2005	235.6	
AOC_32	32M-01-17XBR	10/3/2005	232.1	
AOC_32	32M-01-17XBR	6/5/2006	234.3	
AOC_32	32M-01-17XBR	6/7/2006	234.7	
AOC_32	32M-01-17XBR	10/17/2006	232.7	
AOC_32	32M-01-17XBR	10/19/2006	232.3	
AOC_32	32M-01-17XBR	5/22/2007	235.8	
AOC_32	32M-01-17XBR	5/23/2007	235.5	
AOC_32	32M-01-17XBR	10/15/2007	232.0	
AOC_32	32M-01-17XBR	10/16/2007	232.4	
AOC_32	32M-01-17XBR	6/25/2008	233.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32M-01-17XBR	6/26/2008	234.0	
AOC_32	32M-01-17XBR	10/28/2008	234.0	
AOC_32	32M-01-17XBR	10/29/2008	234.4	
AOC_32	32M-01-17XBR	5/8/2009	235.7	
AOC_32	32M-01-17XBR	5/11/2009	236.0	
AOC_32	32M-01-17XBR	10/26/2009	234.3	
AOC_32	32M-01-17XBR	11/9/2009	234.7	
AOC_32	32M-01-17XBR	5/18/2010	236.4	
AOC_32	32M-01-17XBR	5/20/2010	236.0	
AOC_32	32M-01-17XBR	10/7/2010	234.0	
AOC_32	32M-01-17XBR	10/19/2010	234.4	
AOC_32	32M-01-17XBR	6/30/2011	235.6	
AOC_32	32M-01-17XBR	10/13/2011	236.4	
AOC_32	32M-01-17XBR	5/15/2012	234.1	
AOC_32	32M-01-17XBR	10/22/2012	232.5	
AOC_32	32M-01-17XBR	6/11/2013	235.5	
AOC_32	32M-01-17XBR	10/23/2013	231.8	
AOC_32	32M-01-17XBR	6/17/2014	233.4	
AOC_32	32M-01-17XBR	6/28/2015	235.0	
AOC_32	32M-01-17XBR	10/8/2015	232.0	
AOC_32	32M-01-17XBR	5/17/2016	233.3	
AOC_32	32M-01-17XBR	7/7/2017	235.0	
AOC_32	32M-01-17XBR	4/9/2018	235.5	
AOC_32	32M-01-17XBR	12/5/2018	235.9	
AOC_32	32M-01-17XBR	4/8/2019	235.6	
AOC_32	32M-01-17XBR	4/29/2020	235.9	
AOC_32	32M-01-17XBR	5/14/2020	235.9	
AOC_32	32M-01-18XBR	1/30/2002	238.2	
AOC_32	32M-01-18XBR	4/11/2002	240.3	
AOC_32	32M-01-18XBR	7/10/2002	240.8	
AOC_32	32M-01-18XBR	10/1/2002	240.3	
AOC_32	32M-01-18XBR	3/27/2003	245.9	
AOC_32	32M-01-18XBR	6/19/2003	242.8	
AOC_32	32M-01-18XBR	9/23/2003	240.8	
AOC_32	32M-01-18XBR	12/1/2003	240.3	
AOC_32	32M-01-18XBR	5/25/2004	241.7	
AOC_32	32M-01-18XBR	10/7/2004	241.3	
AOC_32	32M-01-18XBR	6/13/2005	242.8	
AOC_32	32M-01-18XBR	10/3/2005	239.0	
AOC_32	32M-01-18XBR	6/5/2006	243.0	
AOC_32	32M-01-18XBR	6/7/2006	243.8	
AOC_32	32M-01-18XBR	10/17/2006	240.5	
AOC_32	32M-01-18XBR	10/19/2006	239.7	
AOC_32	32M-01-18XBR	5/22/2007	244.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32M-01-18XBR	5/23/2007	243.6	
AOC_32	32M-01-18XBR	10/15/2007	238.6	
AOC_32	32M-01-18XBR	10/16/2007	239.4	
AOC_32	32M-01-18XBR	6/25/2008	239.8	
AOC_32	32M-01-18XBR	6/26/2008	240.6	
AOC_32	32M-01-18XBR	10/28/2008	241.0	
AOC_32	32M-01-18XBR	10/29/2008	241.9	
AOC_32	32M-01-18XBR	5/8/2009	243.9	
AOC_32	32M-01-18XBR	5/11/2009	244.7	
AOC_32	32M-01-18XBR	10/26/2009	242.1	
AOC_32	32M-01-18XBR	11/9/2009	242.9	
AOC_32	32M-01-18XBR	5/18/2010	243.9	
AOC_32	32M-01-18XBR	5/20/2010	243.1	
AOC_32	32M-01-18XBR	10/7/2010	242.5	
AOC_32	32M-01-18XBR	10/19/2010	243.3	
AOC_32	32M-01-18XBR	6/30/2011	244.1	
AOC_32	32M-01-18XBR	10/13/2011	244.2	
AOC_32	32M-01-18XBR	5/15/2012	242.6	
AOC_32	32M-01-18XBR	10/22/2012	240.8	
AOC_32	32M-01-18XBR	6/11/2013	247.3	
AOC_32	32M-01-18XBR	10/23/2013	239.0	
AOC_32	32M-01-18XBR	6/17/2014	241.5	
AOC_32	32M-01-18XBR	6/28/2015	239.8	
AOC_32	32M-01-18XBR	10/8/2015	238.6	
AOC_32	32M-01-18XBR	5/17/2016	241.4	
AOC_32	32M-01-18XBR	7/7/2017	242.1	
AOC_32	32M-01-18XBR	4/9/2018	243.0	
AOC_32	32M-01-18XBR	12/5/2018	243.8	
AOC_32	32M-01-18XBR	4/8/2019	241.9	
AOC_32	32M-01-18XBR	4/29/2020	243.5	
AOC_32	32M-01-18XBR	5/14/2020	243.2	
AOC_32	32M-92-01X	3/30/1993	243.5	
AOC_32	32M-92-01X	6/22/1993	242.4	
AOC_32	32M-92-01X	11/8/1993	241.4	
AOC_32	32M-92-01X	6/28/1994	242.7	
AOC_32	32M-92-01X	10/4/1994	241.9	
AOC_32	32M-92-01X	1/31/1995	244.2	
AOC_32	32M-92-01X	5/9/1995	242.4	
AOC_32	32M-92-01X	12/7/1995	243.4	
AOC_32	32M-92-01X	1/15/1997	244.3	
AOC_32	32M-92-01X	4/23/1998	244.2	
AOC_32	32M-92-01X	6/26/1998	244.6	
AOC_32	32M-92-01X	7/1/1998	244.4	
AOC_32	32M-92-01X	7/17/1998	243.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32M-92-01X	7/31/1998	242.6	
AOC_32	32M-92-01X	8/28/1998	241.4	
AOC_32	32M-92-01X	10/14/1998	241.7	
AOC_32	32M-92-01X	12/10/1998	240.7	
AOC_32	32M-92-01X	1/6/1999	243.0	
AOC_32	32M-92-01X	2/23/1999	243.2	
AOC_32	32M-92-01X	6/6/1999	241.8	
AOC_32	32M-92-01X	9/8/1999	239.8	
AOC_32	32M-92-01X	1/30/2002	239.5	
AOC_32	32M-92-01X	4/11/2002	243.2	
AOC_32	32M-92-01X	7/10/2002	242.6	
AOC_32	32M-92-01X	10/1/2002	240.6	
AOC_32	32M-92-01X	3/27/2003	245.1	
AOC_32	32M-92-01X	6/19/2003	243.4	
AOC_32	32M-92-01X	9/23/2003	241.1	
AOC_32	32M-92-01X	12/1/2003	241.3	
AOC_32	32M-92-01X	5/25/2004	243.7	
AOC_32	32M-92-01X	10/7/2004	242.1	
AOC_32	32M-92-01X	6/13/2005	243.9	
AOC_32	32M-92-01X	10/3/2005	240.3	
AOC_32	32M-92-01X	6/5/2006	244.8	
AOC_32	32M-92-01X	6/7/2006	245.5	
AOC_32	32M-92-01X	10/17/2006	241.3	
AOC_32	32M-92-01X	10/19/2006	240.6	
AOC_32	32M-92-01X	5/22/2007	245.2	
AOC_32	32M-92-01X	5/23/2007	244.4	
AOC_32	32M-92-01X	10/15/2007	239.7	
AOC_32	32M-92-01X	10/16/2007	240.5	
AOC_32	32M-92-01X	6/25/2008	242.1	
AOC_32	32M-92-01X	6/26/2008	242.9	
AOC_32	32M-92-01X	10/28/2008	241.7	
AOC_32	32M-92-01X	10/29/2008	242.4	
AOC_32	32M-92-01X	5/8/2009	243.7	
AOC_32	32M-92-01X	5/11/2009	244.5	
AOC_32	32M-92-01X	10/26/2009	238.2	
AOC_32	32M-92-01X	11/9/2009	238.9	
AOC_32	32M-92-01X	5/18/2010	244.0	
AOC_32	32M-92-01X	5/20/2010	243.3	
AOC_32	32M-92-01X	10/7/2010	240.3	
AOC_32	32M-92-01X	10/19/2010	241.0	
AOC_32	32M-92-01X	6/30/2011	242.7	
AOC_32	32M-92-01X	10/13/2011	243.0	
AOC_32	32M-92-01X	5/15/2012	242.2	
AOC_32	32M-92-01X	10/22/2012	239.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32M-92-01X	6/11/2013	243.0	
AOC_32	32M-92-01X	10/23/2013	240.0	
AOC_32	32M-92-01X	6/17/2014	242.8	
AOC_32	32M-92-01X	10/8/2015	239.8	
AOC_32	32M-92-01X	5/17/2016	242.8	
AOC_32	32M-92-01X	6/24/2016	241.7	
AOC_32	32M-92-01X	11/15/2016	239.8	
AOC_32	32M-92-01X	5/22/2017	244.1	
AOC_32	32M-92-01X	7/7/2017	243.1	
AOC_32	32M-92-01X	4/9/2018	244.3	
AOC_32	32M-92-01X	11/1/2018	242.5	
AOC_32	32M-92-01X	12/5/2018	245.5	
AOC_32	32M-92-01X	4/8/2019	243.1	
AOC_32	32M-92-01X	10/22/2019	248.8	
AOC_32	32M-92-01X	4/29/2020	244.5	
AOC_32	32M-92-01X	5/14/2020	244.3	
AOC_32	32M-92-03X	3/30/1993	235.0	
AOC_32	32M-92-03X	11/8/1993	229.6	
AOC_32	32M-92-03X	6/28/1994	232.7	
AOC_32	32M-92-03X	10/4/1994	231.3	
AOC_32	32M-92-03X	1/31/1995	232.3	
AOC_32	32M-92-03X	5/9/1995	231.4	
AOC_32	32M-92-03X	12/7/1995	231.2	
AOC_32	32M-92-03X	1/15/1997	235.4	
AOC_32	32M-92-03X	6/2/1997	234.3	
AOC_32	32M-92-03X	4/23/1998	234.2	
AOC_32	32M-92-03X	10/14/1998	231.7	
AOC_32	32M-92-03X	12/10/1998	230.1	
AOC_32	32M-92-03X	6/6/1999	230.3	
AOC_32	32M-92-03X	9/8/1999	228.4	
AOC_32	32M-92-03X	4/11/2002	230.8	
AOC_32	32M-92-03X	7/10/2002	230.7	
AOC_32	32M-92-03X	10/1/2002	230.1	
AOC_32	32M-92-03X	3/27/2003	233.1	
AOC_32	32M-92-03X	6/19/2003	233.5	
AOC_32	32M-92-03X	9/23/2003	232.1	
AOC_32	32M-92-03X	12/1/2003	231.5	
AOC_32	32M-92-03X	5/25/2004	232.9	
AOC_32	32M-92-03X	10/7/2004	231.8	
AOC_32	32M-92-03X	6/13/2005	234.4	
AOC_32	32M-92-03X	10/3/2005	231.0	
AOC_32	32M-92-03X	6/5/2006	235.0	
AOC_32	32M-92-03X	6/7/2006	236.0	
AOC_32	32M-92-03X	10/17/2006	232.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32M-92-03X	10/19/2006	231.8	
AOC_32	32M-92-03X	5/22/2007	235.9	
AOC_32	32M-92-03X	5/23/2007	235.0	
AOC_32	32M-92-03X	10/15/2007	230.6	
AOC_32	32M-92-03X	10/16/2007	231.6	
AOC_32	32M-92-03X	6/25/2008	233.1	
AOC_32	32M-92-03X	6/26/2008	234.1	
AOC_32	32M-92-03X	10/28/2008	233.0	
AOC_32	32M-92-03X	10/29/2008	233.9	
AOC_32	32M-92-03X	5/8/2009	234.1	
AOC_32	32M-92-03X	5/11/2009	235.1	
AOC_32	32M-92-03X	10/26/2009	228.7	
AOC_32	32M-92-03X	11/9/2009	229.7	
AOC_32	32M-92-03X	5/18/2010	235.7	
AOC_32	32M-92-03X	5/20/2010	234.7	
AOC_32	32M-92-03X	10/7/2010	231.4	
AOC_32	32M-92-03X	10/19/2010	232.4	
AOC_32	32M-92-03X	6/30/2011	233.2	
AOC_32	32M-92-03X	10/13/2011	233.5	
AOC_32	32M-92-03X	5/15/2012	232.2	
AOC_32	32M-92-03X	6/11/2013	234.7	
AOC_32	32M-92-03X	10/23/2013	230.2	
AOC_32	32M-92-03X	6/17/2014	231.7	
AOC_32	32M-92-03X	10/8/2015	230.3	
AOC_32	32M-92-03X	5/17/2016	231.1	
AOC_32	32M-92-03X	7/7/2017	241.0	
AOC_32	32M-92-03X	4/9/2018	233.2	
AOC_32	32M-92-03X	12/5/2018	236.2	
AOC_32	32M-92-03X	4/8/2019	233.4	
AOC_32	32M-92-03X	4/29/2020	234.1	
AOC_32	32M-92-03X	5/14/2020	233.9	
AOC_32	32M-92-07X	3/30/1993		-12.9
AOC_32	32M-92-07X	6/22/1993		-14.7
AOC_32	32M-92-07X	11/8/1993		-15.5
AOC_32	32M-92-07X	6/28/1994		-14.5
AOC_32	32M-92-07X	10/4/1994		-15.4
AOC_32	32M-92-07X	1/31/1995		-13.2
AOC_32	32M-92-07X	5/9/1995		-14.2
AOC_32	32M-92-07X	12/7/1995		-13.9
AOC_32	32M-92-07X	3/26/1996		-13.0
AOC_32	32M-92-07X	1/15/1997		-13.7
AOC_32	32M-92-07X	6/26/1998		-13.2
AOC_32	32M-92-07X	7/1/1998		-13.4
AOC_32	32M-92-07X	7/17/1998		-14.2

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32M-92-07X	7/31/1998		-14.8
AOC_32	32M-92-07X	8/28/1998		-15.9
AOC_32	32M-92-07X	10/14/1998		-16.3
AOC_32	32M-92-07X	12/10/1998		-16.6
AOC_32	32M-92-07X	2/23/1999		-13.5
AOC_32	32M-92-07X	6/6/1999		-14.8
AOC_32	32M-92-07X	9/8/1999		-17.7
AOC_32	32PZ-19-01	4/29/2020	227.2	
AOC_32	32PZ-19-02	4/29/2020	228.0	
AOC_32	32Z-01-05X	1/30/2002		
AOC_32	32Z-01-05X	4/11/2002		
AOC_32	32Z-01-05X	7/10/2002		
AOC_32	32Z-01-05X	10/1/2002		
AOC_32	32Z-01-05X	3/27/2003		
AOC_32	32Z-01-05X	6/19/2003		
AOC_32	32Z-01-05X	9/23/2003		
AOC_32	32Z-01-05X	12/1/2003		
AOC_32	32Z-01-05X	10/7/2004		
AOC_32	32Z-01-05X	6/13/2005		
AOC_32	32Z-01-05X	10/3/2005		
AOC_32	32Z-01-05X	6/5/2006		
AOC_32	32Z-01-05X	10/19/2006		
AOC_32	32Z-01-05X	5/23/2007		
AOC_32	32Z-01-05X	10/15/2007		
AOC_32	32Z-01-05X	6/25/2008		
AOC_32	32Z-01-05X	10/28/2008		
AOC_32	32Z-01-05X	5/8/2009		
AOC_32	32Z-01-05X	10/26/2009		
AOC_32	32Z-01-05X	5/20/2010		
AOC_32	32Z-01-05X	10/7/2010		
AOC_32	32Z-01-05X	10/13/2011		
AOC_32	32Z-01-05X	5/15/2012		
AOC_32	32Z-01-05X	10/22/2012		
AOC_32	32Z-01-05XOB	1/30/2002	230.6	
AOC_32	32Z-01-05XOB	4/11/2002	227.9	
AOC_32	32Z-01-05XOB	7/10/2002	229.8	
AOC_32	32Z-01-05XOB	10/1/2002	229.4	
AOC_32	32Z-01-05XOB	3/27/2003	231.4	
AOC_32	32Z-01-05XOB	6/19/2003	232.6	
AOC_32	32Z-01-05XOB	9/23/2003	232.2	
AOC_32	32Z-01-05XOB	12/1/2003	231.5	
AOC_32	32Z-01-05XOB	10/7/2004	231.2	
AOC_32	32Z-01-05XOB	6/13/2005	233.8	
AOC_32	32Z-01-05XOB	10/3/2005	231.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32Z-01-05XOB	6/5/2006	233.8	
AOC_32	32Z-01-05XOB	6/7/2006	234.6	
AOC_32	32Z-01-05XOB	10/17/2006	232.4	
AOC_32	32Z-01-05XOB	10/19/2006	231.6	
AOC_32	32Z-01-05XOB	5/22/2007	234.3	
AOC_32	32Z-01-05XOB	5/23/2007	233.5	
AOC_32	32Z-01-05XOB	10/15/2007	230.3	
AOC_32	32Z-01-05XOB	10/16/2007	231.1	
AOC_32	32Z-01-05XOB	6/25/2008	232.7	
AOC_32	32Z-01-05XOB	6/26/2008	233.5	
AOC_32	32Z-01-05XOB	10/28/2008	232.7	
AOC_32	32Z-01-05XOB	10/29/2008	233.5	
AOC_32	32Z-01-05XOB	5/8/2009	233.0	
AOC_32	32Z-01-05XOB	5/11/2009	233.8	
AOC_32	32Z-01-05XOB	10/26/2009	231.2	
AOC_32	32Z-01-05XOB	11/9/2009	232.0	
AOC_32	32Z-01-05XOB	5/18/2010	235.3	
AOC_32	32Z-01-05XOB	5/20/2010	234.5	
AOC_32	32Z-01-05XOB	10/7/2010	230.5	
AOC_32	32Z-01-05XOB	10/19/2010	231.3	
AOC_32	32Z-01-05XOB	6/30/2011	232.4	
AOC_32	32Z-01-05XOB	10/13/2011	233.0	
AOC_32	32Z-01-05XOB	5/15/2012	231.2	
AOC_32	32Z-01-05XOB	10/17/2012	229.5	
AOC_32	32Z-01-05XOB	10/22/2012	229.5	
AOC_32	32Z-01-05XOB	6/11/2013	231.4	
AOC_32	32Z-01-05XOB	10/23/2013	230.0	
AOC_32	32Z-01-05XOB	6/17/2014	230.9	
AOC_32	32Z-01-05XOB	10/8/2015	229.5	
AOC_32	32Z-01-05XOB	5/17/2016	229.9	
AOC_32	32Z-01-05XOB	7/7/2017	241.5	
AOC_32	32Z-01-05XOB	4/9/2018	231.5	
AOC_32	32Z-01-05XOB	12/5/2018	235.0	
AOC_32	32Z-01-05XOB	4/8/2019	233.0	
AOC_32	32Z-01-05XOB	4/29/2020	232.7	
AOC_32	32Z-01-05XOB	5/14/2020	232.8	
AOC_32	32Z-01-06X	1/30/2002		
AOC_32	32Z-01-06X	4/11/2002		
AOC_32	32Z-01-06X	7/10/2002		
AOC_32	32Z-01-06X	10/1/2002		
AOC_32	32Z-01-06X	3/27/2003		
AOC_32	32Z-01-06X	6/19/2003		
AOC_32	32Z-01-06X	9/23/2003		
AOC_32	32Z-01-06X	12/1/2003		

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32Z-01-06X	10/7/2004		
AOC_32	32Z-01-06X	6/13/2005		
AOC_32	32Z-01-06X	10/3/2005		
AOC_32	32Z-01-06X	6/5/2006		
AOC_32	32Z-01-06X	10/19/2006		
AOC_32	32Z-01-06X	5/23/2007		
AOC_32	32Z-01-06X	10/15/2007		
AOC_32	32Z-01-06X	6/25/2008		
AOC_32	32Z-01-06X	10/28/2008		
AOC_32	32Z-01-06X	5/8/2009		
AOC_32	32Z-01-06X	10/26/2009		
AOC_32	32Z-01-06X	5/20/2010		
AOC_32	32Z-01-06X	10/7/2010		
AOC_32	32Z-01-06X	6/30/2011		
AOC_32	32Z-01-06X	10/13/2011		
AOC_32	32Z-01-06X	5/15/2012		
AOC_32	32Z-01-06X	10/22/2012		
AOC_32	32Z-01-06XBR	1/30/2002	240.8	
AOC_32	32Z-01-06XBR	4/11/2002	244.8	
AOC_32	32Z-01-06XBR	7/10/2002	243.3	
AOC_32	32Z-01-06XBR	10/1/2002	239.7	
AOC_32	32Z-01-06XBR	3/27/2003	248.8	
AOC_32	32Z-01-06XBR	6/19/2003	245.1	
AOC_32	32Z-01-06XBR	9/23/2003	240.1	
AOC_32	32Z-01-06XBR	12/1/2003	242.5	
AOC_32	32Z-01-06XBR	10/7/2004	243.3	
AOC_32	32Z-01-06XBR	6/13/2005	235.1	
AOC_32	32Z-01-06XBR	10/3/2005	237.6	
AOC_32	32Z-01-06XBR	6/5/2006	247.3	
AOC_32	32Z-01-06XBR	6/7/2006	248.2	
AOC_32	32Z-01-06XBR	10/17/2006	241.5	
AOC_32	32Z-01-06XBR	10/19/2006	240.7	
AOC_32	32Z-01-06XBR	5/22/2007	248.2	
AOC_32	32Z-01-06XBR	5/23/2007	247.4	
AOC_32	32Z-01-06XBR	10/15/2007	237.9	
AOC_32	32Z-01-06XBR	10/16/2007	238.7	
AOC_32	32Z-01-06XBR	6/25/2008	242.8	
AOC_32	32Z-01-06XBR	6/26/2008	243.7	
AOC_32	32Z-01-06XBR	10/28/2008	243.3	
AOC_32	32Z-01-06XBR	10/29/2008	244.2	
AOC_32	32Z-01-06XBR	5/8/2009	247.1	
AOC_32	32Z-01-06XBR	5/11/2009	248.0	
AOC_32	32Z-01-06XBR	10/26/2009	242.8	
AOC_32	32Z-01-06XBR	11/9/2009	243.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32Z-01-06XBR	5/18/2010	245.6	
AOC_32	32Z-01-06XBR	5/20/2010	244.8	
AOC_32	32Z-01-06XBR	10/7/2010	242.9	
AOC_32	32Z-01-06XBR	10/19/2010	243.8	
AOC_32	32Z-01-06XBR	6/30/2011	244.5	
AOC_32	32Z-01-06XBR	10/13/2011	246.8	
AOC_32	32Z-01-06XBR	5/15/2012	245.0	
AOC_32	32Z-01-06XBR	10/22/2012	240.2	
AOC_32	32Z-01-06XBR	6/11/2013	246.1	
AOC_32	32Z-01-06XBR	10/23/2013	239.1	
AOC_32	32Z-01-06XBR	6/17/2014	243.4	
AOC_32	32Z-01-06XBR	10/8/2015	238.4	
AOC_32	32Z-01-06XBR	5/17/2016	244.1	
AOC_32	32Z-01-06XBR	7/7/2017	244.4	
AOC_32	32Z-01-06XBR	12/5/2018	249.0	
AOC_32	32Z-01-06XBR	4/8/2019	245.1	
AOC_32	32Z-01-06XBR	4/29/2020	248.2	
AOC_32	32Z-01-06XBR	5/14/2020	247.5	
AOC_32	32Z-01-07X	1/30/2002		
AOC_32	32Z-01-07X	4/11/2002		
AOC_32	32Z-01-07X	7/10/2002		
AOC_32	32Z-01-07X	10/1/2002		
AOC_32	32Z-01-07X	3/27/2003		
AOC_32	32Z-01-07X	6/19/2003		
AOC_32	32Z-01-07X	9/23/2003		
AOC_32	32Z-01-07X	12/1/2003		
AOC_32	32Z-01-07X	10/7/2004		
AOC_32	32Z-01-07X	6/13/2005		
AOC_32	32Z-01-07X	10/3/2005		
AOC_32	32Z-01-07X	6/5/2006		
AOC_32	32Z-01-07X	10/19/2006		
AOC_32	32Z-01-07X	5/23/2007		
AOC_32	32Z-01-07X	10/15/2007		
AOC_32	32Z-01-07X	6/25/2008		
AOC_32	32Z-01-07X	10/28/2008		
AOC_32	32Z-01-07X	5/8/2009		
AOC_32	32Z-01-07X	10/26/2009		
AOC_32	32Z-01-07X	5/20/2010		
AOC_32	32Z-01-07X	10/7/2010		
AOC_32	32Z-01-07X	6/30/2011		
AOC_32	32Z-01-07X	10/13/2011		
AOC_32	32Z-01-07X	5/15/2012		
AOC_32	32Z-01-07X	10/22/2012		
AOC_32	32Z-01-07XOB	1/30/2002	240.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32Z-01-07XOB	4/11/2002	243.7	
AOC_32	32Z-01-07XOB	7/10/2002	243.2	
AOC_32	32Z-01-07XOB	10/1/2002	240.7	
AOC_32	32Z-01-07XOB	3/27/2003	246.5	
AOC_32	32Z-01-07XOB	6/19/2003	244.2	
AOC_32	32Z-01-07XOB	9/23/2003	241.6	
AOC_32	32Z-01-07XOB	12/1/2003	242.1	
AOC_32	32Z-01-07XOB	10/7/2004	242.8	
AOC_32	32Z-01-07XOB	6/13/2005	244.5	
AOC_32	32Z-01-07XOB	10/3/2005	240.5	
AOC_32	32Z-01-07XOB	6/5/2006	245.9	
AOC_32	32Z-01-07XOB	6/7/2006	246.7	
AOC_32	32Z-01-07XOB	10/17/2006	242.4	
AOC_32	32Z-01-07XOB	10/19/2006	241.6	
AOC_32	32Z-01-07XOB	5/22/2007	246.7	
AOC_32	32Z-01-07XOB	5/23/2007	245.9	
AOC_32	32Z-01-07XOB	10/15/2007	239.8	
AOC_32	32Z-01-07XOB	10/16/2007	240.7	
AOC_32	32Z-01-07XOB	6/25/2008	242.5	
AOC_32	32Z-01-07XOB	6/26/2008	243.3	
AOC_32	32Z-01-07XOB	10/28/2008	242.9	
AOC_32	32Z-01-07XOB	10/29/2008	243.7	
AOC_32	32Z-01-07XOB	5/8/2009	244.4	
AOC_32	32Z-01-07XOB	5/11/2009	245.2	
AOC_32	32Z-01-07XOB	10/26/2009	237.5	
AOC_32	32Z-01-07XOB	11/9/2009	238.3	
AOC_32	32Z-01-07XOB	5/18/2010	244.8	
AOC_32	32Z-01-07XOB	5/20/2010	244.0	
AOC_32	32Z-01-07XOB	10/7/2010	242.1	
AOC_32	32Z-01-07XOB	10/19/2010	242.9	
AOC_32	32Z-01-07XOB	6/30/2011	243.7	
AOC_32	32Z-01-07XOB	10/13/2011	245.0	
AOC_32	32Z-01-07XOB	5/15/2012	243.7	
AOC_32	32Z-01-07XOB	10/22/2012	240.5	
AOC_32	32Z-01-07XOB	6/11/2013	245.2	
AOC_32	32Z-01-07XOB	10/23/2013	240.3	
AOC_32	32Z-01-07XOB	6/17/2014	243.4	
AOC_32	32Z-01-07XOB	10/8/2015	240.0	
AOC_32	32Z-01-07XOB	5/17/2016	243.6	
AOC_32	32Z-01-07XOB	6/24/2016	242.2	
AOC_32	32Z-01-07XOB	11/15/2016	240.9	
AOC_32	32Z-01-07XOB	5/22/2017	245.5	
AOC_32	32Z-01-07XOB	7/7/2017	241.9	
AOC_32	32Z-01-07XOB	4/9/2018	246.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32Z-01-07XOB	11/1/2018	244.2	
AOC_32	32Z-01-07XOB	12/5/2018	247.2	
AOC_32	32Z-01-07XOB	4/8/2019	244.4	
AOC_32	32Z-01-07XOB	10/22/2019	240.1	
AOC_32	32Z-01-07XOB	4/29/2020	246.4	
AOC_32	32Z-01-07XOB	5/14/2020	245.8	
AOC_32	32Z-01-08X	1/30/2002	239.1	
AOC_32	32Z-01-08X	4/11/2002	243.5	
AOC_32	32Z-01-08X	7/10/2002	242.1	
AOC_32	32Z-01-08X	10/1/2002	240.5	
AOC_32	32Z-01-08X	3/27/2003	244.2	
AOC_32	32Z-01-08X	6/19/2003	242.9	
AOC_32	32Z-01-08X	9/23/2003	240.9	
AOC_32	32Z-01-08X	12/1/2003	241.1	
AOC_32	32Z-01-08X	10/7/2004	241.7	
AOC_32	32Z-01-08X	6/13/2005	242.7	
AOC_32	32Z-01-08X	10/3/2005	240.2	
AOC_32	32Z-01-08X	6/5/2006	244.2	
AOC_32	32Z-01-08X	10/19/2006	240.5	
AOC_32	32Z-01-08X	5/23/2007	244.0	
AOC_32	32Z-01-08X	10/15/2007	239.7	
AOC_32	32Z-01-08X	6/25/2008	241.9	
AOC_32	32Z-01-08X	10/28/2008	241.4	
AOC_32	32Z-01-08X	5/8/2009	237.9	
AOC_32	32Z-01-08X	10/26/2009	237.5	
AOC_32	32Z-01-08X	5/20/2010	242.3	
AOC_32	32Z-01-08X	10/7/2010	240.1	
AOC_32	32Z-01-08X	10/13/2011	242.6	
AOC_32	32Z-01-08X	5/15/2012	241.9	
AOC_32	32Z-01-08X	10/22/2012	239.8	
AOC_32	32Z-01-08XOB	1/30/2002	239.1	
AOC_32	32Z-01-08XOB	4/11/2002	243.5	
AOC_32	32Z-01-08XOB	7/10/2002	242.1	
AOC_32	32Z-01-08XOB	10/1/2002	240.5	
AOC_32	32Z-01-08XOB	3/27/2003	244.2	
AOC_32	32Z-01-08XOB	6/19/2003	242.9	
AOC_32	32Z-01-08XOB	9/23/2003	240.9	
AOC_32	32Z-01-08XOB	12/1/2003	241.1	
AOC_32	32Z-01-08XOB	10/7/2004	241.7	
AOC_32	32Z-01-08XOB	6/13/2005	242.7	
AOC_32	32Z-01-08XOB	10/3/2005	240.2	
AOC_32	32Z-01-08XOB	6/5/2006	244.2	
AOC_32	32Z-01-08XOB	6/7/2006	245.1	
AOC_32	32Z-01-08XOB	10/17/2006	241.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32Z-01-08XOB	10/19/2006	240.5	
AOC_32	32Z-01-08XOB	5/22/2007	244.8	
AOC_32	32Z-01-08XOB	5/23/2007	244.0	
AOC_32	32Z-01-08XOB	10/15/2007	239.7	
AOC_32	32Z-01-08XOB	10/16/2007	240.5	
AOC_32	32Z-01-08XOB	6/25/2008	241.9	
AOC_32	32Z-01-08XOB	6/26/2008	242.7	
AOC_32	32Z-01-08XOB	10/28/2008	241.4	
AOC_32	32Z-01-08XOB	10/29/2008	242.3	
AOC_32	32Z-01-08XOB	5/8/2009	237.9	
AOC_32	32Z-01-08XOB	5/11/2009	238.7	
AOC_32	32Z-01-08XOB	10/26/2009	237.5	
AOC_32	32Z-01-08XOB	11/9/2009	238.4	
AOC_32	32Z-01-08XOB	5/18/2010	243.1	
AOC_32	32Z-01-08XOB	5/20/2010	242.3	
AOC_32	32Z-01-08XOB	10/7/2010	240.1	
AOC_32	32Z-01-08XOB	10/19/2010	241.0	
AOC_32	32Z-01-08XOB	6/30/2011	242.4	
AOC_32	32Z-01-08XOB	10/13/2011	242.6	
AOC_32	32Z-01-08XOB	5/15/2012	241.9	
AOC_32	32Z-01-08XOB	10/22/2012	239.8	
AOC_32	32Z-01-08XOB	6/11/2013	242.5	
AOC_32	32Z-01-08XOB	10/23/2013	239.9	
AOC_32	32Z-01-08XOB	6/17/2014	242.6	
AOC_32	32Z-01-08XOB	10/8/2015	239.8	
AOC_32	32Z-01-08XOB	5/17/2016	242.6	
AOC_32	32Z-01-08XOB	7/7/2017	242.7	
AOC_32	32Z-01-08XOB	4/9/2018	243.8	
AOC_32	32Z-01-08XOB	12/5/2018	245.0	
AOC_32	32Z-01-08XOB	4/8/2019	242.8	
AOC_32	32Z-01-08XOB	4/29/2020	244.0	
AOC_32	32Z-01-08XOB	5/14/2020	243.9	
AOC_32	32Z-01-09X	1/30/2002		
AOC_32	32Z-01-09X	4/11/2002		
AOC_32	32Z-01-09X	7/10/2002		
AOC_32	32Z-01-09X	10/1/2002		
AOC_32	32Z-01-09X	3/27/2003		
AOC_32	32Z-01-09X	6/19/2003		
AOC_32	32Z-01-09X	9/23/2003		
AOC_32	32Z-01-09X	12/1/2003		
AOC_32	32Z-01-09X	10/7/2004		
AOC_32	32Z-01-09X	6/13/2005		
AOC_32	32Z-01-09X	10/3/2005		
AOC_32	32Z-01-09X	6/5/2006		

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32Z-01-09X	10/19/2006		
AOC_32	32Z-01-09X	5/23/2007		
AOC_32	32Z-01-09X	10/15/2007		
AOC_32	32Z-01-09X	6/25/2008		
AOC_32	32Z-01-09X	10/28/2008		
AOC_32	32Z-01-09X	5/8/2009		
AOC_32	32Z-01-09X	10/26/2009		
AOC_32	32Z-01-09X	5/20/2010		
AOC_32	32Z-01-09X	10/7/2010		
AOC_32	32Z-01-09X	10/13/2011		
AOC_32	32Z-01-09X	5/15/2012		
AOC_32	32Z-01-09X	10/22/2012		
AOC_32	32Z-01-09XOB	1/30/2002	227.2	
AOC_32	32Z-01-09XOB	4/11/2002	227.8	
AOC_32	32Z-01-09XOB	7/10/2002	229.7	
AOC_32	32Z-01-09XOB	10/1/2002	229.2	
AOC_32	32Z-01-09XOB	3/27/2003	231.3	
AOC_32	32Z-01-09XOB	6/19/2003	232.4	
AOC_32	32Z-01-09XOB	9/23/2003	231.9	
AOC_32	32Z-01-09XOB	12/1/2003	231.3	
AOC_32	32Z-01-09XOB	10/7/2004	230.9	
AOC_32	32Z-01-09XOB	6/13/2005	231.1	
AOC_32	32Z-01-09XOB	10/3/2005	230.7	
AOC_32	32Z-01-09XOB	6/5/2006	233.7	
AOC_32	32Z-01-09XOB	6/7/2006	234.5	
AOC_32	32Z-01-09XOB	10/17/2006	232.0	
AOC_32	32Z-01-09XOB	10/19/2006	231.2	
AOC_32	32Z-01-09XOB	5/22/2007	234.1	
AOC_32	32Z-01-09XOB	5/23/2007	233.3	
AOC_32	32Z-01-09XOB	10/15/2007	229.9	
AOC_32	32Z-01-09XOB	10/16/2007	230.7	
AOC_32	32Z-01-09XOB	6/25/2008	233.3	
AOC_32	32Z-01-09XOB	6/26/2008	233.2	
AOC_32	32Z-01-09XOB	10/28/2008	232.4	
AOC_32	32Z-01-09XOB	10/29/2008	233.2	
AOC_32	32Z-01-09XOB	5/8/2009	232.8	
AOC_32	32Z-01-09XOB	5/11/2009	233.6	
AOC_32	32Z-01-09XOB	10/26/2009	230.8	
AOC_32	32Z-01-09XOB	11/9/2009	231.6	
AOC_32	32Z-01-09XOB	5/18/2010	235.0	
AOC_32	32Z-01-09XOB	5/20/2010	234.2	
AOC_32	32Z-01-09XOB	10/7/2010	230.2	
AOC_32	32Z-01-09XOB	10/19/2010	231.0	
AOC_32	32Z-01-09XOB	6/30/2011	232.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32Z-01-09XOB	10/13/2011	232.7	
AOC_32	32Z-01-09XOB	5/15/2012	230.9	
AOC_32	32Z-01-09XOB	10/22/2012	229.2	
AOC_32	32Z-01-09XOB	10/23/2013	229.6	
AOC_32	32Z-01-09XOB	6/17/2014	230.7	
AOC_32	32Z-01-09XOB	10/8/2015	229.2	
AOC_32	32Z-01-09XOB	5/17/2016	229.8	
AOC_32	32Z-01-09XOB	7/7/2017	232.2	
AOC_32	32Z-01-09XOB	4/9/2018	231.3	
AOC_32	32Z-01-09XOB	12/5/2018	232.6	
AOC_32	32Z-01-09XOB	4/8/2019	232.7	
AOC_32	32Z-01-09XOB	4/29/2020	232.5	
AOC_32	32Z-01-09XOB	5/14/2020	232.6	
AOC_32	32Z-01-10X	1/30/2002		
AOC_32	32Z-01-10X	4/11/2002		
AOC_32	32Z-01-10X	7/10/2002		
AOC_32	32Z-01-10X	10/1/2002		
AOC_32	32Z-01-10X	3/27/2003		
AOC_32	32Z-01-10X	6/19/2003		
AOC_32	32Z-01-10X	9/23/2003		
AOC_32	32Z-01-10X	12/1/2003		
AOC_32	32Z-01-10X	10/7/2004		
AOC_32	32Z-01-10X	6/13/2005		
AOC_32	32Z-01-10X	10/3/2005		
AOC_32	32Z-01-10X	6/5/2006		
AOC_32	32Z-01-10X	10/19/2006		
AOC_32	32Z-01-10X	5/23/2007		
AOC_32	32Z-01-10X	10/15/2007		
AOC_32	32Z-01-10X	6/25/2008		
AOC_32	32Z-01-10X	10/28/2008		
AOC_32	32Z-01-10X	5/8/2009		
AOC_32	32Z-01-10X	10/26/2009		
AOC_32	32Z-01-10X	5/20/2010		
AOC_32	32Z-01-10X	10/7/2010		
AOC_32	32Z-01-10X	6/30/2011		
AOC_32	32Z-01-10X	10/13/2011		
AOC_32	32Z-01-10X	5/15/2012		
AOC_32	32Z-01-10X	10/22/2012		
AOC_32	32Z-01-10XBR	1/30/2002	239.5	
AOC_32	32Z-01-10XBR	4/11/2002	242.1	
AOC_32	32Z-01-10XBR	7/10/2002	240.5	
AOC_32	32Z-01-10XBR	10/1/2002	241.3	
AOC_32	32Z-01-10XBR	3/27/2003	245.3	
AOC_32	32Z-01-10XBR	6/19/2003	240.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32Z-01-10XBR	9/23/2003	240.7	
AOC_32	32Z-01-10XBR	12/1/2003	238.9	
AOC_32	32Z-01-10XBR	10/7/2004	240.7	
AOC_32	32Z-01-10XBR	6/13/2005	241.1	
AOC_32	32Z-01-10XBR	10/3/2005	238.1	
AOC_32	32Z-01-10XBR	6/5/2006	235.2	
AOC_32	32Z-01-10XBR	6/7/2006	236.0	
AOC_32	32Z-01-10XBR	10/17/2006	240.2	
AOC_32	32Z-01-10XBR	10/19/2006	239.4	
AOC_32	32Z-01-10XBR	5/22/2007	242.7	
AOC_32	32Z-01-10XBR	5/23/2007	241.9	
AOC_32	32Z-01-10XBR	10/15/2007	238.4	
AOC_32	32Z-01-10XBR	10/16/2007	239.2	
AOC_32	32Z-01-10XBR	6/25/2008	239.6	
AOC_32	32Z-01-10XBR	6/26/2008	240.4	
AOC_32	32Z-01-10XBR	10/28/2008	241.1	
AOC_32	32Z-01-10XBR	10/29/2008	241.9	
AOC_32	32Z-01-10XBR	5/8/2009	242.5	
AOC_32	32Z-01-10XBR	5/11/2009	243.3	
AOC_32	32Z-01-10XBR	10/26/2009	241.2	
AOC_32	32Z-01-10XBR	11/9/2009	242.1	
AOC_32	32Z-01-10XBR	5/18/2010	241.5	
AOC_32	32Z-01-10XBR	5/20/2010	240.7	
AOC_32	32Z-01-10XBR	10/7/2010	242.3	
AOC_32	32Z-01-10XBR	10/19/2010	243.1	
AOC_32	32Z-01-10XBR	6/30/2011	242.3	
AOC_32	32Z-01-10XBR	10/13/2011	242.7	
AOC_32	32Z-01-10XBR	5/15/2012	242.0	
AOC_32	32Z-01-10XBR	10/22/2012	241.3	
AOC_32	32Z-01-10XBR	6/11/2013	245.2	
AOC_32	32Z-01-10XBR	10/23/2013	237.8	
AOC_32	32Z-01-10XBR	6/17/2014	240.0	
AOC_32	32Z-01-10XBR	10/8/2015	238.9	
AOC_32	32Z-01-10XBR	5/17/2016	240.5	
AOC_32	32Z-01-10XBR	7/7/2017	239.7	
AOC_32	32Z-01-10XBR	4/9/2018	243.0	
AOC_32	32Z-01-10XBR	12/5/2018	244.0	
AOC_32	32Z-01-10XBR	4/8/2019	242.0	
AOC_32	32Z-01-10XBR	4/29/2020	243.4	
AOC_32	32Z-01-10XBR	5/14/2020	242.3	
AOC_32	32Z-01-11X	7/10/2002		
AOC_32	32Z-01-11X	3/27/2003		
AOC_32	32Z-01-11X	6/5/2006		
AOC_32	32Z-01-11X	10/13/2011		

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32Z-01-11XBR	7/10/2002	245.2	
AOC_32	32Z-01-11XBR	3/27/2003	244.7	
AOC_32	32Z-01-11XBR	6/5/2006	244.5	
AOC_32	32Z-01-11XBR	6/7/2006	245.3	
AOC_32	32Z-01-11XBR	10/17/2006		
AOC_32	32Z-01-11XBR	5/22/2007		
AOC_32	32Z-01-11XBR	10/16/2007		
AOC_32	32Z-01-11XBR	6/26/2008		
AOC_32	32Z-01-11XBR	10/29/2008		
AOC_32	32Z-01-11XBR	5/11/2009		
AOC_32	32Z-01-11XBR	11/9/2009		
AOC_32	32Z-01-11XBR	5/18/2010		
AOC_32	32Z-01-11XBR	10/19/2010		
AOC_32	32Z-01-11XBR	10/13/2011	244.6	
AOC_32	32Z-01-11XBR	6/11/2013		
AOC_32	32Z-01-11XBR	10/23/2013		
AOC_32	32Z-01-11XBR	6/17/2014		
AOC_32	32Z-01-11XBR	10/8/2015		
AOC_32	32Z-01-11XBR	5/17/2016		
AOC_32	32Z-01-11XBR	7/7/2017		
AOC_32	32Z-01-11XBR	4/9/2018		
AOC_32	32Z-01-11XBR	12/5/2018	245.5	
AOC_32	32Z-01-11XBR	4/8/2019	244.5	
AOC_32	32Z-01-11XBR	4/29/2020	245.7	
AOC_32	32Z-01-11XBR	5/14/2020	245.3	
AOC_32	32Z-01-12X	1/30/2002		
AOC_32	32Z-01-12X	4/11/2002		
AOC_32	32Z-01-12X	7/10/2002		
AOC_32	32Z-01-12X	10/1/2002		
AOC_32	32Z-01-12X	3/27/2003		
AOC_32	32Z-01-12X	6/19/2003		
AOC_32	32Z-01-12X	9/23/2003		
AOC_32	32Z-01-12X	12/1/2003		
AOC_32	32Z-01-12X	10/7/2004		
AOC_32	32Z-01-12X	6/13/2005		
AOC_32	32Z-01-12X	10/3/2005		
AOC_32	32Z-01-12X	6/5/2006		
AOC_32	32Z-01-12X	10/19/2006		
AOC_32	32Z-01-12X	10/15/2007		
AOC_32	32Z-01-12X	6/25/2008		
AOC_32	32Z-01-12X	10/28/2008		
AOC_32	32Z-01-12X	5/8/2009		
AOC_32	32Z-01-12X	10/26/2009		
AOC_32	32Z-01-12X	5/20/2010		

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32Z-01-12X	10/7/2010		
AOC_32	32Z-01-12X	10/13/2011		
AOC_32	32Z-01-12X	10/22/2012		
AOC_32	32Z-01-12XBR	1/30/2002	233.7	
AOC_32	32Z-01-12XBR	4/11/2002	236.0	
AOC_32	32Z-01-12XBR	7/10/2002	238.0	
AOC_32	32Z-01-12XBR	10/1/2002	236.0	
AOC_32	32Z-01-12XBR	3/27/2003	239.2	
AOC_32	32Z-01-12XBR	6/19/2003	238.9	
AOC_32	32Z-01-12XBR	9/23/2003	237.3	
AOC_32	32Z-01-12XBR	12/1/2003	236.8	
AOC_32	32Z-01-12XBR	10/7/2004	236.9	
AOC_32	32Z-01-12XBR	6/13/2005	239.5	
AOC_32	32Z-01-12XBR	10/3/2005	236.0	
AOC_32	32Z-01-12XBR	6/5/2006	239.7	
AOC_32	32Z-01-12XBR	6/7/2006	240.6	
AOC_32	32Z-01-12XBR	10/17/2006	237.0	
AOC_32	32Z-01-12XBR	10/19/2006	236.1	
AOC_32	32Z-01-12XBR	5/22/2007		
AOC_32	32Z-01-12XBR	10/15/2007	235.2	
AOC_32	32Z-01-12XBR	10/16/2007	236.0	
AOC_32	32Z-01-12XBR	6/25/2008	238.1	
AOC_32	32Z-01-12XBR	6/26/2008	238.9	
AOC_32	32Z-01-12XBR	10/28/2008	237.6	
AOC_32	32Z-01-12XBR	10/29/2008	238.4	
AOC_32	32Z-01-12XBR	5/8/2009	239.3	
AOC_32	32Z-01-12XBR	5/11/2009	240.1	
AOC_32	32Z-01-12XBR	10/26/2009	236.7	
AOC_32	32Z-01-12XBR	11/9/2009	237.5	
AOC_32	32Z-01-12XBR	5/18/2010	240.3	
AOC_32	32Z-01-12XBR	5/20/2010	239.5	
AOC_32	32Z-01-12XBR	10/7/2010	235.5	
AOC_32	32Z-01-12XBR	10/19/2010	236.3	
AOC_32	32Z-01-12XBR	6/30/2011	238.6	
AOC_32	32Z-01-12XBR	10/13/2011	238.7	
AOC_32	32Z-01-12XBR	10/22/2012	235.3	
AOC_32	32Z-01-12XBR	6/11/2013	238.7	
AOC_32	32Z-01-12XBR	10/23/2013	235.7	
AOC_32	32Z-01-12XBR	6/17/2014	238.6	
AOC_32	32Z-01-12XBR	10/8/2015	235.5	
AOC_32	32Z-01-12XBR	5/17/2016	238.6	
AOC_32	32Z-01-12XBR	7/7/2017	238.0	
AOC_32	32Z-01-12XBR	4/9/2018	239.6	
AOC_32	32Z-01-12XBR	12/5/2018	238.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32Z-01-12XBR	4/8/2019	238.9	
AOC_32	32Z-01-12XBR	4/29/2020	240.0	
AOC_32	32Z-01-12XBR	5/14/2020	239.9	
AOC_32	32Z-99-02X	1/30/2002	231.7	
AOC_32	32Z-99-02X	4/11/2002	234.3	
AOC_32	32Z-99-02X	7/10/2002	234.5	
AOC_32	32Z-99-02X	10/1/2002	232.6	
AOC_32	32Z-99-02X	3/27/2003	236.5	
AOC_32	32Z-99-02X	6/19/2003	229.6	
AOC_32	32Z-99-02X	9/23/2003	233.9	
AOC_32	32Z-99-02X	12/1/2003	234.3	
AOC_32	32Z-99-02X	5/25/2004	235.7	
AOC_32	32Z-99-02X	10/7/2004	233.6	
AOC_32	32Z-99-02X	6/13/2005	236.6	
AOC_32	32Z-99-02X	10/3/2005	233.2	
AOC_32	32Z-99-02X	6/7/2006	238.1	
AOC_32	32Z-99-02X	10/17/2006	234.1	
AOC_32	32Z-99-02X	10/19/2006	233.1	
AOC_32	32Z-99-02X	5/22/2007	238.0	
AOC_32	32Z-99-02X	5/23/2007	237.0	
AOC_32	32Z-99-02X	10/15/2007	233.5	
AOC_32	32Z-99-02X	10/16/2007	234.6	
AOC_32	32Z-99-02X	6/25/2008	235.2	
AOC_32	32Z-99-02X	6/26/2008	236.3	
AOC_32	32Z-99-02X	10/28/2008	235.5	
AOC_32	32Z-99-02X	10/29/2008	236.6	
AOC_32	32Z-99-02X	5/8/2009	236.5	
AOC_32	32Z-99-02X	5/11/2009	237.3	
AOC_32	32Z-99-02X	10/26/2009	234.3	
AOC_32	32Z-99-02X	11/9/2009	235.4	
AOC_32	32Z-99-02X	5/18/2010	236.9	
AOC_32	32Z-99-02X	5/20/2010	235.8	
AOC_32	32Z-99-02X	10/7/2010	233.9	
AOC_32	32Z-99-02X	10/19/2010	235.0	
AOC_32	32Z-99-02X	6/30/2011	235.5	
AOC_32	32Z-99-02X	10/13/2011	236.4	
AOC_32	32Z-99-02X	5/15/2012	234.7	
AOC_32	32Z-99-02X	10/22/2012	233.1	
AOC_32	32Z-99-02X	6/11/2013	235.2	
AOC_32	32Z-99-02X	10/23/2013		
AOC_32	32Z-99-02X	6/17/2014	235.4	
AOC_32	32Z-99-02X	10/8/2015	233.0	
AOC_32	32Z-99-02X	12/16/2015	232.1	
AOC_32	32Z-99-02X	5/17/2016		

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	32Z-99-02X	7/7/2017	236.0	
AOC_32	32Z-99-02X	4/9/2018	236.2	
AOC_32	32Z-99-02X	12/5/2018	238.7	
AOC_32	32Z-99-02X	4/8/2019	236.2	
AOC_32	32Z-99-02X	4/29/2020	237.7	
AOC_32	32Z-99-02X	5/14/2020	237.5	
AOC_32	SHL-12	5/26/1992	225.4	
AOC_32	SHL-12	9/15/1992	225.0	
AOC_32	SHL-12	12/22/1992	224.7	
AOC_32	SHL-12	3/30/1993	226.2	
AOC_32	SHL-12	6/22/1993	225.7	
AOC_32	SHL-12	9/30/1993	224.7	
AOC_32	SHL-12	11/8/1993	224.4	
AOC_32	SHL-12	3/30/1994	226.7	
AOC_32	SHL-12	6/28/1994	226.3	
AOC_32	SHL-12	10/4/1994	225.8	
AOC_32	SHL-12	1/31/1995	226.0	
AOC_32	SHL-12	5/9/1995	225.6	
AOC_32	SHL-12	12/7/1995	225.0	
AOC_32	SHL-12	3/26/1996	226.8	
AOC_32	SHL-12	1/15/1997	227.9	
AOC_32	SHL-12	6/2/1997	227.8	
AOC_32	SHL-12	4/23/1998	227.9	
AOC_32	SHL-12	6/19/1998	229.3	
AOC_32	SHL-12	6/26/1998	229.1	
AOC_32	SHL-12	7/1/1998	229.2	
AOC_32	SHL-12	7/17/1998	228.6	
AOC_32	SHL-12	7/31/1998	228.1	
AOC_32	SHL-12	8/28/1998	227.1	
AOC_32	SHL-12	10/14/1998	226.7	
AOC_32	SHL-12	12/10/1998	225.4	
AOC_32	SHL-12	2/23/1999	225.8	
AOC_32	SHL-12	6/6/1999	224.8	
AOC_32	SHL-12	9/8/1999	223.5	
AOC_32	SHL-12	8/19/2008	228.0	
AOC_32	SHL-12	9/15/2008	228.2	
AOC_32	SHL-12	4/28/2009	227.9	
AOC_32	SHL-12	9/14/2009	227.4	
AOC_32	SHL-12	10/26/2009	226.8	
AOC_32	SHL-12	4/27/2010	229.8	
AOC_32	SHL-12	9/14/2010	226.0	
AOC_32	SHL-12	7/25/2011	226.4	
AOC_32	SHL-12	6/26/2012	226.5	
AOC_32	SHL-12	11/6/2012	225.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	SHL-12	4/25/2013	226.0	
AOC_32	SHL-12	4/22/2014	226.0	
AOC_32	SHL-12	10/6/2014	224.9	
AOC_32	SHL-12	6/8/2015	227.0	
AOC_32	SHL-12	6/9/2015	227.0	
AOC_32	SHL-12	6/17/2015	226.6	
AOC_32	SHL-12	10/7/2015	224.9	
AOC_32	SHL-12	12/16/2015	224.3	
AOC_32	SHL-12	6/9/2016	225.0	
AOC_32	SHL-12	6/24/2016	224.7	
AOC_32	SHL-12	8/16/2016	224.2	
AOC_32	SHL-12	11/15/2016	224.0	
AOC_32	SHL-12	5/22/2017	226.7	
AOC_32	SHL-12	11/1/2018	227.9	
AOC_32	SHL-12	12/5/2018	229.8	
AOC_32	SHL-12	10/22/2019	226.0	
AOC_32	SHL-12	4/29/2020	227.9	
AOC_32	SHL-17	5/26/1992	225.3	
AOC_32	SHL-17	9/15/1992	224.7	
AOC_32	SHL-17	12/22/1992	224.8	
AOC_32	SHL-17	3/30/1993	228.3	
AOC_32	SHL-17	6/22/1993	225.6	
AOC_32	SHL-17	9/30/1993	224.9	
AOC_32	SHL-17	11/8/1993	224.5	
AOC_32	SHL-17	3/30/1994	226.8	
AOC_32	SHL-17	10/4/1994	225.8	
AOC_32	SHL-17	1/31/1995	226.0	
AOC_32	SHL-17	5/9/1995	225.6	
AOC_32	SHL-17	12/7/1995	225.0	
AOC_32	SHL-17	3/26/1996	226.7	
AOC_32	SHL-17	7/23/1996	227.3	
AOC_32	SHL-17	1/15/1997	227.7	
AOC_32	SHL-17	6/2/1997	227.5	
AOC_32	SHL-17	4/23/1998	227.9	
AOC_32	SHL-17	6/19/1998	229.7	
AOC_32	SHL-17	6/26/1998	229.5	
AOC_32	SHL-17	7/1/1998	230.1	
AOC_32	SHL-17	7/17/1998	228.5	
AOC_32	SHL-17	7/31/1998	228.6	
AOC_32	SHL-17	8/28/1998	227.1	
AOC_32	SHL-17	10/14/1998	226.9	
AOC_32	SHL-17	12/10/1998	225.8	
AOC_32	SHL-17	2/23/1999	226.0	
AOC_32	SHL-17	6/6/1999	224.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	SHL-17	9/8/1999	223.5	
AOC_32	SHL-17	9/14/2009	227.3	
AOC_32	SHL-17	10/26/2009	227.0	
AOC_32	SHL-17	4/27/2010	229.7	
AOC_32	SHL-17	9/14/2010	225.9	
AOC_32	SHL-17	7/25/2011	226.3	
AOC_32	SHL-17	6/26/2012	227.0	
AOC_32	SHL-17	11/6/2012	225.7	
AOC_32	SHL-17	4/25/2013	225.9	
AOC_32	SHL-17	4/22/2014	226.0	
AOC_32	SHL-17	6/17/2015	226.6	
AOC_32	SHL-17	10/7/2015	224.9	
AOC_32	SHL-17	10/20/2015		
AOC_32	SHL-17	12/16/2015	224.8	
AOC_32	SHL-17	6/9/2016	225.0	
AOC_32	SHL-17	6/24/2016		
AOC_32	SHL-17	8/16/2016	224.5	
AOC_32	SHL-17	11/15/2016	224.1	
AOC_32	SHL-17	5/22/2017	226.8	
AOC_32	SHL-17	11/1/2018	228.2	
AOC_32	SHL-17	12/5/2018	229.9	
AOC_32	SHL-17	10/22/2019	224.9	
AOC_32	SHL-17	4/29/2020	228.3	
AOC_32	SHL-24	5/26/1992	221.8	
AOC_32	SHL-24	9/15/1992	222.0	
AOC_32	SHL-24	12/22/1992	222.0	
AOC_32	SHL-24	3/30/1993	222.9	
AOC_32	SHL-24	6/22/1993	222.3	
AOC_32	SHL-24	9/30/1993	221.7	
AOC_32	SHL-24	11/8/1993	221.8	
AOC_32	SHL-24	3/30/1994	223.5	
AOC_32	SHL-24	6/28/1994	222.7	
AOC_32	SHL-24	10/4/1994	222.6	
AOC_32	SHL-24	1/31/1995	222.9	
AOC_32	SHL-24	5/9/1995	222.2	
AOC_32	SHL-24	12/7/1995	222.2	
AOC_32	SHL-24	3/26/1996	223.2	
AOC_32	SHL-24	7/23/1996	223.6	
AOC_32	SHL-24	1/15/1997	223.9	
AOC_32	SHL-24	6/2/1997	224.0	
AOC_32	SHL-24	4/23/1998	223.8	
AOC_32	SHL-24	6/19/1998	225.1	
AOC_32	SHL-24	6/26/1998	225.0	
AOC_32	SHL-24	7/1/1998	224.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	SHL-24	7/17/1998	224.3	
AOC_32	SHL-24	7/31/1998	223.9	
AOC_32	SHL-24	8/28/1998	223.2	
AOC_32	SHL-24	10/14/1998	222.9	
AOC_32	SHL-24	12/10/1998	222.1	
AOC_32	SHL-24	2/23/1999	222.4	
AOC_32	SHL-24	6/6/1999	221.7	
AOC_32	SHL-24	9/8/1999	220.7	
AOC_32	SHL-24	8/24/2005	223.1	
AOC_32	SHL-24	8/26/2005	223.1	
AOC_32	SHL-24	6/5/2006	225.3	
AOC_32	SHL-24	9/18/2006	223.5	
AOC_32	SHL-24	12/15/2006	223.6	
AOC_32	SHL-24	4/8/2007	223.3	
AOC_32	SHL-24	4/9/2007	223.3	
AOC_32	SHL-24	10/15/2007	222.6	
AOC_32	SHL-24	2/20/2008	224.7	
AOC_32	SHL-24	2/25/2008	224.4	
AOC_32	SHL-24	3/4/2008	224.2	
AOC_32	SHL-24	4/16/2008	224.5	
AOC_32	SHL-24	9/30/2008	224.7	
AOC_32	SHL-24	4/28/2009	224.1	
AOC_32	SHL-24	9/14/2009	223.7	
AOC_32	SHL-24	10/26/2009	223.2	
AOC_32	SHL-24	11/3/2009	223.3	
AOC_32	SHL-24	4/20/2010	225.7	
AOC_32	SHL-24	4/27/2010	225.4	
AOC_32	SHL-24	9/14/2010	222.6	
AOC_32	SHL-24	10/7/2010	223.1	
AOC_32	SHL-24	4/4/2011	223.7	
AOC_32	SHL-24	7/25/2011	222.9	
AOC_32	SHL-24	11/8/2011	224.6	
AOC_32	SHL-24	4/10/2012	220.9	
AOC_32	SHL-24	6/26/2012	222.9	
AOC_32	SHL-24	11/5/2012	223.0	
AOC_32	SHL-24	11/6/2012	223.0	
AOC_32	SHL-24	5/15/2013	222.5	
AOC_32	SHL-24	6/11/2013	223.8	
AOC_32	SHL-24	10/21/2013	221.8	
AOC_32	SHL-24	4/22/2014	223.0	
AOC_32	SHL-24	6/9/2015	223.5	
AOC_32	SHL-24	6/10/2015	223.5	
AOC_32	SHL-24	6/17/2015	222.8	
AOC_32	SHL-24	10/7/2015	222.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	SHL-24	10/20/2015	221.9	
AOC_32	SHL-24	12/16/2015	221.7	
AOC_32	SHL-24	6/9/2016	222.0	
AOC_32	SHL-24	6/24/2016	221.8	
AOC_32	SHL-24	8/16/2016	221.6	
AOC_32	SHL-24	11/15/2016	221.7	
AOC_32	SHL-24	5/22/2017	223.4	
AOC_32	SHL-24	11/1/2018	224.2	
AOC_32	SHL-24	10/22/2019	223.0	
AOC_32	SHL-24	4/29/2020	224.3	
AOC_32	SHL-25	5/26/1992	233.3	
AOC_32	SHL-25	9/15/1992	231.2	
AOC_32	SHL-25	12/22/1992	231.2	
AOC_32	SHL-25	3/30/1993	233.8	
AOC_32	SHL-25	6/22/1993	233.1	
AOC_32	SHL-25	9/30/1993	229.4	
AOC_32	SHL-25	11/8/1993	231.0	
AOC_32	SHL-25	3/30/1994	236.8	
AOC_32	SHL-25	6/28/1994	234.1	
AOC_32	SHL-25	10/4/1994	232.3	
AOC_32	SHL-25	1/31/1995	235.3	
AOC_32	SHL-25	5/9/1995	232.8	
AOC_32	SHL-25	12/7/1995	234.2	
AOC_32	SHL-25	3/26/1996	236.1	
AOC_32	SHL-25	7/23/1996	234.1	
AOC_32	SHL-25	1/15/1997	236.1	
AOC_32	SHL-25	6/2/1997	235.1	
AOC_32	SHL-25	4/23/1998	235.9	
AOC_32	SHL-25	6/19/1998	237.0	
AOC_32	SHL-25	6/26/1998	237.3	
AOC_32	SHL-25	7/1/1998	237.0	
AOC_32	SHL-25	7/17/1998	235.8	
AOC_32	SHL-25	7/31/1998	234.6	
AOC_32	SHL-25	8/28/1998	232.8	
AOC_32	SHL-25	10/14/1998	230.8	
AOC_32	SHL-25	12/10/1998	230.1	
AOC_32	SHL-25	2/23/1999	233.8	
AOC_32	SHL-25	6/6/1999	231.8	
AOC_32	SHL-25	9/8/1999	228.6	
AOC_32	SHL-25	4/11/2002	229.5	
AOC_32	SHL-25	7/10/2002	231.7	
AOC_32	SHL-25	10/1/2002	229.3	
AOC_32	SHL-25	3/27/2003	231.8	
AOC_32	SHL-25	6/19/2003	232.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	SHL-25	9/23/2003	230.9	
AOC_32	SHL-25	12/1/2003	230.6	
AOC_32	SHL-25	10/7/2004	230.3	
AOC_32	SHL-25	5/18/2005	233.6	
AOC_32	SHL-25	6/13/2005	233.6	
AOC_32	SHL-25	10/3/2005	230.3	
AOC_32	SHL-25	6/5/2006	233.3	
AOC_32	SHL-25	6/7/2006	234.4	
AOC_32	SHL-25	10/17/2006	231.5	
AOC_32	SHL-25	10/19/2006	230.4	
AOC_32	SHL-25	5/22/2007	234.4	
AOC_32	SHL-25	5/23/2007	233.3	
AOC_32	SHL-25	10/15/2007	229.4	
AOC_32	SHL-25	10/16/2007	230.5	
AOC_32	SHL-25	6/25/2008	231.8	
AOC_32	SHL-25	6/26/2008	232.9	
AOC_32	SHL-25	10/28/2008	232.0	
AOC_32	SHL-25	10/29/2008	233.1	
AOC_32	SHL-25	5/8/2009	233.1	
AOC_32	SHL-25	5/11/2009	234.2	
AOC_32	SHL-25	10/26/2009	231.6	
AOC_32	SHL-25	11/9/2009	232.7	
AOC_32	SHL-25	5/18/2010	235.3	
AOC_32	SHL-25	10/7/2010	230.8	
AOC_32	SHL-25	10/19/2010	231.9	
AOC_32	SHL-25	6/30/2011	232.8	
AOC_32	SHL-25	10/13/2011	233.9	
AOC_32	SHL-25	5/15/2012	231.5	
AOC_32	SHL-25	10/22/2012	229.9	
AOC_32	SHL-25	6/11/2013	232.2	
AOC_32	SHL-25	10/23/2013	229.8	
AOC_32	SHL-25	4/22/2014	231.9	
AOC_32	SHL-25	6/17/2014	231.3	
AOC_32	SHL-25	10/6/2014	229.4	
AOC_32	SHL-25	6/17/2015	233.9	
AOC_32	SHL-25	10/7/2015	229.7	
AOC_32	SHL-25	10/8/2015	229.6	
AOC_32	SHL-25	12/16/2015	228.7	
AOC_32	SHL-25	5/17/2016	231.2	
AOC_32	SHL-25	6/9/2016	230.5	
AOC_32	SHL-25	6/24/2016	230.2	
AOC_32	SHL-25	8/16/2016	228.9	
AOC_32	SHL-25	11/15/2016	229.0	
AOC_32	SHL-25	5/22/2017	233.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	SHL-25	7/7/2017	232.6	
AOC_32	SHL-25	4/9/2018	232.6	
AOC_32	SHL-25	11/1/2018	232.0	
AOC_32	SHL-25	12/5/2018	234.2	
AOC_32	SHL-25	4/8/2019	233.3	
AOC_32	SHL-25	10/22/2019	230.3	
AOC_32	SHL-25	4/29/2020	233.3	
AOC_32	SHL-25	5/14/2020	233.4	
AOC_32	SHM-93-24A	3/30/1993	222.5	
AOC_32	SHM-93-24A	6/22/1993	221.4	
AOC_32	SHM-93-24A	9/30/1993	220.9	
AOC_32	SHM-93-24A	11/8/1993	221.0	
AOC_32	SHM-93-24A	3/30/1994	222.8	
AOC_32	SHM-93-24A	6/28/1994	221.8	
AOC_32	SHM-93-24A	10/4/1994	221.8	
AOC_32	SHM-93-24A	1/31/1995	222.2	
AOC_32	SHM-93-24A	5/9/1995	221.5	
AOC_32	SHM-93-24A	12/7/1995	221.5	
AOC_32	SHM-93-24A	3/26/1996	222.5	
AOC_32	SHM-93-24A	7/23/1996	222.8	
AOC_32	SHM-93-24A	1/15/1997	223.1	
AOC_32	SHM-93-24A	6/2/1997	223.0	
AOC_32	SHM-93-24A	4/23/1998	222.9	
AOC_32	SHM-93-24A	6/19/1998	224.2	
AOC_32	SHM-93-24A	6/26/1998	224.0	
AOC_32	SHM-93-24A	7/1/1998	223.8	
AOC_32	SHM-93-24A	7/17/1998	223.4	
AOC_32	SHM-93-24A	7/31/1998	223.0	
AOC_32	SHM-93-24A	8/28/1998	222.3	
AOC_32	SHM-93-24A	10/14/1998	222.0	
AOC_32	SHM-93-24A	12/10/1998	221.4	
AOC_32	SHM-93-24A	2/23/1999	221.7	
AOC_32	SHM-93-24A	6/6/1999	220.9	
AOC_32	SHM-93-24A	9/8/1999	220.0	
AOC_32	SHM-93-24A	11/6/2012	222.4	
AOC_32	SHM-93-24A	4/25/2013	222.0	
AOC_32	SHM-93-24A	5/15/2013	221.8	
AOC_32	SHM-93-24A	6/11/2013	223.4	
AOC_32	SHM-93-24A	10/21/2013	221.0	
AOC_32	SHM-93-24A	4/22/2014	222.4	
AOC_32	SHM-93-24A	6/17/2015	222.1	
AOC_32	SHM-93-24A	10/7/2015	221.3	
AOC_32	SHM-93-24A	12/16/2015	221.1	
AOC_32	SHM-93-24A	6/9/2016	221.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_32	SHM-93-24A	6/24/2016	221.2	
AOC_32	SHM-93-24A	8/16/2016	221.1	
AOC_32	SHM-93-24A	11/15/2016	221.1	
AOC_32	SHM-93-24A	5/22/2017	222.7	
AOC_32	SHM-93-24A	11/1/2018	223.3	
AOC_32	SHM-93-24A	10/22/2019	222.3	
AOC_32	SHM-93-24A	4/29/2020	223.6	
AOC_40	CPSG-01	1/3/2020		-3.7
AOC_40	CPSG-01	3/13/2020	244.3	
AOC_40	CPSG-01	9/1/2020	243.9	
AOC_40	CPSG-02	1/3/2020		-1.9
AOC_40	CPSG-02	3/13/2020	243.7	
AOC_40	CPSG-02	8/31/2020	242.0	
AOC_40	CSBSG-01	1/3/2020		-3.0
AOC_40	CSBSG-01	3/13/2020	235.4	
AOC_40	CSBSG-01	8/31/2020	233.5	
AOC_41	41M-92-01X	9/5/1992	222.7	
AOC_41	41M-92-01X	9/30/1993	221.8	
AOC_41	41M-92-01X	12/7/1995	223.2	
AOC_41	41M-92-01X	7/23/1996	223.7	
AOC_41	41M-92-01X	1/15/1997	225.0	
AOC_41	41M-92-01X	6/2/1997	225.0	
AOC_41	41M-92-01X	4/23/1998	225.2	
AOC_41	41M-92-01X	10/14/1998	222.5	
AOC_41	41M-92-01X	12/6/1999	223.1	
AOC_41	41M-93-02A	12/7/1995	246.1	
AOC_41	41M-93-02A	7/23/1996	245.9	
AOC_41	41M-93-02A	1/15/1997	246.1	
AOC_41	41M-93-02A	6/2/1997	245.6	
AOC_41	41M-93-02A	4/23/1998	246.0	
AOC_41	41M-93-02A	10/14/1998	246.0	
AOC_41	41M-93-02A	12/6/1999	246.1	
AOC_41	41M-93-02B	9/30/1993	221.3	
AOC_41	41M-93-02B	12/7/1995	223.3	
AOC_41	41M-93-02B	7/23/1996	224.2	
AOC_41	41M-93-02B	1/15/1997	225.1	
AOC_41	41M-93-02B	6/2/1997	225.4	
AOC_41	41M-93-02B	4/23/1998	225.4	
AOC_41	41M-93-02B	10/14/1998	223.1	
AOC_41	41M-93-02B	12/6/1999	223.2	
AOC_41	41M-93-04X	9/30/1993	221.4	
AOC_41	41M-93-04X	12/7/1995	223.0	
AOC_41	41M-93-04X	7/23/1996	222.6	
AOC_41	41M-93-04X	1/15/1997	223.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_41	41M-93-04X	6/2/1997	223.1	
AOC_41	41M-93-04X	10/27/1997	222.4	
AOC_41	41M-93-04X	4/23/1998	223.8	
AOC_41	41M-93-04X	10/14/1998	223.0	
AOC_41	41M-93-04X	10/21/1998	222.6	
AOC_41	41M-93-04X	10/18/1999	224.0	
AOC_41	41M-93-04X	12/6/1999	224.0	
AOC_41	41M-93-04X	10/25/2000	225.1	
AOC_41	41M-93-04X	10/15/2001	221.8	
AOC_41	41M-93-04X	10/21/2002	223.7	
AOC_41	41M-93-04X	10/28/2003	222.8	
AOC_41	41M-93-04X	11/1/2004	224.6	
AOC_41	41M-93-04X	11/14/2005	224.8	
AOC_41	41M-93-04X	10/24/2006	222.9	
AOC_41	41M-93-04X	10/23/2007	224.4	
AOC_41	41M-93-04X	10/23/2008	224.0	
AOC_41	41M-93-04X	11/13/2009	224.7	
AOC_41	41M-93-04X	10/26/2010	225.4	
AOC_41	41M-93-05X	9/30/1993	222.4	
AOC_41	41M-93-05X	12/7/1995	223.0	
AOC_41	41M-93-05X	1/15/1997	223.5	
AOC_41	41M-93-05X	6/2/1997	222.8	
AOC_41	41M-93-05X	4/23/1998	223.6	
AOC_41	41M-93-05X	10/14/1998	222.8	
AOC_41	41M-93-05X	12/6/1999	223.9	
AOC_41	41M-94-02C	12/7/1995	221.6	
AOC_41	41M-94-02C	7/23/1996	222.4	
AOC_41	41M-94-02C	1/15/1997	223.4	
AOC_41	41M-94-02C	6/2/1997	223.5	
AOC_41	41M-94-02C	4/23/1998	223.5	
AOC_41	41M-94-02C	10/14/1998	221.5	
AOC_41	41M-94-02C	12/6/1999	221.1	
AOC_41	41M-94-03B	12/7/1995	221.2	
AOC_41	41M-94-03B	7/23/1996	221.9	
AOC_41	41M-94-03B	1/15/1997	223.0	
AOC_41	41M-94-03B	6/2/1997	222.9	
AOC_41	41M-94-03B	4/23/1998	223.0	
AOC_41	41M-94-03B	10/14/1998	221.2	
AOC_41	41M-94-03B	10/21/1998	221.2	
AOC_41	41M-94-03B	12/6/1999	220.7	
AOC_41	41M-94-06X	12/7/1995	224.0	
AOC_41	41M-94-06X	1/15/1997	224.4	
AOC_41	41M-94-06X	6/2/1997	224.1	
AOC_41	41M-94-06X	4/23/1998	224.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_41	41M-94-06X	10/14/1998	223.9	
AOC_41	41M-94-06X	12/6/1999	224.1	
AOC_41	41M-94-07X	12/7/1995	223.7	
AOC_41	41M-94-07X	1/15/1997	224.0	
AOC_41	41M-94-07X	6/2/1997	223.7	
AOC_41	41M-94-07X	4/23/1998	224.0	
AOC_41	41M-94-07X	10/14/1998	223.4	
AOC_41	41M-94-07X	12/6/1999	224.0	
AOC_41	41M-94-08A	12/7/1995	223.6	
AOC_41	41M-94-08A	7/23/1996	223.9	
AOC_41	41M-94-08A	1/15/1997	224.9	
AOC_41	41M-94-08A	6/2/1997	224.8	
AOC_41	41M-94-08A	4/23/1998	225.0	
AOC_41	41M-94-08A	10/14/1998	223.4	
AOC_41	41M-94-08A	12/6/1999	223.8	
AOC_41	41M-94-08B	12/7/1995	223.0	
AOC_41	41M-94-08B	7/23/1996	223.5	
AOC_41	41M-94-08B	1/15/1997	224.5	
AOC_41	41M-94-08B	6/2/1997	224.4	
AOC_41	41M-94-08B	4/23/1998	224.6	
AOC_41	41M-94-08B	10/14/1998	223.0	
AOC_41	41M-94-08B	12/6/1999	222.9	
AOC_41	41M-94-09A	12/7/1995	220.4	
AOC_41	41M-94-09A	1/15/1997	221.9	
AOC_41	41M-94-09A	6/2/1997	221.8	
AOC_41	41M-94-09A	4/23/1998	221.9	
AOC_41	41M-94-09A	10/14/1998	219.9	
AOC_41	41M-94-09A	10/18/1999	219.5	
AOC_41	41M-94-09A	12/6/1999	219.7	
AOC_41	41M-94-09A	10/25/2000	220.1	
AOC_41	41M-94-09A	10/15/2001	219.2	
AOC_41	41M-94-09A	10/21/2002	219.9	
AOC_41	41M-94-09A	10/28/2003	220.6	
AOC_41	41M-94-09A	11/1/2004	221.0	
AOC_41	41M-94-09A	11/14/2005	222.5	
AOC_41	41M-94-09A	10/24/2006	221.5	
AOC_41	41M-94-09B	12/7/1995	220.3	
AOC_41	41M-94-09B	1/15/1997	221.8	
AOC_41	41M-94-09B	6/2/1997	221.6	
AOC_41	41M-94-09B	10/27/1997	218.9	
AOC_41	41M-94-09B	4/23/1998	221.8	
AOC_41	41M-94-09B	10/14/1998	219.9	
AOC_41	41M-94-09B	10/18/1999	219.4	
AOC_41	41M-94-09B	12/6/1999	219.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_41	41M-94-09B	10/25/2000	220.0	
AOC_41	41M-94-09B	10/15/2001	219.1	
AOC_41	41M-94-09B	10/21/2002	219.9	
AOC_41	41M-94-09B	10/28/2003	220.6	
AOC_41	41M-94-09B	11/1/2004	220.9	
AOC_41	41M-94-09B	11/14/2005	222.4	
AOC_41	41M-94-09B	10/24/2006	221.4	
AOC_41	41M-94-10X	12/7/1995	227.0	
AOC_41	41M-94-10X	1/15/1997	230.5	
AOC_41	41M-94-10X	6/2/1997	230.7	
AOC_41	41M-94-10X	4/23/1998	232.6	
AOC_41	41M-94-10X	10/14/1998	228.4	
AOC_41	41M-94-10X	12/6/1999	228.8	
AOC_41	41M-94-11X	12/7/1995	223.1	
AOC_41	41M-94-11X	1/15/1997	225.5	
AOC_41	41M-94-11X	6/2/1997	225.8	
AOC_41	41M-94-11X	10/27/1997	222.6	
AOC_41	41M-94-11X	4/23/1998	225.6	
AOC_41	41M-94-11X	10/14/1998	223.9	
AOC_41	41M-94-11X	10/21/1998	223.9	
AOC_41	41M-94-11X	10/18/1999	222.5	
AOC_41	41M-94-11X	12/6/1999	222.9	
AOC_41	41M-94-11X	10/25/2000	223.8	
AOC_41	41M-94-11X	10/15/2001	222.9	
AOC_41	41M-94-11X	10/21/2002	222.4	
AOC_41	41M-94-11X	10/28/2003	223.9	
AOC_41	41M-94-11X	11/1/2004	224.2	
AOC_41	41M-94-11X	11/14/2005	226.1	
AOC_41	41M-94-11X	10/24/2006	225.2	
AOC_41	41M-94-12X	12/7/1995	221.9	
AOC_41	41M-94-12X	1/15/1997	224.1	
AOC_41	41M-94-12X	6/2/1997	224.1	
AOC_41	41M-94-12X	10/27/1997	219.2	
AOC_41	41M-94-12X	4/23/1998	223.8	
AOC_41	41M-94-12X	10/14/1998	220.4	
AOC_41	41M-94-12X	10/21/1998	220.9	
AOC_41	41M-94-12X	10/18/1999	220.0	
AOC_41	41M-94-12X	12/6/1999	221.6	
AOC_41	41M-94-12X	10/25/2000	220.9	
AOC_41	41M-94-12X	10/15/2001	219.9	
AOC_41	41M-94-12X	10/21/2002	220.1	
AOC_41	41M-94-12X	10/28/2003	221.9	
AOC_41	41M-94-12X	11/1/2004	223.2	
AOC_41	41M-94-12X	11/14/2005	225.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_41	41M-94-12X	10/24/2006	223.9	
AOC_41	41M-94-13X	12/7/1995	221.3	
AOC_41	41M-94-13X	7/23/1996	239.3	
AOC_41	41M-94-13X	1/15/1997	223.2	
AOC_41	41M-94-13X	6/2/1997	223.0	
AOC_41	41M-94-13X	4/23/1998	223.8	
AOC_41	41M-94-13X	10/14/1998	220.6	
AOC_41	41M-94-13X	12/6/1999	220.5	
AOC_41	41M-94-13X	10/15/2001	219.8	
AOC_41	41M-94-13X	10/21/2002	220.4	
AOC_41	41M-94-13X	10/28/2003	221.2	
AOC_41	41M-94-13X	11/1/2004	222.4	
AOC_41	41M-94-13X	11/14/2005	224.0	
AOC_41	41M-94-13X	10/24/2006	222.7	
AOC_41	41M-94-14X	12/7/1995	223.2	
AOC_41	41M-94-14X	1/15/1997	223.6	
AOC_41	41M-94-14X	6/2/1997	223.4	
AOC_41	41M-94-14X	10/27/1997	222.6	
AOC_41	41M-94-14X	4/23/1998	223.7	
AOC_41	41M-94-14X	10/14/1998	223.1	
AOC_41	41M-94-14X	10/21/1998	222.9	
AOC_41	41M-94-14X	10/18/1999	224.0	
AOC_41	41M-94-14X	12/6/1999	223.9	
AOC_41	41M-94-14X	10/25/2000	225.1	
AOC_41	41M-94-14X	10/15/2001	222.1	
AOC_41	41M-94-14X	10/21/2002	223.7	
AOC_41	41M-94-14X	10/28/2003	223.1	
AOC_41	41M-94-14X	11/1/2004	224.4	
AOC_41	41M-94-14X	11/14/2005	224.5	
AOC_41	41M-94-14X	10/24/2006	223.0	
AOC_43A	43M-01-16XBR	1/30/2002	228.0	
AOC_43A	43M-01-16XBR	4/11/2002	228.4	
AOC_43A	43M-01-16XBR	7/10/2002	230.9	
AOC_43A	43M-01-16XBR	10/1/2002	230.2	
AOC_43A	43M-01-16XBR	3/27/2003	232.6	
AOC_43A	43M-01-16XBR	6/19/2003	233.4	
AOC_43A	43M-01-16XBR	9/23/2003	232.4	
AOC_43A	43M-01-16XBR	12/1/2003	231.9	
AOC_43A	43M-01-16XBR	10/7/2004	233.6	
AOC_43A	43M-01-16XBR	6/13/2005	234.6	
AOC_43A	43M-01-16XBR	10/3/2005	231.2	
AOC_43A	43M-01-16XBR	6/5/2006	235.3	
AOC_43A	43M-01-16XBR	6/7/2006	236.0	
AOC_43A	43M-01-16XBR	10/17/2006	232.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_43A	43M-01-16XBR	10/19/2006	231.8	
AOC_43A	43M-01-16XBR	5/22/2007	235.0	
AOC_43A	43M-01-16XBR	5/23/2007	234.3	
AOC_43A	43M-01-16XBR	10/15/2007	230.3	
AOC_43A	43M-01-16XBR	10/16/2007	231.1	
AOC_43A	43M-01-16XBR	6/25/2008	233.1	
AOC_43A	43M-01-16XBR	6/26/2008	233.8	
AOC_43A	43M-01-16XBR	10/28/2008	233.0	
AOC_43A	43M-01-16XBR	10/29/2008	233.7	
AOC_43A	43M-01-16XBR	5/8/2009		211.2
AOC_43A	43M-01-16XBR	5/11/2009		211.9
AOC_43A	43M-01-16XBR	10/26/2009		210.1
AOC_43A	43M-01-16XBR	11/9/2009		210.8
AOC_43A	43M-01-16XBR	5/18/2010		214.5
AOC_43A	43M-01-16XBR	5/20/2010		213.8
AOC_43A	43M-01-16XBR	10/7/2010	230.9	
AOC_43A	43M-01-16XBR	10/19/2010	231.6	
AOC_43A	43M-01-16XBR	6/30/2011	233.0	
AOC_43A	43M-01-16XBR	10/13/2011	233.3	
AOC_43A	43M-01-16XBR	10/22/2012	229.8	
AOC_43A	43M-01-16XBR	6/11/2013	232.2	
AOC_43A	43M-01-16XBR	10/23/2013	230.4	
AOC_43A	43M-01-16XBR	6/17/2014	231.5	
AOC_43A	43M-01-16XBR	10/8/2015	231.2	
AOC_43A	43M-01-16XBR	5/17/2016	230.7	
AOC_43A	43M-01-16XBR	7/7/2017	233.1	
AOC_43A	43M-01-16XBR	4/9/2018	232.1	
AOC_43A	43M-01-16XBR	12/5/2018	235.6	
AOC_43A	43M-01-16XBR	4/8/2019	233.7	
AOC_43A	43M-01-16XBR	4/29/2020	232.7	
AOC_43A	43M-01-16XBR	5/14/2020	233.7	
AOC_43A	43M-01-16XOB	1/30/2002	227.9	
AOC_43A	43M-01-16XOB	4/11/2002	228.4	
AOC_43A	43M-01-16XOB	7/10/2002	230.8	
AOC_43A	43M-01-16XOB	10/1/2002	229.9	
AOC_43A	43M-01-16XOB	3/27/2003	232.4	
AOC_43A	43M-01-16XOB	6/19/2003	233.4	
AOC_43A	43M-01-16XOB	9/23/2003	232.4	
AOC_43A	43M-01-16XOB	12/1/2003	231.7	
AOC_43A	43M-01-16XOB	5/25/2004	233.0	
AOC_43A	43M-01-16XOB	10/7/2004	231.6	
AOC_43A	43M-01-16XOB	6/13/2005	234.4	
AOC_43A	43M-01-16XOB	10/3/2005	231.0	
AOC_43A	43M-01-16XOB	6/5/2006	234.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_43A	43M-01-16XOB	6/8/2006	235.5	
AOC_43A	43M-01-16XOB	10/17/2006	232.4	
AOC_43A	43M-01-16XOB	10/19/2006	231.6	
AOC_43A	43M-01-16XOB	5/22/2007	235.0	
AOC_43A	43M-01-16XOB	5/23/2007	234.3	
AOC_43A	43M-01-16XOB	10/15/2007	230.2	
AOC_43A	43M-01-16XOB	10/16/2007	231.0	
AOC_43A	43M-01-16XOB	6/25/2008	233.0	
AOC_43A	43M-01-16XOB	6/26/2008	233.7	
AOC_43A	43M-01-16XOB	10/28/2008	232.9	
AOC_43A	43M-01-16XOB	10/29/2008	233.6	
AOC_43A	43M-01-16XOB	5/8/2009	233.6	
AOC_43A	43M-01-16XOB	5/11/2009	234.4	
AOC_43A	43M-01-16XOB	10/26/2009	231.2	
AOC_43A	43M-01-16XOB	11/9/2009	231.9	
AOC_43A	43M-01-16XOB	5/18/2010	235.6	
AOC_43A	43M-01-16XOB	5/20/2010	234.8	
AOC_43A	43M-01-16XOB	10/7/2010	230.5	
AOC_43A	43M-01-16XOB	10/19/2010	231.3	
AOC_43A	43M-01-16XOB	6/30/2011	233.0	
AOC_43A	43M-01-16XOB	10/13/2011	233.2	
AOC_43A	43M-01-16XOB	5/15/2012	231.4	
AOC_43A	43M-01-16XOB	10/22/2012	229.6	
AOC_43A	43M-01-16XOB	6/11/2013	232.6	
AOC_43A	43M-01-16XOB	10/23/2013	230.0	
AOC_43A	43M-01-16XOB	6/17/2014	231.5	
AOC_43A	43M-01-16XOB	10/8/2015	229.6	
AOC_43A	43M-01-16XOB	5/17/2016	230.6	
AOC_43A	43M-01-16XOB	7/7/2017	233.0	
AOC_43A	43M-01-16XOB	4/9/2018	232.3	
AOC_43A	43M-01-16XOB	12/5/2018	235.7	
AOC_43A	43M-01-16XOB	4/8/2019	233.4	
AOC_43A	43M-01-16XOB	4/29/2020	233.5	
AOC_43A	43M-01-16XOB	5/14/2020	233.5	
AOC_43A	43M-01-17XBR	1/30/2002	227.8	
AOC_43A	43M-01-17XBR	4/11/2002	228.2	
AOC_43A	43M-01-17XBR	7/10/2002	230.3	
AOC_43A	43M-01-17XBR	10/1/2002	229.8	
AOC_43A	43M-01-17XBR	3/27/2003	231.9	
AOC_43A	43M-01-17XBR	6/19/2003	233.1	
AOC_43A	43M-01-17XBR	9/23/2003	232.4	
AOC_43A	43M-01-17XBR	12/1/2003	231.7	
AOC_43A	43M-01-17XBR	5/25/2004	232.5	
AOC_43A	43M-01-17XBR	10/7/2004	231.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_43A	43M-01-17XBR	6/13/2005	231.8	
AOC_43A	43M-01-17XBR	10/3/2005	231.2	
AOC_43A	43M-01-17XBR	6/5/2006	234.1	
AOC_43A	43M-01-17XBR	6/7/2006	234.8	
AOC_43A	43M-01-17XBR	10/17/2006	232.5	
AOC_43A	43M-01-17XBR	10/19/2006	231.8	
AOC_43A	43M-01-17XBR	5/22/2007	234.8	
AOC_43A	43M-01-17XBR	5/23/2007	234.1	
AOC_43A	43M-01-17XBR	10/15/2007	230.3	
AOC_43A	43M-01-17XBR	10/16/2007	231.1	
AOC_43A	43M-01-17XBR	6/25/2008	232.8	
AOC_43A	43M-01-17XBR	6/26/2008	233.6	
AOC_43A	43M-01-17XBR	10/28/2008	232.8	
AOC_43A	43M-01-17XBR	10/29/2008	233.6	
AOC_43A	43M-01-17XBR	5/8/2009	233.3	
AOC_43A	43M-01-17XBR	5/11/2009	234.1	
AOC_43A	43M-01-17XBR	10/26/2009	231.3	
AOC_43A	43M-01-17XBR	11/9/2009	232.1	
AOC_43A	43M-01-17XBR	5/18/2010		218.9
AOC_43A	43M-01-17XBR	5/20/2010		218.2
AOC_43A	43M-01-17XBR	10/7/2010	230.6	
AOC_43A	43M-01-17XBR	10/19/2010	231.4	
AOC_43A	43M-01-17XBR	6/30/2011	232.8	
AOC_43A	43M-01-17XBR	10/13/2011	233.2	
AOC_43A	43M-01-17XBR	10/22/2012	229.7	
AOC_43A	43M-01-17XBR	6/11/2013	231.9	
AOC_43A	43M-01-17XBR	10/23/2013	230.1	
AOC_43A	43M-01-17XBR	6/17/2014	231.4	
AOC_43A	43M-01-17XBR	10/8/2015	230.5	
AOC_43A	43M-01-17XBR	5/17/2016	230.3	
AOC_43A	43M-01-17XBR	7/7/2017	232.8	
AOC_43A	43M-01-17XBR	4/9/2018	231.8	
AOC_43A	43M-01-17XBR	12/5/2018	235.2	
AOC_43A	43M-01-17XBR	4/8/2019	233.7	
AOC_43A	43M-01-17XBR	4/29/2020	232.6	
AOC_43A	43M-01-17XBR	5/14/2020	233.4	
AOC_43A	43M-01-17XOB	1/30/2002	227.3	
AOC_43A	43M-01-17XOB	4/11/2002	227.8	
AOC_43A	43M-01-17XOB	7/10/2002	230.0	
AOC_43A	43M-01-17XOB	10/1/2002	229.7	
AOC_43A	43M-01-17XOB	3/27/2003	231.8	
AOC_43A	43M-01-17XOB	6/19/2003	233.0	
AOC_43A	43M-01-17XOB	9/23/2003	232.3	
AOC_43A	43M-01-17XOB	12/1/2003	231.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_43A	43M-01-17XOB	5/25/2004	232.5	
AOC_43A	43M-01-17XOB	10/7/2004	231.4	
AOC_43A	43M-01-17XOB	6/13/2005	234.2	
AOC_43A	43M-01-17XOB	10/3/2005	231.0	
AOC_43A	43M-01-17XOB	6/5/2006	234.1	
AOC_43A	43M-01-17XOB	6/7/2006	234.9	
AOC_43A	43M-01-17XOB	10/17/2006	232.3	
AOC_43A	43M-01-17XOB	10/19/2006	231.5	
AOC_43A	43M-01-17XOB	5/22/2007	234.5	
AOC_43A	43M-01-17XOB	5/23/2007	233.7	
AOC_43A	43M-01-17XOB	10/15/2007	230.2	
AOC_43A	43M-01-17XOB	10/16/2007	231.0	
AOC_43A	43M-01-17XOB	6/25/2008	232.8	
AOC_43A	43M-01-17XOB	6/26/2008	233.6	
AOC_43A	43M-01-17XOB	10/28/2008	232.7	
AOC_43A	43M-01-17XOB	10/29/2008	233.5	
AOC_43A	43M-01-17XOB	5/8/2009	233.2	
AOC_43A	43M-01-17XOB	5/11/2009	234.0	
AOC_43A	43M-01-17XOB	10/26/2009	231.1	
AOC_43A	43M-01-17XOB	11/9/2009	231.9	
AOC_43A	43M-01-17XOB	5/18/2010	235.5	
AOC_43A	43M-01-17XOB	5/20/2010	234.7	
AOC_43A	43M-01-17XOB	10/7/2010	230.5	
AOC_43A	43M-01-17XOB	10/19/2010	231.3	
AOC_43A	43M-01-17XOB	6/30/2011	232.7	
AOC_43A	43M-01-17XOB	10/13/2011	233.1	
AOC_43A	43M-01-17XOB	5/15/2012	231.2	
AOC_43A	43M-01-17XOB	10/22/2012	229.5	
AOC_43A	43M-01-17XOB	6/11/2013	231.8	
AOC_43A	43M-01-17XOB	10/23/2013	229.9	
AOC_43A	43M-01-17XOB	6/17/2014	231.1	
AOC_43A	43M-01-17XOB	10/8/2015	229.5	
AOC_43A	43M-01-17XOB	5/17/2016	230.2	
AOC_43A	43M-01-17XOB	7/7/2017	232.7	
AOC_43A	43M-01-17XOB	4/9/2018	231.9	
AOC_43A	43M-01-17XOB	12/5/2018	234.2	
AOC_43A	43M-01-17XOB	4/8/2019	233.1	
AOC_43A	43M-01-17XOB	4/29/2020	233.1	
AOC_43A	43M-01-17XOB	5/14/2020	233.1	
AOC_43A	43M-01-20XBR	1/30/2002	226.9	
AOC_43A	43M-01-20XBR	4/11/2002	223.4	
AOC_43A	43M-01-20XBR	7/10/2002	229.5	
AOC_43A	43M-01-20XBR	10/1/2002	229.4	
AOC_43A	43M-01-20XBR	3/27/2003	231.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_43A	43M-01-20XBR	6/19/2003	232.5	
AOC_43A	43M-01-20XBR	9/23/2003	231.9	
AOC_43A	43M-01-20XBR	12/1/2003	231.2	
AOC_43A	43M-01-20XBR	5/25/2004	231.9	
AOC_43A	43M-01-20XBR	10/7/2004	231.0	
AOC_43A	43M-01-20XBR	6/13/2005	233.6	
AOC_43A	43M-01-20XBR	10/3/2005	230.6	
AOC_43A	43M-01-20XBR	6/5/2006	233.7	
AOC_43A	43M-01-20XBR	6/7/2006	234.5	
AOC_43A	43M-01-20XBR	10/17/2006	232.0	
AOC_43A	43M-01-20XBR	10/19/2006	231.2	
AOC_43A	43M-01-20XBR	5/22/2007	228.2	
AOC_43A	43M-01-20XBR	5/23/2007	227.4	
AOC_43A	43M-01-20XBR	6/25/2008	223.4	
AOC_43A	43M-01-20XBR	6/26/2008	224.2	
AOC_43A	43M-01-20XBR	10/28/2008	232.4	
AOC_43A	43M-01-20XBR	10/29/2008		
AOC_43A	43M-01-20XBR	5/8/2009	232.8	
AOC_43A	43M-01-20XBR	5/11/2009	233.6	
AOC_43A	43M-01-20XBR	10/26/2009	230.6	
AOC_43A	43M-01-20XBR	11/9/2009	231.6	
AOC_43A	43M-01-20XBR	5/18/2010	235.0	
AOC_43A	43M-01-20XBR	5/20/2010	234.2	
AOC_43A	43M-01-20XBR	10/7/2010	230.2	
AOC_43A	43M-01-20XBR	10/19/2010	231.0	
AOC_43A	43M-01-20XBR	6/30/2011	232.3	
AOC_43A	43M-01-20XBR	10/13/2011	232.7	
AOC_43A	43M-01-20XBR	5/15/2012	230.9	
AOC_43A	43M-01-20XBR	10/22/2012	229.3	
AOC_43A	43M-01-20XBR	6/11/2013	231.6	
AOC_43A	43M-01-20XBR	10/23/2013	229.6	
AOC_43A	43M-01-20XBR	6/17/2014	230.7	
AOC_43A	43M-01-20XBR	10/8/2015	229.2	
AOC_43A	43M-01-20XBR	5/17/2016	229.8	
AOC_43A	43M-01-20XBR	7/7/2017	232.2	
AOC_43A	43M-01-20XBR	4/9/2018	231.4	
AOC_43A	43M-01-20XBR	12/5/2018	232.7	
AOC_43A	43M-01-20XBR	4/8/2019	231.7	
AOC_43A	43M-01-20XBR	4/29/2020	232.6	
AOC_43A	43M-01-20XBR	5/14/2020	232.6	
AOC_43A	43M-01-20XOB	1/30/2002	227.0	
AOC_43A	43M-01-20XOB	4/11/2002	227.6	
AOC_43A	43M-01-20XOB	7/10/2002	229.6	
AOC_43A	43M-01-20XOB	10/1/2002	228.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_43A	43M-01-20XOB	3/27/2003	231.1	
AOC_43A	43M-01-20XOB	6/19/2003	232.1	
AOC_43A	43M-01-20XOB	9/23/2003	231.6	
AOC_43A	43M-01-20XOB	12/1/2003	230.9	
AOC_43A	43M-01-20XOB	5/25/2004	231.6	
AOC_43A	43M-01-20XOB	10/7/2004	230.7	
AOC_43A	43M-01-20XOB	6/13/2005	233.2	
AOC_43A	43M-01-20XOB	6/5/2006	233.7	
AOC_43A	43M-01-20XOB	6/7/2006	234.7	
AOC_43A	43M-01-20XOB	10/17/2006	232.2	
AOC_43A	43M-01-20XOB	10/19/2006	231.2	
AOC_43A	43M-01-20XOB	5/22/2007	234.4	
AOC_43A	43M-01-20XOB	5/23/2007	233.3	
AOC_43A	43M-01-20XOB	10/15/2007	229.8	
AOC_43A	43M-01-20XOB	10/16/2007	230.9	
AOC_43A	43M-01-20XOB	6/25/2008	232.3	
AOC_43A	43M-01-20XOB	6/26/2008	233.4	
AOC_43A	43M-01-20XOB	10/28/2008	232.3	
AOC_43A	43M-01-20XOB	10/29/2008	233.4	
AOC_43A	43M-01-20XOB	5/8/2009	232.7	
AOC_43A	43M-01-20XOB	5/11/2009	233.8	
AOC_43A	43M-01-20XOB	10/26/2009	230.9	
AOC_43A	43M-01-20XOB	11/9/2009	231.8	
AOC_43A	43M-01-20XOB	5/18/2010	235.1	
AOC_43A	43M-01-20XOB	5/20/2010	234.1	
AOC_43A	43M-01-20XOB	10/7/2010	230.1	
AOC_43A	43M-01-20XOB	10/19/2010	231.2	
AOC_43A	43M-01-20XOB	6/30/2011	232.2	
AOC_43A	43M-01-20XOB	10/13/2011	232.7	
AOC_43A	43M-01-20XOB	5/15/2012	230.8	
AOC_43A	43M-01-20XOB	10/22/2012	228.9	
AOC_43A	43M-01-20XOB	6/11/2013	231.5	
AOC_43A	43M-01-20XOB	10/23/2013	229.5	
AOC_43A	43M-01-20XOB	6/17/2014	230.7	
AOC_43A	43M-01-20XOB	10/8/2015	229.2	
AOC_43A	43M-01-20XOB	5/17/2016	229.7	
AOC_43A	43M-01-20XOB	7/7/2017	232.2	
AOC_43A	43M-01-20XOB	4/9/2018	231.3	
AOC_43A	43M-01-20XOB	12/5/2018	231.5	
AOC_43A	43M-01-20XOB	4/8/2019	232.7	
AOC_43A	43M-01-20XOB	4/29/2020	232.5	
AOC_43A	43M-01-20XOB	5/14/2020	232.5	
AOC_43A	43MA93-05X	11/8/1993	224.7	
AOC_43A	43MA93-05X	6/28/1994	227.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_43A	43MA93-05X	10/4/1994	226.4	
AOC_43A	43MA93-05X	1/31/1995	226.7	
AOC_43A	43MA93-05X	5/9/1995	226.5	
AOC_43A	43MA93-05X	12/7/1995	225.7	
AOC_43A	43MA93-05X	7/23/1996	228.0	
AOC_43A	43MA93-05X	1/15/1997	229.2	
AOC_43A	43MA93-05X	6/2/1997	228.8	
AOC_43A	43MA93-06X	11/8/1993	226.1	
AOC_43A	43MA93-06X	6/28/1994	229.5	
AOC_43A	43MA93-06X	10/4/1994	228.0	
AOC_43A	43MA93-06X	1/31/1995	228.2	
AOC_43A	43MA93-06X	5/9/1995	228.1	
AOC_43A	43MA93-06X	12/7/1995	226.9	
AOC_43A	43MA93-06X	7/23/1996	230.1	
AOC_43A	43MA93-06X	1/15/1997	231.6	
AOC_43A	43MA93-06X	6/2/1997	231.1	
AOC_43A	43MA93-08X	11/8/1993	227.3	
AOC_43A	43MA93-08X	6/28/1994	230.9	
AOC_43A	43MA93-08X	10/4/1994	229.3	
AOC_43A	43MA93-08X	1/31/1995	229.9	
AOC_43A	43MA93-08X	5/9/1995	229.4	
AOC_43A	43MA93-08X	12/7/1995	228.6	
AOC_43A	43MA93-08X	3/26/1996	231.6	
AOC_43G	43GPZ-19-01	6/28/2019	262.0	
AOC_43G	43GPZ-19-01	10/2/2019	262.1	
AOC_43G	43GPZ-19-01	1/2/2020	263.1	
AOC_43G	43GPZ-19-01	2/20/2020	261.9	
AOC_43G	43GPZ-19-01	3/13/2020	262.0	
AOC_43G	43GPZ-19-01	8/31/2020	261.9	
AOC_43G	43GPZ-19-02	6/28/2019	265.9	
AOC_43G	43GPZ-19-02	10/2/2019	261.6	
AOC_43G	43GPZ-19-02	1/2/2020	263.1	
AOC_43G	43GPZ-19-02	2/20/2020	262.2	
AOC_43G	43GPZ-19-02	3/13/2020	262.2	
AOC_43G	43GPZ-19-02	8/31/2020	261.4	
AOC_43G	43GPZ-19-03	6/28/2019	285.0	
AOC_43G	43GPZ-19-03	10/2/2019	283.7	
AOC_43G	43GPZ-19-03	1/2/2020	286.0	
AOC_43G	43GPZ-19-03	2/20/2020	285.4	
AOC_43G	43GPZ-19-03	3/13/2020	285.3	
AOC_43G	43GPZ-19-03	8/31/2020	283.6	
AOC_43G	43GPZ-19-04	6/28/2019	249.7	
AOC_43G	43GPZ-19-04	10/2/2019	247.1	
AOC_43G	43GPZ-19-04	1/2/2020	249.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_43G	43GPZ-19-04	2/20/2020	249.6	
AOC_43G	43GPZ-19-04	3/13/2020	249.5	
AOC_43G	43GPZ-19-04	8/31/2020	246.8	
AOC_43G	43GPZ-19-05	6/28/2019	246.9	
AOC_43G	43GPZ-19-05	10/2/2019	245.2	
AOC_43G	43GPZ-19-05	1/2/2020	247.6	
AOC_43G	43GPZ-19-05	2/20/2020	247.4	
AOC_43G	43GPZ-19-05	3/13/2020	247.2	
AOC_43G	43GPZ-19-05	8/31/2020	245.1	
AOC_43G	43GPZ-19-06	6/28/2019	245.2	
AOC_43G	43GPZ-19-06	10/2/2019	244.3	
AOC_43G	43GPZ-19-06	1/2/2020	245.8	
AOC_43G	43GPZ-19-06	2/20/2020	245.8	
AOC_43G	43GPZ-19-06	3/13/2020	245.8	
AOC_43G	43GPZ-19-06	8/31/2020	243.2	
AOC_43G	43GPZ-19-07	1/2/2020	245.2	
AOC_43G	43GPZ-19-07	2/20/2020	245.3	
AOC_43G	43GPZ-19-07	3/12/2020	245.2	
AOC_43G	43GPZ-19-07	3/13/2020	245.4	
AOC_43G	43GPZ-19-07	8/31/2020	243.2	
AOC_43G	43GPZ-19-08	1/2/2020	246.7	
AOC_43G	43GPZ-19-08	2/20/2020	246.4	
AOC_43G	43GPZ-19-08	3/13/2020	246.3	
AOC_43G	43GPZ-19-08	8/31/2020	242.8	
AOC_43G	AAFES-2	10/12/2005	276.8	
AOC_43G	AAFES-2	10/16/2006	277.9	
AOC_43G	AAFES-2	10/18/2007	277.3	
AOC_43G	AAFES-2	10/27/2008	279.1	
AOC_43G	AAFES-2	11/24/2009	280.2	
AOC_43G	AAFES-2	10/20/2010	280.5	
AOC_43G	AAFES-2	10/24/2013	276.3	
AOC_43G	AAFES-2	10/21/2014	277.5	
AOC_43G	AAFES-2	10/8/2015	279.7	
AOC_43G	AAFES-2	10/14/2016	276.8	
AOC_43G	AAFES-2	10/24/2017	276.2	
AOC_43G	AAFES-2	10/10/2018	279.6	
AOC_43G	AAFES-2	6/28/2019	279.1	
AOC_43G	AAFES-2	10/2/2019	276.3	
AOC_43G	AAFES-2	1/2/2020	280.1	
AOC_43G	AAFES-2	2/20/2020	279.1	
AOC_43G	AAFES-5	10/12/2005	276.6	
AOC_43G	AAFES-5	10/16/2006	277.7	
AOC_43G	AAFES-5	10/18/2007	277.2	
AOC_43G	AAFES-5	10/27/2008	278.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_43G	AAFES-5	11/24/2009	279.0	
AOC_43G	AAFES-5	10/20/2010	279.1	
AOC_43G	AAFES-5	10/24/2013	276.2	
AOC_43G	AAFES-5	10/21/2014	277.1	
AOC_43G	AAFES-5	10/8/2015	279.1	
AOC_43G	AAFES-5	10/14/2016	276.4	
AOC_43G	AAFES-5	10/24/2017	276.3	
AOC_43G	AAFES-5	10/10/2018	278.2	
AOC_43G	AAFES-5	6/28/2019	277.8	
AOC_43G	AAFES-5	10/2/2019	276.3	
AOC_43G	AAFES-5	1/2/2020	278.3	
AOC_43G	AAFES-5	2/20/2020	277.8	
AOC_43G	AAFES-5	3/13/2020	278.7	
AOC_43G	AAFES-5	8/31/2020	276.2	
AOC_43G	AAFES-6R	10/18/2007		
AOC_43G	AAFES-6R	10/27/2008		
AOC_43G	AAFES-6R	11/24/2009		
AOC_43G	AAFES-6R	10/20/2010		
AOC_43G	AAFES-6R	10/24/2013	276.6	
AOC_43G	AAFES-6R	10/21/2014	278.1	
AOC_43G	AAFES-6R	10/8/2015	280.4	
AOC_43G	AAFES-6R	10/14/2016	276.4	
AOC_43G	AAFES-6R	10/24/2017	276.9	
AOC_43G	AAFES-6R	10/10/2018	280.4	
AOC_43G	AAFES-6R	10/2/2019	277.0	
AOC_43G	AAFES-6R	1/2/2020	281.2	
AOC_43G	AAFES-6R	2/20/2020	279.0	
AOC_43G	AAFES-7	6/27/2008	251.0	
AOC_43G	AAFES-7	10/27/2009	251.4	
AOC_43G	AAFES-7	11/24/2009	251.5	
AOC_43G	AAFES-7	10/20/2010	250.6	
AOC_43G	AAFES-7	10/24/2013	247.4	
AOC_43G	AAFES-7	10/21/2014	247.6	
AOC_43G	AAFES-7	10/8/2015	248.2	
AOC_43G	AAFES-7	10/14/2016	245.5	
AOC_43G	AAFES-7	10/24/2017	247.4	
AOC_43G	AAFES-7	10/10/2018	251.4	
AOC_43G	AAFES-7	6/28/2019	250.8	
AOC_43G	AAFES-7	10/2/2019	248.0	
AOC_43G	AAFES-7	1/2/2020	251.6	
AOC_43G	AAFES-7	2/20/2020	251.0	
AOC_43G	AAFES-7	3/13/2020	250.8	
AOC_43G	AAFES-7	8/31/2020	247.4	
AOC_43G	XGM-20-01A	2/20/2020	250.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_43G	XGM-20-01A	3/13/2020	250.0	
AOC_43G	XGM-20-01A	8/31/2020	246.2	
AOC_43G	XGM-20-02A	2/20/2020	253.0	
AOC_43G	XGM-20-02A	3/13/2020	252.7	
AOC_43G	XGM-20-02A	8/31/2020	248.5	
AOC_43G	XGM-20-03A	2/20/2020	254.0	
AOC_43G	XGM-20-03A	3/13/2020	253.9	
AOC_43G	XGM-20-03A	8/31/2020	250.0	
AOC_43G	XGM-93-02X	10/12/2005	279.1	
AOC_43G	XGM-93-02X	10/16/2006	279.2	
AOC_43G	XGM-93-02X	10/18/2007	278.9	
AOC_43G	XGM-93-02X	10/27/2008	279.7	
AOC_43G	XGM-93-02X	11/24/2009	281.0	
AOC_43G	XGM-93-02X	10/20/2010	281.3	
AOC_43G	XGM-93-02X	10/24/2013	278.4	
AOC_43G	XGM-93-02X	10/21/2014	278.9	
AOC_43G	XGM-93-02X	10/8/2015	280.8	
AOC_43G	XGM-93-02X	10/14/2016	278.6	
AOC_43G	XGM-93-02X	10/24/2017	278.3	
AOC_43G	XGM-93-02X	10/10/2018	281.1	
AOC_43G	XGM-93-02X	10/2/2019	279.8	
AOC_43G	XGM-93-02X	1/2/2020	281.7	
AOC_43G	XGM-94-04X	10/12/2005	279.9	
AOC_43G	XGM-94-04X	10/16/2006	280.1	
AOC_43G	XGM-94-04X	10/18/2007	279.7	
AOC_43G	XGM-94-04X	10/27/2008	281.1	
AOC_43G	XGM-94-04X	11/24/2009	282.0	
AOC_43G	XGM-94-04X	10/20/2010	282.2	
AOC_43G	XGM-94-04X	10/24/2013	278.5	
AOC_43G	XGM-94-04X	10/21/2014	279.4	
AOC_43G	XGM-94-04X	10/8/2015	282.0	
AOC_43G	XGM-94-04X	10/14/2016	278.6	
AOC_43G	XGM-94-04X	10/24/2017	278.8	
AOC_43G	XGM-94-04X	10/10/2018	282.0	
AOC_43G	XGM-94-04X	6/28/2019	281.3	
AOC_43G	XGM-94-04X	10/2/2019	279.1	
AOC_43G	XGM-94-04X	1/2/2020	282.3	
AOC_43G	XGM-94-04X	2/20/2020	281.5	
AOC_43G	XGM-94-04X	3/13/2020	281.1	
AOC_43G	XGM-94-04X	8/31/2020	279.1	
AOC_43G	XGM-94-06X	6/27/2008	263.4	
AOC_43G	XGM-94-06X	10/27/2008	263.5	
AOC_43G	XGM-94-06X	6/28/2019	262.9	
AOC_43G	XGM-94-06X	10/2/2019	259.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_43G	XGM-94-06X	1/2/2020	265.7	
AOC_43G	XGM-94-06X	2/20/2020	263.8	
AOC_43G	XGM-94-06X	3/13/2020	263.8	
AOC_43G	XGM-94-06X	8/31/2020	259.2	
AOC_43G	XGM-94-07X	10/12/2005	274.0	
AOC_43G	XGM-94-07X	10/16/2006	274.4	
AOC_43G	XGM-94-07X	10/18/2007	274.1	
AOC_43G	XGM-94-07X	10/27/2008	275.5	
AOC_43G	XGM-94-07X	11/24/2009	276.1	
AOC_43G	XGM-94-07X	10/15/2010	276.1	
AOC_43G	XGM-94-07X	10/24/2013		
AOC_43G	XGM-94-07X	10/21/2014	273.9	
AOC_43G	XGM-94-07X	10/8/2015	277.9	
AOC_43G	XGM-94-07X	10/14/2016	273.2	
AOC_43G	XGM-94-07X	10/24/2017	273.1	
AOC_43G	XGM-94-07X	10/10/2018	275.4	
AOC_43G	XGM-94-07X	6/28/2019	280.1	
AOC_43G	XGM-94-07X	10/2/2019	273.3	
AOC_43G	XGM-94-07X	1/2/2020	275.7	
AOC_43G	XGM-94-07X	2/20/2020	275.3	
AOC_43G	XGM-94-07X	8/31/2020	272.9	
AOC_43G	XGM-94-08X	10/12/2005	272.7	
AOC_43G	XGM-94-08X	10/16/2006	272.4	
AOC_43G	XGM-94-08X	10/18/2007	275.5	
AOC_43G	XGM-94-08X	10/27/2008	273.3	
AOC_43G	XGM-94-08X	11/24/2009	274.4	
AOC_43G	XGM-94-08X	10/20/2010	274.4	
AOC_43G	XGM-94-08X	10/24/2013	271.2	
AOC_43G	XGM-94-08X	10/21/2014	272.2	
AOC_43G	XGM-94-08X	10/8/2015	273.4	
AOC_43G	XGM-94-08X	10/14/2016	271.6	
AOC_43G	XGM-94-08X	10/24/2017	271.2	
AOC_43G	XGM-94-08X	10/10/2018	273.9	
AOC_43G	XGM-94-08X	6/28/2019	272.9	
AOC_43G	XGM-94-08X	10/2/2019	271.5	
AOC_43G	XGM-94-08X	1/2/2020	274.8	
AOC_43G	XGM-94-08X	2/20/2020	273.2	
AOC_43G	XGM-94-10X	10/12/2005	278.2	
AOC_43G	XGM-94-10X	10/16/2006	276.8	
AOC_43G	XGM-94-10X	10/18/2007	275.9	
AOC_43G	XGM-94-10X	10/27/2008	277.1	
AOC_43G	XGM-94-10X	11/24/2009		
AOC_43G	XGM-94-10X	10/20/2010	278.2	
AOC_43G	XGM-94-10X	10/24/2013	275.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_43G	XGM-94-10X	10/21/2014	275.8	
AOC_43G	XGM-94-10X	10/8/2015	277.0	
AOC_43G	XGM-94-10X	10/14/2016	275.3	
AOC_43G	XGM-94-10X	10/24/2017	275.3	
AOC_43G	XGM-94-10X	10/10/2018	277.9	
AOC_43G	XGM-94-10X	6/28/2019	276.8	
AOC_43G	XGM-94-10X	10/2/2019	275.3	
AOC_43G	XGM-94-10X	1/2/2020	278.9	
AOC_43G	XGM-94-10X	2/20/2020	277.4	
AOC_43G	XGM-94-10X	3/13/2020	277.4	
AOC_43G	XGM-94-10X	8/31/2020	275.2	
AOC_43G	XGM-97-12X	10/12/2005	282.1	
AOC_43G	XGM-97-12X	10/16/2006	282.1	
AOC_43G	XGM-97-12X	10/18/2007	282.0	
AOC_43G	XGM-97-12X	10/27/2008	284.0	
AOC_43G	XGM-97-12X	11/24/2009	284.3	
AOC_43G	XGM-97-12X	10/20/2010	284.3	
AOC_43G	XGM-97-12X	10/24/2013	281.4	
AOC_43G	XGM-97-12X	10/21/2014	281.8	
AOC_43G	XGM-97-12X	10/8/2015	283.5	
AOC_43G	XGM-97-12X	10/14/2016	281.4	
AOC_43G	XGM-97-12X	10/24/2017	281.5	
AOC_43G	XGM-97-12X	10/10/2018	284.4	
AOC_43G	XGM-97-12X	6/28/2019	283.6	
AOC_43G	XGM-97-12X	10/2/2019	281.5	
AOC_43G	XGM-97-12X	1/2/2020	284.5	
AOC_43G	XGM-97-12X	2/20/2020	284.0	
AOC_43J	2446-03	10/12/2005	361.6	
AOC_43J	HA-3B	3/13/2020	356.9	
AOC_43J	HA-3S	3/13/2020	354.5	
AOC_43J	HA-4B	3/13/2020	359.3	
AOC_43J	HA-4S	3/13/2020	357.7	
AOC_43J	XJM-93-01X	3/13/2020	364.4	
AOC_43J	XJM-93-04X	3/13/2020	364.1	
AOC_43J	XJM-94-07X	3/13/2020	357.1	
AOC_43J	XJM-94-08X	10/12/2005	358.6	
AOC_43J	XJM-94-08X	3/13/2020	358.7	
AOC_43J	XJM-94-10X	10/12/2005	359.8	
AOC_43J	XJM-94-10X	3/13/2020	361.6	
AOC_43J	XJM-97-11X	10/12/2005	361.3	
AOC_43J	XJM-97-11X	3/13/2020	361.9	
AOC_43J	XJM-97-12X	10/12/2005	362.6	
AOC_43J	XJM-97-13X	10/12/2005	359.1	
AOC_43J	XJM-97-13X	3/13/2020	359.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	3-1	4/28/2009	246.4	
AOC_5	3-1	8/5/2009	243.1	
AOC_5	3-1	9/9/2009	239.1	
AOC_5	3-1	3/17/2010	249.1	
AOC_5	3-2	4/28/2009	245.7	
AOC_5	3-2	9/9/2009	238.0	
AOC_5	3-2	3/17/2010	248.5	
AOC_5	3-2	6/24/2016	240.1	
AOC_5	3-2	11/15/2016	231.3	
AOC_5	3-2	11/1/2018	241.1	
AOC_5	3-2	10/22/2019	228.7	
AOC_5	20-1	10/23/2008	263.7	
AOC_5	20-1	4/24/2009	259.6	
AOC_5	20-1	4/28/2009	263.4	
AOC_5	20-1	5/21/2009	261.6	
AOC_5	20-1	8/4/2009	261.9	
AOC_5	20-1	8/5/2009	260.6	
AOC_5	20-1	9/9/2009	250.2	
AOC_5	20-1	9/10/2009	260.2	
AOC_5	20-1	3/17/2010	268.9	
AOC_5	20-1	6/24/2016	250.3	
AOC_5	20-1	11/15/2016	234.4	
AOC_5	20-1	5/22/2017	260.7	
AOC_5	20-1	11/1/2018	260.2	
AOC_5	20-1	10/22/2019	239.0	
AOC_5	20-2	10/23/2008	262.4	
AOC_5	20-2	4/24/2009	254.9	
AOC_5	20-2	4/28/2009	264.0	
AOC_5	20-2	5/21/2009	259.7	
AOC_5	20-2	8/4/2009	259.5	
AOC_5	20-2	8/5/2009	262.2	
AOC_5	20-2	9/9/2009	250.5	
AOC_5	20-2	9/10/2009	249.1	
AOC_5	20-2	3/17/2010	270.5	
AOC_5	27-1	4/28/2009	268.6	
AOC_5	27-1	8/5/2009	264.8	
AOC_5	27-1	9/9/2009	253.3	
AOC_5	27-1	3/17/2010	272.6	
AOC_5	27-1	6/24/2016	239.5	
AOC_5	27-1	11/15/2016	220.4	
AOC_5	27-1	5/22/2017	259.0	
AOC_5	27-1	11/1/2018	258.1	
AOC_5	27-1	10/22/2019	229.5	
AOC_5	27-2	4/28/2009	266.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	27-2	8/5/2009	263.6	
AOC_5	27-2	9/9/2009	252.9	
AOC_5	27-2	3/17/2010	268.9	
AOC_5	27-2	6/24/2016	250.8	
AOC_5	27-2	11/15/2016	232.4	
AOC_5	27-2	5/22/2017	255.8	
AOC_5	27-2	11/1/2018	254.2	
AOC_5	27-2	10/22/2019	227.7	
AOC_5	27-30B-1	10/23/2008	261.1	
AOC_5	27-30B-1	4/24/2009	253.3	
AOC_5	27-30B-1	5/21/2009	258.5	
AOC_5	27-30B-1	8/4/2009	258.1	
AOC_5	27-30B-1	8/5/2009	261.0	
AOC_5	27-30B-1	9/9/2009	250.0	
AOC_5	27-30B-1	9/10/2009	247.2	
AOC_5	27-30B-1	3/17/2010	267.7	
AOC_5	27-30B-2	10/23/2008	261.0	
AOC_5	27-30B-2	4/24/2009	252.8	
AOC_5	27-30B-2	8/4/2009	257.1	
AOC_5	27-30B-2	8/5/2009	261.0	
AOC_5	27-30B-2	3/17/2010	268.7	
AOC_5	3A-1	4/28/2009	245.3	
AOC_5	3A-1	9/9/2009	237.3	
AOC_5	3A-1	3/17/2010	248.4	
AOC_5	3A-2	4/28/2009	245.9	
AOC_5	3A-2	8/5/2009	242.4	
AOC_5	3A-2	9/9/2009	238.2	
AOC_5	3A-2	3/17/2010	248.9	
AOC_5	CAP-1B	4/28/2009	241.7	
AOC_5	CAP-1B	9/9/2009	234.1	
AOC_5	CAP-1B	3/17/2010	242.7	
AOC_5	CAP-2B	4/28/2009	247.0	
AOC_5	CAP-2B	8/5/2009	243.3	
AOC_5	CAP-2B	9/9/2009	238.0	
AOC_5	CAP-2B	3/17/2010	247.7	
AOC_5	CAP-2B	6/24/2016	235.8	
AOC_5	CAP-2B	11/15/2016		
AOC_5	CAP-2B	5/22/2017	242.9	
AOC_5	CAP-2B	11/1/2018	240.9	
AOC_5	CAP-2B	10/22/2019	227.4	
AOC_5	CAP-3	4/28/2009	244.7	
AOC_5	CAP-3	8/5/2009	250.8	
AOC_5	CAP-3	9/9/2009	237.4	
AOC_5	CAP-3	3/17/2010	247.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	CAP-4	4/28/2009	245.2	
AOC_5	CAP-4	3/17/2010	247.4	
AOC_5	CH-1D	10/13/2009	233.4	
AOC_5	CH-1D	11/2/2009	231.7	
AOC_5	CH-1D	3/17/2010	248.7	
AOC_5	CH-1D	10/7/2015	228.6	
AOC_5	CH-1D	12/16/2015	231.8	
AOC_5	CH-1D	6/24/2016	236.4	
AOC_5	CH-1D	11/16/2016	213.7	
AOC_5	CH-1D	5/22/2017	242.5	
AOC_5	CH-1D	11/1/2018	240.9	
AOC_5	CH-1D	10/22/2019	228.8	
AOC_5	CH-1S	10/13/2009	231.8	
AOC_5	CH-1S	11/2/2009	231.6	
AOC_5	CH-1S	3/17/2010	248.4	
AOC_5	CH-1S	6/24/2016		
AOC_5	CH-1S	11/16/2016	216.3	
AOC_5	CH-1S	5/22/2017	242.2	
AOC_5	CH-1S	11/1/2018	240.7	
AOC_5	CH-1S	10/22/2019	228.6	
AOC_5	EPA-PZ-2012-1A	6/19/2012	212.6	
AOC_5	EPA-PZ-2012-1A	9/11/2012	211.4	
AOC_5	EPA-PZ-2012-1A	11/5/2012	212.9	
AOC_5	EPA-PZ-2012-1A	11/6/2012	213.0	
AOC_5	EPA-PZ-2012-1A	3/13/2013	213.4	
AOC_5	EPA-PZ-2012-1A	4/23/2013	212.7	
AOC_5	EPA-PZ-2012-1A	4/25/2013	212.7	
AOC_5	EPA-PZ-2012-1A	5/15/2013	212.2	
AOC_5	EPA-PZ-2012-1A	5/30/2013	213.1	
AOC_5	EPA-PZ-2012-1A	4/22/2014	213.7	
AOC_5	EPA-PZ-2012-1A	10/6/2014	211.4	
AOC_5	EPA-PZ-2012-1A	6/4/2015	212.6	
AOC_5	EPA-PZ-2012-1A	6/17/2015	212.4	
AOC_5	EPA-PZ-2012-1A	10/20/2015	211.3	
AOC_5	EPA-PZ-2012-1A	12/16/2015	211.7	
AOC_5	EPA-PZ-2012-1A	6/9/2016	212.2	
AOC_5	EPA-PZ-2012-1A	6/23/2016	211.7	
AOC_5	EPA-PZ-2012-1A	8/16/2016	211.0	
AOC_5	EPA-PZ-2012-1A	11/16/2016	212.1	
AOC_5	EPA-PZ-2012-1A	5/22/2017	213.4	
AOC_5	EPA-PZ-2012-1A	5/11/2018	213.5	
AOC_5	EPA-PZ-2012-1A	11/1/2018	213.1	
AOC_5	EPA-PZ-2012-1A	4/11/2019	213.0	
AOC_5	EPA-PZ-2012-1A	10/22/2019	211.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	EPA-PZ-2012-1A	5/18/2020	213.4	
AOC_5	EPA-PZ-2012-1A	5/19/2020	213.5	
AOC_5	EPA-PZ-2012-1B	6/19/2012	212.4	
AOC_5	EPA-PZ-2012-1B	9/11/2012	211.4	
AOC_5	EPA-PZ-2012-1B	11/5/2012	213.0	
AOC_5	EPA-PZ-2012-1B	11/6/2012	212.9	
AOC_5	EPA-PZ-2012-1B	3/13/2013	213.3	
AOC_5	EPA-PZ-2012-1B	4/23/2013	212.7	
AOC_5	EPA-PZ-2012-1B	4/25/2013	212.7	
AOC_5	EPA-PZ-2012-1B	5/15/2013	212.2	
AOC_5	EPA-PZ-2012-1B	5/30/2013	213.1	
AOC_5	EPA-PZ-2012-1B	4/22/2014	213.7	
AOC_5	EPA-PZ-2012-1B	10/6/2014	211.4	
AOC_5	EPA-PZ-2012-1B	6/4/2015	212.7	
AOC_5	EPA-PZ-2012-1B	6/17/2015	212.4	
AOC_5	EPA-PZ-2012-1B	10/20/2015	211.3	
AOC_5	EPA-PZ-2012-1B	12/16/2015	211.7	
AOC_5	EPA-PZ-2012-1B	6/9/2016	212.2	
AOC_5	EPA-PZ-2012-1B	6/23/2016	211.7	
AOC_5	EPA-PZ-2012-1B	8/16/2016	211.0	
AOC_5	EPA-PZ-2012-1B	10/20/2016	210.9	
AOC_5	EPA-PZ-2012-1B	11/16/2016	212.2	
AOC_5	EPA-PZ-2012-1B	5/22/2017	213.4	
AOC_5	EPA-PZ-2012-1B	5/11/2018	213.5	
AOC_5	EPA-PZ-2012-1B	11/1/2018	213.1	
AOC_5	EPA-PZ-2012-1B	4/11/2019	213.0	
AOC_5	EPA-PZ-2012-1B	10/22/2019	211.7	
AOC_5	EPA-PZ-2012-1B	5/18/2020	213.4	
AOC_5	EPA-PZ-2012-1B	5/19/2020	213.4	
AOC_5	EPA-PZ-2012-2A	6/19/2012	212.6	
AOC_5	EPA-PZ-2012-2A	9/11/2012	211.5	
AOC_5	EPA-PZ-2012-2A	11/5/2012	213.0	
AOC_5	EPA-PZ-2012-2A	11/6/2012	213.1	
AOC_5	EPA-PZ-2012-2A	3/13/2013	213.7	
AOC_5	EPA-PZ-2012-2A	4/23/2013	212.8	
AOC_5	EPA-PZ-2012-2A	4/25/2013	212.8	
AOC_5	EPA-PZ-2012-2A	5/15/2013	212.3	
AOC_5	EPA-PZ-2012-2A	5/30/2013	213.4	
AOC_5	EPA-PZ-2012-2A	4/22/2014	213.8	
AOC_5	EPA-PZ-2012-2A	10/6/2014	211.6	
AOC_5	EPA-PZ-2012-2A	6/4/2015	212.9	
AOC_5	EPA-PZ-2012-2A	6/17/2015	212.3	
AOC_5	EPA-PZ-2012-2A	10/20/2015	211.6	
AOC_5	EPA-PZ-2012-2A	12/16/2015	211.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	EPA-PZ-2012-2A	6/9/2016	212.2	
AOC_5	EPA-PZ-2012-2A	6/23/2016	211.8	
AOC_5	EPA-PZ-2012-2A	8/16/2016	211.2	
AOC_5	EPA-PZ-2012-2A	11/16/2016	212.5	
AOC_5	EPA-PZ-2012-2A	5/22/2017	213.4	
AOC_5	EPA-PZ-2012-2A	5/11/2018	213.5	
AOC_5	EPA-PZ-2012-2A	11/1/2018	213.2	
AOC_5	EPA-PZ-2012-2A	4/11/2019	213.0	
AOC_5	EPA-PZ-2012-2A	10/22/2019	212.0	
AOC_5	EPA-PZ-2012-2A	5/18/2020	213.4	
AOC_5	EPA-PZ-2012-2A	5/19/2020	213.5	
AOC_5	EPA-PZ-2012-2B	6/19/2012	212.6	
AOC_5	EPA-PZ-2012-2B	9/11/2012	211.6	
AOC_5	EPA-PZ-2012-2B	11/5/2012	212.9	
AOC_5	EPA-PZ-2012-2B	11/6/2012	213.0	
AOC_5	EPA-PZ-2012-2B	3/13/2013	213.3	
AOC_5	EPA-PZ-2012-2B	4/23/2013	212.7	
AOC_5	EPA-PZ-2012-2B	4/25/2013	212.7	
AOC_5	EPA-PZ-2012-2B	5/15/2013	212.3	
AOC_5	EPA-PZ-2012-2B	5/30/2013	213.1	
AOC_5	EPA-PZ-2012-2B	4/22/2014	213.7	
AOC_5	EPA-PZ-2012-2B	10/6/2014	211.7	
AOC_5	EPA-PZ-2012-2B	6/4/2015	212.8	
AOC_5	EPA-PZ-2012-2B	6/17/2015	212.4	
AOC_5	EPA-PZ-2012-2B	10/20/2015	211.6	
AOC_5	EPA-PZ-2012-2B	12/16/2015	211.9	
AOC_5	EPA-PZ-2012-2B	6/9/2016	212.3	
AOC_5	EPA-PZ-2012-2B	6/23/2016	211.9	
AOC_5	EPA-PZ-2012-2B	8/16/2016	211.3	
AOC_5	EPA-PZ-2012-2B	10/20/2016	211.2	
AOC_5	EPA-PZ-2012-2B	11/16/2016	212.5	
AOC_5	EPA-PZ-2012-2B	5/22/2017	213.3	
AOC_5	EPA-PZ-2012-2B	5/11/2018	213.4	
AOC_5	EPA-PZ-2012-2B	11/1/2018	213.1	
AOC_5	EPA-PZ-2012-2B	4/11/2019	213.0	
AOC_5	EPA-PZ-2012-2B	10/22/2019	211.9	
AOC_5	EPA-PZ-2012-2B	5/18/2020	213.4	
AOC_5	EPA-PZ-2012-2B	5/20/2020	213.3	
AOC_5	EPA-PZ-2012-3A	6/19/2012	212.0	
AOC_5	EPA-PZ-2012-3A	9/11/2012	210.9	
AOC_5	EPA-PZ-2012-3A	11/5/2012	212.5	
AOC_5	EPA-PZ-2012-3A	11/6/2012	212.4	
AOC_5	EPA-PZ-2012-3A	3/13/2013	212.9	
AOC_5	EPA-PZ-2012-3A	4/23/2013	212.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	EPA-PZ-2012-3A	4/25/2013	212.2	
AOC_5	EPA-PZ-2012-3A	5/15/2013	211.6	
AOC_5	EPA-PZ-2012-3A	5/30/2013	212.5	
AOC_5	EPA-PZ-2012-3A	4/22/2014	213.3	
AOC_5	EPA-PZ-2012-3A	10/6/2014	210.8	
AOC_5	EPA-PZ-2012-3A	6/4/2015	212.2	
AOC_5	EPA-PZ-2012-3A	6/17/2015	211.9	
AOC_5	EPA-PZ-2012-3A	10/20/2015	210.6	
AOC_5	EPA-PZ-2012-3A	12/16/2015	211.0	
AOC_5	EPA-PZ-2012-3A	6/9/2016	211.7	
AOC_5	EPA-PZ-2012-3A	6/23/2016	211.1	
AOC_5	EPA-PZ-2012-3A	8/16/2016	210.4	
AOC_5	EPA-PZ-2012-3A	11/16/2016	211.5	
AOC_5	EPA-PZ-2012-3A	5/22/2017	212.9	
AOC_5	EPA-PZ-2012-3A	5/11/2018	212.9	
AOC_5	EPA-PZ-2012-3A	11/1/2018	212.5	
AOC_5	EPA-PZ-2012-3A	4/11/2019	212.5	
AOC_5	EPA-PZ-2012-3A	10/22/2019	211.0	
AOC_5	EPA-PZ-2012-3A	5/18/2020	212.8	
AOC_5	EPA-PZ-2012-3A	5/21/2020	212.7	
AOC_5	EPA-PZ-2012-3B	6/19/2012	212.1	
AOC_5	EPA-PZ-2012-3B	9/11/2012	210.8	
AOC_5	EPA-PZ-2012-3B	11/5/2012	212.4	
AOC_5	EPA-PZ-2012-3B	11/6/2012	212.3	
AOC_5	EPA-PZ-2012-3B	3/13/2013	212.8	
AOC_5	EPA-PZ-2012-3B	4/23/2013	212.2	
AOC_5	EPA-PZ-2012-3B	4/25/2013	212.1	
AOC_5	EPA-PZ-2012-3B	5/15/2013	211.6	
AOC_5	EPA-PZ-2012-3B	5/30/2013	212.5	
AOC_5	EPA-PZ-2012-3B	4/22/2014	213.1	
AOC_5	EPA-PZ-2012-3B	10/6/2014	211.4	
AOC_5	EPA-PZ-2012-3B	6/4/2015	212.1	
AOC_5	EPA-PZ-2012-3B	6/17/2015	211.9	
AOC_5	EPA-PZ-2012-3B	10/20/2015	210.6	
AOC_5	EPA-PZ-2012-3B	12/16/2015	211.0	
AOC_5	EPA-PZ-2012-3B	6/9/2016	211.7	
AOC_5	EPA-PZ-2012-3B	6/23/2016	211.1	
AOC_5	EPA-PZ-2012-3B	8/16/2016	210.3	
AOC_5	EPA-PZ-2012-3B	10/20/2016	210.2	
AOC_5	EPA-PZ-2012-3B	11/16/2016	211.4	
AOC_5	EPA-PZ-2012-3B	5/22/2017	212.8	
AOC_5	EPA-PZ-2012-3B	5/11/2018	212.8	
AOC_5	EPA-PZ-2012-3B	11/1/2018	212.4	
AOC_5	EPA-PZ-2012-3B	4/11/2019	212.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	EPA-PZ-2012-3B	10/22/2019	211.0	
AOC_5	EPA-PZ-2012-3B	5/18/2020	212.9	
AOC_5	EPA-PZ-2012-3B	5/21/2020	212.7	
AOC_5	EPA-PZ-2012-4A	6/19/2012	211.8	
AOC_5	EPA-PZ-2012-4A	9/11/2012	210.6	
AOC_5	EPA-PZ-2012-4A	11/5/2012	212.2	
AOC_5	EPA-PZ-2012-4A	11/6/2012	212.2	
AOC_5	EPA-PZ-2012-4A	3/13/2013	212.7	
AOC_5	EPA-PZ-2012-4A	4/23/2013	212.0	
AOC_5	EPA-PZ-2012-4A	4/25/2013	212.0	
AOC_5	EPA-PZ-2012-4A	5/15/2013	211.4	
AOC_5	EPA-PZ-2012-4A	5/30/2013	212.4	
AOC_5	EPA-PZ-2012-4A	4/22/2014	213.0	
AOC_5	EPA-PZ-2012-4A	10/6/2014	210.5	
AOC_5	EPA-PZ-2012-4A	6/4/2015	211.9	
AOC_5	EPA-PZ-2012-4A	6/17/2015	211.9	
AOC_5	EPA-PZ-2012-4A	10/20/2015	210.4	
AOC_5	EPA-PZ-2012-4A	12/16/2015	210.7	
AOC_5	EPA-PZ-2012-4A	6/9/2016	211.6	
AOC_5	EPA-PZ-2012-4A	6/23/2016	210.8	
AOC_5	EPA-PZ-2012-4A	8/16/2016	210.1	
AOC_5	EPA-PZ-2012-4A	11/16/2016	211.3	
AOC_5	EPA-PZ-2012-4A	5/22/2017	212.6	
AOC_5	EPA-PZ-2012-4A	5/11/2018	212.7	
AOC_5	EPA-PZ-2012-4A	11/1/2018	212.2	
AOC_5	EPA-PZ-2012-4A	4/11/2019	212.2	
AOC_5	EPA-PZ-2012-4A	10/22/2019	210.7	
AOC_5	EPA-PZ-2012-4A	5/18/2020	212.7	
AOC_5	EPA-PZ-2012-4A	5/19/2020	212.7	
AOC_5	EPA-PZ-2012-4B	6/19/2012	211.8	
AOC_5	EPA-PZ-2012-4B	9/11/2012	210.5	
AOC_5	EPA-PZ-2012-4B	11/5/2012	212.0	
AOC_5	EPA-PZ-2012-4B	11/6/2012	212.1	
AOC_5	EPA-PZ-2012-4B	3/13/2013	212.6	
AOC_5	EPA-PZ-2012-4B	4/23/2013	211.9	
AOC_5	EPA-PZ-2012-4B	4/25/2013	211.9	
AOC_5	EPA-PZ-2012-4B	5/15/2013	211.3	
AOC_5	EPA-PZ-2012-4B	5/30/2013	212.2	
AOC_5	EPA-PZ-2012-4B	4/22/2014	213.1	
AOC_5	EPA-PZ-2012-4B	10/6/2014	210.2	
AOC_5	EPA-PZ-2012-4B	6/4/2015	211.7	
AOC_5	EPA-PZ-2012-4B	6/17/2015	211.9	
AOC_5	EPA-PZ-2012-4B	10/20/2015	210.1	
AOC_5	EPA-PZ-2012-4B	12/16/2015	210.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	EPA-PZ-2012-4B	6/9/2016	211.6	
AOC_5	EPA-PZ-2012-4B	6/23/2016	210.8	
AOC_5	EPA-PZ-2012-4B	8/16/2016	209.9	
AOC_5	EPA-PZ-2012-4B	10/20/2016	209.8	
AOC_5	EPA-PZ-2012-4B	11/16/2016	211.2	
AOC_5	EPA-PZ-2012-4B	5/22/2017	212.5	
AOC_5	EPA-PZ-2012-4B	5/11/2018	212.6	
AOC_5	EPA-PZ-2012-4B	11/1/2018	212.2	
AOC_5	EPA-PZ-2012-4B	4/11/2019	211.2	
AOC_5	EPA-PZ-2012-4B	10/22/2019	210.6	
AOC_5	EPA-PZ-2012-4B	5/18/2020	212.5	
AOC_5	EPA-PZ-2012-4B	5/19/2020	212.5	
AOC_5	EPA-PZ-2012-5A	6/19/2012	212.1	
AOC_5	EPA-PZ-2012-5A	9/11/2012	210.9	
AOC_5	EPA-PZ-2012-5A	11/5/2012	212.5	
AOC_5	EPA-PZ-2012-5A	11/6/2012	212.5	
AOC_5	EPA-PZ-2012-5A	3/13/2013	213.5	
AOC_5	EPA-PZ-2012-5A	4/23/2013	212.3	
AOC_5	EPA-PZ-2012-5A	4/25/2013	212.2	
AOC_5	EPA-PZ-2012-5A	5/30/2013	212.7	
AOC_5	EPA-PZ-2012-5A	4/22/2014	213.3	
AOC_5	EPA-PZ-2012-5A	10/6/2014	210.9	
AOC_5	EPA-PZ-2012-5A	6/4/2015	212.3	
AOC_5	EPA-PZ-2012-5A	6/17/2015	211.8	
AOC_5	EPA-PZ-2012-5A	10/20/2015	210.7	
AOC_5	EPA-PZ-2012-5A	12/16/2015	211.2	
AOC_5	EPA-PZ-2012-5A	6/9/2016	211.6	
AOC_5	EPA-PZ-2012-5A	6/23/2016	211.2	
AOC_5	EPA-PZ-2012-5A	8/16/2016	210.5	
AOC_5	EPA-PZ-2012-5A	11/16/2016	211.8	
AOC_5	EPA-PZ-2012-5A	5/22/2017	212.9	
AOC_5	EPA-PZ-2012-5A	5/11/2018	212.9	
AOC_5	EPA-PZ-2012-5A	11/1/2018	212.6	
AOC_5	EPA-PZ-2012-5A	4/11/2019	212.5	
AOC_5	EPA-PZ-2012-5A	10/22/2019	211.1	
AOC_5	EPA-PZ-2012-5A	5/18/2020	208.7	
AOC_5	EPA-PZ-2012-5A	5/22/2020	212.6	
AOC_5	EPA-PZ-2012-5B	6/19/2012	212.1	
AOC_5	EPA-PZ-2012-5B	9/11/2012	211.0	
AOC_5	EPA-PZ-2012-5B	11/5/2012	212.5	
AOC_5	EPA-PZ-2012-5B	11/6/2012	212.4	
AOC_5	EPA-PZ-2012-5B	3/13/2013	212.9	
AOC_5	EPA-PZ-2012-5B	4/23/2013	212.2	
AOC_5	EPA-PZ-2012-5B	4/25/2013	212.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	EPA-PZ-2012-5B	5/15/2013	211.7	
AOC_5	EPA-PZ-2012-5B	5/30/2013	212.5	
AOC_5	EPA-PZ-2012-5B	4/22/2014	213.3	
AOC_5	EPA-PZ-2012-5B	10/6/2014	211.0	
AOC_5	EPA-PZ-2012-5B	6/4/2015	212.3	
AOC_5	EPA-PZ-2012-5B	10/20/2015	210.9	
AOC_5	EPA-PZ-2012-5B	12/16/2015	211.2	
AOC_5	EPA-PZ-2012-5B	6/9/2016	211.7	
AOC_5	EPA-PZ-2012-5B	6/23/2016	211.2	
AOC_5	EPA-PZ-2012-5B	8/16/2016	210.6	
AOC_5	EPA-PZ-2012-5B	10/20/2016	210.5	
AOC_5	EPA-PZ-2012-5B	11/16/2016	211.7	
AOC_5	EPA-PZ-2012-5B	5/22/2017	212.9	
AOC_5	EPA-PZ-2012-5B	5/11/2018	212.9	
AOC_5	EPA-PZ-2012-5B	11/1/2018	212.6	
AOC_5	EPA-PZ-2012-5B	4/11/2019	212.5	
AOC_5	EPA-PZ-2012-5B	10/22/2019	211.1	
AOC_5	EPA-PZ-2012-5B	5/18/2020	212.8	
AOC_5	EPA-PZ-2012-5B	5/22/2020	212.7	
AOC_5	EPA-PZ-2012-6A	6/19/2012	211.9	
AOC_5	EPA-PZ-2012-6A	9/11/2012	210.6	
AOC_5	EPA-PZ-2012-6A	11/5/2012	212.2	
AOC_5	EPA-PZ-2012-6A	11/6/2012	212.1	
AOC_5	EPA-PZ-2012-6A	3/13/2013	212.7	
AOC_5	EPA-PZ-2012-6A	4/23/2013	212.0	
AOC_5	EPA-PZ-2012-6A	4/25/2013	212.0	
AOC_5	EPA-PZ-2012-6A	5/15/2013	211.4	
AOC_5	EPA-PZ-2012-6A	5/30/2013	212.4	
AOC_5	EPA-PZ-2012-6A	4/22/2014	213.0	
AOC_5	EPA-PZ-2012-6A	10/6/2014	210.4	
AOC_5	EPA-PZ-2012-6A	6/4/2015	212.1	
AOC_5	EPA-PZ-2012-6A	6/17/2015	211.6	
AOC_5	EPA-PZ-2012-6A	10/20/2015	210.1	
AOC_5	EPA-PZ-2012-6A	12/16/2015	210.7	
AOC_5	EPA-PZ-2012-6A	6/9/2016	211.3	
AOC_5	EPA-PZ-2012-6A	6/23/2016		
AOC_5	EPA-PZ-2012-6A	8/16/2016	210.0	
AOC_5	EPA-PZ-2012-6A	11/16/2016	211.1	
AOC_5	EPA-PZ-2012-6A	5/22/2017	212.7	
AOC_5	EPA-PZ-2012-6A	5/11/2018	212.8	
AOC_5	EPA-PZ-2012-6A	11/1/2018	212.3	
AOC_5	EPA-PZ-2012-6A	4/11/2019	212.4	
AOC_5	EPA-PZ-2012-6A	10/22/2019	210.6	
AOC_5	EPA-PZ-2012-6A	5/18/2020	212.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	EPA-PZ-2012-6A	5/22/2020	212.5	
AOC_5	EPA-PZ-2012-6B	6/19/2012	211.1	
AOC_5	EPA-PZ-2012-6B	9/11/2012	210.6	
AOC_5	EPA-PZ-2012-6B	11/5/2012	212.0	
AOC_5	EPA-PZ-2012-6B	11/6/2012	212.0	
AOC_5	EPA-PZ-2012-6B	3/13/2013	212.5	
AOC_5	EPA-PZ-2012-6B	4/23/2013	211.9	
AOC_5	EPA-PZ-2012-6B	4/25/2013	211.9	
AOC_5	EPA-PZ-2012-6B	5/15/2013	211.3	
AOC_5	EPA-PZ-2012-6B	5/30/2013	212.2	
AOC_5	EPA-PZ-2012-6B	4/22/2014	212.8	
AOC_5	EPA-PZ-2012-6B	10/6/2014	210.4	
AOC_5	EPA-PZ-2012-6B	6/4/2015	211.8	
AOC_5	EPA-PZ-2012-6B	6/17/2015	211.7	
AOC_5	EPA-PZ-2012-6B	10/7/2015	210.6	
AOC_5	EPA-PZ-2012-6B	10/20/2015	210.0	
AOC_5	EPA-PZ-2012-6B	12/16/2015	210.6	
AOC_5	EPA-PZ-2012-6B	6/9/2016	211.5	
AOC_5	EPA-PZ-2012-6B	6/23/2016	210.7	
AOC_5	EPA-PZ-2012-6B	8/16/2016	209.9	
AOC_5	EPA-PZ-2012-6B	10/20/2016	209.8	
AOC_5	EPA-PZ-2012-6B	11/16/2016	211.1	
AOC_5	EPA-PZ-2012-6B	5/22/2017	211.5	
AOC_5	EPA-PZ-2012-6B	5/11/2018	212.6	
AOC_5	EPA-PZ-2012-6B	11/1/2018	212.2	
AOC_5	EPA-PZ-2012-6B	4/11/2019	212.2	
AOC_5	EPA-PZ-2012-6B	10/22/2019	210.5	
AOC_5	EPA-PZ-2012-6B	5/18/2020	212.7	
AOC_5	EPA-PZ-2012-6B	5/22/2020	212.3	
AOC_5	EPA-PZ-2012-7A	6/19/2012	211.9	
AOC_5	EPA-PZ-2012-7A	9/11/2012	210.7	
AOC_5	EPA-PZ-2012-7A	11/5/2012	212.2	
AOC_5	EPA-PZ-2012-7A	11/6/2012	212.1	
AOC_5	EPA-PZ-2012-7A	3/13/2013	212.5	
AOC_5	EPA-PZ-2012-7A	4/23/2013	212.1	
AOC_5	EPA-PZ-2012-7A	4/25/2013	212.1	
AOC_5	EPA-PZ-2012-7A	5/30/2013	212.3	
AOC_5	EPA-PZ-2012-7A	4/22/2014	213.2	
AOC_5	EPA-PZ-2012-7A	10/6/2014	210.5	
AOC_5	EPA-PZ-2012-7A	6/4/2015	211.9	
AOC_5	EPA-PZ-2012-7A	6/17/2015	211.5	
AOC_5	EPA-PZ-2012-7A	10/20/2015	210.1	
AOC_5	EPA-PZ-2012-7A	12/16/2015	210.7	
AOC_5	EPA-PZ-2012-7A	6/9/2016	211.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	EPA-PZ-2012-7A	6/23/2016	210.9	
AOC_5	EPA-PZ-2012-7A	8/16/2016	210.0	
AOC_5	EPA-PZ-2012-7A	11/16/2016	211.1	
AOC_5	EPA-PZ-2012-7A	5/22/2017	212.8	
AOC_5	EPA-PZ-2012-7A	5/11/2018	212.8	
AOC_5	EPA-PZ-2012-7A	11/1/2018	212.0	
AOC_5	EPA-PZ-2012-7A	4/11/2019	211.2	
AOC_5	EPA-PZ-2012-7A	10/22/2019	206.4	
AOC_5	EPA-PZ-2012-7A	5/18/2020	212.8	
AOC_5	EPA-PZ-2012-7A	5/22/2020	212.6	
AOC_5	EPA-PZ-2012-7B	6/19/2012	211.8	
AOC_5	EPA-PZ-2012-7B	9/11/2012	210.6	
AOC_5	EPA-PZ-2012-7B	11/5/2012	212.1	
AOC_5	EPA-PZ-2012-7B	11/6/2012	212.0	
AOC_5	EPA-PZ-2012-7B	3/13/2013	212.5	
AOC_5	EPA-PZ-2012-7B	4/23/2013	212.0	
AOC_5	EPA-PZ-2012-7B	4/25/2013	211.9	
AOC_5	EPA-PZ-2012-7B	5/15/2013	211.3	
AOC_5	EPA-PZ-2012-7B	5/30/2013	212.2	
AOC_5	EPA-PZ-2012-7B	4/22/2014	213.0	
AOC_5	EPA-PZ-2012-7B	10/6/2014	210.4	
AOC_5	EPA-PZ-2012-7B	6/4/2015	211.9	
AOC_5	EPA-PZ-2012-7B	6/17/2015	211.7	
AOC_5	EPA-PZ-2012-7B	10/20/2015	210.1	
AOC_5	EPA-PZ-2012-7B	12/16/2015	210.7	
AOC_5	EPA-PZ-2012-7B	6/9/2016	211.4	
AOC_5	EPA-PZ-2012-7B	6/23/2016	210.8	
AOC_5	EPA-PZ-2012-7B	8/16/2016	210.0	
AOC_5	EPA-PZ-2012-7B	10/20/2016	209.9	
AOC_5	EPA-PZ-2012-7B	11/16/2016	211.2	
AOC_5	EPA-PZ-2012-7B	5/22/2017	212.7	
AOC_5	EPA-PZ-2012-7B	5/11/2018	212.7	
AOC_5	EPA-PZ-2012-7B	11/1/2018	212.0	
AOC_5	EPA-PZ-2012-7B	4/11/2019	212.2	
AOC_5	EPA-PZ-2012-7B	10/22/2019	210.6	
AOC_5	EPA-PZ-2012-7B	5/18/2020	212.7	
AOC_5	EPA-PZ-2012-7B	5/22/2020	212.4	
AOC_5	EW-01	8/4/2005	212.9	
AOC_5	EW-01	8/24/2005	212.6	
AOC_5	EW-01	8/26/2005	212.0	
AOC_5	EW-01	4/10/2006	213.0	
AOC_5	EW-01	6/5/2006	214.7	
AOC_5	EW-01	9/18/2006	212.8	
AOC_5	EW-01	12/15/2006	213.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	EW-01	2/20/2008	213.8	
AOC_5	EW-01	2/25/2008	214.9	
AOC_5	EW-01	3/4/2008	213.4	
AOC_5	EW-01	2/14/2013	212.7	
AOC_5	EW-01	4/22/2013	199.6	
AOC_5	EW-01	5/15/2013	198.9	
AOC_5	EW-01	6/11/2013	212.6	
AOC_5	EW-01	10/21/2013	211.3	
AOC_5	EW-01	4/22/2014	213.0	
AOC_5	EW-01	10/6/2014	210.2	
AOC_5	EW-01	10/20/2015	191.6	
AOC_5	EW-01	6/23/2016	210.6	
AOC_5	EW-01	5/22/2017	212.6	
AOC_5	EW-01	5/18/2020	200.2	
AOC_5	EW-04	8/24/2005	212.4	
AOC_5	EW-04	8/26/2005	212.2	
AOC_5	EW-04	4/10/2006	212.9	
AOC_5	EW-04	6/5/2006	214.9	
AOC_5	EW-04	9/18/2006	212.6	
AOC_5	EW-04	12/15/2006	213.8	
AOC_5	EW-04	2/20/2008	214.5	
AOC_5	EW-04	2/25/2008	215.0	
AOC_5	EW-04	3/4/2008	213.9	
AOC_5	EW-04	2/14/2013	212.6	
AOC_5	EW-04	3/12/2013	191.2	
AOC_5	EW-04	4/22/2013	190.6	
AOC_5	EW-04	5/15/2013	189.5	
AOC_5	EW-04	6/11/2013	212.8	
AOC_5	EW-04	10/21/2013	211.2	
AOC_5	EW-04	4/22/2014	213.2	
AOC_5	EW-04	10/6/2014	210.4	
AOC_5	EW-04	6/23/2016	193.6	
AOC_5	EW-04	5/22/2017	212.8	
AOC_5	EW-04	5/18/2020	182.7	
AOC_5	MW 4-1	10/22/2019		
AOC_5	MW 7	10/22/2019		
AOC_5	MW-1	10/12/2015		187.2
AOC_5	MW-1	6/24/2016		
AOC_5	MW-1	11/15/2016		
AOC_5	MW-1	5/22/2017	243.5	
AOC_5	MW-1	11/1/2018	242.5	
AOC_5	MW-1	10/22/2019		
AOC_5	MW-11A	6/24/2016	249.7	
AOC_5	MW-11A	11/16/2016	249.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	MW-11A	5/22/2017		
AOC_5	MW-11A	11/1/2018		
AOC_5	MW-11A	10/22/2019	249.7	
AOC_5	MW-14	6/24/2016		
AOC_5	MW-14	11/16/2016		
AOC_5	MW-14	5/22/2017	250.1	
AOC_5	MW-14	11/1/2018	249.8	
AOC_5	MW-14	10/22/2019		
AOC_5	MW-16	6/24/2016	260.6	
AOC_5	MW-16	11/15/2016		
AOC_5	MW-16	5/22/2017		
AOC_5	MW-16	11/1/2018	260.7	
AOC_5	MW-16	10/22/2019	260.7	
AOC_5	MW-22	6/24/2016		
AOC_5	MW-22	11/15/2016		
AOC_5	MW-22	5/22/2017	261.5	
AOC_5	MW-22	11/1/2018	261.3	
AOC_5	MW-22	10/22/2019		
AOC_5	MW-4-1	6/24/2016	239.6	
AOC_5	MW-4-1	11/15/2016		
AOC_5	MW-4-1	5/22/2017	244.1	
AOC_5	MW-4-1	11/1/2018	243.6	
AOC_5	MW-9	6/24/2016	232.0	
AOC_5	MW-9	11/15/2016	232.1	
AOC_5	MW-9	5/22/2017	234.7	
AOC_5	MW-9	11/1/2018		
AOC_5	MW-9	10/22/2019		
AOC_5	N1-P1	12/7/1995	215.5	
AOC_5	N1-P1	3/26/1996	215.9	
AOC_5	N1-P1	6/2/1997	214.7	
AOC_5	N1-P1	4/23/1998	215.8	
AOC_5	N1-P1	6/19/1998	216.3	
AOC_5	N1-P1	6/26/1998	216.1	
AOC_5	N1-P1	7/1/1998	215.9	
AOC_5	N1-P1	7/17/1998	215.5	
AOC_5	N1-P1	7/31/1998	215.4	
AOC_5	N1-P1	8/28/1998	215.1	
AOC_5	N1-P1	10/14/1998	215.2	
AOC_5	N1-P1	12/10/1998	215.1	
AOC_5	N1-P1	2/23/1999	215.4	
AOC_5	N1-P1	6/6/1999	214.9	
AOC_5	N1-P1	9/8/1999	214.5	
AOC_5	N1-P1	11/16/2001	215.1	
AOC_5	N1-P1	8/4/2005	215.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N1-P1	8/24/2005	215.0	
AOC_5	N1-P1	8/26/2005	215.0	
AOC_5	N1-P1	4/10/2006	215.2	
AOC_5	N1-P1	6/5/2006	215.9	
AOC_5	N1-P1	9/18/2006	215.2	
AOC_5	N1-P1	10/19/2006	215.4	
AOC_5	N1-P1	12/15/2006	215.4	
AOC_5	N1-P1	4/8/2007	215.2	
AOC_5	N1-P1	4/9/2007	215.2	
AOC_5	N1-P1	4/26/2007	216.3	
AOC_5	N1-P1	10/15/2007	215.8	
AOC_5	N1-P1	11/7/2007	215.8	
AOC_5	N1-P1	2/20/2008	216.5	
AOC_5	N1-P1	2/25/2008	216.0	
AOC_5	N1-P1	3/4/2008	216.2	
AOC_5	N1-P1	4/16/2008	215.7	
AOC_5	N1-P1	4/28/2008	214.7	
AOC_5	N1-P1	6/10/2008	215.4	
AOC_5	N1-P1	8/19/2008	215.8	
AOC_5	N1-P1	9/15/2008	215.8	
AOC_5	N1-P1	9/30/2008	215.6	
AOC_5	N1-P1	4/28/2009	215.6	
AOC_5	N1-P1	9/14/2009	215.2	
AOC_5	N1-P1	10/26/2009	215.4	
AOC_5	N1-P1	11/3/2009	215.3	
AOC_5	N1-P1	4/20/2010	216.1	
AOC_5	N1-P1	9/14/2010	214.7	
AOC_5	N1-P1	10/7/2010	215.4	
AOC_5	N1-P1	4/4/2011	215.8	
AOC_5	N1-P1	11/8/2011	215.9	
AOC_5	N1-P1	4/10/2012	214.9	
AOC_5	N1-P1	11/5/2012	215.7	
AOC_5	N1-P1	11/6/2012	216.0	
AOC_5	N1-P1	5/15/2013	215.5	
AOC_5	N1-P1	6/11/2013	216.6	
AOC_5	N1-P1	10/21/2013		212.5
AOC_5	N1-P1	4/22/2014	216.0	
AOC_5	N1-P1	10/6/2014	215.9	
AOC_5	N1-P1	6/2/2015	216.0	
AOC_5	N1-P1	6/17/2015	215.4	
AOC_5	N1-P1	8/18/2015	215.3	
AOC_5	N1-P1	10/7/2015	215.3	
AOC_5	N1-P1	10/20/2015	216.1	
AOC_5	N1-P1	12/16/2015	215.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N1-P1	6/9/2016	215.5	
AOC_5	N1-P1	6/24/2016	215.4	
AOC_5	N1-P1	8/16/2016	215.1	
AOC_5	N1-P1	11/15/2016	215.9	
AOC_5	N1-P1	5/22/2017	215.5	
AOC_5	N1-P1	11/1/2018	215.7	
AOC_5	N1-P1	10/22/2019	216.9	
AOC_5	N1-P2	12/7/1995	215.6	
AOC_5	N1-P2	3/26/1996	216.0	
AOC_5	N1-P2	6/2/1997	215.6	
AOC_5	N1-P2	4/23/1998	215.8	
AOC_5	N1-P2	6/19/1998	216.4	
AOC_5	N1-P2	6/26/1998	216.1	
AOC_5	N1-P2	7/1/1998	216.0	
AOC_5	N1-P2	7/17/1998	215.6	
AOC_5	N1-P2	7/31/1998	215.5	
AOC_5	N1-P2	8/28/1998	215.2	
AOC_5	N1-P2	10/14/1998	215.3	
AOC_5	N1-P2	12/10/1998	215.2	
AOC_5	N1-P2	2/23/1999	215.5	
AOC_5	N1-P2	6/6/1999	215.0	
AOC_5	N1-P2	9/8/1999	215.6	
AOC_5	N1-P2	11/16/2001	215.3	
AOC_5	N1-P2	8/4/2005	215.4	
AOC_5	N1-P2	8/24/2005	215.1	
AOC_5	N1-P2	8/26/2005	215.1	
AOC_5	N1-P2	4/10/2006	215.4	
AOC_5	N1-P2	6/5/2006	216.3	
AOC_5	N1-P2	9/18/2006	215.3	
AOC_5	N1-P2	10/19/2006	215.5	
AOC_5	N1-P2	12/15/2006	215.8	
AOC_5	N1-P2	4/8/2007	215.4	
AOC_5	N1-P2	4/9/2007	215.4	
AOC_5	N1-P2	4/26/2007	216.4	
AOC_5	N1-P2	10/15/2007	216.2	
AOC_5	N1-P2	11/7/2007	215.9	
AOC_5	N1-P2	2/20/2008	216.6	
AOC_5	N1-P2	2/25/2008	216.4	
AOC_5	N1-P2	3/4/2008	216.2	
AOC_5	N1-P2	4/16/2008	216.1	
AOC_5	N1-P2	6/10/2008	215.5	
AOC_5	N1-P2	8/19/2008	215.9	
AOC_5	N1-P2	9/15/2008	215.9	
AOC_5	N1-P2	9/30/2008	215.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N1-P2	4/28/2009	215.9	
AOC_5	N1-P2	9/14/2009	215.4	
AOC_5	N1-P2	10/26/2009	215.5	
AOC_5	N1-P2	11/3/2009	215.5	
AOC_5	N1-P2	4/20/2010	216.3	
AOC_5	N1-P2	9/14/2010	214.9	
AOC_5	N1-P2	10/7/2010	215.1	
AOC_5	N1-P2	4/4/2011	216.0	
AOC_5	N1-P2	11/8/2011	216.0	
AOC_5	N1-P2	4/10/2012	215.3	
AOC_5	N1-P2	11/5/2012	216.0	
AOC_5	N1-P2	11/6/2012	216.1	
AOC_5	N1-P2	5/15/2013	215.6	
AOC_5	N1-P2	6/11/2013	216.7	
AOC_5	N1-P2	10/21/2013		212.5
AOC_5	N1-P2	4/22/2014	216.1	
AOC_5	N1-P2	10/6/2014	216.0	
AOC_5	N1-P2	6/2/2015	216.1	
AOC_5	N1-P2	10/7/2015	215.4	
AOC_5	N1-P2	10/20/2015	216.2	
AOC_5	N1-P2	6/24/2016	215.5	
AOC_5	N1-P2	11/15/2016	216.1	
AOC_5	N1-P2	5/22/2017	216.0	
AOC_5	N1-P2	11/1/2018	215.8	
AOC_5	N1-P2	10/22/2019	216.9	
AOC_5	N1-P3	12/7/1995	216.0	
AOC_5	N1-P3	3/26/1996	216.3	
AOC_5	N1-P3	4/23/1998	216.1	
AOC_5	N1-P3	6/19/1998	216.6	
AOC_5	N1-P3	7/1/1998	216.2	
AOC_5	N1-P3	7/17/1998	215.9	
AOC_5	N1-P3	7/31/1998	215.4	
AOC_5	N1-P3	8/28/1998	215.7	
AOC_5	N1-P3	10/14/1998	215.8	
AOC_5	N1-P3	12/10/1998	215.8	
AOC_5	N1-P3	2/23/1999	216.0	
AOC_5	N1-P3	6/6/1999	215.6	
AOC_5	N1-P3	9/8/1999	215.3	
AOC_5	N1-P3	11/16/2001	215.8	
AOC_5	N1-P3	8/4/2005	215.8	
AOC_5	N1-P3	8/24/2005	215.6	
AOC_5	N1-P3	8/26/2005	215.7	
AOC_5	N1-P3	4/10/2006	215.8	
AOC_5	N1-P3	6/5/2006	214.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N1-P3	9/18/2006	215.7	
AOC_5	N1-P3	10/19/2006	216.0	
AOC_5	N1-P3	12/15/2006	216.1	
AOC_5	N1-P3	4/8/2007	214.7	
AOC_5	N1-P3	4/9/2007	214.7	
AOC_5	N1-P3	4/26/2007	216.5	
AOC_5	N1-P3	10/15/2007	217.0	
AOC_5	N1-P3	11/7/2007	216.5	
AOC_5	N1-P3	2/20/2008	217.1	
AOC_5	N1-P3	2/25/2008	216.7	
AOC_5	N1-P3	3/4/2008	216.6	
AOC_5	N1-P3	4/16/2008	216.4	
AOC_5	N1-P3	6/10/2008	215.9	
AOC_5	N1-P3	8/19/2008	216.3	
AOC_5	N1-P3	9/15/2008	216.3	
AOC_5	N1-P3	9/30/2008	216.3	
AOC_5	N1-P3	4/28/2009	216.3	
AOC_5	N1-P3	7/5/2009	216.0	
AOC_5	N1-P3	9/14/2009	215.9	
AOC_5	N1-P3	10/26/2009	216.1	
AOC_5	N1-P3	11/3/2009	216.0	
AOC_5	N1-P3	4/20/2010	216.3	
AOC_5	N1-P3	4/27/2010	216.2	
AOC_5	N1-P3	9/14/2010	215.6	
AOC_5	N1-P3	10/7/2010	216.2	
AOC_5	N1-P3	4/4/2011	216.3	
AOC_5	N1-P3	7/25/2011	215.8	
AOC_5	N1-P3	11/8/2011	216.4	
AOC_5	N1-P3	4/10/2012	215.8	
AOC_5	N1-P3	6/26/2012	216.0	
AOC_5	N1-P3	11/5/2012	216.6	
AOC_5	N1-P3	11/6/2012	216.6	
AOC_5	N1-P3	4/25/2013	216.1	
AOC_5	N1-P3	5/15/2013	216.3	
AOC_5	N1-P3	6/11/2013	216.3	
AOC_5	N1-P3	10/21/2013		212.6
AOC_5	N1-P3	4/22/2014	216.5	
AOC_5	N1-P3	10/6/2014	216.9	
AOC_5	N1-P3	6/2/2015	216.8	
AOC_5	N1-P3	6/17/2015	216.2	
AOC_5	N1-P3	8/18/2015	216.1	
AOC_5	N1-P3	10/7/2015	216.1	
AOC_5	N1-P3	10/20/2015	217.1	
AOC_5	N1-P3	12/16/2015	216.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N1-P3	6/9/2016	216.4	
AOC_5	N1-P3	6/24/2016	216.2	
AOC_5	N1-P3	8/16/2016	215.9	
AOC_5	N1-P3	11/15/2016	216.8	
AOC_5	N1-P3	5/22/2017	216.4	
AOC_5	N1-P3	11/1/2018	216.2	
AOC_5	N1-P3	10/22/2019	217.1	
AOC_5	N2-P1	12/7/1995	216.4	
AOC_5	N2-P1	3/26/1996	216.6	
AOC_5	N2-P1	4/23/1998	216.5	
AOC_5	N2-P1	6/19/1998	217.0	
AOC_5	N2-P1	6/26/1998	216.6	
AOC_5	N2-P1	7/1/1998	216.6	
AOC_5	N2-P1	7/17/1998	216.3	
AOC_5	N2-P1	7/31/1998	216.3	
AOC_5	N2-P1	8/28/1998	216.2	
AOC_5	N2-P1	10/14/1998	216.3	
AOC_5	N2-P1	12/10/1998	216.2	
AOC_5	N2-P1	2/23/1999	216.3	
AOC_5	N2-P1	6/6/1999	216.0	
AOC_5	N2-P1	9/8/1999	215.8	
AOC_5	N2-P1	11/16/2001	216.3	
AOC_5	N2-P1	8/4/2005	216.2	
AOC_5	N2-P1	8/24/2005	216.1	
AOC_5	N2-P1	8/26/2005	216.2	
AOC_5	N2-P1	4/10/2006	216.3	
AOC_5	N2-P1	6/5/2006	216.9	
AOC_5	N2-P1	8/2/2006	216.0	
AOC_5	N2-P1	9/18/2006	216.0	
AOC_5	N2-P1	10/19/2006	216.3	
AOC_5	N2-P1	12/15/2006	216.3	
AOC_5	N2-P1	4/8/2007	216.1	
AOC_5	N2-P1	4/9/2007	216.1	
AOC_5	N2-P1	4/26/2007	216.7	
AOC_5	N2-P1	9/10/2007	216.2	
AOC_5	N2-P1	10/15/2007	217.3	
AOC_5	N2-P1	11/7/2007	216.9	
AOC_5	N2-P1	2/20/2008	217.3	
AOC_5	N2-P1	2/25/2008	216.9	
AOC_5	N2-P1	3/4/2008	217.0	
AOC_5	N2-P1	4/16/2008	216.8	
AOC_5	N2-P1	6/10/2008	216.1	
AOC_5	N2-P1	8/19/2008	216.7	
AOC_5	N2-P1	9/15/2008	216.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N2-P1	9/30/2008	216.7	
AOC_5	N2-P1	4/28/2009	216.7	
AOC_5	N2-P1	9/14/2009	216.4	
AOC_5	N2-P1	10/26/2009	216.5	
AOC_5	N2-P1	11/3/2009	216.3	
AOC_5	N2-P1	4/20/2010	216.6	
AOC_5	N2-P1	4/27/2010	216.2	
AOC_5	N2-P1	9/14/2010	216.1	
AOC_5	N2-P1	10/7/2010	216.7	
AOC_5	N2-P1	4/4/2011	216.7	
AOC_5	N2-P1	7/25/2011	216.2	
AOC_5	N2-P1	11/8/2011	216.7	
AOC_5	N2-P1	4/10/2012	216.3	
AOC_5	N2-P1	11/5/2012	216.7	
AOC_5	N2-P1	11/6/2012	216.8	
AOC_5	N2-P1	5/15/2013	216.4	
AOC_5	N2-P1	6/11/2013	217.5	
AOC_5	N2-P1	10/21/2013		212.9
AOC_5	N2-P1	4/22/2014	216.6	
AOC_5	N2-P1	10/6/2014	217.0	
AOC_5	N2-P1	6/2/2015	217.1	
AOC_5	N2-P1	6/17/2015	216.5	
AOC_5	N2-P1	8/18/2015	216.4	
AOC_5	N2-P1	10/20/2015	217.2	
AOC_5	N2-P1	12/16/2015	216.5	
AOC_5	N2-P1	8/16/2016	216.2	
AOC_5	N2-P1	11/15/2016	217.0	
AOC_5	N2-P1	11/1/2018	216.6	
AOC_5	N2-P1	10/22/2019	217.4	
AOC_5	N2-P2	12/7/1995	216.3	
AOC_5	N2-P2	3/26/1996	216.5	
AOC_5	N2-P2	6/2/1997	216.3	
AOC_5	N2-P2	4/23/1998	216.4	
AOC_5	N2-P2	6/19/1998	216.9	
AOC_5	N2-P2	6/26/1998	216.5	
AOC_5	N2-P2	7/1/1998	216.5	
AOC_5	N2-P2	7/17/1998	216.2	
AOC_5	N2-P2	7/31/1998	216.2	
AOC_5	N2-P2	8/28/1998	216.1	
AOC_5	N2-P2	10/14/1998	216.2	
AOC_5	N2-P2	12/10/1998	216.2	
AOC_5	N2-P2	6/6/1999	216.0	
AOC_5	N2-P2	9/8/1999	215.8	
AOC_5	N2-P2	11/16/2001	216.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N2-P2	8/4/2005	216.2	
AOC_5	N2-P2	8/24/2005	216.0	
AOC_5	N2-P2	8/26/2005	216.1	
AOC_5	N2-P2	4/10/2006	216.3	
AOC_5	N2-P2	6/5/2006	216.8	
AOC_5	N2-P2	8/2/2006	216.4	
AOC_5	N2-P2	9/18/2006	216.4	
AOC_5	N2-P2	10/19/2006	216.6	
AOC_5	N2-P2	12/15/2006	216.7	
AOC_5	N2-P2	4/8/2007	216.0	
AOC_5	N2-P2	4/9/2007	216.0	
AOC_5	N2-P2	4/26/2007	216.6	
AOC_5	N2-P2	9/10/2007	216.2	
AOC_5	N2-P2	10/15/2007	217.3	
AOC_5	N2-P2	11/7/2007	216.9	
AOC_5	N2-P2	2/12/2008	216.9	
AOC_5	N2-P2	2/20/2008	217.3	
AOC_5	N2-P2	2/25/2008	216.8	
AOC_5	N2-P2	3/4/2008	216.9	
AOC_5	N2-P2	4/16/2008	216.6	
AOC_5	N2-P2	4/28/2008	216.4	
AOC_5	N2-P2	6/10/2008	216.3	
AOC_5	N2-P2	8/19/2008	216.6	
AOC_5	N2-P2	9/15/2008	216.6	
AOC_5	N2-P2	9/30/2008	216.6	
AOC_5	N2-P2	4/28/2009	216.5	
AOC_5	N2-P2	7/5/2009	216.4	
AOC_5	N2-P2	9/14/2009	216.3	
AOC_5	N2-P2	10/26/2009	216.5	
AOC_5	N2-P2	11/3/2009	216.6	
AOC_5	N2-P2	4/20/2010	216.5	
AOC_5	N2-P2	9/14/2010	216.1	
AOC_5	N2-P2	10/7/2010	216.6	
AOC_5	N2-P2	4/4/2011	216.6	
AOC_5	N2-P2	7/25/2011	216.2	
AOC_5	N2-P2	11/8/2011	216.6	
AOC_5	N2-P2	4/10/2012	216.2	
AOC_5	N2-P2	6/26/2012	216.4	
AOC_5	N2-P2	11/5/2012	217.0	
AOC_5	N2-P2	11/6/2012	217.1	
AOC_5	N2-P2	4/25/2013	216.4	
AOC_5	N2-P2	5/15/2013	216.8	
AOC_5	N2-P2	5/30/2013	217.4	
AOC_5	N2-P2	6/11/2013	217.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N2-P2	10/21/2013	214.1	
AOC_5	N2-P2	4/22/2014	217.0	
AOC_5	N2-P2	10/6/2014	217.3	
AOC_5	N2-P2	6/2/2015	217.0	
AOC_5	N2-P2	6/17/2015	216.5	
AOC_5	N2-P2	8/18/2015	216.4	
AOC_5	N2-P2	10/7/2015	216.5	
AOC_5	N2-P2	10/20/2015	217.6	
AOC_5	N2-P2	12/16/2015	216.5	
AOC_5	N2-P2	4/6/2016	216.6	
AOC_5	N2-P2	8/16/2016	216.2	
AOC_5	N2-P2	10/20/2016	216.3	
AOC_5	N2-P2	11/15/2016	217.2	
AOC_5	N2-P2	11/1/2018	216.7	
AOC_5	N2-P2	10/22/2019	217.2	
AOC_5	N3-P1	12/7/1995	216.3	
AOC_5	N3-P1	3/26/1996	216.4	
AOC_5	N3-P1	7/23/1996	216.1	
AOC_5	N3-P1	6/2/1997	216.3	
AOC_5	N3-P1	4/23/1998	216.4	
AOC_5	N3-P1	6/19/1998	216.9	
AOC_5	N3-P1	6/26/1998	216.6	
AOC_5	N3-P1	7/1/1998	216.5	
AOC_5	N3-P1	7/17/1998	216.3	
AOC_5	N3-P1	7/31/1998	216.2	
AOC_5	N3-P1	8/28/1998	216.2	
AOC_5	N3-P1	10/14/1998	216.2	
AOC_5	N3-P1	12/10/1998	216.2	
AOC_5	N3-P1	2/23/1999	216.4	
AOC_5	N3-P1	6/6/1999	216.0	
AOC_5	N3-P1	9/8/1999	215.8	
AOC_5	N3-P1	11/16/2001	216.2	
AOC_5	N3-P1	8/4/2005	216.1	
AOC_5	N3-P1	8/24/2005	216.1	
AOC_5	N3-P1	8/26/2005	216.1	
AOC_5	N3-P1	4/10/2006	215.8	
AOC_5	N3-P1	6/5/2006	216.0	
AOC_5	N3-P1	8/2/2006	216.2	
AOC_5	N3-P1	9/18/2006	216.1	
AOC_5	N3-P1	12/15/2006	215.9	
AOC_5	N3-P1	4/8/2007	215.7	
AOC_5	N3-P1	4/9/2007	215.7	
AOC_5	N3-P1	4/26/2007	216.7	
AOC_5	N3-P1	9/10/2007	216.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N3-P1	10/15/2007	216.6	
AOC_5	N3-P1	11/7/2007	216.9	
AOC_5	N3-P1	2/20/2008	217.4	
AOC_5	N3-P1	2/25/2008	216.6	
AOC_5	N3-P1	3/4/2008	216.9	
AOC_5	N3-P1	4/16/2008	216.4	
AOC_5	N3-P1	6/10/2008	216.3	
AOC_5	N3-P1	8/19/2008	216.7	
AOC_5	N3-P1	9/15/2008	216.6	
AOC_5	N3-P1	9/30/2008	216.3	
AOC_5	N3-P1	4/28/2009	216.2	
AOC_5	N3-P1	7/5/2009	216.4	
AOC_5	N3-P1	9/14/2009	216.3	
AOC_5	N3-P1	10/26/2009	216.5	
AOC_5	N3-P1	11/3/2009	215.6	
AOC_5	N3-P1	4/20/2010	216.4	
AOC_5	N3-P1	9/14/2010	216.1	
AOC_5	N3-P1	10/7/2010	216.6	
AOC_5	N3-P1	4/4/2011	216.6	
AOC_5	N3-P1	7/25/2011	216.1	
AOC_5	N3-P1	11/8/2011	216.6	
AOC_5	N3-P1	4/10/2012	215.7	
AOC_5	N3-P1	11/5/2012	216.9	
AOC_5	N3-P1	11/6/2012	217.0	
AOC_5	N3-P1	5/15/2013	216.6	
AOC_5	N3-P1	6/11/2013	217.7	
AOC_5	N3-P1	10/21/2013		213.1
AOC_5	N3-P1	4/22/2014	216.8	
AOC_5	N3-P1	10/6/2014	217.2	
AOC_5	N3-P1	6/2/2015	217.1	
AOC_5	N3-P1	6/17/2015	216.4	
AOC_5	N3-P1	8/18/2015	216.4	
AOC_5	N3-P1	10/20/2015	217.4	
AOC_5	N3-P1	12/16/2015	216.5	
AOC_5	N3-P1	6/9/2016	216.6	
AOC_5	N3-P1	8/16/2016	216.2	
AOC_5	N3-P1	11/15/2016	217.1	
AOC_5	N3-P1	11/1/2018	216.4	
AOC_5	N3-P1	10/22/2019	216.7	
AOC_5	N3-P2	12/7/1995	216.3	
AOC_5	N3-P2	3/26/1996	216.5	
AOC_5	N3-P2	7/23/1996	216.2	
AOC_5	N3-P2	4/23/1998	216.4	
AOC_5	N3-P2	6/19/1998	216.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N3-P2	6/26/1998	216.5	
AOC_5	N3-P2	7/1/1998	216.5	
AOC_5	N3-P2	7/17/1998	216.2	
AOC_5	N3-P2	7/31/1998	216.2	
AOC_5	N3-P2	8/28/1998	216.1	
AOC_5	N3-P2	10/14/1998	216.2	
AOC_5	N3-P2	12/10/1998	216.2	
AOC_5	N3-P2	6/6/1999	216.0	
AOC_5	N3-P2	9/8/1999	215.8	
AOC_5	N3-P2	11/16/2001	216.2	
AOC_5	N3-P2	8/4/2005	216.0	
AOC_5	N3-P2	8/24/2005	216.1	
AOC_5	N3-P2	8/26/2005	216.0	
AOC_5	N3-P2	4/10/2006	216.3	
AOC_5	N3-P2	6/5/2006		213.0
AOC_5	N3-P2	9/18/2006	216.2	
AOC_5	N3-P2	12/15/2006	216.4	
AOC_5	N3-P2	4/8/2007		212.6
AOC_5	N3-P2	4/9/2007		212.6
AOC_5	N3-P2	4/26/2007	216.6	
AOC_5	N3-P2	9/10/2007	216.2	
AOC_5	N3-P2	10/15/2007	217.3	
AOC_5	N3-P2	11/7/2007	216.9	
AOC_5	N3-P2	2/12/2008	216.9	
AOC_5	N3-P2	2/20/2008	217.3	
AOC_5	N3-P2	2/25/2008	216.9	
AOC_5	N3-P2	3/4/2008	217.0	
AOC_5	N3-P2	4/16/2008	216.6	
AOC_5	N3-P2	4/28/2008	216.4	
AOC_5	N3-P2	6/10/2008	216.3	
AOC_5	N3-P2	8/19/2008	216.6	
AOC_5	N3-P2	9/15/2008	216.6	
AOC_5	N3-P2	9/30/2008	216.7	
AOC_5	N3-P2	4/28/2009	216.6	
AOC_5	N3-P2	7/5/2009	216.4	
AOC_5	N3-P2	9/14/2009	216.3	
AOC_5	N3-P2	10/26/2009	216.5	
AOC_5	N3-P2	11/3/2009	216.4	
AOC_5	N3-P2	4/20/2010	216.5	
AOC_5	N3-P2	4/27/2010	216.4	
AOC_5	N3-P2	9/14/2010	216.1	
AOC_5	N3-P2	10/7/2010	216.6	
AOC_5	N3-P2	4/4/2011	216.6	
AOC_5	N3-P2	7/25/2011	216.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N3-P2	11/8/2011	216.6	
AOC_5	N3-P2	4/10/2012	216.2	
AOC_5	N3-P2	6/26/2012	216.4	
AOC_5	N3-P2	11/5/2012	216.9	
AOC_5	N3-P2	11/6/2012	217.0	
AOC_5	N3-P2	4/25/2013	216.4	
AOC_5	N3-P2	5/15/2013	216.6	
AOC_5	N3-P2	5/30/2013	217.2	
AOC_5	N3-P2	6/11/2013	217.7	
AOC_5	N3-P2	10/21/2013		212.1
AOC_5	N3-P2	4/22/2014	216.8	
AOC_5	N3-P2	10/6/2014	217.2	
AOC_5	N3-P2	6/2/2015	217.0	
AOC_5	N3-P2	6/17/2015	216.5	
AOC_5	N3-P2	8/18/2015	216.4	
AOC_5	N3-P2	10/7/2015	216.5	
AOC_5	N3-P2	10/20/2015	217.4	
AOC_5	N3-P2	12/16/2015	216.5	
AOC_5	N3-P2	6/9/2016	216.6	
AOC_5	N3-P2	8/16/2016	216.2	
AOC_5	N3-P2	10/20/2016	217.0	
AOC_5	N3-P2	11/15/2016	217.2	
AOC_5	N3-P2	11/1/2018	216.6	
AOC_5	N3-P2	10/22/2019	217.0	
AOC_5	N4-P1	12/7/1995	216.0	
AOC_5	N4-P1	7/23/1996	215.7	
AOC_5	N4-P1	6/2/1997	215.5	
AOC_5	N4-P1	4/23/1998	215.9	
AOC_5	N4-P1	6/19/1998	216.6	
AOC_5	N4-P1	6/26/1998	216.2	
AOC_5	N4-P1	7/1/1998	216.2	
AOC_5	N4-P1	7/17/1998	215.8	
AOC_5	N4-P1	7/31/1998	215.7	
AOC_5	N4-P1	8/28/1998	215.6	
AOC_5	N4-P1	10/14/1998	215.6	
AOC_5	N4-P1	12/10/1998	215.6	
AOC_5	N4-P1	6/6/1999	215.4	
AOC_5	N4-P1	9/8/1999	215.1	
AOC_5	N4-P1	6/24/2016		
AOC_5	N4-P2	12/7/1995	215.7	
AOC_5	N4-P2	7/23/1996	215.4	
AOC_5	N4-P2	6/2/1997	215.5	
AOC_5	N4-P2	4/23/1998	215.6	
AOC_5	N4-P2	6/19/1998	216.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N4-P2	6/26/1998	215.9	
AOC_5	N4-P2	7/1/1998	215.8	
AOC_5	N4-P2	7/17/1998	215.5	
AOC_5	N4-P2	7/31/1998	215.4	
AOC_5	N4-P2	8/28/1998	215.3	
AOC_5	N4-P2	10/14/1998	215.4	
AOC_5	N4-P2	12/10/1998	215.3	
AOC_5	N4-P2	6/6/1999	215.1	
AOC_5	N4-P2	9/8/1999	214.9	
AOC_5	N4-P2	8/4/2005	215.4	
AOC_5	N4-P2	8/24/2005	215.3	
AOC_5	N4-P2	8/26/2005	215.3	
AOC_5	N4-P2	6/24/2016		
AOC_5	N4-P3	12/7/1995	215.7	
AOC_5	N4-P3	7/23/1996	215.5	
AOC_5	N4-P3	6/2/1997	215.5	
AOC_5	N4-P3	4/23/1998	215.7	
AOC_5	N4-P3	6/19/1998	216.2	
AOC_5	N4-P3	6/26/1998	215.9	
AOC_5	N4-P3	7/1/1998	215.8	
AOC_5	N4-P3	7/17/1998	215.5	
AOC_5	N4-P3	7/31/1998	215.4	
AOC_5	N4-P3	8/28/1998	215.4	
AOC_5	N4-P3	10/14/1998	215.4	
AOC_5	N4-P3	12/10/1998	215.4	
AOC_5	N4-P3	6/6/1999	215.2	
AOC_5	N4-P3	9/8/1999	215.0	
AOC_5	N4-P3	6/24/2016		
AOC_5	N5-P1	12/7/1995	218.5	
AOC_5	N5-P1	7/23/1996	219.7	
AOC_5	N5-P1	6/2/1997	220.6	
AOC_5	N5-P1	4/23/1998	220.3	
AOC_5	N5-P1	6/19/1998	220.6	
AOC_5	N5-P1	6/26/1998	220.7	
AOC_5	N5-P1	7/1/1998	220.7	
AOC_5	N5-P1	7/17/1998	220.6	
AOC_5	N5-P1	7/31/1998	220.2	
AOC_5	N5-P1	8/28/1998	219.6	
AOC_5	N5-P1	10/14/1998	218.8	
AOC_5	N5-P1	12/10/1998	218.4	
AOC_5	N5-P1	2/23/1999	218.3	
AOC_5	N5-P1	6/6/1999	218.4	
AOC_5	N5-P1	9/8/1999	217.3	
AOC_5	N5-P1	11/16/2001	217.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N5-P1	8/4/2005	219.8	
AOC_5	N5-P1	8/24/2005	219.3	
AOC_5	N5-P1	8/26/2005	219.4	
AOC_5	N5-P1	4/10/2006	220.2	
AOC_5	N5-P1	6/5/2006	220.7	
AOC_5	N5-P1	8/2/2006	220.4	
AOC_5	N5-P1	9/18/2006	219.3	
AOC_5	N5-P1	10/19/2006	219.0	
AOC_5	N5-P1	12/15/2006	219.5	
AOC_5	N5-P1	4/8/2007	219.0	
AOC_5	N5-P1	4/9/2007	219.0	
AOC_5	N5-P1	4/26/2007	220.1	
AOC_5	N5-P1	10/15/2007	218.4	
AOC_5	N5-P1	2/20/2008	219.3	
AOC_5	N5-P1	2/25/2008	219.5	
AOC_5	N5-P1	3/4/2008	219.6	
AOC_5	N5-P1	4/16/2008	220.7	
AOC_5	N5-P1	4/28/2008	220.5	
AOC_5	N5-P1	6/10/2008	220.0	
AOC_5	N5-P1	8/19/2008	219.4	
AOC_5	N5-P1	9/15/2008	219.3	
AOC_5	N5-P1	9/30/2008	219.3	
AOC_5	N5-P1	10/3/2008	219.4	
AOC_5	N5-P1	4/28/2009	220.5	
AOC_5	N5-P1	9/14/2009	219.3	
AOC_5	N5-P1	10/22/2009	218.7	
AOC_5	N5-P1	10/26/2009	218.7	
AOC_5	N5-P1	11/3/2009	218.8	
AOC_5	N5-P1	4/20/2010	221.0	
AOC_5	N5-P1	9/14/2010	218.2	
AOC_5	N5-P1	10/7/2010	218.0	
AOC_5	N5-P1	4/4/2011	219.3	
AOC_5	N5-P1	7/25/2011	219.1	
AOC_5	N5-P1	11/8/2011	219.9	
AOC_5	N5-P1	4/10/2012	219.5	
AOC_5	N5-P1	11/5/2012	218.3	
AOC_5	N5-P1	5/15/2013	219.1	
AOC_5	N5-P1	6/11/2013	219.4	
AOC_5	N5-P1	10/21/2013	218.0	
AOC_5	N5-P1	10/22/2013	217.8	
AOC_5	N5-P1	4/22/2014	218.8	
AOC_5	N5-P1	10/6/2014	218.4	
AOC_5	N5-P1	6/3/2015	219.4	
AOC_5	N5-P1	6/17/2015	219.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N5-P1	10/7/2015	218.0	
AOC_5	N5-P1	10/20/2015	217.9	
AOC_5	N5-P1	12/16/2015	217.8	
AOC_5	N5-P1	6/9/2016	218.7	
AOC_5	N5-P1	6/24/2016	218.6	
AOC_5	N5-P1	8/16/2016	217.8	
AOC_5	N5-P1	11/16/2016	217.6	
AOC_5	N5-P1	5/22/2017	220.0	
AOC_5	N5-P1	11/1/2018	219.6	
AOC_5	N5-P1	10/22/2019	218.7	
AOC_5	N5-P2	12/7/1995	218.0	
AOC_5	N5-P2	7/23/1996	219.9	
AOC_5	N5-P2	6/2/1997	220.8	
AOC_5	N5-P2	4/23/1998	220.0	
AOC_5	N5-P2	6/19/1998	220.4	
AOC_5	N5-P2	6/26/1998	220.7	
AOC_5	N5-P2	7/1/1998	220.7	
AOC_5	N5-P2	7/17/1998	220.7	
AOC_5	N5-P2	7/31/1998	220.3	
AOC_5	N5-P2	8/28/1998	219.8	
AOC_5	N5-P2	10/14/1998	218.9	
AOC_5	N5-P2	12/10/1998	218.3	
AOC_5	N5-P2	2/23/1999	218.0	
AOC_5	N5-P2	6/6/1999	218.5	
AOC_5	N5-P2	9/8/1999	217.6	
AOC_5	N5-P2	11/16/2001	218.0	
AOC_5	N5-P2	8/4/2005	220.0	
AOC_5	N5-P2	8/24/2005	219.4	
AOC_5	N5-P2	8/26/2005	219.5	
AOC_5	N5-P2	8/2/2006	220.7	
AOC_5	N5-P2	10/19/2006	219.2	
AOC_5	N5-P2	4/8/2007	222.7	
AOC_5	N5-P2	4/9/2007	222.7	
AOC_5	N5-P2	4/26/2007	219.4	
AOC_5	N5-P2	10/15/2007	218.3	
AOC_5	N5-P2	2/12/2008	218.2	
AOC_5	N5-P2	2/20/2008	218.5	
AOC_5	N5-P2	2/25/2008	218.8	
AOC_5	N5-P2	3/4/2008	218.9	
AOC_5	N5-P2	4/16/2008	220.2	
AOC_5	N5-P2	4/28/2008	220.6	
AOC_5	N5-P2	6/10/2008	220.2	
AOC_5	N5-P2	8/19/2008	219.2	
AOC_5	N5-P2	9/15/2008	219.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N5-P2	9/30/2008	219.1	
AOC_5	N5-P2	10/3/2008	219.0	
AOC_5	N5-P2	4/28/2009	220.4	
AOC_5	N5-P2	9/14/2009	219.5	
AOC_5	N5-P2	10/22/2009	218.9	
AOC_5	N5-P2	10/26/2009	218.7	
AOC_5	N5-P2	11/3/2009	220.3	
AOC_5	N5-P2	4/20/2010	220.6	
AOC_5	N5-P2	4/27/2010	220.9	
AOC_5	N5-P2	9/14/2010	218.4	
AOC_5	N5-P2	10/7/2010	218.3	
AOC_5	N5-P2	4/4/2011	218.7	
AOC_5	N5-P2	7/25/2011	219.3	
AOC_5	N5-P2	11/8/2011	219.4	
AOC_5	N5-P2	4/10/2012	219.6	
AOC_5	N5-P2	6/26/2012	219.3	
AOC_5	N5-P2	11/5/2012	217.8	
AOC_5	N5-P2	11/6/2012	217.9	
AOC_5	N5-P2	4/25/2013	218.9	
AOC_5	N5-P2	5/15/2013	219.0	
AOC_5	N5-P2	6/11/2013	219.2	
AOC_5	N5-P2	10/21/2013	218.3	
AOC_5	N5-P2	10/22/2013	218.4	
AOC_5	N5-P2	4/22/2014	218.1	
AOC_5	N5-P2	10/6/2014	218.0	
AOC_5	N5-P2	6/3/2015	219.4	
AOC_5	N5-P2	6/17/2015	219.2	
AOC_5	N5-P2	10/7/2015	218.2	
AOC_5	N5-P2	10/20/2015	217.9	
AOC_5	N5-P2	12/16/2015	217.6	
AOC_5	N5-P2	6/9/2016	218.8	
AOC_5	N5-P2	6/24/2016	218.7	
AOC_5	N5-P2	8/16/2016	218.0	
AOC_5	N5-P2	5/22/2017	219.6	
AOC_5	N5-P2	11/1/2018	219.3	
AOC_5	N5-P2	10/22/2019	218.4	
AOC_5	N6-P1	12/7/1995	220.6	
AOC_5	N6-P1	3/26/1996	221.9	
AOC_5	N6-P1	6/2/1997	223.4	
AOC_5	N6-P1	4/23/1998	222.9	
AOC_5	N6-P1	6/19/1998	223.2	
AOC_5	N6-P1	6/26/1998	223.4	
AOC_5	N6-P1	7/1/1998	223.4	
AOC_5	N6-P1	7/17/1998	223.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N6-P1	7/31/1998	223.1	
AOC_5	N6-P1	8/28/1998	222.5	
AOC_5	N6-P1	10/14/1998	221.5	
AOC_5	N6-P1	12/10/1998	220.9	
AOC_5	N6-P1	2/23/1999	220.6	
AOC_5	N6-P1	6/6/1999	220.8	
AOC_5	N6-P1	9/8/1999	219.6	
AOC_5	N6-P1	8/4/2005	222.5	
AOC_5	N6-P1	8/24/2005	222.1	
AOC_5	N6-P1	8/26/2005	222.6	
AOC_5	N6-P1	4/10/2006	223.0	
AOC_5	N6-P1	6/5/2006	223.3	
AOC_5	N6-P1	9/18/2006	222.4	
AOC_5	N6-P1	12/15/2006	222.0	
AOC_5	N6-P1	4/8/2007	221.7	
AOC_5	N6-P1	4/9/2007	221.7	
AOC_5	N6-P1	10/15/2007	221.0	
AOC_5	N6-P1	2/20/2008	221.4	
AOC_5	N6-P1	2/25/2008	221.7	
AOC_5	N6-P1	3/4/2008	221.8	
AOC_5	N6-P1	4/16/2008	223.2	
AOC_5	N6-P1	9/15/2008	222.1	
AOC_5	N6-P1	9/30/2008	221.9	
AOC_5	N6-P1	4/28/2009	223.0	
AOC_5	N6-P1	9/14/2009	222.3	
AOC_5	N6-P1	10/26/2009	221.5	
AOC_5	N6-P1	11/3/2009	221.5	
AOC_5	N6-P1	4/20/2010	223.9	
AOC_5	N6-P1	4/27/2010	224.0	
AOC_5	N6-P1	9/14/2010	221.2	
AOC_5	N6-P1	10/7/2010	220.8	
AOC_5	N6-P1	4/4/2011	221.8	
AOC_5	N6-P1	7/25/2011	221.9	
AOC_5	N6-P1	11/8/2011	222.5	
AOC_5	N6-P1	4/10/2012	222.1	
AOC_5	N6-P1	6/26/2012	221.8	
AOC_5	N6-P1	11/5/2012	220.7	
AOC_5	N6-P1	11/6/2012	220.8	
AOC_5	N6-P1	4/25/2013	221.6	
AOC_5	N6-P1	5/15/2013	221.6	
AOC_5	N6-P1	6/11/2013	221.7	
AOC_5	N6-P1	10/21/2013	220.7	
AOC_5	N6-P1	4/22/2014	220.9	
AOC_5	N6-P1	10/6/2014	220.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N6-P1	6/3/2015	222.0	
AOC_5	N6-P1	6/17/2015	221.9	
AOC_5	N6-P1	10/7/2015	220.7	
AOC_5	N6-P1	10/20/2015	220.5	
AOC_5	N6-P1	12/16/2015	220.1	
AOC_5	N6-P1	6/9/2016	221.1	
AOC_5	N6-P1	8/16/2016	220.3	
AOC_5	N6-P1	11/15/2016	219.7	
AOC_5	N6-P1	5/11/2018	222.7	
AOC_5	N6-P1	11/1/2018	222.8	
AOC_5	N6-P1	4/11/2019	224.0	
AOC_5	N6-P1	10/22/2019	221.9	
AOC_5	N6-P1	4/29/2020	223.7	
AOC_5	N7-P1	12/7/1995	223.5	
AOC_5	N7-P1	6/2/1997	226.5	
AOC_5	N7-P1	4/23/1998	226.4	
AOC_5	N7-P1	6/19/1998	227.1	
AOC_5	N7-P1	6/26/1998	227.2	
AOC_5	N7-P1	7/1/1998	227.3	
AOC_5	N7-P1	7/17/1998	227.0	
AOC_5	N7-P1	7/31/1998	226.6	
AOC_5	N7-P1	8/28/1998	225.8	
AOC_5	N7-P1	10/14/1998	225.0	
AOC_5	N7-P1	12/10/1998	224.0	
AOC_5	N7-P1	2/23/1999	224.1	
AOC_5	N7-P1	6/6/1999	223.6	
AOC_5	N7-P1	9/8/1999	222.3	
AOC_5	N7-P1	8/4/2005	225.7	
AOC_5	N7-P1	8/24/2005	225.2	
AOC_5	N7-P1	8/26/2005	225.3	
AOC_5	N7-P1	4/10/2006	226.2	
AOC_5	N7-P1	6/5/2006	227.0	
AOC_5	N7-P1	9/18/2006	225.7	
AOC_5	N7-P1	12/15/2006	225.7	
AOC_5	N7-P1	4/8/2007	225.0	
AOC_5	N7-P1	4/9/2007	225.0	
AOC_5	N7-P1	10/15/2007	224.1	
AOC_5	N7-P1	2/20/2008	225.3	
AOC_5	N7-P1	2/25/2008	225.5	
AOC_5	N7-P1	3/4/2008	225.7	
AOC_5	N7-P1	4/16/2008	226.9	
AOC_5	N7-P1	8/19/2008	225.9	
AOC_5	N7-P1	9/15/2008	226.0	
AOC_5	N7-P1	9/30/2008	226.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N7-P1	4/28/2009	226.2	
AOC_5	N7-P1	9/14/2009	225.8	
AOC_5	N7-P1	10/26/2009	225.0	
AOC_5	N7-P1	11/3/2009	225.0	
AOC_5	N7-P1	4/20/2010	228.1	
AOC_5	N7-P1	9/14/2010	224.5	
AOC_5	N7-P1	10/7/2010	224.4	
AOC_5	N7-P1	4/4/2011	225.4	
AOC_5	N7-P1	7/25/2011	225.0	
AOC_5	N7-P1	11/8/2011	226.3	
AOC_5	N7-P1	4/10/2012	225.2	
AOC_5	N7-P1	6/26/2012	224.9	
AOC_5	N7-P1	11/5/2012	223.9	
AOC_5	N7-P1	11/6/2012	224.0	
AOC_5	N7-P1	5/15/2013	224.3	
AOC_5	N7-P1	6/11/2013	224.8	
AOC_5	N7-P1	10/21/2013	223.8	
AOC_5	N7-P1	4/22/2014	224.1	
AOC_5	N7-P1	10/6/2014	223.4	
AOC_5	N7-P1	6/3/2015	225.3	
AOC_5	N7-P1	6/17/2015	225.0	
AOC_5	N7-P1	10/7/2015	223.5	
AOC_5	N7-P1	10/20/2015	223.3	
AOC_5	N7-P1	12/16/2015	222.9	
AOC_5	N7-P1	6/9/2016	223.7	
AOC_5	N7-P1	6/24/2016		
AOC_5	N7-P1	8/16/2016	222.9	
AOC_5	N7-P1	11/15/2016	222.6	
AOC_5	N7-P1	5/22/2017	225.3	
AOC_5	N7-P1	11/1/2018	226.1	
AOC_5	N7-P1	12/5/2018	227.6	
AOC_5	N7-P1	10/22/2019	224.4	
AOC_5	N7-P1	4/29/2020	226.2	
AOC_5	N7-P2	12/7/1995	223.7	
AOC_5	N7-P2	6/2/1997	226.8	
AOC_5	N7-P2	4/23/1998	226.8	
AOC_5	N7-P2	6/19/1998	227.5	
AOC_5	N7-P2	6/26/1998	227.6	
AOC_5	N7-P2	7/1/1998	227.7	
AOC_5	N7-P2	7/17/1998	227.4	
AOC_5	N7-P2	7/31/1998	227.0	
AOC_5	N7-P2	8/28/1998	226.1	
AOC_5	N7-P2	10/14/1998	225.4	
AOC_5	N7-P2	12/10/1998	224.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N7-P2	2/23/1999	224.5	
AOC_5	N7-P2	6/6/1999	223.9	
AOC_5	N7-P2	9/8/1999	222.6	
AOC_5	N7-P2	8/4/2005	226.0	
AOC_5	N7-P2	8/24/2005	225.6	
AOC_5	N7-P2	8/26/2005	225.6	
AOC_5	N7-P2	4/10/2006	226.6	
AOC_5	N7-P2	6/5/2006	226.3	
AOC_5	N7-P2	9/18/2006	226.1	
AOC_5	N7-P2	12/15/2006	226.0	
AOC_5	N7-P2	4/8/2007	225.3	
AOC_5	N7-P2	4/9/2007	225.3	
AOC_5	N7-P2	10/15/2007	224.4	
AOC_5	N7-P2	2/20/2008	225.6	
AOC_5	N7-P2	2/25/2008	225.9	
AOC_5	N7-P2	3/4/2008	226.1	
AOC_5	N7-P2	4/16/2008	227.3	
AOC_5	N7-P2	6/10/2008	226.5	
AOC_5	N7-P2	8/19/2008	226.3	
AOC_5	N7-P2	9/15/2008	226.4	
AOC_5	N7-P2	9/30/2008	226.5	
AOC_5	N7-P2	4/28/2009	226.7	
AOC_5	N7-P2	9/14/2009	226.2	
AOC_5	N7-P2	10/26/2009	225.4	
AOC_5	N7-P2	11/3/2009	225.4	
AOC_5	N7-P2	4/20/2010	228.6	
AOC_5	N7-P2	4/27/2010	228.5	
AOC_5	N7-P2	9/14/2010	224.8	
AOC_5	N7-P2	10/7/2010	224.6	
AOC_5	N7-P2	4/4/2011	225.7	
AOC_5	N7-P2	7/25/2011	225.3	
AOC_5	N7-P2	11/8/2011	226.8	
AOC_5	N7-P2	4/10/2012	225.4	
AOC_5	N7-P2	6/26/2012	225.2	
AOC_5	N7-P2	11/5/2012	224.2	
AOC_5	N7-P2	11/6/2012	224.3	
AOC_5	N7-P2	4/25/2013	224.8	
AOC_5	N7-P2	5/15/2013	224.6	
AOC_5	N7-P2	6/11/2013	225.0	
AOC_5	N7-P2	10/21/2013	224.0	
AOC_5	N7-P2	4/22/2014	224.4	
AOC_5	N7-P2	10/6/2014	223.6	
AOC_5	N7-P2	6/3/2015	225.6	
AOC_5	N7-P2	6/17/2015	225.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	N7-P2	10/7/2015	223.8	
AOC_5	N7-P2	10/20/2015	223.6	
AOC_5	N7-P2	10/21/2015	223.6	
AOC_5	N7-P2	12/16/2015	223.2	
AOC_5	N7-P2	6/9/2016	223.9	
AOC_5	N7-P2	6/24/2016	223.8	
AOC_5	N7-P2	8/16/2016	223.1	
AOC_5	N7-P2	11/15/2016	222.8	
AOC_5	N7-P2	5/22/2017	225.5	
AOC_5	N7-P2	11/1/2018	226.0	
AOC_5	N7-P2	12/5/2018	228.1	
AOC_5	N7-P2	10/22/2019	224.8	
AOC_5	N7-P2	4/29/2020	226.5	
AOC_5	PSP-01	8/4/2005		
AOC_5	PSP-01	8/24/2005		
AOC_5	PSP-01	8/26/2005		
AOC_5	PSP-01	4/10/2006		
AOC_5	PSP-01	6/5/2006		
AOC_5	PSP-01	9/18/2006		
AOC_5	PSP-01	12/15/2006		
AOC_5	PSP-01	4/8/2007		
AOC_5	PSP-01	4/9/2007		
AOC_5	PSP-01	10/15/2007		
AOC_5	PSP-01	2/20/2008		
AOC_5	PSP-01	2/25/2008		
AOC_5	PSP-01	3/4/2008		
AOC_5	PSP-01	4/16/2008		
AOC_5	PSP-01	4/28/2008		
AOC_5	PSP-01	6/10/2008		
AOC_5	PSP-01	9/30/2008		
AOC_5	PSP-01	4/28/2009		
AOC_5	PSP-01	7/5/2009		
AOC_5	PSP-01	11/3/2009		
AOC_5	PSP-01	4/20/2010		
AOC_5	PSP-01	10/7/2010		
AOC_5	PSP-01	4/4/2011		
AOC_5	PSP-01	11/8/2011		
AOC_5	PSP-01	4/10/2012		
AOC_5	PSP-01	11/5/2012	212.8	
AOC_5	PSP-01	5/15/2013	213.1	
AOC_5	PSP-01	6/11/2013	211.0	
AOC_5	PSP-01	7/20/2013	213.3	
AOC_5	PSP-01	4/22/2014	213.0	
AOC_5	PSP-01	6/2/2015	212.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	PSP-01	10/20/2015		
AOC_5	PSP-01	5/11/2018	216.3	
AOC_5	PSP-01	4/11/2019	216.3	
AOC_5	PSP-01	10/22/2019	217.1	
AOC_5	PZ-12-01	11/5/2012	217.0	
AOC_5	PZ-12-01	11/6/2012	217.1	
AOC_5	PZ-12-01	11/16/2012	216.9	
AOC_5	PZ-12-01	11/21/2012	217.0	
AOC_5	PZ-12-01	11/28/2012	216.8	
AOC_5	PZ-12-01	12/13/2012	216.6	
AOC_5	PZ-12-01	1/16/2013	216.9	
AOC_5	PZ-12-01	2/14/2013	216.7	
AOC_5	PZ-12-01	3/12/2013	217.0	
AOC_5	PZ-12-01	4/22/2013	216.8	
AOC_5	PZ-12-01	4/25/2013	216.8	
AOC_5	PZ-12-01	5/15/2013	216.9	
AOC_5	PZ-12-01	5/28/2013		203.6
AOC_5	PZ-12-01	5/30/2013	217.3	
AOC_5	PZ-12-01	6/11/2013	217.7	
AOC_5	PZ-12-01	10/21/2013	214.1	
AOC_5	PZ-12-01	11/19/2013	216.0	
AOC_5	PZ-12-01	4/22/2014	217.0	
AOC_5	PZ-12-01	10/6/2014	216.9	
AOC_5	PZ-12-01	6/3/2015	217.0	
AOC_5	PZ-12-01	6/17/2015	216.8	
AOC_5	PZ-12-01	8/18/2015	216.6	
AOC_5	PZ-12-01	10/7/2015	216.5	
AOC_5	PZ-12-01	10/20/2015	218.2	
AOC_5	PZ-12-01	12/16/2015	216.5	
AOC_5	PZ-12-01	4/6/2016	216.9	
AOC_5	PZ-12-01	6/9/2016	216.8	
AOC_5	PZ-12-01	6/23/2016	216.7	
AOC_5	PZ-12-01	8/16/2016	216.3	
AOC_5	PZ-12-01	10/20/2016	216.3	
AOC_5	PZ-12-01	11/15/2016	217.0	
AOC_5	PZ-12-01	5/22/2017	217.2	
AOC_5	PZ-12-01	5/11/2018	217.3	
AOC_5	PZ-12-01	11/1/2018	217.1	
AOC_5	PZ-12-01	4/11/2019	217.1	
AOC_5	PZ-12-01	10/22/2019	217.4	
AOC_5	PZ-12-01	5/18/2020	217.4	
AOC_5	PZ-12-02	11/5/2012	217.3	
AOC_5	PZ-12-02	11/6/2012	217.4	
AOC_5	PZ-12-02	11/16/2012	217.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	PZ-12-02	11/21/2012	217.3	
AOC_5	PZ-12-02	11/28/2012	217.2	
AOC_5	PZ-12-02	12/13/2012	217.0	
AOC_5	PZ-12-02	1/16/2013	217.2	
AOC_5	PZ-12-02	2/14/2013	217.1	
AOC_5	PZ-12-02	3/12/2013	217.3	
AOC_5	PZ-12-02	4/22/2013	217.4	
AOC_5	PZ-12-02	4/25/2013	217.4	
AOC_5	PZ-12-02	5/15/2013	217.4	
AOC_5	PZ-12-02	5/21/2013	217.4	
AOC_5	PZ-12-02	5/30/2013	217.7	
AOC_5	PZ-12-02	6/11/2013	217.9	
AOC_5	PZ-12-02	10/21/2013	215.3	
AOC_5	PZ-12-02	11/19/2013	216.3	
AOC_5	PZ-12-02	4/22/2014	217.4	
AOC_5	PZ-12-02	10/6/2014	217.0	
AOC_5	PZ-12-02	6/3/2015	215.8	
AOC_5	PZ-12-02	6/17/2015	217.4	
AOC_5	PZ-12-02	8/18/2015	217.2	
AOC_5	PZ-12-02	10/7/2015	216.8	
AOC_5	PZ-12-02	10/20/2015	217.1	
AOC_5	PZ-12-02	12/16/2015	216.8	
AOC_5	PZ-12-02	4/6/2016	217.4	
AOC_5	PZ-12-02	6/9/2016	217.3	
AOC_5	PZ-12-02	6/23/2016	217.1	
AOC_5	PZ-12-02	8/16/2016	216.7	
AOC_5	PZ-12-02	11/15/2016	217.0	
AOC_5	PZ-12-02	5/22/2017	218.0	
AOC_5	PZ-12-02	5/11/2018	218.0	
AOC_5	PZ-12-02	11/1/2018	217.8	
AOC_5	PZ-12-02	4/11/2019	218.2	
AOC_5	PZ-12-02	10/22/2019	217.7	
AOC_5	PZ-12-02	5/15/2020	218.5	
AOC_5	PZ-12-02	5/18/2020	218.5	
AOC_5	PZ-12-03	11/5/2012	217.0	
AOC_5	PZ-12-03	11/6/2012	217.0	
AOC_5	PZ-12-03	11/16/2012	216.9	
AOC_5	PZ-12-03	11/21/2012	217.0	
AOC_5	PZ-12-03	11/28/2012	216.8	
AOC_5	PZ-12-03	12/13/2012	216.5	
AOC_5	PZ-12-03	1/16/2013	217.0	
AOC_5	PZ-12-03	2/14/2013	216.6	
AOC_5	PZ-12-03	3/12/2013	217.0	
AOC_5	PZ-12-03	4/22/2013	216.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	PZ-12-03	4/25/2013	216.6	
AOC_5	PZ-12-03	5/15/2013	216.8	
AOC_5	PZ-12-03	5/24/2013	217.2	
AOC_5	PZ-12-03	5/30/2013	217.4	
AOC_5	PZ-12-03	6/11/2013	216.9	
AOC_5	PZ-12-03	10/21/2013		213.6
AOC_5	PZ-12-03	11/19/2013	216.1	
AOC_5	PZ-12-03	4/22/2014	216.9	
AOC_5	PZ-12-03	10/6/2014	217.1	
AOC_5	PZ-12-03	6/3/2015	217.0	
AOC_5	PZ-12-03	6/17/2015	216.7	
AOC_5	PZ-12-03	8/18/2015	216.5	
AOC_5	PZ-12-03	10/7/2015	216.5	
AOC_5	PZ-12-03	10/20/2015	217.3	
AOC_5	PZ-12-03	12/16/2015	216.6	
AOC_5	PZ-12-03	4/6/2016	216.8	
AOC_5	PZ-12-03	6/9/2016	216.8	
AOC_5	PZ-12-03	6/23/2016	216.6	
AOC_5	PZ-12-03	8/16/2016	216.3	
AOC_5	PZ-12-03	10/20/2016	216.4	
AOC_5	PZ-12-03	11/15/2016	217.2	
AOC_5	PZ-12-03	5/22/2017	216.9	
AOC_5	PZ-12-03	5/11/2018	217.1	
AOC_5	PZ-12-03	11/1/2018	216.9	
AOC_5	PZ-12-03	4/11/2019	216.9	
AOC_5	PZ-12-03	10/22/2019	216.5	
AOC_5	PZ-12-03	5/18/2020	217.0	
AOC_5	PZ-12-04	11/5/2012	217.8	
AOC_5	PZ-12-04	11/6/2012	217.9	
AOC_5	PZ-12-04	11/16/2012	217.8	
AOC_5	PZ-12-04	11/21/2012	217.8	
AOC_5	PZ-12-04	11/28/2012	217.8	
AOC_5	PZ-12-04	12/13/2012	217.5	
AOC_5	PZ-12-04	1/16/2013	217.7	
AOC_5	PZ-12-04	2/14/2013	217.6	
AOC_5	PZ-12-04	3/12/2013	217.8	
AOC_5	PZ-12-04	3/13/2013	217.9	
AOC_5	PZ-12-04	4/22/2013	218.1	
AOC_5	PZ-12-04	4/25/2013	218.1	
AOC_5	PZ-12-04	5/15/2013	218.1	
AOC_5	PZ-12-04	5/24/2013	218.1	
AOC_5	PZ-12-04	5/30/2013	218.3	
AOC_5	PZ-12-04	6/11/2013	218.5	
AOC_5	PZ-12-04	10/21/2013	216.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	PZ-12-04	11/19/2013	215.9	
AOC_5	PZ-12-04	4/22/2014	217.9	
AOC_5	PZ-12-04	10/6/2014	217.5	
AOC_5	PZ-12-04	6/3/2015	218.4	
AOC_5	PZ-12-04	6/17/2015	218.2	
AOC_5	PZ-12-04	8/18/2015	217.9	
AOC_5	PZ-12-04	10/7/2015	217.5	
AOC_5	PZ-12-04	10/20/2015		211.6
AOC_5	PZ-12-04	12/16/2015	217.3	
AOC_5	PZ-12-04	4/6/2016	218.0	
AOC_5	PZ-12-04	6/9/2016	217.9	
AOC_5	PZ-12-04	6/23/2016	217.9	
AOC_5	PZ-12-04	8/16/2016	217.3	
AOC_5	PZ-12-04	11/15/2016	217.4	
AOC_5	PZ-12-04	5/22/2017	218.7	
AOC_5	PZ-12-04	5/11/2018	218.8	
AOC_5	PZ-12-04	11/1/2018	218.6	
AOC_5	PZ-12-04	4/11/2019	219.2	
AOC_5	PZ-12-04	10/22/2019	218.3	
AOC_5	PZ-12-04	5/18/2020	219.5	
AOC_5	PZ-12-05	11/5/2012	217.2	
AOC_5	PZ-12-05	11/16/2012	217.1	
AOC_5	PZ-12-05	11/21/2012	217.1	
AOC_5	PZ-12-05	11/28/2012	217.0	
AOC_5	PZ-12-05	12/13/2012	216.7	
AOC_5	PZ-12-05	1/16/2013	217.2	
AOC_5	PZ-12-05	2/14/2013	216.8	
AOC_5	PZ-12-05	3/12/2013	217.2	
AOC_5	PZ-12-05	4/22/2013	216.8	
AOC_5	PZ-12-05	4/25/2013	216.9	
AOC_5	PZ-12-05	5/15/2013	217.0	
AOC_5	PZ-12-05	5/22/2013	217.1	
AOC_5	PZ-12-05	5/30/2013	217.5	
AOC_5	PZ-12-05	6/11/2013	218.0	
AOC_5	PZ-12-05	10/21/2013		214.0
AOC_5	PZ-12-05	11/19/2013	216.3	
AOC_5	PZ-12-05	4/22/2014	217.1	
AOC_5	PZ-12-05	10/6/2014	218.3	
AOC_5	PZ-12-05	6/3/2015	217.2	
AOC_5	PZ-12-05	6/17/2015	217.0	
AOC_5	PZ-12-05	8/18/2015	216.7	
AOC_5	PZ-12-05	10/7/2015	216.7	
AOC_5	PZ-12-05	10/20/2015	217.5	
AOC_5	PZ-12-05	12/16/2015	216.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	PZ-12-05	4/6/2016	217.0	
AOC_5	PZ-12-05	6/9/2016	217.0	
AOC_5	PZ-12-05	6/23/2016	216.6	
AOC_5	PZ-12-05	8/16/2016	216.5	
AOC_5	PZ-12-05	10/20/2016	216.6	
AOC_5	PZ-12-05	11/15/2016	217.5	
AOC_5	PZ-12-05	11/16/2016	217.5	
AOC_5	PZ-12-05	5/22/2017	217.2	
AOC_5	PZ-12-05	5/11/2018	217.3	
AOC_5	PZ-12-05	11/1/2018	217.2	
AOC_5	PZ-12-05	4/11/2019	217.1	
AOC_5	PZ-12-05	10/22/2019	217.6	
AOC_5	PZ-12-05	5/18/2020	218.3	
AOC_5	PZ-12-06	11/5/2012	217.9	
AOC_5	PZ-12-06	11/6/2012	218.0	
AOC_5	PZ-12-06	11/16/2012	217.9	
AOC_5	PZ-12-06	11/21/2012	218.0	
AOC_5	PZ-12-06	11/28/2012	217.9	
AOC_5	PZ-12-06	12/13/2012	217.7	
AOC_5	PZ-12-06	1/16/2013	217.9	
AOC_5	PZ-12-06	2/14/2013	217.8	
AOC_5	PZ-12-06	3/12/2013	218.0	
AOC_5	PZ-12-06	3/13/2013	218.0	
AOC_5	PZ-12-06	4/22/2013	218.2	
AOC_5	PZ-12-06	4/25/2013	218.3	
AOC_5	PZ-12-06	5/15/2013	218.3	
AOC_5	PZ-12-06	5/24/2013	218.3	
AOC_5	PZ-12-06	5/30/2013	218.4	
AOC_5	PZ-12-06	6/11/2013	218.6	
AOC_5	PZ-12-06	10/21/2013	216.5	
AOC_5	PZ-12-06	11/19/2013	216.7	
AOC_5	PZ-12-06	4/22/2014	218.0	
AOC_5	PZ-12-06	10/6/2014	217.7	
AOC_5	PZ-12-06	6/3/2015	218.5	
AOC_5	PZ-12-06	6/17/2015	218.4	
AOC_5	PZ-12-06	8/18/2015	218.1	
AOC_5	PZ-12-06	10/7/2015	217.6	
AOC_5	PZ-12-06	10/20/2015	217.8	
AOC_5	PZ-12-06	12/16/2015	217.5	
AOC_5	PZ-12-06	4/6/2016	218.2	
AOC_5	PZ-12-06	6/9/2016	218.1	
AOC_5	PZ-12-06	6/23/2016	218.0	
AOC_5	PZ-12-06	8/16/2016	217.5	
AOC_5	PZ-12-06	11/15/2016	217.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	PZ-12-06	11/16/2016	217.6	
AOC_5	PZ-12-06	5/22/2017	218.9	
AOC_5	PZ-12-06	5/11/2018	219.0	
AOC_5	PZ-12-06	11/1/2018	218.9	
AOC_5	PZ-12-06	4/11/2019	219.5	
AOC_5	PZ-12-06	10/22/2019	218.5	
AOC_5	PZ-12-06	5/18/2020	219.8	
AOC_5	PZ-12-07	11/5/2012	217.7	
AOC_5	PZ-12-07	11/6/2012	217.6	
AOC_5	PZ-12-07	11/16/2012	217.3	
AOC_5	PZ-12-07	11/21/2012	217.3	
AOC_5	PZ-12-07	11/28/2012	217.2	
AOC_5	PZ-12-07	12/13/2012	216.8	
AOC_5	PZ-12-07	1/16/2013	217.3	
AOC_5	PZ-12-07	2/14/2013	216.9	
AOC_5	PZ-12-07	3/12/2013	217.3	
AOC_5	PZ-12-07	4/22/2013	217.0	
AOC_5	PZ-12-07	4/25/2013	217.0	
AOC_5	PZ-12-07	5/15/2013	217.1	
AOC_5	PZ-12-07	5/24/2013	217.2	
AOC_5	PZ-12-07	5/30/2013	217.7	
AOC_5	PZ-12-07	6/11/2013	217.6	
AOC_5	PZ-12-07	10/21/2013		214.2
AOC_5	PZ-12-07	11/19/2013	216.1	
AOC_5	PZ-12-07	4/22/2014	217.4	
AOC_5	PZ-12-07	10/6/2014	217.0	
AOC_5	PZ-12-07	6/3/2015	217.5	
AOC_5	PZ-12-07	6/17/2015	216.8	
AOC_5	PZ-12-07	8/18/2015	216.7	
AOC_5	PZ-12-07	10/7/2015	216.6	
AOC_5	PZ-12-07	10/20/2015	217.3	
AOC_5	PZ-12-07	12/16/2015	216.7	
AOC_5	PZ-12-07	4/6/2016	217.1	
AOC_5	PZ-12-07	6/9/2016	216.9	
AOC_5	PZ-12-07	6/23/2016	216.8	
AOC_5	PZ-12-07	8/16/2016	216.4	
AOC_5	PZ-12-07	10/20/2016	216.5	
AOC_5	PZ-12-07	11/15/2016	217.3	
AOC_5	PZ-12-07	5/22/2017	217.3	
AOC_5	PZ-12-07	5/11/2018	217.4	
AOC_5	PZ-12-07	11/1/2018	217.2	
AOC_5	PZ-12-07	4/11/2019	216.9	
AOC_5	PZ-12-07	10/22/2019	217.5	
AOC_5	PZ-12-07	5/15/2020	217.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	PZ-12-07	5/18/2020	217.2	
AOC_5	PZ-12-08	11/5/2012	218.6	
AOC_5	PZ-12-08	11/6/2012	218.6	
AOC_5	PZ-12-08	11/16/2012	218.5	
AOC_5	PZ-12-08	11/21/2012	218.5	
AOC_5	PZ-12-08	11/28/2012	218.5	
AOC_5	PZ-12-08	12/13/2012	218.2	
AOC_5	PZ-12-08	1/16/2013	218.4	
AOC_5	PZ-12-08	2/14/2013	218.3	
AOC_5	PZ-12-08	3/12/2013	218.6	
AOC_5	PZ-12-08	4/22/2013	218.8	
AOC_5	PZ-12-08	4/25/2013	218.9	
AOC_5	PZ-12-08	5/15/2013	218.8	
AOC_5	PZ-12-08	5/24/2013	218.8	
AOC_5	PZ-12-08	5/30/2013	219.0	
AOC_5	PZ-12-08	6/11/2013	219.2	
AOC_5	PZ-12-08	10/21/2013	217.3	
AOC_5	PZ-12-08	11/19/2013	217.6	
AOC_5	PZ-12-08	4/22/2014	218.7	
AOC_5	PZ-12-08	10/6/2014	218.3	
AOC_5	PZ-12-08	6/3/2015	219.3	
AOC_5	PZ-12-08	6/17/2015	219.3	
AOC_5	PZ-12-08	8/18/2015	218.9	
AOC_5	PZ-12-08	10/7/2015	218.4	
AOC_5	PZ-12-08	10/20/2015	218.4	
AOC_5	PZ-12-08	12/16/2015	218.3	
AOC_5	PZ-12-08	4/6/2016	219.2	
AOC_5	PZ-12-08	6/9/2016	218.9	
AOC_5	PZ-12-08	6/23/2016	218.9	
AOC_5	PZ-12-08	8/16/2016	218.2	
AOC_5	PZ-12-08	11/15/2016	218.3	
AOC_5	PZ-12-08	5/22/2017	220.1	
AOC_5	PZ-12-08	5/11/2018	220.3	
AOC_5	PZ-12-08	11/1/2018	218.1	
AOC_5	PZ-12-08	4/11/2019	220.8	
AOC_5	PZ-12-08	10/22/2019	218.4	
AOC_5	PZ-12-08	5/18/2020	221.0	
AOC_5	PZ-12-08	5/19/2020	220.9	
AOC_5	PZ-12-09	11/5/2012	218.9	
AOC_5	PZ-12-09	11/6/2012	218.7	
AOC_5	PZ-12-09	11/16/2012	218.2	
AOC_5	PZ-12-09	11/21/2012	218.0	
AOC_5	PZ-12-09	11/28/2012	217.9	
AOC_5	PZ-12-09	12/13/2012	217.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	PZ-12-09	1/16/2013	218.8	
AOC_5	PZ-12-09	2/14/2013	217.7	
AOC_5	PZ-12-09	3/12/2013	218.3	
AOC_5	PZ-12-09	4/22/2013	217.8	
AOC_5	PZ-12-09	4/25/2013	217.8	
AOC_5	PZ-12-09	5/15/2013	217.6	
AOC_5	PZ-12-09	5/21/2013	217.5	
AOC_5	PZ-12-09	6/11/2013	219.1	
AOC_5	PZ-12-09	10/21/2013	216.7	
AOC_5	PZ-12-09	11/19/2013	217.2	
AOC_5	PZ-12-09	4/22/2014	218.4	
AOC_5	PZ-12-09	10/6/2014	217.3	
AOC_5	PZ-12-09	6/3/2015	217.7	
AOC_5	PZ-12-09	6/17/2015	217.7	
AOC_5	PZ-12-09	8/18/2015	217.5	
AOC_5	PZ-12-09	10/7/2015	217.3	
AOC_5	PZ-12-09	10/20/2015	217.5	
AOC_5	PZ-12-09	12/16/2015	217.4	
AOC_5	PZ-12-09	4/6/2016	218.1	
AOC_5	PZ-12-09	6/9/2016	217.6	
AOC_5	PZ-12-09	6/23/2016	218.6	
AOC_5	PZ-12-09	8/16/2016	217.1	
AOC_5	PZ-12-09	10/20/2016	217.1	
AOC_5	PZ-12-09	11/16/2016	218.0	
AOC_5	PZ-12-09	5/22/2017	218.3	
AOC_5	PZ-12-09	5/11/2018	218.5	
AOC_5	PZ-12-09	11/1/2018	218.4	
AOC_5	PZ-12-09	4/11/2019	218.0	
AOC_5	PZ-12-09	10/22/2019	218.0	
AOC_5	PZ-12-09	5/15/2020	218.7	
AOC_5	PZ-12-09	5/18/2020	218.6	
AOC_5	PZ-12-10	11/5/2012	219.9	
AOC_5	PZ-12-10	11/6/2012	220.0	
AOC_5	PZ-12-10	11/16/2012	219.7	
AOC_5	PZ-12-10	11/21/2012	219.6	
AOC_5	PZ-12-10	11/28/2012	219.5	
AOC_5	PZ-12-10	12/13/2012	219.2	
AOC_5	PZ-12-10	1/16/2013	219.7	
AOC_5	PZ-12-10	2/14/2013	219.5	
AOC_5	PZ-12-10	3/12/2013	220.1	
AOC_5	PZ-12-10	4/22/2013	219.6	
AOC_5	PZ-12-10	4/25/2013	219.6	
AOC_5	PZ-12-10	5/15/2013	219.4	
AOC_5	PZ-12-10	5/22/2013	219.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	PZ-12-10	6/11/2013	219.1	
AOC_5	PZ-12-10	10/21/2013	218.7	
AOC_5	PZ-12-10	11/19/2013	218.5	
AOC_5	PZ-12-10	4/22/2014	219.9	
AOC_5	PZ-12-10	10/6/2014	218.7	
AOC_5	PZ-12-10	6/3/2015	219.4	
AOC_5	PZ-12-10	6/17/2015	219.5	
AOC_5	PZ-12-10	8/18/2015	219.3	
AOC_5	PZ-12-10	10/7/2015	218.9	
AOC_5	PZ-12-10	10/20/2015	218.8	
AOC_5	PZ-12-10	12/16/2015	218.8	
AOC_5	PZ-12-10	4/6/2016	219.9	
AOC_5	PZ-12-10	6/9/2016	219.4	
AOC_5	PZ-12-10	6/24/2016	219.2	
AOC_5	PZ-12-10	8/16/2016	218.8	
AOC_5	PZ-12-10	11/16/2016	219.2	
AOC_5	PZ-12-10	5/22/2017	220.6	
AOC_5	PZ-12-10	5/11/2018	220.7	
AOC_5	PZ-12-10	11/1/2018	220.5	
AOC_5	PZ-12-10	4/11/2019	220.6	
AOC_5	PZ-12-10	10/22/2019	219.5	
AOC_5	PZ-12-10	5/15/2020	221.4	
AOC_5	PZ-12-10	5/18/2020	221.3	
AOC_5	Q4-1	4/28/2009	263.1	
AOC_5	Q4-1	9/9/2009	251.5	
AOC_5	Q4-1	3/17/2010	266.6	
AOC_5	Q4-1	6/24/2016	249.5	
AOC_5	Q4-1	11/15/2016	233.7	
AOC_5	Q4-1	5/22/2017	258.6	
AOC_5	Q4-1	11/1/2018	258.3	
AOC_5	Q4-1	10/22/2019	235.7	
AOC_5	Q4-2	4/28/2009	264.4	
AOC_5	Q4-2	8/5/2009	264.0	
AOC_5	Q4-2	9/9/2009	248.4	
AOC_5	Q4-2	3/17/2010	269.3	
AOC_5	Q5-1	4/28/2009	258.5	
AOC_5	Q5-1	8/5/2009	256.7	
AOC_5	Q5-1	9/9/2009	248.1	
AOC_5	Q5-1	3/17/2010	261.5	
AOC_5	Q5-1	6/24/2016	247.1	
AOC_5	Q5-1	11/15/2016	230.2	
AOC_5	Q5-1	5/22/2017	255.7	
AOC_5	Q5-1	11/1/2018	255.4	
AOC_5	Q5-1	10/22/2019	232.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	Q5-2	4/28/2009	258.5	
AOC_5	Q5-2	8/5/2009	256.4	
AOC_5	Q5-2	9/9/2009	247.2	
AOC_5	Q5-2	3/17/2010	261.6	
AOC_5	RSK 7	11/1/2018	216.6	
AOC_5	RSK 7	10/22/2019	217.4	
AOC_5	RSK1	9/15/2005	216.2	
AOC_5	RSK1	8/2/2006	216.4	
AOC_5	RSK1	8/10/2006	216.4	
AOC_5	RSK1	10/19/2006	216.5	
AOC_5	RSK1	4/26/2007	216.7	
AOC_5	RSK1	8/21/2007	216.2	
AOC_5	RSK1	11/7/2007	217.0	
AOC_5	RSK1	4/28/2008	216.5	
AOC_5	RSK1	6/10/2008	216.4	
AOC_5	RSK1	8/19/2008	216.7	
AOC_5	RSK1	4/28/2009	216.8	
AOC_5	RSK1	9/14/2009	216.4	
AOC_5	RSK1	10/26/2009	216.6	
AOC_5	RSK1	11/6/2012	217.5	
AOC_5	RSK1	5/30/2013	217.2	
AOC_5	RSK1	6/17/2015	216.5	
AOC_5	RSK1	8/18/2015	216.4	
AOC_5	RSK1	12/16/2015	216.5	
AOC_5	RSK1	6/9/2016	216.7	
AOC_5	RSK1	8/16/2016	216.3	
AOC_5	RSK10	9/15/2005	216.7	
AOC_5	RSK10	10/19/2006	216.9	
AOC_5	RSK10	4/25/2007	217.5	
AOC_5	RSK10	9/11/2007	216.7	
AOC_5	RSK10	11/6/2012	217.1	
AOC_5	RSK11	9/15/2005	216.7	
AOC_5	RSK11	8/2/2006	217.1	
AOC_5	RSK11	10/19/2006	217.0	
AOC_5	RSK11	4/25/2007	217.5	
AOC_5	RSK11	9/11/2007	216.7	
AOC_5	RSK11	11/6/2012	217.1	
AOC_5	RSK12	9/15/2005	216.7	
AOC_5	RSK12	10/19/2006	217.0	
AOC_5	RSK12	4/25/2007	217.5	
AOC_5	RSK12	4/26/2007	217.5	
AOC_5	RSK12	9/10/2007	216.7	
AOC_5	RSK12	9/11/2007	216.7	
AOC_5	RSK12	11/7/2007	217.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	RSK12	2/12/2008	217.6	
AOC_5	RSK12	4/28/2008	217.3	
AOC_5	RSK12	6/10/2008	217.1	
AOC_5	RSK12	8/19/2008	217.4	
AOC_5	RSK12	9/15/2008	217.3	
AOC_5	RSK12	4/28/2009	217.5	
AOC_5	RSK12	7/5/2009	217.2	
AOC_5	RSK12	9/14/2009	216.9	
AOC_5	RSK12	10/26/2009	217.0	
AOC_5	RSK12	4/27/2010	217.5	
AOC_5	RSK12	9/14/2010	216.5	
AOC_5	RSK12	7/25/2011	216.8	
AOC_5	RSK12	6/26/2012	217.0	
AOC_5	RSK12	11/6/2012	217.2	
AOC_5	RSK12	4/25/2013	216.7	
AOC_5	RSK12	5/30/2013	217.4	
AOC_5	RSK12	6/17/2015	216.8	
AOC_5	RSK12	8/18/2015	216.6	
AOC_5	RSK12	10/7/2015	216.6	
AOC_5	RSK12	12/16/2015	216.7	
AOC_5	RSK12	4/6/2016	216.9	
AOC_5	RSK12	6/9/2016	216.9	
AOC_5	RSK12	8/16/2016	216.4	
AOC_5	RSK12	10/20/2016	216.4	
AOC_5	RSK13	9/15/2005	216.6	
AOC_5	RSK13	5/18/2006	218.2	
AOC_5	RSK13	8/2/2006	217.0	
AOC_5	RSK13	10/19/2006	216.9	
AOC_5	RSK13	4/26/2007	217.5	
AOC_5	RSK13	9/12/2007	216.8	
AOC_5	RSK13	11/7/2007	217.2	
AOC_5	RSK13	4/28/2008	217.1	
AOC_5	RSK13	6/10/2008	220.0	
AOC_5	RSK13	8/19/2008	217.3	
AOC_5	RSK13	4/28/2009	217.3	
AOC_5	RSK13	9/14/2009	216.8	
AOC_5	RSK13	10/26/2009	217.0	
AOC_5	RSK13	6/26/2012	216.9	
AOC_5	RSK13	11/6/2012	217.2	
AOC_5	RSK13	5/30/2013	217.4	
AOC_5	RSK13	6/17/2015	216.7	
AOC_5	RSK13	8/18/2015	216.6	
AOC_5	RSK13	10/7/2015	216.6	
AOC_5	RSK13	6/9/2016	216.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	RSK14	9/15/2005	216.6	
AOC_5	RSK14	5/18/2006	218.3	
AOC_5	RSK14	8/2/2006	217.0	
AOC_5	RSK14	10/19/2006	216.9	
AOC_5	RSK14	9/12/2007	216.8	
AOC_5	RSK15	9/15/2005	216.6	
AOC_5	RSK15	5/18/2006	218.3	
AOC_5	RSK15	8/2/2006	217.0	
AOC_5	RSK15	10/19/2006	216.9	
AOC_5	RSK15	4/26/2007	217.6	
AOC_5	RSK15	9/10/2007	216.6	
AOC_5	RSK15	9/12/2007	216.8	
AOC_5	RSK15	11/7/2007	217.3	
AOC_5	RSK15	2/12/2008	217.6	
AOC_5	RSK15	4/28/2008	217.2	
AOC_5	RSK15	6/10/2008	220.0	
AOC_5	RSK15	8/19/2008	217.4	
AOC_5	RSK15	9/15/2008	217.3	
AOC_5	RSK15	4/28/2009	217.4	
AOC_5	RSK15	7/5/2009	217.1	
AOC_5	RSK15	9/14/2009	216.9	
AOC_5	RSK15	10/26/2009	217.0	
AOC_5	RSK15	4/27/2010	217.3	
AOC_5	RSK15	9/14/2010	216.5	
AOC_5	RSK15	7/25/2011	216.8	
AOC_5	RSK15	6/26/2012	216.9	
AOC_5	RSK15	11/6/2012	217.2	
AOC_5	RSK15	4/25/2013	216.7	
AOC_5	RSK15	5/30/2013	217.4	
AOC_5	RSK15	6/17/2015	216.7	
AOC_5	RSK15	8/18/2015	216.5	
AOC_5	RSK15	10/7/2015	216.6	
AOC_5	RSK15	12/16/2015	216.6	
AOC_5	RSK15	4/6/2016	216.8	
AOC_5	RSK15	6/9/2016	216.8	
AOC_5	RSK15	8/16/2016	216.4	
AOC_5	RSK15	10/20/2016	216.4	
AOC_5	RSK15	11/1/2018	216.9	
AOC_5	RSK15	10/22/2019	217.5	
AOC_5	RSK16	9/15/2005	216.4	
AOC_5	RSK16	8/2/2006	216.7	
AOC_5	RSK16	10/19/2006	216.7	
AOC_5	RSK16	4/24/2007	217.1	
AOC_5	RSK16	4/26/2007	217.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	RSK16	11/7/2007	217.1	
AOC_5	RSK16	4/28/2008	216.8	
AOC_5	RSK16	6/10/2008	216.7	
AOC_5	RSK16	8/19/2008	217.0	
AOC_5	RSK16	10/26/2009	216.8	
AOC_5	RSK16	11/6/2012	217.1	
AOC_5	RSK16	5/30/2013	217.3	
AOC_5	RSK16	6/17/2015	216.6	
AOC_5	RSK16	8/18/2015	216.5	
AOC_5	RSK16	12/16/2015	216.5	
AOC_5	RSK16	6/9/2016	216.7	
AOC_5	RSK16	8/16/2016	216.3	
AOC_5	RSK17	9/15/2005	216.4	
AOC_5	RSK17	8/2/2006	216.7	
AOC_5	RSK17	10/19/2006	216.7	
AOC_5	RSK17	4/24/2007	217.1	
AOC_5	RSK17	11/6/2012	217.1	
AOC_5	RSK18	9/15/2005	216.4	
AOC_5	RSK18	8/2/2006	216.6	
AOC_5	RSK18	10/19/2006	216.7	
AOC_5	RSK18	4/24/2007	217.0	
AOC_5	RSK18	11/6/2012	217.0	
AOC_5	RSK19	9/15/2005	216.4	
AOC_5	RSK19	8/2/2006	216.6	
AOC_5	RSK19	10/19/2006	216.7	
AOC_5	RSK19	4/24/2007	217.0	
AOC_5	RSK19	4/26/2007	217.0	
AOC_5	RSK19	9/10/2007	216.4	
AOC_5	RSK19	11/7/2007	217.1	
AOC_5	RSK19	2/12/2008	217.1	
AOC_5	RSK19	4/28/2008	216.8	
AOC_5	RSK19	6/10/2008	216.6	
AOC_5	RSK19	8/19/2008	216.9	
AOC_5	RSK19	9/15/2008	216.9	
AOC_5	RSK19	4/28/2009	217.0	
AOC_5	RSK19	7/5/2009	216.7	
AOC_5	RSK19	9/14/2009	216.6	
AOC_5	RSK19	10/26/2009	216.8	
AOC_5	RSK19	4/27/2010	216.9	
AOC_5	RSK19	9/14/2010	216.2	
AOC_5	RSK19	7/25/2011	216.4	
AOC_5	RSK19	6/26/2012	216.6	
AOC_5	RSK19	11/6/2012	217.0	
AOC_5	RSK19	4/25/2013	216.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	RSK19	5/30/2013	217.2	
AOC_5	RSK19	6/17/2015	216.6	
AOC_5	RSK19	8/18/2015	216.5	
AOC_5	RSK19	10/7/2015	216.5	
AOC_5	RSK19	12/16/2015	216.5	
AOC_5	RSK19	4/6/2016	216.7	
AOC_5	RSK19	6/9/2016	216.7	
AOC_5	RSK19	8/16/2016	216.3	
AOC_5	RSK19	10/20/2016	216.3	
AOC_5	RSK19	11/1/2018	216.8	
AOC_5	RSK19	10/22/2019	217.4	
AOC_5	RSK2	9/15/2005	215.7	
AOC_5	RSK2	8/2/2006	215.9	
AOC_5	RSK2	8/8/2006	216.1	
AOC_5	RSK2	11/6/2012	216.5	
AOC_5	RSK20	9/15/2005	216.4	
AOC_5	RSK20	8/2/2006	216.7	
AOC_5	RSK20	10/19/2006	216.7	
AOC_5	RSK20	4/24/2007	217.1	
AOC_5	RSK20	11/6/2012	217.1	
AOC_5	RSK21	8/2/2006	216.6	
AOC_5	RSK21	10/19/2006	216.7	
AOC_5	RSK21	11/7/2007	217.1	
AOC_5	RSK23	9/10/2007	216.7	
AOC_5	RSK23	11/7/2007	217.3	
AOC_5	RSK23	4/28/2009	217.5	
AOC_5	RSK24	4/26/2007	219.3	
AOC_5	RSK24	9/10/2007	217.8	
AOC_5	RSK24	11/7/2007	219.5	
AOC_5	RSK24	4/28/2008	218.7	
AOC_5	RSK24	6/10/2008	218.4	
AOC_5	RSK24	8/19/2008	219.0	
AOC_5	RSK24	9/15/2008	219.5	
AOC_5	RSK24	4/28/2009	219.0	
AOC_5	RSK24	7/5/2009	218.7	
AOC_5	RSK24	9/14/2009	218.1	
AOC_5	RSK24	10/26/2009	218.8	
AOC_5	RSK24	6/26/2012	218.2	
AOC_5	RSK24	4/25/2013	219.3	
AOC_5	RSK24	6/17/2015	219.6	
AOC_5	RSK24	8/18/2015	219.2	
AOC_5	RSK24	6/9/2016	219.2	
AOC_5	RSK24	8/16/2016	218.5	
AOC_5	RSK25	4/26/2007	218.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	RSK25	9/10/2007	217.0	
AOC_5	RSK25	11/7/2007	217.6	
AOC_5	RSK25	4/28/2008	217.8	
AOC_5	RSK25	6/10/2008	217.5	
AOC_5	RSK25	8/19/2008	218.1	
AOC_5	RSK25	9/15/2008	218.1	
AOC_5	RSK25	4/28/2009	218.0	
AOC_5	RSK25	7/5/2009	217.8	
AOC_5	RSK25	9/14/2009	217.3	
AOC_5	RSK25	10/26/2009	217.3	
AOC_5	RSK25	4/27/2010	218.1	
AOC_5	RSK25	9/14/2010	216.8	
AOC_5	RSK25	7/25/2011	217.1	
AOC_5	RSK25	6/26/2012	217.3	
AOC_5	RSK25	4/25/2013	217.0	
AOC_5	RSK25	5/30/2013	217.7	
AOC_5	RSK25	6/17/2015	216.8	
AOC_5	RSK25	8/18/2015	216.7	
AOC_5	RSK25	10/7/2015	216.6	
AOC_5	RSK25	12/16/2015	216.7	
AOC_5	RSK25	4/6/2016	217.1	
AOC_5	RSK25	6/9/2016	216.9	
AOC_5	RSK25	8/16/2016	216.4	
AOC_5	RSK25	10/20/2016	216.5	
AOC_5	RSK25	11/1/2018	217.3	
AOC_5	RSK25	10/22/2019	217.5	
AOC_5	RSK26	4/26/2007		-20.8
AOC_5	RSK26	9/10/2007		-21.8
AOC_5	RSK26	11/7/2007		-21.3
AOC_5	RSK26	2/12/2008		-20.9
AOC_5	RSK26	4/28/2008		-21.2
AOC_5	RSK26	6/10/2008		-21.3
AOC_5	RSK26	8/19/2008		-21.0
AOC_5	RSK26	9/15/2008		-21.1
AOC_5	RSK26	4/28/2009		-20.9
AOC_5	RSK26	7/5/2009		-21.2
AOC_5	RSK26	9/14/2009		-21.6
AOC_5	RSK26	10/26/2009		-21.5
AOC_5	RSK26	4/27/2010		-20.9
AOC_5	RSK26	9/14/2010		-22.1
AOC_5	RSK26	7/25/2011		-21.7
AOC_5	RSK26	6/26/2012		-21.6
AOC_5	RSK27	4/26/2007	219.8	
AOC_5	RSK27	9/10/2007	218.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	RSK27	11/7/2007	219.3	
AOC_5	RSK27	4/28/2008	219.7	
AOC_5	RSK27	6/10/2008	219.5	
AOC_5	RSK27	8/19/2008	219.6	
AOC_5	RSK27	9/15/2008	219.6	
AOC_5	RSK27	4/28/2009	219.8	
AOC_5	RSK27	7/5/2009	219.6	
AOC_5	RSK27	9/14/2009	219.2	
AOC_5	RSK27	10/26/2009	219.2	
AOC_5	RSK27	4/27/2010	220.0	
AOC_5	RSK27	9/14/2010	218.7	
AOC_5	RSK27	7/25/2011	219.1	
AOC_5	RSK27	6/26/2012	219.2	
AOC_5	RSK27	4/25/2013	220.2	
AOC_5	RSK27	5/30/2013	218.5	
AOC_5	RSK27	6/17/2015	218.5	
AOC_5	RSK27	8/18/2015	218.2	
AOC_5	RSK27	10/7/2015	217.7	
AOC_5	RSK27	12/16/2015	217.6	
AOC_5	RSK27	4/6/2016	218.3	
AOC_5	RSK27	6/9/2016	218.2	
AOC_5	RSK27	8/16/2016	217.6	
AOC_5	RSK27	11/1/2018	219.0	
AOC_5	RSK27	10/22/2019	219.1	
AOC_5	RSK28	4/26/2007	219.6	
AOC_5	RSK28	9/10/2007	218.8	
AOC_5	RSK28	11/7/2007	219.2	
AOC_5	RSK28	2/12/2008	219.5	
AOC_5	RSK28	4/28/2008	219.5	
AOC_5	RSK28	6/10/2008	219.3	
AOC_5	RSK28	8/19/2008	219.4	
AOC_5	RSK28	9/15/2008	219.3	
AOC_5	RSK28	4/28/2009	219.6	
AOC_5	RSK28	7/5/2009	219.3	
AOC_5	RSK28	9/14/2009	219.0	
AOC_5	RSK28	10/26/2009	219.0	
AOC_5	RSK28	4/27/2010	219.7	
AOC_5	RSK28	9/14/2010	218.5	
AOC_5	RSK28	7/25/2011	218.9	
AOC_5	RSK28	6/26/2012	219.0	
AOC_5	RSK28	4/25/2013	220.0	
AOC_5	RSK28	5/30/2013	218.5	
AOC_5	RSK28	6/17/2015	218.4	
AOC_5	RSK28	8/18/2015	218.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	RSK28	10/7/2015	217.6	
AOC_5	RSK28	12/16/2015	217.4	
AOC_5	RSK28	4/6/2016	218.2	
AOC_5	RSK28	6/9/2016	218.1	
AOC_5	RSK28	8/16/2016	217.4	
AOC_5	RSK28	11/1/2018	218.8	
AOC_5	RSK28	10/22/2019	218.5	
AOC_5	RSK29	4/26/2007		-16.9
AOC_5	RSK29	9/10/2007		-17.7
AOC_5	RSK29	11/7/2007		-17.2
AOC_5	RSK29	2/12/2008		-16.9
AOC_5	RSK29	4/28/2008		-17.0
AOC_5	RSK29	6/10/2008		-17.2
AOC_5	RSK29	8/19/2008		-17.0
AOC_5	RSK29	9/15/2008		-17.1
AOC_5	RSK29	4/28/2009		-16.9
AOC_5	RSK29	7/5/2009		-17.2
AOC_5	RSK29	9/14/2009		-17.4
AOC_5	RSK29	10/26/2009		-17.4
AOC_5	RSK29	4/27/2010		-16.8
AOC_5	RSK29	9/14/2010		-17.9
AOC_5	RSK29	7/25/2011		-17.6
AOC_5	RSK29	6/26/2012		-17.4
AOC_5	RSK3	9/15/2005	216.1	
AOC_5	RSK3	8/2/2006	216.3	
AOC_5	RSK3	8/10/2006	216.4	
AOC_5	RSK3	10/19/2006	216.4	
AOC_5	RSK3	8/21/2007	216.2	
AOC_5	RSK3	11/6/2012	216.9	
AOC_5	RSK30	4/26/2007		-13.5
AOC_5	RSK30	9/10/2007		-14.3
AOC_5	RSK30	11/7/2007		-13.8
AOC_5	RSK30	4/28/2008		-13.7
AOC_5	RSK30	6/10/2008		-13.9
AOC_5	RSK30	8/19/2008		-13.7
AOC_5	RSK30	9/15/2008		-13.7
AOC_5	RSK30	4/28/2009		-13.5
AOC_5	RSK30	7/5/2009		-13.8
AOC_5	RSK30	9/14/2009		-14.1
AOC_5	RSK30	10/26/2009		-14.0
AOC_5	RSK30	4/27/2010		-13.5
AOC_5	RSK30	9/14/2010		-14.5
AOC_5	RSK30	7/25/2011		-14.2
AOC_5	RSK30	6/26/2012		-14.0

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	RSK32	11/7/2007	219.1	
AOC_5	RSK32	2/12/2008	219.4	
AOC_5	RSK32	4/28/2008	219.3	
AOC_5	RSK32	6/10/2008	219.1	
AOC_5	RSK32	8/19/2008	219.3	
AOC_5	RSK32	9/15/2008	219.2	
AOC_5	RSK32	4/28/2009	219.5	
AOC_5	RSK32	7/5/2009	219.2	
AOC_5	RSK32	9/14/2009	218.9	
AOC_5	RSK32	10/26/2009	218.9	
AOC_5	RSK32	4/27/2010	219.6	
AOC_5	RSK32	9/14/2010	217.4	
AOC_5	RSK32	7/25/2011	218.8	
AOC_5	RSK32	6/26/2012	218.9	
AOC_5	RSK32	4/25/2013	219.9	
AOC_5	RSK32	5/30/2013	218.3	
AOC_5	RSK32	6/17/2015	218.2	
AOC_5	RSK32	8/18/2015	217.9	
AOC_5	RSK32	10/7/2015	217.4	
AOC_5	RSK32	12/16/2015	217.3	
AOC_5	RSK32	4/6/2016	218.0	
AOC_5	RSK32	6/9/2016	217.9	
AOC_5	RSK32	8/16/2016	217.2	
AOC_5	RSK32	11/1/2018	218.6	
AOC_5	RSK32	10/22/2019	218.3	
AOC_5	RSK33	4/26/2007		-16.4
AOC_5	RSK33	9/10/2007		-17.5
AOC_5	RSK33	11/7/2007		-16.9
AOC_5	RSK33	4/28/2008		-16.7
AOC_5	RSK33	6/10/2008		-16.9
AOC_5	RSK33	8/19/2008		-16.7
AOC_5	RSK33	9/15/2008		-16.7
AOC_5	RSK33	4/28/2009		-16.5
AOC_5	RSK33	7/5/2009		-16.8
AOC_5	RSK33	9/14/2009		-17.2
AOC_5	RSK33	10/26/2009		-17.2
AOC_5	RSK33	4/27/2010		-16.4
AOC_5	RSK33	9/14/2010		-17.7
AOC_5	RSK33	7/25/2011		-17.3
AOC_5	RSK33	6/26/2012		-17.2
AOC_5	RSK34	4/26/2007	217.6	
AOC_5	RSK34	9/10/2007	216.1	
AOC_5	RSK34	11/7/2007	216.6	
AOC_5	RSK34	4/28/2008	217.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	RSK34	6/10/2008	216.9	
AOC_5	RSK34	8/19/2008	217.1	
AOC_5	RSK34	9/15/2008	217.0	
AOC_5	RSK34	4/28/2009	217.4	
AOC_5	RSK34	7/5/2009	217.0	
AOC_5	RSK34	9/14/2009	216.5	
AOC_5	RSK34	10/26/2009	216.4	
AOC_5	RSK34	4/27/2010	217.7	
AOC_5	RSK34	9/14/2010	215.9	
AOC_5	RSK34	7/25/2011	216.4	
AOC_5	RSK34	6/26/2012	216.5	
AOC_5	RSK34	4/25/2013	217.1	
AOC_5	RSK34	5/30/2013	217.3	
AOC_5	RSK34	6/17/2015	217.0	
AOC_5	RSK34	8/18/2015	216.7	
AOC_5	RSK34	10/7/2015	216.2	
AOC_5	RSK34	12/16/2015	216.3	
AOC_5	RSK34	4/6/2016	217.1	
AOC_5	RSK34	6/9/2016	216.7	
AOC_5	RSK34	8/16/2016	216.1	
AOC_5	RSK34	11/1/2018	217.7	
AOC_5	RSK34	10/22/2019	217.1	
AOC_5	RSK35	4/26/2007	219.9	
AOC_5	RSK35	9/10/2007	218.3	
AOC_5	RSK35	11/7/2007	218.9	
AOC_5	RSK35	4/28/2008	219.4	
AOC_5	RSK35	6/10/2008	219.1	
AOC_5	RSK35	8/19/2008	219.4	
AOC_5	RSK35	9/15/2008	219.3	
AOC_5	RSK35	4/28/2009	219.6	
AOC_5	RSK35	7/5/2009	219.3	
AOC_5	RSK35	9/14/2009	218.6	
AOC_5	RSK35	10/26/2009	218.7	
AOC_5	RSK35	4/27/2010	220.0	
AOC_5	RSK35	9/14/2010	218.0	
AOC_5	RSK35	7/25/2011	218.6	
AOC_5	RSK35	6/26/2012	218.7	
AOC_5	RSK35	4/25/2013	219.1	
AOC_5	RSK35	5/30/2013	216.9	
AOC_5	RSK35	6/17/2015	216.4	
AOC_5	RSK35	8/18/2015	216.1	
AOC_5	RSK35	10/7/2015	215.8	
AOC_5	RSK35	12/16/2015	215.9	
AOC_5	RSK35	4/6/2016	216.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	RSK35	6/9/2016	216.3	
AOC_5	RSK35	8/16/2016	215.6	
AOC_5	RSK35	10/20/2016	215.4	
AOC_5	RSK35	11/1/2018	216.9	
AOC_5	RSK35	10/22/2019	216.6	
AOC_5	RSK37	4/26/2007	216.7	
AOC_5	RSK37	8/22/2007	216.2	
AOC_5	RSK37	9/10/2007	216.2	
AOC_5	RSK37	11/7/2007	217.0	
AOC_5	RSK37	2/12/2008	217.0	
AOC_5	RSK37	4/28/2008	216.4	
AOC_5	RSK37	6/10/2008	216.4	
AOC_5	RSK37	8/19/2008	216.7	
AOC_5	RSK37	9/15/2008	216.7	
AOC_5	RSK37	4/28/2009	216.7	
AOC_5	RSK37	7/5/2009	216.4	
AOC_5	RSK37	9/14/2009	216.4	
AOC_5	RSK37	10/26/2009	216.6	
AOC_5	RSK37	4/27/2010	216.5	
AOC_5	RSK37	9/14/2010	216.1	
AOC_5	RSK37	7/25/2011	216.2	
AOC_5	RSK37	6/26/2012	216.4	
AOC_5	RSK37	11/6/2012	217.0	
AOC_5	RSK37	4/25/2013	216.4	
AOC_5	RSK37	5/30/2013	217.2	
AOC_5	RSK37	6/17/2015	216.5	
AOC_5	RSK37	8/18/2015	216.4	
AOC_5	RSK37	10/7/2015	216.5	
AOC_5	RSK37	12/16/2015	216.5	
AOC_5	RSK37	4/6/2016	216.6	
AOC_5	RSK37	6/9/2016	216.7	
AOC_5	RSK37	8/16/2016	216.3	
AOC_5	RSK37	10/20/2016	216.4	
AOC_5	RSK37	11/1/2018	211.8	
AOC_5	RSK37	10/22/2019	217.5	
AOC_5	RSK38	8/22/2007	216.2	
AOC_5	RSK38	11/6/2012	217.0	
AOC_5	RSK39	8/22/2007	216.2	
AOC_5	RSK39	11/6/2012	217.0	
AOC_5	RSK39	10/7/2015	216.5	
AOC_5	RSK4	9/15/2005	215.9	
AOC_5	RSK4	8/2/2006	216.1	
AOC_5	RSK4	8/10/2006	216.8	
AOC_5	RSK4	10/19/2006	216.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	RSK4	8/21/2007	216.0	
AOC_5	RSK4	11/6/2012	216.7	
AOC_5	RSK40	8/22/2007	216.2	
AOC_5	RSK40	11/6/2012	217.0	
AOC_5	RSK41	4/26/2007	216.8	
AOC_5	RSK41	8/22/2007	216.2	
AOC_5	RSK41	11/7/2007	217.0	
AOC_5	RSK41	4/28/2008	216.5	
AOC_5	RSK41	6/10/2008	216.4	
AOC_5	RSK41	8/19/2008	216.8	
AOC_5	RSK41	9/14/2009	216.4	
AOC_5	RSK41	10/26/2009	216.6	
AOC_5	RSK41	11/6/2012	217.1	
AOC_5	RSK41	6/17/2015	216.5	
AOC_5	RSK41	8/18/2015	216.4	
AOC_5	RSK41	6/9/2016	216.7	
AOC_5	RSK41	8/16/2016	216.3	
AOC_5	RSK42	8/22/2007	216.2	
AOC_5	RSK42	11/6/2012	217.0	
AOC_5	RSK42	10/7/2015	216.5	
AOC_5	RSK43	11/7/2007	217.0	
AOC_5	RSK43	8/19/2008	216.7	
AOC_5	RSK43	10/26/2009	216.6	
AOC_5	RSK47	9/10/2007	216.8	
AOC_5	RSK47	11/7/2007	217.3	
AOC_5	RSK48	9/10/2007		-3.7
AOC_5	RSK48	11/7/2007		-3.1
AOC_5	RSK48	2/12/2008		-3.0
AOC_5	RSK48	4/28/2008		-3.4
AOC_5	RSK48	6/10/2008		-3.5
AOC_5	RSK48	8/19/2008		-3.3
AOC_5	RSK48	9/15/2008		-3.2
AOC_5	RSK48	4/28/2009		-3.2
AOC_5	RSK48	7/5/2009		-3.4
AOC_5	RSK48	9/14/2009		-3.5
AOC_5	RSK48	10/26/2009		-3.4
AOC_5	RSK48	4/27/2010		-3.3
AOC_5	RSK48	9/14/2010		-3.9
AOC_5	RSK48	7/25/2011		-3.7
AOC_5	RSK48	6/26/2012		-3.5
AOC_5	RSK48	11/6/2012		-3.1
AOC_5	RSK48	4/25/2013		-3.6
AOC_5	RSK48	5/30/2013		-2.9
AOC_5	RSK49	4/26/2007		-4.7

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	RSK49	9/10/2007		-5.6
AOC_5	RSK49	11/7/2007		-4.9
AOC_5	RSK49	4/28/2008		-5.2
AOC_5	RSK49	6/10/2008		-5.4
AOC_5	RSK49	8/19/2008		-5.1
AOC_5	RSK49	9/15/2008		-5.0
AOC_5	RSK49	4/28/2009		-5.0
AOC_5	RSK49	7/5/2009		-5.3
AOC_5	RSK49	9/14/2009		-5.4
AOC_5	RSK49	10/26/2009		-5.3
AOC_5	RSK49	4/27/2010		-5.1
AOC_5	RSK49	9/14/2010		-5.4
AOC_5	RSK49	7/25/2011		-5.3
AOC_5	RSK49	6/26/2012		-5.4
AOC_5	RSK49	11/6/2012		-4.9
AOC_5	RSK49	4/25/2013		-5.6
AOC_5	RSK49	5/30/2013		-3.8
AOC_5	RSK5	9/15/2005	216.1	
AOC_5	RSK5	8/2/2006	216.2	
AOC_5	RSK5	8/10/2006	216.3	
AOC_5	RSK5	10/19/2006	216.4	
AOC_5	RSK5	8/21/2007	216.2	
AOC_5	RSK5	11/6/2012	216.9	
AOC_5	RSK50	7/5/2009	215.9	
AOC_5	RSK50	9/14/2009	215.8	
AOC_5	RSK50	10/26/2009	215.9	
AOC_5	RSK50	4/27/2010	216.0	
AOC_5	RSK50	9/14/2010	215.4	
AOC_5	RSK50	7/25/2011	215.6	
AOC_5	RSK50	6/26/2012	215.8	
AOC_5	RSK50	11/6/2012	216.2	
AOC_5	RSK50	4/25/2013	215.7	
AOC_5	RSK50	6/17/2015	216.6	
AOC_5	RSK50	8/18/2015	216.4	
AOC_5	RSK50	10/7/2015	216.5	
AOC_5	RSK50	12/16/2015	216.5	
AOC_5	RSK50	4/6/2016	216.7	
AOC_5	RSK50	6/9/2016	216.7	
AOC_5	RSK50	8/16/2016	216.3	
AOC_5	RSK50	10/20/2016	216.3	
AOC_5	RSK6	9/15/2005	216.2	
AOC_5	RSK6	8/2/2006	216.3	
AOC_5	RSK6	8/8/2006	216.5	
AOC_5	RSK6	10/19/2006	216.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	RSK6	8/21/2007	216.2	
AOC_5	RSK6	11/6/2012	216.9	
AOC_5	RSK7	9/15/2005	215.7	
AOC_5	RSK7	8/2/2006	215.9	
AOC_5	RSK7	8/10/2006	215.9	
AOC_5	RSK7	10/19/2006	216.0	
AOC_5	RSK7	4/26/2007	216.2	
AOC_5	RSK7	8/21/2007	215.9	
AOC_5	RSK7	9/10/2007	215.8	
AOC_5	RSK7	11/7/2007	216.5	
AOC_5	RSK7	2/12/2008	216.6	
AOC_5	RSK7	4/28/2008	216.1	
AOC_5	RSK7	6/10/2008	215.9	
AOC_5	RSK7	8/19/2008	216.2	
AOC_5	RSK7	9/15/2008	216.2	
AOC_5	RSK7	4/28/2009	216.3	
AOC_5	RSK7	7/5/2009	216.0	
AOC_5	RSK7	9/14/2009	215.9	
AOC_5	RSK7	10/26/2009	216.1	
AOC_5	RSK7	4/27/2010	216.0	
AOC_5	RSK7	9/14/2010	215.7	
AOC_5	RSK7	7/25/2011	215.8	
AOC_5	RSK7	6/26/2012	216.0	
AOC_5	RSK7	11/6/2012	216.5	
AOC_5	RSK7	4/25/2013	216.0	
AOC_5	RSK7	5/30/2013	216.8	
AOC_5	RSK7	6/17/2015	216.5	
AOC_5	RSK7	8/18/2015	216.4	
AOC_5	RSK7	10/7/2015	216.5	
AOC_5	RSK7	12/16/2015	216.5	
AOC_5	RSK7	4/6/2016	216.6	
AOC_5	RSK7	6/9/2016	216.7	
AOC_5	RSK7	8/16/2016	216.3	
AOC_5	RSK7	10/20/2016	216.3	
AOC_5	RSK8	9/15/2005	216.6	
AOC_5	RSK8	8/2/2006	217.1	
AOC_5	RSK8	10/19/2006	216.9	
AOC_5	RSK8	4/25/2007	217.5	
AOC_5	RSK8	4/26/2007	217.5	
AOC_5	RSK8	9/11/2007	216.7	
AOC_5	RSK8	11/7/2007	217.2	
AOC_5	RSK8	4/28/2008	217.2	
AOC_5	RSK8	6/10/2008	217.1	
AOC_5	RSK8	8/19/2008	217.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	RSK8	4/28/2009	217.4	
AOC_5	RSK8	9/14/2009	216.9	
AOC_5	RSK8	10/26/2009	217.0	
AOC_5	RSK8	6/26/2012	216.9	
AOC_5	RSK8	11/6/2012	217.1	
AOC_5	RSK8	5/30/2013	217.4	
AOC_5	RSK8	6/17/2015	216.8	
AOC_5	RSK8	8/18/2015	216.7	
AOC_5	RSK8	10/7/2015	216.7	
AOC_5	RSK8	6/9/2016	216.9	
AOC_5	RSK9	9/15/2005	216.7	
AOC_5	RSK9	5/18/2006	218.1	
AOC_5	RSK9	8/2/2006	217.1	
AOC_5	RSK9	10/19/2006	217.0	
AOC_5	RSK9	4/25/2007	217.5	
AOC_5	RSK9	9/12/2007	216.7	
AOC_5	RSK9	11/6/2012	217.1	
AOC_5	SHL-1	3/30/1993	269.8	
AOC_5	SHL-1	9/30/1993	266.3	
AOC_5	SHL-1	3/30/1994	270.2	
AOC_5	SHL-1	12/7/1995	269.7	
AOC_5	SHL-1	3/26/1996	270.1	
AOC_5	SHL-1	4/23/1998	268.8	
AOC_5	SHL-1	6/19/1998	269.9	
AOC_5	SHL-1	6/26/1998	269.6	
AOC_5	SHL-1	7/1/1998	269.8	
AOC_5	SHL-1	10/14/1998	264.6	
AOC_5	SHL-1	4/26/2007	269.9	
AOC_5	SHL-1	4/28/2008	269.1	
AOC_5	SHL-1	6/10/2008	264.3	
AOC_5	SHL-1	9/15/2008	264.3	
AOC_5	SHL-1	4/28/2009	267.8	
AOC_5	SHL-1	9/14/2009	264.3	
AOC_5	SHL-1	10/26/2009	264.2	
AOC_5	SHL-1	4/22/2014	270.0	
AOC_5	SHL-1	6/24/2016	264.3	
AOC_5	SHL-1	11/15/2016		
AOC_5	SHL-1	5/22/2017	269.6	
AOC_5	SHL-1	11/1/2018	269.0	
AOC_5	SHL-1	10/22/2019	264.5	
AOC_5	SHL-10	5/26/1992	216.8	
AOC_5	SHL-10	9/15/1992	216.6	
AOC_5	SHL-10	12/22/1992	217.2	
AOC_5	SHL-10	3/30/1993	217.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-10	6/22/1993	216.6	
AOC_5	SHL-10	9/30/1993	216.7	
AOC_5	SHL-10	11/8/1993	216.9	
AOC_5	SHL-10	3/30/1994	217.8	
AOC_5	SHL-10	6/28/1994	216.7	
AOC_5	SHL-10	10/4/1994	217.0	
AOC_5	SHL-10	1/31/1995	217.4	
AOC_5	SHL-10	5/9/1995	216.7	
AOC_5	SHL-10	12/7/1995	217.2	
AOC_5	SHL-10	3/26/1996	217.6	
AOC_5	SHL-10	7/23/1996	217.0	
AOC_5	SHL-10	6/2/1997	216.8	
AOC_5	SHL-10	4/23/1998	217.3	
AOC_5	SHL-10	6/19/1998	218.2	
AOC_5	SHL-10	6/26/1998	218.0	
AOC_5	SHL-10	7/1/1998	217.8	
AOC_5	SHL-10	7/17/1998	217.2	
AOC_5	SHL-10	8/28/1998	216.7	
AOC_5	SHL-10	10/14/1998	216.7	
AOC_5	SHL-10	12/10/1998	216.7	
AOC_5	SHL-10	2/23/1999	216.8	
AOC_5	SHL-10	6/6/1999	216.5	
AOC_5	SHL-10	9/8/1999	216.5	
AOC_5	SHL-10	11/16/2001	216.6	
AOC_5	SHL-10	8/24/2005	218.3	
AOC_5	SHL-10	4/10/2006	218.5	
AOC_5	SHL-10	6/5/2006	219.9	
AOC_5	SHL-10	9/18/2006	218.4	
AOC_5	SHL-10	12/15/2006	219.3	
AOC_5	SHL-10	4/8/2007	217.2	
AOC_5	SHL-10	4/9/2007	217.2	
AOC_5	SHL-10	4/26/2007	218.3	
AOC_5	SHL-10	9/10/2007	216.5	
AOC_5	SHL-10	10/15/2007	217.5	
AOC_5	SHL-10	2/20/2008	218.8	
AOC_5	SHL-10	2/25/2008	218.4	
AOC_5	SHL-10	3/4/2008	218.0	
AOC_5	SHL-10	4/16/2008	217.6	
AOC_5	SHL-10	8/19/2008	217.6	
AOC_5	SHL-10	9/15/2008	217.7	
AOC_5	SHL-10	9/30/2008	217.4	
AOC_5	SHL-10	10/3/2008	217.4	
AOC_5	SHL-10	4/28/2009	217.5	
AOC_5	SHL-10	7/5/2009	217.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-10	9/14/2009	216.9	
AOC_5	SHL-10	10/20/2009	216.9	
AOC_5	SHL-10	10/26/2009	216.9	
AOC_5	SHL-10	11/3/2009	217.0	
AOC_5	SHL-10	4/20/2010	217.9	
AOC_5	SHL-10	4/27/2010	217.6	
AOC_5	SHL-10	9/14/2010	216.4	
AOC_5	SHL-10	10/7/2010	216.8	
AOC_5	SHL-10	4/4/2011	217.6	
AOC_5	SHL-10	7/25/2011	216.7	
AOC_5	SHL-10	11/8/2011	217.6	
AOC_5	SHL-10	4/10/2012	216.8	
AOC_5	SHL-10	6/26/2012	216.9	
AOC_5	SHL-10	11/5/2012	217.7	
AOC_5	SHL-10	11/6/2012	217.5	
AOC_5	SHL-10	2/14/2013	216.9	
AOC_5	SHL-10	3/12/2013	217.4	
AOC_5	SHL-10	4/22/2013	217.0	
AOC_5	SHL-10	4/25/2013	217.0	
AOC_5	SHL-10	5/15/2013	217.0	
AOC_5	SHL-10	5/22/2013	217.0	
AOC_5	SHL-10	6/11/2013	218.0	
AOC_5	SHL-10	10/21/2013	214.3	
AOC_5	SHL-10	4/22/2014	217.5	
AOC_5	SHL-10	10/6/2014	216.9	
AOC_5	SHL-10	6/2/2015	214.1	
AOC_5	SHL-10	6/17/2015	216.8	
AOC_5	SHL-10	8/18/2015	216.7	
AOC_5	SHL-10	10/7/2015	216.6	
AOC_5	SHL-10	10/20/2015	217.2	
AOC_5	SHL-10	12/16/2015	216.7	
AOC_5	SHL-10	6/9/2016	216.9	
AOC_5	SHL-10	8/16/2016	216.4	
AOC_5	SHL-10	5/22/2017	217.3	
AOC_5	SHL-10	5/11/2018	217.3	
AOC_5	SHL-10	11/1/2018	210.6	
AOC_5	SHL-10	4/11/2019	216.9	
AOC_5	SHL-10	10/22/2019	217.5	
AOC_5	SHL-10	5/15/2020	227.1	
AOC_5	SHL-10	5/18/2020	217.4	
AOC_5	SHL-11	5/26/1992	216.6	
AOC_5	SHL-11	9/15/1992	216.5	
AOC_5	SHL-11	12/22/1992	216.8	
AOC_5	SHL-11	3/30/1993	217.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-11	6/22/1993	216.5	
AOC_5	SHL-11	9/30/1993	216.5	
AOC_5	SHL-11	11/8/1993	216.4	
AOC_5	SHL-11	3/30/1994	217.2	
AOC_5	SHL-11	6/28/1994	216.6	
AOC_5	SHL-11	10/4/1994	216.6	
AOC_5	SHL-11	1/31/1995	216.8	
AOC_5	SHL-11	5/9/1995	216.6	
AOC_5	SHL-11	12/7/1995	216.6	
AOC_5	SHL-11	3/26/1996	217.1	
AOC_5	SHL-11	7/23/1996	216.8	
AOC_5	SHL-11	1/15/1997	217.0	
AOC_5	SHL-11	6/2/1997	217.0	
AOC_5	SHL-11	4/23/1998	217.0	
AOC_5	SHL-11	6/19/1998	217.5	
AOC_5	SHL-11	6/26/1998	217.3	
AOC_5	SHL-11	7/1/1998	217.2	
AOC_5	SHL-11	7/17/1998	217.0	
AOC_5	SHL-11	7/31/1998	216.8	
AOC_5	SHL-11	8/28/1998	216.6	
AOC_5	SHL-11	10/14/1998	216.7	
AOC_5	SHL-11	12/10/1998	216.5	
AOC_5	SHL-11	2/23/1999	216.6	
AOC_5	SHL-11	6/6/1999	216.3	
AOC_5	SHL-11	9/8/1999	215.9	
AOC_5	SHL-11	11/16/2001	216.5	
AOC_5	SHL-11	8/4/2005	216.7	
AOC_5	SHL-11	8/24/2005	216.5	
AOC_5	SHL-11	8/26/2005	216.6	
AOC_5	SHL-11	4/10/2006	216.9	
AOC_5	SHL-11	6/5/2006	217.5	
AOC_5	SHL-11	9/18/2006	216.7	
AOC_5	SHL-11	10/19/2006	216.8	
AOC_5	SHL-11	12/15/2006	216.9	
AOC_5	SHL-11	4/8/2007	216.9	
AOC_5	SHL-11	4/9/2007	216.9	
AOC_5	SHL-11	4/26/2007	217.3	
AOC_5	SHL-11	9/10/2007	216.5	
AOC_5	SHL-11	10/15/2007	217.3	
AOC_5	SHL-11	11/7/2007	217.0	
AOC_5	SHL-11	2/12/2008	217.3	
AOC_5	SHL-11	2/20/2008	217.7	
AOC_5	SHL-11	2/25/2008	217.4	
AOC_5	SHL-11	3/4/2008	217.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-11	4/16/2008	217.3	
AOC_5	SHL-11	4/28/2008	217.1	
AOC_5	SHL-11	6/10/2008	216.9	
AOC_5	SHL-11	9/15/2008	217.1	
AOC_5	SHL-11	9/30/2008	217.1	
AOC_5	SHL-11	10/3/2008	217.1	
AOC_5	SHL-11	4/28/2009	217.2	
AOC_5	SHL-11	7/5/2009	217.0	
AOC_5	SHL-11	9/14/2009	216.7	
AOC_5	SHL-11	10/21/2009	216.7	
AOC_5	SHL-11	10/26/2009	216.8	
AOC_5	SHL-11	11/3/2009	216.8	
AOC_5	SHL-11	4/20/2010	217.4	
AOC_5	SHL-11	4/27/2010	217.3	
AOC_5	SHL-11	9/14/2010	216.3	
AOC_5	SHL-11	10/7/2010	216.7	
AOC_5	SHL-11	4/4/2011	217.0	
AOC_5	SHL-11	7/25/2011	216.6	
AOC_5	SHL-11	11/8/2011	217.2	
AOC_5	SHL-11	4/10/2012	216.6	
AOC_5	SHL-11	6/26/2012	216.7	
AOC_5	SHL-11	11/5/2012	216.9	
AOC_5	SHL-11	11/6/2012	217.0	
AOC_5	SHL-11	2/14/2013	216.6	
AOC_5	SHL-11	3/12/2013	216.9	
AOC_5	SHL-11	4/22/2013	216.6	
AOC_5	SHL-11	4/25/2013	216.6	
AOC_5	SHL-11	5/15/2013	216.8	
AOC_5	SHL-11	5/23/2013	217.0	
AOC_5	SHL-11	5/30/2013	217.3	
AOC_5	SHL-11	6/11/2013	217.7	
AOC_5	SHL-11	10/21/2013	213.8	
AOC_5	SHL-11	10/22/2013	213.7	
AOC_5	SHL-11	4/22/2014	217.0	
AOC_5	SHL-11	4/23/2014	216.9	
AOC_5	SHL-11	10/6/2014	217.0	
AOC_5	SHL-11	6/4/2015	217.1	
AOC_5	SHL-11	6/17/2015	216.7	
AOC_5	SHL-11	8/18/2015	216.5	
AOC_5	SHL-11	10/7/2015	216.5	
AOC_5	SHL-11	10/20/2015	215.8	
AOC_5	SHL-11	12/16/2015	216.5	
AOC_5	SHL-11	4/6/2016	216.8	
AOC_5	SHL-11	6/9/2016	216.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-11	6/23/2016	216.6	
AOC_5	SHL-11	8/16/2016	216.3	
AOC_5	SHL-11	10/20/2016	216.3	
AOC_5	SHL-11	11/15/2016	217.0	
AOC_5	SHL-11	5/22/2017	217.0	
AOC_5	SHL-11	5/11/2018	217.1	
AOC_5	SHL-11	11/1/2018	216.9	
AOC_5	SHL-11	4/11/2019	216.9	
AOC_5	SHL-11	10/22/2019	217.4	
AOC_5	SHL-11	5/18/2020	217.1	
AOC_5	SHL-12	5/26/1992	225.4	
AOC_5	SHL-12	9/15/1992	225.0	
AOC_5	SHL-12	12/22/1992	224.7	
AOC_5	SHL-12	3/30/1993	226.2	
AOC_5	SHL-12	6/22/1993	225.7	
AOC_5	SHL-12	9/30/1993	224.7	
AOC_5	SHL-12	11/8/1993	224.4	
AOC_5	SHL-12	3/30/1994	226.7	
AOC_5	SHL-12	6/28/1994	226.3	
AOC_5	SHL-12	10/4/1994	225.8	
AOC_5	SHL-12	1/31/1995	226.0	
AOC_5	SHL-12	5/9/1995	225.6	
AOC_5	SHL-12	12/7/1995	225.0	
AOC_5	SHL-12	3/26/1996	226.8	
AOC_5	SHL-12	1/15/1997	227.9	
AOC_5	SHL-12	6/2/1997	227.8	
AOC_5	SHL-12	4/23/1998	227.9	
AOC_5	SHL-12	6/19/1998	229.3	
AOC_5	SHL-12	6/26/1998	229.1	
AOC_5	SHL-12	7/1/1998	229.2	
AOC_5	SHL-12	7/17/1998	228.6	
AOC_5	SHL-12	7/31/1998	228.1	
AOC_5	SHL-12	8/28/1998	227.1	
AOC_5	SHL-12	10/14/1998	226.7	
AOC_5	SHL-12	12/10/1998	225.4	
AOC_5	SHL-12	2/23/1999	225.8	
AOC_5	SHL-12	6/6/1999	224.8	
AOC_5	SHL-12	9/8/1999	223.5	
AOC_5	SHL-12	8/19/2008	228.0	
AOC_5	SHL-12	9/15/2008	228.2	
AOC_5	SHL-12	4/28/2009	227.9	
AOC_5	SHL-12	9/14/2009	227.4	
AOC_5	SHL-12	10/26/2009	226.8	
AOC_5	SHL-12	4/27/2010	229.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-12	9/14/2010	226.0	
AOC_5	SHL-12	7/25/2011	226.4	
AOC_5	SHL-12	6/26/2012	226.5	
AOC_5	SHL-12	11/6/2012	225.7	
AOC_5	SHL-12	4/25/2013	226.0	
AOC_5	SHL-12	4/22/2014	226.0	
AOC_5	SHL-12	10/6/2014	224.9	
AOC_5	SHL-12	6/8/2015	227.0	
AOC_5	SHL-12	6/9/2015	227.0	
AOC_5	SHL-12	6/17/2015	226.6	
AOC_5	SHL-12	10/7/2015	224.9	
AOC_5	SHL-12	12/16/2015	224.3	
AOC_5	SHL-12	6/9/2016	225.0	
AOC_5	SHL-12	6/24/2016	224.7	
AOC_5	SHL-12	8/16/2016	224.2	
AOC_5	SHL-12	11/15/2016	224.0	
AOC_5	SHL-12	5/22/2017	226.7	
AOC_5	SHL-12	11/1/2018	227.9	
AOC_5	SHL-12	12/5/2018	229.8	
AOC_5	SHL-12	10/22/2019	226.0	
AOC_5	SHL-12	4/29/2020	227.9	
AOC_5	SHL-13	5/26/1992	213.7	
AOC_5	SHL-13	9/15/1992	213.1	
AOC_5	SHL-13	12/22/1992	214.1	
AOC_5	SHL-13	3/30/1993	213.1	
AOC_5	SHL-13	6/22/1993	213.4	
AOC_5	SHL-13	9/30/1993	213.5	
AOC_5	SHL-13	11/8/1993	213.6	
AOC_5	SHL-13	3/30/1994	215.0	
AOC_5	SHL-13	6/28/1994	213.5	
AOC_5	SHL-13	10/4/1994	213.7	
AOC_5	SHL-13	1/31/1995	214.3	
AOC_5	SHL-13	5/9/1995	213.5	
AOC_5	SHL-13	12/7/1995	214.0	
AOC_5	SHL-13	3/26/1996	214.7	
AOC_5	SHL-13	7/23/1996	213.8	
AOC_5	SHL-13	6/2/1997	214.1	
AOC_5	SHL-13	4/23/1998	214.4	
AOC_5	SHL-13	6/19/1998	215.1	
AOC_5	SHL-13	6/26/1998	214.9	
AOC_5	SHL-13	7/1/1998	214.7	
AOC_5	SHL-13	7/17/1998	214.0	
AOC_5	SHL-13	7/31/1998	213.7	
AOC_5	SHL-13	8/28/1998	213.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-13	10/14/1998	213.5	
AOC_5	SHL-13	12/10/1998	213.4	
AOC_5	SHL-13	2/23/1999	213.9	
AOC_5	SHL-13	6/6/1999	213.1	
AOC_5	SHL-13	9/8/1999	212.5	
AOC_5	SHL-13	11/16/2001	213.2	
AOC_5	SHL-13	8/4/2005	213.7	
AOC_5	SHL-13	8/24/2005	213.1	
AOC_5	SHL-13	8/26/2005	213.2	
AOC_5	SHL-13	4/10/2006	213.8	
AOC_5	SHL-13	6/5/2006	215.0	
AOC_5	SHL-13	9/18/2006	213.4	
AOC_5	SHL-13	10/19/2006	213.7	
AOC_5	SHL-13	12/15/2006	214.3	
AOC_5	SHL-13	4/8/2007	214.1	
AOC_5	SHL-13	4/9/2007	214.1	
AOC_5	SHL-13	10/15/2007	214.0	
AOC_5	SHL-13	2/20/2008	215.2	
AOC_5	SHL-13	2/25/2008	214.9	
AOC_5	SHL-13	3/4/2008	214.7	
AOC_5	SHL-13	4/16/2008	214.6	
AOC_5	SHL-13	8/19/2008	214.2	
AOC_5	SHL-13	9/15/2008	214.2	
AOC_5	SHL-13	9/30/2008	214.2	
AOC_5	SHL-13	10/1/2008	214.3	
AOC_5	SHL-13	4/28/2009	214.4	
AOC_5	SHL-13	7/5/2009	213.8	
AOC_5	SHL-13	9/14/2009	213.3	
AOC_5	SHL-13	10/19/2009	213.3	
AOC_5	SHL-13	10/26/2009	213.5	
AOC_5	SHL-13	11/3/2009	213.6	
AOC_5	SHL-13	4/20/2010	215.0	
AOC_5	SHL-13	9/14/2010	212.6	
AOC_5	SHL-13	10/7/2010	213.4	
AOC_5	SHL-13	4/4/2011	214.5	
AOC_5	SHL-13	7/25/2011	213.0	
AOC_5	SHL-13	11/8/2011	214.4	
AOC_5	SHL-13	4/10/2012	213.3	
AOC_5	SHL-13	6/26/2012	213.5	
AOC_5	SHL-13	11/5/2012	214.1	
AOC_5	SHL-13	11/6/2012	214.0	
AOC_5	SHL-13	4/25/2013	213.6	
AOC_5	SHL-13	5/15/2013	213.4	
AOC_5	SHL-13	5/30/2013	214.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-13	6/11/2013	215.1	
AOC_5	SHL-13	10/21/2013	211.5	
AOC_5	SHL-13	10/22/2013	211.3	
AOC_5	SHL-13	4/22/2014	214.7	
AOC_5	SHL-13	10/6/2014	213.8	
AOC_5	SHL-13	6/2/2015	214.4	
AOC_5	SHL-13	6/17/2015	213.5	
AOC_5	SHL-13	8/18/2015	213.2	
AOC_5	SHL-13	10/7/2015	213.0	
AOC_5	SHL-13	10/20/2015	213.9	
AOC_5	SHL-13	12/16/2015	213.3	
AOC_5	SHL-13	6/9/2016	213.6	
AOC_5	SHL-13	8/16/2016	212.9	
AOC_5	SHL-13	10/20/2016	212.8	
AOC_5	SHL-13	11/15/2016	214.0	
AOC_5	SHL-13	11/1/2018	214.1	
AOC_5	SHL-13	10/22/2019	214.1	
AOC_5	SHL-15	5/26/1992	242.0	
AOC_5	SHL-15	9/15/1992	240.5	
AOC_5	SHL-15	12/22/1992	240.8	
AOC_5	SHL-15	3/30/1993	242.8	
AOC_5	SHL-15	6/22/1993	241.7	
AOC_5	SHL-15	9/30/1993	240.8	
AOC_5	SHL-15	11/8/1993	241.0	
AOC_5	SHL-15	3/30/1994	244.4	
AOC_5	SHL-15	6/28/1994	242.1	
AOC_5	SHL-15	10/4/1994	241.5	
AOC_5	SHL-15	1/31/1995	243.3	
AOC_5	SHL-15	5/9/1995	241.9	
AOC_5	SHL-15	12/7/1995	242.6	
AOC_5	SHL-15	3/26/1996	243.7	
AOC_5	SHL-15	7/23/1996	242.3	
AOC_5	SHL-15	1/15/1997	243.4	
AOC_5	SHL-15	6/2/1997	242.7	
AOC_5	SHL-15	4/23/1998	243.3	
AOC_5	SHL-15	6/19/1998	243.8	
AOC_5	SHL-15	6/26/1998	243.6	
AOC_5	SHL-15	7/1/1998	243.4	
AOC_5	SHL-15	7/17/1998	242.8	
AOC_5	SHL-15	7/31/1998	242.1	
AOC_5	SHL-15	8/28/1998	241.1	
AOC_5	SHL-15	10/14/1998	241.2	
AOC_5	SHL-15	12/10/1998	240.3	
AOC_5	SHL-15	2/23/1999	242.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-15	6/6/1999	241.5	
AOC_5	SHL-15	9/8/1999	239.5	
AOC_5	SHL-15	1/30/2002	239.3	
AOC_5	SHL-15	4/11/2002	242.1	
AOC_5	SHL-15	7/10/2002	242.1	
AOC_5	SHL-15	10/1/2002	239.8	
AOC_5	SHL-15	6/19/2003	241.8	
AOC_5	SHL-15	9/23/2003	240.5	
AOC_5	SHL-15	12/1/2003	240.7	
AOC_5	SHL-15	5/25/2004	243.7	
AOC_5	SHL-15	10/7/2004	241.9	
AOC_5	SHL-15	5/18/2005	243.2	
AOC_5	SHL-15	6/13/2005	243.2	
AOC_5	SHL-15	8/4/2005	241.7	
AOC_5	SHL-15	8/24/2005	241.0	
AOC_5	SHL-15	8/26/2005	240.9	
AOC_5	SHL-15	10/3/2005	239.9	
AOC_5	SHL-15	4/10/2006	241.8	
AOC_5	SHL-15	6/5/2006	243.9	
AOC_5	SHL-15	6/7/2006	244.2	
AOC_5	SHL-15	9/18/2006	240.6	
AOC_5	SHL-15	10/17/2006	240.6	
AOC_5	SHL-15	10/19/2006	240.2	
AOC_5	SHL-15	12/15/2006	242.5	
AOC_5	SHL-15	4/8/2007	243.0	
AOC_5	SHL-15	4/9/2007	243.0	
AOC_5	SHL-15	5/22/2007	247.0	
AOC_5	SHL-15	10/15/2007	239.3	
AOC_5	SHL-15	10/16/2007	239.3	
AOC_5	SHL-15	2/20/2008	244.6	
AOC_5	SHL-15	2/25/2008	244.4	
AOC_5	SHL-15	3/4/2008	244.1	
AOC_5	SHL-15	4/16/2008	243.9	
AOC_5	SHL-15	6/25/2008	241.7	
AOC_5	SHL-15	6/26/2008	242.1	
AOC_5	SHL-15	9/30/2008	241.8	
AOC_5	SHL-15	10/3/2008	241.9	
AOC_5	SHL-15	10/28/2008	241.4	
AOC_5	SHL-15	10/29/2008	241.7	
AOC_5	SHL-15	4/28/2009	243.2	
AOC_5	SHL-15	5/8/2009	243.1	
AOC_5	SHL-15	5/11/2009	243.5	
AOC_5	SHL-15	9/14/2009	241.4	
AOC_5	SHL-15	10/22/2009	240.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-15	10/26/2009	240.3	
AOC_5	SHL-15	11/3/2009	240.8	
AOC_5	SHL-15	11/9/2009	241.0	
AOC_5	SHL-15	4/20/2010	244.3	
AOC_5	SHL-15	5/18/2010	243.1	
AOC_5	SHL-15	10/7/2010	239.4	
AOC_5	SHL-15	10/19/2010	240.7	
AOC_5	SHL-15	4/4/2011	244.1	
AOC_5	SHL-15	6/30/2011	242.3	
AOC_5	SHL-15	10/13/2011	242.6	
AOC_5	SHL-15	11/8/2011	243.1	
AOC_5	SHL-15	4/10/2012	241.6	
AOC_5	SHL-15	5/15/2012	241.8	
AOC_5	SHL-15	10/22/2012	239.6	
AOC_5	SHL-15	11/5/2012	241.1	
AOC_5	SHL-15	11/6/2012	241.0	
AOC_5	SHL-15	5/15/2013	242.3	
AOC_5	SHL-15	6/11/2013	242.5	
AOC_5	SHL-15	10/21/2013	239.6	
AOC_5	SHL-15	10/22/2013	239.2	
AOC_5	SHL-15	10/23/2013	239.6	
AOC_5	SHL-15	4/22/2014	243.8	
AOC_5	SHL-15	6/17/2014	242.5	
AOC_5	SHL-15	10/6/2014	239.7	
AOC_5	SHL-15	6/8/2015	242.1	
AOC_5	SHL-15	6/9/2015	242.1	
AOC_5	SHL-15	6/17/2015	242.0	
AOC_5	SHL-15	10/7/2015	239.5	
AOC_5	SHL-15	10/8/2015	239.5	
AOC_5	SHL-15	12/16/2015	239.1	
AOC_5	SHL-15	5/17/2016	242.5	
AOC_5	SHL-15	6/9/2016	241.8	
AOC_5	SHL-15	6/24/2016	241.4	
AOC_5	SHL-15	8/16/2016	239.9	
AOC_5	SHL-15	11/15/2016	239.5	
AOC_5	SHL-15	5/22/2017	243.3	
AOC_5	SHL-15	7/7/2017	242.6	
AOC_5	SHL-15	4/9/2018	243.6	
AOC_5	SHL-15	11/1/2018	242.2	
AOC_5	SHL-15	12/5/2018	244.4	
AOC_5	SHL-15	4/8/2019	242.7	
AOC_5	SHL-15	10/22/2019	239.5	
AOC_5	SHL-15	4/29/2020	243.8	
AOC_5	SHL-15	5/14/2020	243.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-17	5/26/1992	225.3	
AOC_5	SHL-17	9/15/1992	224.7	
AOC_5	SHL-17	12/22/1992	224.8	
AOC_5	SHL-17	3/30/1993	228.3	
AOC_5	SHL-17	6/22/1993	225.6	
AOC_5	SHL-17	9/30/1993	224.9	
AOC_5	SHL-17	11/8/1993	224.5	
AOC_5	SHL-17	3/30/1994	226.8	
AOC_5	SHL-17	10/4/1994	225.8	
AOC_5	SHL-17	1/31/1995	226.0	
AOC_5	SHL-17	5/9/1995	225.6	
AOC_5	SHL-17	12/7/1995	225.0	
AOC_5	SHL-17	3/26/1996	226.7	
AOC_5	SHL-17	7/23/1996	227.3	
AOC_5	SHL-17	1/15/1997	227.7	
AOC_5	SHL-17	6/2/1997	227.5	
AOC_5	SHL-17	4/23/1998	227.9	
AOC_5	SHL-17	6/19/1998	229.7	
AOC_5	SHL-17	6/26/1998	229.5	
AOC_5	SHL-17	7/1/1998	230.1	
AOC_5	SHL-17	7/17/1998	228.5	
AOC_5	SHL-17	7/31/1998	228.6	
AOC_5	SHL-17	8/28/1998	227.1	
AOC_5	SHL-17	10/14/1998	226.9	
AOC_5	SHL-17	12/10/1998	225.8	
AOC_5	SHL-17	2/23/1999	226.0	
AOC_5	SHL-17	6/6/1999	224.8	
AOC_5	SHL-17	9/8/1999	223.5	
AOC_5	SHL-17	9/14/2009	227.3	
AOC_5	SHL-17	10/26/2009	227.0	
AOC_5	SHL-17	4/27/2010	229.7	
AOC_5	SHL-17	9/14/2010	225.9	
AOC_5	SHL-17	7/25/2011	226.3	
AOC_5	SHL-17	6/26/2012	227.0	
AOC_5	SHL-17	11/6/2012	225.7	
AOC_5	SHL-17	4/25/2013	225.9	
AOC_5	SHL-17	4/22/2014	226.0	
AOC_5	SHL-17	6/17/2015	226.6	
AOC_5	SHL-17	10/7/2015	224.9	
AOC_5	SHL-17	10/20/2015		
AOC_5	SHL-17	12/16/2015	224.8	
AOC_5	SHL-17	6/9/2016	225.0	
AOC_5	SHL-17	6/24/2016		
AOC_5	SHL-17	8/16/2016	224.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-17	11/15/2016	224.1	
AOC_5	SHL-17	5/22/2017	226.8	
AOC_5	SHL-17	11/1/2018	228.2	
AOC_5	SHL-17	12/5/2018	229.9	
AOC_5	SHL-17	10/22/2019	224.9	
AOC_5	SHL-17	4/29/2020	228.3	
AOC_5	SHL-18	5/26/1992	217.9	
AOC_5	SHL-18	9/15/1992	217.7	
AOC_5	SHL-18	12/22/1992	218.3	
AOC_5	SHL-18	3/30/1993	218.1	
AOC_5	SHL-18	6/22/1993	217.7	
AOC_5	SHL-18	9/30/1993	217.8	
AOC_5	SHL-18	11/8/1993	217.9	
AOC_5	SHL-18	3/30/1994	219.0	
AOC_5	SHL-18	6/28/1994	217.9	
AOC_5	SHL-18	10/4/1994	218.2	
AOC_5	SHL-18	1/31/1995	218.6	
AOC_5	SHL-18	5/9/1995	217.8	
AOC_5	SHL-18	12/7/1995	218.3	
AOC_5	SHL-18	3/26/1996	218.8	
AOC_5	SHL-18	7/23/1996	218.4	
AOC_5	SHL-18	1/15/1997	218.8	
AOC_5	SHL-18	6/2/1997	218.7	
AOC_5	SHL-18	4/23/1998	218.6	
AOC_5	SHL-18	6/19/1998	220.0	
AOC_5	SHL-18	6/26/1998	219.6	
AOC_5	SHL-18	7/1/1998	219.4	
AOC_5	SHL-18	7/17/1998	218.7	
AOC_5	SHL-18	7/31/1998	218.3	
AOC_5	SHL-18	8/28/1998	217.9	
AOC_5	SHL-18	10/14/1998	218.0	
AOC_5	SHL-18	12/10/1998	217.7	
AOC_5	SHL-18	2/23/1999	218.0	
AOC_5	SHL-18	6/6/1999	217.4	
AOC_5	SHL-18	9/8/1999	216.9	
AOC_5	SHL-18	11/16/2001	217.5	
AOC_5	SHL-18	8/4/2005	218.3	
AOC_5	SHL-18	8/24/2005	218.0	
AOC_5	SHL-18	8/26/2005	218.0	
AOC_5	SHL-18	4/10/2006	218.2	
AOC_5	SHL-18	6/5/2006	219.8	
AOC_5	SHL-18	9/18/2006	218.1	
AOC_5	SHL-18	10/19/2006	218.1	
AOC_5	SHL-18	12/15/2006	219.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-18	4/8/2007	218.7	
AOC_5	SHL-18	4/9/2007	218.7	
AOC_5	SHL-18	10/15/2007	218.4	
AOC_5	SHL-18	2/20/2008	220.0	
AOC_5	SHL-18	2/25/2008	219.7	
AOC_5	SHL-18	3/4/2008	219.4	
AOC_5	SHL-18	4/16/2008	219.1	
AOC_5	SHL-18	8/19/2008	219.2	
AOC_5	SHL-18	9/15/2008	219.4	
AOC_5	SHL-18	9/30/2008	219.3	
AOC_5	SHL-18	4/28/2009	219.0	
AOC_5	SHL-18	7/5/2009	218.9	
AOC_5	SHL-18	9/14/2009	218.3	
AOC_5	SHL-18	10/26/2009	218.2	
AOC_5	SHL-18	11/3/2009	218.3	
AOC_5	SHL-18	4/20/2010	219.9	
AOC_5	SHL-18	4/27/2010	219.5	
AOC_5	SHL-18	9/14/2010	217.7	
AOC_5	SHL-18	10/7/2010	218.1	
AOC_5	SHL-18	4/4/2011	219.1	
AOC_5	SHL-18	7/25/2011	218.0	
AOC_5	SHL-18	11/8/2011	219.3	
AOC_5	SHL-18	4/10/2012	218.0	
AOC_5	SHL-18	6/26/2012	218.3	
AOC_5	SHL-18	11/5/2012	219.0	
AOC_5	SHL-18	11/6/2012	219.0	
AOC_5	SHL-18	4/25/2013	218.3	
AOC_5	SHL-18	5/15/2013	218.2	
AOC_5	SHL-18	6/11/2013	219.3	
AOC_5	SHL-18	10/21/2013	216.0	
AOC_5	SHL-18	4/22/2014	218.9	
AOC_5	SHL-18	10/6/2014	218.0	
AOC_5	SHL-18	6/2/2015	218.6	
AOC_5	SHL-18	6/17/2015	218.1	
AOC_5	SHL-18	8/18/2015	217.9	
AOC_5	SHL-18	10/7/2015	217.7	
AOC_5	SHL-18	10/20/2015	218.2	
AOC_5	SHL-18	12/16/2015	217.7	
AOC_5	SHL-18	6/9/2016	218.0	
AOC_5	SHL-18	6/24/2016	217.8	
AOC_5	SHL-18	8/16/2016	217.6	
AOC_5	SHL-18	11/15/2016	218.2	
AOC_5	SHL-18	5/22/2017	218.8	
AOC_5	SHL-18	11/1/2018	218.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-18	10/22/2019	212.4	
AOC_5	SHL-18	4/29/2020	219.3	
AOC_5	SHL-19	5/26/1992	217.2	
AOC_5	SHL-19	9/15/1992	217.0	
AOC_5	SHL-19	12/22/1992	218.1	
AOC_5	SHL-19	3/30/1993	217.4	
AOC_5	SHL-19	6/22/1993	217.0	
AOC_5	SHL-19	9/30/1993	217.3	
AOC_5	SHL-19	11/8/1993	217.2	
AOC_5	SHL-19	3/30/1994	218.0	
AOC_5	SHL-19	6/28/1994	217.3	
AOC_5	SHL-19	10/4/1994	217.6	
AOC_5	SHL-19	1/31/1995	217.8	
AOC_5	SHL-19	5/9/1995	217.2	
AOC_5	SHL-19	12/7/1995	218.1	
AOC_5	SHL-19	3/26/1996	218.2	
AOC_5	SHL-19	7/23/1996	218.7	
AOC_5	SHL-19	1/15/1997	218.3	
AOC_5	SHL-19	6/2/1997	217.7	
AOC_5	SHL-19	4/23/1998	217.7	
AOC_5	SHL-19	6/19/1998	218.9	
AOC_5	SHL-19	6/26/1998	218.5	
AOC_5	SHL-19	7/1/1998	218.3	
AOC_5	SHL-19	7/17/1998	217.8	
AOC_5	SHL-19	7/31/1998	217.6	
AOC_5	SHL-19	8/28/1998	217.2	
AOC_5	SHL-19	10/14/1998	217.5	
AOC_5	SHL-19	12/10/1998	217.0	
AOC_5	SHL-19	2/23/1999	217.2	
AOC_5	SHL-19	6/6/1999	215.8	
AOC_5	SHL-19	9/8/1999	216.4	
AOC_5	SHL-19	11/16/2001	216.8	
AOC_5	SHL-19	8/4/2005	217.4	
AOC_5	SHL-19	8/24/2005	217.1	
AOC_5	SHL-19	8/26/2005	217.1	
AOC_5	SHL-19	4/10/2006	217.6	
AOC_5	SHL-19	6/5/2006	219.1	
AOC_5	SHL-19	8/2/2006	217.4	
AOC_5	SHL-19	9/18/2006	217.2	
AOC_5	SHL-19	10/19/2006	217.2	
AOC_5	SHL-19	12/15/2006	217.9	
AOC_5	SHL-19	4/8/2007	218.0	
AOC_5	SHL-19	4/9/2007	218.0	
AOC_5	SHL-19	4/26/2007	218.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-19	9/10/2007	216.9	
AOC_5	SHL-19	10/15/2007	217.7	
AOC_5	SHL-19	11/7/2007	217.6	
AOC_5	SHL-19	2/12/2008	218.8	
AOC_5	SHL-19	2/20/2008	219.0	
AOC_5	SHL-19	2/25/2008	218.6	
AOC_5	SHL-19	3/4/2008	218.2	
AOC_5	SHL-19	4/16/2008	218.1	
AOC_5	SHL-19	4/28/2008	217.8	
AOC_5	SHL-19	6/10/2008	217.5	
AOC_5	SHL-19	8/19/2008	218.1	
AOC_5	SHL-19	9/15/2008	218.1	
AOC_5	SHL-19	9/30/2008	218.1	
AOC_5	SHL-19	10/3/2008	218.1	
AOC_5	SHL-19	4/28/2009	218.0	
AOC_5	SHL-19	9/14/2009	217.3	
AOC_5	SHL-19	10/22/2009	217.2	
AOC_5	SHL-19	10/26/2009	217.3	
AOC_5	SHL-19	11/3/2009	217.4	
AOC_5	SHL-19	4/20/2010	218.4	
AOC_5	SHL-19	4/27/2010	218.1	
AOC_5	SHL-19	9/14/2010	217.3	
AOC_5	SHL-19	10/7/2010	217.0	
AOC_5	SHL-19	4/4/2011	218.0	
AOC_5	SHL-19	7/25/2011	217.1	
AOC_5	SHL-19	11/8/2011	218.1	
AOC_5	SHL-19	4/10/2012	217.3	
AOC_5	SHL-19	6/26/2012	217.3	
AOC_5	SHL-19	11/5/2012	217.9	
AOC_5	SHL-19	11/6/2012	217.7	
AOC_5	SHL-19	2/14/2013	217.0	
AOC_5	SHL-19	3/12/2013	217.4	
AOC_5	SHL-19	4/22/2013	217.1	
AOC_5	SHL-19	4/25/2013	217.1	
AOC_5	SHL-19	5/15/2013	217.1	
AOC_5	SHL-19	5/24/2013	217.2	
AOC_5	SHL-19	5/30/2013	217.8	
AOC_5	SHL-19	6/11/2013	218.4	
AOC_5	SHL-19	10/21/2013	214.3	
AOC_5	SHL-19	10/24/2013	214.2	
AOC_5	SHL-19	4/22/2014	217.5	
AOC_5	SHL-19	10/6/2014	217.0	
AOC_5	SHL-19	6/4/2015	217.0	
AOC_5	SHL-19	6/17/2015	216.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-19	8/18/2015	216.7	
AOC_5	SHL-19	10/7/2015	216.6	
AOC_5	SHL-19	10/20/2015	217.3	
AOC_5	SHL-19	12/16/2015	216.7	
AOC_5	SHL-19	4/6/2016	217.2	
AOC_5	SHL-19	6/9/2016	216.9	
AOC_5	SHL-19	8/16/2016	216.4	
AOC_5	SHL-19	11/15/2016	217.3	
AOC_5	SHL-19	5/22/2017	217.4	
AOC_5	SHL-19	5/11/2018	217.5	
AOC_5	SHL-19	11/1/2018	217.3	
AOC_5	SHL-19	4/11/2019	216.9	
AOC_5	SHL-19	10/22/2019	217.5	
AOC_5	SHL-19	5/18/2020	217.4	
AOC_5	SHL-19	5/19/2020	218.2	
AOC_5	SHL-20	5/26/1992	216.7	
AOC_5	SHL-20	9/15/1992	216.5	
AOC_5	SHL-20	12/22/1992	216.9	
AOC_5	SHL-20	3/30/1993	217.1	
AOC_5	SHL-20	6/22/1993	216.6	
AOC_5	SHL-20	9/30/1993	216.5	
AOC_5	SHL-20	11/8/1993	216.5	
AOC_5	SHL-20	3/30/1994	217.3	
AOC_5	SHL-20	6/28/1994	216.7	
AOC_5	SHL-20	10/4/1994	216.7	
AOC_5	SHL-20	1/31/1995	216.9	
AOC_5	SHL-20	5/9/1995	216.6	
AOC_5	SHL-20	12/7/1995	216.7	
AOC_5	SHL-20	3/26/1996	217.2	
AOC_5	SHL-20	7/23/1996	216.9	
AOC_5	SHL-20	1/15/1997	217.2	
AOC_5	SHL-20	6/2/1997	217.1	
AOC_5	SHL-20	4/23/1998	217.1	
AOC_5	SHL-20	6/19/1998	217.7	
AOC_5	SHL-20	6/26/1998	217.4	
AOC_5	SHL-20	7/1/1998	217.3	
AOC_5	SHL-20	7/17/1998	217.1	
AOC_5	SHL-20	7/31/1998	217.0	
AOC_5	SHL-20	8/28/1998	216.8	
AOC_5	SHL-20	10/14/1998	216.7	
AOC_5	SHL-20	12/10/1998	216.6	
AOC_5	SHL-20	2/23/1999	216.6	
AOC_5	SHL-20	6/6/1999	216.4	
AOC_5	SHL-20	9/8/1999	215.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-20	11/16/2001	216.5	
AOC_5	SHL-20	8/4/2005	216.9	
AOC_5	SHL-20	8/24/2005	216.6	
AOC_5	SHL-20	8/26/2005	216.7	
AOC_5	SHL-20	4/10/2006	217.0	
AOC_5	SHL-20	6/5/2006	217.6	
AOC_5	SHL-20	8/2/2006	217.1	
AOC_5	SHL-20	9/18/2006	216.7	
AOC_5	SHL-20	10/19/2006	216.8	
AOC_5	SHL-20	12/15/2006	217.1	
AOC_5	SHL-20	4/8/2007	217.0	
AOC_5	SHL-20	4/9/2007	217.0	
AOC_5	SHL-20	4/26/2007	217.4	
AOC_5	SHL-20	9/10/2007	216.5	
AOC_5	SHL-20	10/15/2007	217.3	
AOC_5	SHL-20	11/7/2007	217.0	
AOC_5	SHL-20	2/20/2008	217.7	
AOC_5	SHL-20	2/25/2008	217.5	
AOC_5	SHL-20	3/4/2008	217.4	
AOC_5	SHL-20	4/16/2008	217.4	
AOC_5	SHL-20	4/28/2008	217.2	
AOC_5	SHL-20	6/10/2008	217.0	
AOC_5	SHL-20	9/30/2008	217.2	
AOC_5	SHL-20	10/3/2008	217.2	
AOC_5	SHL-20	4/28/2009	217.3	
AOC_5	SHL-20	9/14/2009	216.8	
AOC_5	SHL-20	10/21/2009	216.8	
AOC_5	SHL-20	10/26/2009	216.9	
AOC_5	SHL-20	11/3/2009	216.9	
AOC_5	SHL-20	4/20/2010	217.5	
AOC_5	SHL-20	10/7/2010	216.7	
AOC_5	SHL-20	4/4/2011	217.1	
AOC_5	SHL-20	11/8/2011	217.3	
AOC_5	SHL-20	4/10/2012	216.7	
AOC_5	SHL-20	6/26/2012	216.8	
AOC_5	SHL-20	11/5/2012	217.5	
AOC_5	SHL-20	11/6/2012	217.5	
AOC_5	SHL-20	2/14/2013	217.3	
AOC_5	SHL-20	3/12/2013	217.5	
AOC_5	SHL-20	4/22/2013	217.6	
AOC_5	SHL-20	5/15/2013	217.7	
AOC_5	SHL-20	5/22/2013	217.7	
AOC_5	SHL-20	5/30/2013	217.9	
AOC_5	SHL-20	6/11/2013	218.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-20	10/21/2013	215.7	
AOC_5	SHL-20	10/22/2013	215.6	
AOC_5	SHL-20	4/22/2014	217.6	
AOC_5	SHL-20	4/23/2014	217.5	
AOC_5	SHL-20	10/6/2014	217.2	
AOC_5	SHL-20	6/4/2015	217.9	
AOC_5	SHL-20	6/5/2015	217.9	
AOC_5	SHL-20	6/17/2015	217.7	
AOC_5	SHL-20	8/18/2015	217.4	
AOC_5	SHL-20	10/7/2015	217.1	
AOC_5	SHL-20	10/20/2015	217.4	
AOC_5	SHL-20	12/16/2015	217.0	
AOC_5	SHL-20	4/6/2016	217.6	
AOC_5	SHL-20	6/9/2016	217.5	
AOC_5	SHL-20	6/23/2016	217.4	
AOC_5	SHL-20	8/16/2016	216.9	
AOC_5	SHL-20	11/15/2016	217.2	
AOC_5	SHL-20	5/22/2017	218.3	
AOC_5	SHL-20	5/11/2018	218.3	
AOC_5	SHL-20	11/1/2018	217.0	
AOC_5	SHL-20	4/11/2019	218.6	
AOC_5	SHL-20	10/22/2019	218.0	
AOC_5	SHL-20	5/18/2020	218.8	
AOC_5	SHL-21	5/26/1992	214.7	
AOC_5	SHL-21	9/15/1992	214.0	
AOC_5	SHL-21	12/22/1992	215.2	
AOC_5	SHL-21	3/30/1993	214.9	
AOC_5	SHL-21	6/22/1993	214.4	
AOC_5	SHL-21	9/30/1993	213.9	
AOC_5	SHL-21	11/8/1993	214.5	
AOC_5	SHL-21	3/30/1994	215.4	
AOC_5	SHL-21	6/28/1994	214.7	
AOC_5	SHL-21	10/4/1994	214.7	
AOC_5	SHL-21	1/31/1995	215.5	
AOC_5	SHL-21	5/9/1995	214.5	
AOC_5	SHL-21	12/7/1995	215.0	
AOC_5	SHL-21	3/26/1996	215.9	
AOC_5	SHL-21	7/23/1996	214.9	
AOC_5	SHL-21	4/23/1998	215.7	
AOC_5	SHL-21	6/19/1998	216.3	
AOC_5	SHL-21	6/26/1998	216.3	
AOC_5	SHL-21	7/1/1998	216.1	
AOC_5	SHL-21	7/17/1998	215.5	
AOC_5	SHL-21	7/31/1998	215.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-21	8/28/1998	214.2	
AOC_5	SHL-21	10/14/1998	214.0	
AOC_5	SHL-21	12/10/1998	214.1	
AOC_5	SHL-21	2/23/1999	214.6	
AOC_5	SHL-21	6/6/1999	213.9	
AOC_5	SHL-21	9/8/1999	213.0	
AOC_5	SHL-21	11/16/2001	213.7	
AOC_5	SHL-21	8/24/2005	214.2	
AOC_5	SHL-21	4/10/2006	215.0	
AOC_5	SHL-21	6/5/2006	216.3	
AOC_5	SHL-21	9/18/2006	214.3	
AOC_5	SHL-21	12/15/2006	215.5	
AOC_5	SHL-21	4/8/2007	214.9	
AOC_5	SHL-21	4/9/2007	214.9	
AOC_5	SHL-21	4/26/2007	216.6	
AOC_5	SHL-21	10/15/2007		210.9
AOC_5	SHL-21	2/20/2008	216.0	
AOC_5	SHL-21	2/25/2008	216.1	
AOC_5	SHL-21	3/4/2008	215.8	
AOC_5	SHL-21	4/16/2008	216.0	
AOC_5	SHL-21	6/10/2008	214.9	
AOC_5	SHL-21	7/16/2008	214.1	
AOC_5	SHL-21	8/19/2008	215.2	
AOC_5	SHL-21	9/15/2008	215.0	
AOC_5	SHL-21	9/30/2008	214.9	
AOC_5	SHL-21	10/6/2008	215.1	
AOC_5	SHL-21	1/22/2009	215.3	
AOC_5	SHL-21	4/28/2009	215.6	
AOC_5	SHL-21	7/5/2009	215.2	
AOC_5	SHL-21	7/16/2009	215.1	
AOC_5	SHL-21	9/14/2009	214.0	
AOC_5	SHL-21	10/26/2009	213.9	
AOC_5	SHL-21	11/3/2009	214.4	
AOC_5	SHL-21	4/20/2010	217.0	
AOC_5	SHL-21	4/27/2010	216.5	
AOC_5	SHL-21	9/14/2010	213.1	
AOC_5	SHL-21	10/7/2010	213.3	
AOC_5	SHL-21	4/4/2011	215.6	
AOC_5	SHL-21	7/25/2011	213.9	
AOC_5	SHL-21	11/8/2011	215.9	
AOC_5	SHL-21	4/10/2012	214.2	
AOC_5	SHL-21	6/26/2012	214.2	
AOC_5	SHL-21	9/11/2012	213.4	
AOC_5	SHL-21	11/5/2012	214.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-21	11/6/2012	214.8	
AOC_5	SHL-21	3/13/2013	214.7	
AOC_5	SHL-21	4/23/2013	214.6	
AOC_5	SHL-21	4/25/2013	214.6	
AOC_5	SHL-21	5/15/2013	214.1	
AOC_5	SHL-21	5/30/2013	214.8	
AOC_5	SHL-21	6/11/2013	215.1	
AOC_5	SHL-21	10/21/2013	212.2	
AOC_5	SHL-21	4/22/2014	215.3	
AOC_5	SHL-21	10/6/2014	213.3	
AOC_5	SHL-21	6/17/2015	214.2	
AOC_5	SHL-21	10/7/2015	213.1	
AOC_5	SHL-21	10/20/2015	213.6	
AOC_5	SHL-21	12/16/2015	213.6	
AOC_5	SHL-21	6/9/2016	214.9	
AOC_5	SHL-21	8/16/2016	213.0	
AOC_5	SHL-21	10/20/2016	212.9	
AOC_5	SHL-22	5/26/1992	212.9	
AOC_5	SHL-22	9/15/1992	212.0	
AOC_5	SHL-22	12/22/1992	213.7	
AOC_5	SHL-22	3/30/1993	213.7	
AOC_5	SHL-22	6/22/1993	212.3	
AOC_5	SHL-22	9/30/1993	212.2	
AOC_5	SHL-22	11/8/1993	212.8	
AOC_5	SHL-22	3/30/1994	214.4	
AOC_5	SHL-22	6/28/1994	212.6	
AOC_5	SHL-22	10/4/1994	212.0	
AOC_5	SHL-22	1/31/1995	213.7	
AOC_5	SHL-22	5/9/1995	212.5	
AOC_5	SHL-22	12/7/1995	213.2	
AOC_5	SHL-22	3/26/1996	214.1	
AOC_5	SHL-22	7/23/1996	213.0	
AOC_5	SHL-22	1/15/1997	213.8	
AOC_5	SHL-22	6/2/1997	213.4	
AOC_5	SHL-22	4/23/1998	213.8	
AOC_5	SHL-22	6/19/1998	215.0	
AOC_5	SHL-22	6/26/1998	214.6	
AOC_5	SHL-22	7/1/1998	214.5	
AOC_5	SHL-22	7/17/1998	213.5	
AOC_5	SHL-22	7/31/1998	212.9	
AOC_5	SHL-22	8/28/1998	212.1	
AOC_5	SHL-22	10/14/1998	212.3	
AOC_5	SHL-22	12/10/1998	212.3	
AOC_5	SHL-22	2/23/1999	212.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-22	6/6/1999	211.9	
AOC_5	SHL-22	9/8/1999	211.1	
AOC_5	SHL-22	11/16/2001	211.9	
AOC_5	SHL-22	8/4/2005	212.8	
AOC_5	SHL-22	8/24/2005	212.2	
AOC_5	SHL-22	8/26/2005	212.0	
AOC_5	SHL-22	4/10/2006	212.8	
AOC_5	SHL-22	6/5/2006	214.5	
AOC_5	SHL-22	9/18/2006	212.4	
AOC_5	SHL-22	10/19/2006	212.3	
AOC_5	SHL-22	12/15/2006	213.5	
AOC_5	SHL-22	4/8/2007	213.6	
AOC_5	SHL-22	4/9/2007	213.6	
AOC_5	SHL-22	10/15/2007	211.3	
AOC_5	SHL-22	10/19/2007	211.1	
AOC_5	SHL-22	2/20/2008	214.2	
AOC_5	SHL-22	2/25/2008	214.5	
AOC_5	SHL-22	3/4/2008	213.6	
AOC_5	SHL-22	4/16/2008	213.7	
AOC_5	SHL-22	7/15/2008	211.6	
AOC_5	SHL-22	9/30/2008	212.9	
AOC_5	SHL-22	1/20/2009	212.9	
AOC_5	SHL-22	4/28/2009	213.2	
AOC_5	SHL-22	7/15/2009	212.6	
AOC_5	SHL-22	11/3/2009	211.8	
AOC_5	SHL-22	4/20/2010	214.2	
AOC_5	SHL-22	10/7/2010	210.9	
AOC_5	SHL-22	4/4/2011	213.4	
AOC_5	SHL-22	11/8/2011	213.4	
AOC_5	SHL-22	4/10/2012	211.5	
AOC_5	SHL-22	6/26/2012	211.9	
AOC_5	SHL-22	9/11/2012	210.8	
AOC_5	SHL-22	11/5/2012	212.3	
AOC_5	SHL-22	11/6/2012	212.3	
AOC_5	SHL-22	3/13/2013	212.8	
AOC_5	SHL-22	4/23/2013	212.1	
AOC_5	SHL-22	5/15/2013	211.5	
AOC_5	SHL-22	5/28/2013	212.7	
AOC_5	SHL-22	5/30/2013	212.4	
AOC_5	SHL-22	6/11/2013	212.9	
AOC_5	SHL-22	10/21/2013	210.9	
AOC_5	SHL-22	10/23/2013	210.3	
AOC_5	SHL-22	4/22/2014	213.1	
AOC_5	SHL-22	4/24/2014	212.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-22	10/6/2014	210.7	
AOC_5	SHL-22	6/4/2015	212.1	
AOC_5	SHL-22	6/17/2015	211.8	
AOC_5	SHL-22	10/20/2015	210.5	
AOC_5	SHL-22	12/16/2015	211.0	
AOC_5	SHL-22	6/9/2016	211.6	
AOC_5	SHL-22	8/16/2016	210.3	
AOC_5	SHL-22	11/16/2016	211.4	
AOC_5	SHL-22	11/1/2018	212.4	
AOC_5	SHL-22	10/22/2019	210.9	
AOC_5	SHL-23	5/26/1992	214.0	
AOC_5	SHL-23	9/15/1992	212.8	
AOC_5	SHL-23	12/22/1992	214.8	
AOC_5	SHL-23	3/30/1993	213.8	
AOC_5	SHL-23	6/22/1993	213.3	
AOC_5	SHL-23	9/30/1993	212.6	
AOC_5	SHL-23	11/8/1993	213.8	
AOC_5	SHL-23	3/30/1994	215.4	
AOC_5	SHL-23	6/28/1994	214.0	
AOC_5	SHL-23	10/4/1994	213.9	
AOC_5	SHL-23	1/31/1995	215.3	
AOC_5	SHL-23	5/9/1995	213.5	
AOC_5	SHL-23	12/7/1995	214.9	
AOC_5	SHL-23	3/26/1996	215.8	
AOC_5	SHL-23	7/23/1996	214.0	
AOC_5	SHL-23	6/2/1997	214.9	
AOC_5	SHL-23	4/23/1998	215.4	
AOC_5	SHL-23	6/19/1998	216.4	
AOC_5	SHL-23	6/26/1998	216.6	
AOC_5	SHL-23	7/1/1998	216.3	
AOC_5	SHL-23	7/17/1998	215.2	
AOC_5	SHL-23	7/31/1998	214.3	
AOC_5	SHL-23	8/28/1998	213.1	
AOC_5	SHL-23	10/14/1998	212.8	
AOC_5	SHL-23	12/10/1998	212.9	
AOC_5	SHL-23	2/23/1999	213.7	
AOC_5	SHL-23	6/6/1999	212.8	
AOC_5	SHL-23	9/8/1999	211.6	
AOC_5	SHL-23	11/16/2001	212.3	
AOC_5	SHL-23	8/4/2005	213.9	
AOC_5	SHL-23	8/24/2005	213.1	
AOC_5	SHL-23	8/26/2005	213.1	
AOC_5	SHL-23	4/10/2006	214.0	
AOC_5	SHL-23	6/5/2006	216.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-23	9/18/2006	213.1	
AOC_5	SHL-23	12/15/2006	215.0	
AOC_5	SHL-23	4/8/2007	214.9	
AOC_5	SHL-23	4/9/2007	214.9	
AOC_5	SHL-23	4/26/2007	217.5	
AOC_5	SHL-23	10/15/2007	211.6	
AOC_5	SHL-23	2/20/2008	215.7	
AOC_5	SHL-23	2/25/2008	216.3	
AOC_5	SHL-23	3/4/2008	215.7	
AOC_5	SHL-23	4/16/2008	215.7	
AOC_5	SHL-23	6/10/2008	213.8	
AOC_5	SHL-23	7/16/2008	212.5	
AOC_5	SHL-23	8/19/2008	214.2	
AOC_5	SHL-23	9/15/2008	213.8	
AOC_5	SHL-23	9/30/2008	213.6	
AOC_5	SHL-23	10/6/2008	214.2	
AOC_5	SHL-23	1/20/2009	214.7	
AOC_5	SHL-23	4/28/2009	215.1	
AOC_5	SHL-23	9/14/2009	212.4	
AOC_5	SHL-23	10/26/2009	211.9	
AOC_5	SHL-23	11/3/2009	212.5	
AOC_5	SHL-23	4/20/2010	216.6	
AOC_5	SHL-23	4/27/2010	215.7	
AOC_5	SHL-23	9/14/2010	211.3	
AOC_5	SHL-23	10/7/2010	211.1	
AOC_5	SHL-23	4/4/2011	215.6	
AOC_5	SHL-23	7/25/2011	212.3	
AOC_5	SHL-23	11/8/2011	215.0	
AOC_5	SHL-23	4/10/2012	213.0	
AOC_5	SHL-23	6/26/2012	212.8	
AOC_5	SHL-23	9/11/2012	211.4	
AOC_5	SHL-23	11/5/2012	212.9	
AOC_5	SHL-23	11/6/2012	212.9	
AOC_5	SHL-23	3/13/2013	213.2	
AOC_5	SHL-23	4/23/2013	213.6	
AOC_5	SHL-23	4/25/2013	213.6	
AOC_5	SHL-23	5/15/2013	212.6	
AOC_5	SHL-23	5/30/2013	213.4	
AOC_5	SHL-23	6/11/2013	213.6	
AOC_5	SHL-23	10/21/2013	211.6	
AOC_5	SHL-23	4/22/2014	215.0	
AOC_5	SHL-23	10/6/2014	210.9	
AOC_5	SHL-23	6/9/2015	212.7	
AOC_5	SHL-23	6/10/2015	212.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-23	6/17/2015	212.3	
AOC_5	SHL-23	10/20/2015	210.6	
AOC_5	SHL-23	12/16/2015	211.4	
AOC_5	SHL-23	6/9/2016	212.0	
AOC_5	SHL-23	6/24/2016	211.6	
AOC_5	SHL-23	8/16/2016	210.6	
AOC_5	SHL-23	10/20/2016	210.4	
AOC_5	SHL-23	11/16/2016	211.7	
AOC_5	SHL-23	5/22/2017	214.5	
AOC_5	SHL-23	11/1/2018	213.4	
AOC_5	SHL-23	10/22/2019	211.1	
AOC_5	SHL-24	5/26/1992	221.8	
AOC_5	SHL-24	9/15/1992	222.0	
AOC_5	SHL-24	12/22/1992	222.0	
AOC_5	SHL-24	3/30/1993	222.9	
AOC_5	SHL-24	6/22/1993	222.3	
AOC_5	SHL-24	9/30/1993	221.7	
AOC_5	SHL-24	11/8/1993	221.8	
AOC_5	SHL-24	3/30/1994	223.5	
AOC_5	SHL-24	6/28/1994	222.7	
AOC_5	SHL-24	10/4/1994	222.6	
AOC_5	SHL-24	1/31/1995	222.9	
AOC_5	SHL-24	5/9/1995	222.2	
AOC_5	SHL-24	12/7/1995	222.2	
AOC_5	SHL-24	3/26/1996	223.2	
AOC_5	SHL-24	7/23/1996	223.6	
AOC_5	SHL-24	1/15/1997	223.9	
AOC_5	SHL-24	6/2/1997	224.0	
AOC_5	SHL-24	4/23/1998	223.8	
AOC_5	SHL-24	6/19/1998	225.1	
AOC_5	SHL-24	6/26/1998	225.0	
AOC_5	SHL-24	7/1/1998	224.8	
AOC_5	SHL-24	7/17/1998	224.3	
AOC_5	SHL-24	7/31/1998	223.9	
AOC_5	SHL-24	8/28/1998	223.2	
AOC_5	SHL-24	10/14/1998	222.9	
AOC_5	SHL-24	12/10/1998	222.1	
AOC_5	SHL-24	2/23/1999	222.4	
AOC_5	SHL-24	6/6/1999	221.7	
AOC_5	SHL-24	9/8/1999	220.7	
AOC_5	SHL-24	8/24/2005	223.1	
AOC_5	SHL-24	8/26/2005	223.1	
AOC_5	SHL-24	6/5/2006	225.3	
AOC_5	SHL-24	9/18/2006	223.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-24	12/15/2006	223.6	
AOC_5	SHL-24	4/8/2007	223.3	
AOC_5	SHL-24	4/9/2007	223.3	
AOC_5	SHL-24	10/15/2007	222.6	
AOC_5	SHL-24	2/20/2008	224.7	
AOC_5	SHL-24	2/25/2008	224.4	
AOC_5	SHL-24	3/4/2008	224.2	
AOC_5	SHL-24	4/16/2008	224.5	
AOC_5	SHL-24	9/30/2008	224.7	
AOC_5	SHL-24	4/28/2009	224.1	
AOC_5	SHL-24	9/14/2009	223.7	
AOC_5	SHL-24	10/26/2009	223.2	
AOC_5	SHL-24	11/3/2009	223.3	
AOC_5	SHL-24	4/20/2010	225.7	
AOC_5	SHL-24	4/27/2010	225.4	
AOC_5	SHL-24	9/14/2010	222.6	
AOC_5	SHL-24	10/7/2010	223.1	
AOC_5	SHL-24	4/4/2011	223.7	
AOC_5	SHL-24	7/25/2011	222.9	
AOC_5	SHL-24	11/8/2011	224.6	
AOC_5	SHL-24	4/10/2012	220.9	
AOC_5	SHL-24	6/26/2012	222.9	
AOC_5	SHL-24	11/5/2012	223.0	
AOC_5	SHL-24	11/6/2012	223.0	
AOC_5	SHL-24	5/15/2013	222.5	
AOC_5	SHL-24	6/11/2013	223.8	
AOC_5	SHL-24	10/21/2013	221.8	
AOC_5	SHL-24	4/22/2014	223.0	
AOC_5	SHL-24	6/9/2015	223.5	
AOC_5	SHL-24	6/10/2015	223.5	
AOC_5	SHL-24	6/17/2015	222.8	
AOC_5	SHL-24	10/7/2015	222.0	
AOC_5	SHL-24	10/20/2015	221.9	
AOC_5	SHL-24	12/16/2015	221.7	
AOC_5	SHL-24	6/9/2016	222.0	
AOC_5	SHL-24	6/24/2016	221.8	
AOC_5	SHL-24	8/16/2016	221.6	
AOC_5	SHL-24	11/15/2016	221.7	
AOC_5	SHL-24	5/22/2017	223.4	
AOC_5	SHL-24	11/1/2018	224.2	
AOC_5	SHL-24	10/22/2019	223.0	
AOC_5	SHL-24	4/29/2020	224.3	
AOC_5	SHL-25	5/26/1992	233.3	
AOC_5	SHL-25	9/15/1992	231.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-25	12/22/1992	231.2	
AOC_5	SHL-25	3/30/1993	233.8	
AOC_5	SHL-25	6/22/1993	233.1	
AOC_5	SHL-25	9/30/1993	229.4	
AOC_5	SHL-25	11/8/1993	231.0	
AOC_5	SHL-25	3/30/1994	236.8	
AOC_5	SHL-25	6/28/1994	234.1	
AOC_5	SHL-25	10/4/1994	232.3	
AOC_5	SHL-25	1/31/1995	235.3	
AOC_5	SHL-25	5/9/1995	232.8	
AOC_5	SHL-25	12/7/1995	234.2	
AOC_5	SHL-25	3/26/1996	236.1	
AOC_5	SHL-25	7/23/1996	234.1	
AOC_5	SHL-25	1/15/1997	236.1	
AOC_5	SHL-25	6/2/1997	235.1	
AOC_5	SHL-25	4/23/1998	235.9	
AOC_5	SHL-25	6/19/1998	237.0	
AOC_5	SHL-25	6/26/1998	237.3	
AOC_5	SHL-25	7/1/1998	237.0	
AOC_5	SHL-25	7/17/1998	235.8	
AOC_5	SHL-25	7/31/1998	234.6	
AOC_5	SHL-25	8/28/1998	232.8	
AOC_5	SHL-25	10/14/1998	230.8	
AOC_5	SHL-25	12/10/1998	230.1	
AOC_5	SHL-25	2/23/1999	233.8	
AOC_5	SHL-25	6/6/1999	231.8	
AOC_5	SHL-25	9/8/1999	228.6	
AOC_5	SHL-25	4/11/2002	229.5	
AOC_5	SHL-25	7/10/2002	231.7	
AOC_5	SHL-25	10/1/2002	229.3	
AOC_5	SHL-25	3/27/2003	231.8	
AOC_5	SHL-25	6/19/2003	232.3	
AOC_5	SHL-25	9/23/2003	230.9	
AOC_5	SHL-25	12/1/2003	230.6	
AOC_5	SHL-25	10/7/2004	230.3	
AOC_5	SHL-25	5/18/2005	233.6	
AOC_5	SHL-25	6/13/2005	233.6	
AOC_5	SHL-25	10/3/2005	230.3	
AOC_5	SHL-25	6/5/2006	233.3	
AOC_5	SHL-25	6/7/2006	234.4	
AOC_5	SHL-25	10/17/2006	231.5	
AOC_5	SHL-25	10/19/2006	230.4	
AOC_5	SHL-25	5/22/2007	234.4	
AOC_5	SHL-25	5/23/2007	233.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-25	10/15/2007	229.4	
AOC_5	SHL-25	10/16/2007	230.5	
AOC_5	SHL-25	6/25/2008	231.8	
AOC_5	SHL-25	6/26/2008	232.9	
AOC_5	SHL-25	10/28/2008	232.0	
AOC_5	SHL-25	10/29/2008	233.1	
AOC_5	SHL-25	5/8/2009	233.1	
AOC_5	SHL-25	5/11/2009	234.2	
AOC_5	SHL-25	10/26/2009	231.6	
AOC_5	SHL-25	11/9/2009	232.7	
AOC_5	SHL-25	5/18/2010	235.3	
AOC_5	SHL-25	10/7/2010	230.8	
AOC_5	SHL-25	10/19/2010	231.9	
AOC_5	SHL-25	6/30/2011	232.8	
AOC_5	SHL-25	10/13/2011	233.9	
AOC_5	SHL-25	5/15/2012	231.5	
AOC_5	SHL-25	10/22/2012	229.9	
AOC_5	SHL-25	6/11/2013	232.2	
AOC_5	SHL-25	10/23/2013	229.8	
AOC_5	SHL-25	4/22/2014	231.9	
AOC_5	SHL-25	6/17/2014	231.3	
AOC_5	SHL-25	10/6/2014	229.4	
AOC_5	SHL-25	6/17/2015	233.9	
AOC_5	SHL-25	10/7/2015	229.7	
AOC_5	SHL-25	10/8/2015	229.6	
AOC_5	SHL-25	12/16/2015	228.7	
AOC_5	SHL-25	5/17/2016	231.2	
AOC_5	SHL-25	6/9/2016	230.5	
AOC_5	SHL-25	6/24/2016	230.2	
AOC_5	SHL-25	8/16/2016	228.9	
AOC_5	SHL-25	11/15/2016	229.0	
AOC_5	SHL-25	5/22/2017	233.0	
AOC_5	SHL-25	7/7/2017	232.6	
AOC_5	SHL-25	4/9/2018	232.6	
AOC_5	SHL-25	11/1/2018	232.0	
AOC_5	SHL-25	12/5/2018	234.2	
AOC_5	SHL-25	4/8/2019	233.3	
AOC_5	SHL-25	10/22/2019	230.3	
AOC_5	SHL-25	4/29/2020	233.3	
AOC_5	SHL-25	5/14/2020	233.4	
AOC_5	SHL-3	5/26/1992	217.1	
AOC_5	SHL-3	9/15/1992	216.9	
AOC_5	SHL-3	12/22/1992	217.5	
AOC_5	SHL-3	3/30/1993	217.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-3	6/22/1993	216.9	
AOC_5	SHL-3	9/30/1993	217.0	
AOC_5	SHL-3	11/8/1993	217.1	
AOC_5	SHL-3	3/30/1994	218.0	
AOC_5	SHL-3	6/28/1994	217.0	
AOC_5	SHL-3	10/4/1994	217.3	
AOC_5	SHL-3	1/31/1995	217.6	
AOC_5	SHL-3	5/9/1995	216.9	
AOC_5	SHL-3	12/7/1995	217.5	
AOC_5	SHL-3	3/26/1996	217.7	
AOC_5	SHL-3	7/23/1996	218.1	
AOC_5	SHL-3	1/15/1997	217.7	
AOC_5	SHL-3	4/23/1998	218.3	
AOC_5	SHL-3	6/19/1998	218.5	
AOC_5	SHL-3	6/26/1998	218.4	
AOC_5	SHL-3	7/1/1998	218.2	
AOC_5	SHL-3	7/17/1998	217.6	
AOC_5	SHL-3	7/31/1998	217.3	
AOC_5	SHL-3	8/28/1998	217.0	
AOC_5	SHL-3	10/14/1998	217.0	
AOC_5	SHL-3	12/10/1998	216.7	
AOC_5	SHL-3	2/23/1999	217.1	
AOC_5	SHL-3	6/6/1999	216.7	
AOC_5	SHL-3	9/8/1999	216.3	
AOC_5	SHL-3	11/16/2001	216.8	
AOC_5	SHL-3	8/4/2005	216.5	
AOC_5	SHL-3	8/24/2005	216.2	
AOC_5	SHL-3	8/26/2005	216.2	
AOC_5	SHL-3	4/10/2006	217.2	
AOC_5	SHL-3	6/5/2006	217.5	
AOC_5	SHL-3	9/18/2006	216.3	
AOC_5	SHL-3	10/19/2006	217.2	
AOC_5	SHL-3	12/15/2006	217.4	
AOC_5	SHL-3	4/8/2007	217.5	
AOC_5	SHL-3	4/9/2007	217.5	
AOC_5	SHL-3	4/26/2007	218.5	
AOC_5	SHL-3	10/15/2007	217.8	
AOC_5	SHL-3	2/20/2008	218.1	
AOC_5	SHL-3	2/25/2008	217.7	
AOC_5	SHL-3	3/4/2008	217.4	
AOC_5	SHL-3	4/16/2008	217.1	
AOC_5	SHL-3	6/10/2008	217.3	
AOC_5	SHL-3	8/19/2008	217.8	
AOC_5	SHL-3	9/15/2008	217.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-3	9/30/2008	217.0	
AOC_5	SHL-3	4/28/2009	217.0	
AOC_5	SHL-3	7/5/2009	216.9	
AOC_5	SHL-3	9/14/2009	217.2	
AOC_5	SHL-3	10/26/2009	217.2	
AOC_5	SHL-3	11/3/2009	216.1	
AOC_5	SHL-3	4/20/2010	217.6	
AOC_5	SHL-3	4/27/2010	218.0	
AOC_5	SHL-3	9/14/2010	216.8	
AOC_5	SHL-3	10/7/2010	216.4	
AOC_5	SHL-3	4/4/2011	217.2	
AOC_5	SHL-3	7/25/2011	217.0	
AOC_5	SHL-3	11/8/2011	217.2	
AOC_5	SHL-3	4/10/2012	216.3	
AOC_5	SHL-3	6/26/2012	216.5	
AOC_5	SHL-3	11/5/2012	217.9	
AOC_5	SHL-3	11/6/2012	216.2	
AOC_5	SHL-3	2/14/2013	217.2	
AOC_5	SHL-3	3/12/2013	217.7	
AOC_5	SHL-3	4/22/2013	217.4	
AOC_5	SHL-3	4/25/2013	216.6	
AOC_5	SHL-3	5/15/2013	217.3	
AOC_5	SHL-3	6/11/2013	218.2	
AOC_5	SHL-3	10/21/2013	215.0	
AOC_5	SHL-3	4/22/2014	217.8	
AOC_5	SHL-3	10/6/2014	217.4	
AOC_5	SHL-3	6/2/2015	216.6	
AOC_5	SHL-3	6/17/2015	217.2	
AOC_5	SHL-3	8/18/2015	217.1	
AOC_5	SHL-3	10/7/2015	217.0	
AOC_5	SHL-3	10/20/2015	217.8	
AOC_5	SHL-3	12/16/2015	217.0	
AOC_5	SHL-3	6/9/2016	217.2	
AOC_5	SHL-3	8/16/2016	216.8	
AOC_5	SHL-3	11/15/2016	217.7	
AOC_5	SHL-3	11/1/2018	216.8	
AOC_5	SHL-3	10/22/2019	217.6	
AOC_5	SHL-3	4/29/2020	217.3	
AOC_5	SHL-4	5/26/1992	216.4	
AOC_5	SHL-4	9/15/1992	216.3	
AOC_5	SHL-4	12/22/1992	216.9	
AOC_5	SHL-4	3/30/1993	217.1	
AOC_5	SHL-4	6/22/1993	216.3	
AOC_5	SHL-4	9/30/1993	216.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-4	11/8/1993	216.4	
AOC_5	SHL-4	3/30/1994	217.1	
AOC_5	SHL-4	10/4/1994	216.5	
AOC_5	SHL-4	1/31/1995	216.7	
AOC_5	SHL-4	5/9/1995	216.4	
AOC_5	SHL-4	12/7/1995	216.8	
AOC_5	SHL-4	3/26/1996	217.3	
AOC_5	SHL-4	7/23/1996	217.0	
AOC_5	SHL-4	1/15/1997	217.3	
AOC_5	SHL-4	6/2/1997	217.0	
AOC_5	SHL-4	4/23/1998	217.1	
AOC_5	SHL-4	6/19/1998	217.8	
AOC_5	SHL-4	6/26/1998	217.5	
AOC_5	SHL-4	7/1/1998	217.4	
AOC_5	SHL-4	7/17/1998	217.1	
AOC_5	SHL-4	7/31/1998	217.0	
AOC_5	SHL-4	8/28/1998	216.8	
AOC_5	SHL-4	10/14/1998	216.9	
AOC_5	SHL-4	12/10/1998	216.7	
AOC_5	SHL-4	2/23/1999	216.7	
AOC_5	SHL-4	6/6/1999	216.4	
AOC_5	SHL-4	9/8/1999	216.1	
AOC_5	SHL-4	11/16/2001	216.6	
AOC_5	SHL-4	8/4/2005	216.9	
AOC_5	SHL-4	8/24/2005	216.7	
AOC_5	SHL-4	8/26/2005	216.4	
AOC_5	SHL-4	4/10/2006	217.0	
AOC_5	SHL-4	6/5/2006	218.0	
AOC_5	SHL-4	9/18/2006	216.8	
AOC_5	SHL-4	10/19/2006	216.9	
AOC_5	SHL-4	12/15/2006	217.2	
AOC_5	SHL-4	4/8/2007	217.3	
AOC_5	SHL-4	4/9/2007	217.3	
AOC_5	SHL-4	10/15/2007	217.5	
AOC_5	SHL-4	2/20/2008	218.0	
AOC_5	SHL-4	2/25/2008	217.6	
AOC_5	SHL-4	3/4/2008	217.6	
AOC_5	SHL-4	4/16/2008	217.4	
AOC_5	SHL-4	9/30/2008	217.5	
AOC_5	SHL-4	10/3/2008	217.4	
AOC_5	SHL-4	4/28/2009	217.4	
AOC_5	SHL-4	9/14/2009	216.9	
AOC_5	SHL-4	10/22/2009	216.9	
AOC_5	SHL-4	11/3/2009	217.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-4	4/20/2010	217.5	
AOC_5	SHL-4	10/7/2010	216.9	
AOC_5	SHL-4	4/4/2011	217.3	
AOC_5	SHL-4	11/8/2011	217.4	
AOC_5	SHL-4	4/10/2012	216.8	
AOC_5	SHL-4	6/26/2012	216.9	
AOC_5	SHL-4	11/5/2012	217.2	
AOC_5	SHL-4	11/6/2012	217.2	
AOC_5	SHL-4	2/14/2013	216.7	
AOC_5	SHL-4	3/12/2013	217.0	
AOC_5	SHL-4	4/22/2013	216.7	
AOC_5	SHL-4	5/15/2013	216.9	
AOC_5	SHL-4	5/24/2013	217.1	
AOC_5	SHL-4	6/11/2013	217.6	
AOC_5	SHL-4	10/21/2013	213.7	
AOC_5	SHL-4	11/19/2013	216.1	
AOC_5	SHL-4	4/22/2014	217.0	
AOC_5	SHL-4	10/6/2014	217.1	
AOC_5	SHL-4	6/2/2015	217.1	
AOC_5	SHL-4	6/17/2015	216.6	
AOC_5	SHL-4	8/18/2015	216.5	
AOC_5	SHL-4	10/7/2015	216.6	
AOC_5	SHL-4	10/20/2015	217.4	
AOC_5	SHL-4	12/16/2015	216.6	
AOC_5	SHL-4	4/6/2016	216.8	
AOC_5	SHL-4	6/9/2016	216.8	
AOC_5	SHL-4	8/16/2016	216.3	
AOC_5	SHL-4	11/15/2016	218.2	
AOC_5	SHL-4	5/22/2017	217.0	
AOC_5	SHL-4	5/11/2018	217.1	
AOC_5	SHL-4	11/1/2018	216.8	
AOC_5	SHL-4	4/11/2019	216.8	
AOC_5	SHL-4	10/22/2019	217.5	
AOC_5	SHL-4	5/18/2020	217.4	
AOC_5	SHL-4	5/20/2020	216.9	
AOC_5	SHL-5	5/26/1992	213.5	
AOC_5	SHL-5	9/15/1992	212.5	
AOC_5	SHL-5	12/22/1992	215.2	
AOC_5	SHL-5	3/30/1993	215.8	
AOC_5	SHL-5	6/22/1993	212.7	
AOC_5	SHL-5	9/30/1993	214.4	
AOC_5	SHL-5	11/8/1993	214.5	
AOC_5	SHL-5	3/30/1994	215.9	
AOC_5	SHL-5	6/28/1994	212.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-5	10/4/1994	214.3	
AOC_5	SHL-5	1/31/1995	214.7	
AOC_5	SHL-5	5/9/1995	213.3	
AOC_5	SHL-5	12/7/1995	214.4	
AOC_5	SHL-5	3/26/1996	215.3	
AOC_5	SHL-5	7/23/1996	213.7	
AOC_5	SHL-5	1/15/1997	211.8	
AOC_5	SHL-5	6/2/1997	214.1	
AOC_5	SHL-5	4/23/1998	214.9	
AOC_5	SHL-5	6/19/1998	215.7	
AOC_5	SHL-5	6/26/1998	215.3	
AOC_5	SHL-5	7/1/1998	215.2	
AOC_5	SHL-5	7/17/1998	213.7	
AOC_5	SHL-5	7/31/1998	213.0	
AOC_5	SHL-5	8/28/1998	212.0	
AOC_5	SHL-5	12/10/1998	213.7	
AOC_5	SHL-5	2/23/1999	213.0	
AOC_5	SHL-5	6/6/1999	212.0	
AOC_5	SHL-5	9/8/1999	211.0	
AOC_5	SHL-5	11/16/2001	212.2	
AOC_5	SHL-5	8/4/2005	213.1	
AOC_5	SHL-5	8/24/2005	212.3	
AOC_5	SHL-5	8/26/2005	212.2	
AOC_5	SHL-5	4/10/2006	214.5	
AOC_5	SHL-5	6/5/2006	215.7	
AOC_5	SHL-5	9/18/2006	212.7	
AOC_5	SHL-5	12/15/2006	214.8	
AOC_5	SHL-5	4/8/2007	215.4	
AOC_5	SHL-5	4/9/2007	215.4	
AOC_5	SHL-5	4/26/2007	215.7	
AOC_5	SHL-5	10/15/2007	211.8	
AOC_5	SHL-5	2/20/2008	216.0	
AOC_5	SHL-5	2/25/2008	215.4	
AOC_5	SHL-5	3/4/2008	215.4	
AOC_5	SHL-5	4/16/2008	215.0	
AOC_5	SHL-5	6/10/2008	213.1	
AOC_5	SHL-5	7/15/2008	212.2	
AOC_5	SHL-5	8/19/2008	214.8	
AOC_5	SHL-5	9/30/2008	215.4	
AOC_5	SHL-5	10/1/2008	215.6	
AOC_5	SHL-5	1/21/2009	214.4	
AOC_5	SHL-5	4/28/2009	215.0	
AOC_5	SHL-5	7/15/2009	214.1	
AOC_5	SHL-5	10/19/2009	212.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-5	10/26/2009	214.4	
AOC_5	SHL-5	11/3/2009	214.4	
AOC_5	SHL-5	4/20/2010	215.4	
AOC_5	SHL-5	9/14/2010	210.9	
AOC_5	SHL-5	10/7/2010	211.5	
AOC_5	SHL-5	4/4/2011	215.3	
AOC_5	SHL-5	11/8/2011	215.2	
AOC_5	SHL-5	4/10/2012	213.1	
AOC_5	SHL-5	6/26/2012	213.3	
AOC_5	SHL-5	9/11/2012	211.3	
AOC_5	SHL-5	11/5/2012	214.7	
AOC_5	SHL-5	11/6/2012	214.7	
AOC_5	SHL-5	2/14/2013	213.7	
AOC_5	SHL-5	3/12/2013	216.0	
AOC_5	SHL-5	3/13/2013	216.0	
AOC_5	SHL-5	4/22/2013	214.0	
AOC_5	SHL-5	4/23/2013	214.0	
AOC_5	SHL-5	5/15/2013	212.8	
AOC_5	SHL-5	5/21/2013	212.7	
AOC_5	SHL-5	5/30/2013	216.0	
AOC_5	SHL-5	6/11/2013	216.1	
AOC_5	SHL-5	10/21/2013	211.0	
AOC_5	SHL-5	10/22/2013	209.8	
AOC_5	SHL-5	4/22/2014	215.1	
AOC_5	SHL-5	10/6/2014	211.2	
AOC_5	SHL-5	6/2/2015	214.8	
AOC_5	SHL-5	6/17/2015	212.6	
AOC_5	SHL-5	10/20/2015	211.0	
AOC_5	SHL-5	12/16/2015	212.1	
AOC_5	SHL-5	6/9/2016	212.2	
AOC_5	SHL-5	8/16/2016	210.6	
AOC_5	SHL-5	11/15/2016	213.3	
AOC_5	SHL-5	11/1/2018	214.9	
AOC_5	SHL-5	10/22/2019	212.0	
AOC_5	SHL-5+WT-5	11/1/2018	214.9	
AOC_5	SHL-6	5/26/1992	224.7	
AOC_5	SHL-6	9/15/1992	225.4	
AOC_5	SHL-6	12/22/1992	224.1	
AOC_5	SHL-6	3/30/1993	224.7	
AOC_5	SHL-6	6/22/1993	224.8	
AOC_5	SHL-6	9/30/1993	224.0	
AOC_5	SHL-6	11/8/1993	223.9	
AOC_5	SHL-6	3/30/1994	225.7	
AOC_5	SHL-6	6/28/1994	225.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-6	10/4/1994	225.2	
AOC_5	SHL-6	1/31/1995	225.3	
AOC_5	SHL-6	5/9/1995	224.8	
AOC_5	SHL-6	12/7/1995	224.5	
AOC_5	SHL-6	3/26/1996	225.9	
AOC_5	SHL-6	7/23/1996	226.6	
AOC_5	SHL-6	1/15/1997	226.9	
AOC_5	SHL-6	6/2/1997	227.0	
AOC_5	SHL-6	4/23/1998	226.7	
AOC_5	SHL-6	6/19/1998	228.0	
AOC_5	SHL-6	6/26/1998	228.0	
AOC_5	SHL-6	7/1/1998	227.9	
AOC_5	SHL-6	7/17/1998	227.5	
AOC_5	SHL-6	7/31/1998	226.9	
AOC_5	SHL-6	8/28/1998	226.2	
AOC_5	SHL-6	2/23/1999	225.0	
AOC_5	SHL-7	5/26/1992	217.8	
AOC_5	SHL-7	9/15/1992	218.4	
AOC_5	SHL-7	12/22/1992	217.9	
AOC_5	SHL-7	3/30/1993	220.0	
AOC_5	SHL-7	6/22/1993	218.5	
AOC_5	SHL-7	9/30/1993	217.2	
AOC_5	SHL-7	11/8/1993	217.5	
AOC_5	SHL-7	3/30/1994	219.1	
AOC_5	SHL-7	6/28/1994	218.8	
AOC_5	SHL-7	10/4/1994	218.0	
AOC_5	SHL-7	1/31/1995	218.5	
AOC_5	SHL-7	5/9/1995	217.5	
AOC_5	SHL-7	12/7/1995	218.2	
AOC_5	SHL-7	3/26/1996	218.6	
AOC_5	SHL-7	7/23/1996	219.4	
AOC_5	SHL-7	1/15/1997	218.8	
AOC_5	SHL-7	6/2/1997	218.9	
AOC_5	SHL-7	4/23/1998	218.6	
AOC_5	SHL-7	6/19/1998	220.1	
AOC_5	SHL-7	6/26/1998	219.9	
AOC_5	SHL-7	7/1/1998	219.6	
AOC_5	SHL-7	7/17/1998	218.9	
AOC_5	SHL-7	7/31/1998	218.4	
AOC_5	SHL-7	8/28/1998	217.8	
AOC_5	SHL-7	10/14/1998	217.8	
AOC_5	SHL-7	12/10/1998	217.4	
AOC_5	SHL-7	2/23/1999	217.8	
AOC_5	SHL-7	6/6/1999	217.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-7	9/8/1999	216.5	
AOC_5	SHL-7	4/25/2013	219.2	
AOC_5	SHL-7	6/17/2015	219.0	
AOC_5	SHL-7	8/18/2015	218.8	
AOC_5	SHL-7	10/7/2015	218.5	
AOC_5	SHL-7	12/16/2015	218.4	
AOC_5	SHL-7	6/9/2016	218.8	
AOC_5	SHL-7	6/24/2016	218.4	
AOC_5	SHL-7	8/16/2016	218.4	
AOC_5	SHL-7	11/15/2016		
AOC_5	SHL-7	5/22/2017	220.5	
AOC_5	SHL-7	11/1/2018	219.8	
AOC_5	SHL-7	10/22/2019	218.2	
AOC_5	SHL-7	4/29/2020	219.3	
AOC_5	SHL-8D	5/26/1992	213.3	
AOC_5	SHL-8D	9/15/1992	212.8	
AOC_5	SHL-8D	12/22/1992	213.7	
AOC_5	SHL-8D	6/22/1993	212.9	
AOC_5	SHL-8D	9/30/1993	212.9	
AOC_5	SHL-8D	11/8/1993	213.3	
AOC_5	SHL-8D	3/30/1994	214.6	
AOC_5	SHL-8D	6/28/1994	213.1	
AOC_5	SHL-8D	10/4/1994	213.3	
AOC_5	SHL-8D	1/31/1995	214.0	
AOC_5	SHL-8D	5/9/1995	213.8	
AOC_5	SHL-8D	12/7/1995	213.8	
AOC_5	SHL-8D	3/26/1996	214.4	
AOC_5	SHL-8D	7/23/1996	213.5	
AOC_5	SHL-8D	6/2/1997	213.7	
AOC_5	SHL-8D	4/23/1998	214.1	
AOC_5	SHL-8D	6/19/1998	215.0	
AOC_5	SHL-8D	6/26/1998	214.7	
AOC_5	SHL-8D	7/1/1998	214.6	
AOC_5	SHL-8D	7/17/1998	213.8	
AOC_5	SHL-8D	7/31/1998	213.3	
AOC_5	SHL-8D	8/28/1998	212.7	
AOC_5	SHL-8D	10/14/1998	212.9	
AOC_5	SHL-8D	12/10/1998	212.8	
AOC_5	SHL-8D	2/23/1999	213.4	
AOC_5	SHL-8D	6/6/1999	212.6	
AOC_5	SHL-8D	9/8/1999	211.9	
AOC_5	SHL-8D	11/16/2001	212.6	
AOC_5	SHL-8D	8/4/2005	213.3	
AOC_5	SHL-8D	8/24/2005	212.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-8D	8/26/2005	212.8	
AOC_5	SHL-8D	4/10/2006	213.4	
AOC_5	SHL-8D	6/5/2006	214.8	
AOC_5	SHL-8D	9/18/2006	212.9	
AOC_5	SHL-8D	10/19/2006	213.1	
AOC_5	SHL-8D	12/15/2006	213.9	
AOC_5	SHL-8D	4/8/2007	213.6	
AOC_5	SHL-8D	4/9/2007	213.6	
AOC_5	SHL-8D	10/15/2007	212.8	
AOC_5	SHL-8D	2/20/2008	214.8	
AOC_5	SHL-8D	2/25/2008	214.7	
AOC_5	SHL-8D	3/4/2008	214.3	
AOC_5	SHL-8D	4/16/2008	214.3	
AOC_5	SHL-8D	7/15/2008	212.7	
AOC_5	SHL-8D	9/30/2008	213.7	
AOC_5	SHL-8D	10/1/2008	213.8	
AOC_5	SHL-8D	1/21/2009	213.6	
AOC_5	SHL-8D	4/28/2009	213.9	
AOC_5	SHL-8D	7/15/2009	213.4	
AOC_5	SHL-8D	10/19/2009	212.4	
AOC_5	SHL-8D	10/26/2009	212.9	
AOC_5	SHL-8D	11/3/2009	212.9	
AOC_5	SHL-8D	4/20/2010	214.8	
AOC_5	SHL-8D	10/7/2010	212.3	
AOC_5	SHL-8D	4/4/2011	214.0	
AOC_5	SHL-8D	11/8/2011	214.0	
AOC_5	SHL-8D	4/10/2012	212.7	
AOC_5	SHL-8D	9/11/2012	212.1	
AOC_5	SHL-8D	11/5/2012	213.3	
AOC_5	SHL-8D	11/6/2012	213.3	
AOC_5	SHL-8D	3/13/2013	213.6	
AOC_5	SHL-8D	4/23/2013	213.0	
AOC_5	SHL-8D	4/25/2013	213.0	
AOC_5	SHL-8D	5/15/2013	212.7	
AOC_5	SHL-8D	5/21/2013	212.7	
AOC_5	SHL-8D	5/30/2013	213.5	
AOC_5	SHL-8D	6/11/2013	214.0	
AOC_5	SHL-8D	10/21/2013	211.2	
AOC_5	SHL-8D	10/22/2013	210.8	
AOC_5	SHL-8D	4/22/2014	213.9	
AOC_5	SHL-8D	10/6/2014	212.2	
AOC_5	SHL-8D	6/2/2015	213.3	
AOC_5	SHL-8D	6/17/2015	212.8	
AOC_5	SHL-8D	8/18/2015	212.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-8D	10/20/2015	212.3	
AOC_5	SHL-8D	12/16/2015	212.4	
AOC_5	SHL-8D	6/9/2016	212.7	
AOC_5	SHL-8D	8/16/2016	211.8	
AOC_5	SHL-8D	10/20/2016	211.8	
AOC_5	SHL-8D	11/15/2016	212.8	
AOC_5	SHL-8D	11/1/2018	213.4	
AOC_5	SHL-8D	10/22/2019	212.6	
AOC_5	SHL-8S	5/26/1992	213.3	
AOC_5	SHL-8S	9/15/1992	212.4	
AOC_5	SHL-8S	12/22/1992	214.1	
AOC_5	SHL-8S	3/30/1993	214.2	
AOC_5	SHL-8S	6/22/1993	212.9	
AOC_5	SHL-8S	9/30/1993	212.9	
AOC_5	SHL-8S	11/8/1993	213.3	
AOC_5	SHL-8S	3/30/1994	214.7	
AOC_5	SHL-8S	6/28/1994	213.1	
AOC_5	SHL-8S	10/4/1994	213.9	
AOC_5	SHL-8S	1/31/1995	214.0	
AOC_5	SHL-8S	5/9/1995	213.1	
AOC_5	SHL-8S	12/7/1995	213.7	
AOC_5	SHL-8S	3/26/1996	214.4	
AOC_5	SHL-8S	7/23/1996	213.4	
AOC_5	SHL-8S	6/2/1997	213.7	
AOC_5	SHL-8S	4/23/1998	214.1	
AOC_5	SHL-8S	6/19/1998	215.0	
AOC_5	SHL-8S	6/26/1998	214.7	
AOC_5	SHL-8S	7/1/1998	214.5	
AOC_5	SHL-8S	7/17/1998	213.7	
AOC_5	SHL-8S	7/31/1998	213.3	
AOC_5	SHL-8S	8/28/1998	212.7	
AOC_5	SHL-8S	10/14/1998	213.0	
AOC_5	SHL-8S	12/10/1998	212.8	
AOC_5	SHL-8S	2/23/1999	213.4	
AOC_5	SHL-8S	6/6/1999	212.6	
AOC_5	SHL-8S	9/8/1999	211.9	
AOC_5	SHL-8S	11/16/2001	212.7	
AOC_5	SHL-8S	8/4/2005	213.3	
AOC_5	SHL-8S	8/24/2005	212.8	
AOC_5	SHL-8S	8/26/2005	212.7	
AOC_5	SHL-8S	4/10/2006	213.5	
AOC_5	SHL-8S	6/5/2006	214.8	
AOC_5	SHL-8S	9/18/2006	213.2	
AOC_5	SHL-8S	10/19/2006	213.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-8S	12/15/2006	214.0	
AOC_5	SHL-8S	4/8/2007	213.5	
AOC_5	SHL-8S	4/9/2007	213.5	
AOC_5	SHL-8S	4/26/2007	215.1	
AOC_5	SHL-8S	10/15/2007	212.8	
AOC_5	SHL-8S	2/20/2008	214.8	
AOC_5	SHL-8S	2/25/2008	214.7	
AOC_5	SHL-8S	3/4/2008	214.3	
AOC_5	SHL-8S	4/16/2008	214.3	
AOC_5	SHL-8S	6/10/2008		190.0
AOC_5	SHL-8S	7/15/2008	212.7	
AOC_5	SHL-8S	9/30/2008	213.8	
AOC_5	SHL-8S	10/1/2008	213.8	
AOC_5	SHL-8S	1/21/2009	213.6	
AOC_5	SHL-8S	4/28/2009	214.0	
AOC_5	SHL-8S	7/5/2009	213.5	
AOC_5	SHL-8S	7/15/2009	213.4	
AOC_5	SHL-8S	10/19/2009	212.6	
AOC_5	SHL-8S	10/26/2009	213.0	
AOC_5	SHL-8S	11/3/2009	213.1	
AOC_5	SHL-8S	4/20/2010	214.8	
AOC_5	SHL-8S	10/7/2010	212.4	
AOC_5	SHL-8S	4/4/2011	214.1	
AOC_5	SHL-8S	11/8/2011	214.1	
AOC_5	SHL-8S	4/10/2012	212.8	
AOC_5	SHL-8S	6/26/2012	213.0	
AOC_5	SHL-8S	9/11/2012	212.1	
AOC_5	SHL-8S	11/5/2012	213.4	
AOC_5	SHL-8S	11/6/2012	213.4	
AOC_5	SHL-8S	3/13/2013	213.7	
AOC_5	SHL-8S	4/23/2013	213.2	
AOC_5	SHL-8S	4/25/2013	213.1	
AOC_5	SHL-8S	5/15/2013	212.8	
AOC_5	SHL-8S	5/28/2013	213.6	
AOC_5	SHL-8S	5/30/2013	213.6	
AOC_5	SHL-8S	6/11/2013	214.2	
AOC_5	SHL-8S	10/21/2013	211.3	
AOC_5	SHL-8S	10/22/2013	209.8	
AOC_5	SHL-8S	4/22/2014	213.9	
AOC_5	SHL-8S	10/6/2014	212.4	
AOC_5	SHL-8S	6/2/2015	213.4	
AOC_5	SHL-8S	6/17/2015	212.8	
AOC_5	SHL-8S	8/18/2015	212.3	
AOC_5	SHL-8S	10/20/2015	212.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-8S	12/16/2015	212.5	
AOC_5	SHL-8S	6/9/2016	212.8	
AOC_5	SHL-8S	8/16/2016	212.0	
AOC_5	SHL-8S	11/15/2016	213.0	
AOC_5	SHL-8S	11/1/2018	213.5	
AOC_5	SHL-8S	10/22/2019	212.6	
AOC_5	SHL-9	5/26/1992	212.8	
AOC_5	SHL-9	9/15/1992	211.9	
AOC_5	SHL-9	12/22/1992	213.7	
AOC_5	SHL-9	3/30/1993	213.9	
AOC_5	SHL-9	6/22/1993	212.3	
AOC_5	SHL-9	9/30/1993	212.1	
AOC_5	SHL-9	11/8/1993	212.9	
AOC_5	SHL-9	3/30/1994	214.9	
AOC_5	SHL-9	6/28/1994	212.7	
AOC_5	SHL-9	1/31/1995	213.9	
AOC_5	SHL-9	5/9/1995	212.6	
AOC_5	SHL-9	12/7/1995	213.4	
AOC_5	SHL-9	3/26/1996	214.4	
AOC_5	SHL-9	7/23/1996	213.0	
AOC_5	SHL-9	6/2/1997	213.4	
AOC_5	SHL-9	4/23/1998	214.0	
AOC_5	SHL-9	6/19/1998	215.2	
AOC_5	SHL-9	7/1/1998	214.7	
AOC_5	SHL-9	7/17/1998	213.6	
AOC_5	SHL-9	8/28/1998	212.0	
AOC_5	SHL-9	10/14/1998	212.3	
AOC_5	SHL-9	12/10/1998	212.2	
AOC_5	SHL-9	2/23/1999	213.2	
AOC_5	SHL-9	6/6/1999	211.7	
AOC_5	SHL-9	9/8/1999	211.0	
AOC_5	SHL-9	11/16/2001	211.8	
AOC_5	SHL-9	8/4/2005	212.8	
AOC_5	SHL-9	8/24/2005	212.1	
AOC_5	SHL-9	8/26/2005	212.1	
AOC_5	SHL-9	4/10/2006	212.9	
AOC_5	SHL-9	6/5/2006	214.8	
AOC_5	SHL-9	9/18/2006	212.4	
AOC_5	SHL-9	12/15/2006	213.6	
AOC_5	SHL-9	4/8/2007	213.9	
AOC_5	SHL-9	4/9/2007	213.9	
AOC_5	SHL-9	10/15/2007	211.2	
AOC_5	SHL-9	2/20/2008	214.9	
AOC_5	SHL-9	2/25/2008	214.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHL-9	3/4/2008	213.9	
AOC_5	SHL-9	4/16/2008	213.8	
AOC_5	SHL-9	7/15/2008	211.8	
AOC_5	SHL-9	9/30/2008	213.0	
AOC_5	SHL-9	10/1/2008		203.1
AOC_5	SHL-9	1/20/2009	213.1	
AOC_5	SHL-9	4/28/2009	213.5	
AOC_5	SHL-9	7/15/2009	215.6	
AOC_5	SHL-9	10/19/2009	211.0	
AOC_5	SHL-9	11/3/2009	211.8	
AOC_5	SHL-9	4/20/2010	214.3	
AOC_5	SHL-9	9/14/2010	210.8	
AOC_5	SHL-9	10/7/2010	210.8	
AOC_5	SHL-9	4/4/2011	213.8	
AOC_5	SHL-9	11/8/2011	213.6	
AOC_5	SHL-9	4/10/2012	211.9	
AOC_5	SHL-9	6/26/2012	211.8	
AOC_5	SHL-9	9/11/2012	210.7	
AOC_5	SHL-9	11/5/2012	212.3	
AOC_5	SHL-9	11/6/2012	212.3	
AOC_5	SHL-9	2/14/2013	212.4	
AOC_5	SHL-9	3/12/2013	216.1	
AOC_5	SHL-9	3/13/2013	213.6	
AOC_5	SHL-9	4/22/2013	212.2	
AOC_5	SHL-9	4/23/2013	212.3	
AOC_5	SHL-9	4/25/2013	212.3	
AOC_5	SHL-9	5/15/2013	211.6	
AOC_5	SHL-9	5/28/2013	212.9	
AOC_5	SHL-9	5/30/2013	212.6	
AOC_5	SHL-9	6/11/2013		205.9
AOC_5	SHL-9	10/21/2013	210.9	
AOC_5	SHL-9	10/23/2013	210.6	
AOC_5	SHL-9	4/22/2014	213.3	
AOC_5	SHL-9	4/23/2014	213.2	
AOC_5	SHL-9	10/6/2014	210.6	
AOC_5	SHL-9	6/2/2015	212.4	
AOC_5	SHL-9	6/17/2015	211.8	
AOC_5	SHL-9	10/20/2015	210.5	
AOC_5	SHL-9	12/16/2015	211.0	
AOC_5	SHL-9	6/9/2016	211.5	
AOC_5	SHL-9	8/16/2016	210.2	
AOC_5	SHL-9	10/16/2016	211.5	
AOC_5	SHL-9	11/1/2018	212.5	
AOC_5	SHL-9	10/22/2019	209.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-05-39A	8/4/2005	210.0	
AOC_5	SHM-05-39A	8/24/2005	209.6	
AOC_5	SHM-05-39A	8/26/2005	209.6	
AOC_5	SHM-05-39A	4/10/2006	210.3	
AOC_5	SHM-05-39A	6/5/2006	211.7	
AOC_5	SHM-05-39A	9/18/2006	210.1	
AOC_5	SHM-05-39A	12/15/2006	211.0	
AOC_5	SHM-05-39A	4/8/2007	211.0	
AOC_5	SHM-05-39A	4/9/2007	211.0	
AOC_5	SHM-05-39A	10/15/2007	209.5	
AOC_5	SHM-05-39A	2/20/2008	211.8	
AOC_5	SHM-05-39A	2/25/2008	211.7	
AOC_5	SHM-05-39A	4/16/2008	211.2	
AOC_5	SHM-05-39A	9/30/2008	210.5	
AOC_5	SHM-05-39A	10/2/2008	210.7	
AOC_5	SHM-05-39A	4/28/2009	213.4	
AOC_5	SHM-05-39A	10/20/2009	209.4	
AOC_5	SHM-05-39A	11/3/2009	209.9	
AOC_5	SHM-05-39A	4/20/2010	211.7	
AOC_5	SHM-05-39A	10/7/2010	209.2	
AOC_5	SHM-05-39A	4/4/2011	211.0	
AOC_5	SHM-05-39A	11/8/2011	210.9	
AOC_5	SHM-05-39A	4/10/2012	209.1	
AOC_5	SHM-05-39A	11/5/2012	210.1	
AOC_5	SHM-05-39A	4/25/2013	209.9	
AOC_5	SHM-05-39A	5/15/2013	209.6	
AOC_5	SHM-05-39A	5/30/2013	210.1	
AOC_5	SHM-05-39A	6/11/2013	210.6	
AOC_5	SHM-05-39A	10/21/2013	209.0	
AOC_5	SHM-05-39A	10/24/2013	208.8	
AOC_5	SHM-05-39A	4/22/2014	211.0	
AOC_5	SHM-05-39A	10/6/2014	209.2	
AOC_5	SHM-05-39A	6/2/2015	209.9	
AOC_5	SHM-05-39A	6/17/2015	209.6	
AOC_5	SHM-05-39A	10/20/2015	209.0	
AOC_5	SHM-05-39A	6/9/2016	209.6	
AOC_5	SHM-05-39A	8/16/2016	208.8	
AOC_5	SHM-05-39A	11/1/2018	210.2	
AOC_5	SHM-05-39A	10/22/2019	209.1	
AOC_5	SHM-05-39B	8/4/2005	209.2	
AOC_5	SHM-05-39B	8/24/2005	208.8	
AOC_5	SHM-05-39B	8/26/2005	208.8	
AOC_5	SHM-05-39B	4/10/2006	209.5	
AOC_5	SHM-05-39B	6/5/2006	210.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-05-39B	9/18/2006	209.3	
AOC_5	SHM-05-39B	12/15/2006	205.9	
AOC_5	SHM-05-39B	4/8/2007	210.1	
AOC_5	SHM-05-39B	4/9/2007	210.1	
AOC_5	SHM-05-39B	10/15/2007	208.9	
AOC_5	SHM-05-39B	2/20/2008	211.0	
AOC_5	SHM-05-39B	2/25/2008	210.9	
AOC_5	SHM-05-39B	4/16/2008	210.4	
AOC_5	SHM-05-39B	9/30/2008	209.6	
AOC_5	SHM-05-39B	10/2/2008	208.0	
AOC_5	SHM-05-39B	4/28/2009	210.0	
AOC_5	SHM-05-39B	10/20/2009	208.4	
AOC_5	SHM-05-39B	11/3/2009	209.1	
AOC_5	SHM-05-39B	4/20/2010	210.8	
AOC_5	SHM-05-39B	10/7/2010	208.1	
AOC_5	SHM-05-39B	4/4/2011	210.2	
AOC_5	SHM-05-39B	11/8/2011	210.0	
AOC_5	SHM-05-39B	4/10/2012	209.6	
AOC_5	SHM-05-39B	11/5/2012	209.2	
AOC_5	SHM-05-39B	4/25/2013	209.1	
AOC_5	SHM-05-39B	5/15/2013	208.8	
AOC_5	SHM-05-39B	5/30/2013	209.3	
AOC_5	SHM-05-39B	6/11/2013	209.7	
AOC_5	SHM-05-39B	10/21/2013	208.4	
AOC_5	SHM-05-39B	4/22/2014	210.2	
AOC_5	SHM-05-39B	10/6/2014	208.5	
AOC_5	SHM-05-39B	6/2/2015	209.1	
AOC_5	SHM-05-39B	6/17/2015	208.9	
AOC_5	SHM-05-39B	10/20/2015	208.4	
AOC_5	SHM-05-39B	6/9/2016	208.9	
AOC_5	SHM-05-39B	8/16/2016	208.2	
AOC_5	SHM-05-39B	10/20/2016	208.3	
AOC_5	SHM-05-39B	11/1/2018	209.4	
AOC_5	SHM-05-39B	10/22/2019		
AOC_5	SHM-05-40X	8/4/2005	209.0	
AOC_5	SHM-05-40X	8/24/2005	208.6	
AOC_5	SHM-05-40X	8/26/2005	208.6	
AOC_5	SHM-05-40X	4/10/2006	209.2	
AOC_5	SHM-05-40X	6/5/2006	210.7	
AOC_5	SHM-05-40X	9/18/2006	209.1	
AOC_5	SHM-05-40X	12/15/2006	210.0	
AOC_5	SHM-05-40X	4/8/2007	210.0	
AOC_5	SHM-05-40X	4/9/2007	210.0	
AOC_5	SHM-05-40X	10/15/2007	208.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-05-40X	2/20/2008	210.9	
AOC_5	SHM-05-40X	2/25/2008	210.9	
AOC_5	SHM-05-40X	3/4/2008	210.4	
AOC_5	SHM-05-40X	4/16/2008	210.3	
AOC_5	SHM-05-40X	9/30/2008	209.4	
AOC_5	SHM-05-40X	4/28/2009	209.8	
AOC_5	SHM-05-40X	10/20/2009	208.4	
AOC_5	SHM-05-40X	11/3/2009	208.8	
AOC_5	SHM-05-40X	4/20/2010	211.0	
AOC_5	SHM-05-40X	10/7/2010	208.0	
AOC_5	SHM-05-40X	4/4/2011	210.1	
AOC_5	SHM-05-40X	11/8/2011	209.9	
AOC_5	SHM-05-40X	4/10/2012	208.6	
AOC_5	SHM-05-40X	11/5/2012	209.0	
AOC_5	SHM-05-40X	4/25/2013	208.9	
AOC_5	SHM-05-40X	5/15/2013	208.5	
AOC_5	SHM-05-40X	5/30/2013	209.0	
AOC_5	SHM-05-40X	6/11/2013	209.3	
AOC_5	SHM-05-40X	10/21/2013	208.1	
AOC_5	SHM-05-40X	10/24/2013	208.0	
AOC_5	SHM-05-40X	4/22/2014	210.1	
AOC_5	SHM-05-40X	10/6/2014	208.1	
AOC_5	SHM-05-40X	6/2/2015	208.7	
AOC_5	SHM-05-40X	6/17/2015	208.6	
AOC_5	SHM-05-40X	10/20/2015	208.0	
AOC_5	SHM-05-40X	12/16/2015	208.3	
AOC_5	SHM-05-40X	6/9/2016	208.5	
AOC_5	SHM-05-40X	6/23/2016	208.4	
AOC_5	SHM-05-40X	8/16/2016	207.8	
AOC_5	SHM-05-40X	10/20/2016	207.9	
AOC_5	SHM-05-40X	11/16/2016	208.7	
AOC_5	SHM-05-40X	5/22/2017	209.5	
AOC_5	SHM-05-40X	5/11/2018	212.8	
AOC_5	SHM-05-40X	11/1/2018	209.3	
AOC_5	SHM-05-40X	4/11/2019	209.3	
AOC_5	SHM-05-40X	10/22/2019	208.2	
AOC_5	SHM-05-40X	5/18/2020	209.5	
AOC_5	SHM-05-40X	5/19/2020	209.5	
AOC_5	SHM-05-41A	8/4/2005	212.3	
AOC_5	SHM-05-41A	8/24/2005	211.8	
AOC_5	SHM-05-41A	8/26/2005	211.7	
AOC_5	SHM-05-41A	4/10/2006	212.4	
AOC_5	SHM-05-41A	6/5/2006	214.0	
AOC_5	SHM-05-41A	9/18/2006	212.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-05-41A	12/15/2006	213.2	
AOC_5	SHM-05-41A	4/8/2007	213.3	
AOC_5	SHM-05-41A	4/9/2007	213.3	
AOC_5	SHM-05-41A	10/15/2007	210.9	
AOC_5	SHM-05-41A	2/20/2008	213.9	
AOC_5	SHM-05-41A	2/25/2008	214.2	
AOC_5	SHM-05-41A	3/4/2008	213.4	
AOC_5	SHM-05-41A	4/16/2008	213.4	
AOC_5	SHM-05-41A	9/30/2008	212.5	
AOC_5	SHM-05-41A	10/2/2008	212.6	
AOC_5	SHM-05-41A	4/28/2009	212.9	
AOC_5	SHM-05-41A	10/20/2009	210.8	
AOC_5	SHM-05-41A	11/3/2009	211.5	
AOC_5	SHM-05-41A	4/20/2010	213.9	
AOC_5	SHM-05-41A	10/7/2010	210.5	
AOC_5	SHM-05-41A	4/4/2011	213.2	
AOC_5	SHM-05-41A	11/8/2011	213.1	
AOC_5	SHM-05-41A	4/10/2012	211.5	
AOC_5	SHM-05-41A	9/11/2012	210.5	
AOC_5	SHM-05-41A	11/5/2012	211.9	
AOC_5	SHM-05-41A	11/6/2012	211.9	
AOC_5	SHM-05-41A	3/13/2013	212.3	
AOC_5	SHM-05-41A	4/23/2013	211.8	
AOC_5	SHM-05-41A	4/25/2013	211.8	
AOC_5	SHM-05-41A	5/15/2013	211.2	
AOC_5	SHM-05-41A	5/22/2013	211.2	
AOC_5	SHM-05-41A	5/30/2013	212.0	
AOC_5	SHM-05-41A	6/11/2013	212.5	
AOC_5	SHM-05-41A	10/21/2013	210.6	
AOC_5	SHM-05-41A	10/23/2013	210.5	
AOC_5	SHM-05-41A	4/22/2014	212.8	
AOC_5	SHM-05-41A	4/23/2014	212.8	
AOC_5	SHM-05-41A	10/6/2014	210.4	
AOC_5	SHM-05-41A	6/2/2015	211.6	
AOC_5	SHM-05-41A	6/17/2015	211.3	
AOC_5	SHM-05-41A	10/20/2015	210.1	
AOC_5	SHM-05-41A	12/16/2015	210.6	
AOC_5	SHM-05-41A	6/9/2016	211.1	
AOC_5	SHM-05-41A	8/16/2016	210.0	
AOC_5	SHM-05-41A	11/16/2016	211.1	
AOC_5	SHM-05-41A	11/1/2018	212.0	
AOC_5	SHM-05-41A	10/22/2019	210.5	
AOC_5	SHM-05-41B	8/4/2005	212.3	
AOC_5	SHM-05-41B	8/24/2005	211.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-05-41B	8/26/2005	211.7	
AOC_5	SHM-05-41B	4/10/2006	212.4	
AOC_5	SHM-05-41B	6/5/2006	214.1	
AOC_5	SHM-05-41B	9/18/2006	212.0	
AOC_5	SHM-05-41B	12/15/2006	213.2	
AOC_5	SHM-05-41B	4/8/2007	213.3	
AOC_5	SHM-05-41B	4/9/2007	213.3	
AOC_5	SHM-05-41B	10/15/2007	211.0	
AOC_5	SHM-05-41B	2/20/2008	214.0	
AOC_5	SHM-05-41B	2/25/2008	214.2	
AOC_5	SHM-05-41B	3/4/2008	213.3	
AOC_5	SHM-05-41B	4/16/2008	213.4	
AOC_5	SHM-05-41B	9/30/2008	212.5	
AOC_5	SHM-05-41B	10/1/2008	212.6	
AOC_5	SHM-05-41B	4/28/2009	213.0	
AOC_5	SHM-05-41B	10/20/2009	210.8	
AOC_5	SHM-05-41B	11/3/2009	211.5	
AOC_5	SHM-05-41B	4/20/2010	214.0	
AOC_5	SHM-05-41B	9/14/2010	210.5	
AOC_5	SHM-05-41B	10/7/2010	210.6	
AOC_5	SHM-05-41B	4/4/2011	213.2	
AOC_5	SHM-05-41B	11/8/2011	213.1	
AOC_5	SHM-05-41B	4/10/2012	211.5	
AOC_5	SHM-05-41B	9/11/2012	210.5	
AOC_5	SHM-05-41B	11/5/2012	211.9	
AOC_5	SHM-05-41B	11/6/2012	211.9	
AOC_5	SHM-05-41B	3/13/2013	212.4	
AOC_5	SHM-05-41B	4/23/2013	211.8	
AOC_5	SHM-05-41B	4/25/2013	211.8	
AOC_5	SHM-05-41B	5/15/2013	211.2	
AOC_5	SHM-05-41B	5/22/2013	211.2	
AOC_5	SHM-05-41B	5/30/2013	212.1	
AOC_5	SHM-05-41B	6/11/2013	212.5	
AOC_5	SHM-05-41B	10/21/2013	210.6	
AOC_5	SHM-05-41B	10/23/2013	210.5	
AOC_5	SHM-05-41B	4/22/2014	212.9	
AOC_5	SHM-05-41B	4/23/2014	212.8	
AOC_5	SHM-05-41B	10/6/2014	210.4	
AOC_5	SHM-05-41B	6/2/2015	211.9	
AOC_5	SHM-05-41B	6/8/2015	211.4	
AOC_5	SHM-05-41B	6/17/2015	211.3	
AOC_5	SHM-05-41B	10/20/2015	210.1	
AOC_5	SHM-05-41B	12/16/2015	210.6	
AOC_5	SHM-05-41B	6/9/2016	211.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-05-41B	6/23/2016	210.7	
AOC_5	SHM-05-41B	8/16/2016	210.0	
AOC_5	SHM-05-41B	10/20/2016	209.9	
AOC_5	SHM-05-41B	11/16/2016	211.1	
AOC_5	SHM-05-41B	5/22/2017	212.3	
AOC_5	SHM-05-41B	5/11/2018	212.4	
AOC_5	SHM-05-41B	11/1/2018	212.0	
AOC_5	SHM-05-41B	4/11/2019	210.7	
AOC_5	SHM-05-41B	10/22/2019		182.2
AOC_5	SHM-05-41B	5/18/2020	212.4	
AOC_5	SHM-05-41B	5/21/2020	212.2	
AOC_5	SHM-05-41C	8/4/2005	212.3	
AOC_5	SHM-05-41C	8/24/2005	211.8	
AOC_5	SHM-05-41C	8/26/2005	211.7	
AOC_5	SHM-05-41C	4/10/2006	212.4	
AOC_5	SHM-05-41C	6/5/2006	214.1	
AOC_5	SHM-05-41C	9/18/2006	212.0	
AOC_5	SHM-05-41C	12/15/2006	213.2	
AOC_5	SHM-05-41C	4/8/2007	213.3	
AOC_5	SHM-05-41C	4/9/2007	213.3	
AOC_5	SHM-05-41C	10/15/2007	211.0	
AOC_5	SHM-05-41C	2/20/2008	213.9	
AOC_5	SHM-05-41C	2/25/2008	214.2	
AOC_5	SHM-05-41C	3/4/2008	213.6	
AOC_5	SHM-05-41C	4/16/2008	213.4	
AOC_5	SHM-05-41C	9/30/2008	212.5	
AOC_5	SHM-05-41C	10/2/2008	212.7	
AOC_5	SHM-05-41C	4/28/2009	213.0	
AOC_5	SHM-05-41C	10/20/2009	210.8	
AOC_5	SHM-05-41C	11/3/2009	211.5	
AOC_5	SHM-05-41C	4/20/2010	213.9	
AOC_5	SHM-05-41C	9/14/2010	210.5	
AOC_5	SHM-05-41C	10/7/2010	210.6	
AOC_5	SHM-05-41C	4/4/2011	213.1	
AOC_5	SHM-05-41C	11/8/2011	213.1	
AOC_5	SHM-05-41C	4/10/2012	211.5	
AOC_5	SHM-05-41C	9/11/2012	210.5	
AOC_5	SHM-05-41C	11/5/2012	211.9	
AOC_5	SHM-05-41C	11/6/2012	211.9	
AOC_5	SHM-05-41C	3/13/2013	212.3	
AOC_5	SHM-05-41C	4/23/2013	211.7	
AOC_5	SHM-05-41C	5/15/2013	211.2	
AOC_5	SHM-05-41C	5/21/2013	211.3	
AOC_5	SHM-05-41C	5/30/2013	212.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-05-41C	6/11/2013	212.5	
AOC_5	SHM-05-41C	10/21/2013	210.6	
AOC_5	SHM-05-41C	10/23/2013	210.4	
AOC_5	SHM-05-41C	4/22/2014	212.8	
AOC_5	SHM-05-41C	4/23/2014	212.7	
AOC_5	SHM-05-41C	10/6/2014	210.2	
AOC_5	SHM-05-41C	6/2/2015	211.7	
AOC_5	SHM-05-41C	6/8/2015	211.4	
AOC_5	SHM-05-41C	6/17/2015	211.4	
AOC_5	SHM-05-41C	10/20/2015	210.2	
AOC_5	SHM-05-41C	12/16/2015	210.7	
AOC_5	SHM-05-41C	6/9/2016	211.2	
AOC_5	SHM-05-41C	6/23/2016	210.7	
AOC_5	SHM-05-41C	11/16/2016	211.1	
AOC_5	SHM-05-41C	5/22/2017	212.4	
AOC_5	SHM-05-41C	5/11/2018	212.5	
AOC_5	SHM-05-41C	11/1/2018	212.0	
AOC_5	SHM-05-41C	4/11/2019	211.8	
AOC_5	SHM-05-41C	10/22/2019	210.4	
AOC_5	SHM-05-41C	5/18/2020	212.3	
AOC_5	SHM-05-41C	5/21/2020	211.9	
AOC_5	SHM-05-42A	8/4/2005	212.3	
AOC_5	SHM-05-42A	8/24/2005	211.8	
AOC_5	SHM-05-42A	8/26/2005	211.7	
AOC_5	SHM-05-42A	4/10/2006	212.5	
AOC_5	SHM-05-42A	6/5/2006	214.0	
AOC_5	SHM-05-42A	8/2/2006	212.4	
AOC_5	SHM-05-42A	9/18/2006	212.0	
AOC_5	SHM-05-42A	12/15/2006	213.2	
AOC_5	SHM-05-42A	4/8/2007	213.3	
AOC_5	SHM-05-42A	4/9/2007	213.3	
AOC_5	SHM-05-42A	10/15/2007	211.2	
AOC_5	SHM-05-42A	2/25/2008	214.3	
AOC_5	SHM-05-42A	3/4/2008	213.6	
AOC_5	SHM-05-42A	4/16/2008	213.3	
AOC_5	SHM-05-42A	9/30/2008	212.6	
AOC_5	SHM-05-42A	10/2/2008	212.3	
AOC_5	SHM-05-42A	4/28/2009	213.0	
AOC_5	SHM-05-42A	10/21/2009	211.1	
AOC_5	SHM-05-42A	11/3/2009	211.7	
AOC_5	SHM-05-42A	4/20/2010	214.5	
AOC_5	SHM-05-42A	9/14/2010	210.6	
AOC_5	SHM-05-42A	10/7/2010	210.9	
AOC_5	SHM-05-42A	4/4/2011	213.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-05-42A	11/8/2011	213.1	
AOC_5	SHM-05-42A	4/10/2012	211.6	
AOC_5	SHM-05-42A	6/26/2012	211.7	
AOC_5	SHM-05-42A	9/11/2012	210.6	
AOC_5	SHM-05-42A	11/5/2012	212.1	
AOC_5	SHM-05-42A	11/6/2012	212.1	
AOC_5	SHM-05-42A	3/13/2013	212.6	
AOC_5	SHM-05-42A	4/23/2013	211.9	
AOC_5	SHM-05-42A	4/25/2013	211.9	
AOC_5	SHM-05-42A	5/15/2013	211.4	
AOC_5	SHM-05-42A	5/22/2013	211.4	
AOC_5	SHM-05-42A	5/30/2013	212.2	
AOC_5	SHM-05-42A	6/11/2013	212.8	
AOC_5	SHM-05-42A	10/21/2013	210.7	
AOC_5	SHM-05-42A	10/23/2013	210.4	
AOC_5	SHM-05-42A	4/22/2014	212.9	
AOC_5	SHM-05-42A	4/23/2014	212.9	
AOC_5	SHM-05-42A	10/6/2014	210.7	
AOC_5	SHM-05-42A	6/2/2015	212.0	
AOC_5	SHM-05-42A	6/17/2015	211.5	
AOC_5	SHM-05-42A	10/20/2015	210.5	
AOC_5	SHM-05-42A	12/16/2015	210.9	
AOC_5	SHM-05-42A	6/9/2016	211.3	
AOC_5	SHM-05-42A	8/16/2016	210.3	
AOC_5	SHM-05-42A	11/16/2016	211.4	
AOC_5	SHM-05-42A	11/1/2018	212.3	
AOC_5	SHM-05-42A	10/22/2019	208.8	
AOC_5	SHM-05-42B	8/4/2005	212.4	
AOC_5	SHM-05-42B	8/24/2005	211.9	
AOC_5	SHM-05-42B	8/26/2005	211.7	
AOC_5	SHM-05-42B	4/10/2006	212.5	
AOC_5	SHM-05-42B	6/5/2006	214.1	
AOC_5	SHM-05-42B	8/2/2006	212.5	
AOC_5	SHM-05-42B	9/18/2006	212.1	
AOC_5	SHM-05-42B	12/15/2006	213.2	
AOC_5	SHM-05-42B	4/8/2007	213.4	
AOC_5	SHM-05-42B	4/9/2007	213.4	
AOC_5	SHM-05-42B	10/15/2007	211.2	
AOC_5	SHM-05-42B	2/25/2008	214.2	
AOC_5	SHM-05-42B	3/4/2008	213.7	
AOC_5	SHM-05-42B	4/16/2008	213.3	
AOC_5	SHM-05-42B	9/30/2008	212.6	
AOC_5	SHM-05-42B	10/2/2008	212.7	
AOC_5	SHM-05-42B	4/28/2009	213.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-05-42B	10/21/2009	211.0	
AOC_5	SHM-05-42B	11/3/2009	211.7	
AOC_5	SHM-05-42B	4/20/2010	213.9	
AOC_5	SHM-05-42B	9/14/2010	210.6	
AOC_5	SHM-05-42B	10/7/2010	210.8	
AOC_5	SHM-05-42B	4/4/2011	213.1	
AOC_5	SHM-05-42B	11/8/2011	213.1	
AOC_5	SHM-05-42B	4/10/2012	211.6	
AOC_5	SHM-05-42B	9/11/2012	210.6	
AOC_5	SHM-05-42B	11/5/2012	212.1	
AOC_5	SHM-05-42B	11/6/2012	212.0	
AOC_5	SHM-05-42B	3/13/2013	212.5	
AOC_5	SHM-05-42B	4/23/2013	211.9	
AOC_5	SHM-05-42B	5/15/2013	211.4	
AOC_5	SHM-05-42B	5/22/2013	211.4	
AOC_5	SHM-05-42B	5/30/2013	212.2	
AOC_5	SHM-05-42B	6/11/2013	212.8	
AOC_5	SHM-05-42B	10/21/2013	210.7	
AOC_5	SHM-05-42B	10/23/2013	210.5	
AOC_5	SHM-05-42B	4/22/2014	212.9	
AOC_5	SHM-05-42B	4/23/2014	212.9	
AOC_5	SHM-05-42B	10/6/2014	210.6	
AOC_5	SHM-05-42B	6/2/2015	211.9	
AOC_5	SHM-05-42B	6/17/2015	211.5	
AOC_5	SHM-05-42B	10/20/2015	210.5	
AOC_5	SHM-05-42B	12/16/2015	210.9	
AOC_5	SHM-05-42B	6/9/2016	211.3	
AOC_5	SHM-05-42B	8/16/2016	210.2	
AOC_5	SHM-05-42B	10/20/2016	210.1	
AOC_5	SHM-05-42B	11/16/2016	211.3	
AOC_5	SHM-05-42B	11/1/2018	212.1	
AOC_5	SHM-05-42B	10/22/2019	209.3	
AOC_5	SHM-07-03	2/20/2008	208.0	
AOC_5	SHM-07-03	5/15/2013	208.1	
AOC_5	SHM-07-03	5/28/2013	208.2	
AOC_5	SHM-07-03	6/11/2013	208.7	
AOC_5	SHM-07-03	10/21/2013	207.4	
AOC_5	SHM-07-03	4/22/2014	209.7	
AOC_5	SHM-07-03	10/6/2014	207.4	
AOC_5	SHM-07-03	6/9/2015	208.2	
AOC_5	SHM-07-03	6/10/2015	208.2	
AOC_5	SHM-07-03	6/17/2015	207.9	
AOC_5	SHM-07-03	12/16/2015	207.6	
AOC_5	SHM-07-03	6/9/2016	207.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-07-03	6/23/2016	207.7	
AOC_5	SHM-07-03	8/16/2016	207.0	
AOC_5	SHM-07-03	10/20/2016	207.2	
AOC_5	SHM-07-03	11/16/2016	207.8	
AOC_5	SHM-07-03	5/22/2017	208.9	
AOC_5	SHM-07-03	5/11/2018	208.8	
AOC_5	SHM-07-03	11/1/2018	208.5	
AOC_5	SHM-07-03	4/11/2019	208.4	
AOC_5	SHM-07-03	10/22/2019	203.9	
AOC_5	SHM-07-03	5/15/2020	208.9	
AOC_5	SHM-07-03	5/18/2020	208.9	
AOC_5	SHM-07-05	2/20/2008	209.3	
AOC_5	SHM-07-05	5/15/2013	209.1	
AOC_5	SHM-07-05	6/11/2013	209.2	
AOC_5	SHM-07-05	10/21/2013	208.8	
AOC_5	SHM-07-05	4/22/2014	208.4	
AOC_5	SHM-07-05	10/6/2014	208.8	
AOC_5	SHM-07-05	6/8/2015	209.1	
AOC_5	SHM-07-05	6/9/2015	209.1	
AOC_5	SHM-07-05	6/17/2015	208.9	
AOC_5	SHM-07-05	12/16/2015	208.8	
AOC_5	SHM-07-05	6/9/2016	208.9	
AOC_5	SHM-07-05	6/23/2016	208.7	
AOC_5	SHM-07-05	11/16/2016	209.2	
AOC_5	SHM-07-05	5/22/2017	207.5	
AOC_5	SHM-07-05	5/11/2018	209.6	
AOC_5	SHM-07-05X	11/1/2018	208.9	
AOC_5	SHM-07-05X	4/11/2019	209.2	
AOC_5	SHM-07-05X	10/22/2019	208.1	
AOC_5	SHM-07-05X	5/18/2020	220.7	
AOC_5	SHM-10-01	11/5/2012	205.5	
AOC_5	SHM-10-01	5/15/2013	206.1	
AOC_5	SHM-10-01	5/29/2013	206.4	
AOC_5	SHM-10-01	6/11/2013	207.2	
AOC_5	SHM-10-01	10/21/2013	205.6	
AOC_5	SHM-10-01	4/22/2014	206.7	
AOC_5	SHM-10-01	10/6/2014	205.6	
AOC_5	SHM-10-01	6/1/2015	206.0	
AOC_5	SHM-10-01	6/9/2015	205.7	
AOC_5	SHM-10-01	6/17/2015	205.5	
AOC_5	SHM-10-01	10/20/2015	205.3	
AOC_5	SHM-10-01	12/16/2015	205.6	
AOC_5	SHM-10-01	6/9/2016	205.5	
AOC_5	SHM-10-01	11/1/2018	206.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-10-01	10/22/2019	205.5	
AOC_5	SHM-10-02	11/5/2012	205.8	
AOC_5	SHM-10-02	5/15/2013	204.4	
AOC_5	SHM-10-02	5/29/2013	205.6	
AOC_5	SHM-10-02	6/11/2013	206.5	
AOC_5	SHM-10-02	10/21/2013	204.7	
AOC_5	SHM-10-02	4/22/2014	205.8	
AOC_5	SHM-10-02	10/6/2014	204.6	
AOC_5	SHM-10-02	6/8/2015	205.0	
AOC_5	SHM-10-02	6/9/2015	205.0	
AOC_5	SHM-10-02	11/1/2018	206.3	
AOC_5	SHM-10-02	10/22/2019	204.8	
AOC_5	SHM-10-03	11/5/2012	205.9	
AOC_5	SHM-10-03	5/15/2013	205.7	
AOC_5	SHM-10-03	5/24/2013	205.6	
AOC_5	SHM-10-03	6/11/2013	206.6	
AOC_5	SHM-10-03	10/21/2013	205.1	
AOC_5	SHM-10-03	4/22/2014	206.4	
AOC_5	SHM-10-03	10/6/2014	205.0	
AOC_5	SHM-10-03	6/9/2015	205.5	
AOC_5	SHM-10-03	6/10/2015	205.5	
AOC_5	SHM-10-03	11/1/2018	206.4	
AOC_5	SHM-10-03	10/22/2019	205.2	
AOC_5	SHM-10-04	11/5/2012	206.4	
AOC_5	SHM-10-04	5/15/2013	206.5	
AOC_5	SHM-10-04	5/29/2013	206.7	
AOC_5	SHM-10-04	6/11/2013	207.4	
AOC_5	SHM-10-04	10/21/2013	206.4	
AOC_5	SHM-10-04	4/22/2014	207.5	
AOC_5	SHM-10-04	10/6/2014	206.4	
AOC_5	SHM-10-04	6/8/2015	206.8	
AOC_5	SHM-10-04	6/9/2015	206.8	
AOC_5	SHM-10-04	11/1/2018	207.9	
AOC_5	SHM-10-04	10/22/2019	205.9	
AOC_5	SHM-10-05A	11/5/2012	209.9	
AOC_5	SHM-10-05A	5/15/2013	209.5	
AOC_5	SHM-10-05A	5/22/2013	209.5	
AOC_5	SHM-10-05A	6/11/2013	210.4	
AOC_5	SHM-10-05A	10/21/2013	209.0	
AOC_5	SHM-10-05A	4/22/2014	210.9	
AOC_5	SHM-10-05A	10/6/2014	209.7	
AOC_5	SHM-10-05A	6/9/2015	209.9	
AOC_5	SHM-10-05A	6/10/2015	209.9	
AOC_5	SHM-10-05A	6/17/2015	209.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-10-05A	12/16/2015	209.7	
AOC_5	SHM-10-05A	6/9/2016	209.9	
AOC_5	SHM-10-05A	11/16/2016	210.1	
AOC_5	SHM-10-05A	11/1/2018	210.1	
AOC_5	SHM-10-05A	10/22/2019	209.4	
AOC_5	SHM-10-06	6/26/2012	213.7	
AOC_5	SHM-10-06	9/11/2012	212.6	
AOC_5	SHM-10-06	11/5/2012	214.1	
AOC_5	SHM-10-06	11/6/2012	214.0	
AOC_5	SHM-10-06	3/13/2013	214.3	
AOC_5	SHM-10-06	4/23/2013	213.9	
AOC_5	SHM-10-06	4/25/2013	213.9	
AOC_5	SHM-10-06	5/15/2013	213.5	
AOC_5	SHM-10-06	5/23/2013	213.8	
AOC_5	SHM-10-06	5/30/2013	214.2	
AOC_5	SHM-10-06	6/11/2013	213.7	
AOC_5	SHM-10-06	10/21/2013	212.1	
AOC_5	SHM-10-06	4/22/2014	214.7	
AOC_5	SHM-10-06	5/21/2014	214.1	
AOC_5	SHM-10-06	9/30/2014	212.5	
AOC_5	SHM-10-06	10/6/2014	212.6	
AOC_5	SHM-10-06	6/2/2015	213.9	
AOC_5	SHM-10-06	6/17/2015	213.6	
AOC_5	SHM-10-06	10/20/2015	212.5	
AOC_5	SHM-10-06	12/16/2015	212.8	
AOC_5	SHM-10-06	6/9/2016	213.4	
AOC_5	SHM-10-06	8/16/2016	212.2	
AOC_5	SHM-10-06	10/20/2016	212.0	
AOC_5	SHM-10-06	11/16/2016	213.4	
AOC_5	SHM-10-06	11/1/2018	214.4	
AOC_5	SHM-10-06	10/22/2019	212.9	
AOC_5	SHM-10-06A	6/26/2012	213.8	
AOC_5	SHM-10-06A	9/11/2012	212.9	
AOC_5	SHM-10-06A	11/5/2012	214.3	
AOC_5	SHM-10-06A	11/6/2012	214.2	
AOC_5	SHM-10-06A	2/14/2013	213.9	
AOC_5	SHM-10-06A	3/12/2013	214.3	
AOC_5	SHM-10-06A	3/13/2013	214.5	
AOC_5	SHM-10-06A	4/22/2013	214.0	
AOC_5	SHM-10-06A	4/23/2013	214.1	
AOC_5	SHM-10-06A	4/25/2013	214.0	
AOC_5	SHM-10-06A	5/15/2013	213.6	
AOC_5	SHM-10-06A	5/22/2013	213.6	
AOC_5	SHM-10-06A	5/30/2013	214.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-10-06A	6/11/2013	214.9	
AOC_5	SHM-10-06A	10/21/2013	212.0	
AOC_5	SHM-10-06A	11/20/2013	212.6	
AOC_5	SHM-10-06A	4/22/2014	214.8	
AOC_5	SHM-10-06A	5/21/2014	214.3	
AOC_5	SHM-10-06A	9/30/2014	212.8	
AOC_5	SHM-10-06A	10/6/2014	212.9	
AOC_5	SHM-10-06A	6/2/2015	214.0	
AOC_5	SHM-10-06A	6/17/2015	213.7	
AOC_5	SHM-10-06A	10/20/2015	212.8	
AOC_5	SHM-10-06A	12/16/2015	213.1	
AOC_5	SHM-10-06A	6/9/2016	213.5	
AOC_5	SHM-10-06A	8/16/2016	212.5	
AOC_5	SHM-10-06A	10/20/2016	212.4	
AOC_5	SHM-10-06A	11/16/2016	213.7	
AOC_5	SHM-10-06A	11/1/2018	214.6	
AOC_5	SHM-10-06A	10/22/2019	213.2	
AOC_5	SHM-10-07	9/14/2010	218.9	
AOC_5	SHM-10-07	6/26/2012	219.4	
AOC_5	SHM-10-07	11/5/2012	218.1	
AOC_5	SHM-10-07	11/6/2012	219.1	
AOC_5	SHM-10-07	2/14/2013	219.0	
AOC_5	SHM-10-07	3/12/2013	219.2	
AOC_5	SHM-10-07	4/22/2013	219.6	
AOC_5	SHM-10-07	4/25/2013	219.7	
AOC_5	SHM-10-07	5/15/2013	219.8	
AOC_5	SHM-10-07	5/23/2013	219.4	
AOC_5	SHM-10-07	6/11/2013	219.9	
AOC_5	SHM-10-07	10/21/2013	218.6	
AOC_5	SHM-10-07	4/22/2014	219.1	
AOC_5	SHM-10-07	10/6/2014	218.8	
AOC_5	SHM-10-07	6/3/2015	220.0	
AOC_5	SHM-10-07	6/17/2015	220.0	
AOC_5	SHM-10-07	8/18/2015	219.6	
AOC_5	SHM-10-07	10/7/2015	219.0	
AOC_5	SHM-10-07	10/20/2015	218.8	
AOC_5	SHM-10-07	12/16/2015	218.6	
AOC_5	SHM-10-07	4/6/2016	219.4	
AOC_5	SHM-10-07	6/9/2016	219.4	
AOC_5	SHM-10-07	8/16/2016	218.7	
AOC_5	SHM-10-07	11/16/2016	218.5	
AOC_5	SHM-10-07	5/11/2018		207.0
AOC_5	SHM-10-07	11/1/2018	220.3	
AOC_5	SHM-10-07	10/22/2019	219.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-10-08	11/5/2012	205.8	
AOC_5	SHM-10-08	5/15/2013	205.4	
AOC_5	SHM-10-08	6/11/2013	206.6	
AOC_5	SHM-10-08	10/21/2013	204.6	
AOC_5	SHM-10-08	4/22/2014	205.6	
AOC_5	SHM-10-08	10/6/2014	204.5	
AOC_5	SHM-10-08	6/8/2015	204.8	
AOC_5	SHM-10-08	11/1/2018	205.4	
AOC_5	SHM-10-08	10/22/2019	204.4	
AOC_5	SHM-10-10	11/5/2012	206.6	
AOC_5	SHM-10-10	5/15/2013	206.5	
AOC_5	SHM-10-10	5/29/2013	205.7	
AOC_5	SHM-10-10	6/11/2013	207.4	
AOC_5	SHM-10-10	10/21/2013	206.4	
AOC_5	SHM-10-10	11/20/2013	206.3	
AOC_5	SHM-10-10	4/22/2014	207.2	
AOC_5	SHM-10-10	10/6/2014	206.3	
AOC_5	SHM-10-10	6/3/2015	206.9	
AOC_5	SHM-10-10	6/17/2015	206.4	
AOC_5	SHM-10-10	10/20/2015	206.2	
AOC_5	SHM-10-10	12/16/2015	206.4	
AOC_5	SHM-10-10	6/9/2016	206.5	
AOC_5	SHM-10-10	11/1/2018	206.9	
AOC_5	SHM-10-10	10/22/2019	206.1	
AOC_5	SHM-10-11	9/14/2010	223.3	
AOC_5	SHM-10-11	11/5/2012	222.6	
AOC_5	SHM-10-11	11/6/2012	222.7	
AOC_5	SHM-10-11	2/14/2013	222.5	
AOC_5	SHM-10-11	3/12/2013	222.8	
AOC_5	SHM-10-11	4/22/2013	223.5	
AOC_5	SHM-10-11	4/25/2013	223.5	
AOC_5	SHM-10-11	5/15/2013	223.4	
AOC_5	SHM-10-11	5/23/2013	223.3	
AOC_5	SHM-10-11	6/11/2013	223.5	
AOC_5	SHM-10-11	10/21/2013	222.8	
AOC_5	SHM-10-11	11/19/2013	222.2	
AOC_5	SHM-10-11	4/22/2014	222.8	
AOC_5	SHM-10-11	10/6/2014	222.3	
AOC_5	SHM-10-11	6/3/2015	224.4	
AOC_5	SHM-10-11	6/17/2015	223.9	
AOC_5	SHM-10-11	10/20/2015	222.4	
AOC_5	SHM-10-11	12/16/2015	222.0	
AOC_5	SHM-10-11	6/9/2016	222.9	
AOC_5	SHM-10-11	8/16/2016	222.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-10-11	11/15/2016	221.6	
AOC_5	SHM-10-11	11/1/2018	224.6	
AOC_5	SHM-10-11	12/5/2018	225.9	
AOC_5	SHM-10-11	4/11/2019	225.6	
AOC_5	SHM-10-11	10/22/2019	223.5	
AOC_5	SHM-10-11	4/29/2020	225.1	
AOC_5	SHM-10-12	9/14/2010	220.9	
AOC_5	SHM-10-12	6/26/2012	221.6	
AOC_5	SHM-10-12	11/5/2012	220.4	
AOC_5	SHM-10-12	11/6/2012	220.5	
AOC_5	SHM-10-12	2/14/2013	220.5	
AOC_5	SHM-10-12	3/12/2013	220.7	
AOC_5	SHM-10-12	4/22/2013	221.5	
AOC_5	SHM-10-12	4/25/2013	221.5	
AOC_5	SHM-10-12	5/15/2013	222.1	
AOC_5	SHM-10-12	5/23/2013	221.5	
AOC_5	SHM-10-12	6/11/2013	221.6	
AOC_5	SHM-10-12	10/21/2013	220.6	
AOC_5	SHM-10-12	11/19/2013	220.1	
AOC_5	SHM-10-12	4/22/2014	220.6	
AOC_5	SHM-10-12	10/6/2014	220.2	
AOC_5	SHM-10-12	6/3/2015	221.8	
AOC_5	SHM-10-12	6/17/2015	221.7	
AOC_5	SHM-10-12	10/20/2015	220.3	
AOC_5	SHM-10-12	12/16/2015	219.9	
AOC_5	SHM-10-12	6/9/2016	221.1	
AOC_5	SHM-10-12	8/16/2016	220.2	
AOC_5	SHM-10-12	11/15/2016	219.6	
AOC_5	SHM-10-12	11/1/2018	222.0	
AOC_5	SHM-10-12	10/22/2019	221.4	
AOC_5	SHM-10-12	4/29/2020	223.2	
AOC_5	SHM-10-13	9/14/2010	218.2	
AOC_5	SHM-10-13	11/5/2012	218.3	
AOC_5	SHM-10-13	11/6/2012	218.4	
AOC_5	SHM-10-13	2/14/2013	218.0	
AOC_5	SHM-10-13	3/12/2013	218.6	
AOC_5	SHM-10-13	4/22/2013	219.1	
AOC_5	SHM-10-13	5/15/2013	219.0	
AOC_5	SHM-10-13	5/23/2013	219.0	
AOC_5	SHM-10-13	6/11/2013	219.3	
AOC_5	SHM-10-13	10/21/2013	217.9	
AOC_5	SHM-10-13	4/22/2014	218.7	
AOC_5	SHM-10-13	10/6/2014	217.9	
AOC_5	SHM-10-13	6/3/2015	219.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-10-13	6/17/2015	219.2	
AOC_5	SHM-10-13	10/20/2015	217.9	
AOC_5	SHM-10-13	12/16/2015	217.7	
AOC_5	SHM-10-13	6/9/2016	218.7	
AOC_5	SHM-10-13	8/16/2016	217.8	
AOC_5	SHM-10-13	11/16/2016	217.7	
AOC_5	SHM-10-13	11/1/2018	219.6	
AOC_5	SHM-10-13	10/22/2019	218.8	
AOC_5	SHM-10-14	9/14/2010	216.6	
AOC_5	SHM-10-14	6/26/2012	217.8	
AOC_5	SHM-10-14	11/5/2012	217.1	
AOC_5	SHM-10-14	11/6/2012	217.3	
AOC_5	SHM-10-14	2/14/2013	217.3	
AOC_5	SHM-10-14	3/12/2013	217.5	
AOC_5	SHM-10-14	4/22/2013	218.0	
AOC_5	SHM-10-14	4/25/2013	218.0	
AOC_5	SHM-10-14	5/15/2013	217.7	
AOC_5	SHM-10-14	5/23/2013	217.6	
AOC_5	SHM-10-14	6/11/2013	218.2	
AOC_5	SHM-10-14	10/21/2013	216.4	
AOC_5	SHM-10-14	4/22/2014	217.9	
AOC_5	SHM-10-14	10/6/2014	216.4	
AOC_5	SHM-10-14	6/3/2015	218.0	
AOC_5	SHM-10-14	6/17/2015	217.8	
AOC_5	SHM-10-14	10/20/2015	216.4	
AOC_5	SHM-10-14	12/16/2015	216.5	
AOC_5	SHM-10-14	6/9/2016	217.4	
AOC_5	SHM-10-14	8/16/2016	216.3	
AOC_5	SHM-10-14	11/16/2016	216.5	
AOC_5	SHM-10-14	11/1/2018	218.4	
AOC_5	SHM-10-14	10/22/2019	217.1	
AOC_5	SHM-10-15	9/14/2010	218.8	
AOC_5	SHM-10-15	11/5/2012	218.6	
AOC_5	SHM-10-15	11/6/2012	218.7	
AOC_5	SHM-10-15	4/25/2013	219.9	
AOC_5	SHM-10-15	5/15/2013	219.8	
AOC_5	SHM-10-15	5/24/2013	219.7	
AOC_5	SHM-10-15	6/11/2013	218.9	
AOC_5	SHM-10-15	10/21/2013	218.5	
AOC_5	SHM-10-15	11/20/2013	217.9	
AOC_5	SHM-10-15	4/22/2014	219.3	
AOC_5	SHM-10-15	10/6/2014	218.3	
AOC_5	SHM-10-15	6/3/2015	220.1	
AOC_5	SHM-10-15	6/17/2015	219.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-10-15	10/20/2015	218.3	
AOC_5	SHM-10-15	12/16/2015	218.1	
AOC_5	SHM-10-15	6/9/2016	219.4	
AOC_5	SHM-10-15	8/16/2016	218.3	
AOC_5	SHM-10-15	11/16/2016	218.0	
AOC_5	SHM-10-15	11/1/2018	220.2	
AOC_5	SHM-10-15	10/22/2019	219.3	
AOC_5	SHM-10-16	9/14/2010	210.5	
AOC_5	SHM-10-16	6/26/2012	211.6	
AOC_5	SHM-10-16	11/5/2012	211.9	
AOC_5	SHM-10-16	11/6/2012	212.0	
AOC_5	SHM-10-16	3/13/2013	212.4	
AOC_5	SHM-10-16	4/25/2013	211.7	
AOC_5	SHM-10-16	5/15/2013	211.2	
AOC_5	SHM-10-16	5/28/2013	212.2	
AOC_5	SHM-10-16	5/30/2013	212.0	
AOC_5	SHM-10-16	6/11/2013	211.5	
AOC_5	SHM-10-16	10/21/2013	210.6	
AOC_5	SHM-10-16	11/20/2013	210.0	
AOC_5	SHM-10-16	4/22/2014	212.8	
AOC_5	SHM-10-16	10/6/2014	210.4	
AOC_5	SHM-10-16	6/3/2015	211.7	
AOC_5	SHM-10-16	6/17/2015	211.3	
AOC_5	SHM-10-16	10/20/2015	210.2	
AOC_5	SHM-10-16	12/16/2015	210.7	
AOC_5	SHM-10-16	6/9/2016	211.1	
AOC_5	SHM-10-16	6/23/2016	210.7	
AOC_5	SHM-10-16	8/16/2016	210.0	
AOC_5	SHM-10-16	10/20/2016	209.9	
AOC_5	SHM-10-16	11/16/2016	211.2	
AOC_5	SHM-10-16	5/22/2017		201.0
AOC_5	SHM-10-16	11/1/2018	212.0	
AOC_5	SHM-10-16	10/22/2019	210.6	
AOC_5	SHM-11-02	11/5/2012	217.9	
AOC_5	SHM-11-02	11/6/2012	218.0	
AOC_5	SHM-11-02	5/15/2013	218.0	
AOC_5	SHM-11-02	5/30/2013	218.3	
AOC_5	SHM-11-02	6/11/2013	218.6	
AOC_5	SHM-11-02	10/21/2013	215.9	
AOC_5	SHM-11-02	11/20/2013	216.9	
AOC_5	SHM-11-02	4/22/2014	217.9	
AOC_5	SHM-11-02	4/24/2014	217.9	
AOC_5	SHM-11-02	10/6/2014	217.6	
AOC_5	SHM-11-02	6/2/2015	218.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-11-02	6/5/2015	217.5	
AOC_5	SHM-11-02	6/17/2015	218.0	
AOC_5	SHM-11-02	8/18/2015	217.8	
AOC_5	SHM-11-02	10/7/2015	217.5	
AOC_5	SHM-11-02	10/20/2015	217.8	
AOC_5	SHM-11-02	12/16/2015	217.4	
AOC_5	SHM-11-02	6/9/2016	217.8	
AOC_5	SHM-11-02	6/23/2016	217.8	
AOC_5	SHM-11-02	8/16/2016	217.2	
AOC_5	SHM-11-02	11/16/2016	217.8	
AOC_5	SHM-11-02	5/22/2017	218.4	
AOC_5	SHM-11-02	5/11/2018	218.6	
AOC_5	SHM-11-02	11/1/2018	218.4	
AOC_5	SHM-11-02	4/11/2019	218.8	
AOC_5	SHM-11-02	10/22/2019	218.4	
AOC_5	SHM-11-02	5/18/2020	219.2	
AOC_5	SHM-11-02	5/19/2020	220.0	
AOC_5	SHM-11-06	11/5/2012	216.4	
AOC_5	SHM-11-06	11/6/2012	216.3	
AOC_5	SHM-11-06	2/14/2013	215.9	
AOC_5	SHM-11-06	3/12/2013	216.3	
AOC_5	SHM-11-06	4/22/2013	216.3	
AOC_5	SHM-11-06	4/25/2013	216.3	
AOC_5	SHM-11-06	5/15/2013	216.1	
AOC_5	SHM-11-06	5/28/2013	215.8	
AOC_5	SHM-11-06	5/30/2013	216.6	
AOC_5	SHM-11-06	6/11/2013	216.8	
AOC_5	SHM-11-06	10/21/2013	213.9	
AOC_5	SHM-11-06	11/20/2013	214.7	
AOC_5	SHM-11-06	4/22/2014	216.6	
AOC_5	SHM-11-06	10/6/2014	215.5	
AOC_5	SHM-11-06	6/3/2015	216.3	
AOC_5	SHM-11-06	6/17/2015	216.1	
AOC_5	SHM-11-06	8/18/2015	215.7	
AOC_5	SHM-11-06	10/7/2015	215.3	
AOC_5	SHM-11-06	10/20/2015	215.6	
AOC_5	SHM-11-06	12/16/2015	215.5	
AOC_5	SHM-11-06	4/6/2016	216.4	
AOC_5	SHM-11-06	6/9/2016	215.9	
AOC_5	SHM-11-06	8/16/2016	215.1	
AOC_5	SHM-11-06	5/22/2017	218.4	
AOC_5	SHM-11-06	5/11/2018	217.0	
AOC_5	SHM-11-06	11/1/2018	216.7	
AOC_5	SHM-11-06	4/11/2019	216.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-11-06	10/22/2019	216.1	
AOC_5	SHM-11-06	5/18/2020	217.2	
AOC_5	SHM-11-06	5/20/2020	217.2	
AOC_5	SHM-11-07	11/5/2012	217.9	
AOC_5	SHM-11-07	2/14/2013	217.7	
AOC_5	SHM-11-07	3/12/2013	217.9	
AOC_5	SHM-11-07	3/13/2013	218.0	
AOC_5	SHM-11-07	4/22/2013	218.2	
AOC_5	SHM-11-07	5/15/2013	218.2	
AOC_5	SHM-11-07	5/30/2013	218.4	
AOC_5	SHM-11-07	6/11/2013	218.6	
AOC_5	SHM-11-07	10/21/2013	216.6	
AOC_5	SHM-11-07	4/22/2014	217.9	
AOC_5	SHM-11-07	10/6/2014	217.6	
AOC_5	SHM-11-07	6/3/2015	218.5	
AOC_5	SHM-11-07	6/17/2015	218.4	
AOC_5	SHM-11-07	8/18/2015	218.1	
AOC_5	SHM-11-07	10/7/2015	217.6	
AOC_5	SHM-11-07	10/20/2015	217.8	
AOC_5	SHM-11-07	12/16/2015	217.4	
AOC_5	SHM-11-07	6/9/2016	218.1	
AOC_5	SHM-11-07	8/16/2016	217.4	
AOC_5	SHM-11-07	11/1/2018	218.8	
AOC_5	SHM-11-07	10/22/2019	218.4	
AOC_5	SHM-13-01	10/21/2013	204.9	
AOC_5	SHM-13-01	11/21/2013	204.8	
AOC_5	SHM-13-01	4/22/2014	206.0	
AOC_5	SHM-13-01	10/6/2014	204.7	
AOC_5	SHM-13-01	6/3/2015	205.2	
AOC_5	SHM-13-01	10/20/2015	204.6	
AOC_5	SHM-13-01	12/16/2015	204.9	
AOC_5	SHM-13-01	11/16/2016	205.4	
AOC_5	SHM-13-01	11/1/2018	205.7	
AOC_5	SHM-13-01	10/22/2019	204.6	
AOC_5	SHM-13-02	5/15/2013	206.2	
AOC_5	SHM-13-02	5/29/2013	206.4	
AOC_5	SHM-13-02	6/11/2013	207.2	
AOC_5	SHM-13-02	10/21/2013	205.8	
AOC_5	SHM-13-02	11/21/2013	205.7	
AOC_5	SHM-13-02	4/22/2014	206.8	
AOC_5	SHM-13-02	10/6/2014	205.8	
AOC_5	SHM-13-02	6/17/2015	205.9	
AOC_5	SHM-13-02	10/20/2015	205.7	
AOC_5	SHM-13-02	12/16/2015	205.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-13-02	6/9/2016	205.9	
AOC_5	SHM-13-02	11/1/2018	206.5	
AOC_5	SHM-13-02	10/22/2019	205.7	
AOC_5	SHM-13-03	5/15/2013	207.0	
AOC_5	SHM-13-03	5/29/2013	206.2	
AOC_5	SHM-13-03	6/11/2013	207.8	
AOC_5	SHM-13-03	10/21/2013	207.0	
AOC_5	SHM-13-03	11/20/2013	206.9	
AOC_5	SHM-13-03	4/22/2014	207.7	
AOC_5	SHM-13-03	4/23/2014	207.7	
AOC_5	SHM-13-03	10/6/2014	206.9	
AOC_5	SHM-13-03	6/2/2015	206.9	
AOC_5	SHM-13-03	6/8/2015	206.7	
AOC_5	SHM-13-03	6/17/2015	206.5	
AOC_5	SHM-13-03	10/20/2015	206.3	
AOC_5	SHM-13-03	6/9/2016	206.8	
AOC_5	SHM-13-03	6/23/2016	206.6	
AOC_5	SHM-13-03	5/22/2017	207.0	
AOC_5	SHM-13-03	5/11/2018		201.8
AOC_5	SHM-13-03	11/1/2018	207.2	
AOC_5	SHM-13-03	4/11/2019	207.2	
AOC_5	SHM-13-03	10/22/2019	206.4	
AOC_5	SHM-13-03	5/18/2020	206.9	
AOC_5	SHM-13-03	5/21/2020	206.9	
AOC_5	SHM-13-04	5/15/2013	207.9	
AOC_5	SHM-13-04	5/28/2013	208.1	
AOC_5	SHM-13-04	6/11/2013	208.5	
AOC_5	SHM-13-04	10/21/2013	207.6	
AOC_5	SHM-13-04	4/22/2014	209.2	
AOC_5	SHM-13-04	4/24/2014	209.1	
AOC_5	SHM-13-04	10/6/2014	207.5	
AOC_5	SHM-13-04	6/2/2015	208.0	
AOC_5	SHM-13-04	6/9/2015	208.1	
AOC_5	SHM-13-04	6/17/2015	207.9	
AOC_5	SHM-13-04	10/20/2015	207.4	
AOC_5	SHM-13-04	12/16/2015	207.7	
AOC_5	SHM-13-04	6/9/2016	207.9	
AOC_5	SHM-13-04	6/24/2016	207.7	
AOC_5	SHM-13-04	8/16/2016	207.2	
AOC_5	SHM-13-04	11/16/2016		
AOC_5	SHM-13-04	5/22/2017	208.6	
AOC_5	SHM-13-04	5/11/2018	208.5	
AOC_5	SHM-13-04	11/1/2018	208.2	
AOC_5	SHM-13-04	4/11/2019	208.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-13-04	10/22/2019	207.3	
AOC_5	SHM-13-04	5/18/2020	208.5	
AOC_5	SHM-13-04	5/20/2020	208.4	
AOC_5	SHM-13-05	5/15/2013	208.4	
AOC_5	SHM-13-05	5/28/2013	208.6	
AOC_5	SHM-13-05	6/11/2013	209.2	
AOC_5	SHM-13-05	10/21/2013	208.1	
AOC_5	SHM-13-05	11/21/2013	208.0	
AOC_5	SHM-13-05	4/22/2014	209.6	
AOC_5	SHM-13-05	10/6/2014	207.2	
AOC_5	SHM-13-05	6/2/2015	208.7	
AOC_5	SHM-13-05	6/17/2015	208.5	
AOC_5	SHM-13-05	10/20/2015	208.1	
AOC_5	SHM-13-05	12/16/2015	208.4	
AOC_5	SHM-13-05	6/9/2016	208.5	
AOC_5	SHM-13-05	8/16/2016	207.9	
AOC_5	SHM-13-05	11/1/2018	208.9	
AOC_5	SHM-13-05	10/22/2019	208.0	
AOC_5	SHM-13-06	6/11/2013	207.5	
AOC_5	SHM-13-06	6/13/2013	208.0	
AOC_5	SHM-13-06	10/21/2013	206.4	
AOC_5	SHM-13-06	11/21/2013	206.3	
AOC_5	SHM-13-06	4/22/2014	207.6	
AOC_5	SHM-13-06	4/24/2014	207.5	
AOC_5	SHM-13-06	10/6/2014	206.3	
AOC_5	SHM-13-06	6/2/2015	206.9	
AOC_5	SHM-13-06	6/8/2015	206.8	
AOC_5	SHM-13-06	6/17/2015	206.5	
AOC_5	SHM-13-06	10/20/2015		
AOC_5	SHM-13-06	12/16/2015	206.5	
AOC_5	SHM-13-06	12/22/2015	206.5	
AOC_5	SHM-13-06	6/9/2016	206.6	
AOC_5	SHM-13-06	6/24/2016	206.4	
AOC_5	SHM-13-06	11/16/2016		
AOC_5	SHM-13-06	5/22/2017		
AOC_5	SHM-13-06	5/11/2018	207.0	
AOC_5	SHM-13-06	11/1/2018	207.0	
AOC_5	SHM-13-06	4/11/2019	206.9	
AOC_5	SHM-13-06	10/22/2019	206.2	
AOC_5	SHM-13-06	5/18/2020	206.8	
AOC_5	SHM-13-06	5/19/2020	206.8	
AOC_5	SHM-13-07	11/21/2013	206.6	
AOC_5	SHM-13-07	4/22/2014	207.9	
AOC_5	SHM-13-07	4/24/2014	207.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-13-07	10/6/2014	206.7	
AOC_5	SHM-13-07	6/2/2015	207.3	
AOC_5	SHM-13-07	6/8/2015	207.1	
AOC_5	SHM-13-07	6/17/2015	206.9	
AOC_5	SHM-13-07	10/20/2015	206.6	
AOC_5	SHM-13-07	12/16/2015	206.8	
AOC_5	SHM-13-07	6/9/2016	206.9	
AOC_5	SHM-13-07	6/24/2016	206.8	
AOC_5	SHM-13-07	5/22/2017	207.5	
AOC_5	SHM-13-07	5/11/2018	207.3	
AOC_5	SHM-13-07	11/1/2018		
AOC_5	SHM-13-07	4/11/2019	207.2	
AOC_5	SHM-13-07	10/22/2019	206.4	
AOC_5	SHM-13-07	5/18/2020	207.1	
AOC_5	SHM-13-07	5/22/2020	207.0	
AOC_5	SHM-13-08	6/11/2013	208.2	
AOC_5	SHM-13-08	6/13/2013	208.6	
AOC_5	SHM-13-08	10/21/2013	207.9	
AOC_5	SHM-13-08	11/21/2013	207.3	
AOC_5	SHM-13-08	4/22/2014	208.6	
AOC_5	SHM-13-08	4/24/2014	208.6	
AOC_5	SHM-13-08	10/6/2014	208.2	
AOC_5	SHM-13-08	6/2/2015	207.8	
AOC_5	SHM-13-08	6/8/2015	206.8	
AOC_5	SHM-13-08	6/17/2015	207.6	
AOC_5	SHM-13-08	10/20/2015	207.3	
AOC_5	SHM-13-08	12/16/2015	207.5	
AOC_5	SHM-13-08	6/9/2016	207.7	
AOC_5	SHM-13-08	6/24/2016	207.6	
AOC_5	SHM-13-08	5/22/2017	208.1	
AOC_5	SHM-13-08	5/11/2018	208.0	
AOC_5	SHM-13-08	11/1/2018	207.9	
AOC_5	SHM-13-08	4/11/2019	207.0	
AOC_5	SHM-13-08	10/22/2019	207.0	
AOC_5	SHM-13-08	5/18/2020	207.8	
AOC_5	SHM-13-08	5/22/2020	207.7	
AOC_5	SHM-13-14D	2/19/2014	207.0	
AOC_5	SHM-13-14D	4/23/2014	207.6	
AOC_5	SHM-13-14D	10/6/2014	206.9	
AOC_5	SHM-13-14D	6/9/2016	207.1	
AOC_5	SHM-13-14D	11/1/2018	207.3	
AOC_5	SHM-13-14D	10/22/2019	206.5	
AOC_5	SHM-13-14S	2/19/2014		202.9
AOC_5	SHM-13-14S	4/23/2014	207.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-13-14S	10/6/2014	206.8	
AOC_5	SHM-13-14S	6/9/2016	207.0	
AOC_5	SHM-13-14S	11/1/2018	207.2	
AOC_5	SHM-13-14S	10/22/2019	206.4	
AOC_5	SHM-13-15	2/19/2014	206.9	
AOC_5	SHM-13-15	4/23/2014	207.5	
AOC_5	SHM-13-15	10/6/2014	206.8	
AOC_5	SHM-13-15	6/9/2016	207.0	
AOC_5	SHM-13-15	11/1/2018		
AOC_5	SHM-13-15	10/22/2019	206.3	
AOC_5	SHM-93-01A	3/30/1993	220.3	
AOC_5	SHM-93-01A	6/22/1993	219.6	
AOC_5	SHM-93-01A	9/30/1993	218.8	
AOC_5	SHM-93-01A	11/8/1993	220.2	
AOC_5	SHM-93-01A	3/30/1994	220.5	
AOC_5	SHM-93-01A	6/28/1994	220.1	
AOC_5	SHM-93-01A	10/4/1994	220.4	
AOC_5	SHM-93-01A	1/31/1995	221.0	
AOC_5	SHM-93-01A	5/9/1995	219.7	
AOC_5	SHM-93-01A	12/7/1995	220.8	
AOC_5	SHM-93-01A	3/26/1996	220.9	
AOC_5	SHM-93-01A	7/23/1996	220.4	
AOC_5	SHM-93-01A	6/2/1997	220.3	
AOC_5	SHM-93-01A	6/19/1998	222.8	
AOC_5	SHM-93-01A	6/26/1998	222.2	
AOC_5	SHM-93-01A	7/1/1998	221.7	
AOC_5	SHM-93-01A	7/17/1998	220.9	
AOC_5	SHM-93-01A	7/31/1998	220.4	
AOC_5	SHM-93-01A	8/28/1998	219.8	
AOC_5	SHM-93-01A	10/14/1998	219.6	
AOC_5	SHM-93-01A	12/10/1998	219.3	
AOC_5	SHM-93-01A	2/23/1999	219.0	
AOC_5	SHM-93-01A	6/6/1999	219.2	
AOC_5	SHM-93-01A	9/8/1999	218.5	
AOC_5	SHM-93-01A	11/16/2001	218.9	
AOC_5	SHM-93-01A	4/26/2007	221.8	
AOC_5	SHM-93-01A	4/28/2008		234.7
AOC_5	SHM-93-01A	10/26/2009	219.5	
AOC_5	SHM-93-01A	4/27/2010	221.1	
AOC_5	SHM-93-01A	9/14/2010	219.0	
AOC_5	SHM-93-01A	7/25/2011	219.8	
AOC_5	SHM-93-01A	10/7/2015	219.2	
AOC_5	SHM-93-01A	4/29/2020	221.8	
AOC_5	SHM-93-10C	3/30/1993	217.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-93-10C	6/22/1993	217.2	
AOC_5	SHM-93-10C	9/30/1993	217.2	
AOC_5	SHM-93-10C	11/8/1993	217.3	
AOC_5	SHM-93-10C	3/30/1994	218.2	
AOC_5	SHM-93-10C	6/28/1994	217.3	
AOC_5	SHM-93-10C	10/4/1994	217.5	
AOC_5	SHM-93-10C	1/31/1995	217.9	
AOC_5	SHM-93-10C	5/9/1995	217.2	
AOC_5	SHM-93-10C	12/7/1995	217.7	
AOC_5	SHM-93-10C	3/26/1996	218.0	
AOC_5	SHM-93-10C	7/23/1996	217.7	
AOC_5	SHM-93-10C	1/15/1997	218.0	
AOC_5	SHM-93-10C	6/2/1997	217.8	
AOC_5	SHM-93-10C	4/23/1998	217.9	
AOC_5	SHM-93-10C	6/19/1998	218.9	
AOC_5	SHM-93-10C	6/26/1998	218.7	
AOC_5	SHM-93-10C	7/1/1998	218.5	
AOC_5	SHM-93-10C	7/17/1998	217.9	
AOC_5	SHM-93-10C	7/31/1998	217.7	
AOC_5	SHM-93-10C	8/28/1998	217.4	
AOC_5	SHM-93-10C	10/14/1998	217.4	
AOC_5	SHM-93-10C	12/10/1998	217.3	
AOC_5	SHM-93-10C	2/23/1999	217.4	
AOC_5	SHM-93-10C	6/6/1999	217.0	
AOC_5	SHM-93-10C	9/8/1999	215.7	
AOC_5	SHM-93-10C	8/4/2005	218.0	
AOC_5	SHM-93-10C	8/24/2005	217.8	
AOC_5	SHM-93-10C	4/10/2006	218.0	
AOC_5	SHM-93-10C	6/5/2006	219.3	
AOC_5	SHM-93-10C	9/18/2006	217.9	
AOC_5	SHM-93-10C	12/15/2006	218.8	
AOC_5	SHM-93-10C	4/8/2007	218.5	
AOC_5	SHM-93-10C	4/9/2007	218.5	
AOC_5	SHM-93-10C	10/15/2007	218.3	
AOC_5	SHM-93-10C	2/20/2008	219.6	
AOC_5	SHM-93-10C	2/25/2008	219.3	
AOC_5	SHM-93-10C	3/4/2008	219.1	
AOC_5	SHM-93-10C	4/16/2008	218.9	
AOC_5	SHM-93-10C	9/30/2008	217.8	
AOC_5	SHM-93-10C	10/3/2008	219.0	
AOC_5	SHM-93-10C	4/28/2009	218.8	
AOC_5	SHM-93-10C	10/20/2009	218.0	
AOC_5	SHM-93-10C	11/3/2009	218.2	
AOC_5	SHM-93-10C	4/20/2010	219.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-93-10C	10/7/2010	218.0	
AOC_5	SHM-93-10C	4/4/2011	218.8	
AOC_5	SHM-93-10C	11/8/2011	219.1	
AOC_5	SHM-93-10C	4/10/2012	218.1	
AOC_5	SHM-93-10C	11/5/2012	218.8	
AOC_5	SHM-93-10C	11/6/2012	218.8	
AOC_5	SHM-93-10C	5/15/2013	218.2	
AOC_5	SHM-93-10C	6/11/2013	219.2	
AOC_5	SHM-93-10C	10/21/2013	216.2	
AOC_5	SHM-93-10C	4/22/2014	218.7	
AOC_5	SHM-93-10C	10/6/2014	217.9	
AOC_5	SHM-93-10C	10/20/2015	218.2	
AOC_5	SHM-93-10D	3/30/1994	218.7	
AOC_5	SHM-93-10D	6/28/1994	217.2	
AOC_5	SHM-93-10D	10/4/1994	217.5	
AOC_5	SHM-93-10D	5/9/1995	217.0	
AOC_5	SHM-93-10D	12/7/1995	217.6	
AOC_5	SHM-93-10D	3/26/1996	217.7	
AOC_5	SHM-93-10D	1/15/1997	217.8	
AOC_5	SHM-93-10D	6/2/1997	217.6	
AOC_5	SHM-93-10D	4/23/1998	217.6	
AOC_5	SHM-93-10D	6/19/1998	218.3	
AOC_5	SHM-93-10D	6/26/1998	218.4	
AOC_5	SHM-93-10D	7/1/1998	218.2	
AOC_5	SHM-93-10D	7/17/1998	217.7	
AOC_5	SHM-93-10D	7/31/1998	217.5	
AOC_5	SHM-93-10D	8/28/1998	217.2	
AOC_5	SHM-93-10D	10/14/1998	217.1	
AOC_5	SHM-93-10D	12/10/1998	217.0	
AOC_5	SHM-93-10D	2/23/1999	217.2	
AOC_5	SHM-93-10D	6/6/1999	216.8	
AOC_5	SHM-93-10D	9/8/1999	216.4	
AOC_5	SHM-93-10D	8/4/2005	217.6	
AOC_5	SHM-93-10D	8/24/2005	217.4	
AOC_5	SHM-93-10D	8/26/2005	217.4	
AOC_5	SHM-93-10D	4/10/2006	217.7	
AOC_5	SHM-93-10D	6/5/2006	218.8	
AOC_5	SHM-93-10D	9/18/2006	217.5	
AOC_5	SHM-93-10D	12/15/2006	218.4	
AOC_5	SHM-93-10D	4/8/2007	217.8	
AOC_5	SHM-93-10D	4/9/2007	217.8	
AOC_5	SHM-93-10D	10/15/2007	217.9	
AOC_5	SHM-93-10D	2/20/2008	219.1	
AOC_5	SHM-93-10D	2/25/2008	219.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-93-10D	3/4/2008	218.7	
AOC_5	SHM-93-10D	4/16/2008	218.1	
AOC_5	SHM-93-10D	9/30/2008	219.2	
AOC_5	SHM-93-10D	10/3/2008	218.4	
AOC_5	SHM-93-10D	4/28/2009	218.2	
AOC_5	SHM-93-10D	11/3/2009	217.7	
AOC_5	SHM-93-10D	4/20/2010	219.0	
AOC_5	SHM-93-10D	10/7/2010	217.4	
AOC_5	SHM-93-10D	4/4/2011	218.4	
AOC_5	SHM-93-10D	11/8/2011	218.3	
AOC_5	SHM-93-10D	4/10/2012	217.4	
AOC_5	SHM-93-10D	11/5/2012	218.1	
AOC_5	SHM-93-10D	11/6/2012	218.1	
AOC_5	SHM-93-10D	5/15/2013	217.5	
AOC_5	SHM-93-10D	6/11/2013	218.2	
AOC_5	SHM-93-10D	10/21/2013	215.2	
AOC_5	SHM-93-10D	4/22/2014	217.9	
AOC_5	SHM-93-10D	10/6/2014	217.3	
AOC_5	SHM-93-10D	11/1/2018	217.8	
AOC_5	SHM-93-10D	10/22/2019	218.0	
AOC_5	SHM-93-18B	3/30/1993	218.4	
AOC_5	SHM-93-18B	6/22/1993	217.7	
AOC_5	SHM-93-18B	9/30/1993	217.8	
AOC_5	SHM-93-18B	11/8/1993	217.9	
AOC_5	SHM-93-18B	3/30/1994	219.1	
AOC_5	SHM-93-18B	6/28/1994	217.9	
AOC_5	SHM-93-18B	10/4/1994	218.3	
AOC_5	SHM-93-18B	1/31/1995	219.7	
AOC_5	SHM-93-18B	5/9/1995	217.8	
AOC_5	SHM-93-18B	12/7/1995	218.4	
AOC_5	SHM-93-18B	3/26/1996	218.8	
AOC_5	SHM-93-18B	7/23/1996	218.5	
AOC_5	SHM-93-18B	1/15/1997	218.9	
AOC_5	SHM-93-18B	6/2/1997	218.8	
AOC_5	SHM-93-18B	4/23/1998	218.7	
AOC_5	SHM-93-18B	6/19/1998	220.1	
AOC_5	SHM-93-18B	6/26/1998	219.7	
AOC_5	SHM-93-18B	7/1/1998	219.5	
AOC_5	SHM-93-18B	7/17/1998	218.8	
AOC_5	SHM-93-18B	7/31/1998	218.4	
AOC_5	SHM-93-18B	8/28/1998	218.0	
AOC_5	SHM-93-18B	10/14/1998	218.1	
AOC_5	SHM-93-18B	12/10/1998	217.8	
AOC_5	SHM-93-18B	2/23/1999	218.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-93-18B	6/6/1999	217.5	
AOC_5	SHM-93-18B	9/8/1999	216.9	
AOC_5	SHM-93-18B	11/16/2001	217.5	
AOC_5	SHM-93-18B	8/4/2005	218.4	
AOC_5	SHM-93-18B	8/24/2005	218.0	
AOC_5	SHM-93-18B	8/26/2005	218.0	
AOC_5	SHM-93-18B	4/10/2006	218.2	
AOC_5	SHM-93-18B	6/5/2006	219.9	
AOC_5	SHM-93-18B	9/18/2006	218.1	
AOC_5	SHM-93-18B	10/19/2006	218.2	
AOC_5	SHM-93-18B	12/15/2006	219.3	
AOC_5	SHM-93-18B	4/8/2007	218.8	
AOC_5	SHM-93-18B	4/9/2007	218.8	
AOC_5	SHM-93-18B	10/15/2007	218.5	
AOC_5	SHM-93-18B	2/20/2008	220.1	
AOC_5	SHM-93-18B	2/25/2008	219.7	
AOC_5	SHM-93-18B	3/4/2008	219.4	
AOC_5	SHM-93-18B	4/16/2008	219.2	
AOC_5	SHM-93-18B	9/30/2008	219.3	
AOC_5	SHM-93-18B	4/28/2009	219.0	
AOC_5	SHM-93-18B	11/3/2009	218.4	
AOC_5	SHM-93-18B	4/20/2010	220.0	
AOC_5	SHM-93-18B	10/7/2010	218.2	
AOC_5	SHM-93-18B	4/4/2011	219.2	
AOC_5	SHM-93-18B	11/8/2011	219.4	
AOC_5	SHM-93-18B	4/10/2012	218.1	
AOC_5	SHM-93-18B	11/5/2012	219.0	
AOC_5	SHM-93-18B	11/6/2012	219.0	
AOC_5	SHM-93-18B	5/15/2013	218.2	
AOC_5	SHM-93-18B	6/11/2013	219.4	
AOC_5	SHM-93-18B	10/21/2013	216.1	
AOC_5	SHM-93-18B	4/22/2014	218.9	
AOC_5	SHM-93-18B	10/6/2014	218.0	
AOC_5	SHM-93-18B	6/17/2015	218.2	
AOC_5	SHM-93-18B	8/18/2015	218.0	
AOC_5	SHM-93-18B	10/7/2015	217.8	
AOC_5	SHM-93-18B	10/20/2015	218.3	
AOC_5	SHM-93-18B	12/16/2015	217.8	
AOC_5	SHM-93-18B	6/9/2016	218.1	
AOC_5	SHM-93-18B	6/24/2016	217.9	
AOC_5	SHM-93-18B	8/16/2016	217.6	
AOC_5	SHM-93-18B	11/15/2016	218.2	
AOC_5	SHM-93-18B	5/22/2017	218.9	
AOC_5	SHM-93-18B	11/1/2018	219.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-93-18B	10/22/2019	221.7	
AOC_5	SHM-93-18B	4/29/2020	219.4	
AOC_5	SHM-93-22B	6/26/1998	214.5	
AOC_5	SHM-93-22B	7/1/1998	214.4	
AOC_5	SHM-93-22B	7/17/1998	213.5	
AOC_5	SHM-93-22B	7/31/1998	212.8	
AOC_5	SHM-93-22B	8/28/1998	212.0	
AOC_5	SHM-93-22B	10/14/1998	212.3	
AOC_5	SHM-93-22B	12/10/1998	212.2	
AOC_5	SHM-93-22B	2/23/1999	212.9	
AOC_5	SHM-93-22B	6/6/1999	211.9	
AOC_5	SHM-93-22B	9/8/1999	211.1	
AOC_5	SHM-93-22B	11/16/2001	211.9	
AOC_5	SHM-93-22B	8/4/2005	212.7	
AOC_5	SHM-93-22B	8/24/2005	212.2	
AOC_5	SHM-93-22B	8/26/2005	212.0	
AOC_5	SHM-93-22B	4/10/2006	212.7	
AOC_5	SHM-93-22B	6/5/2006	214.4	
AOC_5	SHM-93-22B	7/15/2006	212.5	
AOC_5	SHM-93-22B	9/18/2006	212.4	
AOC_5	SHM-93-22B	12/15/2006	213.5	
AOC_5	SHM-93-22B	4/8/2007	213.5	
AOC_5	SHM-93-22B	4/9/2007	213.5	
AOC_5	SHM-93-22B	10/15/2007	211.3	
AOC_5	SHM-93-22B	2/20/2008	213.3	
AOC_5	SHM-93-22B	2/25/2008	213.2	
AOC_5	SHM-93-22B	3/4/2008	212.5	
AOC_5	SHM-93-22B	4/16/2008	213.6	
AOC_5	SHM-93-22B	7/15/2008	211.6	
AOC_5	SHM-93-22B	9/30/2008	212.8	
AOC_5	SHM-93-22B	10/1/2008	212.9	
AOC_5	SHM-93-22B	1/20/2009	212.9	
AOC_5	SHM-93-22B	4/28/2009	213.2	
AOC_5	SHM-93-22B	10/16/2009	211.1	
AOC_5	SHM-93-22B	11/3/2009	211.8	
AOC_5	SHM-93-22B	4/20/2010	214.1	
AOC_5	SHM-93-22B	9/14/2010	210.8	
AOC_5	SHM-93-22B	10/7/2010	210.9	
AOC_5	SHM-93-22B	4/4/2011	213.4	
AOC_5	SHM-93-22B	11/8/2011	213.4	
AOC_5	SHM-93-22B	4/10/2012	211.9	
AOC_5	SHM-93-22B	6/26/2012	211.9	
AOC_5	SHM-93-22B	9/11/2012	210.8	
AOC_5	SHM-93-22B	11/5/2012	212.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-93-22B	11/6/2012	212.2	
AOC_5	SHM-93-22B	3/13/2013	212.8	
AOC_5	SHM-93-22B	4/23/2013	212.1	
AOC_5	SHM-93-22B	4/25/2013	212.0	
AOC_5	SHM-93-22B	5/15/2013	210.5	
AOC_5	SHM-93-22B	5/28/2013	212.6	
AOC_5	SHM-93-22B	5/30/2013	212.4	
AOC_5	SHM-93-22B	6/11/2013	212.9	
AOC_5	SHM-93-22B	10/21/2013	210.9	
AOC_5	SHM-93-22B	10/23/2013	210.7	
AOC_5	SHM-93-22B	4/22/2014	210.1	
AOC_5	SHM-93-22B	4/24/2014	213.0	
AOC_5	SHM-93-22B	10/6/2014	210.7	
AOC_5	SHM-93-22B	6/2/2015	211.0	
AOC_5	SHM-93-22B	6/8/2015	211.5	
AOC_5	SHM-93-22B	6/17/2015	211.7	
AOC_5	SHM-93-22B	10/20/2015	210.4	
AOC_5	SHM-93-22B	12/16/2015	211.0	
AOC_5	SHM-93-22B	6/9/2016	211.6	
AOC_5	SHM-93-22B	6/23/2016	211.0	
AOC_5	SHM-93-22B	6/24/2016	211.0	
AOC_5	SHM-93-22B	8/16/2016	210.3	
AOC_5	SHM-93-22B	10/20/2016	210.2	
AOC_5	SHM-93-22B	11/16/2016	211.4	
AOC_5	SHM-93-22B	5/22/2017	211.7	
AOC_5	SHM-93-22B	5/11/2018	212.8	
AOC_5	SHM-93-22B	11/1/2018	212.3	
AOC_5	SHM-93-22B	4/11/2019	212.3	
AOC_5	SHM-93-22B	10/22/2019	210.9	
AOC_5	SHM-93-22B	5/18/2020	212.7	
AOC_5	SHM-93-22B	5/21/2020	212.5	
AOC_5	SHM-93-22C	3/30/1993	213.6	
AOC_5	SHM-93-22C	6/22/1993	212.3	
AOC_5	SHM-93-22C	9/30/1993	212.2	
AOC_5	SHM-93-22C	11/8/1993	212.9	
AOC_5	SHM-93-22C	3/30/1994	214.5	
AOC_5	SHM-93-22C	6/28/1994	212.6	
AOC_5	SHM-93-22C	10/4/1994	212.9	
AOC_5	SHM-93-22C	1/31/1995	213.7	
AOC_5	SHM-93-22C	5/9/1995	212.5	
AOC_5	SHM-93-22C	12/7/1995	213.4	
AOC_5	SHM-93-22C	3/26/1996	214.3	
AOC_5	SHM-93-22C	7/23/1996	213.0	
AOC_5	SHM-93-22C	1/15/1997	213.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-93-22C	6/2/1997	213.4	
AOC_5	SHM-93-22C	4/23/1998	213.8	
AOC_5	SHM-93-22C	6/19/1998	215.0	
AOC_5	SHM-93-22C	6/26/1998	214.6	
AOC_5	SHM-93-22C	7/1/1998	214.5	
AOC_5	SHM-93-22C	7/17/1998	213.6	
AOC_5	SHM-93-22C	7/31/1998	212.9	
AOC_5	SHM-93-22C	8/28/1998	212.1	
AOC_5	SHM-93-22C	10/14/1998	212.3	
AOC_5	SHM-93-22C	12/10/1998	212.2	
AOC_5	SHM-93-22C	2/23/1999	212.9	
AOC_5	SHM-93-22C	6/6/1999	211.9	
AOC_5	SHM-93-22C	9/8/1999	211.1	
AOC_5	SHM-93-22C	11/16/2001	211.9	
AOC_5	SHM-93-22C	8/4/2005	212.8	
AOC_5	SHM-93-22C	8/24/2005	212.2	
AOC_5	SHM-93-22C	8/26/2005	212.1	
AOC_5	SHM-93-22C	4/10/2006	212.8	
AOC_5	SHM-93-22C	6/5/2006	214.5	
AOC_5	SHM-93-22C	9/18/2006	212.4	
AOC_5	SHM-93-22C	12/15/2006	213.5	
AOC_5	SHM-93-22C	4/8/2007	213.7	
AOC_5	SHM-93-22C	4/9/2007	213.7	
AOC_5	SHM-93-22C	10/15/2007	211.3	
AOC_5	SHM-93-22C	2/20/2008	214.6	
AOC_5	SHM-93-22C	2/25/2008	214.5	
AOC_5	SHM-93-22C	3/4/2008	213.8	
AOC_5	SHM-93-22C	4/16/2008	213.8	
AOC_5	SHM-93-22C	7/15/2008	211.7	
AOC_5	SHM-93-22C	9/30/2008	212.9	
AOC_5	SHM-93-22C	10/2/2008	213.1	
AOC_5	SHM-93-22C	1/20/2009	210.5	
AOC_5	SHM-93-22C	4/28/2009	213.4	
AOC_5	SHM-93-22C	7/16/2009	211.5	
AOC_5	SHM-93-22C	10/21/2009	210.9	
AOC_5	SHM-93-22C	11/3/2009	211.9	
AOC_5	SHM-93-22C	4/20/2010	214.2	
AOC_5	SHM-93-22C	10/7/2010	210.9	
AOC_5	SHM-93-22C	4/4/2011	213.6	
AOC_5	SHM-93-22C	11/8/2011	213.5	
AOC_5	SHM-93-22C	4/10/2012	210.8	
AOC_5	SHM-93-22C	6/26/2012	211.8	
AOC_5	SHM-93-22C	9/11/2012	210.9	
AOC_5	SHM-93-22C	11/5/2012	212.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-93-22C	11/6/2012	212.3	
AOC_5	SHM-93-22C	3/13/2013	213.6	
AOC_5	SHM-93-22C	4/23/2013	212.2	
AOC_5	SHM-93-22C	5/15/2013	211.6	
AOC_5	SHM-93-22C	5/28/2013	212.7	
AOC_5	SHM-93-22C	5/30/2013	212.1	
AOC_5	SHM-93-22C	6/11/2013	212.9	
AOC_5	SHM-93-22C	10/21/2013	210.7	
AOC_5	SHM-93-22C	4/22/2014	213.3	
AOC_5	SHM-93-22C	4/24/2014	213.1	
AOC_5	SHM-93-22C	10/6/2014	210.7	
AOC_5	SHM-93-22C	6/17/2015	211.5	
AOC_5	SHM-93-22C	10/20/2015	210.5	
AOC_5	SHM-93-22C	12/16/2015	211.0	
AOC_5	SHM-93-22C	6/9/2016	211.3	
AOC_5	SHM-93-22C	8/16/2016	210.3	
AOC_5	SHM-93-22C	11/16/2016	211.4	
AOC_5	SHM-93-22C	11/1/2018	212.4	
AOC_5	SHM-93-22C	10/22/2019	210.8	
AOC_5	SHM-93-24A	3/30/1993	222.5	
AOC_5	SHM-93-24A	6/22/1993	221.4	
AOC_5	SHM-93-24A	9/30/1993	220.9	
AOC_5	SHM-93-24A	11/8/1993	221.0	
AOC_5	SHM-93-24A	3/30/1994	222.8	
AOC_5	SHM-93-24A	6/28/1994	221.8	
AOC_5	SHM-93-24A	10/4/1994	221.8	
AOC_5	SHM-93-24A	1/31/1995	222.2	
AOC_5	SHM-93-24A	5/9/1995	221.5	
AOC_5	SHM-93-24A	12/7/1995	221.5	
AOC_5	SHM-93-24A	3/26/1996	222.5	
AOC_5	SHM-93-24A	7/23/1996	222.8	
AOC_5	SHM-93-24A	1/15/1997	223.1	
AOC_5	SHM-93-24A	6/2/1997	223.0	
AOC_5	SHM-93-24A	4/23/1998	222.9	
AOC_5	SHM-93-24A	6/19/1998	224.2	
AOC_5	SHM-93-24A	6/26/1998	224.0	
AOC_5	SHM-93-24A	7/1/1998	223.8	
AOC_5	SHM-93-24A	7/17/1998	223.4	
AOC_5	SHM-93-24A	7/31/1998	223.0	
AOC_5	SHM-93-24A	8/28/1998	222.3	
AOC_5	SHM-93-24A	10/14/1998	222.0	
AOC_5	SHM-93-24A	12/10/1998	221.4	
AOC_5	SHM-93-24A	2/23/1999	221.7	
AOC_5	SHM-93-24A	6/6/1999	220.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-93-24A	9/8/1999	220.0	
AOC_5	SHM-93-24A	11/6/2012	222.4	
AOC_5	SHM-93-24A	4/25/2013	222.0	
AOC_5	SHM-93-24A	5/15/2013	221.8	
AOC_5	SHM-93-24A	6/11/2013	223.4	
AOC_5	SHM-93-24A	10/21/2013	221.0	
AOC_5	SHM-93-24A	4/22/2014	222.4	
AOC_5	SHM-93-24A	6/17/2015	222.1	
AOC_5	SHM-93-24A	10/7/2015	221.3	
AOC_5	SHM-93-24A	12/16/2015	221.1	
AOC_5	SHM-93-24A	6/9/2016	221.4	
AOC_5	SHM-93-24A	6/24/2016	221.2	
AOC_5	SHM-93-24A	8/16/2016	221.1	
AOC_5	SHM-93-24A	11/15/2016	221.1	
AOC_5	SHM-93-24A	5/22/2017	222.7	
AOC_5	SHM-93-24A	11/1/2018	223.3	
AOC_5	SHM-93-24A	10/22/2019	222.3	
AOC_5	SHM-93-24A	4/29/2020	223.6	
AOC_5	SHM-95-27X	4/29/2020	224.3	
AOC_5	SHM-96-22B	8/24/2005	211.7	
AOC_5	SHM-96-22B	4/10/2006	212.2	
AOC_5	SHM-96-22B	6/5/2006	213.9	
AOC_5	SHM-96-22B	9/18/2006	211.9	
AOC_5	SHM-96-22B	12/15/2006	213.0	
AOC_5	SHM-96-22B	4/9/2007	213.1	
AOC_5	SHM-96-22B	10/15/2007	210.9	
AOC_5	SHM-96-22B	2/20/2008	213.7	
AOC_5	SHM-96-22B	2/25/2008	214.0	
AOC_5	SHM-96-22B	3/4/2008	213.1	
AOC_5	SHM-96-22B	4/16/2008	213.2	
AOC_5	SHM-96-22B	7/15/2008	211.1	
AOC_5	SHM-96-22B	9/30/2008	212.3	
AOC_5	SHM-96-22B	10/1/2008	212.5	
AOC_5	SHM-96-22B	1/20/2009	212.5	
AOC_5	SHM-96-5B	7/17/1998	213.7	
AOC_5	SHM-96-5B	7/31/1998	213.1	
AOC_5	SHM-96-5B	8/28/1998	212.3	
AOC_5	SHM-96-5B	10/14/1998	212.5	
AOC_5	SHM-96-5B	12/10/1998	212.5	
AOC_5	SHM-96-5B	2/23/1999	213.1	
AOC_5	SHM-96-5B	6/6/1999	212.2	
AOC_5	SHM-96-5B	9/8/1999	211.4	
AOC_5	SHM-96-5B	11/16/2001	212.2	
AOC_5	SHM-96-5B	8/4/2005	213.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-96-5B	8/24/2005	212.5	
AOC_5	SHM-96-5B	8/26/2005	212.3	
AOC_5	SHM-96-5B	4/10/2006	213.1	
AOC_5	SHM-96-5B	6/5/2006	214.7	
AOC_5	SHM-96-5B	9/18/2006	212.7	
AOC_5	SHM-96-5B	12/15/2006	213.8	
AOC_5	SHM-96-5B	4/8/2007	213.8	
AOC_5	SHM-96-5B	4/9/2007	213.8	
AOC_5	SHM-96-5B	10/15/2007	211.8	
AOC_5	SHM-96-5B	2/20/2008	214.5	
AOC_5	SHM-96-5B	2/25/2008	214.7	
AOC_5	SHM-96-5B	3/4/2008	213.9	
AOC_5	SHM-96-5B	4/16/2008	213.9	
AOC_5	SHM-96-5B	7/15/2008	212.0	
AOC_5	SHM-96-5B	9/30/2008	213.2	
AOC_5	SHM-96-5B	10/1/2008	213.3	
AOC_5	SHM-96-5B	1/21/2009	213.2	
AOC_5	SHM-96-5B	4/28/2009	213.5	
AOC_5	SHM-96-5B	7/15/2009	212.9	
AOC_5	SHM-96-5B	10/19/2009	211.5	
AOC_5	SHM-96-5B	11/3/2009	212.2	
AOC_5	SHM-96-5B	4/20/2010	214.5	
AOC_5	SHM-96-5B	9/14/2010	211.1	
AOC_5	SHM-96-5B	10/7/2010	211.3	
AOC_5	SHM-96-5B	4/4/2011	213.7	
AOC_5	SHM-96-5B	11/8/2011	213.7	
AOC_5	SHM-96-5B	4/10/2012	212.2	
AOC_5	SHM-96-5B	6/26/2012	212.4	
AOC_5	SHM-96-5B	9/11/2012	211.2	
AOC_5	SHM-96-5B	11/5/2012	212.7	
AOC_5	SHM-96-5B	11/6/2012	212.6	
AOC_5	SHM-96-5B	3/13/2013	213.1	
AOC_5	SHM-96-5B	4/23/2013	212.4	
AOC_5	SHM-96-5B	4/25/2013	212.4	
AOC_5	SHM-96-5B	5/15/2013	211.9	
AOC_5	SHM-96-5B	5/21/2013	212.0	
AOC_5	SHM-96-5B	5/30/2013	212.8	
AOC_5	SHM-96-5B	6/11/2013	212.4	
AOC_5	SHM-96-5B	10/21/2013	211.1	
AOC_5	SHM-96-5B	10/22/2013	210.6	
AOC_5	SHM-96-5B	4/22/2014	213.2	
AOC_5	SHM-96-5B	5/21/2014	212.7	
AOC_5	SHM-96-5B	9/30/2014	211.1	
AOC_5	SHM-96-5B	10/6/2014	211.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-96-5B	6/2/2015	212.5	
AOC_5	SHM-96-5B	6/5/2015	212.2	
AOC_5	SHM-96-5B	6/17/2015	212.1	
AOC_5	SHM-96-5B	10/20/2015	211.1	
AOC_5	SHM-96-5B	12/16/2015	211.4	
AOC_5	SHM-96-5B	6/9/2016	212.0	
AOC_5	SHM-96-5B	6/23/2016	211.4	
AOC_5	SHM-96-5B	8/16/2016	210.8	
AOC_5	SHM-96-5B	10/20/2016	210.7	
AOC_5	SHM-96-5B	11/15/2016	211.8	
AOC_5	SHM-96-5B	5/22/2017	213.2	
AOC_5	SHM-96-5B	5/11/2018	213.2	
AOC_5	SHM-96-5B	11/1/2018	212.8	
AOC_5	SHM-96-5B	4/11/2019	212.7	
AOC_5	SHM-96-5B	10/22/2019	211.4	
AOC_5	SHM-96-5B	5/18/2020	213.1	
AOC_5	SHM-96-5B	5/19/2020	213.1	
AOC_5	SHM-96-5C	6/26/1998	214.8	
AOC_5	SHM-96-5C	7/1/1998	214.6	
AOC_5	SHM-96-5C	7/17/1998	213.7	
AOC_5	SHM-96-5C	7/31/1998	213.1	
AOC_5	SHM-96-5C	8/28/1998	212.3	
AOC_5	SHM-96-5C	10/14/1998	212.5	
AOC_5	SHM-96-5C	2/23/1999	213.2	
AOC_5	SHM-96-5C	6/6/1999	212.2	
AOC_5	SHM-96-5C	9/8/1999	211.4	
AOC_5	SHM-96-5C	11/16/2001	212.2	
AOC_5	SHM-96-5C	8/4/2005	213.0	
AOC_5	SHM-96-5C	8/24/2005	212.4	
AOC_5	SHM-96-5C	8/26/2005	212.3	
AOC_5	SHM-96-5C	4/10/2006	213.1	
AOC_5	SHM-96-5C	6/5/2006	214.7	
AOC_5	SHM-96-5C	9/18/2006	212.7	
AOC_5	SHM-96-5C	12/15/2006	213.8	
AOC_5	SHM-96-5C	4/8/2007	213.8	
AOC_5	SHM-96-5C	4/9/2007	213.8	
AOC_5	SHM-96-5C	10/15/2007	211.8	
AOC_5	SHM-96-5C	2/20/2008	214.5	
AOC_5	SHM-96-5C	2/25/2008	214.7	
AOC_5	SHM-96-5C	3/4/2008	213.9	
AOC_5	SHM-96-5C	4/16/2008	214.0	
AOC_5	SHM-96-5C	7/15/2008	212.1	
AOC_5	SHM-96-5C	9/30/2008	213.3	
AOC_5	SHM-96-5C	10/1/2008	213.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-96-5C	1/21/2009	213.2	
AOC_5	SHM-96-5C	4/28/2009	213.5	
AOC_5	SHM-96-5C	7/15/2009	212.9	
AOC_5	SHM-96-5C	10/19/2009	211.6	
AOC_5	SHM-96-5C	11/3/2009	212.2	
AOC_5	SHM-96-5C	4/20/2010	214.5	
AOC_5	SHM-96-5C	10/7/2010	211.3	
AOC_5	SHM-96-5C	4/4/2011	213.7	
AOC_5	SHM-96-5C	11/8/2011	213.7	
AOC_5	SHM-96-5C	4/10/2012	210.1	
AOC_5	SHM-96-5C	6/26/2012	212.4	
AOC_5	SHM-96-5C	9/11/2012	211.2	
AOC_5	SHM-96-5C	11/5/2012	212.7	
AOC_5	SHM-96-5C	11/6/2012	212.7	
AOC_5	SHM-96-5C	3/13/2013	213.1	
AOC_5	SHM-96-5C	4/23/2013	212.4	
AOC_5	SHM-96-5C	5/15/2013	211.9	
AOC_5	SHM-96-5C	5/28/2013	213.0	
AOC_5	SHM-96-5C	5/30/2013	212.8	
AOC_5	SHM-96-5C	6/11/2013	213.4	
AOC_5	SHM-96-5C	10/21/2013	211.1	
AOC_5	SHM-96-5C	10/22/2013	211.0	
AOC_5	SHM-96-5C	4/22/2014	213.4	
AOC_5	SHM-96-5C	10/6/2014	211.2	
AOC_5	SHM-96-5C	6/3/2015	212.4	
AOC_5	SHM-96-5C	6/17/2015	212.1	
AOC_5	SHM-96-5C	10/20/2015	211.0	
AOC_5	SHM-96-5C	12/16/2015	211.4	
AOC_5	SHM-96-5C	6/9/2016	212.0	
AOC_5	SHM-96-5C	8/16/2016	210.8	
AOC_5	SHM-96-5C	11/15/2016	211.8	
AOC_5	SHM-96-5C	11/1/2018	212.8	
AOC_5	SHM-96-5C	10/22/2019	211.4	
AOC_5	SHM-99-31A	6/6/1999	209.8	
AOC_5	SHM-99-31A	9/8/1999	209.0	
AOC_5	SHM-99-31A	11/16/2001	210.3	
AOC_5	SHM-99-31A	8/4/2005	210.8	
AOC_5	SHM-99-31A	8/24/2005	209.9	
AOC_5	SHM-99-31A	8/26/2005	210.0	
AOC_5	SHM-99-31A	4/10/2006	211.8	
AOC_5	SHM-99-31A	6/5/2006	213.3	
AOC_5	SHM-99-31A	9/18/2006	210.6	
AOC_5	SHM-99-31A	12/15/2006	212.4	
AOC_5	SHM-99-31A	4/8/2007	212.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-99-31A	4/9/2007	212.5	
AOC_5	SHM-99-31A	10/15/2007	210.4	
AOC_5	SHM-99-31A	2/25/2008	212.6	
AOC_5	SHM-99-31A	3/4/2008	212.5	
AOC_5	SHM-99-31A	4/16/2008	212.4	
AOC_5	SHM-99-31A	9/30/2008	212.8	
AOC_5	SHM-99-31A	10/2/2008	212.7	
AOC_5	SHM-99-31A	4/28/2009	212.4	
AOC_5	SHM-99-31A	10/20/2009	210.9	
AOC_5	SHM-99-31A	11/3/2009	211.5	
AOC_5	SHM-99-31A	4/20/2010	212.6	
AOC_5	SHM-99-31A	10/7/2010	211.2	
AOC_5	SHM-99-31A	4/4/2011	212.4	
AOC_5	SHM-99-31A	11/8/2011	212.6	
AOC_5	SHM-99-31A	4/10/2012	210.5	
AOC_5	SHM-99-31A	11/5/2012	212.2	
AOC_5	SHM-99-31A	4/25/2013	211.2	
AOC_5	SHM-99-31A	5/30/2013	212.2	
AOC_5	SHM-99-31A	10/23/2013	209.8	
AOC_5	SHM-99-31A	10/6/2014	209.9	
AOC_5	SHM-99-31A	6/17/2015	210.4	
AOC_5	SHM-99-31A	12/16/2015	210.8	
AOC_5	SHM-99-31A	6/9/2016	210.3	
AOC_5	SHM-99-31A	8/16/2016	209.5	
AOC_5	SHM-99-31A	11/1/2018	212.6	
AOC_5	SHM-99-31A	10/22/2019	210.4	
AOC_5	SHM-99-31B	6/6/1999	209.8	
AOC_5	SHM-99-31B	9/8/1999	209.1	
AOC_5	SHM-99-31B	11/16/2001	210.0	
AOC_5	SHM-99-31B	8/4/2005	210.5	
AOC_5	SHM-99-31B	8/24/2005	210.1	
AOC_5	SHM-99-31B	8/26/2005	210.1	
AOC_5	SHM-99-31B	4/10/2006	210.8	
AOC_5	SHM-99-31B	6/5/2006	212.0	
AOC_5	SHM-99-31B	9/18/2006	210.5	
AOC_5	SHM-99-31B	12/15/2006	211.4	
AOC_5	SHM-99-31B	4/8/2007	211.4	
AOC_5	SHM-99-31B	4/9/2007	211.4	
AOC_5	SHM-99-31B	10/15/2007	210.0	
AOC_5	SHM-99-31B	2/25/2008	212.0	
AOC_5	SHM-99-31B	3/4/2008	211.6	
AOC_5	SHM-99-31B	4/16/2008	212.6	
AOC_5	SHM-99-31B	9/30/2008	211.0	
AOC_5	SHM-99-31B	10/2/2008	211.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-99-31B	4/28/2009	211.3	
AOC_5	SHM-99-31B	10/20/2009	209.9	
AOC_5	SHM-99-31B	11/3/2009	210.3	
AOC_5	SHM-99-31B	4/20/2010	212.0	
AOC_5	SHM-99-31B	10/7/2010	209.7	
AOC_5	SHM-99-31B	4/4/2011	211.3	
AOC_5	SHM-99-31B	11/8/2011	211.3	
AOC_5	SHM-99-31B	4/10/2012	210.1	
AOC_5	SHM-99-31B	11/5/2012	210.5	
AOC_5	SHM-99-31B	5/30/2013	210.6	
AOC_5	SHM-99-31B	10/23/2013	209.3	
AOC_5	SHM-99-31B	10/6/2014	209.5	
AOC_5	SHM-99-31B	6/17/2015	210.0	
AOC_5	SHM-99-31B	12/16/2015	209.8	
AOC_5	SHM-99-31B	6/9/2016	210.0	
AOC_5	SHM-99-31B	8/16/2016	209.2	
AOC_5	SHM-99-31B	11/1/2018	210.6	
AOC_5	SHM-99-31B	10/22/2019	209.5	
AOC_5	SHM-99-31C	6/6/1999	209.7	
AOC_5	SHM-99-31C	9/8/1999	209.0	
AOC_5	SHM-99-31C	11/16/2001	210.0	
AOC_5	SHM-99-31C	8/4/2005	210.4	
AOC_5	SHM-99-31C	8/24/2005	210.0	
AOC_5	SHM-99-31C	8/26/2005	210.0	
AOC_5	SHM-99-31C	4/10/2006	210.7	
AOC_5	SHM-99-31C	6/5/2006	212.0	
AOC_5	SHM-99-31C	9/18/2006	210.4	
AOC_5	SHM-99-31C	12/15/2006	211.4	
AOC_5	SHM-99-31C	4/8/2007	211.4	
AOC_5	SHM-99-31C	4/9/2007	211.4	
AOC_5	SHM-99-31C	10/15/2007	209.9	
AOC_5	SHM-99-31C	2/25/2008	212.0	
AOC_5	SHM-99-31C	3/4/2008	211.6	
AOC_5	SHM-99-31C	4/16/2008	211.5	
AOC_5	SHM-99-31C	9/30/2008	210.9	
AOC_5	SHM-99-31C	10/2/2008	211.0	
AOC_5	SHM-99-31C	4/28/2009	211.2	
AOC_5	SHM-99-31C	10/20/2009	209.8	
AOC_5	SHM-99-31C	11/3/2009	210.2	
AOC_5	SHM-99-31C	4/20/2010	211.9	
AOC_5	SHM-99-31C	10/7/2010	209.6	
AOC_5	SHM-99-31C	4/4/2011	211.3	
AOC_5	SHM-99-31C	11/8/2011	211.2	
AOC_5	SHM-99-31C	4/10/2012	210.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-99-31C	11/5/2012	210.5	
AOC_5	SHM-99-31C	4/25/2013	210.3	
AOC_5	SHM-99-31C	5/30/2013	210.5	
AOC_5	SHM-99-31C	10/23/2013	209.1	
AOC_5	SHM-99-31C	10/6/2014	209.5	
AOC_5	SHM-99-31C	6/17/2015	210.0	
AOC_5	SHM-99-31C	12/16/2015	209.8	
AOC_5	SHM-99-31C	6/9/2016	209.9	
AOC_5	SHM-99-31C	8/16/2016	209.2	
AOC_5	SHM-99-31C	10/20/2016	209.1	
AOC_5	SHM-99-31C	11/1/2018	210.6	
AOC_5	SHM-99-31C	10/22/2019	209.5	
AOC_5	SHM-99-32X	6/6/1999	211.0	
AOC_5	SHM-99-32X	9/8/1999	210.3	
AOC_5	SHM-99-32X	11/16/2001	211.2	
AOC_5	SHM-99-32X	8/4/2005	211.6	
AOC_5	SHM-99-32X	8/24/2005	211.1	
AOC_5	SHM-99-32X	8/26/2005	211.1	
AOC_5	SHM-99-32X	4/10/2006	211.7	
AOC_5	SHM-99-32X	6/5/2006	213.1	
AOC_5	SHM-99-32X	9/18/2006	211.5	
AOC_5	SHM-99-32X	12/15/2006	212.4	
AOC_5	SHM-99-32X	4/8/2007	212.5	
AOC_5	SHM-99-32X	4/9/2007	212.5	
AOC_5	SHM-99-32X	10/15/2007	211.0	
AOC_5	SHM-99-32X	9/30/2008	212.0	
AOC_5	SHM-99-32X	10/2/2008	212.2	
AOC_5	SHM-99-32X	4/28/2009	212.3	
AOC_5	SHM-99-32X	10/20/2009	210.9	
AOC_5	SHM-99-32X	11/3/2009	211.3	
AOC_5	SHM-99-32X	4/20/2010	213.0	
AOC_5	SHM-99-32X	10/7/2010	210.7	
AOC_5	SHM-99-32X	4/4/2011	212.3	
AOC_5	SHM-99-32X	11/8/2011	212.3	
AOC_5	SHM-99-32X	4/10/2012	211.0	
AOC_5	SHM-99-32X	11/5/2012	211.6	
AOC_5	SHM-99-32X	4/25/2013	211.3	
AOC_5	SHM-99-32X	5/15/2013	211.0	
AOC_5	SHM-99-32X	5/30/2013	211.6	
AOC_5	SHM-99-32X	6/11/2013	212.2	
AOC_5	SHM-99-32X	10/21/2013	210.1	
AOC_5	SHM-99-32X	10/23/2013	210.0	
AOC_5	SHM-99-32X	4/22/2014	212.3	
AOC_5	SHM-99-32X	10/6/2014	210.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHM-99-32X	6/17/2015	211.1	
AOC_5	SHM-99-32X	10/20/2015	210.5	
AOC_5	SHM-99-32X	12/16/2015	210.9	
AOC_5	SHM-99-32X	6/9/2016	211.0	
AOC_5	SHM-99-32X	8/16/2016	210.2	
AOC_5	SHM-99-32X	10/20/2016	210.2	
AOC_5	SHM-99-32X	11/16/2016	211.3	
AOC_5	SHM-99-32X	11/1/2018	212.0	
AOC_5	SHM-99-32X	10/22/2019	210.5	
AOC_5	SHP-01-36X	11/16/2001	216.1	
AOC_5	SHP-01-36X	8/4/2005	216.0	
AOC_5	SHP-01-36X	8/24/2005	216.8	
AOC_5	SHP-01-36X	8/26/2005	215.9	
AOC_5	SHP-01-36X	6/5/2006	216.7	
AOC_5	SHP-01-36X	12/15/2006	215.7	
AOC_5	SHP-01-36X	4/8/2007	215.8	
AOC_5	SHP-01-36X	4/9/2007	215.8	
AOC_5	SHP-01-36X	4/26/2007	216.5	
AOC_5	SHP-01-36X	10/15/2007	217.8	
AOC_5	SHP-01-36X	11/7/2007	216.7	
AOC_5	SHP-01-36X	2/12/2008	216.7	
AOC_5	SHP-01-36X	2/20/2008	217.1	
AOC_5	SHP-01-36X	2/25/2008	217.2	
AOC_5	SHP-01-36X	3/4/2008	216.7	
AOC_5	SHP-01-36X	4/16/2008	216.4	
AOC_5	SHP-01-36X	4/28/2008	216.2	
AOC_5	SHP-01-36X	6/10/2008	216.0	
AOC_5	SHP-01-36X	8/19/2008	216.4	
AOC_5	SHP-01-36X	9/15/2008	216.4	
AOC_5	SHP-01-36X	9/30/2008	216.4	
AOC_5	SHP-01-36X	10/6/2008	216.2	
AOC_5	SHP-01-36X	4/28/2009	216.4	
AOC_5	SHP-01-36X	7/5/2009	216.1	
AOC_5	SHP-01-36X	9/14/2009	216.0	
AOC_5	SHP-01-36X	10/21/2009	216.1	
AOC_5	SHP-01-36X	10/26/2009	216.2	
AOC_5	SHP-01-36X	11/3/2009	216.2	
AOC_5	SHP-01-36X	4/20/2010	216.4	
AOC_5	SHP-01-36X	4/27/2010	216.2	
AOC_5	SHP-01-36X	9/14/2010	215.7	
AOC_5	SHP-01-36X	10/7/2010	216.4	
AOC_5	SHP-01-36X	4/4/2011	217.4	
AOC_5	SHP-01-36X	7/25/2011	215.9	
AOC_5	SHP-01-36X	11/8/2011	216.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-01-36X	4/10/2012	215.9	
AOC_5	SHP-01-36X	6/26/2012	216.2	
AOC_5	SHP-01-36X	11/5/2012	216.7	
AOC_5	SHP-01-36X	11/6/2012	216.7	
AOC_5	SHP-01-36X	4/25/2013	216.2	
AOC_5	SHP-01-36X	5/15/2013	216.4	
AOC_5	SHP-01-36X	6/11/2013	217.5	
AOC_5	SHP-01-36X	10/21/2013	212.8	
AOC_5	SHP-01-36X	11/19/2013	215.8	
AOC_5	SHP-01-36X	4/22/2014	216.6	
AOC_5	SHP-01-36X	10/6/2014	217.1	
AOC_5	SHP-01-36X	6/3/2015	216.9	
AOC_5	SHP-01-36X	6/17/2015	216.3	
AOC_5	SHP-01-36X	8/18/2015	216.2	
AOC_5	SHP-01-36X	10/7/2015	216.3	
AOC_5	SHP-01-36X	10/20/2015	217.5	
AOC_5	SHP-01-36X	12/16/2015	216.3	
AOC_5	SHP-01-36X	6/9/2016	216.5	
AOC_5	SHP-01-36X	8/16/2016	216.1	
AOC_5	SHP-01-36X	10/20/2016	216.1	
AOC_5	SHP-01-36X	11/15/2016	217.0	
AOC_5	SHP-01-36X	5/22/2017	216.4	
AOC_5	SHP-01-36X	5/11/2018	216.6	
AOC_5	SHP-01-36X	11/1/2018	216.3	
AOC_5	SHP-01-36X	4/11/2019	216.2	
AOC_5	SHP-01-36X	10/22/2019	217.3	
AOC_5	SHP-01-36X	5/18/2020	218.8	
AOC_5	SHP-01-36X	5/20/2020	216.4	
AOC_5	SHP-01-37X	11/16/2001	216.2	
AOC_5	SHP-01-37X	8/4/2005	216.0	
AOC_5	SHP-01-37X	8/24/2005	215.9	
AOC_5	SHP-01-37X	8/26/2005	216.3	
AOC_5	SHP-01-37X	4/10/2006	216.1	
AOC_5	SHP-01-37X	6/5/2006	216.7	
AOC_5	SHP-01-37X	9/18/2006	216.1	
AOC_5	SHP-01-37X	12/15/2006	216.3	
AOC_5	SHP-01-37X	4/8/2007	216.0	
AOC_5	SHP-01-37X	4/9/2007	216.0	
AOC_5	SHP-01-37X	4/26/2007	216.5	
AOC_5	SHP-01-37X	9/10/2007	216.0	
AOC_5	SHP-01-37X	10/15/2007		214.2
AOC_5	SHP-01-37X	11/7/2007	216.8	
AOC_5	SHP-01-37X	2/12/2008	216.8	
AOC_5	SHP-01-37X	2/20/2008	217.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-01-37X	2/25/2008	216.8	
AOC_5	SHP-01-37X	3/4/2008	216.8	
AOC_5	SHP-01-37X	4/16/2008	216.5	
AOC_5	SHP-01-37X	4/28/2008	216.3	
AOC_5	SHP-01-37X	6/10/2008	216.1	
AOC_5	SHP-01-37X	8/19/2008	216.5	
AOC_5	SHP-01-37X	9/15/2008	216.5	
AOC_5	SHP-01-37X	9/30/2008	216.5	
AOC_5	SHP-01-37X	10/6/2008	216.3	
AOC_5	SHP-01-37X	4/28/2009	216.4	
AOC_5	SHP-01-37X	7/5/2009	216.2	
AOC_5	SHP-01-37X	9/14/2009	216.1	
AOC_5	SHP-01-37X	10/21/2009	216.3	
AOC_5	SHP-01-37X	10/26/2009	216.3	
AOC_5	SHP-01-37X	11/3/2009	216.3	
AOC_5	SHP-01-37X	4/20/2010	216.4	
AOC_5	SHP-01-37X	4/27/2010	216.3	
AOC_5	SHP-01-37X	9/14/2010	215.9	
AOC_5	SHP-01-37X	10/7/2010	216.6	
AOC_5	SHP-01-37X	4/4/2011	216.5	
AOC_5	SHP-01-37X	7/25/2011	216.0	
AOC_5	SHP-01-37X	11/8/2011	216.5	
AOC_5	SHP-01-37X	4/10/2012	216.1	
AOC_5	SHP-01-37X	6/26/2012	216.3	
AOC_5	SHP-01-37X	11/5/2012	216.8	
AOC_5	SHP-01-37X	11/6/2012	216.9	
AOC_5	SHP-01-37X	4/25/2013	216.3	
AOC_5	SHP-01-37X	5/15/2013	216.6	
AOC_5	SHP-01-37X	6/11/2013	217.6	
AOC_5	SHP-01-37X	10/21/2013		212.8
AOC_5	SHP-01-37X	11/19/2013	216.0	
AOC_5	SHP-01-37X	4/22/2014	216.7	
AOC_5	SHP-01-37X	10/6/2014	217.2	
AOC_5	SHP-01-37X	6/3/2015	217.0	
AOC_5	SHP-01-37X	6/17/2015	216.4	
AOC_5	SHP-01-37X	8/18/2015	216.3	
AOC_5	SHP-01-37X	10/7/2015	216.4	
AOC_5	SHP-01-37X	10/20/2015	217.4	
AOC_5	SHP-01-37X	12/16/2015	216.4	
AOC_5	SHP-01-37X	4/6/2016	216.4	
AOC_5	SHP-01-37X	6/9/2016	216.6	
AOC_5	SHP-01-37X	8/16/2016	216.2	
AOC_5	SHP-01-37X	10/20/2016	216.3	
AOC_5	SHP-01-37X	11/15/2016	217.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-01-37X	5/22/2017	216.4	
AOC_5	SHP-01-37X	5/11/2018	216.7	
AOC_5	SHP-01-37X	11/1/2018	216.4	
AOC_5	SHP-01-37X	4/11/2019	216.3	
AOC_5	SHP-01-37X	10/22/2019	216.9	
AOC_5	SHP-01-37X	5/18/2020	219.5	
AOC_5	SHP-01-37X	5/20/2020	216.4	
AOC_5	SHP-01-38A	11/16/2001	216.5	
AOC_5	SHP-01-38A	8/4/2005	216.6	
AOC_5	SHP-01-38A	8/24/2005	216.5	
AOC_5	SHP-01-38A	8/26/2005	216.5	
AOC_5	SHP-01-38A	4/10/2006	216.8	
AOC_5	SHP-01-38A	6/5/2006	217.4	
AOC_5	SHP-01-38A	9/18/2006	216.7	
AOC_5	SHP-01-38A	12/15/2006	216.9	
AOC_5	SHP-01-38A	4/8/2007	216.5	
AOC_5	SHP-01-38A	4/9/2007	216.5	
AOC_5	SHP-01-38A	4/26/2007	217.1	
AOC_5	SHP-01-38A	9/10/2007	216.5	
AOC_5	SHP-01-38A	10/15/2007	217.4	
AOC_5	SHP-01-38A	2/12/2008	217.3	
AOC_5	SHP-01-38A	2/20/2008	217.5	
AOC_5	SHP-01-38A	2/25/2008	217.2	
AOC_5	SHP-01-38A	3/4/2008	217.4	
AOC_5	SHP-01-38A	4/16/2008	217.0	
AOC_5	SHP-01-38A	8/19/2008	217.0	
AOC_5	SHP-01-38A	9/30/2008	217.1	
AOC_5	SHP-01-38A	10/6/2008	216.9	
AOC_5	SHP-01-38A	4/28/2009	217.0	
AOC_5	SHP-01-38A	7/5/2009	216.8	
AOC_5	SHP-01-38A	10/21/2009	216.7	
AOC_5	SHP-01-38A	10/26/2009	216.9	
AOC_5	SHP-01-38A	11/3/2009	216.8	
AOC_5	SHP-01-38A	4/20/2010	217.1	
AOC_5	SHP-01-38A	9/14/2010	216.9	
AOC_5	SHP-01-38A	10/7/2010	216.8	
AOC_5	SHP-01-38A	4/4/2011	216.9	
AOC_5	SHP-01-38A	11/8/2011	217.0	
AOC_5	SHP-01-38A	4/10/2012	216.6	
AOC_5	SHP-01-38A	11/5/2012	217.0	
AOC_5	SHP-01-38A	4/25/2013	216.6	
AOC_5	SHP-01-38A	5/15/2013	216.8	
AOC_5	SHP-01-38A	5/23/2013	217.1	
AOC_5	SHP-01-38A	5/30/2013	217.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-01-38A	6/11/2013	217.8	
AOC_5	SHP-01-38A	10/21/2013	213.6	
AOC_5	SHP-01-38A	11/19/2013	216.2	
AOC_5	SHP-01-38A	4/22/2014	216.9	
AOC_5	SHP-01-38A	10/6/2014	217.2	
AOC_5	SHP-01-38A	6/3/2015	217.2	
AOC_5	SHP-01-38A	6/17/2015	216.6	
AOC_5	SHP-01-38A	8/18/2015	216.5	
AOC_5	SHP-01-38A	10/7/2015	216.6	
AOC_5	SHP-01-38A	10/20/2015	217.4	
AOC_5	SHP-01-38A	12/16/2015	216.6	
AOC_5	SHP-01-38A	4/6/2016	216.7	
AOC_5	SHP-01-38A	6/9/2016	216.7	
AOC_5	SHP-01-38A	8/16/2016	216.3	
AOC_5	SHP-01-38A	10/20/2016	216.4	
AOC_5	SHP-01-38A	11/16/2016	217.3	
AOC_5	SHP-01-38A	5/22/2017	216.9	
AOC_5	SHP-01-38A	5/11/2018	217.0	
AOC_5	SHP-01-38A	11/1/2018	216.8	
AOC_5	SHP-01-38A	4/11/2019	216.8	
AOC_5	SHP-01-38A	10/22/2019	217.5	
AOC_5	SHP-01-38A	5/18/2020	217.3	
AOC_5	SHP-01-38A	5/21/2020	216.8	
AOC_5	SHP-01-38B	11/16/2001	216.5	
AOC_5	SHP-01-38B	8/4/2005	216.7	
AOC_5	SHP-01-38B	8/24/2005	216.5	
AOC_5	SHP-01-38B	8/26/2005	216.7	
AOC_5	SHP-01-38B	4/10/2006	216.9	
AOC_5	SHP-01-38B	6/5/2006	217.5	
AOC_5	SHP-01-38B	9/18/2006	216.8	
AOC_5	SHP-01-38B	12/15/2006	217.0	
AOC_5	SHP-01-38B	4/8/2007	216.6	
AOC_5	SHP-01-38B	4/9/2007	216.6	
AOC_5	SHP-01-38B	4/26/2007	217.4	
AOC_5	SHP-01-38B	9/10/2007	216.6	
AOC_5	SHP-01-38B	10/15/2007	217.4	
AOC_5	SHP-01-38B	2/20/2008	217.7	
AOC_5	SHP-01-38B	2/25/2008	217.3	
AOC_5	SHP-01-38B	3/4/2008	217.4	
AOC_5	SHP-01-38B	4/16/2008	217.3	
AOC_5	SHP-01-38B	8/19/2008	217.1	
AOC_5	SHP-01-38B	9/30/2008	217.2	
AOC_5	SHP-01-38B	4/28/2009	217.2	
AOC_5	SHP-01-38B	7/5/2009	217.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-01-38B	10/26/2009	216.9	
AOC_5	SHP-01-38B	11/3/2009	216.9	
AOC_5	SHP-01-38B	4/20/2010	217.3	
AOC_5	SHP-01-38B	10/7/2010	216.9	
AOC_5	SHP-01-38B	4/4/2011	217.2	
AOC_5	SHP-01-38B	11/8/2011	217.2	
AOC_5	SHP-01-38B	4/10/2012	216.7	
AOC_5	SHP-01-38B	11/5/2012	217.0	
AOC_5	SHP-01-38B	5/15/2013	216.8	
AOC_5	SHP-01-38B	5/23/2013	217.1	
AOC_5	SHP-01-38B	6/11/2013	217.8	
AOC_5	SHP-01-38B	10/21/2013	213.6	
AOC_5	SHP-01-38B	4/22/2014	216.9	
AOC_5	SHP-01-38B	10/6/2014	217.2	
AOC_5	SHP-01-38B	6/3/2015	217.2	
AOC_5	SHP-01-38B	6/17/2015	216.6	
AOC_5	SHP-01-38B	8/18/2015	216.5	
AOC_5	SHP-01-38B	10/20/2015	217.4	
AOC_5	SHP-01-38B	12/16/2015	216.6	
AOC_5	SHP-01-38B	6/9/2016	216.8	
AOC_5	SHP-01-38B	8/16/2016	216.3	
AOC_5	SHP-01-38B	5/11/2018	217.1	
AOC_5	SHP-01-38B	11/1/2018	216.8	
AOC_5	SHP-01-38B	4/11/2019	216.8	
AOC_5	SHP-01-38B	10/22/2019	217.5	
AOC_5	SHP-05-43	8/24/2005	215.3	
AOC_5	SHP-05-43	4/10/2006	215.9	
AOC_5	SHP-05-43	6/5/2006	216.5	
AOC_5	SHP-05-43	9/18/2006	215.4	
AOC_5	SHP-05-43	10/19/2006	215.5	
AOC_5	SHP-05-43	12/15/2006	216.1	
AOC_5	SHP-05-43	4/8/2007		208.4
AOC_5	SHP-05-43	4/9/2007		208.4
AOC_5	SHP-05-43	4/26/2007	216.9	
AOC_5	SHP-05-43	10/15/2007	215.7	
AOC_5	SHP-05-43	11/7/2007	215.6	
AOC_5	SHP-05-43	2/12/2008	216.5	
AOC_5	SHP-05-43	2/20/2008	216.7	
AOC_5	SHP-05-43	2/25/2008	216.8	
AOC_5	SHP-05-43	3/4/2008	216.6	
AOC_5	SHP-05-43	4/16/2008	216.6	
AOC_5	SHP-05-43	4/28/2008	216.3	
AOC_5	SHP-05-43	6/10/2008	215.8	
AOC_5	SHP-05-43	8/19/2008	216.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-05-43	9/15/2008	216.0	
AOC_5	SHP-05-43	9/30/2008	215.8	
AOC_5	SHP-05-43	4/28/2009	216.3	
AOC_5	SHP-05-43	7/5/2009	216.0	
AOC_5	SHP-05-43	9/14/2009	215.3	
AOC_5	SHP-05-43	10/26/2009	215.3	
AOC_5	SHP-05-43	11/3/2009	215.5	
AOC_5	SHP-05-43	4/20/2010	217.2	
AOC_5	SHP-05-43	4/27/2010	217.0	
AOC_5	SHP-05-43	9/14/2010	214.6	
AOC_5	SHP-05-43	10/7/2010	215.0	
AOC_5	SHP-05-43	4/4/2011	216.3	
AOC_5	SHP-05-43	7/25/2011	215.2	
AOC_5	SHP-05-43	11/8/2011	216.5	
AOC_5	SHP-05-43	4/10/2012	215.4	
AOC_5	SHP-05-43	6/26/2012	215.5	
AOC_5	SHP-05-43	11/5/2012	216.0	
AOC_5	SHP-05-43	11/6/2012	216.0	
AOC_5	SHP-05-43	2/14/2013	215.4	
AOC_5	SHP-05-43	3/12/2013	215.8	
AOC_5	SHP-05-43	4/22/2013	215.7	
AOC_5	SHP-05-43	4/25/2013	215.7	
AOC_5	SHP-05-43	5/15/2013	215.6	
AOC_5	SHP-05-43	6/11/2013	216.3	
AOC_5	SHP-05-43	10/21/2013	213.1	
AOC_5	SHP-05-43	4/22/2014	216.2	
AOC_5	SHP-05-43	10/6/2014	215.3	
AOC_5	SHP-05-43	6/2/2015	215.9	
AOC_5	SHP-05-43	6/17/2015	215.6	
AOC_5	SHP-05-43	8/18/2015	215.3	
AOC_5	SHP-05-43	10/7/2015	215.0	
AOC_5	SHP-05-43	10/20/2015	215.4	
AOC_5	SHP-05-43	12/16/2015	215.1	
AOC_5	SHP-05-43	4/6/2016	215.9	
AOC_5	SHP-05-43	6/9/2016	215.5	
AOC_5	SHP-05-43	8/16/2016	214.8	
AOC_5	SHP-05-43	5/11/2018	216.3	
AOC_5	SHP-05-43	11/1/2018	216.0	
AOC_5	SHP-05-43	4/11/2019	216.0	
AOC_5	SHP-05-43	10/22/2019	215.7	
AOC_5	SHP-05-44	8/24/2005	215.7	
AOC_5	SHP-05-44	4/10/2006	216.1	
AOC_5	SHP-05-44	6/5/2006	216.3	
AOC_5	SHP-05-44	9/18/2006	215.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-05-44	10/19/2006	216.0	
AOC_5	SHP-05-44	12/15/2006	216.3	
AOC_5	SHP-05-44	4/8/2007		205.6
AOC_5	SHP-05-44	4/9/2007		205.6
AOC_5	SHP-05-44	4/26/2007	216.9	
AOC_5	SHP-05-44	9/10/2007	215.6	
AOC_5	SHP-05-44	10/15/2007	217.1	
AOC_5	SHP-05-44	11/7/2007	216.3	
AOC_5	SHP-05-44	2/12/2008	216.7	
AOC_5	SHP-05-44	2/20/2008	217.1	
AOC_5	SHP-05-44	2/25/2008	216.9	
AOC_5	SHP-05-44	3/4/2008	216.8	
AOC_5	SHP-05-44	4/16/2008	216.7	
AOC_5	SHP-05-44	4/28/2008	216.4	
AOC_5	SHP-05-44	6/10/2008	216.1	
AOC_5	SHP-05-44	8/19/2008	216.4	
AOC_5	SHP-05-44	9/15/2008	216.3	
AOC_5	SHP-05-44	9/30/2008	216.2	
AOC_5	SHP-05-44	4/28/2009	216.1	
AOC_5	SHP-05-44	7/5/2009	216.2	
AOC_5	SHP-05-44	9/14/2009	215.8	
AOC_5	SHP-05-44	10/26/2009	215.9	
AOC_5	SHP-05-44	11/3/2009	216.0	
AOC_5	SHP-05-44	4/20/2010	217.0	
AOC_5	SHP-05-44	4/27/2010	216.8	
AOC_5	SHP-05-44	9/14/2010	215.3	
AOC_5	SHP-05-44	10/7/2010	215.7	
AOC_5	SHP-05-44	4/4/2011	216.5	
AOC_5	SHP-05-44	7/25/2011	215.7	
AOC_5	SHP-05-44	11/8/2011	216.6	
AOC_5	SHP-05-44	4/10/2012	215.9	
AOC_5	SHP-05-44	6/26/2012	215.9	
AOC_5	SHP-05-44	11/5/2012	216.5	
AOC_5	SHP-05-44	11/6/2012	216.4	
AOC_5	SHP-05-44	2/14/2013	216.0	
AOC_5	SHP-05-44	3/12/2013	216.3	
AOC_5	SHP-05-44	4/22/2013	216.1	
AOC_5	SHP-05-44	4/25/2013	216.2	
AOC_5	SHP-05-44	5/15/2013	216.1	
AOC_5	SHP-05-44	5/30/2013	216.7	
AOC_5	SHP-05-44	6/11/2013	216.9	
AOC_5	SHP-05-44	10/21/2013	213.2	
AOC_5	SHP-05-44	4/22/2014	216.5	
AOC_5	SHP-05-44	10/6/2014	216.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-05-44	6/2/2015	216.5	
AOC_5	SHP-05-44	6/17/2015	216.1	
AOC_5	SHP-05-44	8/18/2015	215.9	
AOC_5	SHP-05-44	10/7/2015	215.7	
AOC_5	SHP-05-44	10/20/2015		206.1
AOC_5	SHP-05-44	12/16/2015	215.8	
AOC_5	SHP-05-44	4/6/2016	216.3	
AOC_5	SHP-05-44	6/9/2016	216.1	
AOC_5	SHP-05-44	8/16/2016	215.5	
AOC_5	SHP-05-44	10/20/2016	215.5	
AOC_5	SHP-05-44	11/15/2016	216.3	
AOC_5	SHP-05-44	5/11/2018	216.6	
AOC_5	SHP-05-44	11/1/2018	216.8	
AOC_5	SHP-05-44	4/11/2019	216.4	
AOC_5	SHP-05-44	10/22/2019	215.7	
AOC_5	SHP-05-45A	8/4/2005	213.4	
AOC_5	SHP-05-45A	8/24/2005	212.8	
AOC_5	SHP-05-45A	8/26/2005	212.3	
AOC_5	SHP-05-45A	4/10/2006	213.3	
AOC_5	SHP-05-45A	6/5/2006	214.9	
AOC_5	SHP-05-45A	9/18/2006	213.0	
AOC_5	SHP-05-45A	10/19/2006	212.5	
AOC_5	SHP-05-45A	12/15/2006	213.9	
AOC_5	SHP-05-45A	4/8/2007	213.6	
AOC_5	SHP-05-45A	4/9/2007	213.6	
AOC_5	SHP-05-45A	4/26/2007	215.4	
AOC_5	SHP-05-45A	10/15/2007	211.3	
AOC_5	SHP-05-45A	2/20/2008	214.4	
AOC_5	SHP-05-45A	2/25/2008	215.1	
AOC_5	SHP-05-45A	3/4/2008	213.8	
AOC_5	SHP-05-45A	4/16/2008	213.9	
AOC_5	SHP-05-45A	4/28/2008		222.0
AOC_5	SHP-05-45A	6/10/2008	212.6	
AOC_5	SHP-05-45A	8/19/2008	213.3	
AOC_5	SHP-05-45A	9/15/2008	213.7	
AOC_5	SHP-05-45A	9/30/2008	213.1	
AOC_5	SHP-05-45A	4/28/2009	213.5	
AOC_5	SHP-05-45A	9/14/2009	211.6	
AOC_5	SHP-05-45A	10/26/2009	212.4	
AOC_5	SHP-05-45A	11/3/2009	211.9	
AOC_5	SHP-05-45A	4/20/2010	214.4	
AOC_5	SHP-05-45A	9/14/2010	211.0	
AOC_5	SHP-05-45A	10/7/2010	210.8	
AOC_5	SHP-05-45A	4/4/2011	213.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-05-45A	7/25/2011	211.6	
AOC_5	SHP-05-45A	11/8/2011	213.7	
AOC_5	SHP-05-45A	4/10/2012	210.2	
AOC_5	SHP-05-45A	6/26/2012	211.9	
AOC_5	SHP-05-45A	9/11/2012	210.6	
AOC_5	SHP-05-45A	11/5/2012	212.4	
AOC_5	SHP-05-45A	11/6/2012	212.4	
AOC_5	SHP-05-45A	3/13/2013	212.8	
AOC_5	SHP-05-45A	4/23/2013	212.2	
AOC_5	SHP-05-45A	4/25/2013	211.5	
AOC_5	SHP-05-45A	5/15/2013	211.7	
AOC_5	SHP-05-45A	5/30/2013	212.5	
AOC_5	SHP-05-45A	6/11/2013	212.9	
AOC_5	SHP-05-45A	10/21/2013	211.4	
AOC_5	SHP-05-45A	4/22/2014	213.2	
AOC_5	SHP-05-45A	10/6/2014	210.6	
AOC_5	SHP-05-45A	6/3/2015	212.5	
AOC_5	SHP-05-45A	6/17/2015	212.2	
AOC_5	SHP-05-45A	10/20/2015	210.3	
AOC_5	SHP-05-45A	12/16/2015	210.8	
AOC_5	SHP-05-45A	6/9/2016	212.1	
AOC_5	SHP-05-45A	8/16/2016	210.2	
AOC_5	SHP-05-45A	10/20/2016	210.0	
AOC_5	SHP-05-45A	11/1/2018	212.4	
AOC_5	SHP-05-45A	10/22/2019	210.8	
AOC_5	SHP-05-45B	8/4/2005	213.5	
AOC_5	SHP-05-45B	8/24/2005	212.8	
AOC_5	SHP-05-45B	8/26/2005	212.0	
AOC_5	SHP-05-45B	4/10/2006	213.3	
AOC_5	SHP-05-45B	6/5/2006	214.9	
AOC_5	SHP-05-45B	9/18/2006	213.0	
AOC_5	SHP-05-45B	10/19/2006	212.5	
AOC_5	SHP-05-45B	12/15/2006	214.0	
AOC_5	SHP-05-45B	4/8/2007	213.6	
AOC_5	SHP-05-45B	4/9/2007	213.6	
AOC_5	SHP-05-45B	4/26/2007	215.3	
AOC_5	SHP-05-45B	10/15/2007	211.2	
AOC_5	SHP-05-45B	2/20/2008	214.3	
AOC_5	SHP-05-45B	2/25/2008	215.1	
AOC_5	SHP-05-45B	3/4/2008	213.8	
AOC_5	SHP-05-45B	4/16/2008	214.0	
AOC_5	SHP-05-45B	4/28/2008		184.7
AOC_5	SHP-05-45B	6/10/2008	212.6	
AOC_5	SHP-05-45B	8/19/2008	213.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-05-45B	9/30/2008	213.9	
AOC_5	SHP-05-45B	4/28/2009	213.5	
AOC_5	SHP-05-45B	9/14/2009	211.5	
AOC_5	SHP-05-45B	10/26/2009	212.5	
AOC_5	SHP-05-45B	11/3/2009	211.8	
AOC_5	SHP-05-45B	4/20/2010	214.3	
AOC_5	SHP-05-45B	4/27/2010	213.8	
AOC_5	SHP-05-45B	9/14/2010	211.1	
AOC_5	SHP-05-45B	10/7/2010	210.8	
AOC_5	SHP-05-45B	4/4/2011	213.5	
AOC_5	SHP-05-45B	7/25/2011	211.6	
AOC_5	SHP-05-45B	11/8/2011	213.7	
AOC_5	SHP-05-45B	4/10/2012	212.2	
AOC_5	SHP-05-45B	6/26/2012	212.0	
AOC_5	SHP-05-45B	9/11/2012	210.6	
AOC_5	SHP-05-45B	11/5/2012	212.3	
AOC_5	SHP-05-45B	11/6/2012	212.2	
AOC_5	SHP-05-45B	3/13/2013	212.6	
AOC_5	SHP-05-45B	4/23/2013	212.1	
AOC_5	SHP-05-45B	4/25/2013	213.4	
AOC_5	SHP-05-45B	5/15/2013	211.6	
AOC_5	SHP-05-45B	5/30/2013	212.4	
AOC_5	SHP-05-45B	6/11/2013	212.9	
AOC_5	SHP-05-45B	10/21/2013	211.5	
AOC_5	SHP-05-45B	4/22/2014	213.2	
AOC_5	SHP-05-45B	10/6/2014	210.8	
AOC_5	SHP-05-45B	6/3/2015	212.6	
AOC_5	SHP-05-45B	6/17/2015	212.3	
AOC_5	SHP-05-45B	10/20/2015	210.4	
AOC_5	SHP-05-45B	12/16/2015	210.9	
AOC_5	SHP-05-45B	6/9/2016	212.1	
AOC_5	SHP-05-45B	8/16/2016	210.3	
AOC_5	SHP-05-45B	10/20/2016	210.1	
AOC_5	SHP-05-45B	11/1/2018	212.2	
AOC_5	SHP-05-45B	10/22/2019	210.7	
AOC_5	SHP-05-46A	8/4/2005	213.5	
AOC_5	SHP-05-46A	8/24/2005	212.9	
AOC_5	SHP-05-46A	8/26/2005	212.4	
AOC_5	SHP-05-46A	4/10/2006	213.4	
AOC_5	SHP-05-46A	6/5/2006	215.1	
AOC_5	SHP-05-46A	9/18/2006	213.1	
AOC_5	SHP-05-46A	10/19/2006	212.7	
AOC_5	SHP-05-46A	12/15/2006	214.2	
AOC_5	SHP-05-46A	4/8/2007	213.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-05-46A	4/9/2007	213.8	
AOC_5	SHP-05-46A	4/26/2007	215.5	
AOC_5	SHP-05-46A	10/15/2007	212.3	
AOC_5	SHP-05-46A	2/20/2008	215.2	
AOC_5	SHP-05-46A	2/25/2008	215.8	
AOC_5	SHP-05-46A	3/4/2008	214.7	
AOC_5	SHP-05-46A	4/16/2008	214.9	
AOC_5	SHP-05-46A	4/28/2008	213.5	
AOC_5	SHP-05-46A	6/10/2008	213.6	
AOC_5	SHP-05-46A	8/19/2008	213.5	
AOC_5	SHP-05-46A	9/15/2008	214.5	
AOC_5	SHP-05-46A	9/30/2008	213.9	
AOC_5	SHP-05-46A	4/28/2009	214.4	
AOC_5	SHP-05-46A	7/5/2009	213.7	
AOC_5	SHP-05-46A	9/14/2009	212.6	
AOC_5	SHP-05-46A	10/26/2009	213.2	
AOC_5	SHP-05-46A	11/3/2009	212.9	
AOC_5	SHP-05-46A	4/20/2010	215.4	
AOC_5	SHP-05-46A	9/14/2010	211.9	
AOC_5	SHP-05-46A	10/7/2010	211.8	
AOC_5	SHP-05-46A	4/4/2011	214.5	
AOC_5	SHP-05-46A	7/25/2011	212.6	
AOC_5	SHP-05-46A	11/8/2011	214.6	
AOC_5	SHP-05-46A	4/10/2012	213.1	
AOC_5	SHP-05-46A	6/26/2012	212.8	
AOC_5	SHP-05-46A	9/11/2012	211.1	
AOC_5	SHP-05-46A	11/5/2012	213.4	
AOC_5	SHP-05-46A	11/6/2012	212.6	
AOC_5	SHP-05-46A	2/14/2013	213.7	
AOC_5	SHP-05-46A	3/12/2013	213.5	
AOC_5	SHP-05-46A	3/13/2013	213.0	
AOC_5	SHP-05-46A	4/22/2013	213.2	
AOC_5	SHP-05-46A	4/23/2013	212.6	
AOC_5	SHP-05-46A	4/25/2013	213.2	
AOC_5	SHP-05-46A	5/15/2013	212.6	
AOC_5	SHP-05-46A	5/30/2013	212.8	
AOC_5	SHP-05-46A	6/11/2013	213.9	
AOC_5	SHP-05-46A	10/21/2013	212.2	
AOC_5	SHP-05-46A	4/22/2014	214.1	
AOC_5	SHP-05-46A	10/6/2014	210.8	
AOC_5	SHP-05-46A	6/3/2015	212.8	
AOC_5	SHP-05-46A	6/17/2015	213.0	
AOC_5	SHP-05-46A	10/20/2015	211.4	
AOC_5	SHP-05-46A	12/16/2015	211.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-05-46A	6/9/2016	212.3	
AOC_5	SHP-05-46A	8/16/2016	210.6	
AOC_5	SHP-05-46A	10/20/2016	210.4	
AOC_5	SHP-05-46A	11/1/2018	213.3	
AOC_5	SHP-05-46A	10/22/2019	211.2	
AOC_5	SHP-05-46B	8/4/2005	213.6	
AOC_5	SHP-05-46B	8/24/2005	213.0	
AOC_5	SHP-05-46B	8/26/2005	212.6	
AOC_5	SHP-05-46B	4/10/2006	213.5	
AOC_5	SHP-05-46B	6/5/2006	215.2	
AOC_5	SHP-05-46B	9/18/2006	213.2	
AOC_5	SHP-05-46B	12/15/2006	214.1	
AOC_5	SHP-05-46B	4/8/2007	213.8	
AOC_5	SHP-05-46B	4/9/2007	213.8	
AOC_5	SHP-05-46B	10/15/2007	211.0	
AOC_5	SHP-05-46B	2/20/2008	214.0	
AOC_5	SHP-05-46B	2/25/2008	214.6	
AOC_5	SHP-05-46B	3/4/2008	213.5	
AOC_5	SHP-05-46B	4/16/2008	213.6	
AOC_5	SHP-05-46B	4/28/2008	213.6	
AOC_5	SHP-05-46B	6/10/2008	212.4	
AOC_5	SHP-05-46B	9/15/2008	213.2	
AOC_5	SHP-05-46B	9/30/2008	212.7	
AOC_5	SHP-05-46B	4/28/2009	213.1	
AOC_5	SHP-05-46B	7/5/2009	212.5	
AOC_5	SHP-05-46B	9/14/2009	211.3	
AOC_5	SHP-05-46B	10/26/2009	212.0	
AOC_5	SHP-05-46B	11/3/2009	211.7	
AOC_5	SHP-05-46B	4/20/2010	214.1	
AOC_5	SHP-05-46B	4/27/2010	213.6	
AOC_5	SHP-05-46B	9/14/2010	210.6	
AOC_5	SHP-05-46B	10/7/2010	210.6	
AOC_5	SHP-05-46B	4/4/2011	213.3	
AOC_5	SHP-05-46B	7/25/2011	211.3	
AOC_5	SHP-05-46B	11/8/2011	213.4	
AOC_5	SHP-05-46B	4/10/2012	211.9	
AOC_5	SHP-05-46B	6/26/2012	211.5	
AOC_5	SHP-05-46B	9/11/2012	211.1	
AOC_5	SHP-05-46B	11/5/2012	212.1	
AOC_5	SHP-05-46B	11/6/2012	212.7	
AOC_5	SHP-05-46B	3/13/2013	213.1	
AOC_5	SHP-05-46B	4/23/2013	212.6	
AOC_5	SHP-05-46B	5/15/2013	211.4	
AOC_5	SHP-05-46B	5/30/2013	212.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-05-46B	6/11/2013	212.7	
AOC_5	SHP-05-46B	10/21/2013	210.9	
AOC_5	SHP-05-46B	4/22/2014	212.9	
AOC_5	SHP-05-46B	10/6/2014	210.5	
AOC_5	SHP-05-46B	6/17/2015	210.8	
AOC_5	SHP-05-46B	10/20/2015	210.1	
AOC_5	SHP-05-46B	12/16/2015	211.3	
AOC_5	SHP-05-46B	6/9/2016	212.4	
AOC_5	SHP-05-46B	8/16/2016	210.7	
AOC_5	SHP-05-46B	10/20/2016	210.5	
AOC_5	SHP-05-46B	5/11/2018	213.4	
AOC_5	SHP-05-46B	11/1/2018	212.9	
AOC_5	SHP-05-46B	4/11/2019	212.8	
AOC_5	SHP-05-46B	10/22/2019	211.3	
AOC_5	SHP-05-47A	8/4/2005	212.8	
AOC_5	SHP-05-47A	8/24/2005	211.4	
AOC_5	SHP-05-47A	4/10/2006	212.0	
AOC_5	SHP-05-47A	9/18/2006	211.7	
AOC_5	SHP-05-47A	12/15/2006	212.7	
AOC_5	SHP-05-47A	4/8/2007	211.8	
AOC_5	SHP-05-47A	4/9/2007	211.8	
AOC_5	SHP-05-47A	10/15/2007	211.9	
AOC_5	SHP-05-47A	2/25/2008	213.1	
AOC_5	SHP-05-47A	3/4/2008	213.1	
AOC_5	SHP-05-47A	4/16/2008	213.1	
AOC_5	SHP-05-47A	9/30/2008	213.0	
AOC_5	SHP-05-47A	4/28/2009	213.0	
AOC_5	SHP-05-47A	11/3/2009	212.7	
AOC_5	SHP-05-47A	4/20/2010	212.8	
AOC_5	SHP-05-47A	10/7/2010	214.5	
AOC_5	SHP-05-47A	4/4/2011	215.0	
AOC_5	SHP-05-47A	11/8/2011	212.9	
AOC_5	SHP-05-47A	4/10/2012	212.1	
AOC_5	SHP-05-47A	11/5/2012	212.6	
AOC_5	SHP-05-47A	11/6/2012	212.8	
AOC_5	SHP-05-47A	5/15/2013	212.0	
AOC_5	SHP-05-47A	5/30/2013	211.9	
AOC_5	SHP-05-47A	4/22/2014	212.7	
AOC_5	SHP-05-47A	6/3/2015	213.0	
AOC_5	SHP-05-47A	10/7/2015	211.4	
AOC_5	SHP-05-47A	10/20/2015	212.3	
AOC_5	SHP-05-47A	12/16/2015	212.9	
AOC_5	SHP-05-47A	11/15/2016	212.9	
AOC_5	SHP-05-47A	5/11/2018	212.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-05-47A	11/1/2018	212.6	
AOC_5	SHP-05-47A	4/11/2019	213.2	
AOC_5	SHP-05-47A	10/22/2019	211.8	
AOC_5	SHP-05-47B	8/4/2005	214.2	
AOC_5	SHP-05-47B	8/24/2005	211.5	
AOC_5	SHP-05-47B	8/26/2005	211.6	
AOC_5	SHP-05-47B	4/10/2006	212.2	
AOC_5	SHP-05-47B	9/18/2006	211.8	
AOC_5	SHP-05-47B	12/15/2006	212.7	
AOC_5	SHP-05-47B	4/8/2007	212.8	
AOC_5	SHP-05-47B	4/9/2007	212.8	
AOC_5	SHP-05-47B	10/15/2007	212.3	
AOC_5	SHP-05-47B	2/25/2008	213.7	
AOC_5	SHP-05-47B	3/4/2008	213.3	
AOC_5	SHP-05-47B	4/16/2008	213.2	
AOC_5	SHP-05-47B	9/30/2008	213.4	
AOC_5	SHP-05-47B	4/28/2009	213.0	
AOC_5	SHP-05-47B	11/3/2009	212.9	
AOC_5	SHP-05-47B	4/20/2010	212.9	
AOC_5	SHP-05-47B	10/7/2010	210.7	
AOC_5	SHP-05-47B	4/4/2011	210.4	
AOC_5	SHP-05-47B	11/8/2011	213.4	
AOC_5	SHP-05-47B	4/10/2012	212.3	
AOC_5	SHP-05-47B	11/5/2012	212.8	
AOC_5	SHP-05-47B	11/6/2012	212.9	
AOC_5	SHP-05-47B	5/15/2013	212.6	
AOC_5	SHP-05-47B	5/30/2013	212.7	
AOC_5	SHP-05-47B	10/21/2013	211.5	
AOC_5	SHP-05-47B	4/22/2014	213.5	
AOC_5	SHP-05-47B	6/3/2015	211.0	
AOC_5	SHP-05-47B	6/17/2015	211.9	
AOC_5	SHP-05-47B	10/7/2015	211.4	
AOC_5	SHP-05-47B	10/20/2015	212.4	
AOC_5	SHP-05-47B	12/16/2015	212.9	
AOC_5	SHP-05-47B	6/9/2016	212.7	
AOC_5	SHP-05-47B	8/16/2016	211.4	
AOC_5	SHP-05-47B	11/15/2016	213.0	
AOC_5	SHP-05-47B	5/11/2018	213.2	
AOC_5	SHP-05-47B	11/1/2018	212.6	
AOC_5	SHP-05-47B	4/11/2019	213.2	
AOC_5	SHP-05-47B	10/22/2019	213.0	
AOC_5	SHP-05-48A	8/4/2005	211.8	
AOC_5	SHP-05-48A	4/10/2006	213.8	
AOC_5	SHP-05-48A	6/5/2006	214.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-05-48A	9/18/2006	213.1	
AOC_5	SHP-05-48A	4/8/2007	213.9	
AOC_5	SHP-05-48A	4/9/2007	213.9	
AOC_5	SHP-05-48A	2/25/2008	215.1	
AOC_5	SHP-05-48A	3/4/2008	214.7	
AOC_5	SHP-05-48A	4/16/2008	213.8	
AOC_5	SHP-05-48A	9/30/2008	213.8	
AOC_5	SHP-05-48A	4/28/2009	213.9	
AOC_5	SHP-05-48A	11/3/2009	213.7	
AOC_5	SHP-05-48A	4/20/2010	212.5	
AOC_5	SHP-05-48A	10/7/2010	212.3	
AOC_5	SHP-05-48A	4/4/2011	213.9	
AOC_5	SHP-05-48A	11/8/2011	212.6	
AOC_5	SHP-05-48A	11/5/2012	211.4	
AOC_5	SHP-05-48A	5/30/2013	212.4	
AOC_5	SHP-05-48A	4/22/2014	212.6	
AOC_5	SHP-05-48A	6/3/2015	212.5	
AOC_5	SHP-05-48A	10/20/2015		
AOC_5	SHP-05-48A	11/1/2018	212.7	
AOC_5	SHP-05-48A	10/22/2019	213.5	
AOC_5	SHP-05-48B	8/4/2005	211.3	
AOC_5	SHP-05-48B	4/10/2006	211.0	
AOC_5	SHP-05-48B	6/5/2006	211.9	
AOC_5	SHP-05-48B	9/18/2006	210.4	
AOC_5	SHP-05-48B	12/15/2006	211.1	
AOC_5	SHP-05-48B	4/8/2007	211.0	
AOC_5	SHP-05-48B	4/9/2007	211.0	
AOC_5	SHP-05-48B	2/25/2008	212.2	
AOC_5	SHP-05-48B	3/4/2008	212.1	
AOC_5	SHP-05-48B	4/16/2008	211.1	
AOC_5	SHP-05-48B	9/30/2008	211.4	
AOC_5	SHP-05-48B	4/28/2009	210.9	
AOC_5	SHP-05-48B	11/3/2009	211.0	
AOC_5	SHP-05-48B	4/20/2010	212.4	
AOC_5	SHP-05-48B	10/7/2010	210.5	
AOC_5	SHP-05-48B	4/4/2011	211.1	
AOC_5	SHP-05-48B	11/8/2011	212.8	
AOC_5	SHP-05-48B	4/10/2012	211.2	
AOC_5	SHP-05-48B	11/5/2012	212.4	
AOC_5	SHP-05-48B	5/15/2013	211.9	
AOC_5	SHP-05-48B	5/30/2013	212.4	
AOC_5	SHP-05-48B	4/22/2014	212.5	
AOC_5	SHP-05-48B	6/3/2015	212.4	
AOC_5	SHP-05-48B	6/17/2015	210.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-05-48B	10/20/2015		
AOC_5	SHP-05-48B	5/11/2018	212.7	
AOC_5	SHP-05-48B	11/1/2018	212.7	
AOC_5	SHP-05-48B	4/11/2019	212.8	
AOC_5	SHP-05-48B	10/22/2019	213.1	
AOC_5	SHP-05-49A	8/24/2005	210.7	
AOC_5	SHP-05-49A	4/10/2006	212.3	
AOC_5	SHP-05-49A	6/5/2006	211.7	
AOC_5	SHP-05-49A	9/18/2006	210.9	
AOC_5	SHP-05-49A	12/15/2006	211.4	
AOC_5	SHP-05-49A	10/15/2007	212.2	
AOC_5	SHP-05-49A	2/25/2008	212.9	
AOC_5	SHP-05-49A	3/4/2008	212.8	
AOC_5	SHP-05-49A	4/16/2008	211.2	
AOC_5	SHP-05-49A	9/30/2008	212.5	
AOC_5	SHP-05-49A	4/28/2009	212.7	
AOC_5	SHP-05-49A	11/3/2009	212.6	
AOC_5	SHP-05-49A	4/20/2010	211.1	
AOC_5	SHP-05-49A	10/7/2010	212.5	
AOC_5	SHP-05-49A	4/4/2011	212.6	
AOC_5	SHP-05-49A	11/8/2011	211.3	
AOC_5	SHP-05-49A	11/5/2012	211.0	
AOC_5	SHP-05-49A	4/25/2013	210.9	
AOC_5	SHP-05-49A	4/22/2014	211.0	
AOC_5	SHP-05-49A	6/3/2015	212.9	
AOC_5	SHP-05-49A	10/20/2015		
AOC_5	SHP-05-49A	12/16/2015	210.8	
AOC_5	SHP-05-49A	5/11/2018	211.2	
AOC_5	SHP-05-49A	11/1/2018	211.3	
AOC_5	SHP-05-49A	4/11/2019	211.2	
AOC_5	SHP-05-49A	10/22/2019	211.0	
AOC_5	SHP-05-49B	8/4/2005	210.8	
AOC_5	SHP-05-49B	8/24/2005	210.9	
AOC_5	SHP-05-49B	8/26/2005	210.5	
AOC_5	SHP-05-49B	6/5/2006	212.0	
AOC_5	SHP-05-49B	9/18/2006	210.5	
AOC_5	SHP-05-49B	12/15/2006	210.9	
AOC_5	SHP-05-49B	2/20/2008	210.5	
AOC_5	SHP-05-49B	2/25/2008	209.7	
AOC_5	SHP-05-49B	3/4/2008	209.7	
AOC_5	SHP-05-49B	4/16/2008	210.2	
AOC_5	SHP-05-49B	9/30/2008	209.9	
AOC_5	SHP-05-49B	4/28/2009	209.6	
AOC_5	SHP-05-49B	11/3/2009	209.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-05-49B	4/20/2010	210.9	
AOC_5	SHP-05-49B	10/7/2010	209.5	
AOC_5	SHP-05-49B	4/4/2011	209.5	
AOC_5	SHP-05-49B	11/8/2011	211.1	
AOC_5	SHP-05-49B	4/10/2012	210.6	
AOC_5	SHP-05-49B	11/5/2012	211.2	
AOC_5	SHP-05-49B	5/15/2013	210.7	
AOC_5	SHP-05-49B	10/21/2013	210.8	
AOC_5	SHP-05-49B	4/22/2014	211.3	
AOC_5	SHP-05-49B	10/6/2014	210.7	
AOC_5	SHP-05-49B	6/3/2015	210.7	
AOC_5	SHP-05-49B	6/17/2015	210.5	
AOC_5	SHP-05-49B	10/20/2015	210.4	
AOC_5	SHP-05-49B	12/16/2015	210.6	
AOC_5	SHP-05-49B	8/16/2016	210.2	
AOC_5	SHP-05-49B	5/11/2018	211.4	
AOC_5	SHP-05-49B	11/1/2018	211.5	
AOC_5	SHP-05-49B	4/11/2019	211.2	
AOC_5	SHP-05-49B	10/22/2019	211.0	
AOC_5	SHP-07-01BD	2/20/2008		
AOC_5	SHP-07-01BS	2/20/2008		
AOC_5	SHP-07-01CD	2/20/2008		
AOC_5	SHP-07-01CS	2/20/2008		
AOC_5	SHP-07-01DD	2/20/2008		
AOC_5	SHP-07-01DS	2/20/2008		
AOC_5	SHP-07-03A	2/20/2008	210.6	
AOC_5	SHP-07-03A	6/11/2013	206.7	
AOC_5	SHP-07-03A	10/21/2013	204.6	
AOC_5	SHP-07-03A	10/6/2014	204.5	
AOC_5	SHP-07-03B	2/20/2008	211.6	
AOC_5	SHP-07-03C	2/20/2008		
AOC_5	SHP-07-03D	2/20/2008		
AOC_5	SHP-07-03E	2/20/2008		
AOC_5	SHP-07-03E	5/15/2013		
AOC_5	SHP-07-05X	4/25/2013		
AOC_5	SHP-07-05X	5/15/2013		
AOC_5	SHP-07-05X	5/30/2013		
AOC_5	SHP-07-05X	6/11/2013		
AOC_5	SHP-13-03	4/23/2014		-2.6
AOC_5	SHP-2016-06A	5/22/2017	215.6	
AOC_5	SHP-2016-06A	5/11/2018	214.8	
AOC_5	SHP-2016-06A	11/1/2018	212.2	
AOC_5	SHP-2016-06A	4/11/2019	214.1	
AOC_5	SHP-2016-06A	10/22/2019	211.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-2016-06A	5/18/2020	222.2	
AOC_5	SHP-2016-06A	5/21/2020	213.3	
AOC_5	SHP-2016-06B	5/22/2017	222.1	
AOC_5	SHP-2016-06B	5/11/2018	221.7	
AOC_5	SHP-2016-06B	11/1/2018	220.6	
AOC_5	SHP-2016-06B	4/11/2019	221.6	
AOC_5	SHP-2016-06B	10/22/2019	217.8	
AOC_5	SHP-2016-06B	5/18/2020	215.6	
AOC_5	SHP-2016-06B	5/21/2020	220.9	
AOC_5	SHP-2016-06C	5/11/2018	222.0	
AOC_5	SHP-2016-06C	11/1/2018	220.8	
AOC_5	SHP-2016-06C	4/11/2019	222.4	
AOC_5	SHP-2016-06C	10/22/2019	218.2	
AOC_5	SHP-2016-06C	5/18/2020	222.2	
AOC_5	SHP-2016-06C	5/21/2020	221.6	
AOC_5	SHP-2016-07A	5/22/2017	251.0	
AOC_5	SHP-2016-07A	5/11/2018	251.4	
AOC_5	SHP-2016-07A	11/1/2018	248.7	
AOC_5	SHP-2016-07A	4/11/2019	249.7	
AOC_5	SHP-2016-07A	10/22/2019		
AOC_5	SHP-2016-07A	5/18/2020	250.4	
AOC_5	SHP-2016-07A	5/20/2020	250.1	
AOC_5	SHP-2016-07B	5/22/2017	242.9	
AOC_5	SHP-2016-07B	5/11/2018	244.4	
AOC_5	SHP-2016-07B	11/1/2018	241.9	
AOC_5	SHP-2016-07B	4/11/2019	243.3	
AOC_5	SHP-2016-07B	10/22/2019	229.5	
AOC_5	SHP-2016-07B	5/15/2020	243.9	
AOC_5	SHP-2016-07B	5/18/2020	243.6	
AOC_5	SHP-2016-1A	8/16/2016		210.0
AOC_5	SHP-2016-1A	10/20/2016		209.9
AOC_5	SHP-2016-1A	5/22/2017	213.0	
AOC_5	SHP-2016-1A	5/11/2018	213.1	
AOC_5	SHP-2016-1A	11/1/2018	212.5	
AOC_5	SHP-2016-1A	4/11/2019	212.6	
AOC_5	SHP-2016-1A	10/22/2019	210.4	
AOC_5	SHP-2016-1A	5/15/2020	213.2	
AOC_5	SHP-2016-1A	5/18/2020	213.0	
AOC_5	SHP-2016-1B	8/16/2016	209.2	
AOC_5	SHP-2016-1B	10/20/2016	208.8	
AOC_5	SHP-2016-1B	5/22/2017	210.8	
AOC_5	SHP-2016-1B	5/11/2018	211.4	
AOC_5	SHP-2016-1B	11/1/2018	210.6	
AOC_5	SHP-2016-1B	4/11/2019	211.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-2016-1B	10/22/2019	209.5	
AOC_5	SHP-2016-1B	5/15/2020	211.5	
AOC_5	SHP-2016-1B	5/18/2020	211.1	
AOC_5	SHP-2016-2A	8/16/2016	210.1	
AOC_5	SHP-2016-2A	10/20/2016	210.0	
AOC_5	SHP-2016-2A	5/22/2017	212.5	
AOC_5	SHP-2016-2A	5/11/2018	212.7	
AOC_5	SHP-2016-2A	11/1/2018	212.8	
AOC_5	SHP-2016-2A	4/11/2019	212.2	
AOC_5	SHP-2016-2A	10/22/2019	210.5	
AOC_5	SHP-2016-2A	5/18/2020	212.7	
AOC_5	SHP-2016-2A	5/20/2020	211.6	
AOC_5	SHP-2016-2B	10/20/2016	210.0	
AOC_5	SHP-2016-2B	5/22/2017	212.6	
AOC_5	SHP-2016-2B	5/11/2018	212.6	
AOC_5	SHP-2016-2B	11/1/2018	212.7	
AOC_5	SHP-2016-2B	4/11/2019	212.2	
AOC_5	SHP-2016-2B	10/22/2019	209.7	
AOC_5	SHP-2016-2B	5/18/2020	212.6	
AOC_5	SHP-2016-2B	5/20/2020	212.5	
AOC_5	SHP-2016-3A	8/16/2016	209.7	
AOC_5	SHP-2016-3A	10/20/2016	210.1	
AOC_5	SHP-2016-3A	5/22/2017	212.6	
AOC_5	SHP-2016-3A	5/11/2018	212.8	
AOC_5	SHP-2016-3A	11/1/2018	212.1	
AOC_5	SHP-2016-3A	4/11/2019	212.3	
AOC_5	SHP-2016-3A	10/22/2019	210.7	
AOC_5	SHP-2016-3A	5/18/2020	212.4	
AOC_5	SHP-2016-3A	5/20/2020	212.6	
AOC_5	SHP-2016-3B	8/16/2016	210.1	
AOC_5	SHP-2016-3B	10/20/2016	210.1	
AOC_5	SHP-2016-3B	5/22/2017	212.7	
AOC_5	SHP-2016-3B	5/11/2018	212.7	
AOC_5	SHP-2016-3B	11/1/2018	212.2	
AOC_5	SHP-2016-3B	4/11/2019	212.3	
AOC_5	SHP-2016-3B	10/22/2019	210.8	
AOC_5	SHP-2016-3B	5/18/2020	212.6	
AOC_5	SHP-2016-3B	5/20/2020	212.5	
AOC_5	SHP-2016-4A	8/16/2016	210.0	
AOC_5	SHP-2016-4A	10/20/2016	210.0	
AOC_5	SHP-2016-4A	5/22/2017	212.6	
AOC_5	SHP-2016-4A	5/11/2018	212.7	
AOC_5	SHP-2016-4A	11/1/2018	212.2	
AOC_5	SHP-2016-4A	4/11/2019	212.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-2016-4A	10/22/2019		205.1
AOC_5	SHP-2016-4A	5/18/2020	212.6	
AOC_5	SHP-2016-4A	5/21/2020	212.5	
AOC_5	SHP-2016-4B	8/16/2016	210.0	
AOC_5	SHP-2016-4B	10/20/2016	210.0	
AOC_5	SHP-2016-4B	5/22/2017	212.5	
AOC_5	SHP-2016-4B	5/11/2018	212.7	
AOC_5	SHP-2016-4B	11/1/2018	212.2	
AOC_5	SHP-2016-4B	4/11/2019	212.2	
AOC_5	SHP-2016-4B	10/22/2019	210.7	
AOC_5	SHP-2016-4B	5/18/2020	212.6	
AOC_5	SHP-2016-4B	5/21/2020	212.4	
AOC_5	SHP-2016-5A	8/16/2016	210.1	
AOC_5	SHP-2016-5A	10/20/2016	210.0	
AOC_5	SHP-2016-5A	5/22/2017	212.6	
AOC_5	SHP-2016-5A	5/11/2018	212.7	
AOC_5	SHP-2016-5A	11/1/2018	212.2	
AOC_5	SHP-2016-5A	4/11/2019	212.2	
AOC_5	SHP-2016-5A	10/22/2019	210.9	
AOC_5	SHP-2016-5A	5/18/2020	212.7	
AOC_5	SHP-2016-5A	5/21/2020	212.5	
AOC_5	SHP-2016-5B	8/16/2016	210.0	
AOC_5	SHP-2016-5B	10/20/2016	209.9	
AOC_5	SHP-2016-5B	5/22/2017	212.6	
AOC_5	SHP-2016-5B	5/11/2018	212.7	
AOC_5	SHP-2016-5B	11/1/2018	212.2	
AOC_5	SHP-2016-5B	4/11/2019	212.2	
AOC_5	SHP-2016-5B	10/22/2019	210.7	
AOC_5	SHP-2016-5B	5/18/2020	212.7	
AOC_5	SHP-2016-5B	5/21/2020	212.5	
AOC_5	SHP-2017-01	5/11/2018	212.1	
AOC_5	SHP-2017-01	11/1/2018	210.9	
AOC_5	SHP-2017-01	4/11/2019	211.1	
AOC_5	SHP-2017-01	10/22/2019	209.5	
AOC_5	SHP-2017-01	5/18/2020	212.0	
AOC_5	SHP-2017-02	5/11/2018	211.4	
AOC_5	SHP-2017-02	11/1/2018	211.2	
AOC_5	SHP-2017-02	4/11/2019	210.8	
AOC_5	SHP-2017-02	10/22/2019	209.3	
AOC_5	SHP-2017-02	5/18/2020	211.5	
AOC_5	SHP-99-01B	6/6/1999	263.2	
AOC_5	SHP-99-01B	4/26/2007	268.7	
AOC_5	SHP-99-01B	4/28/2008	268.1	
AOC_5	SHP-99-01B	6/10/2008	265.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-99-01B	8/19/2008	263.4	
AOC_5	SHP-99-01B	5/15/2013	267.3	
AOC_5	SHP-99-01B	6/11/2013	268.3	
AOC_5	SHP-99-01B	4/22/2014	269.2	
AOC_5	SHP-99-01B	6/17/2015	263.7	
AOC_5	SHP-99-01B	6/9/2016	266.2	
AOC_5	SHP-99-01B	6/24/2016	263.8	
AOC_5	SHP-99-01B	11/15/2016		
AOC_5	SHP-99-01B	5/22/2017	268.4	
AOC_5	SHP-99-01B	11/1/2018	267.7	
AOC_5	SHP-99-01B	10/22/2019	263.3	
AOC_5	SHP-99-01C	6/6/1999	261.2	
AOC_5	SHP-99-01C	9/8/1999	249.2	
AOC_5	SHP-99-01C	11/16/2001	248.9	
AOC_5	SHP-99-01C	4/26/2007	266.2	
AOC_5	SHP-99-01C	4/28/2008	264.5	
AOC_5	SHP-99-01C	6/10/2008	262.4	
AOC_5	SHP-99-01C	8/19/2008	260.4	
AOC_5	SHP-99-01C	11/6/2012	252.7	
AOC_5	SHP-99-01C	5/15/2013	263.2	
AOC_5	SHP-99-01C	6/11/2013	264.9	
AOC_5	SHP-99-01C	10/21/2013	249.8	
AOC_5	SHP-99-01C	4/22/2014	266.1	
AOC_5	SHP-99-01C	10/6/2014	250.0	
AOC_5	SHP-99-01C	6/2/2015	262.2	
AOC_5	SHP-99-01C	6/17/2015	261.0	
AOC_5	SHP-99-01C	10/20/2015	249.6	
AOC_5	SHP-99-01C	12/16/2015	248.8	
AOC_5	SHP-99-01C	6/9/2016	261.9	
AOC_5	SHP-99-01C	6/24/2016	260.2	
AOC_5	SHP-99-01C	11/15/2016	249.1	
AOC_5	SHP-99-01C	5/22/2017	265.0	
AOC_5	SHP-99-01C	11/1/2018	263.6	
AOC_5	SHP-99-01C	10/22/2019	249.6	
AOC_5	SHP-99-29X	6/6/1999	219.4	
AOC_5	SHP-99-29X	9/8/1999	217.7	
AOC_5	SHP-99-29X	11/16/2001	218.2	
AOC_5	SHP-99-29X	4/26/2007	221.5	
AOC_5	SHP-99-29X	10/15/2007	218.8	
AOC_5	SHP-99-29X	2/20/2008	220.2	
AOC_5	SHP-99-29X	2/25/2008	220.5	
AOC_5	SHP-99-29X	3/4/2008	220.7	
AOC_5	SHP-99-29X	4/16/2008	222.1	
AOC_5	SHP-99-29X	9/15/2008	220.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-99-29X	9/30/2008	220.0	
AOC_5	SHP-99-29X	10/6/2008	218.9	
AOC_5	SHP-99-29X	4/28/2009	222.1	
AOC_5	SHP-99-29X	9/14/2009	220.5	
AOC_5	SHP-99-29X	10/22/2009	219.6	
AOC_5	SHP-99-29X	10/26/2009	219.5	
AOC_5	SHP-99-29X	11/3/2009	219.5	
AOC_5	SHP-99-29X	4/20/2010	222.5	
AOC_5	SHP-99-29X	4/27/2010	222.6	
AOC_5	SHP-99-29X	9/14/2010	218.9	
AOC_5	SHP-99-29X	10/7/2010	217.6	
AOC_5	SHP-99-29X	4/4/2011	220.9	
AOC_5	SHP-99-29X	7/25/2011	220.3	
AOC_5	SHP-99-29X	11/8/2011	221.0	
AOC_5	SHP-99-29X	4/10/2012	221.0	
AOC_5	SHP-99-29X	6/26/2012	220.6	
AOC_5	SHP-99-29X	11/5/2012	218.8	
AOC_5	SHP-99-29X	11/6/2012	218.9	
AOC_5	SHP-99-29X	4/25/2013	220.8	
AOC_5	SHP-99-29X	5/15/2013	220.6	
AOC_5	SHP-99-29X	6/11/2013	220.6	
AOC_5	SHP-99-29X	10/21/2013	218.8	
AOC_5	SHP-99-29X	10/22/2013	218.6	
AOC_5	SHP-99-29X	4/22/2014	220.0	
AOC_5	SHP-99-29X	10/6/2014	218.5	
AOC_5	SHP-99-29X	6/3/2015	220.7	
AOC_5	SHP-99-29X	6/17/2015	220.5	
AOC_5	SHP-99-29X	10/7/2015	218.6	
AOC_5	SHP-99-29X	10/20/2015	218.4	
AOC_5	SHP-99-29X	12/16/2015	218.3	
AOC_5	SHP-99-29X	6/9/2016	220.1	
AOC_5	SHP-99-29X	8/16/2016	218.6	
AOC_5	SHP-99-29X	11/16/2016	218.1	
AOC_5	SHP-99-29X	5/11/2018	221.5	
AOC_5	SHP-99-29X	11/1/2018	220.6	
AOC_5	SHP-99-29X	4/11/2019	222.5	
AOC_5	SHP-99-29X	10/22/2019	219.4	
AOC_5	SHP-99-31A	4/10/2012	209.0	
AOC_5	SHP-99-31A	11/5/2012	210.7	
AOC_5	SHP-99-31A	5/15/2013	209.0	
AOC_5	SHP-99-31A	6/11/2013	208.9	
AOC_5	SHP-99-31A	10/21/2013	208.3	
AOC_5	SHP-99-31A	4/22/2014	209.5	
AOC_5	SHP-99-31A	10/6/2014	208.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-99-31A	6/3/2015	208.7	
AOC_5	SHP-99-31A	10/20/2015	208.0	
AOC_5	SHP-99-31A	10/21/2015	208.0	
AOC_5	SHP-99-31B	4/10/2012		-4.4
AOC_5	SHP-99-31B	11/5/2012		-3.9
AOC_5	SHP-99-31B	5/15/2013		-4.4
AOC_5	SHP-99-31B	6/11/2013		-3.3
AOC_5	SHP-99-31B	10/21/2013		-5.0
AOC_5	SHP-99-31B	4/22/2014		-3.0
AOC_5	SHP-99-31B	10/6/2014		-4.9
AOC_5	SHP-99-31B	6/3/2015		-4.0
AOC_5	SHP-99-31B	10/20/2015		-4.9
AOC_5	SHP-99-31C	4/10/2012		-4.6
AOC_5	SHP-99-31C	11/5/2012		-4.1
AOC_5	SHP-99-31C	5/15/2013		-4.7
AOC_5	SHP-99-31C	6/11/2013		-3.6
AOC_5	SHP-99-31C	10/21/2013		-5.3
AOC_5	SHP-99-31C	4/22/2014		-1.9
AOC_5	SHP-99-31C	10/6/2014		-5.1
AOC_5	SHP-99-31C	6/3/2015		-4.3
AOC_5	SHP-99-31C	10/20/2015		-5.2
AOC_5	SHP-99-31C	11/16/2016		-4.4
AOC_5	SHP-99-33A	2/23/1999	211.5	
AOC_5	SHP-99-33A	6/6/1999	209.7	
AOC_5	SHP-99-33A	9/8/1999	208.9	
AOC_5	SHP-99-33A	11/16/2001	209.9	
AOC_5	SHP-99-33A	8/4/2005	210.2	
AOC_5	SHP-99-33A	8/24/2005	209.9	
AOC_5	SHP-99-33A	8/26/2005	209.8	
AOC_5	SHP-99-33A	4/10/2006	210.9	
AOC_5	SHP-99-33A	6/5/2006	212.4	
AOC_5	SHP-99-33A	9/18/2006	210.4	
AOC_5	SHP-99-33A	12/15/2006	211.5	
AOC_5	SHP-99-33A	4/25/2013	210.6	
AOC_5	SHP-99-33A	5/30/2013	211.0	
AOC_5	SHP-99-33A	10/20/2015		
AOC_5	SHP-99-33B	2/23/1999	210.6	
AOC_5	SHP-99-33B	6/6/1999	209.4	
AOC_5	SHP-99-33B	9/8/1999	208.6	
AOC_5	SHP-99-33B	11/16/2001	209.6	
AOC_5	SHP-99-33B	8/4/2005	210.4	
AOC_5	SHP-99-33B	8/24/2005	210.2	
AOC_5	SHP-99-33B	8/26/2005	210.2	
AOC_5	SHP-99-33B	4/10/2006	210.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-99-33B	6/5/2006	212.0	
AOC_5	SHP-99-33B	9/18/2006	210.5	
AOC_5	SHP-99-33B	12/15/2006	211.3	
AOC_5	SHP-99-34A	2/23/1999	210.0	
AOC_5	SHP-99-34A	6/6/1999	208.8	
AOC_5	SHP-99-34A	9/8/1999	208.5	
AOC_5	SHP-99-34A	11/16/2001	209.1	
AOC_5	SHP-99-34A	8/4/2005	209.0	
AOC_5	SHP-99-34A	8/24/2005	208.9	
AOC_5	SHP-99-34A	8/26/2005	208.9	
AOC_5	SHP-99-34A	6/5/2006	211.0	
AOC_5	SHP-99-34A	12/15/2006	209.9	
AOC_5	SHP-99-34A	4/8/2007	209.8	
AOC_5	SHP-99-34A	4/9/2007	209.8	
AOC_5	SHP-99-34A	10/15/2007	209.2	
AOC_5	SHP-99-34A	2/20/2008	211.0	
AOC_5	SHP-99-34A	2/25/2008	210.2	
AOC_5	SHP-99-34A	3/4/2008	210.2	
AOC_5	SHP-99-34A	4/16/2008	210.1	
AOC_5	SHP-99-34A	9/30/2008	210.4	
AOC_5	SHP-99-34A	4/28/2009	210.2	
AOC_5	SHP-99-34A	11/3/2009	211.0	
AOC_5	SHP-99-34A	4/20/2010	210.0	
AOC_5	SHP-99-34A	10/7/2010	209.9	
AOC_5	SHP-99-34A	4/4/2011	210.0	
AOC_5	SHP-99-34A	11/8/2011	210.3	
AOC_5	SHP-99-34A	4/10/2012	209.2	
AOC_5	SHP-99-34B	2/23/1999	212.9	
AOC_5	SHP-99-34B	6/6/1999	211.6	
AOC_5	SHP-99-34B	9/8/1999	210.9	
AOC_5	SHP-99-34B	11/16/2001	211.4	
AOC_5	SHP-99-34B	8/4/2005	211.4	
AOC_5	SHP-99-34B	8/24/2005	211.6	
AOC_5	SHP-99-34B	8/26/2005	211.7	
AOC_5	SHP-99-34B	4/10/2006	211.7	
AOC_5	SHP-99-34B	6/5/2006	212.9	
AOC_5	SHP-99-34B	9/18/2006	212.0	
AOC_5	SHP-99-34B	12/15/2006	212.5	
AOC_5	SHP-99-34B	4/8/2007	212.5	
AOC_5	SHP-99-34B	4/9/2007	212.5	
AOC_5	SHP-99-34B	10/15/2007	211.1	
AOC_5	SHP-99-34B	2/20/2008	212.6	
AOC_5	SHP-99-34B	2/25/2008	213.3	
AOC_5	SHP-99-34B	3/4/2008	213.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-99-34B	4/16/2008	212.6	
AOC_5	SHP-99-34B	9/30/2008	212.3	
AOC_5	SHP-99-34B	4/28/2009	212.1	
AOC_5	SHP-99-34B	11/3/2009	213.0	
AOC_5	SHP-99-34B	4/20/2010	213.4	
AOC_5	SHP-99-34B	10/7/2010	211.0	
AOC_5	SHP-99-34B	4/4/2011	213.1	
AOC_5	SHP-99-34B	11/8/2011	212.7	
AOC_5	SHP-99-34B	4/10/2012	211.3	
AOC_5	SHP-99-34B	11/5/2012	211.7	
AOC_5	SHP-99-34B	4/25/2013	212.1	
AOC_5	SHP-99-34B	5/15/2013	211.6	
AOC_5	SHP-99-34B	5/30/2013	211.9	
AOC_5	SHP-99-34B	6/11/2013	212.3	
AOC_5	SHP-99-34B	10/21/2013	210.7	
AOC_5	SHP-99-34B	10/6/2014	211.1	
AOC_5	SHP-99-34B	6/3/2015	212.0	
AOC_5	SHP-99-34B	6/17/2015	211.8	
AOC_5	SHP-99-34B	10/20/2015	211.0	
AOC_5	SHP-99-34B	12/16/2015	211.5	
AOC_5	SHP-99-34B	6/9/2016	211.7	
AOC_5	SHP-99-34B	8/16/2016	210.8	
AOC_5	SHP-99-34B	10/20/2016	210.8	
AOC_5	SHP-99-34B	11/1/2018	212.3	
AOC_5	SHP-99-34B	10/22/2019	211.1	
AOC_5	SHP-99-35X	6/6/1999	217.8	
AOC_5	SHP-99-35X	9/8/1999	220.1	
AOC_5	SHP-99-35X	11/16/2001	220.6	
AOC_5	SHP-99-35X	8/4/2005	222.0	
AOC_5	SHP-99-35X	8/24/2005	221.8	
AOC_5	SHP-99-35X	8/26/2005	223.2	
AOC_5	SHP-99-35X	4/10/2006	222.5	
AOC_5	SHP-99-35X	6/5/2006	222.6	
AOC_5	SHP-99-35X	9/18/2006	221.9	
AOC_5	SHP-99-35X	12/15/2006	221.5	
AOC_5	SHP-99-35X	4/8/2007	221.5	
AOC_5	SHP-99-35X	4/9/2007	221.5	
AOC_5	SHP-99-35X	10/15/2007	221.0	
AOC_5	SHP-99-35X	2/20/2008	221.2	
AOC_5	SHP-99-35X	2/25/2008	221.3	
AOC_5	SHP-99-35X	3/4/2008	221.5	
AOC_5	SHP-99-35X	4/16/2008	222.6	
AOC_5	SHP-99-35X	6/10/2008	222.4	
AOC_5	SHP-99-35X	8/19/2008	221.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHP-99-35X	9/15/2008	221.5	
AOC_5	SHP-99-35X	9/30/2008	218.6	
AOC_5	SHP-99-35X	4/28/2009	222.4	
AOC_5	SHP-99-35X	9/14/2009	221.7	
AOC_5	SHP-99-35X	10/26/2009	221.3	
AOC_5	SHP-99-35X	11/3/2009	221.3	
AOC_5	SHP-99-35X	4/20/2010	223.0	
AOC_5	SHP-99-35X	4/27/2010	223.3	
AOC_5	SHP-99-35X	9/14/2010	221.1	
AOC_5	SHP-99-35X	10/7/2010	221.0	
AOC_5	SHP-99-35X	4/4/2011	221.4	
AOC_5	SHP-99-35X	7/25/2011	221.5	
AOC_5	SHP-99-35X	11/8/2011	221.8	
AOC_5	SHP-99-35X	4/10/2012	221.7	
AOC_5	SHP-99-35X	6/26/2012	221.4	
AOC_5	SHP-99-35X	11/5/2012	220.7	
AOC_5	SHP-99-35X	11/6/2012	220.8	
AOC_5	SHP-99-35X	4/25/2013	221.4	
AOC_5	SHP-99-35X	5/15/2013	221.4	
AOC_5	SHP-99-35X	6/11/2013	221.4	
AOC_5	SHP-99-35X	10/21/2013	221.3	
AOC_5	SHP-99-35X	4/22/2014	221.2	
AOC_5	SHP-99-35X	10/6/2014	223.3	
AOC_5	SHP-99-35X	6/3/2015	221.9	
AOC_5	SHP-99-35X	6/17/2015	221.9	
AOC_5	SHP-99-35X	10/20/2015	222.7	
AOC_5	SHP-99-35X	12/16/2015	219.6	
AOC_5	SHP-99-35X	6/9/2016	221.6	
AOC_5	SHP-99-35X	8/16/2016	221.2	
AOC_5	SHP-99-35X	11/15/2016	220.5	
AOC_5	SHP-99-35X	5/11/2018	222.5	
AOC_5	SHP-99-35X	11/1/2018		232.3
AOC_5	SHP-99-35X	4/11/2019	223.7	
AOC_5	SHP-99-35X	10/22/2019	221.9	
AOC_5	SHP-99-35X	4/29/2020	223.4	
AOC_5	SHSG-13-01G	7/20/2013	198.1	
AOC_5	SHSG-13-01G	4/23/2014	198.6	
AOC_5	SHSG-13-01G	10/6/2014		
AOC_5	SHSG-13-01G	10/7/2014	198.7	
AOC_5	SHSG-13-01G	10/20/2015		
AOC_5	SHSG-13-01G	10/22/2019	200.5	
AOC_5	SHSG-13-02G	7/20/2013	202.9	
AOC_5	SHSG-13-02G	4/23/2014	202.5	
AOC_5	SHSG-13-02G	10/6/2014		

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_5	SHSG-13-02G	10/7/2014	202.1	
AOC_5	SHSG-13-02G	10/20/2015		
AOC_5	SHSG-14-01G	4/23/2014	208.8	
AOC_5	SHSG-14-01G	10/22/2019	212.3	
AOC_50	50PZ-19-01	8/14/2019	209.9	
AOC_50	50PZ-19-01	10/7/2019	209.0	
AOC_50	50PZ-19-01	4/27/2020	210.2	
AOC_50	50PZ-19-02	8/14/2019	207.0	
AOC_50	50PZ-19-02	10/7/2019	205.9	
AOC_50	50PZ-19-02	4/27/2020	207.7	
AOC_50	50PZ-19-03	10/7/2019	213.3	
AOC_50	50PZ-19-03	4/27/2020	214.8	
AOC_50	50PZ-19-04	10/7/2019	208.2	
AOC_50	50PZ-19-04	4/27/2020	209.3	
AOC_50	50PZ-19-05	10/7/2019	212.1	
AOC_50	50PZ-19-05	4/27/2020	212.9	
AOC_50	50PZ-19-06	10/7/2019	204.5	
AOC_50	50PZ-19-06	4/27/2020	207.6	
AOC_50	50PZ-19-07	10/7/2019	201.0	
AOC_50	50PZ-19-07	4/27/2020	202.6	
AOC_50	G6M-01-01X	10/12/2015	201.0	
AOC_50	G6M-02-01X	6/15/2015	208.0	
AOC_50	G6M-02-01X	10/12/2015	206.4	
AOC_50	G6M-02-01X	2/3/2016	206.4	
AOC_50	G6M-02-01X	5/18/2016	207.4	
AOC_50	G6M-02-01X	11/7/2016		
AOC_50	G6M-02-01X	5/15/2017		
AOC_50	G6M-02-01X	10/2/2017	207.3	
AOC_50	G6M-02-01X	4/2/2018	208.3	
AOC_50	G6M-02-01X	10/15/2018	209.3	
AOC_50	G6M-02-01X	4/2/2019	210.3	
AOC_50	G6M-02-01X	8/14/2019	209.1	
AOC_50	G6M-02-01X	10/7/2019	208.1	
AOC_50	G6M-02-01X	4/27/2020	209.3	
AOC_50	G6M-02-01X	5/11/2020	209.7	
AOC_50	G6M-02-02X	10/12/2015	207.4	
AOC_50	G6M-02-03X	8/21/2015	203.2	
AOC_50	G6M-02-03X	10/12/2015	202.7	
AOC_50	G6M-02-03X	5/18/2016	204.0	
AOC_50	G6M-02-03X	11/7/2016	202.6	
AOC_50	G6M-02-03X	5/15/2017	205.6	
AOC_50	G6M-02-03X	10/2/2017		174.4
AOC_50	G6M-02-03X	8/14/2019	204.9	
AOC_50	G6M-02-03X	10/7/2019	203.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_50	G6M-02-03X	4/27/2020	206.4	
AOC_50	G6M-02-03X	5/11/2020	206.5	
AOC_50	G6M-02-04X	6/15/2015	204.8	
AOC_50	G6M-02-04X	8/21/2015	203.2	
AOC_50	G6M-02-04X	9/14/2015	202.8	
AOC_50	G6M-02-04X	10/12/2015	202.6	
AOC_50	G6M-02-04X	5/18/2016	203.9	
AOC_50	G6M-02-04X	11/7/2016	202.5	
AOC_50	G6M-02-04X	5/15/2017	205.6	
AOC_50	G6M-02-04X	10/2/2017	203.3	
AOC_50	G6M-02-04X	4/2/2018	205.3	
AOC_50	G6M-02-04X	10/15/2018	206.2	
AOC_50	G6M-02-04X	4/2/2019	206.4	
AOC_50	G6M-02-04X	8/14/2019	204.8	
AOC_50	G6M-02-04X	10/7/2019	202.9	
AOC_50	G6M-02-04X	4/27/2020	206.3	
AOC_50	G6M-02-04X	5/11/2020	206.5	
AOC_50	G6M-02-06X	8/21/2015	205.8	
AOC_50	G6M-02-06X	5/18/2016	201.5	
AOC_50	G6M-02-06X	11/7/2016	201.2	
AOC_50	G6M-02-06X	5/15/2017	204.4	
AOC_50	G6M-02-06X	10/2/2017	200.4	
AOC_50	G6M-02-06X	4/2/2018	203.6	
AOC_50	G6M-02-06X	10/15/2018	204.7	
AOC_50	G6M-02-06X	4/2/2019	204.4	
AOC_50	G6M-02-06X	10/7/2019	201.3	
AOC_50	G6M-02-06X	4/27/2020	204.4	
AOC_50	G6M-02-06X	5/11/2020	203.9	
AOC_50	G6M-02-07X	6/15/2015		148.7
AOC_50	G6M-02-07X	8/21/2015		
AOC_50	G6M-02-07X	5/18/2016	201.3	
AOC_50	G6M-02-07X	11/7/2016	201.0	
AOC_50	G6M-02-07X	5/15/2017	204.0	
AOC_50	G6M-02-07X	10/2/2017	200.5	
AOC_50	G6M-02-07X	4/2/2018	203.5	
AOC_50	G6M-02-07X	10/15/2018	204.5	
AOC_50	G6M-02-07X	4/2/2019	204.1	
AOC_50	G6M-02-07X	10/7/2019	201.1	
AOC_50	G6M-02-07X	4/27/2020	204.2	
AOC_50	G6M-02-07X	5/11/2020	203.7	
AOC_50	G6M-02-08X	8/21/2015	210.2	
AOC_50	G6M-02-08X	9/9/2015	209.8	
AOC_50	G6M-02-08X	10/12/2015	209.3	
AOC_50	G6M-02-08X	2/3/2016	210.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_50	G6M-02-08X	5/18/2016	210.1	
AOC_50	G6M-02-08X	11/7/2016	208.5	
AOC_50	G6M-02-08X	5/15/2017	209.8	
AOC_50	G6M-02-08X	10/2/2017	209.3	
AOC_50	G6M-02-08X	4/2/2018	210.1	
AOC_50	G6M-02-08X	10/15/2018	212.3	
AOC_50	G6M-02-08X	4/2/2019	211.7	
AOC_50	G6M-02-08X	8/14/2019	211.9	
AOC_50	G6M-02-08X	10/7/2019	209.6	
AOC_50	G6M-02-08X	4/27/2020	210.9	
AOC_50	G6M-02-08X	5/11/2020	212.7	
AOC_50	G6M-02-09X	8/21/2015	204.0	
AOC_50	G6M-02-09X	10/12/2015	203.5	
AOC_50	G6M-02-10X	10/12/2015	202.4	
AOC_50	G6M-02-11X	6/15/2015	202.8	
AOC_50	G6M-02-11X	8/21/2015	202.1	
AOC_50	G6M-02-11X	9/10/2015	201.6	
AOC_50	G6M-02-11X	10/12/2015	201.5	
AOC_50	G6M-02-11X	2/3/2016	202.2	
AOC_50	G6M-02-11X	5/18/2016	202.8	
AOC_50	G6M-02-11X	11/7/2016	201.9	
AOC_50	G6M-02-11X	5/15/2017	204.7	
AOC_50	G6M-02-11X	10/2/2017	202.0	
AOC_50	G6M-02-11X	4/2/2018	204.5	
AOC_50	G6M-02-11X	10/15/2018	205.5	
AOC_50	G6M-02-11X	4/2/2019	205.3	
AOC_50	G6M-02-11X	8/14/2019	203.5	
AOC_50	G6M-02-11X	10/7/2019	202.3	
AOC_50	G6M-02-11X	4/27/2020	205.5	
AOC_50	G6M-02-11X	5/11/2020	205.4	
AOC_50	G6M-02-12X	6/15/2015	202.7	
AOC_50	G6M-02-12X	10/12/2015	200.5	
AOC_50	G6M-02-12X	5/18/2016	202.7	
AOC_50	G6M-02-12X	11/7/2016	201.8	
AOC_50	G6M-02-12X	5/15/2017	204.7	
AOC_50	G6M-02-12X	10/2/2017	201.8	
AOC_50	G6M-02-12X	10/7/2019	203.2	
AOC_50	G6M-02-12X	4/27/2020	205.4	
AOC_50	G6M-02-12X	5/11/2020	205.3	
AOC_50	G6M-02-13X	6/15/2015	203.6	
AOC_50	G6M-02-13X	8/21/2015	202.9	
AOC_50	G6M-02-13X	9/11/2015	201.4	
AOC_50	G6M-02-13X	10/12/2015	202.3	
AOC_50	G6M-02-13X	5/18/2016	203.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_50	G6M-02-13X	11/7/2016	197.0	
AOC_50	G6M-02-13X	5/15/2017	205.3	
AOC_50	G6M-02-13X	10/2/2017	202.9	
AOC_50	G6M-02-13X	4/2/2018	205.1	
AOC_50	G6M-02-13X	10/15/2018	206.0	
AOC_50	G6M-02-13X	4/2/2019		155.5
AOC_50	G6M-02-13X	10/7/2019	202.8	
AOC_50	G6M-02-13X	4/27/2020	205.9	
AOC_50	G6M-02-13X	5/11/2020	206.1	
AOC_50	G6M-02-31BR	10/12/2015	208.3	
AOC_50	G6M-03-01X	6/15/2015	211.1	
AOC_50	G6M-03-01X	8/21/2015	210.2	
AOC_50	G6M-03-01X	9/10/2015	210.2	
AOC_50	G6M-03-01X	10/12/2015	209.3	
AOC_50	G6M-03-01X	2/3/2016	209.2	
AOC_50	G6M-03-01X	5/18/2016	210.1	
AOC_50	G6M-03-01X	11/7/2016	208.7	
AOC_50	G6M-03-01X	5/15/2017	211.7	
AOC_50	G6M-03-01X	10/2/2017	210.5	
AOC_50	G6M-03-01X	4/27/2020	212.7	
AOC_50	G6M-03-02X	6/15/2015	210.2	
AOC_50	G6M-03-02X	10/12/2015	209.7	
AOC_50	G6M-03-02X	5/18/2016	210.5	
AOC_50	G6M-03-02X	11/7/2016	208.8	
AOC_50	G6M-03-02X	5/15/2017	211.2	
AOC_50	G6M-03-02X	10/2/2017	210.9	
AOC_50	G6M-03-04X	10/12/2015	210.5	
AOC_50	G6M-03-07X	6/15/2015	205.7	
AOC_50	G6M-03-07X	9/14/2015	204.5	
AOC_50	G6M-03-07X	10/12/2015	204.2	
AOC_50	G6M-03-07X	2/3/2016	204.4	
AOC_50	G6M-03-07X	5/18/2016	205.3	
AOC_50	G6M-03-07X	11/7/2016	203.8	
AOC_50	G6M-03-07X	5/15/2017	206.7	
AOC_50	G6M-03-07X	10/2/2017	205.0	
AOC_50	G6M-03-07X	4/2/2018	206.4	
AOC_50	G6M-03-07X	10/15/2018	207.4	
AOC_50	G6M-03-07X	4/2/2019	207.9	
AOC_50	G6M-03-07X	8/14/2019	206.7	
AOC_50	G6M-03-07X	10/7/2019	205.2	
AOC_50	G6M-03-07X	4/27/2020	207.2	
AOC_50	G6M-03-07X	5/11/2020	207.7	
AOC_50	G6M-03-07X	5/13/2020	207.7	
AOC_50	G6M-03-08X	6/15/2015	202.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_50	G6M-03-08X	10/12/2015	201.3	
AOC_50	G6M-03-08X	2/3/2016	202.4	
AOC_50	G6M-03-08X	5/18/2016	202.6	
AOC_50	G6M-03-08X	11/7/2016	201.7	
AOC_50	G6M-03-08X	5/15/2017	204.5	
AOC_50	G6M-03-08X	10/2/2017	201.7	
AOC_50	G6M-03-08X	10/7/2019	202.0	
AOC_50	G6M-03-08X	4/27/2020	205.2	
AOC_50	G6M-03-08X	5/13/2020	204.8	
AOC_50	G6M-03-09X	6/15/2015	202.5	
AOC_50	G6M-03-09X	10/12/2015	201.3	
AOC_50	G6M-03-09X	2/3/2016	201.9	
AOC_50	G6M-03-09X	5/18/2016	202.5	
AOC_50	G6M-03-09X	11/7/2016	201.6	
AOC_50	G6M-03-09X	5/15/2017	204.4	
AOC_50	G6M-03-09X	10/2/2017	201.6	
AOC_50	G6M-03-09X	10/7/2019	202.0	
AOC_50	G6M-03-09X	4/27/2020	205.2	
AOC_50	G6M-03-09X	5/11/2020	205.1	
AOC_50	G6M-03-10X	6/15/2015	202.6	
AOC_50	G6M-03-10X	8/21/2015	201.9	
AOC_50	G6M-03-10X	9/10/2015		234.4
AOC_50	G6M-03-10X	10/12/2015	201.4	
AOC_50	G6M-03-10X	2/3/2016	201.8	
AOC_50	G6M-03-10X	5/18/2016	202.6	
AOC_50	G6M-03-10X	11/7/2016	201.7	
AOC_50	G6M-03-10X	5/15/2017	204.6	
AOC_50	G6M-03-10X	10/2/2017	201.7	
AOC_50	G6M-03-10X	4/2/2018	204.3	
AOC_50	G6M-03-10X	10/15/2018	205.3	
AOC_50	G6M-03-10X	4/2/2019	205.1	
AOC_50	G6M-03-10X	8/14/2019	203.3	
AOC_50	G6M-03-10X	10/7/2019	202.1	
AOC_50	G6M-03-10X	4/27/2020	205.3	
AOC_50	G6M-03-10X	5/11/2020	205.2	
AOC_50	G6M-03-11X	10/12/2015	201.9	
AOC_50	G6M-04-01X	6/15/2015	208.6	
AOC_50	G6M-04-01X	8/21/2015	207.9	
AOC_50	G6M-04-01X	10/12/2015	207.1	
AOC_50	G6M-04-01X	2/3/2016	206.9	
AOC_50	G6M-04-01X	5/18/2016	208.1	
AOC_50	G6M-04-01X	11/7/2016		
AOC_50	G6M-04-01X	5/15/2017		
AOC_50	G6M-04-01X	10/2/2017	208.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_50	G6M-04-01X	4/2/2018	209.1	
AOC_50	G6M-04-01X	10/15/2018	209.9	
AOC_50	G6M-04-01X	4/2/2019	211.0	
AOC_50	G6M-04-01X	8/14/2019	209.8	
AOC_50	G6M-04-01X	10/7/2019	208.7	
AOC_50	G6M-04-01X	4/27/2020	209.9	
AOC_50	G6M-04-01X	5/11/2020	210.2	
AOC_50	G6M-04-02X	6/15/2015	206.4	
AOC_50	G6M-04-02X	8/21/2015	207.5	
AOC_50	G6M-04-02X	9/11/2015	205.1	
AOC_50	G6M-04-02X	10/12/2015	204.8	
AOC_50	G6M-04-02X	2/3/2016	204.7	
AOC_50	G6M-04-02X	5/18/2016	206.0	
AOC_50	G6M-04-02X	11/7/2016	204.2	
AOC_50	G6M-04-02X	5/15/2017	206.9	
AOC_50	G6M-04-02X	10/2/2017	205.9	
AOC_50	G6M-04-02X	4/2/2018	207.0	
AOC_50	G6M-04-02X	10/15/2018	207.9	
AOC_50	G6M-04-02X	4/2/2019	208.7	
AOC_50	G6M-04-02X	8/14/2019	207.4	
AOC_50	G6M-04-02X	10/7/2019	205.8	
AOC_50	G6M-04-02X	4/27/2020	207.7	
AOC_50	G6M-04-02X	5/11/2020	205.2	
AOC_50	G6M-04-02X	5/12/2020	208.2	
AOC_50	G6M-04-03X	6/15/2015	208.3	
AOC_50	G6M-04-03X	8/21/2015	207.3	
AOC_50	G6M-04-03X	10/12/2015	205.7	
AOC_50	G6M-04-03X	2/3/2016	205.3	
AOC_50	G6M-04-03X	5/18/2016	206.8	
AOC_50	G6M-04-03X	5/15/2017	207.8	
AOC_50	G6M-04-03X	10/2/2017	206.8	
AOC_50	G6M-04-03X	4/2/2018	207.9	
AOC_50	G6M-04-03X	10/15/2018	208.7	
AOC_50	G6M-04-03X	4/2/2019	209.7	
AOC_50	G6M-04-03X	8/14/2019	208.3	
AOC_50	G6M-04-03X	10/7/2019	207.3	
AOC_50	G6M-04-03X	4/27/2020	208.8	
AOC_50	G6M-04-03X	5/11/2020	209.0	
AOC_50	G6M-04-03X	5/12/2020	208.9	
AOC_50	G6M-04-04X	6/15/2015	204.4	
AOC_50	G6M-04-04X	8/21/2015	203.6	
AOC_50	G6M-04-04X	9/14/2015	203.1	
AOC_50	G6M-04-04X	10/12/2015	202.9	
AOC_50	G6M-04-04X	2/3/2016	203.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_50	G6M-04-04X	5/18/2016	204.2	
AOC_50	G6M-04-04X	5/15/2017	205.6	
AOC_50	G6M-04-04X	10/2/2017	203.9	
AOC_50	G6M-04-04X	4/2/2018	205.5	
AOC_50	G6M-04-04X	10/15/2018	206.3	
AOC_50	G6M-04-04X	4/2/2019	206.8	
AOC_50	G6M-04-04X	8/14/2019	205.3	
AOC_50	G6M-04-04X	10/7/2019	203.8	
AOC_50	G6M-04-04X	4/27/2020	206.4	
AOC_50	G6M-04-04X	5/11/2020	206.5	
AOC_50	G6M-04-05X	6/15/2015	202.3	
AOC_50	G6M-04-05X	9/10/2015	201.4	
AOC_50	G6M-04-05X	10/12/2015	201.3	
AOC_50	G6M-04-05X	2/3/2016	201.7	
AOC_50	G6M-04-05X	5/18/2016	202.6	
AOC_50	G6M-04-05X	5/15/2017	204.6	
AOC_50	G6M-04-05X	10/2/2017	201.7	
AOC_50	G6M-04-05X	4/2/2018	204.3	
AOC_50	G6M-04-05X	10/15/2018	205.3	
AOC_50	G6M-04-05X	4/2/2019	205.1	
AOC_50	G6M-04-05X	8/14/2019	203.2	
AOC_50	G6M-04-05X	10/7/2019	202.0	
AOC_50	G6M-04-05X	4/27/2020	205.2	
AOC_50	G6M-04-05X	5/13/2020	204.0	
AOC_50	G6M-04-06X	6/15/2015	201.7	
AOC_50	G6M-04-06X	10/12/2015	200.8	
AOC_50	G6M-04-06X	5/18/2016	201.8	
AOC_50	G6M-04-06X	11/7/2016	201.2	
AOC_50	G6M-04-06X	5/15/2017	204.0	
AOC_50	G6M-04-06X	10/2/2017	200.7	
AOC_50	G6M-04-06X	10/7/2019	201.3	
AOC_50	G6M-04-06X	4/27/2020	204.4	
AOC_50	G6M-04-06X	5/11/2020	204.1	
AOC_50	G6M-04-07X	6/15/2015	201.8	
AOC_50	G6M-04-07X	10/12/2015	199.9	
AOC_50	G6M-04-07X	5/18/2016	201.9	
AOC_50	G6M-04-07X	11/7/2016	201.3	
AOC_50	G6M-04-07X	5/15/2017	203.7	
AOC_50	G6M-04-07X	10/2/2017	200.7	
AOC_50	G6M-04-07X	4/2/2018	203.3	
AOC_50	G6M-04-07X	10/15/2018	204.6	
AOC_50	G6M-04-07X	4/2/2019	204.3	
AOC_50	G6M-04-07X	10/7/2019	201.4	
AOC_50	G6M-04-07X	4/27/2020	204.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_50	G6M-04-07X	5/11/2020	204.3	
AOC_50	G6M-04-07X	5/12/2020	212.3	
AOC_50	G6M-04-08X	10/7/2019	201.3	
AOC_50	G6M-04-08X	4/27/2020	204.6	
AOC_50	G6M-04-08X	5/13/2020	203.8	
AOC_50	G6M-04-09X	6/15/2015	210.8	
AOC_50	G6M-04-09X	10/12/2015	209.0	
AOC_50	G6M-04-09X	2/3/2016	208.8	
AOC_50	G6M-04-09X	5/18/2016	209.9	
AOC_50	G6M-04-09X	11/7/2016	207.7	
AOC_50	G6M-04-09X	5/15/2017	211.1	
AOC_50	G6M-04-09X	10/2/2017	211.8	
AOC_50	G6M-04-09X	4/2/2018	211.3	
AOC_50	G6M-04-09X	10/15/2018	211.8	
AOC_50	G6M-04-09X	4/2/2019	213.0	
AOC_50	G6M-04-09X	10/7/2019	210.7	
AOC_50	G6M-04-09X	4/27/2020	212.2	
AOC_50	G6M-04-09X	5/11/2020	212.4	
AOC_50	G6M-04-10A	6/15/2015	211.2	
AOC_50	G6M-04-10A	8/21/2015	210.4	
AOC_50	G6M-04-10A	10/12/2015	209.6	
AOC_50	G6M-04-10A	5/18/2016	210.4	
AOC_50	G6M-04-10A	11/7/2016	208.7	
AOC_50	G6M-04-10A	5/15/2017	211.6	
AOC_50	G6M-04-10A	10/2/2017	210.7	
AOC_50	G6M-04-10A	4/2/2018	211.9	
AOC_50	G6M-04-10A	4/2/2019	212.5	
AOC_50	G6M-04-10A	8/14/2019	211.2	
AOC_50	G6M-04-10A	10/7/2019	210.9	
AOC_50	G6M-04-10A	4/27/2020	212.7	
AOC_50	G6M-04-10A	5/11/2020	213.0	
AOC_50	G6M-04-10A	5/12/2020	212.9	
AOC_50	G6M-04-10X	6/15/2015	210.3	
AOC_50	G6M-04-10X	8/21/2015	210.0	
AOC_50	G6M-04-10X	9/9/2015	209.5	
AOC_50	G6M-04-10X	10/12/2015	209.1	
AOC_50	G6M-04-10X	2/3/2016	209.6	
AOC_50	G6M-04-10X	5/18/2016	209.7	
AOC_50	G6M-04-10X	11/7/2016	208.2	
AOC_50	G6M-04-10X	5/15/2017	211.2	
AOC_50	G6M-04-10X	10/2/2017	210.3	
AOC_50	G6M-04-10X	4/2/2018	211.4	
AOC_50	G6M-04-10X	10/15/2018	212.1	
AOC_50	G6M-04-10X	4/2/2019	213.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_50	G6M-04-10X	8/14/2019	211.7	
AOC_50	G6M-04-10X	10/7/2019	210.6	
AOC_50	G6M-04-10X	4/27/2020	212.1	
AOC_50	G6M-04-10X	5/11/2020	212.4	
AOC_50	G6M-04-11X	6/15/2015	210.0	
AOC_50	G6M-04-11X	10/12/2015	208.3	
AOC_50	G6M-04-11X	5/18/2016	209.0	
AOC_50	G6M-04-11X	11/7/2016	207.3	
AOC_50	G6M-04-11X	5/15/2017	210.2	
AOC_50	G6M-04-11X	10/2/2017	209.3	
AOC_50	G6M-04-11X	4/2/2018	210.4	
AOC_50	G6M-04-11X	10/15/2018	211.1	
AOC_50	G6M-04-11X	4/2/2019	212.2	
AOC_50	G6M-04-11X	8/14/2019	210.9	
AOC_50	G6M-04-11X	10/7/2019	209.9	
AOC_50	G6M-04-11X	4/27/2020	211.0	
AOC_50	G6M-04-11X	5/11/2020	211.6	
AOC_50	G6M-04-12X	8/21/2015	211.0	
AOC_50	G6M-04-13X	6/15/2015	211.3	
AOC_50	G6M-04-13X	8/21/2015	210.4	
AOC_50	G6M-04-13X	10/12/2015	209.6	
AOC_50	G6M-04-13X	5/18/2016	210.6	
AOC_50	G6M-04-13X	11/7/2016	208.5	
AOC_50	G6M-04-13X	5/15/2017	211.8	
AOC_50	G6M-04-13X	10/2/2017	210.7	
AOC_50	G6M-04-13X	4/2/2018	211.9	
AOC_50	G6M-04-13X	10/15/2018	212.6	
AOC_50	G6M-04-13X	4/2/2019	213.5	
AOC_50	G6M-04-13X	10/7/2019	211.1	
AOC_50	G6M-04-13X	4/27/2020	212.7	
AOC_50	G6M-04-13X	5/11/2020	213.0	
AOC_50	G6M-04-14X	5/18/2016	201.7	
AOC_50	G6M-04-14X	11/7/2016	201.3	
AOC_50	G6M-04-14X	5/15/2017	204.2	
AOC_50	G6M-04-14X	10/2/2017		190.2
AOC_50	G6M-04-14X	4/2/2018	203.8	
AOC_50	G6M-04-14X	10/15/2018	204.8	
AOC_50	G6M-04-14X	4/2/2019	204.4	
AOC_50	G6M-04-14X	10/7/2019	201.3	
AOC_50	G6M-04-14X	4/27/2020	201.6	
AOC_50	G6M-04-14X	5/13/2020	203.8	
AOC_50	G6M-04-15X	6/15/2015	210.8	
AOC_50	G6M-04-15X	10/12/2015	209.1	
AOC_50	G6M-04-15X	5/18/2016	210.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_50	G6M-04-15X	11/7/2016	208.2	
AOC_50	G6M-04-15X	5/15/2017	211.1	
AOC_50	G6M-04-15X	10/2/2017	210.2	
AOC_50	G6M-04-15X	4/2/2018	211.3	
AOC_50	G6M-04-15X	10/15/2018	211.9	
AOC_50	G6M-04-15X	4/2/2019	212.9	
AOC_50	G6M-04-15X	8/14/2019	211.7	
AOC_50	G6M-04-15X	10/7/2019	210.6	
AOC_50	G6M-04-15X	4/27/2020	212.1	
AOC_50	G6M-04-15X	5/11/2020	212.4	
AOC_50	G6M-04-22X	6/15/2015	209.7	
AOC_50	G6M-04-22X	10/12/2015	208.1	
AOC_50	G6M-04-22X	5/18/2016	208.9	
AOC_50	G6M-04-22X	11/7/2016	207.1	
AOC_50	G6M-04-22X	5/15/2017	209.9	
AOC_50	G6M-04-22X	10/2/2017	209.3	
AOC_50	G6M-04-22X	4/2/2018	210.0	
AOC_50	G6M-04-22X	10/15/2018	210.7	
AOC_50	G6M-04-22X	4/2/2019	211.9	
AOC_50	G6M-04-22X	8/14/2019	210.8	
AOC_50	G6M-04-22X	10/7/2019	209.8	
AOC_50	G6M-04-22X	4/27/2020	210.8	
AOC_50	G6M-04-22X	5/11/2020	211.3	
AOC_50	G6M-04-31X	6/15/2015		184.5
AOC_50	G6M-04-31X	10/12/2015	208.2	
AOC_50	G6M-04-31X	5/18/2016	208.7	
AOC_50	G6M-04-31X	11/7/2016	207.3	
AOC_50	G6M-04-31X	5/15/2017	210.0	
AOC_50	G6M-04-31X	10/2/2017	204.6	
AOC_50	G6M-04-31X	4/2/2018	210.3	
AOC_50	G6M-04-31X	10/15/2018	211.1	
AOC_50	G6M-04-31X	4/2/2019	212.2	
AOC_50	G6M-04-31X	8/14/2019	211.0	
AOC_50	G6M-04-31X	10/7/2019	209.9	
AOC_50	G6M-04-31X	4/27/2020	211.3	
AOC_50	G6M-04-31X	5/11/2020	211.5	
AOC_50	G6M-06-01X	4/27/2020	206.0	
AOC_50	G6M-07-01X	4/2/2019	210.5	
AOC_50	G6M-07-01X	5/11/2020	209.8	
AOC_50	G6M-07-01X	5/13/2020	209.9	
AOC_50	G6M-07-02X	6/15/2015	211.4	
AOC_50	G6M-07-02X	10/12/2015	209.7	
AOC_50	G6M-07-02X	5/18/2016	210.4	
AOC_50	G6M-07-02X	11/7/2016	208.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_50	G6M-07-02X	5/15/2017	211.3	
AOC_50	G6M-07-02X	10/2/2017	210.5	
AOC_50	G6M-07-02X	4/2/2018	211.2	
AOC_50	G6M-07-02X	10/15/2018	213.0	
AOC_50	G6M-07-02X	4/2/2019	212.9	
AOC_50	G6M-07-02X	8/14/2019	212.3	
AOC_50	G6M-07-02X	10/7/2019	210.6	
AOC_50	G6M-07-02X	4/27/2020	212.0	
AOC_50	G6M-07-02X	5/11/2020	213.1	
AOC_50	G6M-07-02X	5/12/2020	213.0	
AOC_50	G6M-13-01X	6/15/2015	202.6	
AOC_50	G6M-13-01X	10/12/2015	201.4	
AOC_50	G6M-13-01X	2/3/2016	201.9	
AOC_50	G6M-13-01X	5/18/2016	202.7	
AOC_50	G6M-13-01X	11/7/2016	201.8	
AOC_50	G6M-13-01X	5/15/2017	204.6	
AOC_50	G6M-13-01X	10/2/2017	201.9	
AOC_50	G6M-13-01X	4/2/2018	204.4	
AOC_50	G6M-13-01X	10/15/2018	205.4	
AOC_50	G6M-13-01X	4/2/2019	205.1	
AOC_50	G6M-13-01X	8/14/2019	203.4	
AOC_50	G6M-13-01X	10/7/2019	210.3	
AOC_50	G6M-13-01X	4/27/2020	205.7	
AOC_50	G6M-13-01X	5/11/2020	205.3	
AOC_50	G6M-13-02X	6/15/2015	203.6	
AOC_50	G6M-13-02X	10/12/2015	202.3	
AOC_50	G6M-13-02X	5/18/2016	203.6	
AOC_50	G6M-13-02X	11/7/2016	202.3	
AOC_50	G6M-13-02X	5/15/2017	205.2	
AOC_50	G6M-13-02X	10/2/2017	202.9	
AOC_50	G6M-13-02X	4/2/2018	205.1	
AOC_50	G6M-13-02X	10/15/2018	205.9	
AOC_50	G6M-13-02X	4/2/2019	206.2	
AOC_50	G6M-13-02X	8/14/2019	204.5	
AOC_50	G6M-13-02X	10/7/2019	203.0	
AOC_50	G6M-13-02X	4/27/2020	206.0	
AOC_50	G6M-13-02X	5/11/2020	205.8	
AOC_50	G6M-13-02X	5/12/2020	205.9	
AOC_50	G6M-13-03X	6/15/2015	206.2	
AOC_50	G6M-13-03X	10/12/2015	204.6	
AOC_50	G6M-13-03X	5/18/2016	205.8	
AOC_50	G6M-13-03X	11/7/2016	204.0	
AOC_50	G6M-13-03X	5/15/2017	207.0	
AOC_50	G6M-13-03X	10/2/2017	205.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_50	G6M-13-03X	4/2/2018	207.0	
AOC_50	G6M-13-03X	10/15/2018	207.7	
AOC_50	G6M-13-03X	4/2/2019	211.5	
AOC_50	G6M-13-03X	8/14/2019	207.1	
AOC_50	G6M-13-03X	10/7/2019	205.5	
AOC_50	G6M-13-03X	4/27/2020	207.8	
AOC_50	G6M-13-03X	5/11/2020	208.0	
AOC_50	G6M-13-04X	6/15/2015	203.0	
AOC_50	G6M-13-04X	10/12/2015	201.6	
AOC_50	G6M-13-04X	2/3/2016	202.2	
AOC_50	G6M-13-04X	5/18/2016	202.9	
AOC_50	G6M-13-04X	11/7/2016	201.9	
AOC_50	G6M-13-04X	5/15/2017	204.7	
AOC_50	G6M-13-04X	10/2/2017	202.1	
AOC_50	G6M-13-04X	4/2/2018	204.6	
AOC_50	G6M-13-04X	10/15/2018	205.6	
AOC_50	G6M-13-04X	4/2/2019	205.4	
AOC_50	G6M-13-04X	8/14/2019	202.7	
AOC_50	G6M-13-04X	10/7/2019	202.4	
AOC_50	G6M-13-04X	4/27/2020	205.6	
AOC_50	G6M-13-04X	5/11/2020	205.4	
AOC_50	G6M-13-05X	6/15/2015	210.7	
AOC_50	G6M-13-05X	10/12/2015	209.0	
AOC_50	G6M-13-05X	2/3/2016	209.0	
AOC_50	G6M-13-05X	5/18/2016	209.9	
AOC_50	G6M-13-05X	11/7/2016	208.2	
AOC_50	G6M-13-05X	5/15/2017	211.1	
AOC_50	G6M-13-05X	10/2/2017	210.0	
AOC_50	G6M-13-05X	4/2/2018	211.2	
AOC_50	G6M-13-05X	10/15/2018	211.9	
AOC_50	G6M-13-05X	4/2/2019	212.8	
AOC_50	G6M-13-05X	8/14/2019	211.6	
AOC_50	G6M-13-05X	10/7/2019	210.5	
AOC_50	G6M-13-05X	4/27/2020	211.5	
AOC_50	G6M-13-05X	5/11/2020	212.3	
AOC_50	G6M-13-05X	5/12/2020	212.2	
AOC_50	G6M-13-06X	6/15/2015	210.5	
AOC_50	G6M-13-06X	8/21/2015	209.7	
AOC_50	G6M-13-06X	9/9/2015	209.2	
AOC_50	G6M-13-06X	10/12/2015	208.6	
AOC_50	G6M-13-06X	2/3/2016	208.5	
AOC_50	G6M-13-06X	5/18/2016	209.8	
AOC_50	G6M-13-06X	11/7/2016	207.8	
AOC_50	G6M-13-06X	5/15/2017	210.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_50	G6M-13-06X	10/2/2017	210.0	
AOC_50	G6M-13-06X	4/2/2018	211.0	
AOC_50	G6M-13-06X	10/15/2018	211.7	
AOC_50	G6M-13-06X	4/2/2019	212.7	
AOC_50	G6M-13-06X	10/7/2019	210.4	
AOC_50	G6M-13-06X	4/27/2020	211.6	
AOC_50	G6M-13-06X	5/11/2020	212.1	
AOC_50	G6M-18-01	4/2/2019	205.5	
AOC_50	G6M-18-01	8/14/2019	203.8	
AOC_50	G6M-18-01	10/7/2019	202.3	
AOC_50	G6M-18-01	4/27/2020	205.6	
AOC_50	G6M-18-01	5/11/2020	205.7	
AOC_50	G6M-18-02	4/2/2019	204.4	
AOC_50	G6M-18-02	8/14/2019	202.5	
AOC_50	G6M-18-02	10/7/2019	201.1	
AOC_50	G6M-18-02	4/27/2020	204.7	
AOC_50	G6M-18-02	5/11/2020	204.5	
AOC_50	G6M-92-10X	10/12/2015	210.8	
AOC_50	G6M-93-13X	9/9/2015	211.1	
AOC_50	G6M-93-13X	10/12/2015	210.5	
AOC_50	G6M-93-13X	2/3/2016	210.3	
AOC_50	G6M-93-13X	5/18/2016	211.6	
AOC_50	G6M-93-13X	11/7/2016	209.5	
AOC_50	G6M-93-13X	5/15/2017	212.7	
AOC_50	G6M-93-13X	10/2/2017	211.8	
AOC_50	G6M-94-15A	10/12/2015	211.9	
AOC_50	G6M-95-19X	6/15/2015	211.6	
AOC_50	G6M-95-19X	10/12/2015	209.7	
AOC_50	G6M-95-19X	5/18/2016	210.6	
AOC_50	G6M-95-19X	11/7/2016	208.6	
AOC_50	G6M-95-19X	5/15/2017	211.9	
AOC_50	G6M-95-19X	10/2/2017	210.9	
AOC_50	G6M-95-19X	4/2/2018	212.1	
AOC_50	G6M-95-19X	10/15/2018	212.7	
AOC_50	G6M-95-19X	4/2/2019	213.7	
AOC_50	G6M-95-19X	8/14/2019	212.2	
AOC_50	G6M-95-19X	10/7/2019	211.2	
AOC_50	G6M-95-19X	4/27/2020	212.8	
AOC_50	G6M-95-19X	5/11/2020	213.1	
AOC_50	G6M-95-20X	6/15/2015	212.2	
AOC_50	G6M-95-20X	10/12/2015	209.9	
AOC_50	G6M-95-20X	5/18/2016	210.8	
AOC_50	G6M-95-20X	11/7/2016	209.0	
AOC_50	G6M-95-20X	5/15/2017	212.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_50	G6M-95-20X	10/2/2017	211.0	
AOC_50	G6M-95-20X	4/2/2018	213.4	
AOC_50	G6M-95-20X	10/15/2018	213.1	
AOC_50	G6M-95-20X	4/2/2019	213.9	
AOC_50	G6M-95-20X	8/14/2019	212.4	
AOC_50	G6M-95-20X	10/7/2019	211.3	
AOC_50	G6M-95-20X	4/27/2020	213.1	
AOC_50	G6M-95-20X	5/11/2020	213.4	
AOC_50	G6M-96-22A	6/15/2015	212.8	
AOC_50	G6M-96-22A	10/12/2015	211.0	
AOC_50	G6M-96-22A	5/18/2016	211.8	
AOC_50	G6M-96-22A	11/7/2016	210.7	
AOC_50	G6M-96-22A	5/15/2017	213.8	
AOC_50	G6M-96-22A	10/2/2017	211.7	
AOC_50	G6M-96-22A	8/14/2019	212.9	
AOC_50	G6M-96-22A	10/7/2019	211.8	
AOC_50	G6M-96-22A	4/27/2020	214.4	
AOC_50	G6M-96-22A	5/11/2020	214.2	
AOC_50	G6M-96-22B	6/15/2015	212.2	
AOC_50	G6M-96-22B	10/12/2015	210.2	
AOC_50	G6M-96-22B	5/18/2016	211.4	
AOC_50	G6M-96-22B	11/7/2016	210.0	
AOC_50	G6M-96-22B	5/15/2017	213.1	
AOC_50	G6M-96-22B	10/2/2017	211.2	
AOC_50	G6M-96-22B	8/14/2019	212.5	
AOC_50	G6M-96-22B	10/7/2019	211.5	
AOC_50	G6M-96-22B	4/27/2020	213.7	
AOC_50	G6M-96-22B	5/11/2020	213.7	
AOC_50	G6M-96-25A	10/12/2015	211.2	
AOC_50	G6M-96-25A	8/14/2019	213.3	
AOC_50	G6M-96-25B	10/12/2015	208.5	
AOC_50	G6M-96-25B	8/14/2019	210.8	
AOC_50	G6M-96-26A	10/12/2015	210.8	
AOC_50	G6M-96-26B	10/12/2015	209.8	
AOC_50	G6M-97-05B	10/12/2015	201.2	
AOC_50	G6M-97-05B	2/3/2016	201.4	
AOC_50	G6M-97-05B	5/18/2016	202.2	
AOC_50	G6M-97-05B	11/7/2016	201.5	
AOC_50	G6M-97-05B	5/15/2017	204.2	
AOC_50	G6M-97-05B	10/2/2017	201.5	
AOC_50	G6M-97-05B	4/2/2018	205.1	
AOC_50	G6M-97-05B	10/15/2018	205.1	
AOC_50	G6M-97-05B	4/2/2019	204.8	
AOC_50	G6M-97-05B	8/14/2019	203.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_50	G6M-97-05B	10/7/2019	201.8	
AOC_50	G6M-97-05B	4/27/2020	204.9	
AOC_50	G6M-97-05B	5/11/2020	204.9	
AOC_50	G6M-97-09B	10/12/2015	208.7	
AOC_50	G6M-97-27X	10/12/2015	210.4	
AOC_50	G6M-97-28X	10/12/2015	202.5	
AOC_50	G6M-97-28X	5/18/2016	203.9	
AOC_50	G6M-97-28X	11/7/2016	202.4	
AOC_50	G6M-97-28X	5/15/2017	205.4	
AOC_50	G6M-97-28X	10/2/2017	203.3	
AOC_50	G6M-97-28X	4/2/2018	205.2	
AOC_50	G6M-97-28X	10/15/2018	206.1	
AOC_50	G6M-97-28X	4/2/2019	206.3	
AOC_50	G6M-97-28X	8/14/2019	204.7	
AOC_50	G6M-97-28X	10/7/2019	203.2	
AOC_50	G6M-97-28X	4/27/2020	206.2	
AOC_50	G6M-97-28X	5/11/2020	206.4	
AOC_50	G6M-97-29X	10/12/2015	202.2	
AOC_50	G6M-98-32X	10/12/2015	202.4	
AOC_50	G6P-97-05X	4/2/2019	211.9	
AOC_50	G6P-97-05X	8/14/2019	210.7	
AOC_50	G6P-97-05X	10/7/2019	209.4	
AOC_50	G6P-97-05X	4/27/2020	211.5	
AOC_50	G6P-97-05X	5/11/2020	211.8	
AOC_50	MW-3	6/15/2015	203.0	
AOC_50	MW-3	10/12/2015	201.6	
AOC_50	MW-3	2/3/2016	202.0	
AOC_50	MW-3	5/18/2016	202.8	
AOC_50	MW-3	11/7/2016	202.0	
AOC_50	MW-3	5/15/2017	204.7	
AOC_50	MW-3	10/2/2017	201.6	
AOC_50	MW-3	10/7/2019	202.5	
AOC_50	MW-3	4/27/2020	205.6	
AOC_50	MW-3	5/13/2020	205.4	
AOC_50	MW-4	10/12/2015	202.5	
AOC_50	MW-5	10/12/2015	202.5	
AOC_50	MW-6	10/12/2015	201.9	
AOC_50	MW-7	6/15/2015	203.1	
AOC_50	MW-7	10/12/2015	201.9	
AOC_50	MW-7	5/18/2016	207.2	
AOC_50	MW-7	6/24/2016		253.1
AOC_50	MW-7	11/7/2016	202.0	
AOC_50	MW-7	11/15/2016		
AOC_50	MW-7	5/15/2017	205.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_50	MW-7	5/22/2017		258.9
AOC_50	MW-7	10/2/2017	202.3	
AOC_50	MW-7	4/2/2018	204.6	
AOC_50	MW-7	10/15/2018	205.7	
AOC_50	MW-7	11/1/2018		
AOC_50	MW-7	4/2/2019	205.6	
AOC_50	MW-7	10/7/2019	201.8	
AOC_50	MW-7	4/27/2020	205.6	
AOC_50	MW-7	5/11/2020	205.7	
AOC_50	MW-7 (IT)	10/7/2019		
AOC_50	MW-7 (IT)	4/27/2020	208.6	
AOC_50	XSA-12-95X	6/15/2015	199.3	
AOC_50	XSA-12-95X	10/12/2015	200.8	
AOC_50	XSA-12-95X	5/18/2016	201.4	
AOC_50	XSA-12-95X	5/15/2017		233.0
AOC_50	XSA-12-95X	10/2/2017	195.3	
AOC_50	XSA-12-95X	4/2/2018	200.8	
AOC_50	XSA-12-95X	10/15/2018	203.6	
AOC_50	XSA-12-95X	4/2/2019	202.4	
AOC_50	XSA-12-95X	10/7/2019	199.2	
AOC_50	XSA-12-95X	4/27/2020	204.3	
AOC_50	XSA-12-95X	5/11/2020	209.5	
AOC_50	XSA-12-96X	6/15/2015	203.4	
AOC_50	XSA-12-96X	5/18/2016	201.4	
AOC_50	XSA-12-96X	5/15/2017		226.0
AOC_50	XSA-12-96X	10/2/2017	200.4	
AOC_50	XSA-12-96X	4/2/2018	203.9	
AOC_50	XSA-12-96X	10/15/2018	204.4	
AOC_50	XSA-12-96X	4/2/2019	204.0	
AOC_50	XSA-12-96X	10/7/2019	201.0	
AOC_50	XSA-12-96X	4/27/2020	204.2	
AOC_50	XSA-12-96X	5/11/2020	204.9	
AOC_50	XSA-12-96X	5/12/2020	218.5	
AOC_50	XSA-12-97X	6/15/2015	197.3	
AOC_50	XSA-12-97X	10/12/2015	200.3	
AOC_50	XSA-12-97X	5/18/2016	201.4	
AOC_50	XSA-12-97X	11/7/2016	197.1	
AOC_50	XSA-12-97X	5/15/2017		233.5
AOC_50	XSA-12-97X	10/2/2017	196.5	
AOC_50	XSA-12-97X	4/2/2018	200.2	
AOC_50	XSA-12-97X	10/15/2018	205.2	
AOC_50	XSA-12-97X	4/2/2019	202.9	
AOC_50	XSA-12-97X	10/7/2019	199.6	
AOC_50	XSA-12-97X	4/27/2020	204.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_50	XSA-12-97X	5/11/2020	216.5	
AOC_50	XSA-12-98X	6/15/2015		143.7
AOC_50	XSA-12-98X	4/2/2018	203.4	
AOC_50	XSA-12-98X	10/15/2018	206.6	
AOC_50	XSA-12-98X	4/2/2019	204.1	
AOC_50	XSA-12-98X	10/7/2019	200.7	
AOC_50	XSA-12-98X	4/27/2020	206.7	
AOC_50	XSA-12-98X	5/11/2020	205.4	
AOC_57	5702MW-19-01A	3/12/2020	223.8	
AOC_57	5702MW-19-01B	3/12/2020	223.8	
AOC_57	5702MW-20-01A	3/12/2020	219.4	
AOC_57	5702MW-20-01B	3/12/2020	220.5	
AOC_57	5702MW-20-02A	3/12/2020	222.6	
AOC_57	5702MW-20-03A	3/12/2020	220.7	
AOC_57	5702MW-20-04A	3/12/2020	221.2	
AOC_57	5702MW-20-05A	3/12/2020	219.9	
AOC_57	5702MW-20-05B	3/12/2020	221.2	
AOC_57	5702MW-20-06A	3/12/2020	221.3	
AOC_57	5702MW-20-07A	3/12/2020	219.2	
AOC_57	5703MW-20-01A	3/12/2020	220.9	
AOC_57	5703MW-20-01B	3/12/2020	220.5	
AOC_57	5703MW-20-02A	3/12/2020	222.3	
AOC_57	5703MW-20-03A	3/12/2020	220.7	
AOC_57	5703MW-20-04A	3/12/2020	221.1	
AOC_57	5703PZ-19-01	3/12/2020	219.9	
AOC_57	57M-03-01X	5/18/2005	221.6	
AOC_57	57M-03-01X	11/7/2005	222.0	
AOC_57	57M-03-01X	6/5/2006	222.5	
AOC_57	57M-03-01X	6/9/2006	224.7	
AOC_57	57M-03-01X	10/17/2006	223.4	
AOC_57	57M-03-01X	10/19/2006	221.3	
AOC_57	57M-03-01X	5/23/2007	222.0	
AOC_57	57M-03-01X	10/15/2007	220.8	
AOC_57	57M-03-01X	6/25/2008	221.6	
AOC_57	57M-03-01X	5/8/2009	222.2	
AOC_57	57M-03-01X	5/20/2010	222.3	
AOC_57	57M-03-01X	6/30/2011	221.7	
AOC_57	57M-03-01X	5/15/2012	221.8	
AOC_57	57M-03-01X	6/13/2013	222.0	
AOC_57	57M-03-01X	6/18/2014	221.1	
AOC_57	57M-03-01X	6/21/2015	221.1	
AOC_57	57M-03-01X	5/19/2016	220.9	
AOC_57	57M-03-01X	6/19/2017	221.7	
AOC_57	57M-03-01X	5/8/2018	221.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_57	57M-03-01X	9/28/2018	222.1	
AOC_57	57M-03-01X	4/5/2019	222.0	
AOC_57	57M-03-01X	3/12/2020	221.4	
AOC_57	57M-03-01X	5/13/2020	221.9	
AOC_57	57M-03-02X	12/1/2003	220.1	
AOC_57	57M-03-02X	5/25/2004	219.8	
AOC_57	57M-03-02X	10/7/2004	219.6	
AOC_57	57M-03-02X	5/18/2005	219.9	
AOC_57	57M-03-02X	11/7/2005	220.3	
AOC_57	57M-03-02X	6/5/2006	220.6	
AOC_57	57M-03-02X	6/9/2006	222.9	
AOC_57	57M-03-02X	10/17/2006	222.0	
AOC_57	57M-03-02X	10/19/2006	219.7	
AOC_57	57M-03-02X	5/23/2007	220.0	
AOC_57	57M-03-02X	10/15/2007	219.5	
AOC_57	57M-03-02X	6/25/2008	220.1	
AOC_57	57M-03-02X	5/8/2009	221.0	
AOC_57	57M-03-02X	5/20/2010	220.6	
AOC_57	57M-03-02X	6/30/2011	219.9	
AOC_57	57M-03-02X	5/15/2012	220.4	
AOC_57	57M-03-02X	6/13/2013	220.9	
AOC_57	57M-03-02X	6/18/2014	219.5	
AOC_57	57M-03-02X	6/21/2015	219.6	
AOC_57	57M-03-02X	5/19/2016	219.6	
AOC_57	57M-03-02X	6/19/2017	220.1	
AOC_57	57M-03-02X	5/8/2018	220.2	
AOC_57	57M-03-02X	10/1/2018	220.4	
AOC_57	57M-03-02X	4/5/2019	220.3	
AOC_57	57M-03-02X	3/12/2020	219.8	
AOC_57	57M-03-02X	5/13/2020	220.0	
AOC_57	57M-03-03X	5/18/2005	219.1	
AOC_57	57M-03-03X	11/7/2005	219.3	
AOC_57	57M-03-03X	6/5/2006	219.5	
AOC_57	57M-03-03X	6/9/2006	223.1	
AOC_57	57M-03-03X	10/17/2006	222.5	
AOC_57	57M-03-03X	10/19/2006	218.9	
AOC_57	57M-03-03X	5/23/2007	219.0	
AOC_57	57M-03-03X	10/15/2007	219.0	
AOC_57	57M-03-03X	6/25/2008	219.3	
AOC_57	57M-03-03X	5/8/2009	219.3	
AOC_57	57M-03-03X	5/20/2010	219.4	
AOC_57	57M-03-03X	6/30/2011	219.1	
AOC_57	57M-03-03X	5/15/2012	219.5	
AOC_57	57M-03-03X	6/13/2013	219.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_57	57M-03-03X	6/18/2014	218.6	
AOC_57	57M-03-03X	6/21/2015	218.9	
AOC_57	57M-03-03X	5/19/2016	219.0	
AOC_57	57M-03-03X	6/19/2017		210.3
AOC_57	57M-03-03X	5/8/2018	219.3	
AOC_57	57M-03-03X	10/1/2018	219.2	
AOC_57	57M-03-03X	4/5/2019	219.1	
AOC_57	57M-03-03X	3/12/2020	219.1	
AOC_57	57M-03-03X	5/13/2020	219.3	
AOC_57	57M-03-04X	12/1/2003	219.4	
AOC_57	57M-03-04X	5/25/2004	219.1	
AOC_57	57M-03-04X	10/7/2004	219.0	
AOC_57	57M-03-04X	5/18/2005	219.1	
AOC_57	57M-03-04X	11/7/2005	219.4	
AOC_57	57M-03-04X	6/5/2006	216.5	
AOC_57	57M-03-04X	6/9/2006	219.1	
AOC_57	57M-03-04X	10/17/2006	221.6	
AOC_57	57M-03-04X	10/19/2006	219.0	
AOC_57	57M-03-04X	5/23/2007	219.0	
AOC_57	57M-03-04X	10/15/2007	219.0	
AOC_57	57M-03-04X	6/25/2008	219.2	
AOC_57	57M-03-04X	5/8/2009	219.7	
AOC_57	57M-03-04X	5/20/2010	219.4	
AOC_57	57M-03-04X	6/30/2011	219.1	
AOC_57	57M-03-04X	5/15/2012	219.6	
AOC_57	57M-03-04X	6/13/2013	219.6	
AOC_57	57M-03-04X	6/18/2014	218.9	
AOC_57	57M-03-04X	6/21/2015	218.9	
AOC_57	57M-03-04X	5/19/2016	219.0	
AOC_57	57M-03-04X	6/19/2017	219.2	
AOC_57	57M-03-04X	5/8/2018	219.4	
AOC_57	57M-03-04X	10/1/2018	219.4	
AOC_57	57M-03-04X	4/5/2019	219.4	
AOC_57	57M-03-04X	3/12/2020	219.1	
AOC_57	57M-03-04X	5/13/2020	219.3	
AOC_57	57M-03-05X	12/1/2003	219.4	
AOC_57	57M-03-05X	5/25/2004	219.3	
AOC_57	57M-03-05X	10/7/2004	219.1	
AOC_57	57M-03-05X	5/18/2005	219.3	
AOC_57	57M-03-05X	11/7/2005	219.5	
AOC_57	57M-03-05X	6/5/2006	219.5	
AOC_57	57M-03-05X	6/9/2006	221.9	
AOC_57	57M-03-05X	10/17/2006	221.7	
AOC_57	57M-03-05X	10/19/2006	219.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_57	57M-03-05X	5/23/2007	219.3	
AOC_57	57M-03-05X	10/15/2007	219.1	
AOC_57	57M-03-05X	6/25/2008	219.4	
AOC_57	57M-03-05X	5/8/2009	219.5	
AOC_57	57M-03-05X	5/20/2010	219.5	
AOC_57	57M-03-05X	6/30/2011	219.2	
AOC_57	57M-03-05X	5/15/2012	219.5	
AOC_57	57M-03-05X	6/13/2013	219.5	
AOC_57	57M-03-05X	6/18/2014	219.1	
AOC_57	57M-03-05X	6/21/2015	219.1	
AOC_57	57M-03-05X	5/19/2016	219.2	
AOC_57	57M-03-05X	6/19/2017	219.2	
AOC_57	57M-03-05X	5/8/2018	219.5	
AOC_57	57M-03-05X	10/1/2018	219.5	
AOC_57	57M-03-05X	4/5/2019	219.4	
AOC_57	57M-03-05X	3/12/2020	219.3	
AOC_57	57M-03-05X	5/13/2020	219.4	
AOC_57	57M-03-06X	5/18/2005	219.3	
AOC_57	57M-03-06X	11/7/2005	219.4	
AOC_57	57M-03-06X	6/5/2006	219.6	
AOC_57	57M-03-06X	6/9/2006	222.2	
AOC_57	57M-03-06X	10/17/2006	221.8	
AOC_57	57M-03-06X	10/19/2006	219.1	
AOC_57	57M-03-06X	5/23/2007	219.3	
AOC_57	57M-03-06X	10/15/2007	219.1	
AOC_57	57M-03-06X	6/25/2008	219.4	
AOC_57	57M-03-06X	5/8/2009	219.7	
AOC_57	57M-03-06X	5/20/2010	219.5	
AOC_57	57M-03-06X	6/30/2011	219.2	
AOC_57	57M-03-06X	5/15/2012	219.6	
AOC_57	57M-03-06X	6/13/2013	219.6	
AOC_57	57M-03-06X	6/18/2014		210.3
AOC_57	57M-03-06X	6/21/2015	219.1	
AOC_57	57M-03-06X	5/19/2016	219.1	
AOC_57	57M-03-06X	6/19/2017	219.2	
AOC_57	57M-03-06X	5/8/2018	219.5	
AOC_57	57M-03-06X	9/28/2018	219.5	
AOC_57	57M-03-06X	4/5/2019	219.5	
AOC_57	57M-03-06X	3/12/2020	219.1	
AOC_57	57M-03-06X	5/13/2020	219.5	
AOC_57	57M-95-03X	5/18/2005	222.6	
AOC_57	57M-95-03X	11/7/2005	223.2	
AOC_57	57M-95-03X	6/5/2006	224.0	
AOC_57	57M-95-03X	6/9/2006	226.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_57	57M-95-03X	10/17/2006	223.9	
AOC_57	57M-95-03X	10/19/2006	221.8	
AOC_57	57M-95-03X	5/23/2007	223.2	
AOC_57	57M-95-03X	10/15/2007	220.9	
AOC_57	57M-95-03X	6/25/2008	221.9	
AOC_57	57M-95-03X	6/28/2008	224.1	
AOC_57	57M-95-03X	5/8/2009	222.6	
AOC_57	57M-95-03X	5/20/2010	222.7	
AOC_57	57M-95-03X	6/30/2011	221.7	
AOC_57	57M-95-03X	5/15/2012	221.9	
AOC_57	57M-95-03X	6/13/2013	222.3	
AOC_57	57M-95-03X	6/18/2014	221.2	
AOC_57	57M-95-03X	6/21/2015	221.3	
AOC_57	57M-95-03X	5/19/2016	221.3	
AOC_57	57M-95-03X	6/19/2017	222.0	
AOC_57	57M-95-03X	5/8/2018	222.4	
AOC_57	57M-95-03X	9/29/2018	222.2	
AOC_57	57M-95-03X	4/5/2019	222.9	
AOC_57	57M-95-03X	3/12/2020	222.1	
AOC_57	57M-95-03X	5/13/2020	222.5	
AOC_57	57M-95-05X	5/18/2005	220.7	
AOC_57	57M-95-05X	11/7/2005	221.0	
AOC_57	57M-95-05X	6/5/2006	221.4	
AOC_57	57M-95-05X	6/9/2006	223.5	
AOC_57	57M-95-05X	10/17/2006	222.6	
AOC_57	57M-95-05X	10/19/2006	220.5	
AOC_57	57M-95-05X	5/23/2007	220.8	
AOC_57	57M-95-05X	10/15/2007	220.3	
AOC_57	57M-95-05X	6/25/2008	220.9	
AOC_57	57M-95-05X	5/8/2009	221.7	
AOC_57	57M-95-05X	5/20/2010	221.5	
AOC_57	57M-95-05X	6/30/2011	221.0	
AOC_57	57M-95-05X	5/15/2012	221.2	
AOC_57	57M-95-05X	6/13/2013	222.0	
AOC_57	57M-95-05X	6/18/2014	220.4	
AOC_57	57M-95-05X	6/21/2015	220.5	
AOC_57	57M-95-05X	5/19/2016	220.3	
AOC_57	57M-95-05X	6/19/2017		225.8
AOC_57	57M-95-05X	5/8/2018	221.1	
AOC_57	57M-95-05X	9/28/2018	221.7	
AOC_57	57M-95-05X	4/5/2019	221.1	
AOC_57	57M-95-05X	3/12/2020	220.4	
AOC_57	57M-95-05X	5/13/2020	221.0	
AOC_57	57M-95-06X	5/18/2005	221.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_57	57M-95-06X	11/7/2005	222.4	
AOC_57	57M-95-06X	6/5/2006	223.2	
AOC_57	57M-95-06X	6/9/2006	225.4	
AOC_57	57M-95-06X	10/17/2006	223.8	
AOC_57	57M-95-06X	10/19/2006	221.7	
AOC_57	57M-95-06X	5/23/2007	222.5	
AOC_57	57M-95-06X	10/15/2007	221.0	
AOC_57	57M-95-06X	6/25/2008	221.8	
AOC_57	57M-95-06X	5/8/2009	222.3	
AOC_57	57M-95-06X	5/20/2010	222.5	
AOC_57	57M-95-06X	6/30/2011	221.8	
AOC_57	57M-95-06X	5/15/2012	221.9	
AOC_57	57M-95-06X	6/13/2013	221.9	
AOC_57	57M-95-06X	6/18/2014	221.3	
AOC_57	57M-95-06X	6/21/2015	220.7	
AOC_57	57M-95-06X	5/19/2016	221.0	
AOC_57	57M-95-06X	6/19/2017	222.7	
AOC_57	57M-95-06X	5/8/2018	223.0	
AOC_57	57M-95-06X	9/25/2018	222.0	
AOC_57	57M-95-06X	4/5/2019	222.3	
AOC_57	57M-95-06X	3/12/2020	221.6	
AOC_57	57M-95-06X	5/13/2020	222.1	
AOC_57	57M-95-07X	5/18/2005	219.8	
AOC_57	57M-95-07X	11/7/2005	220.0	
AOC_57	57M-95-07X	6/5/2006	220.2	
AOC_57	57M-95-07X	6/9/2006	222.4	
AOC_57	57M-95-07X	10/17/2006	221.8	
AOC_57	57M-95-07X	10/19/2006	219.6	
AOC_57	57M-95-07X	5/23/2007	219.8	
AOC_57	57M-95-07X	10/15/2007	219.5	
AOC_57	57M-95-07X	6/25/2008	219.9	
AOC_57	57M-95-07X	5/8/2009	220.5	
AOC_57	57M-95-07X	5/20/2010	220.2	
AOC_57	57M-95-07X	6/30/2011	219.8	
AOC_57	57M-95-07X	5/15/2012	220.2	
AOC_57	57M-95-07X	6/13/2013	220.5	
AOC_57	57M-95-07X	6/18/2014	219.5	
AOC_57	57M-95-07X	6/21/2015	219.6	
AOC_57	57M-95-07X	5/19/2016	219.6	
AOC_57	57M-95-07X	6/19/2017	219.8	
AOC_57	57M-95-07X	5/8/2018	220.1	
AOC_57	57M-95-07X	10/1/2018	220.2	
AOC_57	57M-95-07X	4/5/2019	220.1	
AOC_57	57M-95-07X	3/12/2020	219.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_57	57M-95-07X	5/13/2020	220.0	
AOC_57	57M-96-09X	5/18/2005	225.8	
AOC_57	57M-96-09X	11/7/2005	226.7	
AOC_57	57M-96-09X	6/9/2006	226.7	
AOC_57	57M-96-09X	10/17/2006	224.9	
AOC_57	57M-96-09X	5/23/2007	226.0	
AOC_57	57M-96-09X	10/15/2007	224.1	
AOC_57	57M-96-10X	5/18/2005	222.2	
AOC_57	57M-96-10X	11/7/2005	222.6	
AOC_57	57M-96-10X	6/5/2006	223.0	
AOC_57	57M-96-10X	6/9/2006	223.8	
AOC_57	57M-96-10X	10/17/2006	222.4	
AOC_57	57M-96-10X	10/19/2006	221.6	
AOC_57	57M-96-10X	5/23/2007	222.5	
AOC_57	57M-96-10X	10/15/2007	221.2	
AOC_57	57M-96-10X	6/25/2008	221.6	
AOC_57	57M-96-10X	6/28/2008	222.4	
AOC_57	57M-96-10X	5/8/2009	222.7	
AOC_57	57M-96-10X	5/20/2010	222.2	
AOC_57	57M-96-10X	6/30/2011	221.5	
AOC_57	57M-96-10X	5/15/2012	221.9	
AOC_57	57M-96-10X	6/13/2013		
AOC_57	57M-96-10X	6/18/2014	221.3	
AOC_57	57M-96-10X	6/21/2015	221.3	
AOC_57	57M-96-10X	5/19/2016		
AOC_57	57M-96-10X	6/19/2017		
AOC_57	57M-96-10X	5/8/2018	222.2	
AOC_57	57M-96-10X	4/5/2019	222.5	
AOC_57	57M-96-10X	5/13/2020	222.2	
AOC_57	57M-96-11X	5/18/2005	219.6	
AOC_57	57M-96-11X	11/7/2005	219.8	
AOC_57	57M-96-11X	6/5/2006	219.8	
AOC_57	57M-96-11X	6/9/2006	222.0	
AOC_57	57M-96-11X	10/17/2006	221.4	
AOC_57	57M-96-11X	10/19/2006	219.3	
AOC_57	57M-96-11X	5/23/2007	219.7	
AOC_57	57M-96-11X	10/15/2007	219.2	
AOC_57	57M-96-11X	6/25/2008	218.5	
AOC_57	57M-96-11X	6/28/2008	220.7	
AOC_57	57M-96-11X	5/8/2009	219.8	
AOC_57	57M-96-11X	5/20/2010	219.6	
AOC_57	57M-96-11X	6/30/2011	219.2	
AOC_57	57M-96-11X	5/15/2012	219.2	
AOC_57	57M-96-11X	6/13/2013	219.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_57	57M-96-11X	6/18/2014	218.7	
AOC_57	57M-96-11X	6/21/2015	219.1	
AOC_57	57M-96-11X	5/19/2016	219.2	
AOC_57	57M-96-11X	6/19/2017	219.3	
AOC_57	57M-96-11X	5/8/2018	219.4	
AOC_57	57M-96-11X	9/24/2018	219.3	
AOC_57	57M-96-11X	4/5/2019	219.5	
AOC_57	57M-96-11X	3/12/2020	219.5	
AOC_57	57M-96-11X	5/13/2020	219.2	
AOC_57	57M-96-12X	5/18/2005	221.3	
AOC_57	57M-96-12X	11/7/2005	221.6	
AOC_57	57M-96-12X	6/5/2006	221.9	
AOC_57	57M-96-12X	6/9/2006	223.9	
AOC_57	57M-96-12X	10/17/2006	223.0	
AOC_57	57M-96-12X	10/19/2006	221.0	
AOC_57	57M-96-12X	5/23/2007	221.5	
AOC_57	57M-96-12X	10/15/2007	220.4	
AOC_57	57M-96-12X	6/25/2008	221.1	
AOC_57	57M-96-12X	6/28/2008	223.1	
AOC_57	57M-96-12X	5/8/2009	221.5	
AOC_57	57M-96-12X	5/20/2010	221.5	
AOC_57	57M-96-12X	6/30/2011	220.7	
AOC_57	57M-96-12X	5/15/2012	221.0	
AOC_57	57M-96-12X	6/13/2013	221.2	
AOC_57	57M-96-12X	6/18/2014	220.3	
AOC_57	57M-96-12X	6/21/2015	220.4	
AOC_57	57M-96-12X	5/19/2016	220.5	
AOC_57	57M-96-12X	6/19/2017	220.9	
AOC_57	57M-96-12X	5/8/2018	221.3	
AOC_57	57M-96-12X	9/25/2018	221.1	
AOC_57	57M-96-12X	4/5/2019	221.5	
AOC_57	57M-96-12X	3/12/2020	221.0	
AOC_57	57M-96-12X	5/13/2020	221.3	
AOC_57	57M-96-13X	5/18/2005	220.1	
AOC_57	57M-96-13X	11/7/2005	221.4	
AOC_57	57M-96-13X	6/5/2006	221.6	
AOC_57	57M-96-13X	6/9/2006	223.7	
AOC_57	57M-96-13X	10/17/2006	223.0	
AOC_57	57M-96-13X	10/19/2006	220.9	
AOC_57	57M-96-13X	5/23/2007	221.4	
AOC_57	57M-96-13X	10/15/2007	220.4	
AOC_57	57M-96-13X	6/25/2008	220.9	
AOC_57	57M-96-13X	5/8/2009	221.4	
AOC_57	57M-96-13X	5/20/2010	221.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_57	57M-96-13X	6/30/2011	220.6	
AOC_57	57M-96-13X	5/15/2012	221.0	
AOC_57	57M-96-13X	6/13/2013	221.1	
AOC_57	57M-96-13X	6/18/2014	220.2	
AOC_57	57M-96-13X	6/21/2015	220.3	
AOC_57	57M-96-13X	5/19/2016	220.6	
AOC_57	57M-96-13X	6/19/2017	220.8	
AOC_57	57M-96-13X	5/8/2018	221.2	
AOC_57	57M-96-13X	9/25/2018	221.1	
AOC_57	57M-96-13X	4/5/2019	221.4	
AOC_57	57M-96-13X	3/12/2020	221.0	
AOC_57	57M-96-13X	5/13/2020	221.2	
AOC_57	57P-98-03X	5/18/2005	218.0	
AOC_57	57P-98-03X	11/7/2005	218.1	
AOC_57	57P-98-03X	6/9/2006		
AOC_57	57P-98-03X	10/17/2006		
AOC_57	57P-98-03X	10/19/2006	218.0	
AOC_57	57P-98-03X	5/23/2007	218.1	
AOC_57	57P-98-03X	10/15/2007	218.0	
AOC_57	57P-98-03X	6/25/2008	218.1	
AOC_57	57P-98-03X	6/28/2008	220.3	
AOC_57	57P-98-03X	5/8/2009	218.3	
AOC_57	57P-98-03X	5/20/2010	218.2	
AOC_57	57P-98-03X	6/30/2011	217.7	
AOC_57	57P-98-03X	5/15/2012	218.0	
AOC_57	57P-98-03X	6/13/2013	218.3	
AOC_57	57P-98-03X	6/18/2014	217.7	
AOC_57	57P-98-03X	6/19/2017		
AOC_57	57P-98-03X	5/8/2018	218.1	
AOC_57	57P-98-03X	9/24/2018	218.0	
AOC_57	57P-98-03X	4/5/2019	218.1	
AOC_57	57P-98-03X	3/12/2020	218.1	
AOC_57	57P-98-03X	5/13/2020	218.1	
AOC_57	57P-98-04X	6/25/2008	218.3	
AOC_57	57P-98-04X	6/28/2008	220.3	
AOC_57	57P-98-04X	5/8/2009	218.4	
AOC_57	57P-98-04X	5/20/2010	218.3	
AOC_57	57P-98-04X	6/30/2011	218.2	
AOC_57	57P-98-04X	5/15/2012	218.3	
AOC_57	57P-98-04X	6/13/2013	218.4	
AOC_57	57P-98-04X	6/18/2014		
AOC_57	57P-98-04X	6/19/2017	218.1	
AOC_57	57P-98-04X	5/8/2018	218.2	
AOC_57	57P-98-04X	9/24/2018	218.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_57	57P-98-04X	4/5/2019	218.2	
AOC_57	57P-98-04X	3/12/2020	218.2	
AOC_57	57P-98-04X	5/13/2020	217.7	
AOC_57	57WP-05-01	6/9/2006		
AOC_57	57WP-05-01	10/17/2006		
AOC_57	57WP-05-01	5/23/2007		
AOC_57	57WP-05-01	10/15/2007		
AOC_57	57WP-05-01	6/25/2008		
AOC_57	57WP-05-01	5/8/2009		
AOC_57	57WP-05-01	5/20/2010		
AOC_57	57WP-05-01	6/13/2013		-1.1
AOC_57	57WP-05-01	6/18/2014		-1.9
AOC_57	57WP-05-01	5/19/2016		-2.1
AOC_57	57WP-05-01	6/19/2017		
AOC_57	57WP-05-01	5/13/2020		-1.7
AOC_57	57WP-06-02	6/5/2006	219.3	
AOC_57	57WP-06-02	6/14/2006		
AOC_57	57WP-06-02	10/17/2006		
AOC_57	57WP-06-02	10/19/2006	218.9	
AOC_57	57WP-06-02	5/23/2007	219.1	
AOC_57	57WP-06-02	10/15/2007	219.0	
AOC_57	57WP-06-02	6/25/2008	219.3	
AOC_57	57WP-06-02	6/28/2008	221.9	
AOC_57	57WP-06-02	5/8/2009	219.8	
AOC_57	57WP-06-02	5/20/2010		
AOC_57	57WP-06-02	6/30/2011	219.2	
AOC_57	57WP-06-02	5/15/2012	219.7	
AOC_57	57WP-06-02	6/13/2013	219.7	
AOC_57	57WP-06-02	6/18/2014	219.0	
AOC_57	57WP-06-02	5/19/2016	219.1	
AOC_57	57WP-06-02	6/19/2017	219.4	
AOC_57	57WP-06-02	5/8/2018	218.5	
AOC_57	57WP-06-02	10/1/2018	219.5	
AOC_57	57WP-06-02	4/5/2019	219.4	
AOC_57	57WP-06-02	3/12/2020	219.2	
AOC_57	57WP-06-02	5/13/2020	219.5	
AOC_57	57WP-06-03	6/5/2006	220.3	
AOC_57	57WP-06-03	6/14/2006		
AOC_57	57WP-06-03	10/17/2006		
AOC_57	57WP-06-03	10/19/2006	219.7	
AOC_57	57WP-06-03	5/23/2007	220.2	
AOC_57	57WP-06-03	10/15/2007	219.6	
AOC_57	57WP-06-03	6/25/2008	220.0	
AOC_57	57WP-06-03	6/28/2008	222.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_57	57WP-06-03	5/8/2009	220.4	
AOC_57	57WP-06-03	5/20/2010		
AOC_57	57WP-06-03	6/30/2011	219.8	
AOC_57	57WP-06-03	5/15/2012	219.7	
AOC_57	57WP-06-03	6/13/2013	220.0	
AOC_57	57WP-06-03	6/18/2014	219.4	
AOC_57	57WP-06-03	6/19/2017	219.9	
AOC_57	57WP-06-03	5/8/2018	219.9	
AOC_57	57WP-06-03	9/28/2018	220.0	
AOC_57	57WP-06-03	4/5/2019	219.7	
AOC_57	57WP-06-03	3/12/2020	219.8	
AOC_57	57WP-06-03	5/13/2020	219.9	
AOC_69W	69W-94-12	5/18/2005	221.8	
AOC_69W	69W-94-12	5/23/2005	222.6	
AOC_69W	69W-94-12	10/3/2005	222.0	
AOC_69W	69W-94-12	10/14/2005	222.8	
AOC_69W	69W-94-12	6/5/2006	222.4	
AOC_69W	69W-94-12	6/13/2006	223.2	
AOC_69W	69W-94-12	10/15/2007	219.7	
AOC_69W	69W-94-12	10/17/2007	220.5	
AOC_69W	69W-94-12	10/28/2008	221.3	
AOC_69W	69W-94-12	10/22/2009	221.2	
AOC_69W	69W-94-12	10/26/2009	220.4	
AOC_69W	69W-94-12	10/7/2010	219.9	
AOC_69W	69W-94-12	10/15/2010	220.7	
AOC_69W	69W-94-12	10/13/2011	221.6	
AOC_69W	69W-94-12	10/22/2012	219.3	
AOC_69W	69W-94-12	11/6/2013	219.4	
AOC_69W	69W-94-12	10/20/2014	219.1	
AOC_69W	69W-94-12	10/7/2015	219.3	
AOC_69W	69W-94-12	10/25/2016	218.6	
AOC_69W	69W-94-12	10/30/2017	221.7	
AOC_69W	69W-94-12	10/8/2018	221.8	
AOC_69W	69W-94-12	10/2/2019	222.7	
AOC_69W	69W-94-13	5/18/2005	221.7	
AOC_69W	69W-94-13	5/23/2005	222.5	
AOC_69W	69W-94-13	10/3/2005	221.7	
AOC_69W	69W-94-13	10/14/2005	222.5	
AOC_69W	69W-94-13	6/5/2006	222.2	
AOC_69W	69W-94-13	6/13/2006	223.0	
AOC_69W	69W-94-13	10/15/2007	219.4	
AOC_69W	69W-94-13	10/17/2007	220.2	
AOC_69W	69W-94-13	10/28/2008	221.1	
AOC_69W	69W-94-13	10/22/2009	220.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_69W	69W-94-13	10/26/2009	220.0	
AOC_69W	69W-94-13	10/7/2010	219.9	
AOC_69W	69W-94-13	10/15/2010	220.7	
AOC_69W	69W-94-13	10/13/2011	221.5	
AOC_69W	69W-94-13	10/22/2012	219.1	
AOC_69W	69W-94-13	11/6/2013	219.2	
AOC_69W	69W-94-13	10/20/2014	219.0	
AOC_69W	69W-94-13	10/7/2015	219.2	
AOC_69W	69W-94-13	10/25/2016	218.3	
AOC_69W	69W-94-13	10/30/2017	221.6	
AOC_69W	69W-94-13	10/8/2018	221.8	
AOC_69W	69W-94-13	10/2/2019	219.7	
AOC_69W	69W-94-14	5/18/2005	220.8	
AOC_69W	69W-94-14	5/23/2005	221.6	
AOC_69W	69W-94-14	10/3/2005	220.8	
AOC_69W	69W-94-14	10/14/2005	221.6	
AOC_69W	69W-94-14	6/5/2006	221.2	
AOC_69W	69W-94-14	6/13/2006	222.0	
AOC_69W	69W-94-14	10/15/2007	218.7	
AOC_69W	69W-94-14	10/17/2007	219.5	
AOC_69W	69W-94-14	10/28/2008	220.2	
AOC_69W	69W-94-14	10/22/2009	220.4	
AOC_69W	69W-94-14	10/26/2009	219.6	
AOC_69W	69W-94-14	10/7/2010	219.3	
AOC_69W	69W-94-14	10/15/2010	220.1	
AOC_69W	69W-94-14	10/13/2011	220.6	
AOC_69W	69W-94-14	10/22/2012	218.5	
AOC_69W	69W-94-14	11/6/2013	218.5	
AOC_69W	69W-94-14	10/20/2014	218.3	
AOC_69W	69W-94-14	10/7/2015	218.5	
AOC_69W	69W-94-14	10/25/2016	217.8	
AOC_69W	69W-94-14	10/30/2017	221.2	
AOC_69W	69W-94-14	10/9/2018	221.0	
AOC_69W	69W-94-14	10/2/2019	218.8	
AOC_69W	69WP-08-01	10/28/2008		-2.3
AOC_69W	69WP-08-01	10/22/2009		
AOC_69W	69WP-08-01	10/26/2009		-2.9
AOC_69W	69WP-08-01	10/7/2010		-2.7
AOC_69W	69WP-08-01	10/15/2010		
AOC_69W	69WP-08-01	10/13/2011		-2.2
AOC_69W	69WP-08-01	10/22/2012		-3.9
AOC_69W	69WP-08-01	11/6/2013		-3.9
AOC_69W	69WP-08-01	10/20/2014		-4.0
AOC_69W	69WP-08-01	10/7/2015		-3.8

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_69W	69WP-08-01	10/25/2016		-4.6
AOC_69W	69WP-08-01	10/30/2017		-2.4
AOC_69W	69WP-08-01	10/9/2018		-2.0
AOC_69W	69WP-08-01	6/28/2019		-2.1
AOC_69W	69WP-08-01	10/2/2019		-3.6
AOC_69W	69WP-13-01	11/6/2013	217.5	
AOC_69W	69WP-13-01	10/20/2014	217.3	
AOC_69W	69WP-13-01	10/7/2015	217.4	
AOC_69W	69WP-13-01	10/25/2016	216.6	
AOC_69W	69WP-13-01	10/30/2017	218.8	
AOC_69W	69WP-13-01	10/9/2018	219.0	
AOC_69W	69WP-13-01	10/2/2019	217.4	
AOC_69W	ZWM-01-25X	5/18/2005	220.0	
AOC_69W	ZWM-01-25X	5/23/2005	220.8	
AOC_69W	ZWM-01-25X	10/3/2005	220.3	
AOC_69W	ZWM-01-25X	10/14/2005	221.1	
AOC_69W	ZWM-01-25X	6/5/2006	220.5	
AOC_69W	ZWM-01-25X	6/13/2006	221.3	
AOC_69W	ZWM-01-25X	10/15/2007	218.2	
AOC_69W	ZWM-01-25X	10/17/2007	219.0	
AOC_69W	ZWM-01-25X	10/28/2008	219.6	
AOC_69W	ZWM-01-25X	10/22/2009	219.8	
AOC_69W	ZWM-01-25X	10/26/2009	219.0	
AOC_69W	ZWM-01-25X	10/7/2010	218.9	
AOC_69W	ZWM-01-25X	10/15/2010	219.7	
AOC_69W	ZWM-01-25X	10/13/2011	219.9	
AOC_69W	ZWM-01-25X	10/22/2012	218.0	
AOC_69W	ZWM-01-25X	11/6/2013	218.1	
AOC_69W	ZWM-01-25X	10/20/2014	217.8	
AOC_69W	ZWM-01-25X	10/7/2015	218.0	
AOC_69W	ZWM-01-25X	10/25/2016	217.3	
AOC_69W	ZWM-01-25X	10/30/2017	220.7	
AOC_69W	ZWM-01-25X	10/9/2018	220.2	
AOC_69W	ZWM-01-25X	10/2/2019	218.3	
AOC_69W	ZWM-01-26X	5/18/2005	220.6	
AOC_69W	ZWM-01-26X	5/23/2005	221.4	
AOC_69W	ZWM-01-26X	10/3/2005	221.3	
AOC_69W	ZWM-01-26X	10/14/2005	222.1	
AOC_69W	ZWM-01-26X	6/5/2006	221.4	
AOC_69W	ZWM-01-26X	6/13/2006	222.2	
AOC_69W	ZWM-01-26X	10/15/2007	218.8	
AOC_69W	ZWM-01-26X	10/17/2007	219.6	
AOC_69W	ZWM-01-26X	10/28/2008	220.2	
AOC_69W	ZWM-01-26X	10/22/2009	220.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_69W	ZWM-01-26X	10/26/2009	219.7	
AOC_69W	ZWM-01-26X	10/7/2010	219.0	
AOC_69W	ZWM-01-26X	10/15/2010	219.8	
AOC_69W	ZWM-01-26X	10/13/2011	220.4	
AOC_69W	ZWM-01-26X	10/22/2012	218.6	
AOC_69W	ZWM-01-26X	11/6/2013	218.7	
AOC_69W	ZWM-01-26X	10/20/2014	218.5	
AOC_69W	ZWM-01-26X	10/7/2015	218.7	
AOC_69W	ZWM-01-26X	10/25/2016	218.0	
AOC_69W	ZWM-01-26X	10/30/2017	221.2	
AOC_69W	ZWM-01-26X	10/8/2018	220.6	
AOC_69W	ZWM-01-26X	5/16/2019	220.9	
AOC_69W	ZWM-01-26X	6/28/2019	222.4	
AOC_69W	ZWM-01-26X	10/2/2019	218.9	
AOC_69W	ZWM-95-15X	5/18/2005	220.5	
AOC_69W	ZWM-95-15X	5/23/2005	221.3	
AOC_69W	ZWM-95-15X	10/3/2005	220.6	
AOC_69W	ZWM-95-15X	10/14/2005	221.4	
AOC_69W	ZWM-95-15X	6/5/2006	220.9	
AOC_69W	ZWM-95-15X	6/13/2006	221.7	
AOC_69W	ZWM-95-15X	10/15/2007	218.5	
AOC_69W	ZWM-95-15X	10/17/2007	219.3	
AOC_69W	ZWM-95-15X	10/28/2008	220.0	
AOC_69W	ZWM-95-15X	10/22/2009	220.2	
AOC_69W	ZWM-95-15X	10/26/2009	219.4	
AOC_69W	ZWM-95-15X	10/7/2010	219.3	
AOC_69W	ZWM-95-15X	10/15/2010	220.1	
AOC_69W	ZWM-95-15X	10/13/2011	220.4	
AOC_69W	ZWM-95-15X	10/22/2012	218.3	
AOC_69W	ZWM-95-15X	11/6/2013	218.4	
AOC_69W	ZWM-95-15X	10/20/2014	218.1	
AOC_69W	ZWM-95-15X	10/7/2015	218.3	
AOC_69W	ZWM-95-15X	10/25/2016	217.6	
AOC_69W	ZWM-95-15X	10/30/2017	221.0	
AOC_69W	ZWM-95-15X	10/9/2018	220.9	
AOC_69W	ZWM-95-15X	10/2/2019	218.7	
AOC_69W	ZWM-95-16X	5/18/2005	223.3	
AOC_69W	ZWM-95-16X	5/23/2005	224.1	
AOC_69W	ZWM-95-16X	10/3/2005	223.2	
AOC_69W	ZWM-95-16X	10/14/2005	224.0	
AOC_69W	ZWM-95-16X	6/5/2006	224.1	
AOC_69W	ZWM-95-16X	6/13/2006	224.9	
AOC_69W	ZWM-95-16X	10/15/2007	220.7	
AOC_69W	ZWM-95-16X	10/17/2007	221.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_69W	ZWM-95-16X	10/28/2008	222.5	
AOC_69W	ZWM-95-16X	10/22/2009	222.6	
AOC_69W	ZWM-95-16X	10/26/2009	221.8	
AOC_69W	ZWM-95-16X	10/7/2010	220.7	
AOC_69W	ZWM-95-16X	10/15/2010	221.5	
AOC_69W	ZWM-95-16X	10/13/2011	223.1	
AOC_69W	ZWM-95-16X	11/6/2013		
AOC_69W	ZWM-95-16X	10/20/2014		
AOC_69W	ZWM-95-16X	10/7/2015	220.5	
AOC_69W	ZWM-95-16X	10/25/2016	219.5	
AOC_69W	ZWM-95-16X	10/30/2017	221.4	
AOC_69W	ZWM-95-16X	10/8/2018	223.3	
AOC_69W	ZWM-95-16X	10/2/2019	221.0	
AOC_69W	ZWM-95-17X	12/7/1995	222.9	
AOC_69W	ZWM-95-17X	3/26/1996	225.0	
AOC_69W	ZWM-95-17X	7/23/1996	224.3	
AOC_69W	ZWM-95-17X	1/15/1997	225.2	
AOC_69W	ZWM-95-17X	6/2/1997	224.9	
AOC_69W	ZWM-95-17X	10/14/1998	222.7	
AOC_69W	ZWM-95-17X	12/10/1998	221.5	
AOC_69W	ZWM-95-17X	2/23/1999	222.6	
AOC_69W	ZWM-95-17X	6/6/1999	222.2	
AOC_69W	ZWM-95-17X	9/8/1999	230.2	
AOC_69W	ZWM-95-17X	5/18/2005	224.7	
AOC_69W	ZWM-95-17X	5/23/2005	225.5	
AOC_69W	ZWM-95-17X	10/3/2005	224.4	
AOC_69W	ZWM-95-17X	10/14/2005	225.2	
AOC_69W	ZWM-95-17X	6/5/2006	225.6	
AOC_69W	ZWM-95-17X	6/13/2006	226.4	
AOC_69W	ZWM-95-17X	10/15/2007	221.7	
AOC_69W	ZWM-95-17X	10/17/2007	222.5	
AOC_69W	ZWM-95-17X	10/28/2008	223.8	
AOC_69W	ZWM-95-17X	10/22/2009	223.6	
AOC_69W	ZWM-95-17X	10/26/2009	222.8	
AOC_69W	ZWM-95-17X	10/7/2010	221.7	
AOC_69W	ZWM-95-17X	10/15/2010	222.5	
AOC_69W	ZWM-95-17X	10/13/2011	224.4	
AOC_69W	ZWM-95-17X	10/22/2012	221.3	
AOC_69W	ZWM-95-17X	11/6/2013	221.5	
AOC_69W	ZWM-95-17X	10/20/2014	221.2	
AOC_69W	ZWM-95-17X	10/7/2015	221.4	
AOC_69W	ZWM-95-17X	10/25/2016	230.2	
AOC_69W	ZWM-95-17X	10/30/2017	222.3	
AOC_69W	ZWM-95-17X	10/8/2018	224.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_69W	ZWM-95-17X	5/16/2019	224.9	
AOC_69W	ZWM-95-17X	6/28/2019	224.4	
AOC_69W	ZWM-95-17X	10/2/2019	221.9	
AOC_69W	ZWM-95-18X	5/18/2005	219.4	
AOC_69W	ZWM-95-18X	5/23/2005	220.2	
AOC_69W	ZWM-95-18X	10/3/2005	219.4	
AOC_69W	ZWM-95-18X	10/14/2005	220.2	
AOC_69W	ZWM-95-18X	6/5/2006	219.6	
AOC_69W	ZWM-95-18X	6/13/2006	220.4	
AOC_69W	ZWM-95-18X	10/15/2007	217.6	
AOC_69W	ZWM-95-18X	10/17/2007	218.4	
AOC_69W	ZWM-95-18X	10/28/2008	218.9	
AOC_69W	ZWM-95-18X	10/22/2009	219.1	
AOC_69W	ZWM-95-18X	10/26/2009	218.3	
AOC_69W	ZWM-95-18X	10/7/2010	218.6	
AOC_69W	ZWM-95-18X	10/15/2010	219.4	
AOC_69W	ZWM-95-18X	10/13/2011	219.2	
AOC_69W	ZWM-95-18X	10/22/2012	217.3	
AOC_69W	ZWM-95-18X	11/6/2013	217.4	
AOC_69W	ZWM-95-18X	10/20/2014	217.2	
AOC_69W	ZWM-95-18X	10/7/2015	217.4	
AOC_69W	ZWM-95-18X	10/25/2016	216.6	
AOC_69W	ZWM-95-18X	10/30/2017	219.5	
AOC_69W	ZWM-95-18X	10/9/2018	219.5	
AOC_69W	ZWM-95-18X	10/2/2019	217.6	
AOC_69W	ZWM-99-22X	6/19/2003	222.4	
AOC_69W	ZWM-99-22X	9/23/2003	224.2	
AOC_69W	ZWM-99-22X	5/25/2004	222.2	
AOC_69W	ZWM-99-22X	10/7/2004	220.7	
AOC_69W	ZWM-99-22X	5/18/2005	222.5	
AOC_69W	ZWM-99-22X	6/13/2005	222.5	
AOC_69W	ZWM-99-22X	10/3/2005	222.4	
AOC_69W	ZWM-99-22X	10/14/2005	223.2	
AOC_69W	ZWM-99-22X	6/5/2006	223.0	
AOC_69W	ZWM-99-22X	6/13/2006	223.8	
AOC_69W	ZWM-99-22X	10/15/2007	219.9	
AOC_69W	ZWM-99-22X	10/17/2007	220.7	
AOC_69W	ZWM-99-22X	9/30/2008	221.7	
AOC_69W	ZWM-99-22X	10/28/2008	221.7	
AOC_69W	ZWM-99-22X	10/22/2009	221.7	
AOC_69W	ZWM-99-22X	10/26/2009	220.9	
AOC_69W	ZWM-99-22X	10/7/2010	220.3	
AOC_69W	ZWM-99-22X	10/15/2010	221.1	
AOC_69W	ZWM-99-22X	10/13/2011	222.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_69W	ZWM-99-22X	10/22/2012	219.7	
AOC_69W	ZWM-99-22X	11/6/2013	219.8	
AOC_69W	ZWM-99-22X	10/20/2014	219.5	
AOC_69W	ZWM-99-22X	10/7/2015	219.7	
AOC_69W	ZWM-99-22X	10/25/2016	218.6	
AOC_69W	ZWM-99-22X	10/30/2017	221.7	
AOC_69W	ZWM-99-22X	10/8/2018	222.5	
AOC_69W	ZWM-99-22X	10/2/2019	220.1	
AOC_69W	ZWM-99-23X	5/18/2005	220.8	
AOC_69W	ZWM-99-23X	5/23/2005	221.6	
AOC_69W	ZWM-99-23X	10/3/2005	221.0	
AOC_69W	ZWM-99-23X	10/14/2005	221.8	
AOC_69W	ZWM-99-23X	6/5/2006	220.2	
AOC_69W	ZWM-99-23X	6/13/2006	221.0	
AOC_69W	ZWM-99-23X	10/15/2007	218.7	
AOC_69W	ZWM-99-23X	10/17/2007	219.5	
AOC_69W	ZWM-99-23X	10/28/2008	220.2	
AOC_69W	ZWM-99-23X	10/22/2009	220.3	
AOC_69W	ZWM-99-23X	10/26/2009	219.5	
AOC_69W	ZWM-99-23X	10/7/2010	219.3	
AOC_69W	ZWM-99-23X	10/15/2010	220.1	
AOC_69W	ZWM-99-23X	10/13/2011	220.5	
AOC_69W	ZWM-99-23X	10/22/2012	218.4	
AOC_69W	ZWM-99-23X	11/6/2013	218.6	
AOC_69W	ZWM-99-23X	10/20/2014	218.3	
AOC_69W	ZWM-99-23X	10/7/2015	215.1	
AOC_69W	ZWM-99-23X	10/25/2016	217.7	
AOC_69W	ZWM-99-23X	10/30/2017	220.9	
AOC_69W	ZWM-99-23X	10/9/2018	220.9	
AOC_69W	ZWM-99-23X	10/2/2019	218.9	
AOC_69W	ZWM-99-24X	5/18/2005	221.3	
AOC_69W	ZWM-99-24X	5/23/2005	222.1	
AOC_69W	ZWM-99-24X	10/3/2005	221.3	
AOC_69W	ZWM-99-24X	10/14/2005	221.1	
AOC_69W	ZWM-99-24X	6/5/2006	224.7	
AOC_69W	ZWM-99-24X	6/13/2006	225.5	
AOC_69W	ZWM-99-24X	10/15/2007	219.1	
AOC_69W	ZWM-99-24X	10/17/2007	219.9	
AOC_69W	ZWM-99-24X	10/28/2008	220.8	
AOC_69W	ZWM-99-24X	10/22/2009	220.9	
AOC_69W	ZWM-99-24X	10/26/2009	220.1	
AOC_69W	ZWM-99-24X	10/7/2010	219.7	
AOC_69W	ZWM-99-24X	10/15/2010	220.5	
AOC_69W	ZWM-99-24X	10/13/2011	221.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_69W	ZWM-99-24X	10/22/2012	218.9	
AOC_69W	ZWM-99-24X	11/6/2013	218.9	
AOC_69W	ZWM-99-24X	10/20/2014	218.7	
AOC_69W	ZWM-99-24X	10/7/2015	218.9	
AOC_69W	ZWM-99-24X	10/25/2016	218.1	
AOC_69W	ZWM-99-24X	10/30/2017	221.9	
AOC_69W	ZWM-99-24X	10/8/2018	221.5	
AOC_69W	ZWM-99-24X	10/2/2019	219.2	
AOC_69W	ZWP-95-01X	12/7/1995	220.6	
AOC_69W	ZWP-95-01X	3/26/1996	221.4	
AOC_69W	ZWP-95-01X	7/23/1996	221.6	
AOC_69W	ZWP-95-01X	1/15/1997	221.4	
AOC_69W	ZWP-95-01X	6/2/1997	221.3	
AOC_69W	ZWP-95-01X	10/14/1998	220.0	
AOC_69W	ZWP-95-01X	12/10/1998	218.9	
AOC_69W	ZWP-95-01X	2/23/1999	220.2	
AOC_69W	ZWP-95-01X	6/6/1999	219.6	
AOC_69W	ZWP-95-01X	9/8/1999	217.7	
AOC_69W	ZWP-95-01X	5/18/2005	221.3	
AOC_69W	ZWP-95-01X	5/23/2005	222.1	
AOC_69W	ZWP-95-01X	10/3/2005	221.3	
AOC_69W	ZWP-95-01X	10/14/2005	222.1	
AOC_69W	ZWP-95-01X	6/5/2006	221.7	
AOC_69W	ZWP-95-01X	6/13/2006	222.5	
AOC_69W	ZWP-95-01X	10/15/2007	219.1	
AOC_69W	ZWP-95-01X	10/17/2007	219.9	
AOC_69W	ZWP-95-01X	10/28/2008	220.8	
AOC_69W	ZWP-95-01X	10/22/2009	220.8	
AOC_69W	ZWP-95-01X	10/26/2009	220.0	
AOC_69W	ZWP-95-01X	10/7/2010	219.7	
AOC_69W	ZWP-95-01X	10/15/2010	220.5	
AOC_69W	ZWP-95-01X	10/13/2011	221.1	
AOC_69W	ZWP-95-01X	10/22/2012	219.0	
AOC_69W	ZWP-95-01X	11/6/2013	218.9	
AOC_69W	ZWP-95-01X	10/20/2014	218.7	
AOC_69W	ZWP-95-01X	10/7/2015	218.9	
AOC_69W	ZWP-95-01X	10/25/2016	218.1	
AOC_69W	ZWP-95-01X	10/30/2017	221.8	
AOC_69W	ZWP-95-01X	10/8/2018	221.6	
AOC_69W	ZWP-95-01X	5/16/2019	221.8	
AOC_69W	ZWP-95-01X	6/28/2019	223.3	
AOC_69W	ZWP-95-01X	10/2/2019	219.2	
AOC_69W	ZWP-95-02X	12/7/1995	218.8	
AOC_69W	ZWP-95-02X	3/26/1996	219.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_69W	ZWP-95-02X	7/23/1996	219.3	
AOC_69W	ZWP-95-02X	1/15/1997	219.6	
AOC_69W	ZWP-95-02X	6/2/1997	219.5	
AOC_69W	ZWP-95-02X	10/14/1998	218.5	
AOC_69W	ZWP-95-02X	12/10/1998	217.6	
AOC_69W	ZWP-95-02X	2/23/1999	218.6	
AOC_69W	ZWP-95-02X	6/6/1999	218.1	
AOC_69W	ZWP-95-02X	9/8/1999	216.4	
AOC_69W	ZWP-95-02X	5/18/2005	219.4	
AOC_69W	ZWP-95-02X	5/23/2005	220.2	
AOC_69W	ZWP-95-02X	10/3/2005	219.5	
AOC_69W	ZWP-95-02X	10/14/2005	220.3	
AOC_69W	ZWP-95-02X	6/5/2006	219.7	
AOC_69W	ZWP-95-02X	6/13/2006	220.5	
AOC_69W	ZWP-95-02X	10/15/2007	217.7	
AOC_69W	ZWP-95-02X	10/17/2007	218.5	
AOC_69W	ZWP-95-02X	10/28/2008	219.2	
AOC_69W	ZWP-95-02X	10/22/2009	219.3	
AOC_69W	ZWP-95-02X	10/26/2009	218.5	
AOC_69W	ZWP-95-02X	10/7/2010	218.4	
AOC_69W	ZWP-95-02X	10/15/2010	219.2	
AOC_69W	ZWP-95-02X	10/13/2011	219.3	
AOC_69W	ZWP-95-02X	10/22/2012	217.5	
AOC_69W	ZWP-95-02X	11/6/2013	217.6	
AOC_69W	ZWP-95-02X	10/20/2014	217.3	
AOC_69W	ZWP-95-02X	10/7/2015	217.4	
AOC_69W	ZWP-95-02X	10/25/2016	216.7	
AOC_69W	ZWP-95-02X	10/30/2017	219.8	
AOC_69W	ZWP-95-02X	10/8/2018	219.7	
AOC_69W	ZWP-95-02X	10/2/2019	217.6	
AOC_74	74MW-19-04A	3/12/2020	220.7	
AOC_74	74PZ-19-01	3/19/2019	223.7	
AOC_74	74PZ-19-01	3/12/2020	222.9	
AOC_74	74PZ-19-02	3/19/2019	226.5	
AOC_74	74PZ-19-02	3/12/2020	225.2	
AOC_74	74PZ-19-03	3/19/2019	226.2	
AOC_74	74PZ-19-03	3/12/2020	224.9	
AOC_74	74PZ-19-04	3/19/2019	220.8	
AOC_74	74PZ-19-04	3/12/2020	220.3	
AOC_74	74PZ-19-05	3/19/2019	224.8	
AOC_74	74PZ-19-05	3/12/2020	223.5	
AOC_74	74PZ-19-06	3/19/2019	223.2	
AOC_74	74PZ-19-06	3/12/2020	222.3	
AOC_74	74PZ-19-07	3/19/2019	221.1	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_74	74PZ-19-07	3/12/2020	220.7	
AOC_74	74PZ-19-08	3/19/2019	220.3	
AOC_74	74PZ-19-08	3/12/2020	220.1	
AOC_74	74PZ-19-09	3/19/2019	220.3	
AOC_74	74PZ-19-09	3/12/2020	219.4	
AOC_74	74PZ-19-10	3/12/2020	219.0	
AOC_74	74PZ-20-01	3/12/2020	220.2	
AOC_74	74PZ-20-02	3/12/2020	224.2	
AOC_74	74PZ-20-03	3/12/2020	221.5	
AOC_74	74PZ-20-04	3/12/2020	224.2	
AOC_74	74PZ-20-05	3/12/2020	223.0	
AOC_75	75MW-19-01BR	2/20/2020	243.5	
AOC_75	75MW-19-01BR	3/12/2020	234.9	
AOC_75	75MW-19-01BR	8/31/2020	241.5	
AOC_75	75MW-19-02A	3/12/2020	230.4	
AOC_75	75MW-19-02B	3/12/2020	230.3	
AOC_75	75MW-19-02BR	3/12/2020	229.4	
AOC_75	75MW-19-02C	3/12/2020	229.4	
AOC_75	75MW-19-04A	3/12/2020	225.1	
AOC_75	75MW-19-04B	3/12/2020	225.0	
AOC_75	75PZ-19-01	3/12/2020	224.9	
AOC_75	75PZ-19-02	1/2/2020	231.9	
AOC_75	75PZ-19-02	3/12/2020	231.9	
AOC_75	75PZ-19-03	1/2/2020	228.5	
AOC_75	75PZ-19-03	3/12/2020	231.6	
AOC_75	75PZ-19-04	1/2/2020	233.9	
AOC_75	75PZ-19-04	3/12/2020	234.2	
AOC_75	75PZ-20-01	3/12/2020	225.3	
AOC_75	75PZ-20-02	3/12/2020	229.4	
AOC_75	75PZ-20-03	3/12/2020	229.9	
AOC_75	75PZ-20-04	3/12/2020	231.0	
AOC_75	75PZ-20-05	3/12/2020	232.7	
AOC_75	75PZ-20-05	8/31/2020	231.5	
AOC_75	75PZ-20-06	3/12/2020	231.2	
AOC_75	75PZ-20-07	3/12/2020	224.5	
AOC_75	MW75-UNKNOWN	3/12/2020	227.0	
AOC_76	76PZ-19-01	5/16/2019	243.9	
AOC_76	76PZ-19-01	6/28/2019	242.4	
AOC_76	76PZ-19-01	1/2/2020	243.8	
AOC_76	76PZ-19-01	2/20/2020	243.3	
AOC_76	76PZ-19-01	3/13/2020	243.4	
AOC_76	76PZ-19-01	8/31/2020	239.4	
AOC_76	76PZ-19-02	5/16/2019	230.8	
AOC_76	76PZ-19-02	6/28/2019	230.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_76	76PZ-19-03	5/16/2019	244.5	
AOC_76	76PZ-19-03	6/28/2019	243.3	
AOC_76	76PZ-19-03	1/2/2020	244.8	
AOC_76	76PZ-19-03	2/20/2020	244.5	
AOC_76	76PZ-19-03	3/13/2020	244.4	
AOC_76	76PZ-19-03	8/31/2020	240.7	
AOC_76	76PZ-19-04	5/16/2019	243.4	
AOC_76	76PZ-19-04	6/28/2019	242.9	
AOC_76	76PZ-19-04	1/2/2020	243.3	
AOC_76	76PZ-19-04	2/20/2020	243.5	
AOC_76	76PZ-19-04	3/13/2020	243.1	
AOC_76	76PZ-19-05	5/16/2019	242.8	
AOC_76	76PZ-19-05	6/28/2019	243.6	
AOC_76	76PZ-19-05	1/2/2020	242.6	
AOC_76	76PZ-19-05	2/20/2020	242.4	
AOC_76	76PZ-19-05	3/13/2020	242.3	
AOC_76	76PZ-19-06	5/16/2019	232.7	
AOC_76	76PZ-19-06	6/28/2019	233.1	
AOC_76	76PZ-19-07	5/16/2019	241.0	
AOC_76	76PZ-19-07	6/28/2019	239.9	
AOC_76	76PZ-19-08	5/16/2019	219.4	
AOC_76	76PZ-19-08	6/28/2019	218.9	
AOC_76	76PZ-19-09	5/16/2019	213.4	
AOC_76	76PZ-19-09	6/28/2019	212.6	
AOC_76	76PZ-19-10	5/16/2019	241.3	
AOC_76	76PZ-19-10	6/28/2019	240.6	
AOC_76	76PZ-19-11	5/16/2019	242.5	
AOC_76	76PZ-19-11	6/28/2019	241.7	
AOC_76	76PZ-19-12	5/16/2019	212.2	
AOC_76	76PZ-19-12	6/28/2019	211.5	
AOC_76	76PZ-19-13	5/16/2019	242.2	
AOC_76	76PZ-19-13	6/28/2019	241.4	
AOC_76	76PZ-19-14	5/16/2019	214.5	
AOC_76	76PZ-19-14	6/28/2019	213.7	
AOC_76	76PZ-19-15	5/16/2019	243.2	
AOC_76	76PZ-19-15	6/28/2019	242.4	
AOC_76	76PZ-19-15	1/2/2020	243.4	
AOC_76	76PZ-19-15	2/20/2020	243.4	
AOC_76	76PZ-19-15	3/13/2020	243.3	
AOC_76	76PZ-19-16	5/16/2019	232.8	
AOC_76	76PZ-19-16	6/28/2019	232.3	
AOC_76	76PZ-19-17	6/28/2019	211.7	
AOC_76	76PZ-19-18	6/28/2019	243.5	
AOC_76	76PZ-19-18	1/2/2020	243.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
AOC_76	76PZ-19-18	2/20/2020	243.7	
AOC_76	76PZ-19-18	3/12/2020	243.5	
AOC_76	76PZ-19-18	3/13/2020	243.6	
AOC_76	76PZ-19-18	8/31/2020	242.5	
AOC_76	76PZ-19-19	6/28/2019	237.2	
Cs_44_and	G3M-92-01X	6/22/1993		-23.3
Cs_44_and	G3M-92-01X	9/30/1993		-24.0
Cs_44_and	G3M-92-01X	11/8/1993		-24.3
Cs_44_and	G3M-92-03X	3/30/1993		-27.1
Cs_44_and	G3M-92-03X	6/22/1993		-24.6
Cs_44_and	G3M-92-03X	9/30/1993		-25.7
Cs_44_and	G3M-92-03X	11/8/1993		-25.8
Cs_44_and	G3M-92-04X	9/30/1993		-27.4
Cs_44_and	G3M-92-04X	11/8/1993		-27.5
Cs_44_and	G3M-92-05X	9/15/1992		-9.8
Cs_44_and	G3M-92-05X	12/22/1992		-30.4
Cs_44_and	G3M-92-05X	3/30/1993		-29.9
Cs_44_and	G3M-92-05X	6/22/1993		-29.4
Cs_44_and	G3M-92-05X	9/30/1993		-30.4
Cs_44_and	G3M-92-05X	11/8/1993		-30.6
Cs_44_and	G3M-92-05X	3/30/1994		-29.7
Cs_44_and	G3M-92-05X	6/28/1994		-28.9
Cs_44_and	G3M-92-05X	10/4/1994		-29.3
Cs_44_and	G3M-92-05X	1/31/1995		-29.2
Cs_44_and	G3M-92-05X	5/9/1995		-29.4
Cs_44_and	G3M-92-05X	12/7/1995		-29.9
Cs_44_and	G3M-92-05X	3/26/1996		-28.9
Cs_44_and	G3M-92-05X	7/23/1996		-28.0
Cs_44_and	G3M-92-05X	1/15/1997		-27.4
Cs_44_and	G3M-92-05X	12/10/1998		-29.5
Cs_44_and	G3M-92-05X	2/23/1999		-29.8
Cs_44_and	G3M-92-05X	6/6/1999		-30.1
Cs_44_and	G3M-92-05X	9/8/1999		-31.2
Cs_44_and	G3M-92-06X	3/30/1993		-27.3
Cs_44_and	G3M-92-06X	6/22/1993		-24.7
Cs_44_and	G3M-92-06X	9/30/1993		-25.8
Cs_44_and	G3M-92-06X	11/8/1993		-25.9
_and_Resid	2019001-03G	3/30/1993		-8.0
_and_Resid	2019001-03G	6/22/1993		-9.0
Consolidate	LFM-03-07	5/22/2006	301.0	
Consolidate	LFM-03-07	10/18/2006	293.0	
Consolidate	LFM-03-07	5/21/2007	301.2	
Consolidate	LFM-03-07	10/15/2007		
Consolidate	LFM-03-07	6/25/2008	294.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
Consolidate	LFM-03-07	10/23/2008	295.7	
Consolidate	LFM-03-07	5/5/2009	298.9	
Consolidate	LFM-03-07	10/21/2009	292.9	
Consolidate	LFM-03-07	5/21/2010		
Consolidate	LFM-03-07	10/13/2010	293.5	
Consolidate	LFM-03-07	6/12/2013	297.1	
Consolidate	LFM-03-07	10/25/2013		
Consolidate	LFM-03-07	6/19/2014	296.8	
Consolidate	LFM-03-07	10/23/2014	293.7	
Consolidate	LFM-03-07	6/10/2015	296.9	
Consolidate	LFM-03-07	10/6/2015		
Consolidate	LFM-03-07	5/17/2016		
Consolidate	LFM-03-07	10/12/2016		
Consolidate	LFM-03-07	6/21/2017		
Consolidate	LFM-03-07	10/26/2017		
Consolidate	LFM-03-07	4/5/2018	298.7	
Consolidate	LFM-03-07	10/11/2018	297.3	
Consolidate	LFM-03-07	4/9/2019	296.8	
Consolidate	LFM-03-07	10/4/2019	292.0	
Consolidate	LFM-03-07	5/14/2020	298.3	
Consolidate	LFM-03-07	8/31/2020	292.1	
Consolidate	LFM-99-01B	5/22/2006	327.0	
Consolidate	LFM-99-01B	10/18/2006	324.8	
Consolidate	LFM-99-01B	5/21/2007	327.2	
Consolidate	LFM-99-01B	10/15/2007	324.1	
Consolidate	LFM-99-01B	6/25/2008	325.7	
Consolidate	LFM-99-01B	10/24/2008	325.6	
Consolidate	LFM-99-01B	5/5/2009	326.6	
Consolidate	LFM-99-01B	10/21/2009	324.9	
Consolidate	LFM-99-01B	5/21/2010	326.1	
Consolidate	LFM-99-01B	10/13/2010	324.3	
Consolidate	LFM-99-01B	6/12/2013	325.7	
Consolidate	LFM-99-01B	10/25/2013	326.6	
Consolidate	LFM-99-01B	6/19/2014	325.2	
Consolidate	LFM-99-01B	10/23/2014	323.5	
Consolidate	LFM-99-01B	6/10/2015	325.2	
Consolidate	LFM-99-01B	10/6/2015	323.4	
Consolidate	LFM-99-01B	5/17/2016	325.5	
Consolidate	LFM-99-01B	10/12/2016	322.7	
Consolidate	LFM-99-01B	6/21/2017	325.6	
Consolidate	LFM-99-01B	10/26/2017	323.3	
Consolidate	LFM-99-01B	4/5/2018	325.9	
Consolidate	LFM-99-01B	10/11/2018	324.9	
Consolidate	LFM-99-01B	4/9/2019	325.6	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
Consolidate	LFM-99-01B	10/4/2019	323.4	
Consolidate	LFM-99-01B	5/13/2020	325.9	
Consolidate	LFM-99-01B	8/31/2020	323.3	
Consolidate	LFM-99-02B	5/22/2006	340.9	
Consolidate	LFM-99-02B	10/18/2006	335.0	
Consolidate	LFM-99-02B	5/21/2007	339.7	
Consolidate	LFM-99-02B	10/15/2007	334.3	
Consolidate	LFM-99-02B	6/25/2008	335.4	
Consolidate	LFM-99-02B	10/23/2008	335.6	
Consolidate	LFM-99-02B	5/5/2009	337.0	
Consolidate	LFM-99-02B	10/21/2009	334.7	
Consolidate	LFM-99-02B	5/21/2010	336.3	
Consolidate	LFM-99-02B	10/13/2010	335.2	
Consolidate	LFM-99-02B	6/12/2013	337.9	
Consolidate	LFM-99-02B	10/25/2013	332.5	
Consolidate	LFM-99-02B	6/19/2014	335.1	
Consolidate	LFM-99-02B	10/23/2014	334.3	
Consolidate	LFM-99-02B	6/11/2015	335.3	
Consolidate	LFM-99-02B	10/6/2015	333.3	
Consolidate	LFM-99-02B	5/17/2016	335.4	
Consolidate	LFM-99-02B	10/12/2016	332.2	
Consolidate	LFM-99-02B	6/21/2017	336.4	
Consolidate	LFM-99-02B	10/26/2017	333.6	
Consolidate	LFM-99-02B	4/5/2018	337.9	
Consolidate	LFM-99-02B	10/11/2018	336.1	
Consolidate	LFM-99-02B	4/9/2019	336.1	
Consolidate	LFM-99-02B	10/4/2019	332.6	
Consolidate	LFM-99-02B	3/13/2020	336.6	
Consolidate	LFM-99-02B	5/13/2020	338.0	
Consolidate	LFM-99-02B	5/15/2020	337.8	
Consolidate	LFM-99-02B	8/31/2020	331.9	
Consolidate	LFM-99-03B	5/22/2006	304.7	
Consolidate	LFM-99-03B	10/18/2006	299.0	
Consolidate	LFM-99-03B	5/21/2007	308.0	
Consolidate	LFM-99-03B	10/15/2007	299.0	
Consolidate	LFM-99-03B	6/25/2008	300.7	
Consolidate	LFM-99-03B	10/24/2008	300.3	
Consolidate	LFM-99-03B	5/5/2009	303.3	
Consolidate	LFM-99-03B	10/21/2009	299.2	
Consolidate	LFM-99-03B	5/21/2010	302.1	
Consolidate	LFM-99-03B	10/13/2010	299.5	
Consolidate	LFM-99-03B	6/12/2013	306.4	
Consolidate	LFM-99-03B	10/25/2013	298.2	
Consolidate	LFM-99-03B	6/19/2014	300.9	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
Consolidate	LFM-99-03B	10/23/2014	298.3	
Consolidate	LFM-99-03B	10/6/2015	298.6	
Consolidate	LFM-99-03B	5/17/2016	300.9	
Consolidate	LFM-99-03B	10/12/2016	298.2	
Consolidate	LFM-99-03B	6/21/2017	302.3	
Consolidate	LFM-99-03B	10/26/2017	298.1	
Consolidate	LFM-99-03B	4/5/2018	303.6	
Consolidate	LFM-99-03B	10/11/2018	302.1	
Consolidate	LFM-99-03B	4/9/2019	302.3	
Consolidate	LFM-99-03B	10/4/2019	298.2	
Consolidate	LFM-99-03B	5/13/2020	302.9	
Consolidate	LFM-99-03B	8/31/2020	298.1	
Consolidate	LFM-99-05A	5/22/2006	298.0	
Consolidate	LFM-99-05A	10/18/2006	291.9	
Consolidate	LFM-99-05A	5/21/2007	298.4	
Consolidate	LFM-99-05A	10/15/2007	291.1	
Consolidate	LFM-99-05A	6/25/2008	293.5	
Consolidate	LFM-99-05A	10/23/2008	294.0	
Consolidate	LFM-99-05A	5/5/2009	295.7	
Consolidate	LFM-99-05A	10/21/2009	292.2	
Consolidate	LFM-99-05A	5/21/2010		
Consolidate	LFM-99-05A	10/13/2010	293.2	
Consolidate	LFM-99-05A	6/12/2013	297.2	
Consolidate	LFM-99-05A	10/25/2013	290.7	
Consolidate	LFM-99-05A	6/19/2014	293.7	
Consolidate	LFM-99-05A	10/23/2014	291.4	
Consolidate	LFM-99-05A	6/11/2015	294.3	
Consolidate	LFM-99-05A	10/6/2015	290.6	
Consolidate	LFM-99-05A	5/17/2016	293.6	
Consolidate	LFM-99-05A	10/12/2016	290.0	
Consolidate	LFM-99-05A	6/21/2017	295.5	
Consolidate	LFM-99-05A	10/26/2017	291.3	
Consolidate	LFM-99-05A	4/5/2018	299.1	
Consolidate	LFM-99-05A	10/11/2018	294.9	
Consolidate	LFM-99-05A	4/9/2019	294.7	
Consolidate	LFM-99-05A	10/4/2019	290.7	
Consolidate	LFM-99-05A	3/13/2020	294.6	
Consolidate	LFM-99-05A	5/13/2020	295.9	
Consolidate	LFM-99-05A	5/14/2020	295.9	
Consolidate	LFM-99-05A	8/31/2020	290.7	
Consolidate	LFM-99-05B	5/22/2006	300.5	
Consolidate	LFM-99-05B	10/18/2006	294.2	
Consolidate	LFM-99-05B	5/21/2007	301.2	
Consolidate	LFM-99-05B	10/15/2007	293.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
Consolidate	LFM-99-05B	6/25/2008	295.8	
Consolidate	LFM-99-05B	10/23/2008	296.4	
Consolidate	LFM-99-05B	5/5/2009	298.4	
Consolidate	LFM-99-05B	10/21/2009	294.5	
Consolidate	LFM-99-05B	5/21/2010	297.3	
Consolidate	LFM-99-05B	10/13/2010	295.5	
Consolidate	LFM-99-05B	6/12/2013	297.2	
Consolidate	LFM-99-05B	10/25/2013	292.9	
Consolidate	LFM-99-05B	6/19/2014	296.4	
Consolidate	LFM-99-05B	10/23/2014	293.6	
Consolidate	LFM-99-05B	6/10/2015	296.7	
Consolidate	LFM-99-05B	10/6/2015	292.9	
Consolidate	LFM-99-05B	5/17/2016	296.3	
Consolidate	LFM-99-05B	10/12/2016	292.3	
Consolidate	LFM-99-05B	6/21/2017	298.3	
Consolidate	LFM-99-05B	10/26/2017	293.3	
Consolidate	LFM-99-05B	4/5/2018	296.1	
Consolidate	LFM-99-05B	10/11/2018	297.8	
Consolidate	LFM-99-05B	4/9/2019	300.7	
Consolidate	LFM-99-05B	10/4/2019	293.0	
Consolidate	LFM-99-05B	3/13/2020	297.5	
Consolidate	LFM-99-05B	5/13/2020	298.9	
Consolidate	LFM-99-05B	8/31/2020	293.0	
Consolidate	LFM-99-06A	5/22/2006	310.1	
Consolidate	LFM-99-06A	10/18/2006	302.7	
Consolidate	LFM-99-06A	5/21/2007	309.7	
Consolidate	LFM-99-06A	10/15/2007	298.7	
Consolidate	LFM-99-06A	6/25/2008	304.1	
Consolidate	LFM-99-06A	10/23/2008	305.2	
Consolidate	LFM-99-06A	5/5/2009	307.6	
Consolidate	LFM-99-06A	10/21/2009	300.8	
Consolidate	LFM-99-06A	5/21/2010	305.3	
Consolidate	LFM-99-06A	10/13/2010	299.9	
Consolidate	LFM-99-06A	6/12/2013	329.0	
Consolidate	LFM-99-06A	10/25/2013	319.5	
Consolidate	LFM-99-06A	6/19/2014	325.5	
Consolidate	LFM-99-06A	10/23/2014	319.6	
Consolidate	LFM-99-06A	6/10/2015	325.6	
Consolidate	LFM-99-06ARP	10/7/2015	320.2	
Consolidate	LFM-99-06ARP	5/17/2016	322.6	
Consolidate	LFM-99-06ARP	10/12/2016	318.8	
Consolidate	LFM-99-06ARP	6/21/2017	323.4	
Consolidate	LFM-99-06ARP	10/26/2017	320.1	
Consolidate	LFM-99-06ARP	4/5/2018	323.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
Consolidate	LFM-99-06ARP	10/11/2018	323.0	
Consolidate	LFM-99-06ARP	4/9/2019	322.6	
Consolidate	LFM-99-06ARP	10/4/2019	319.5	
Consolidate	LFM-99-06ARP	3/13/2020	323.0	
Consolidate	LFM-99-06ARP	5/13/2020	323.3	
Consolidate	LFM-99-06ARP	5/14/2020	323.2	
Consolidate	LFM-99-06ARP	8/31/2020	319.6	
er_Fort_De	1C	3/13/2020	244.3	
er_Fort_De	1C	8/31/2020	242.1	
er_Fort_De	1D-D	2/20/2020	245.2	
er_Fort_De	1D-D	3/13/2020	245.2	
er_Fort_De	1D-D	8/31/2020	242.8	
er_Fort_De	1D-S	2/20/2020	245.1	
er_Fort_De	1D-S	3/13/2020	245.2	
er_Fort_De	1D-S	8/31/2020	242.8	
er_Fort_De	1E-D	3/13/2020	242.2	
er_Fort_De	1E-D	8/31/2020	239.9	
er_Fort_De	1E-S	3/13/2020	242.7	
er_Fort_De	1E-S	8/31/2020	240.4	
er_Fort_De	1F-D	3/13/2020	253.2	
er_Fort_De	1F-D	8/31/2020	249.7	
er_Fort_De	1F-S	3/13/2020	256.6	
er_Fort_De	1F-S	8/31/2020	249.8	
er_Fort_De	B202-1	5/26/1992		-26.9
er_Fort_De	B202-1	9/15/1992		-28.6
er_Fort_De	B202-1	12/22/1992		-28.9
er_Fort_De	B202-1	3/30/1993		-27.5
er_Fort_De	B202-1	6/22/1993		-28.1
er_Fort_De	B202-1	9/30/1993		-29.0
er_Fort_De	B202-1	11/8/1993		-29.2
er_Fort_De	B202-1	3/30/1994		-27.1
er_Fort_De	B202-1	6/28/1994		-27.4
er_Fort_De	B202-1	10/4/1994		-27.8
er_Fort_De	B202-1	1/31/1995		-27.7
er_Fort_De	B202-1	5/9/1995		-28.0
er_Fort_De	B202-1	12/7/1995		-28.6
er_Fort_De	B202-1	3/26/1996		-27.0
er_Fort_De	B202-1	7/23/1996		-26.3
er_Fort_De	B202-1	1/15/1997		-25.8
er_Fort_De	B202-1	6/2/1997		-25.8
er_Fort_De	B202-1	4/23/1998		-25.9
er_Fort_De	B202-1	6/26/1998		-24.6
er_Fort_De	B202-1	7/1/1998		-24.6
er_Fort_De	B202-1	7/17/1998		-25.2

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
er_Fort_De	B202-1	7/31/1998		-25.7
er_Fort_De	B202-1	8/28/1998		-26.6
er_Fort_De	B202-1	10/14/1998		-27.0
er_Fort_De	B202-1	12/10/1998		-28.2
er_Fort_De	B202-1	2/23/1999		-27.9
er_Fort_De	B202-1	6/6/1999		-28.8
er_Fort_De	B202-1	9/8/1999		-30.7
er_Fort_De	B202-2	5/26/1992		-30.4
er_Fort_De	B202-2	9/15/1992		-32.3
er_Fort_De	B202-2	12/22/1992		-32.8
er_Fort_De	B202-2	3/30/1993		-32.2
er_Fort_De	B202-2	6/22/1993		-31.8
er_Fort_De	B202-2	9/30/1993		-32.9
er_Fort_De	B202-2	11/8/1993		-33.0
er_Fort_De	B202-2	3/30/1994		-31.1
er_Fort_De	B202-2	6/28/1994		-31.2
er_Fort_De	B202-2	10/4/1994		-31.5
er_Fort_De	B202-2	1/31/1995		-31.4
er_Fort_De	B202-2	12/7/1995		-32.2
er_Fort_De	B202-2	3/26/1996		-30.7
er_Fort_De	B202-2	7/23/1996		-30.0
er_Fort_De	B202-2	1/15/1997		-29.5
er_Fort_De	B202-2	4/23/1998		-29.8
er_Fort_De	B202-2	7/1/1998		-28.5
er_Fort_De	B202-2	7/17/1998		-28.9
er_Fort_De	B202-2	7/31/1998		-29.4
er_Fort_De	B202-2	8/28/1998		-30.2
er_Fort_De	B202-2	10/14/1998		-30.9
er_Fort_De	B202-2	12/10/1998		-32.0
er_Fort_De	B202-2	2/23/1999		-31.7
er_Fort_De	B202-2	6/6/1999		-32.5
er_Fort_De	B202-2	9/8/1999		-33.8
er_Fort_De	B202-3	5/26/1992		-29.4
er_Fort_De	B202-3	5/27/1992		-31.3
er_Fort_De	B202-3	9/15/1992		-31.5
er_Fort_De	B202-3	12/22/1992		-32.1
er_Fort_De	B202-3	3/30/1993		-31.5
er_Fort_De	B202-3	6/22/1993		-31.0
er_Fort_De	B202-3	9/30/1993		-32.3
er_Fort_De	B202-3	11/8/1993		-32.3
er_Fort_De	B202-3	3/30/1994		-30.5
er_Fort_De	B202-3	6/28/1994		-30.3
er_Fort_De	B202-3	10/4/1994		-30.7
er_Fort_De	B202-3	1/31/1995		-30.7

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
er_Fort_De	B202-3	5/9/1995		-31.0
er_Fort_De	B202-3	12/7/1995		-31.6
er_Fort_De	B202-3	3/26/1996		-30.0
er_Fort_De	B202-3	7/23/1996		-29.1
er_Fort_De	B202-3	1/15/1997		-28.7
er_Fort_De	B202-3	6/2/1997		-28.5
er_Fort_De	B202-3	4/23/1998		-29.0
er_Fort_De	B202-3	7/1/1998		-27.9
er_Fort_De	B202-3	7/17/1998		-28.0
er_Fort_De	B202-3	7/31/1998		-28.5
er_Fort_De	B202-3	8/28/1998		-29.3
er_Fort_De	B202-3	10/14/1998		-30.2
er_Fort_De	B202-3	12/10/1998		-31.2
er_Fort_De	B202-3	2/23/1999		-31.0
er_Fort_De	B202-3	6/6/1999		-31.8
er_Fort_De	B202-3	9/8/1999		-33.1
er_Fort_De	EA-04	5/26/1992		
er_Fort_De	EA-04	6/1/1992		
er_Fort_De	EA-05	5/26/1992		
er_Fort_De	EA-05	6/1/1992		
er_Fort_De	FD40	5/26/1992		
er_Fort_De	FD40	6/1/1992		
er_Fort_De	POL-1	5/26/1992		-19.1
er_Fort_De	POL-1	9/15/1992		-20.0
er_Fort_De	POL-1	12/22/1992		-19.0
er_Fort_De	POL-1	3/30/1993		-15.3
er_Fort_De	POL-1	6/22/1993		-19.4
er_Fort_De	POL-1	9/30/1993		-19.3
er_Fort_De	POL-1	11/8/1993		-19.2
er_Fort_De	POL-1	6/28/1994		-19.3
er_Fort_De	POL-1	10/4/1994		-19.3
er_Fort_De	POL-1	1/31/1995		-18.0
er_Fort_De	POL-1	5/9/1995		-19.2
er_Fort_De	POL-1	12/7/1995		-18.7
er_Fort_De	POL-1	3/26/1996		-17.7
er_Fort_De	POL-1	7/23/1996		-18.8
er_Fort_De	POL-1	1/15/1997		-17.9
er_Fort_De	POL-1	6/2/1997		-18.7
er_Fort_De	POL-1	4/23/1998		-18.3
er_Fort_De	POL-1	10/14/1998		-19.3
er_Fort_De	POL-1	12/10/1998		-20.1
er_Fort_De	POL-1	2/23/1999		-18.8
er_Fort_De	POL-2	5/26/1992		-27.7
er_Fort_De	POL-2	9/15/1992		-28.3

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
er_Fort_De	POL-2	12/22/1992		-28.0
er_Fort_De	POL-2	3/30/1993		-26.7
er_Fort_De	POL-2	6/22/1993		-25.4
er_Fort_De	POL-2	9/30/1993		-29.4
er_Fort_De	POL-2	11/8/1993		-27.9
er_Fort_De	POL-2	6/28/1994		-24.4
er_Fort_De	POL-2	10/4/1994		-27.4
er_Fort_De	POL-2	1/31/1995		-27.0
er_Fort_De	POL-2	5/9/1995		-27.4
er_Fort_De	POL-2	12/7/1995		-28.2
er_Fort_De	POL-2	1/15/1997		-23.7
er_Fort_De	POL-2	6/2/1997		-26.3
er_Fort_De	POL-2	4/23/1998		-24.7
er_Fort_De	POL-2	10/14/1998		-27.2
er_Fort_De	POL-2	12/10/1998		-28.7
er_Fort_De	POL-2	2/23/1999		-28.2
er_Fort_De	POL-3	5/26/1992		-25.4
er_Fort_De	POL-3	9/15/1992		-25.0
er_Fort_De	POL-3	12/22/1992		-26.7
er_Fort_De	POL-3	3/30/1993		-23.9
er_Fort_De	POL-3	6/22/1993		-25.7
er_Fort_De	POL-3	9/30/1993		-27.0
er_Fort_De	POL-3	11/8/1993		-26.7
er_Fort_De	POL-3	6/28/1994		-25.3
er_Fort_De	POL-3	10/4/1994		-25.9
er_Fort_De	POL-3	1/31/1995		-24.0
er_Fort_De	POL-3	5/9/1995		-25.9
er_Fort_De	POL-3	12/7/1995		-24.8
er_Fort_De	POL-3	1/15/1997		-22.8
er_Fort_De	POL-3	4/23/1998		-23.9
er_Fort_De	POL-3	10/14/1998		-25.9
er_Fort_De	POL-3	12/10/1998		-27.3
er_Fort_De	POL-3	2/23/1999		-25.2
er_Fort_De	SMW-2	4/23/1998		
er_Fort_De	SMW-2	6/19/1998		
er_Fort_De	SMW-2	2/23/1999		
er_Fort_De	SMW-2	9/8/1999		
er_Fort_De	SMW-2	1/19/2000		
er_Fort_De	SMW-2	5/24/2000		
er_Fort_De	SMW-2	11/14/2000		
er_Fort_De	SMW-2	5/10/2001		
er_Fort_De	SMW-2	11/16/2001		
er_Fort_De	SMW-2	7/10/2002		
er_Fort_De	SMW-2	6/19/2003		

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
er_Fort_De	SMW-2	12/1/2003		
er_Fort_De	SMW-2	5/25/2004		
er_Fort_De	SMW-2	8/30/2004		
er_Fort_De	SMW-2	12/8/2004		
er_Fort_De	SMW-2	5/18/2005		
er_Fort_De	SMW-2	11/7/2005		
er_Fort_De	SMW-2	12/8/2005		
er_Fort_De	SMW-2	2/16/2006		
er_Fort_De	SMW-2	6/5/2006		
er_Fort_De	SMW-2	9/18/2006		
er_Fort_De	SMW-2	12/15/2006		
er_Fort_De	SMW-2	5/7/2007		
er_Fort_De	SMW-2	6/25/2007		
er_Fort_De	SMW-2	11/17/2008		
er_Fort_De	SMW-2	4/28/2009		
er_Fort_De	SMW-2	7/5/2009		
er_Fort_De	SMW-2	10/26/2009		
er_Fort_De	SMW-2	1/22/2010		
er_Fort_De	SMW-2	4/6/2010		
er_Fort_De	SMW-2	7/7/2010		
er_Fort_De	SMW-2	1/14/2011		
er_Fort_De	SMW-2	4/4/2011		
er_Fort_De	SMW-2	7/25/2011		
er_Fort_De	SMW-2	10/13/2011		
er_Fort_De	SMW-2	4/10/2012		
er_Fort_De	SMW-2	4/22/2013		
er_Fort_De	WBP-93-01	10/4/1994		
er_Fort_De	WBP-93-01	1/31/1995		
er_Fort_De	WBP-93-01	5/9/1995		
er_Fort_De	WBP-93-01	12/7/1995		
er_Fort_De	WBP-93-01	6/5/2006		
er_Fort_De	WBP-93-01	12/15/2006		
ve_Pond_A	92-1	5/26/1992	216.2	
ve_Pond_A	92-1	6/1/1992		209.8
ve_Pond_A	92-1	10/2/2018	214.4	
ve_Pond_A	92-1	3/12/2020	214.8	
ve_Pond_A	92-2	5/26/1992		-7.4
ve_Pond_A	92-2	6/1/1992		-11.7
ve_Pond_A	92-3	5/26/1992	216.2	
ve_Pond_A	92-3	6/1/1992		209.9
ve_Pond_A	92-3	10/2/2018	214.1	
ve_Pond_A	92-3	3/12/2020	214.5	
ve_Pond_A	92-4	5/26/1992	246.4	
ve_Pond_A	92-4	6/1/1992	241.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
ve_Pond_A	92-4	10/2/2018	214.5	
ve_Pond_A	92-4	3/12/2020	214.8	
ve_Pond_A	92-5	5/26/1992	216.1	
ve_Pond_A	92-5	6/1/1992	215.9	
ve_Pond_A	CSMS-11-01	10/2/2018	216.1	
ve_Pond_A	CSMS-11-01	3/19/2019	216.1	
ve_Pond_A	CSMS-11-01	3/12/2020	216.3	
ve_Pond_A	CSMS-11-02	10/2/2018	215.1	
ve_Pond_A	CSMS-11-02	3/19/2019	214.9	
ve_Pond_A	CSMS-11-02	3/12/2020	215.4	
ve_Pond_A	GF-1	10/2/2018	214.1	
ve_Pond_A	GF-1	3/12/2020	214.5	
ve_Pond_A	GF-2	10/2/2018	214.2	
ve_Pond_A	GF-2	3/12/2020	214.7	
ve_Pond_A	GF-3A	10/2/2018	214.6	
ve_Pond_A	GF-3A	3/12/2020	215.6	
ve_Pond_A	GF-3B	10/2/2018	216.1	
ve_Pond_A	GF-3B	3/12/2020	216.1	
ve_Pond_A	GF-4	10/2/2018	212.5	
ve_Pond_A	GF-4	3/12/2020	213.5	
ve_Pond_A	GPMW-19-01A	3/12/2020	216.4	
ve_Pond_A	GPMW-19-01BR	3/12/2020	216.1	
ve_Pond_A	GPPZ-19-01	3/12/2020	216.0	
ve_Pond_A	MNG-1	5/26/1992		
ve_Pond_A	MNG-2	5/26/1992		-17.5
ve_Pond_A	MNG-2	3/30/1993		-16.8
ve_Pond_A	MNG-2	6/22/1993		-17.7
ve_Pond_A	MNG-2	9/30/1993		-17.7
ve_Pond_A	MNG-2	11/8/1993		-17.9
ve_Pond_A	MNG-2	12/20/2011		-19.2
ve_Pond_A	MNG-2R	10/2/2018	216.9	
ve_Pond_A	MNG-2R	3/19/2019	217.2	
ve_Pond_A	MNG-2R	3/12/2020	217.0	
ve_Pond_A	MNG-3R	10/2/2018	215.0	
ve_Pond_A	MNG-3R	3/19/2019	214.9	
ve_Pond_A	MNG-3R	3/12/2020	215.4	
ve_Pond_A	MNG-4	5/26/1992		
ve_Pond_A	MNG-5	5/26/1992		-15.9
ve_Pond_A	MNG-5	3/30/1993		-15.7
ve_Pond_A	MNG-5	6/22/1993		-15.9
ve_Pond_A	MNG-5	11/8/1993		-16.5
ve_Pond_A	MNG-5	12/20/2011		-15.2
ve_Pond_A	MNG-5R	10/2/2018	219.2	
ve_Pond_A	MNG-5R	3/19/2019	219.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
ve_Pond_A	MNG-5R	3/12/2020	219.1	
ve_Pond_A	MNG-6	5/26/1992		-34.0
ve_Pond_A	MNG-6	6/1/1992		-34.6
ve_Pond_A	MNG-6	3/30/1993		-33.1
ve_Pond_A	MNG-6	6/22/1993		-33.8
ve_Pond_A	MNG-6	9/30/1993		-33.8
ve_Pond_A	MNG-6	11/8/1993		-33.9
ve_Pond_A	MNG-6	12/20/2011		-35.0
ve_Pond_A	MNG-6R	10/2/2018	216.7	
ve_Pond_A	MNG-6R	3/19/2019	216.8	
ve_Pond_A	MNG-6R	3/12/2020	216.7	
ve_Pond_A	MNG-7	5/26/1992		
ve_Pond_A	MNG-7	6/1/1992		
ve_Pond_A	MNG-7	3/30/1993		
ve_Pond_A	MNG-7	9/30/1993		
ve_Pond_A	MNG-7	11/8/1993		
MacPherso	McPh-Sentinel	6/10/2008	204.7	
MacPherso	McPh-Sentinel	8/19/2008	203.7	
MacPherso	McPh-Sentinel	11/17/2008	204.1	
MacPherso	McPh-Sentinel	4/28/2009	203.8	
MacPherso	McPh-Sentinel	8/5/2009	204.3	
MacPherso	McPh-Sentinel	4/20/2010	205.8	
MacPherso	McPh-Sentinel	7/7/2010	203.0	
MacPherso	McPh-Sentinel	12/23/2010	203.9	
MacPherso	McPh-Sentinel	4/4/2011	205.7	
MacPherso	McPh-Sentinel	7/25/2011	203.4	
MacPherso	McPh-Sentinel	4/10/2012	203.8	
MacPherso	McPh-Sentinel	4/22/2013	204.2	
MacPherso	McPh-Sentinel	5/16/2019	205.4	
MacPherso	McPh-Sentinel	6/28/2019	204.3	
MacPherso	MPP-93-01	6/28/1994		
MacPherso	MPP-93-01	10/4/1994		
MacPherso	MPP-93-01	5/9/1995		
MacPherso	MPP-93-01	12/7/1995		
MacPherso	MPP-93-01	3/26/1996		
MacPherso	MPP-93-01	7/23/1996		
MacPherso	MPP-93-01	1/15/1997		
MacPherso	MPP-93-01	6/2/1997		
MacPherso	MPP-93-01	10/14/1998		
MacPherso	MPP-93-01	12/10/1998		
MacPherso	MPP-93-01	2/23/1999		
MacPherso	MPP-93-01	6/6/1999		
MacPherso	MPP-93-01	9/8/1999		
MacPherso	MPP-93-02	10/14/1998	202.5	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
MacPherso	MPP-93-02	12/10/1998	202.1	
MacPherso	MPP-93-02	2/23/1999	203.3	
MacPherso	MPP-93-02	6/6/1999	201.4	
MacPherso	MPP-93-02	9/8/1999	201.0	
MacPherso	MPP-93-02	5/16/2019	205.1	
MacPherso	MPP-93-02	6/28/2019	203.8	
MacPherso	MPP-93-03	6/28/1994	201.8	
MacPherso	MPP-93-03	10/4/1994	203.6	
MacPherso	MPP-93-03	1/31/1995	203.8	
MacPherso	MPP-93-03	5/9/1995	202.0	
MacPherso	MPP-93-03	12/7/1995	202.9	
MacPherso	MPP-93-03	3/26/1996	205.2	
MacPherso	MPP-93-03	7/23/1996	203.0	
MacPherso	MPP-93-03	1/15/1997	204.3	
MacPherso	MPP-93-03	6/2/1997	203.2	
MacPherso	MPP-93-03	5/16/2019	204.9	
MacPherso	MPP-93-03	6/28/2019	203.7	
MacPherso	MPPZ-19-01	5/16/2019	206.6	
MacPherso	MPPZ-19-01	6/28/2019	206.0	
MacPherso	MPPZ-19-02	6/28/2019	206.6	
MacPherso	MPPZ-19-03	5/16/2019	205.5	
MacPherso	MPPZ-19-03	6/28/2019	204.4	
lashua_Rive	NRSG-01	4/27/2020	202.7	
ton_Well_F	CPSG-01	1/3/2020		-3.7
ton_Well_F	CPSG-01	3/13/2020	244.3	
ton_Well_F	CPSG-01	9/1/2020	243.9	
ton_Well_F	CPSG-02	1/3/2020		-1.9
ton_Well_F	CPSG-02	3/13/2020	243.7	
ton_Well_F	CPSG-02	8/31/2020	242.0	
ton_Well_F	CSBSG-01	1/3/2020		-3.0
ton_Well_F	CSBSG-01	3/13/2020	235.4	
ton_Well_F	CSBSG-01	8/31/2020	233.5	
ton_Well_F	PTW-A	3/13/2020	243.4	
ton_Well_F	PTW-A	8/31/2020	241.0	
ton_Well_F	PTW-B	3/13/2020	242.5	
ton_Well_F	PTW-B	8/31/2020	236.1	
ton_Well_F	PWPZ-19-01	1/3/2020	243.0	
ton_Well_F	PWPZ-19-01	3/13/2020	243.8	
ton_Well_F	PWPZ-19-01	8/31/2020	241.1	
ton_Well_F	PWPZ-19-02	1/3/2020	237.2	
ton_Well_F	PWPZ-19-02	3/13/2020	237.2	
ton_Well_F	PWPZ-19-02	8/31/2020	236.1	
ton_Well_F	PWPZ-19-03	1/3/2020	243.6	
ton_Well_F	PWPZ-19-03	3/13/2020	242.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
ton_Well_F	PWPZ-19-03	8/31/2020	239.6	
ton_Well_F	PWPZ-19-04	1/3/2020	247.4	
ton_Well_F	PWPZ-19-04	3/13/2020	248.8	
ton_Well_F	PWPZ-19-04	8/31/2020	247.4	
ton_Well_F	PWPZ-19-05	1/3/2020	243.6	
ton_Well_F	PWPZ-19-05	3/13/2020	244.2	
ton_Well_F	PWPZ-19-05	8/31/2020	242.7	
ton_Well_F	PWPZ-19-06	1/3/2020	243.4	
ton_Well_F	PWPZ-19-06	8/31/2020	241.7	
ton_Well_F	PWPZ-19-07	1/3/2020	247.6	
ton_Well_F	PWPZ-19-07	3/13/2020	247.0	
ton_Well_F	PWPZ-19-07	8/31/2020	242.3	
ton_Well_F	PWPZ-19-08	1/3/2020	243.4	
ton_Well_F	PWPZ-19-08	3/13/2020	242.8	
ton_Well_F	PWPZ-19-08	8/31/2020	241.6	
ton_Well_F	PWPZ-19-09	1/3/2020	243.3	
ton_Well_F	PWPZ-19-09	3/13/2020	243.7	
ton_Well_F	PWPZ-19-09	8/31/2020	241.7	
ton_Well_F	PWPZ-19-10	1/3/2020	243.6	
ton_Well_F	PWPZ-19-10	3/13/2020	243.9	
ton_Well_F	PWPZ-19-10	8/31/2020	241.7	
ton_Well_F	PWPZ-20-01	3/13/2020	243.0	
ton_Well_F	PWPZ-20-01	8/31/2020	239.3	
ton_Well_F	PWPZ-20-02	8/31/2020		
ton_Well_F	PWPZ-20-03	8/31/2020		-18.0
ton_Well_F	PWPZ-20-04	8/31/2020		-29.5
ton_Well_F	PWPZ-20-05	8/31/2020		
ton_Well_F	PWPZ-20-06	8/31/2020		-10.8
ton_Well_F	PWPZ-20-07	9/1/2020		-7.4
ton_Well_F	PWPZ-20-08	8/31/2020		-80.4
ton_Well_F	PWPZ-20-09	8/31/2020		-75.0
ton_Well_F	PWPZ-20-10	8/31/2020		-12.3
ton_Well_F	PWPZ-20-11	8/31/2020		
ton_Well_F	PWPZ-20-12	8/31/2020		-12.3
ton_Well_F	PWPZ-20-13	8/31/2020		-10.5
Pond_and_	RPSG-01	1/3/2020		-2.2
Pond_and_	RPSG-01	2/20/2020	244.9	
Pond_and_	RPSG-01	3/13/2020	245.1	
Pond_and_	RPSG-01	8/31/2020	243.7	
okin_Well_	MLSG-01	1/3/2020		-2.0
okin_Well_	MLSG-01	3/13/2020	242.3	
okin_Well_	MLSG-01	8/31/2020	240.9	
okin_Well_	MW-9D	3/13/2020	233.7	
okin_Well_	MW-A	3/13/2020	230.8	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
okin_Well_	MW-B	3/13/2020	231.5	
okin_Well_	MW-C	3/13/2020	231.5	
okin_Well_	MW-D	3/13/2020	230.8	
okin_Well_	MW-E	3/13/2020	230.8	
okin_Well_	MW-F	3/13/2020	230.7	
okin_Well_	MW-G	3/13/2020	233.8	
okin_Well_	MW-H	3/13/2020	232.0	
okin_Well_	MW-I	3/13/2020	230.5	
okin_Well_	MW-J	3/13/2020	233.8	
okin_Well_	MW-K	3/13/2020	233.8	
okin_Well_	SWMW-20-01A	3/13/2020	357.4	
okin_Well_	SWMW-20-01A	8/31/2020	351.6	
okin_Well_	SWPZ-19-01	3/13/2020	230.0	
okin_Well_	SWPZ-19-03	3/13/2020	241.2	
okin_Well_	SWPZ-19-03	8/31/2020	236.4	
okin_Well_	SWPZ-19-04	3/13/2020	232.2	
okin_Well_	SWPZ-20-01	3/13/2020	329.2	
okin_Well_	SWPZ-20-01	8/31/2020	327.3	
okin_Well_	SWPZ-20-02	3/13/2020	242.4	
okin_Well_	SWPZ-20-02	8/31/2020	240.6	
SP_Other	28M-92-01X	9/5/1992	238.1	
SP_Other	28M-92-01X	9/30/1993	237.6	
SP_Other	28M-92-01X	12/7/1995	241.4	
SP_Other	28M-92-01X	7/23/1996	240.3	
SP_Other	28M-92-01X	1/15/1997	241.4	
SP_Other	28M-92-01X	6/2/1997	241.4	
SP_Other	28M-92-01X	4/23/1998	247.6	
SP_Other	28M-92-02X	9/5/1992	236.9	
SP_Other	28M-92-02X	9/30/1993	236.8	
SP_Other	28M-92-02X	12/7/1995	237.3	
SP_Other	28M-92-02X	7/23/1996	239.1	
SP_Other	28M-92-02X	4/23/1998	245.5	
SP_Other	28M-92-03X	9/5/1992	227.6	
SP_Other	28M-92-03X	9/30/1993	233.2	
SP_Other	28M-92-04X	9/5/1992	235.7	
SP_Other	28M-92-04X	9/30/1993	230.1	
SP_Other	28M-92-04X	12/7/1995	236.2	
SP_Other	28M-92-04X	7/23/1996	237.6	
SP_Other	28M-92-04X	4/23/1998	244.3	
SP_Other	SPM-93-02X	7/23/1996	313.3	
SP_Other	SPM-93-02X	1/15/1997	316.3	
SP_Other	SPM-93-02X	4/23/1998	316.6	
SP_Other	SPM-93-02X	10/14/1998	311.6	
SP_Other	SPM-93-02X	12/6/1999	313.2	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
SP_Other	SPM-93-02X	10/26/2010	245.5	
SP_Other	SPM-93-02X	11/25/2014	247.4	
SP_Other	SPM-93-02X	11/26/2014	311.9	
SP_Other	SPM-93-02X	12/8/2015	245.4	
SP_Other	SPM-93-02X	12/10/2015	309.3	
SP_Other	SPM-93-02X	11/2/2016	243.7	
SP_Other	SPM-93-02X	11/27/2017	247.4	
SP_Other	SPM-93-02X	11/19/2018	250.5	
SP_Other	SPM-93-02X	11/26/2019	247.5	
SP_Other	SPM-93-03X	7/23/1996	247.0	
SP_Other	SPM-93-03X	1/15/1997	249.0	
SP_Other	SPM-93-03X	6/2/1997	248.4	
SP_Other	SPM-93-03X	4/23/1998	249.4	
SP_Other	SPM-93-03X	12/6/1999	247.4	
SP_Other	SPM-93-03X	10/21/2008		
SP_Other	SPM-93-03X	11/12/2009		
SP_Other	SPM-93-03X	10/26/2010		
SP_Other	SPM-93-05X	7/23/1996	232.4	
SP_Other	SPM-93-05X	1/15/1997	233.1	
SP_Other	SPM-93-05X	6/2/1997	233.4	
SP_Other	SPM-93-05X	4/23/1998	233.2	
SP_Other	SPM-93-05X	10/14/1998	232.1	
SP_Other	SPM-93-05X	12/6/1999	230.8	
SP_Other	SPM-93-05X	10/21/2008		
SP_Other	SPM-93-05X	10/26/2010	232.0	
SP_Other	SPM-93-05X	10/17/2011	232.6	
SP_Other	SPM-93-05X	11/13/2012		
SP_Other	SPM-93-05X	11/13/2013	231.2	
SP_Other	SPM-93-05X	11/25/2014	231.6	
SP_Other	SPM-93-05X	12/8/2015	231.1	
SP_Other	SPM-93-05X	11/2/2016	230.6	
SP_Other	SPM-93-05X	11/27/2017	231.7	
SP_Other	SPM-93-05X	2/22/2018	233.8	
SP_Other	SPM-93-05X	11/19/2018	233.7	
SP_Other	SPM-93-05X	11/25/2019	232.3	
SP_Other	SPM-93-07X	7/23/1996	240.1	
SP_Other	SPM-93-07X	10/14/1998	240.1	
SP_Other	SPM-93-07X	12/6/1999	235.3	
SP_Other	SPM-93-07X	10/22/2008		
SP_Other	SPM-93-07X	10/26/2010	240.7	
SP_Other	SPM-93-07X	10/18/2011	239.9	
SP_Other	SPM-93-07X	11/14/2013	237.5	
SP_Other	SPM-93-07X	11/25/2014	236.2	
SP_Other	SPM-93-07X	12/7/2015	235.7	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
SP_Other	SPM-93-07X	10/31/2016	234.0	
SP_Other	SPM-93-07X	2/22/2018	236.4	
SP_Other	SPM-93-07X	11/19/2018	239.1	
SP_Other	SPM-93-07X	11/25/2019	239.4	
SP_Other	SPM-93-08X	7/23/1996	241.0	
SP_Other	SPM-93-08X	10/27/1997	239.8	
SP_Other	SPM-93-08X	10/14/1998	241.1	
SP_Other	SPM-93-08X	10/21/1998	241.0	
SP_Other	SPM-93-08X	10/18/1999	236.9	
SP_Other	SPM-93-08X	12/6/1999	236.3	
SP_Other	SPM-93-08X	10/25/2000	238.5	
SP_Other	SPM-93-08X	10/15/2001	238.4	
SP_Other	SPM-93-08X	10/21/2002	235.0	
SP_Other	SPM-93-08X	10/28/2003	238.5	
SP_Other	SPM-93-08X	11/1/2004	237.7	
SP_Other	SPM-93-08X	11/14/2005	241.8	
SP_Other	SPM-93-08X	10/24/2006	241.9	
SP_Other	SPM-93-08X	10/23/2007	240.7	
SP_Other	SPM-93-08X	10/22/2008	241.4	
SP_Other	SPM-93-08X	11/12/2009	240.7	
SP_Other	SPM-93-08X	10/26/2010	240.9	
SP_Other	SPM-93-08X	10/18/2011	240.1	
SP_Other	SPM-93-08X	11/13/2012	238.2	
SP_Other	SPM-93-08X	11/14/2013	237.5	
SP_Other	SPM-93-08X	11/25/2014	236.4	
SP_Other	SPM-93-08X	12/7/2015	235.9	
SP_Other	SPM-93-08X	10/31/2016	234.4	
SP_Other	SPM-93-08X	11/13/2017	236.4	
SP_Other	SPM-93-08X	11/19/2018	239.5	
SP_Other	SPM-93-08X	11/25/2019	239.7	
SP_Other	SPM-93-09X	7/23/1996	235.6	
SP_Other	SPM-93-09X	1/15/1997	236.3	
SP_Other	SPM-93-09X	6/2/1997	237.0	
SP_Other	SPM-93-09X	4/23/1998	236.1	
SP_Other	SPM-93-09X	10/14/1998	235.5	
SP_Other	SPM-93-09X	12/6/1999	232.5	
SP_Other	SPM-93-09X	10/23/2008		
SP_Other	SPM-93-09X	11/25/2009		
SP_Other	SPM-93-09X	10/26/2010	235.1	
SP_Other	SPM-93-09X	10/18/2011	235.0	
SP_Other	SPM-93-09X	11/15/2012	234.0	
SP_Other	SPM-93-09X	11/13/2013		
SP_Other	SPM-93-09X	11/26/2014	232.8	
SP_Other	SPM-93-09X	12/7/2015	232.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
SP_Other	SPM-93-09X	10/31/2016	231.2	
SP_Other	SPM-93-09X	2/22/2018	233.0	
SP_Other	SPM-93-09X	11/19/2018	235.2	
SP_Other	SPM-93-09X	11/26/2019	234.6	
SP_Other	SPM-93-10X	7/23/1996	235.5	
SP_Other	SPM-93-10X	1/15/1997	235.7	
SP_Other	SPM-93-10X	6/2/1997	236.7	
SP_Other	SPM-93-10X	10/27/1997	234.3	
SP_Other	SPM-93-10X	4/23/1998	235.6	
SP_Other	SPM-93-10X	10/14/1998	235.2	
SP_Other	SPM-93-10X	10/21/1998	235.5	
SP_Other	SPM-93-10X	10/18/1999	233.1	
SP_Other	SPM-93-10X	12/6/1999	232.1	
SP_Other	SPM-93-10X	10/25/2000	234.0	
SP_Other	SPM-93-10X	10/15/2001	233.6	
SP_Other	SPM-93-10X	10/21/2002	231.4	
SP_Other	SPM-93-10X	10/28/2003	234.0	
SP_Other	SPM-93-10X	11/1/2004	233.2	
SP_Other	SPM-93-10X	11/14/2005	235.9	
SP_Other	SPM-93-10X	10/25/2006	236.0	
SP_Other	SPM-93-10X	10/24/2007	235.2	
SP_Other	SPM-93-10X	10/23/2008	235.5	
SP_Other	SPM-93-10X	11/25/2009	235.4	
SP_Other	SPM-93-10X	10/26/2010	235.2	
SP_Other	SPM-93-10X	10/18/2011	234.8	
SP_Other	SPM-93-10X	11/15/2012	233.6	
SP_Other	SPM-93-10X	11/13/2013	233.2	
SP_Other	SPM-93-10X	11/26/2014	232.5	
SP_Other	SPM-93-10X	12/7/2015	232.1	
SP_Other	SPM-93-10X	10/31/2016	231.0	
SP_Other	SPM-93-10X	11/13/2017	232.5	
SP_Other	SPM-93-10X	11/19/2018	234.8	
SP_Other	SPM-93-10X	11/26/2019	234.3	
SP_Other	SPM-93-11X	6/2/1997	236.0	
SP_Other	SPM-93-11X	10/14/1998	233.5	
SP_Other	SPM-93-11X	12/6/1999	231.3	
SP_Other	SPM-93-11X	10/21/2009		
SP_Other	SPM-93-11X	11/25/2009		
SP_Other	SPM-93-11X	10/26/2010		
SP_Other	SPM-93-11X	10/18/2011	234.1	
SP_Other	SPM-93-11X	11/15/2012	232.7	
SP_Other	SPM-93-11X	11/13/2013	247.2	
SP_Other	SPM-93-11X	11/26/2014	231.9	
SP_Other	SPM-93-11X	12/7/2015	231.3	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
SP_Other	SPM-93-11X	10/31/2016	230.1	
SP_Other	SPM-93-11X	11/27/2017	232.7	
SP_Other	SPM-93-11X	2/22/2018	233.0	
SP_Other	SPM-93-11X	11/19/2018	235.5	
SP_Other	SPM-93-11X	11/26/2019	233.2	
SP_Other	SPM-93-12X	6/2/1997	236.6	
SP_Other	SPM-93-12X	10/27/1997	232.6	
SP_Other	SPM-93-12X	10/14/1998	234.1	
SP_Other	SPM-93-12X	10/21/1998	234.3	
SP_Other	SPM-93-12X	10/18/1999	231.9	
SP_Other	SPM-93-12X	12/6/1999	232.1	
SP_Other	SPM-93-12X	10/25/2000	233.3	
SP_Other	SPM-93-12X	10/15/2001	232.6	
SP_Other	SPM-93-12X	10/21/2002	231.1	
SP_Other	SPM-93-12X	10/28/2003	233.5	
SP_Other	SPM-93-12X	11/1/2004	232.9	
SP_Other	SPM-93-12X	11/14/2005	235.9	
SP_Other	SPM-93-12X	10/25/2006	234.6	
SP_Other	SPM-93-12X	10/23/2007	233.5	
SP_Other	SPM-93-12X	10/21/2008	234.2	
SP_Other	SPM-93-12X	11/25/2009	234.4	
SP_Other	SPM-93-12X	10/25/2010	233.2	
SP_Other	SPM-93-12X	10/18/2011	234.2	
SP_Other	SPM-93-12X	11/15/2012	232.8	
SP_Other	SPM-93-12X	11/13/2013	232.2	
SP_Other	SPM-93-12X	11/26/2014	233.0	
SP_Other	SPM-93-12X	12/7/2015	230.9	
SP_Other	SPM-93-12X	10/31/2016	230.4	
SP_Other	SPM-93-12X	11/27/2017	232.6	
SP_Other	SPM-93-12X	11/19/2018	235.7	
SP_Other	SPM-93-12X	11/25/2019	233.1	
SP_Other	SPM-93-13X	10/14/1998	279.7	
SP_Other	SPM-93-13X	10/21/2008		
SP_Other	SPM-93-13X	11/12/2009		
SP_Other	SPM-93-13X	10/25/2010	278.6	
SP_Other	SPM-93-13X	10/18/2011	278.6	
SP_Other	SPM-93-13X	11/5/2012	278.1	
SP_Other	SPM-93-13X	11/13/2013	278.8	
SP_Other	SPM-93-13X	11/25/2014	276.9	
SP_Other	SPM-93-13X	12/8/2015	276.3	
SP_Other	SPM-93-13X	11/2/2016		
SP_Other	SPM-93-13X	11/19/2018	282.2	
SP_Other	SPM-93-13X	11/26/2019	278.0	
SP_Other	SPM-93-15X	7/23/1996	355.4	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
SP_Other	SPM-93-15X	1/15/1997	356.0	
SP_Other	SPM-93-15X	6/2/1997	356.0	
SP_Other	SPM-93-15X	4/23/1998	356.2	
SP_Other	SPM-93-15X	10/14/1998	355.2	
SP_Other	SPM-93-15X	12/6/1999	350.9	
SP_Other	SPM-93-15X	10/21/2008		
SP_Other	SPM-93-15X	10/26/2010	355.5	
SP_Other	SPM-93-15X	10/18/2011		
SP_Other	SPM-93-15X	11/13/2013	352.8	
SP_Other	SPM-93-15X	11/26/2014	355.4	
SP_Other	SPM-93-15X	11/14/2015	355.9	
SP_Other	SPM-93-15X	12/7/2015	352.8	
SP_Other	SPM-93-15X	11/2/2016	351.1	
SP_Other	SPM-93-15X	11/27/2017	355.4	
SP_Other	SPM-93-15X	11/19/2018	358.3	
SP_Other	SPM-93-15X	11/26/2019	356.3	
SP_Other	SPM-93-16X	7/23/1996	232.5	
SP_Other	SPM-93-16X	1/15/1997	232.9	
SP_Other	SPM-93-16X	6/2/1997	233.5	
SP_Other	SPM-93-16X	10/27/1997	232.1	
SP_Other	SPM-93-16X	4/23/1998	232.7	
SP_Other	SPM-93-16X	10/14/1998	232.3	
SP_Other	SPM-93-16X	10/21/1998	233.1	
SP_Other	SPM-93-16X	10/18/1999	230.8	
SP_Other	SPM-93-16X	12/6/1999	230.6	
SP_Other	SPM-93-16X	10/25/2000	232.1	
SP_Other	SPM-93-16X	10/15/2001	231.6	
SP_Other	SPM-93-16X	10/21/2002	229.4	
SP_Other	SPM-93-16X	10/28/2003	232.1	
SP_Other	SPM-93-16X	11/1/2004	231.4	
SP_Other	SPM-93-16X	11/14/2005	233.4	
SP_Other	SPM-93-16X	10/25/2006	233.5	
SP_Other	SPM-93-16X	10/24/2007	232.9	
SP_Other	SPM-93-16X	10/23/2008	233.2	
SP_Other	SPM-93-16X	11/25/2009	233.2	
SP_Other	SPM-93-16X	10/26/2010	232.9	
SP_Other	SPM-93-16X	10/18/2011	232.6	
SP_Other	SPM-93-16X	11/15/2012	231.7	
SP_Other	SPM-93-16X	11/13/2013	231.3	
SP_Other	SPM-93-16X	11/26/2014	230.9	
SP_Other	SPM-93-16X	12/7/2015	230.5	
SP_Other	SPM-93-16X	10/31/2016	229.7	
SP_Other	SPM-93-16X	11/13/2017	231.2	
SP_Other	SPM-93-16X	11/19/2018	233.0	

Table E.1

Measured Water Levels

Site	Well	Date	Measured Water Level (used for target average)	Measured Water Level (not used for target average)
SP_Other	SPM-93-16X	11/26/2019	232.5	
SP_Other	SPM-97-24X	10/27/1997	222.9	
SP_Other	SPM-97-24X	10/21/1998	224.2	
SP_Other	SPM-97-24X	10/18/1999	222.4	
SP_Other	SPM-97-24X	12/6/1999	222.5	
SP_Other	SPM-97-24X	10/25/2000	223.5	
SP_Other	SPM-97-24X	10/15/2001	223.1	
SP_Other	SPM-97-24X	10/21/2002	222.1	
SP_Other	SPM-97-24X	10/28/2003	223.9	
SP_Other	SPM-97-24X	11/1/2004	223.8	
SP_Other	SPM-97-24X	11/14/2005	226.6	
SP_Other	SPM-97-24X	10/24/2006	225.4	
SP_Other	SPM-97-24X	10/23/2007	224.6	
SP_Other	SPM-97-24X	10/21/2008	225.9	
SP_Other	SPM-97-24X	11/13/2009	225.3	
SP_Other	SPM-97-24X	10/25/2010	224.7	
SP_Other	SPM-97-24X	10/18/2011	225.7	
SP_Other	SPM-97-24X	11/15/2012	223.9	
SP_Other	SPM-97-24X	11/14/2013	223.4	
SP_Other	SPM-97-24X	11/25/2014	223.5	
SP_Other	SPM-97-24X	12/7/2015	222.0	
SP_Other	SPM-97-24X	10/31/2016	222.0	
SP_Other	SPM-97-24X	11/13/2017	223.6	
SP_Other	SPM-97-24X	11/19/2018	226.3	
SP_Other	SPM-97-24X	11/25/2019	240.1	

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
32M-01-13XBR	Main	AOC_32	629547.2	3025296.5	244.6	234.6	242.1	238.0	4.1
32M-01-14XBR	Main	AOC_32	629684.8	3025386.1	218.3	208.3	234.0	232.4	1.6
32M-01-14XOB	Main	AOC_32	629692.7	3025382.0	237.0	227.0	232.3	233.1	-0.8
32M-01-15XBR	Main	AOC_32	629568.1	3025254.0	223.5	213.5	237.9	237.5	0.4
32M-01-16XBR	Main	AOC_32	629604.1	3025102.0	236.7	226.7	234.4	237.0	-2.6
32M-01-17XBR	Main	AOC_32	629696.5	3025242.2	215.5	205.5	234.1	233.1	1.1
32M-01-18XBR	Main	AOC_32	629515.0	3025246.9	244.6	234.6	241.9	238.6	3.3
32M-92-01X	Main	AOC_32	629189.6	3025740.0	245.3	235.3	242.6	244.3	-1.7
32M-92-03X	Main	AOC_32	628772.0	3025213.2	235.0	225.0	232.8	232.9	-0.1
32PZ-19-01	Main	AOC_32	630756.5	3025650.8	228.4	218.4	227.2	224.9	2.3
32PZ-19-02	Main	AOC_32	630585.9	3024968.9	228.3	218.3	228.0	227.2	0.8
32Z-01-05XOB	Main	AOC_32	629137.5	3024524.9	235.5	225.5	232.1	232.5	-0.4
32Z-01-06XBR	Main	AOC_32	629526.4	3025592.1	243.1	233.1	243.7	238.7	5.0
32Z-01-07XOB	Main	AOC_32	629418.4	3025655.6	245.0	235.0	243.2	242.1	1.0
32Z-01-08XOB	Main	AOC_32	629071.0	3025511.6	246.6	236.6	241.8	243.4	-1.6
32Z-01-09XOB	Main	AOC_32	628871.7	3024575.9	234.3	224.3	231.6	231.8	-0.2
32Z-01-10XBR	Main	AOC_32	629597.3	3024914.4	245.3	235.3	241.0	236.6	4.4
32Z-01-11XBR	Main	AOC_32	629315.8	3025496.1	253.7	243.7	245.0	243.0	2.1
32Z-01-12XBR	Main	AOC_32	629002.2	3025272.7	230.5	220.5	237.8	237.1	0.7
32Z-99-02X	Main	AOC_32	629874.1	3024769.1	243.0	228.0	235.1	234.4	0.7
SHL-12	Main	AOC_32	630003.0	3025341.6	232.2	217.2	226.5	226.5	-0.1
SHL-17	Main	AOC_32	630287.5	3025390.8	225.9	215.9	226.5	225.9	0.7
SHL-24	Main	AOC_32	631303.0	3025638.5	126.8	116.8	223.1	222.8	0.4
SHL-25	Main	AOC_32	629698.6	3025251.9	232.8	222.8	232.4	233.5	-1.1
SHM-93-24A	Main	AOC_32	631308.1	3025647.4	222.2	212.2	222.1	223.1	-1.0
43M-01-16XBR	Main	AOC_43A	628980.9	3025055.1	209.5	199.5	232.4	232.5	-0.1
43M-01-16XOB	Main	AOC_43A	628981.2	3025060.4	233.1	223.1	232.4	232.6	-0.3
43M-01-17XBR	Main	AOC_43A	629073.3	3024934.9	211.0	201.0	232.1	232.2	-0.2
43M-01-17XOB	Main	AOC_43A	629073.3	3024941.0	235.0	225.0	232.0	232.4	-0.3
43M-01-20XBR	Main	AOC_43A	628852.1	3024830.0	189.5	179.5	230.9	231.3	-0.4
43M-01-20XOB	Main	AOC_43A	628852.0	3024833.8	233.8	223.8	231.6	231.3	0.3

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
43GPZ-19-01	Main	AOC_43G	626413.8	3020566.2	271.3	261.3	262.2	261.7	0.5
43GPZ-19-02	Main	AOC_43G	626472.6	3021108.8	271.1	261.1	262.7	260.9	1.8
43GPZ-19-03	Main	AOC_43G	626037.3	3021045.1	293.2	283.2	284.8	283.6	1.2
43GPZ-19-04	Main	AOC_43G	627045.5	3020688.1	252.2	242.2	248.7	248.1	0.6
43GPZ-19-05	Main	AOC_43G	627085.1	3020948.2	249.1	239.1	246.6	246.3	0.2
43GPZ-19-06	Main	AOC_43G	627231.6	3021120.8	245.1	235.1	245.0	245.1	-0.1
43GPZ-19-07	Main	AOC_43G	628085.6	3021393.0	243.7	233.7	244.9	243.5	1.4
43GPZ-19-08	Main	AOC_43G	626733.2	3021680.4	244.9	234.9	245.6	245.4	0.2
AAFES-2	Main	AOC_43G	626168.5	3020965.1	283.3	268.3	278.3	278.3	0.0
AAFES-5	Main	AOC_43G	626200.2	3020999.4	284.5	269.5	277.6	276.9	0.6
AAFES-6R	Main	AOC_43G	626119.8	3020911.0	281.8	271.8	278.4	279.6	-1.1
AAFES-7	Main	AOC_43G	626711.6	3020857.9	251.7	241.7	249.5	249.6	-0.2
XGM-20-01A	Main	AOC_43G	626682.6	3021077.4	247.4	237.4	248.8	248.5	0.3
XGM-20-02A	Main	AOC_43G	626578.5	3021013.9	252.4	242.4	251.4	253.3	-1.9
XGM-20-03A	Main	AOC_43G	626603.9	3020862.4	248.9	238.9	252.6	252.6	0.1
XGM-93-02X	Main	AOC_43G	626109.4	3020956.9	281.4	271.4	279.8	280.2	-0.5
XGM-94-04X	Main	AOC_43G	626072.6	3020880.0	280.1	270.1	280.5	280.8	-0.4
XGM-94-06X	Main	AOC_43G	626430.0	3020773.6	264.4	254.4	262.7	262.6	0.1
XGM-94-07X	Main	AOC_43G	626257.9	3020925.6	275.2	265.2	275.1	274.5	0.5
XGM-94-08X	Main	AOC_43G	626239.6	3020799.5	272.9	262.9	273.0	272.9	0.1
XGM-94-10X	Main	AOC_43G	626132.6	3020730.5	278.1	268.1	276.7	276.4	0.3
XGM-97-12X	Main	AOC_43G	626086.0	3020989.4	285.3	275.3	282.9	281.5	1.4
2446-03	Main	AOC_43J	623519.5	3018185.4	360.7	350.7	361.6	360.8	0.8
HA-3B	Main	AOC_43J	623729.3	3018253.3	327.2	319.2	356.9	357.8	-1.0
HA-3S	Main	AOC_43J	623734.9	3018255.1	359.0	346.0	354.5	355.6	-1.2
HA-4B	Main	AOC_43J	623729.5	3018170.4	329.8	321.8	359.3	357.8	1.5
HA-4S	Main	AOC_43J	623724.5	3018172.2	361.8	348.8	357.7	356.1	1.6
XJM-93-01X	Main	AOC_43J	623416.3	3018256.2	361.9	351.9	364.4	361.6	2.8
XJM-93-04X	Main	AOC_43J	623399.7	3018150.5	363.4	353.4	364.1	362.1	2.0
XJM-94-07X	Main	AOC_43J	623743.8	3018055.8	357.7	347.7	357.1	357.3	-0.1
XJM-94-08X	Main	AOC_43J	623635.6	3017979.7	358.3	348.3	358.6	359.0	-0.4

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
XJM-94-10X	Main	AOC_43J	623407.6	3017989.0	360.4	350.4	360.7	362.0	-1.3
XJM-97-11X	Main	AOC_43J	623378.0	3017992.7	343.0	333.0	361.6	362.4	-0.9
XJM-97-12X	Main	AOC_43J	623496.1	3018120.6	348.0	338.0	362.6	361.0	1.6
XJM-97-13X	Main	AOC_43J	623640.5	3017979.5	324.3	314.3	359.4	357.9	1.5
CAP-4	Main	AOC_5	629284.5	3027088.6	237.7	232.9	246.3	238.7	7.6
EPA-PZ-2012-1A	Main	AOC_5	630191.1	3028055.9	196.2	191.2	212.5	212.8	-0.3
EPA-PZ-2012-1B	Main	AOC_5	630192.9	3028057.1	146.3	141.3	212.5	212.7	-0.2
EPA-PZ-2012-2A	Main	AOC_5	630287.3	3028124.7	201.6	196.6	212.6	213.0	-0.3
EPA-PZ-2012-2B	Main	AOC_5	630290.4	3028124.7	146.6	141.6	212.5	213.0	-0.5
EPA-PZ-2012-3A	Main	AOC_5	630062.5	3028088.1	200.1	195.1	212.0	212.4	-0.5
EPA-PZ-2012-3B	Main	AOC_5	630064.6	3028086.1	150.6	145.6	211.9	212.4	-0.5
EPA-PZ-2012-4A	Main	AOC_5	629992.1	3028045.3	203.7	198.7	211.7	212.2	-0.5
EPA-PZ-2012-4B	Main	AOC_5	629989.9	3028043.8	144.0	139.0	211.5	212.0	-0.5
EPA-PZ-2012-5A	Main	AOC_5	630151.9	3028184.9	198.4	193.4	211.9	212.5	-0.6
EPA-PZ-2012-5B	Main	AOC_5	630155.3	3028186.1	147.7	142.7	212.0	212.4	-0.5
EPA-PZ-2012-6A	Main	AOC_5	629894.7	3028066.3	206.5	201.5	211.7	212.0	-0.3
EPA-PZ-2012-6B	Main	AOC_5	629894.4	3028069.2	156.6	151.6	211.4	211.8	-0.4
EPA-PZ-2012-7A	Main	AOC_5	629801.1	3028106.5	210.6	205.6	211.5	212.0	-0.5
EPA-PZ-2012-7B	Main	AOC_5	629800.9	3028109.2	175.5	170.5	211.6	212.0	-0.4
EW-01	Main	AOC_5	629942.8	3027960.2	167.0	142.0	209.9	207.9	2.0
EW-04	Main	AOC_5	629895.3	3027991.0	157.4	132.4	207.1	207.0	0.1
MW-1	Main	AOC_5	629284.7	3027071.2	242.3	240.3	243.0	239.2	3.8
N1-P1	Main	AOC_5	630723.4	3027867.8	162.8	157.8	215.5	215.4	0.1
N1-P2	Main	AOC_5	630723.4	3027867.8	187.8	182.8	215.8	215.4	0.3
N1-P3	Main	AOC_5	630723.4	3027867.8	215.8	210.8	216.1	215.6	0.6
N2-P1	Main	AOC_5	630658.7	3027311.1	185.6	180.6	216.5	216.3	0.2
N2-P2	Main	AOC_5	630658.7	3027311.1	216.6	211.6	216.5	216.3	0.2
N3-P1	Main	AOC_5	630778.0	3027130.2	186.8	183.8	216.4	216.5	-0.1
N3-P2	Main	AOC_5	630778.0	3027130.2	214.8	209.8	216.5	216.5	0.1
N4-P1	Main	AOC_5	631241.2	3026763.6	141.4	136.4	215.8	216.9	-1.1
N4-P2	Main	AOC_5	631241.2	3026763.6	179.4	174.4	215.5	216.8	-1.4

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
N4-P3	Main	AOC_5	631241.2	3026763.6	215.9	210.9	215.5	216.6	-1.0
N5-P1	Main	AOC_5	629805.8	3027173.2	145.0	143.0	219.2	218.2	1.1
N5-P2	Main	AOC_5	629805.8	3027173.2	217.5	212.5	219.2	218.2	1.1
N6-P1	Main	AOC_5	630017.1	3026338.6	170.6	168.6	221.9	221.9	0.0
N7-P1	Main	AOC_5	629990.9	3025618.3	187.2	185.2	225.2	225.3	-0.1
N7-P2	Main	AOC_5	629990.9	3025618.3	224.2	219.2	225.5	225.3	0.2
PZ-12-01	Main	AOC_5	630488.5	3027384.4	209.9	199.9	216.8	216.5	0.4
PZ-12-02	Main	AOC_5	630467.8	3027384.0	209.8	199.8	217.3	217.4	-0.1
PZ-12-03	Main	AOC_5	630474.5	3027193.5	208.9	198.9	216.8	216.6	0.2
PZ-12-04	Main	AOC_5	630452.9	3027193.8	211.1	201.1	217.9	217.8	0.1
PZ-12-05	Main	AOC_5	630479.4	3027087.3	210.1	200.1	217.1	216.7	0.4
PZ-12-06	Main	AOC_5	630454.8	3027081.9	213.4	203.4	218.1	218.1	0.0
PZ-12-07	Main	AOC_5	630568.5	3026971.8	220.8	210.8	217.1	217.2	-0.1
PZ-12-08	Main	AOC_5	630546.1	3026962.3	219.7	209.7	218.8	218.7	0.1
PZ-12-09	Main	AOC_5	630740.9	3026801.4	218.4	208.4	217.9	218.3	-0.4
PZ-12-10	Main	AOC_5	630724.0	3026778.5	219.0	209.0	219.6	219.5	0.1
RSK 15	Main	AOC_5	630585.3	3027062.0	217.4	212.4	217.2	216.8	0.4
RSK 19	Main	AOC_5	630560.4	3027219.5	215.7	210.7	217.1	216.5	0.6
RSK 37	Main	AOC_5	630730.2	3027114.5	217.5	212.5	214.6	216.5	-1.9
RSK 7	Main	AOC_5	630635.7	3027270.4	217.3	212.3	217.0	216.4	0.6
SHL-10	Main	AOC_5	630877.3	3026867.7	222.6	207.6	217.2	217.4	-0.2
SHL-11	Main	AOC_5	630495.9	3027316.4	222.0	207.0	216.8	216.5	0.3
SHL-13	Main	AOC_5	630540.4	3028105.4	214.0	199.0	213.8	214.2	-0.4
SHL-15	Main	AOC_5	629326.4	3025829.4	245.0	235.0	241.9	243.7	-1.8
SHL-17	Main	AOC_5	630287.5	3025390.8	225.9	215.9	226.5	225.9	0.7
SHL-18	Main	AOC_5	631186.4	3026475.2	219.7	209.7	218.4	219.3	-0.9
SHL-19	Main	AOC_5	630665.0	3026946.0	218.6	208.6	217.5	217.6	-0.1
SHL-20	Main	AOC_5	630463.3	3027329.6	195.7	185.7	217.1	217.5	-0.3
SHL-21	Main	AOC_5	630364.0	3027884.4	216.1	206.1	214.7	214.0	0.8
SHL-22	Main	AOC_5	630056.4	3028163.0	113.9	103.9	212.6	212.2	0.3
SHL-23	Main	AOC_5	629712.8	3027915.9	216.4	206.4	213.6	212.8	0.9

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
SHL-3	Main	AOC_5	630911.0	3026705.2	221.8	211.8	217.2	218.2	-1.0
SHL-4	Main	AOC_5	630576.2	3027057.2	223.1	213.1	216.9	216.8	0.1
SHL-5	Main	AOC_5	630192.2	3028125.1	213.8	203.8	213.8	212.7	1.1
SHL-6	Main	AOC_5	630951.2	3025248.8	198.5	188.5	225.8	225.8	0.0
SHL-7	Main	AOC_5	631332.8	3026277.9	223.8	213.8	218.5	219.8	-1.3
SHL-8D	Main	AOC_5	630407.1	3028126.6	150.8	148.8	213.3	213.5	-0.3
SHL-8S	Main	AOC_5	630407.1	3028126.6	166.8	164.8	213.3	213.5	-0.2
SHL-9	Main	AOC_5	630009.6	3028146.8	205.7	195.7	212.7	212.2	0.4
SHM-05-39A	Main	AOC_5	629761.4	3028544.3	184.8	182.8	210.2	210.0	0.3
SHM-05-39B	Main	AOC_5	629765.3	3028543.7	155.8	153.8	209.3	210.0	-0.7
SHM-05-40X	Main	AOC_5	629636.8	3028514.2	191.5	189.5	209.2	209.3	-0.1
SHM-05-41A	Main	AOC_5	629796.1	3028290.8	180.7	178.7	212.0	211.8	0.2
SHM-05-41B	Main	AOC_5	629796.3	3028299.2	160.5	158.5	211.9	211.8	0.1
SHM-05-41C	Main	AOC_5	629795.8	3028285.5	134.9	129.9	212.0	211.8	0.1
SHM-05-42A	Main	AOC_5	630017.6	3028376.1	173.7	171.7	212.0	211.9	0.1
SHM-05-42B	Main	AOC_5	630017.6	3028376.1	143.7	141.7	212.0	211.9	0.0
SHM-07-03	Main	AOC_5	629411.1	3028444.6	203.0	193.0	208.0	208.1	-0.1
SHM-07-05	Main	AOC_5	629632.1	3028513.3	168.3	159.3	208.9	209.3	-0.4
SHM-10-01	Main	AOC_5	628868.4	3028617.3	146.2	136.2	205.9	205.9	0.0
SHM-10-05A	Main	AOC_5	630441.8	3028943.4	185.4	175.4	209.8	211.5	-1.6
SHM-10-06	Main	AOC_5	630215.6	3027882.5	160.5	150.5	213.4	213.1	0.3
SHM-10-06A	Main	AOC_5	630300.7	3027895.7	169.0	159.0	213.6	213.6	0.1
SHM-10-07	Main	AOC_5	630301.4	3026889.8	205.0	195.0	219.3	219.3	0.0
SHM-10-10	Main	AOC_5	629105.3	3028873.6	159.4	149.4	206.5	206.4	0.1
SHM-10-11	Main	AOC_5	629990.6	3025971.5	211.2	201.2	223.3	223.5	-0.2
SHM-10-12	Main	AOC_5	629717.5	3026718.5	207.6	197.6	221.0	220.6	0.4
SHM-10-13	Main	AOC_5	629906.1	3027156.9	181.5	171.5	218.5	218.3	0.3
SHM-10-14	Main	AOC_5	629784.8	3027372.9	174.8	154.8	217.3	217.0	0.3
SHM-10-15	Main	AOC_5	629680.9	3027101.4	197.0	187.0	219.0	218.7	0.3
SHM-10-16	Main	AOC_5	629834.2	3028355.3	141.7	131.7	211.2	211.7	-0.5
SHM-11-02	Main	AOC_5	630457.8	3027075.7	186.7	172.7	218.0	218.0	0.0

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
SHM-11-06	Main	AOC_5	630411.3	3027590.1	208.3	198.3	216.1	215.9	0.2
SHM-11-07	Main	AOC_5	630414.6	3027132.5	197.2	192.2	218.0	217.9	0.1
SHM-13-01	Main	AOC_5	628556.7	3028294.8	166.8	156.8	205.1	205.4	-0.4
SHM-13-02	Main	AOC_5	628980.6	3028713.9	156.9	146.9	206.1	206.2	-0.1
SHM-13-03	Main	AOC_5	629173.4	3028990.9	167.9	157.9	206.9	206.5	0.4
SHM-13-04	Main	AOC_5	629479.6	3028606.2	207.3	197.3	208.1	207.9	0.2
SHM-13-05	Main	AOC_5	629829.5	3028776.7	150.4	140.4	208.4	208.8	-0.4
SHM-13-06	Main	AOC_5	629245.1	3028694.9	188.2	178.2	206.8	206.9	-0.1
SHM-13-07	Main	AOC_5	629331.4	3028760.8	199.1	189.1	207.0	207.1	-0.1
SHM-13-08	Main	AOC_5	629515.3	3028837.5	173.2	163.2	207.8	207.5	0.2
SHM-13-14D	Main	AOC_5	629391.9	3029016.6	162.5	152.5	207.1	207.0	0.1
SHM-13-14S	Main	AOC_5	629392.3	3029020.6	202.7	192.7	206.9	206.9	0.0
SHM-13-15	Main	AOC_5	629273.5	3029072.2	156.0	146.0	206.9	206.7	0.2
SHM-93-01A	Main	AOC_5	630677.0	3026712.0	225.2	215.2	220.2	220.1	0.2
SHM-93-10C	Main	AOC_5	630886.1	3026846.2	202.1	192.1	218.1	217.5	0.6
SHM-93-10D	Main	AOC_5	630894.7	3026828.8	196.8	186.8	217.8	217.5	0.3
SHM-93-18B	Main	AOC_5	631180.2	3026453.2	156.7	146.7	218.6	219.0	-0.4
SHM-93-22B	Main	AOC_5	630071.9	3028169.9	136.5	126.5	212.2	212.2	-0.1
SHM-93-22C	Main	AOC_5	630045.7	3028158.6	94.6	84.6	212.6	212.2	0.4
SHM-95-27X	Main	AOC_5	630752.7	3026164.5	204.8	194.8	224.3	223.0	1.3
SHM-96-22B	Main	AOC_5	630071.9	3028169.8	136.2	126.2	212.6	212.2	0.4
SHM-96-5B	Main	AOC_5	630158.1	3028112.9	137.4	127.4	212.5	212.5	0.0
SHM-96-5C	Main	AOC_5	630172.7	3028105.4	167.4	157.4	212.7	212.7	0.0
SHM-99-31A	Main	AOC_5	629895.0	3028559.1	208.8	198.8	211.4	210.7	0.7
SHM-99-31B	Main	AOC_5	629901.2	3028559.5	162.5	152.5	210.6	210.7	-0.1
SHM-99-31C	Main	AOC_5	629908.8	3028561.8	144.6	134.6	210.4	210.6	-0.2
SHM-99-32X	Main	AOC_5	630168.8	3028574.7	147.1	137.1	211.4	211.4	0.0
SHP-01-36X	Main	AOC_5	630737.9	3027688.8	217.0	212.0	216.4	215.8	0.6
SHP-01-37X	Main	AOC_5	630696.9	3027498.4	217.7	212.7	216.5	216.1	0.4
SHP-01-38A	Main	AOC_5	630545.5	3027171.5	217.3	212.3	216.8	216.5	0.3
SHP-01-38B	Main	AOC_5	630544.0	3027178.2	200.9	195.9	216.9	216.6	0.4

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
SHP-05-43	Main	AOC_5	630532.5	3027747.0	207.9	197.9	215.8	215.2	0.6
SHP-05-44	Main	AOC_5	630587.6	3027588.5	204.6	194.6	216.2	215.8	0.4
SHP-05-45A	Main	AOC_5	629995.5	3027962.0	206.3	201.3	212.5	212.3	0.2
SHP-05-45B	Main	AOC_5	629995.5	3027956.8	161.7	151.7	212.6	212.0	0.6
SHP-05-46A	Main	AOC_5	630041.5	3027941.1	206.3	201.3	213.2	212.5	0.6
SHP-05-46B	Main	AOC_5	630041.8	3027946.6	161.0	151.0	212.5	212.4	0.1
SHP-05-47A	Main	AOC_5	630523.3	3028226.4	212.4	211.4	212.6	212.5	0.1
SHP-05-47B	Main	AOC_5	630524.0	3028226.3	210.3	209.3	212.5	212.5	0.0
SHP-05-48A	Main	AOC_5	630046.4	3028569.6	212.1	211.1	213.3	211.0	2.3
SHP-05-48B	Main	AOC_5	630045.6	3028569.7	211.0	210.0	211.7	211.0	0.7
SHP-05-49A	Main	AOC_5	630250.6	3028663.7	211.3	210.3	211.7	210.0	1.7
SHP-05-49B	Main	AOC_5	630250.1	3028663.9	209.9	208.9	210.6	210.0	0.6
SHP-2016-06A	Main	AOC_5	629710.3	3027906.2	159.1	154.1	214.8	212.7	2.2
SHP-2016-06B	Main	AOC_5	629710.3	3027906.2	138.1	128.1	220.0	212.6	7.5
SHP-2016-06C	Main	AOC_5	629710.3	3027906.2	117.1	107.1	221.2	213.0	8.2
SHP-2016-07A	Main	AOC_5	629219.8	3026882.0	241.0	231.0	250.2	251.5	-1.3
SHP-2016-07B	Main	AOC_5	629219.8	3026882.0	193.0	183.0	241.4	243.8	-2.5
SHP-2016-1A	Main	AOC_5	629933.5	3027979.6	211.7	201.7	212.5	212.0	0.5
SHP-2016-1B	Main	AOC_5	629933.5	3027979.6	149.7	139.7	210.4	210.5	-0.1
SHP-2016-2A	Main	AOC_5	629925.8	3028200.3	203.7	198.7	211.7	212.1	-0.4
SHP-2016-2B	Main	AOC_5	629925.8	3028200.3	143.7	138.7	211.9	212.0	-0.2
SHP-2016-3A	Main	AOC_5	630007.3	3028174.3	201.1	196.1	211.7	212.2	-0.5
SHP-2016-3B	Main	AOC_5	630007.3	3028174.3	141.1	136.1	211.8	212.2	-0.4
SHP-2016-4A	Main	AOC_5	629902.2	3028146.7	202.6	197.6	211.8	212.1	-0.2
SHP-2016-4B	Main	AOC_5	629902.2	3028146.7	142.6	137.6	211.7	212.0	-0.3
SHP-2016-5A	Main	AOC_5	629963.6	3028113.5	199.9	194.9	211.8	212.2	-0.4
SHP-2016-5B	Main	AOC_5	629963.6	3028113.5	139.9	134.9	211.7	212.1	-0.4
SHP-99-01B	Main	AOC_5	629226.6	3026537.3	267.8	263.8	266.2	258.3	7.9
SHP-99-29X	Main	AOC_5	629539.1	3027143.4	222.5	212.5	219.9	220.1	-0.2
SHP-99-31A	Main	AOC_5	629895.0	3028559.1	208.6	198.6	208.8	210.7	-1.8
SHP-99-33A	Main	AOC_5	629818.1	3028551.6	210.6	205.6	210.5	210.2	0.3

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
SHP-99-33B	Main	AOC_5	629815.6	3028550.2	146.7	141.7	210.3	210.3	0.0
SHP-99-34A	Main	AOC_5	630294.4	3028552.4	207.1	202.1	209.8	210.5	-0.7
SHP-99-34B	Main	AOC_5	630294.4	3028552.4	148.2	143.2	211.9	211.9	0.0
SHP-99-35X	Main	AOC_5	629722.7	3026547.2	226.5	216.5	221.6	221.6	0.0
5702MW-19-01A	Main	AOC_57	632239.6	3023025.7	227.7	217.7	223.8	224.6	-0.7
5702MW-19-01B	Main	AOC_57	632237.0	3023020.9	207.9	197.9	223.8	224.4	-0.6
5702MW-20-01A	Main	AOC_57	632765.2	3022575.6	189.6	179.6	219.4	219.9	-0.5
5702MW-20-01B	Main	AOC_57	632761.6	3022574.4	149.7	139.7	220.5	220.5	0.0
5702MW-20-02A	Main	AOC_57	632508.3	3022840.0	211.7	201.7	222.6	223.1	-0.5
5702MW-20-03A	Main	AOC_57	632530.3	3022636.0	208.8	198.8	220.7	221.1	-0.4
5702MW-20-04A	Main	AOC_57	632758.4	3022723.5	162.7	152.7	221.2	221.8	-0.6
5702MW-20-05A	Main	AOC_57	632578.8	3022546.0	193.3	183.3	219.9	220.5	-0.6
5702MW-20-05B	Main	AOC_57	632575.5	3022550.8	153.3	143.3	221.2	220.9	0.3
5702MW-20-06A	Main	AOC_57	632671.4	3022688.5	164.1	154.1	221.3	221.5	-0.2
5702MW-20-07A	Main	AOC_57	632695.3	3022514.6	189.4	179.4	219.2	219.8	-0.6
5703MW-20-01A	Main	AOC_57	633310.1	3022963.7	223.2	213.2	220.9	220.8	0.1
5703MW-20-01B	Main	AOC_57	633315.6	3022962.9	175.1	165.1	220.5	221.0	-0.6
5703MW-20-02A	Main	AOC_57	633213.6	3022994.6	223.5	213.5	222.3	221.8	0.5
5703MW-20-03A	Main	AOC_57	633168.5	3022909.3	173.0	163.0	220.7	221.2	-0.4
5703MW-20-04A	Main	AOC_57	633265.6	3022990.4	169.2	159.2	221.1	221.5	-0.4
5703PZ-19-01	Main	AOC_57	633266.6	3022896.6	157.7	152.7	219.9	220.5	-0.6
57M-03-01X	Main	AOC_57	632664.4	3022695.1	224.4	214.4	221.9	221.3	0.6
57M-03-02X	Main	AOC_57	632652.7	3022574.6	221.0	211.0	220.3	220.0	0.3
57M-03-03X	Main	AOC_57	632697.3	3022501.2	217.0	207.0	219.5	219.1	0.4
57M-03-04X	Main	AOC_57	632732.8	3022512.8	217.5	207.5	219.2	219.1	0.1
57M-03-05X	Main	AOC_57	632765.3	3022567.8	217.6	207.6	219.5	219.4	0.1
57M-03-06X	Main	AOC_57	632784.1	3022592.3	218.3	208.3	219.6	219.5	0.1
57M-95-03X	Main	AOC_57	633253.4	3022997.2	223.8	213.8	222.5	221.5	1.1
57M-95-05X	Main	AOC_57	632528.2	3022618.5	223.0	213.0	221.2	220.9	0.2
57M-95-06X	Main	AOC_57	632762.5	3022717.5	220.8	210.8	222.2	221.3	0.9
57M-95-07X	Main	AOC_57	632547.8	3022491.6	218.5	208.5	220.1	219.9	0.2

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
57M-96-09X	Main	AOC_57	633132.3	3023093.8	226.6	216.6	225.7	223.2	2.6
57M-96-10X	Main	AOC_57	633338.5	3022925.4	223.3	213.3	222.2	220.1	2.1
57M-96-11X	Main	AOC_57	633267.8	3022891.5	218.0	208.0	219.6	219.7	-0.1
57M-96-12X	Main	AOC_57	633169.9	3022906.1	220.8	210.8	221.4	220.8	0.6
57M-96-13X	Main	AOC_57	633110.6	3022859.3	221.2	211.2	221.1	220.6	0.5
57P-98-03X	Main	AOC_57	633313.9	3022869.6	216.1	213.1	218.2	219.0	-0.8
57P-98-04X	Main	AOC_57	633254.2	3022867.9	216.2	213.2	218.4	219.2	-0.9
57WP-06-02	Main	AOC_57	632703.3	3022505.5	200.3	195.3	219.4	219.1	0.3
57WP-06-03	Main	AOC_57	633262.7	3022888.6	205.5	200.5	220.0	219.5	0.5
69W-94-12	Main	AOC_69W	627516.1	3025287.9	222.7	212.7	221.0	220.8	0.2
69W-94-13	Main	AOC_69W	627446.8	3025279.1	221.5	211.5	220.7	220.5	0.2
69W-94-14	Main	AOC_69W	627389.5	3025372.8	221.7	211.7	219.9	219.5	0.4
69WP-13-01	Main	AOC_69W	627169.6	3025781.1	218.0	218.0	217.7	216.5	1.2
ZWM-01-25X	Main	AOC_69W	627456.7	3025484.3	216.5	206.5	219.4	219.3	0.1
ZWM-01-26X	Main	AOC_69W	627550.4	3025430.9	217.9	207.9	220.1	220.2	0.0
ZWM-95-15X	Main	AOC_69W	627316.1	3025417.1	216.3	206.3	219.8	218.9	0.9
ZWM-95-16X	Main	AOC_69W	627553.1	3025146.4	222.5	212.5	222.3	221.9	0.4
ZWM-95-17X	Main	AOC_69W	627675.0	3024871.1	220.5	210.5	223.8	223.8	0.0
ZWM-95-18X	Main	AOC_69W	627306.7	3025554.4	214.7	204.7	218.7	218.1	0.5
ZWM-99-22X	Main	AOC_69W	627463.6	3025190.2	222.3	212.3	221.4	221.1	0.3
ZWM-99-23X	Main	AOC_69W	627474.0	3025406.2	218.7	208.7	219.7	219.8	-0.1
ZWM-99-24X	Main	AOC_69W	627307.2	3025302.5	217.3	207.3	220.6	219.4	1.2
ZWP-95-01X	Main	AOC_69W	627245.4	3025297.7	213.6	211.6	220.5	218.7	1.8
ZWP-95-02X	Main	AOC_69W	627252.2	3025503.8	210.4	208.4	218.7	217.9	0.8
74MW-19-04A	Main	AOC_74	634137.2	3023949.2	204.1	194.1	220.7	220.3	0.4
74PZ-19-01	Main	AOC_74	633692.5	3023395.6	225.5	215.5	223.3	222.6	0.7
74PZ-19-02	Main	AOC_74	633310.6	3023830.3	226.7	216.7	225.8	224.2	1.7
74PZ-19-03	Main	AOC_74	633069.4	3024181.0	220.6	210.6	225.5	224.0	1.6
74PZ-19-04	Main	AOC_74	634144.9	3023948.7	216.7	206.7	220.6	220.1	0.5
74PZ-19-05	Main	AOC_74	633822.5	3024351.2	223.2	213.2	224.1	222.8	1.4
74PZ-19-06	Main	AOC_74	633401.1	3024738.9	217.5	207.5	222.8	221.8	0.9

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
74PZ-19-07	Main	AOC_74	633824.1	3024827.5	218.6	208.6	220.9	220.2	0.7
74PZ-19-08	Main	AOC_74	634083.7	3024747.7	224.0	214.0	220.2	219.7	0.5
74PZ-19-09	Main	AOC_74	634521.9	3024557.0	219.5	209.5	219.9	219.2	0.7
74PZ-19-10	Main	AOC_74	634140.8	3023949.0	186.4	184.4	219.0	220.4	-1.4
74PZ-20-01	Main	AOC_74	634446.6	3024411.3	218.4	208.4	220.2	219.6	0.6
74PZ-20-02	Main	AOC_74	633699.0	3023988.0	217.6	207.6	224.2	223.7	0.5
74PZ-20-03	Main	AOC_74	634138.7	3024551.1	227.0	217.0	221.5	220.4	1.0
74PZ-20-04	Main	AOC_74	633457.2	3024309.0	225.5	215.5	224.2	223.6	0.6
74PZ-20-05	Main	AOC_74	634092.9	3024184.3	224.4	214.4	223.0	221.7	1.3
75MW-19-01BR	Main	AOC_75	628945.5	3021955.2	224.4	214.4	240.0	239.9	0.1
75MW-19-02A	Main	AOC_75	630775.3	3022532.7	210.3	200.3	230.4	229.7	0.7
75MW-19-02B	Main	AOC_75	630766.9	3022534.0	177.9	167.9	230.3	229.6	0.7
75MW-19-02BR	Main	AOC_75	630771.2	3022530.0	-60.1	-70.1	229.4	228.2	1.2
75MW-19-02C	Main	AOC_75	630773.9	3022561.9	38.0	28.0	229.4	228.9	0.5
75MW-19-04A	Main	AOC_75	631715.4	3022035.1	208.1	198.1	225.1	224.9	0.2
75MW-19-04B	Main	AOC_75	631713.0	3022030.7	178.0	168.0	225.0	224.8	0.2
75PZ-19-01	Main	AOC_75	631721.6	3022028.2	226.8	216.8	224.9	224.7	0.2
75PZ-19-02	Main	AOC_75	630327.0	3021645.3	233.0	223.0	231.9	230.8	1.0
75PZ-19-03	Main	AOC_75	630373.5	3022129.2	232.4	222.4	230.0	230.5	-0.5
75PZ-19-04	Main	AOC_75	629580.6	3022269.7	225.4	215.4	234.0	233.2	0.8
75PZ-20-01	Main	AOC_75	631915.7	3022301.2	224.9	214.9	225.3	224.3	1.0
75PZ-20-02	Main	AOC_75	631327.9	3022659.4	231.4	221.4	229.4	228.2	1.2
75PZ-20-03	Main	AOC_75	631092.2	3022208.9	229.5	219.5	229.9	229.0	0.9
75PZ-20-04	Main	AOC_75	630904.4	3021622.3	232.3	222.3	231.0	229.7	1.2
75PZ-20-05	Main	AOC_75	629855.6	3021245.4	233.5	223.5	232.1	231.7	0.4
75PZ-20-06	Main	AOC_75	630363.8	3022430.8	233.4	223.4	231.2	230.4	0.8
75PZ-20-07	Main	AOC_75	631557.9	3021697.1	224.3	214.3	224.5	224.7	-0.2
MW75-UNKNOWN	Main	AOC_75	631457.2	3021873.5	226.2	216.2	227.0	226.4	0.6
76PZ-19-01	Main	AOC_76	626641.5	3022569.0	243.5	233.5	242.7	242.2	0.5
76PZ-19-02	Main	AOC_76	627192.4	3024051.2	232.0	222.0	230.7	231.5	-0.8
76PZ-19-03	Main	AOC_76	627039.9	3022344.8	242.1	232.1	243.7	243.1	0.6

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
76PZ-19-04	Main	AOC_76	627714.4	3022221.7	244.6	234.6	243.3	242.9	0.4
76PZ-19-05	Main	AOC_76	626962.4	3022593.5	249.4	239.4	242.7	242.0	0.7
76PZ-19-06	Main	AOC_76	626789.2	3024036.0	234.9	224.9	232.9	232.4	0.5
76PZ-19-07	Main	AOC_76	626799.1	3023127.0	242.8	232.8	240.4	239.7	0.7
76PZ-19-08	Main	AOC_76	626609.8	3025581.7	210.3	200.3	219.2	219.3	-0.1
76PZ-19-09	Main	AOC_76	626848.9	3026474.5	210.8	200.8	213.0	212.8	0.2
76PZ-19-10	Main	AOC_76	627234.3	3022936.4	237.8	227.8	240.9	240.1	0.8
76PZ-19-11	Main	AOC_76	627286.1	3022638.8	240.8	230.8	242.1	241.1	1.0
76PZ-19-12	Main	AOC_76	627312.1	3026676.9	208.7	198.7	211.8	212.0	-0.2
76PZ-19-13	Main	AOC_76	627786.6	3022831.1	237.0	227.0	241.8	241.8	0.0
76PZ-19-14	Main	AOC_76	626358.0	3026359.8	213.1	203.1	214.1	213.4	0.7
76PZ-19-15	Main	AOC_76	627308.8	3022325.3	242.0	232.0	243.1	242.4	0.7
76PZ-19-16	Main	AOC_76	627493.3	3024063.7	229.8	219.8	232.6	232.2	0.3
76PZ-19-17	Main	AOC_76	625295.7	3026158.2	213.2	203.2	211.7	211.8	-0.1
76PZ-19-18	Main	AOC_76	627858.6	3021732.0	242.3	232.3	243.4	243.1	0.3
76PZ-19-19	Main	AOC_76	626100.4	3023685.9	240.0	230.0	237.2	237.8	-0.6
LFM-99-01B	Main	Devens_Consolidated_Landfill	624305.8	3018613.3	302.9	293.6	325.1	325.8	-0.7
LFM-99-02B	Main	Devens_Consolidated_Landfill	624305.6	3018229.3	338.5	329.2	335.6	338.9	-3.3
LFM-99-03B	Main	Devens_Consolidated_Landfill	624498.7	3019102.6	303.1	293.8	301.0	303.4	-2.5
LFM-99-05A	Main	Devens_Consolidated_Landfill	624886.5	3018948.0	296.8	287.5	293.8	296.8	-3.0
LFM-99-05B	Main	Devens_Consolidated_Landfill	624874.2	3018950.9	264.3	260.0	296.1	297.4	-1.3
LFM-99-06ARP	Main	Devens_Consolidated_Landfill	624993.4	3018340.6	325.1	315.8	321.8	313.3	8.5
1C	Main	Former_Fort_Devens	628164.0	3018704.9	199.6	194.6	243.2	243.3	-0.1
1D-D	Main	Former_Fort_Devens	627828.5	3020605.9	196.8	191.8	244.4	244.1	0.4
1D-S	Main	Former_Fort_Devens	627828.1	3020607.0	235.7	232.7	244.4	243.7	0.7
1E-D	Main	Former_Fort_Devens	629332.9	3018993.0	183.1	178.1	241.0	241.7	-0.7
1E-S	Main	Former_Fort_Devens	629334.2	3018993.7	241.2	238.2	241.5	241.5	0.0
1F-D	Main	Former_Fort_Devens	626720.6	3019761.0	233.8	228.8	251.5	252.5	-1.0
1F-S	Main	Former_Fort_Devens	626720.1	3019762.8	253.9	248.9	253.2	253.0	0.2
92-1	Main	Grove_Pond_Area	634242.2	3025938.4	172.5	166.5	215.1	215.0	0.1
92-3	Main	Grove_Pond_Area	634255.6	3025909.4	168.4	162.4	214.9	215.1	-0.1

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
92-5	Main	Grove_Pond_Area	633899.9	3026858.2	187.9	181.9	216.0	216.8	-0.8
CSMS-11-01	Main	Grove_Pond_Area	633877.8	3025631.5	220.7	210.7	216.1	215.6	0.6
CSMS-11-02	Main	Grove_Pond_Area	634304.2	3025614.1	218.9	208.9	215.1	215.6	-0.5
GF-1	Main	Grove_Pond_Area	634311.6	3026001.0	105.0	100.0	214.3	215.4	-1.1
GF-2	Main	Grove_Pond_Area	634185.3	3026015.9	107.6	100.6	214.5	215.3	-0.8
GF-3A	Main	Grove_Pond_Area	634258.3	3026080.1	121.5	116.5	215.1	215.4	-0.3
GF-3B	Main	Grove_Pond_Area	634258.5	3026074.2	210.6	205.6	216.1	216.2	-0.1
GF-4	Main	Grove_Pond_Area	634009.5	3026033.2	145.3	140.3	213.0	214.9	-2.0
GPMW-19-01A	Main	Grove_Pond_Area	633761.0	3025549.9	206.1	196.1	216.4	215.8	0.5
GPMW-19-01BR	Main	Grove_Pond_Area	633756.2	3025551.7	75.8	65.8	216.1	215.7	0.4
GPPZ-19-01	Main	Grove_Pond_Area	633757.6	3025557.0	145.7	140.7	216.0	215.5	0.4
MNG-2R	Main	Grove_Pond_Area	633011.0	3025606.6	219.5	209.5	217.0	217.8	-0.8
MNG-3R	Main	Grove_Pond_Area	634063.8	3025615.7	196.5	186.5	215.1	215.4	-0.3
MNG-5R	Main	Grove_Pond_Area	633156.5	3025390.3	223.5	213.5	219.3	218.7	0.5
MNG-6R	Main	Grove_Pond_Area	633467.4	3025321.2	219.7	209.7	216.7	217.2	-0.5
MPPZ-19-01	Main	MacPherson	626772.5	3027552.4	205.9	195.9	206.3	205.9	0.4
MPPZ-19-02	Main	MacPherson	627597.8	3027639.8	208.4	198.4	206.6	206.8	-0.2
PTW-A	Main	Patton_Well_Field	627734.7	3017995.9	194.9	189.9	242.2	241.0	1.3
PTW-B	Main	Patton_Well_Field	627732.3	3017995.8	187.6	182.6	239.3	241.0	-1.7
PWPZ-19-01	Main	Patton_Well_Field	628836.7	3019177.4	245.4	235.4	242.6	242.7	-0.1
PWPZ-19-02	Main	Patton_Well_Field	629733.7	3019425.1	237.1	227.1	236.8	237.0	-0.2
PWPZ-19-03	Main	Patton_Well_Field	630045.3	3018441.0	240.6	230.6	242.0	242.7	-0.7
PWPZ-19-04	Main	Patton_Well_Field	629277.9	3017203.4	248.4	238.4	247.9	247.4	0.5
PWPZ-19-05	Main	Patton_Well_Field	628514.8	3017150.1	242.7	232.7	243.5	244.2	-0.7
PWPZ-19-06	Main	Patton_Well_Field	628252.4	3018162.8	246.6	236.6	242.5	242.7	-0.2
PWPZ-19-07	Main	Patton_Well_Field	629411.3	3017814.9	244.7	234.8	245.6	245.8	-0.1
PWPZ-19-08	Main	Patton_Well_Field	628023.5	3018358.7	243.9	233.9	242.6	242.8	-0.2
PWPZ-19-09	Main	Patton_Well_Field	627777.7	3018422.6	244.5	234.5	242.9	243.1	-0.2
PWPZ-19-10	Main	Patton_Well_Field	627087.5	3018039.3	242.5	232.5	243.0	242.4	0.6
PWPZ-20-01	Main	Patton_Well_Field	627584.9	3017383.2	239.4	229.4	241.2	241.5	-0.4
MW-9D	Main	Shabokin_Well_Field	625898.9	3014610.8	172.4	162.4	233.7	231.8	1.9

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
MW-A	Main	Shabokin_Well_Field	625607.2	3014651.3	216.9	206.9	230.8	230.8	-0.1
MW-B	Main	Shabokin_Well_Field	625725.4	3014904.6	189.2	179.2	231.5	232.5	-1.0
MW-C	Main	Shabokin_Well_Field	625726.4	3014906.0	174.1	164.1	231.5	232.5	-1.0
MW-D	Main	Shabokin_Well_Field	625747.5	3014608.5	182.3	172.3	230.8	231.0	-0.2
MW-E	Main	Shabokin_Well_Field	625746.0	3014609.6	180.2	170.2	230.8	231.0	-0.2
MW-F	Main	Shabokin_Well_Field	625739.7	3014543.6	221.5	211.5	230.7	230.9	-0.2
MW-G	Main	Shabokin_Well_Field	625976.2	3014731.1	171.5	166.5	233.8	232.7	1.1
MW-H	Main	Shabokin_Well_Field	625817.6	3014401.7	217.7	207.7	232.0	231.1	0.9
MW-I	Main	Shabokin_Well_Field	625666.6	3014428.4	234.4	224.4	230.5	230.6	-0.1
MW-J	Main	Shabokin_Well_Field	626019.1	3014726.8	203.5	193.5	233.8	232.8	1.0
MW-K	Main	Shabokin_Well_Field	626018.3	3014725.3	203.5	193.5	233.8	232.8	1.0
SWMW-20-01A	Main	Shabokin_Well_Field	623813.1	3017855.1	358.0	348.0	354.5	354.6	-0.1
SWPZ-19-01	Main	Shabokin_Well_Field	625364.6	3014476.9	231.0	221.0	230.0	230.2	-0.2
SWPZ-19-03	Main	Shabokin_Well_Field	625580.7	3015861.3	242.4	232.4	238.8	238.8	0.0
SWPZ-19-04	Main	Shabokin_Well_Field	623974.7	3015553.2	233.9	223.9	232.2	231.8	0.4
SWPZ-20-01	Main	Shabokin_Well_Field	623460.8	3017049.2	323.6	313.6	328.3	331.1	-2.8
SWPZ-20-02	Main	Shabokin_Well_Field	625457.4	3016909.4	244.5	234.5	241.5	243.0	-1.5
MW-01A	North	AOC_20	626348.8	3030902.0	200.7	185.7	206.8	206.4	0.4
MW-02A	North	AOC_20	626214.8	3031750.7	205.7	190.7	206.7	206.9	-0.3
MW-04	North	AOC_20	625446.4	3032569.7	207.7	192.7	208.1	207.5	0.6
MW-06	North	AOC_20	624410.4	3033479.8	217.7	202.7	222.1	221.9	0.1
MW-07	North	AOC_20	624609.6	3031439.8	220.7	205.7	219.9	219.5	0.3
MW-WC1A	North	AOC_20	625913.9	3030133.6	203.2	191.7	207.2	206.8	0.4
MW-WC2	North	AOC_20	625338.2	3029975.5	205.0	190.5	209.5	208.2	1.3
PZ-1	North	AOC_20	625639.9	3031669.9	202.1	197.1	211.9	212.5	-0.7
PZ-5	North	AOC_20	625922.3	3030540.1	199.3	194.3	208.0	207.9	0.0
30PZ-19-01	North	AOC_30	626817.1	3035431.2	203.3	193.3	206.5	206.2	0.3
30PZ-19-02	North	AOC_30	626870.2	3034956.6	197.5	187.5	206.1	205.9	0.3
30PZ-19-03	North	AOC_30	626448.8	3035148.1	198.0	188.0	203.5	203.4	0.1
30PZ-19-04	North	AOC_30	626262.8	3034929.9	199.9	189.9	203.0	202.9	0.1
30PZ-19-05	North	AOC_30	627375.5	3035471.4	204.1	194.1	212.7	211.9	0.8

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
31PZ-19-01	North	AOC_31	626075.5	3034166.0	199.7	189.7	202.6	202.7	-0.1
31PZ-19-02D	North	AOC_31	625372.9	3033989.4	141.3	136.3	202.4	201.9	0.5
31PZ-19-02S	North	AOC_31	625374.2	3033989.9	198.3	193.3	202.1	201.7	0.4
SHM-10-02	North	AOC_5	628381.4	3028700.1	167.2	157.2	205.3	205.3	0.0
SHM-10-03	North	AOC_5	628436.3	3029000.3	171.3	161.3	205.7	205.6	0.1
SHM-10-04	North	AOC_5	628959.2	3029485.3	155.0	145.0	206.8	206.8	0.0
SHM-10-08	North	AOC_5	628351.7	3028526.5	165.9	155.9	205.2	205.2	0.0
50PZ-19-01	North	AOC_50	627821.1	3034978.4	206.8	196.8	209.7	209.1	0.6
50PZ-19-02	North	AOC_50	627345.5	3034648.6	208.2	198.2	206.9	206.6	0.3
50PZ-19-03	North	AOC_50	628849.2	3033897.4	215.6	205.6	214.1	212.5	1.5
50PZ-19-04	North	AOC_50	628182.7	3033509.9	212.0	202.0	208.8	208.4	0.3
50PZ-19-05	North	AOC_50	629266.5	3032501.4	217.2	207.2	212.5	212.6	-0.1
50PZ-19-06	North	AOC_50	628574.6	3031601.9	203.0	193.0	206.1	206.9	-0.9
50PZ-19-07	North	AOC_50	625891.4	3034626.9	203.0	193.0	201.8	202.0	-0.2
G6M-01-01X	North	AOC_50	626357.9	3033351.1	133.6	113.6	201.0	203.3	-2.2
G6M-02-01X	North	AOC_50	627859.2	3034746.2	183.1	168.1	208.3	208.5	-0.2
G6M-02-02X	North	AOC_50	627949.0	3034667.6	183.3	168.3	207.4	208.6	-1.3
G6M-02-03X	North	AOC_50	627143.5	3034149.4	173.7	158.7	204.3	204.9	-0.6
G6M-02-04X	North	AOC_50	627229.7	3034065.5	173.0	158.0	204.5	205.0	-0.5
G6M-02-06X	North	AOC_50	626093.3	3033118.1	149.7	139.7	203.2	202.3	0.9
G6M-02-07X	North	AOC_50	625702.4	3033654.5	177.7	167.7	202.8	202.2	0.6
G6M-02-08X	North	AOC_50	628301.7	3035050.8	162.7	152.7	210.4	210.9	-0.5
G6M-02-09X	North	AOC_50	627285.6	3033980.1	172.7	157.7	203.7	205.0	-1.3
G6M-02-10X	North	AOC_50	626714.0	3033677.5	139.3	129.3	202.4	203.9	-1.5
G6M-02-11X	North	AOC_50	626634.3	3033609.1	136.9	126.9	203.3	203.8	-0.5
G6M-02-12X	North	AOC_50	626546.4	3033555.9	133.9	123.9	203.1	203.7	-0.6
G6M-02-13X	North	AOC_50	627017.9	3033970.1	153.8	143.8	203.4	204.5	-1.1
G6M-02-31BR	North	AOC_50	628213.0	3034878.8	169.3	159.3	208.3	210.0	-1.7
G6M-03-01X	North	AOC_50	628308.9	3035060.1	172.9	152.9	210.4	211.0	-0.6
G6M-03-02X	North	AOC_50	628302.7	3035041.0	194.7	179.7	210.2	210.9	-0.7
G6M-03-04X	North	AOC_50	628431.6	3035001.4	209.5	194.5	210.5	211.3	-0.8

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
G6M-03-07X	North	AOC_50	627560.6	3034422.7	182.8	172.8	206.0	206.9	-0.9
G6M-03-08X	North	AOC_50	626483.2	3033490.5	134.4	119.4	202.9	203.7	-0.8
G6M-03-09X	North	AOC_50	626480.2	3033541.8	132.9	117.9	202.8	203.7	-0.9
G6M-03-10X	North	AOC_50	626447.6	3033630.8	144.5	129.5	203.3	203.8	-0.5
G6M-03-11X	North	AOC_50	626365.2	3033366.2	148.3	133.3	201.9	203.3	-1.4
G6M-04-01X	North	AOC_50	627999.9	3034762.4	179.7	169.7	208.9	209.0	-0.2
G6M-04-02X	North	AOC_50	627651.6	3034493.3	184.5	174.5	206.4	207.3	-0.9
G6M-04-03X	North	AOC_50	627791.6	3034595.3	179.8	169.8	207.8	208.0	-0.2
G6M-04-04X	North	AOC_50	627448.7	3034333.8	169.7	159.7	204.7	206.2	-1.4
G6M-04-05X	North	AOC_50	626482.5	3033496.6	158.6	148.6	203.2	203.7	-0.5
G6M-04-06X	North	AOC_50	626248.4	3033359.0	167.2	157.2	202.2	202.9	-0.7
G6M-04-07X	North	AOC_50	626248.4	3033349.2	141.8	131.8	203.4	202.9	0.4
G6M-04-08X	North	AOC_50	625617.4	3033449.9	123.2	113.2	203.2	202.2	1.0
G6M-04-09X	North	AOC_50	628303.8	3034944.5	187.4	177.4	210.8	210.5	0.3
G6M-04-10A	North	AOC_50	628385.4	3034996.1	192.4	182.4	211.3	211.1	0.2
G6M-04-10X	North	AOC_50	628380.0	3034998.9	170.5	160.5	210.7	211.0	-0.3
G6M-04-11X	North	AOC_50	628110.6	3034988.6	193.3	183.3	210.1	210.0	0.1
G6M-04-12X	North	AOC_50	628232.5	3035032.2	169.9	159.9	211.0	210.5	0.5
G6M-04-13X	North	AOC_50	628411.0	3034974.1	194.2	184.2	211.4	211.1	0.2
G6M-04-14X	North	AOC_50	625817.7	3033359.0	128.5	118.5	203.0	202.3	0.6
G6M-04-15X	North	AOC_50	628330.9	3034916.3	181.7	171.7	210.9	210.6	0.4
G6M-04-22X	North	AOC_50	628167.9	3034895.3	180.2	170.2	209.9	209.9	0.0
G6M-04-31X	North	AOC_50	628210.0	3034869.2	186.3	176.3	209.7	210.0	-0.3
G6M-06-01X	North	AOC_50	626954.6	3034144.1	158.5	138.5	206.0	204.6	1.4
G6M-07-01X	North	AOC_50	627885.2	3034805.0	184.2	173.2	210.1	208.7	1.3
G6M-07-02X	North	AOC_50	628407.4	3034987.4	200.4	195.4	211.4	211.1	0.3
G6M-13-01X	North	AOC_50	626402.1	3033736.9	140.2	130.2	204.0	203.8	0.3
G6M-13-02X	North	AOC_50	626820.1	3034076.7	149.0	139.0	204.4	204.4	0.0
G6M-13-03X	North	AOC_50	627535.4	3034543.7	184.8	174.8	206.7	207.0	-0.3
G6M-13-04X	North	AOC_50	626602.7	3033706.7	140.0	130.0	203.6	203.9	-0.3
G6M-13-05X	North	AOC_50	628219.4	3035037.3	178.9	168.9	210.8	210.4	0.4

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
G6M-13-06X	North	AOC_50	628269.8	3034982.1	175.4	165.4	210.3	210.5	-0.2
G6M-18-01	North	AOC_50	626508.0	3034124.3	148.6	138.6	204.6	204.1	0.5
G6M-18-02	North	AOC_50	626102.2	3033809.1	142.7	132.7	203.4	203.0	0.5
G6M-92-10X	North	AOC_50	628503.4	3035008.3	213.4	203.4	210.8	211.5	-0.8
G6M-93-13X	North	AOC_50	628274.3	3034988.4	213.9	203.9	211.1	210.6	0.5
G6M-94-15A	North	AOC_50	628328.6	3034924.4	217.7	207.7	211.9	210.7	1.2
G6M-95-19X	North	AOC_50	628384.3	3035057.7	174.4	164.4	211.6	211.2	0.4
G6M-95-20X	North	AOC_50	628485.8	3035005.9	204.5	199.5	212.0	211.5	0.5
G6M-96-22A	North	AOC_50	628391.1	3035142.8	176.3	166.3	212.5	211.8	0.7
G6M-96-22B	North	AOC_50	628384.4	3035149.2	150.9	145.9	211.9	211.8	0.2
G6M-96-25A	North	AOC_50	628065.4	3035061.0	214.3	204.6	212.3	210.2	2.1
G6M-96-25B	North	AOC_50	628065.4	3035061.0	175.9	165.9	209.7	210.1	-0.5
G6M-96-26A	North	AOC_50	628547.7	3034950.7	214.8	204.8	210.8	211.5	-0.8
G6M-96-26B	North	AOC_50	628554.4	3034947.6	154.9	144.9	209.8	211.4	-1.6
G6M-97-05B	North	AOC_50	626265.1	3033730.4	135.9	130.9	203.2	203.5	-0.3
G6M-97-09B	North	AOC_50	628271.9	3034545.3	185.8	175.8	208.7	209.7	-1.0
G6M-97-28X	North	AOC_50	627185.8	3034102.8	163.1	158.1	204.6	204.9	-0.3
G6M-97-29X	North	AOC_50	626733.8	3033672.1	85.0	75.0	202.2	203.9	-1.7
G6M-98-32X	North	AOC_50	626756.3	3033673.1	134.2	129.2	202.4	203.9	-1.5
G6P-97-05X	North	AOC_50	627296.4	3035151.1	201.6	191.6	211.1	208.5	2.6
MW-3	North	AOC_50	626756.6	3033717.3	137.4	126.4	203.1	204.0	-0.9
MW-6	North	AOC_50	626819.0	3033733.4	138.6	128.6	201.9	204.1	-2.2
MW-7	North	AOC_50	626806.1	3033767.8	138.7	128.7	204.2	204.1	0.1
MW-7 (IT)	North	AOC_50	627288.7	3035121.8	216.2	206.2	208.6	208.4	0.2
XSA-12-95X	North	AOC_50	626165.5	3033422.6	144.9	134.9	201.7	202.8	-1.1
XSA-12-96X	North	AOC_50	626043.1	3033529.4	146.6	136.6	204.6	202.7	2.0
XSA-12-97X	North	AOC_50	625909.0	3033633.5	139.4	129.4	201.9	202.5	-0.6
XSA-12-98X	North	AOC_50	625683.8	3033711.6	144.1	134.1	204.5	202.2	2.2
MPP-93-02	North	MacPherson	626050.3	3028511.6	187.7	182.7	202.8	203.3	-0.6
MPP-93-03	North	MacPherson	626054.7	3028924.5	187.1	182.1	203.5	203.2	0.3
MPPZ-19-03	North	MacPherson	626527.7	3028166.8	206.8	196.8	204.9	203.6	1.4

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
McPh-Sentinel	North	MacPherson	626470.0	3028078.7	118.9	113.9	204.3	203.6	0.7
25M-92-05X	South	AOC_25	614591.4	3005719.1	329.7	319.7	332.2	332.9	-0.7
25M-92-06X	South	AOC_25	615496.2	3005640.7	286.7	276.7	289.2	289.2	0.1
25M-92-07X	South	AOC_25	615490.0	3005962.2	290.0	280.0	294.4	293.5	0.9
25M-92-08X	South	AOC_25	615308.4	3005999.6	290.3	270.3	301.5	302.8	-1.2
26M-10-09X	South	AOC_25	614430.2	3008788.0	277.6	267.6	274.6	271.9	2.7
26M-14-10X	South	AOC_25	614911.3	3008660.4	276.5	266.5	275.2	271.6	3.6
26M-14-11X	South	AOC_25	615141.8	3008109.0	281.3	271.3	287.7	286.3	1.4
26M-92-01X	South	AOC_25	614915.2	3007313.5	313.6	303.6	309.3	308.5	0.8
26M-92-02X	South	AOC_25	614255.8	3008196.5	261.3	241.3	285.4	285.3	0.1
26M-92-03X	South	AOC_25	614252.7	3008189.9	284.6	274.6	285.3	285.3	0.0
26M-92-04X	South	AOC_25	614416.0	3008106.1	284.7	274.7	286.1	286.0	0.1
26M-92-05X	South	AOC_25	613741.7	3008158.4	285.5	275.5	287.1	287.1	-0.1
26M-92-06X	South	AOC_25	614046.3	3007845.9	289.2	279.2	290.0	291.5	-1.5
26M-92-07X	South	AOC_25	614696.7	3007822.5	288.0	278.0	288.6	288.9	-0.3
26WP-06-01R	South	AOC_25	614285.2	3008321.9	276.2	273.2	282.6	283.0	-0.5
26WP-08-02R	South	AOC_25	614059.2	3008937.9	272.9	269.9	279.8	278.1	1.7
26WP-09-01R	South	AOC_25	614325.0	3008610.7	277.9	274.9	281.1	281.4	-0.3
26WP-09-02R	South	AOC_25	614511.6	3008983.7	266.9	263.9	272.2	264.9	7.3
26WP-09-03R	South	AOC_25	613685.7	3008585.7	282.8	279.8	284.7	283.8	0.9
27M-93-07X	South	AOC_25	616843.1	3008814.5	222.1	212.1	238.3	239.2	-1.0
27M-93-09X	South	AOC_25	616861.9	3009179.3	215.9	205.9	236.4	236.5	-0.2
27M-93-10X	South	AOC_25	616872.1	3009166.4	234.5	224.5	235.6	236.6	-1.0
SPM-93-06X	South	AOC_25	615772.7	3009836.3	196.3	186.3	231.0	232.6	-1.6
SPM-97-23X	South	AOC_25	616719.8	3009865.2	205.2	195.2	229.5	230.6	-1.1
26M-97-08X	South	AOC_26	614221.5	3008209.6	272.4	262.4	285.4	285.1	0.3
26WP-06-01	South	AOC_26	614255.0	3008319.7	277.2	275.2	282.2	283.1	-0.9
26WP-08-02	South	AOC_26	614024.7	3008895.1	272.3	269.3	279.3	279.3	0.0
26WP-09-02	South	AOC_26	614504.9	3008971.9	249.5	246.5	261.1	265.0	-3.9
26WP-09-03	South	AOC_26	613717.7	3008555.6	284.2	281.2	283.7	283.9	-0.1
27M-92-01X	South	AOC_27	616851.2	3009431.5	235.2	225.2	233.5	234.0	-0.5

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
27M-93-05X	South	AOC_27	616850.7	3009444.6	175.0	165.0	232.7	233.2	-0.5
27M-93-06X	South	AOC_27	616841.1	3009437.9	198.5	188.5	233.1	233.7	-0.7
27M-93-08X	South	AOC_27	617066.6	3009359.1	199.4	189.4	232.8	233.6	-0.8
41M-92-01X	South	AOC_41	619695.0	3005472.6	219.8	209.8	223.6	223.2	0.3
41M-93-02B	South	AOC_41	619679.9	3005541.1	224.1	214.1	223.9	223.2	0.7
41M-93-04X	South	AOC_41	619669.0	3005242.1	221.8	217.8	223.5	223.5	0.0
41M-93-05X	South	AOC_41	619667.6	3005291.3	223.9	218.9	223.1	223.5	-0.3
41M-94-02C	South	AOC_41	619686.0	3005557.7	207.7	197.7	222.4	223.2	-0.8
41M-94-03B	South	AOC_41	619817.0	3005676.4	200.3	190.3	221.9	222.2	-0.3
41M-94-06X	South	AOC_41	619231.2	3005288.2	223.1	213.1	224.2	225.1	-0.9
41M-94-07X	South	AOC_41	619327.8	3005238.6	220.7	216.2	223.8	224.0	-0.2
41M-94-08A	South	AOC_41	619472.4	3005341.3	223.2	213.2	224.2	224.1	0.1
41M-94-08B	South	AOC_41	619465.9	3005341.1	206.1	196.1	223.7	224.3	-0.6
41M-94-09A	South	AOC_41	620029.3	3005820.6	221.4	211.4	220.7	221.2	-0.5
41M-94-09B	South	AOC_41	620035.9	3005820.8	204.6	194.6	220.5	221.1	-0.6
41M-94-10X	South	AOC_41	619345.9	3005403.3	225.4	215.4	229.7	227.6	2.1
41M-94-11X	South	AOC_41	619581.6	3005646.5	221.1	211.1	224.0	225.7	-1.7
41M-94-12X	South	AOC_41	620063.8	3005542.5	220.1	210.1	221.9	222.3	-0.3
41M-94-13X	South	AOC_41	619902.2	3005455.8	221.1	211.1	223.3	222.8	0.4
41M-94-14X	South	AOC_41	619430.1	3005218.7	218.9	213.9	223.5	223.7	-0.2
SPM-93-03X	South	SP_Other	615028.3	3010706.7	232.3	222.3	248.2	248.5	-0.2
SPM-93-05X	South	SP_Other	615762.5	3009845.7	223.8	213.8	232.2	232.4	-0.2
SPM-93-07X	South	SP_Other	618829.2	3007567.0	240.7	230.7	237.9	237.8	0.1
SPM-93-08X	South	SP_Other	618822.4	3007576.6	216.6	206.6	238.8	237.9	0.9
SPM-93-09X	South	SP_Other	617753.1	3005113.3	233.6	223.6	234.4	234.5	-0.1
SPM-93-10X	South	SP_Other	617740.3	3005100.0	207.7	197.7	234.2	234.5	-0.3
SPM-93-11X	South	SP_Other	615750.5	3002137.0	233.4	223.4	234.0	234.5	-0.5
SPM-93-12X	South	SP_Other	615756.7	3002150.3	202.9	192.9	233.3	234.1	-0.8
SPM-93-13X	South	SP_Other	615603.7	3007891.8	283.1	273.1	278.6	277.3	1.3
SPM-93-15X	South	SP_Other	613462.9	3002929.1	351.4	341.4	354.9	352.3	2.6
SPM-93-16X	South	SP_Other	617276.5	3004580.8	192.0	182.0	232.0	233.4	-1.3

Table E.2

Target Water Levels

Location	Post	Group	Easting	Northing	Top of Screen (feet/MSL)	Bottom of Screen (feet/MSL)	Target Water Level (feet/MSL)	Calculated Water Level (feet/MSL)	Residual[1] (feet)
SPM-97-24X	South	SP_Other	619281.0	3006553.9	201.2	191.2	224.7	225.8	-1.1

Note:

[1] Residual is calculated as Target Water Level - Calculated Water Level.

Table E.3

Three-Point Gradient Method – Magnitudes and Directions

Post	Definition Monitoring Wells	Estimated Direction (degrees)	Calculated Direction (degrees)	Direction Difference[1,3] (degrees)	Estimated Magnitude	Calculated Magnitude	Transformed[2] Estimated Magnitude	Transformed[2] Calculated Magnitude	Transformed Magnitude Residual[3]
South	25M-92-06X, 25M-92-05X, 25M-92-08X	101.9	105.6	-3.6	4.77E-02	4.90E-02	4.6	4.5	0.1
South	41M-94-11X, SPM-93-09X, SPM-93-08X	124.5	123.7	0.7	8.62E-03	7.17E-03	10.8	11.8	-1.0
South	27M-93-08X, 27M-93-09X, 27M-93-06X	23.7	22.0	1.7	1.44E-02	1.21E-02	8.3	9.1	-0.8
South	26M-10-09X, 26WP-09-01R, 26WP-08-02	35.4	37.1	-1.7	3.19E-02	4.68E-02	5.6	4.6	1.0
South	26WP-08-02, 26M-92-05X, 26WP-09-03	29.3	32.0	-2.7	9.96E-03	1.01E-02	10.0	10.0	0.1
South	26WP-08-02, 26WP-09-01R, 26M-92-05X	16.6	12.4	4.1	9.89E-03	1.00E-02	10.1	10.0	0.1
South	26M-92-07X, 26M-92-06X, 26M-92-04X	12.8	17.1	-4.3	1.17E-02	1.55E-02	9.2	8.0	1.2
South	26M-92-07X, 26M-92-04X, 26M-14-10X	21.5	24.1	-2.7	1.56E-02	2.03E-02	8.0	7.0	1.0
South	26M-14-10X, 26M-14-11X, 26M-92-07X	331.8	338.5	-6.8	2.10E-02	2.47E-02	6.9	6.4	0.5
South	26WP-09-01R, 26M-92-03X, 26M-92-05X	17.5	19.6	-2.1	9.78E-03	9.14E-03	10.1	10.5	-0.3
South	26M-92-04X, 26M-92-06X, 26M-92-03X	6.8	13.8	-7.0	1.30E-02	1.63E-02	8.8	7.8	0.9
South	26M-92-03X, 26M-92-06X, 26M-92-05X	12.7	8.8	3.9	1.25E-02	1.68E-02	8.9	7.7	1.2
South	26WP-09-02R, 26M-10-09X, 26WP-08-02	63.3	44.7	18.6	1.50E-02	3.57E-02	8.2	5.3	2.9
South	26WP-09-02R, 26M-14-10X, 26M-10-09X	8.4	15.8	-7.4	1.17E-02	3.33E-02	9.2	5.5	3.8
South	26M-14-11X, 26M-92-01X, 26M-92-07X	329.8	335.1	-5.3	3.77E-02	3.54E-02	5.1	5.3	-0.2
Former Main	PWPZ-19-07, PWPZ-19-04, PWPZ-19-05	309.3	309.0	0.3	7.81E-03	5.67E-03	11.3	13.3	-2.0
Former Main	LFM-99-05A, LFM-99-01B, LFM-99-03B	42.3	42.1	0.2	4.90E-02	4.55E-02	4.5	4.7	-0.2
Former Main	LFM-99-05A, LFM-03-07, LFM-99-01B	56.5	52.3	4.1	4.68E-02	4.36E-02	4.6	4.8	-0.2
Former Main	LFM-03-07, LFM-99-06ARP, LFM-99-01B	24.3	39.9	-15.6	9.62E-02	5.41E-02	3.2	4.3	-1.1
Former Main	LFM-99-02B, LFM-99-01B, LFM-99-06ARP	29.8	42.9	-13.1	3.16E-02	4.67E-02	5.6	4.6	1.0
Former Main	SWPZ-20-02, SWPZ-19-03, SWPZ-20-01	86.6	88.4	-1.8	4.37E-02	4.42E-02	4.8	4.8	0.0
Former Main	PWPZ-19-06, PWPZ-19-08, 1C	211.3	214.1	-2.8	1.62E-03	1.51E-03	24.9	25.7	-0.9
Former Main	PWPZ-19-07, PWPZ-19-06, PWPZ-19-01	297.5	299.8	-2.2	2.62E-03	2.58E-03	19.5	19.7	-0.1
Former Main	PWPZ-19-07, PWPZ-19-05, PWPZ-19-06	276.7	289.2	-12.5	2.61E-03	2.52E-03	19.6	19.9	-0.4
Former Main	PWPZ-19-06, 1C, PWPZ-19-01	123.4	120.2	3.2	1.81E-03	1.73E-03	23.5	24.0	-0.5
Former Main	1D-D, 1F-S, 43GPZ-19-04	64.5	58.7	5.8	6.43E-03	6.46E-03	12.5	12.4	0.0
Former Main	PWPZ-19-01, PWPZ-19-02, 1E-S	35.4	37.3	-1.9	8.06E-03	7.72E-03	11.1	11.4	-0.2
Former Main	1E-S, PWPZ-19-07, PWPZ-19-01	44.2	44.9	-0.7	5.18E-03	5.42E-03	13.9	13.6	0.3
Former Main	PWPZ-19-03, PWPZ-19-07, 1E-S	31.1	19.0	12.1	4.23E-03	3.89E-03	15.4	16.0	-0.7
Former Main	XGM-94-08X, 43GPZ-19-01, XGM-94-10X	108.3	110.5	-2.2	4.56E-02	4.58E-02	4.7	4.7	0.0
Former Main	XGM-94-06X, 43GPZ-19-01, XGM-94-08X	97.2	99.0	-1.7	5.38E-02	5.38E-02	4.3	4.3	0.0
Former Main	43GPZ-19-02, XGM-94-07X, AAFES-5	82.7	79.6	3.1	5.22E-02	5.56E-02	4.4	4.2	0.1
Former Main	XGM-94-07X, XGM-94-08X, AAFES-6R	127.0	115.7	11.4	3.31E-02	4.26E-02	5.5	4.8	0.7
Former Main	43GPZ-19-06, 43GPZ-19-05, XGM-20-01A	63.4	70.1	-6.7	7.45E-03	6.45E-03	11.6	12.5	-0.9
Former Main	43GPZ-19-05, 43GPZ-19-04, AAFES-7	38.9	53.1	-14.1	9.54E-03	9.36E-03	10.2	10.3	-0.1
Former Main	76PZ-19-01, 76PZ-19-05, 76PZ-19-03	353.2	2.4	-9.3	3.75E-03	4.31E-03	16.3	15.2	1.1
Former Main	76PZ-19-11, 76PZ-19-05, 76PZ-19-10	18.5	29.5	-11.0	4.48E-03	4.55E-03	14.9	14.8	0.1

Table E.3

Three-Point Gradient Method – Magnitudes and Directions

Post	Definition Monitoring Wells	Estimated Direction (degrees)	Calculated Direction (degrees)	Direction Difference[1,3] (degrees)	Estimated Magnitude	Calculated Magnitude	Transformed[2] Estimated Magnitude	Transformed[2] Calculated Magnitude	Transformed Magnitude Residual[3]
Former Main	76PZ-19-05, 76PZ-19-07, 76PZ-19-10	11.4	14.9	-3.4	4.72E-03	4.90E-03	14.6	14.3	0.3
Former Main	76PZ-19-01, 76PZ-19-07, 76PZ-19-05	353.4	2.3	-8.8	4.22E-03	4.41E-03	15.4	15.1	0.3
Former Main	76PZ-19-02, 76PZ-19-07, 76PZ-19-06	31.9	13.0	19.0	9.84E-03	8.32E-03	10.1	11.0	-0.9
Former Main	76PZ-19-10, 76PZ-19-07, 76PZ-19-02	17.8	18.4	-0.7	9.76E-03	8.22E-03	10.1	11.0	-0.9
Former Main	76PZ-19-16, 76PZ-19-13, 76PZ-19-02	312.0	338.7	-26.6	8.86E-03	7.65E-03	10.6	11.4	-0.8
Former Main	75PZ-19-02, 75PZ-20-05, 75PZ-19-04	130.9	109.2	21.7	2.22E-03	2.58E-03	21.2	19.7	1.6
Former Main	75PZ-19-03, 75PZ-19-02, 75PZ-19-04	59.8	84.4	-24.5	6.51E-03	3.45E-03	12.4	17.0	-4.6
Former Main	76PZ-19-03, 43GPZ-19-08, 76PZ-19-01	346.3	355.9	-9.7	3.24E-03	3.54E-03	17.6	16.8	0.8
Former Main	76PZ-19-18, 43GPZ-19-08, 76PZ-19-04	64.1	63.3	0.7	2.06E-03	2.20E-03	22.1	21.3	0.8
Former Main	76PZ-19-18, 43GPZ-19-06, 43GPZ-19-08	69.9	57.7	12.2	1.98E-03	2.32E-03	22.5	20.8	1.7
Former Main	43GPZ-19-06, XGM-20-01A, 43GPZ-19-08	53.4	51.2	2.3	8.14E-03	7.53E-03	11.1	11.5	-0.4
Former Main	76PZ-19-11, 76PZ-19-15, 76PZ-19-03	33.9	33.2	0.8	4.23E-03	5.15E-03	15.4	13.9	1.4
Former Main	76PZ-19-03, 76PZ-19-05, 76PZ-19-11	18.2	23.2	-5.1	4.53E-03	5.34E-03	14.9	13.7	1.2
Former Main	43GPZ-19-08, 76PZ-19-03, 76PZ-19-15	51.7	50.6	1.1	2.84E-03	3.45E-03	18.8	17.0	1.7
Former Main	57M-03-02X, 57M-95-07X, 57M-95-05X	149.5	148.8	0.7	8.79E-03	9.07E-03	10.7	10.5	0.2
Former Main	57M-03-05X, 57M-03-02X, 57M-95-06X	162.6	159.4	3.2	1.88E-02	1.38E-02	7.3	8.5	-1.2
Former Main	57M-03-01X, 57M-03-02X, 57M-95-05X	170.6	161.1	9.5	1.39E-02	1.13E-02	8.5	9.4	-0.9
Former Main	57M-95-06X, 57M-03-02X, 57M-03-01X	180.7	170.6	10.1	1.35E-02	1.07E-02	8.6	9.7	-1.1
Former Main	57M-03-02X, 57M-03-03X, 57M-95-07X	149.4	147.9	1.5	8.97E-03	1.04E-02	10.6	9.8	0.7
Former Main	57M-03-02X, 57M-03-05X, 57M-03-03X	136.6	150.8	-14.2	9.18E-03	1.04E-02	10.4	9.8	0.6
Former Main	57M-96-11X, 57M-96-12X, 57M-95-03X	151.0	150.0	0.9	2.96E-02	1.82E-02	5.8	7.4	-1.6
Former Main	57M-96-12X, 57M-96-11X, 57M-96-13X	147.8	147.3	0.6	2.76E-02	1.72E-02	6.0	7.6	-1.6
Former Main	57P-98-03X, 57M-96-11X, 57M-96-10X	182.3	168.5	13.8	7.01E-02	2.19E-02	3.8	6.8	-3.0
Former Main	57P-98-03X, 57P-98-04X, 57M-96-11X	175.1	166.6	8.5	5.45E-02	2.10E-02	4.3	6.9	-2.6
Former Main	57M-95-03X, 57M-96-12X, 57M-96-09X	156.3	158.4	-2.1	2.32E-02	1.26E-02	6.6	8.9	-2.3
Former Main	57M-96-12X, 57M-96-13X, 57M-96-09X	148.7	149.0	-0.3	2.41E-02	1.32E-02	6.4	8.7	-2.3
Former Main	74PZ-19-05, 74PZ-19-02, 74PZ-19-03	36.6	42.1	-5.4	2.36E-03	1.90E-03	20.6	22.9	-2.4
Former Main	74PZ-19-08, 74PZ-19-05, 74PZ-19-07	35.4	33.8	1.6	8.27E-03	6.46E-03	11.0	12.4	-1.4
Former Main	74PZ-19-09, 74PZ-19-05, 74PZ-19-08	28.6	33.5	-4.9	8.30E-03	6.46E-03	11.0	12.4	-1.5
Former Main	74PZ-19-09, 74PZ-19-04, 74PZ-19-05	114.5	109.3	5.2	7.76E-03	6.08E-03	11.4	12.8	-1.5
Former Main	74PZ-19-02, 74PZ-19-05, 74PZ-19-04	116.6	115.2	1.4	7.62E-03	5.74E-03	11.5	13.2	-1.7
Former Main	74PZ-19-05, 74PZ-19-06, 74PZ-19-07	23.7	26.7	-3.0	7.37E-03	6.01E-03	11.6	12.9	-1.2
Former Main	74PZ-19-05, 74PZ-19-03, 74PZ-19-06	10.7	14.1	-3.4	4.52E-03	3.45E-03	14.9	17.0	-2.2
Former Main	SHM-11-07, SHM-10-07, SHM-10-13	15.8	10.4	5.4	4.83E-03	5.30E-03	14.4	13.7	0.7
Former Main	MNG-6R, 74PZ-19-06, MNG-5R	47.9	42.4	5.5	1.37E-02	9.78E-03	8.5	10.1	-1.6
Former Main	74PZ-19-07, 74PZ-19-06, MNG-6R	12.6	16.0	-3.4	1.04E-02	8.03E-03	9.8	11.2	-1.3
Former Main	CSMS-11-02, 74PZ-19-07, MNG-6R	354.0	357.9	-4.0	7.92E-03	5.98E-03	11.2	12.9	-1.7

Table E.3

Three-Point Gradient Method – Magnitudes and Directions

Post	Definition Monitoring Wells	Estimated Direction (degrees)	Calculated Direction (degrees)	Direction Difference[1,3] (degrees)	Estimated Magnitude	Calculated Magnitude	Transformed[2] Estimated Magnitude	Transformed[2] Calculated Magnitude	Transformed Magnitude Residual[3]
Former Main	74PZ-19-08, 74PZ-19-07, CSMS-11-02	41.1	38.7	2.4	6.38E-03	5.03E-03	12.5	14.1	-1.6
Former Main	74PZ-19-09, 74PZ-19-08, CSMS-11-02	30.6	36.6	-6.0	5.94E-03	4.95E-03	13.0	14.2	-1.2
Former Main	69W-94-12, ZWM-99-22X, 69W-94-13	324.1	324.1	0.0	9.04E-03	7.76E-03	10.5	11.4	-0.8
Former Main	ZWM-95-16X, ZWM-99-22X, 69W-94-12	321.9	323.1	-1.2	9.83E-03	8.07E-03	10.1	11.1	-1.0
Former Main	ZWM-01-26X, ZWM-99-23X, ZWM-01-25X	290.4	309.3	-18.8	7.14E-03	8.57E-03	11.8	10.8	1.0
Former Main	ZWM-95-15X, 69W-94-14, ZWM-99-24X	15.8	312.8	63.0	7.81E-03	7.89E-03	11.3	11.3	0.1
Former Main	69W-94-14, 69W-94-13, ZWM-99-24X	7.6	313.8	53.8	8.73E-03	9.22E-03	10.7	10.4	0.3
Former Main	ZWM-01-25X, ZWM-95-15X, ZWM-95-18X	352.3	313.4	38.9	7.86E-03	7.24E-03	11.3	11.8	-0.5
Former Main	43M-01-20XOB, ZWM-95-17X, 32M-92-03X	236.2	229.7	6.5	8.13E-03	8.59E-03	11.1	10.8	0.3
Former Main	43M-01-16XOB, 32M-92-03X, 32Z-01-08XOB	212.1	214.0	-1.8	2.19E-02	2.53E-02	6.8	6.3	0.5
Former Main	32Z-01-05XOB, 32Z-01-09XOB, 43M-01-17XOB	267.4	269.4	-2.0	2.05E-03	2.86E-03	22.1	18.7	3.4
Former Main	43M-01-16XOB, 43M-01-17XOB, 43M-01-20XOB	191.1	211.6	-20.5	3.13E-03	5.11E-03	17.9	14.0	3.9
Former Main	32M-01-17XBR, 32Z-01-10XBR, 32M-01-18XBR	79.7	86.9	-7.2	4.41E-02	3.07E-02	4.8	5.7	-0.9
Former Main	SHM-10-12, SHP-99-35X, SHP-99-01B	86.2	84.0	2.1	9.00E-02	7.42E-02	3.3	3.7	-0.3
Former Main	SHM-10-11, SHP-99-01B, SHP-99-35X	63.5	63.0	0.6	9.95E-02	8.22E-02	3.2	3.5	-0.3
Former Main	SHM-10-11, N7-P1, SHL-15	78.7	80.3	-1.6	2.74E-02	2.98E-02	6.0	5.8	0.2
Former Main	N7-P1, SHL-12, 32M-01-14XOB	74.0	75.7	-1.7	2.02E-02	2.25E-02	7.0	6.7	0.4
Former Main	SHM-10-13, SHM-10-12, SHM-10-15	8.5	5.2	3.3	5.40E-03	5.25E-03	13.6	13.8	-0.2
Former Main	SHM-10-13, SHM-10-15, SHM-10-14	6.1	2.7	3.4	6.02E-03	6.03E-03	12.9	12.9	0.0
Former Main	SHM-10-15, SHP-99-29X, SHM-10-14	66.5	79.3	-12.8	8.32E-03	1.09E-02	11.0	9.6	1.4
Former Main	SHM-10-07, SHM-10-12, SHM-10-13	17.2	9.6	7.7	5.25E-03	5.14E-03	13.8	14.0	-0.1
Former Main	SHP-05-44, PZ-12-02, SHM-11-06	358.0	6.5	-8.5	5.48E-03	7.42E-03	13.5	11.6	1.9
Former Main	SHP-01-36X, SHP-01-37X, SHP-05-44	294.1	314.5	-20.4	2.26E-03	2.20E-03	21.0	21.3	-0.3
Former Main	N2-P1, SHP-01-38A, SHL-11	61.7	65.3	-3.6	1.85E-03	1.44E-03	23.3	26.3	-3.1
Former Main	PZ-12-03, SHP-01-38A, PZ-12-05	10.2	35.5	-25.3	3.05E-03	1.20E-03	18.1	28.8	-10.7
Former Main	SHL-11, PZ-12-01, N2-P1	114.4	50.4	63.9	1.73E-03	1.72E-03	24.1	24.1	0.0
Former Main	SHP-01-37X, N2-P1, PZ-12-01	96.5	52.1	44.4	1.81E-03	1.63E-03	23.5	24.8	-1.2
Former Main	N3-P1, SHL-19, SHL-4	6.9	353.4	13.5	5.41E-03	6.49E-03	13.6	12.4	1.2
Former Main	SHL-10, SHL-19, N3-P1	32.9	27.2	5.7	4.92E-03	5.12E-03	14.3	14.0	0.3
Former Main	SHP-05-44, SHP-01-37X, PZ-12-01	358.0	359.5	-1.6	3.29E-03	3.41E-03	17.4	17.1	0.3
Former Main	SHM-11-06, SHP-05-43, SHP-05-44	354.8	12.7	-17.9	2.39E-03	3.68E-03	20.4	16.5	4.0
Former Main	SHP-05-44, SHP-05-43, SHP-01-36X	302.3	318.6	-16.3	2.97E-03	3.38E-03	18.4	17.2	1.1
Former Main	SHP-01-36X, SHP-05-43, N1-P1	340.6	313.6	27.0	4.94E-03	3.21E-03	14.2	17.7	-3.4
Former Main	N1-P1, SHP-05-43, SHL-21	339.0	320.2	18.7	5.65E-03	6.00E-03	13.3	12.9	0.4
Former Main	SHP-05-43, SHM-11-06, SHL-21	327.5	337.6	-10.1	5.17E-03	6.69E-03	13.9	12.2	1.7
Former Main	PZ-12-08, PZ-12-10, SHM-93-01A	24.0	23.2	0.8	7.99E-03	7.43E-03	11.2	11.6	-0.4
Former Main	SHL-18, SHL-3, N4-P1	18.8	18.7	0.1	8.95E-03	8.18E-03	10.6	11.1	-0.5

Table E.3

Three-Point Gradient Method – Magnitudes and Directions

Post	Definition Monitoring Wells	Estimated Direction (degrees)	Calculated Direction (degrees)	Direction Difference[1,3] (degrees)	Estimated Magnitude	Calculated Magnitude	Transformed[2] Estimated Magnitude	Transformed[2] Calculated Magnitude	Transformed Magnitude Residual[3]
Former Main	PZ-12-09, SHL-10, SHL-3	80.2	34.0	46.2	4.80E-03	6.46E-03	14.4	12.4	2.0
Former Main	PZ-12-10, SHM-93-01A, SHL-3	88.0	68.3	19.7	1.30E-02	8.68E-03	8.8	10.7	-1.9
Former Main	PZ-12-09, SHL-19, SHL-10	31.6	25.2	6.4	5.47E-03	7.18E-03	13.5	11.8	1.7
Former Main	SHL-19, PZ-12-07, SHL-4	301.3	332.9	-31.6	4.03E-03	5.61E-03	15.7	13.4	2.4
Former Main	SHM-11-07, PZ-12-06, SHM-10-07	30.3	19.8	10.4	4.79E-03	5.15E-03	14.5	13.9	0.5
Former Main	PZ-12-08, SHM-10-07, PZ-12-06	358.6	4.8	-6.2	6.19E-03	5.86E-03	12.7	13.1	-0.3
Former Main	SHL-4, PZ-12-05, SHP-01-38A	55.4	341.5	73.9	2.82E-03	2.19E-03	18.8	21.4	-2.5
Former Main	PZ-12-06, SHM-11-07, PZ-12-04	325.4	336.7	-11.4	1.74E-03	2.81E-03	24.0	18.9	5.1
Former Main	SHP-01-38A, PZ-12-03, SHL-11	302.9	56.9	-114.0	3.86E-04	5.92E-04	50.9	41.1	9.8
Former Main	SHL-8D, SHL-21, EPA-PZ-2012-2B	319.4	299.5	20.0	9.50E-03	5.26E-03	10.3	13.8	-3.5
Former Main	SHL-8D, SHP-05-47B, SHP-99-34A	357.0	14.9	-17.8	8.01E-03	8.02E-03	11.2	11.2	0.0
Former Main	SHL-13, SHP-05-47B, SHL-8D	346.7	348.3	-1.6	1.07E-02	1.37E-02	9.7	8.5	1.1
Former Main	SHL-13, SHL-21, SHL-8D	335.3	299.7	35.6	7.33E-03	5.20E-03	11.7	13.9	-2.2
Former Main	N1-P1, SHL-21, SHL-13	341.0	298.3	42.7	6.16E-03	4.49E-03	12.7	14.9	-2.2
Former Main	SHM-05-42A, SHM-05-41B, SHM-99-31C	337.9	336.3	1.7	7.49E-03	6.05E-03	11.6	12.9	-1.3
Former Main	SHM-99-32X, SHM-05-42A, SHM-99-31C	326.9	326.3	0.7	7.42E-03	6.02E-03	11.6	12.9	-1.3
Former Main	SHM-13-06, SHM-05-40X, SHM-07-03	277.2	279.4	-2.2	5.82E-03	5.75E-03	13.1	13.2	-0.1
Former Main	SHM-10-15, SHP-99-01B, SHP-99-29X	21.8	26.5	-4.6	6.82E-02	5.60E-02	3.8	4.2	-0.4
Former Main	SHM-10-12, SHP-99-01B, SHM-10-15	81.1	80.5	0.6	8.81E-02	7.32E-02	3.4	3.7	-0.3
Former Main	SHM-11-07, SHM-10-13, SHM-10-14	12.3	8.9	3.3	6.56E-03	6.52E-03	12.3	12.4	0.0
Former Main	SHM-11-07, SHM-10-14, SHM-11-06	6.8	3.0	3.8	4.03E-03	4.38E-03	15.8	15.1	0.7
Former Main	SHM-05-40X, SHM-13-08, SHM-13-05	342.6	324.0	18.5	4.18E-03	5.18E-03	15.5	13.9	1.6
Former Main	SHM-10-10, SHM-13-06, SHM-10-01	266.7	281.8	-15.2	2.43E-03	2.69E-03	20.3	19.3	1.0
Former Main	SHM-10-01, SHM-13-06, SHM-07-03	310.8	311.0	-0.2	3.94E-03	4.06E-03	15.9	15.7	0.2
Former Main	SHL-12, SHL-17, 32Z-99-02X	349.3	359.9	-10.6	1.61E-02	1.38E-02	7.9	8.5	-0.6
Former Main	SHL-12, SHL-17, N7-P2	346.3	19.4	-33.0	3.65E-03	4.75E-03	16.6	14.5	2.1
Former North	G6M-02-06X, XSA-12-95X, G6M-04-07X	302.2	247.0	55.2	1.57E-02	2.48E-03	8.0	20.1	-12.1
Former North	G6M-18-01, G6M-18-02, 31PZ-19-01	294.5	279.6	14.9	4.73E-03	3.12E-03	14.5	17.9	-3.4
Former North	G6M-13-01X, G6M-03-10X, G6M-97-05B	210.2	244.8	-34.6	1.12E-02	2.49E-03	9.4	20.0	-10.6
Former North	XSA-12-95X, G6M-97-05B, G6M-03-10X	212.3	240.5	-28.2	4.93E-03	2.78E-03	14.2	19.0	-4.7
Former North	G6M-18-02, G6M-02-07X, 31PZ-19-01	310.9	285.3	25.6	3.21E-03	2.24E-03	17.7	21.2	-3.5
Former North	31PZ-19-01, G6M-02-07X, 31PZ-19-02S	316.3	272.1	44.1	1.51E-03	1.42E-03	25.8	26.5	-0.8
Former North	G6M-04-01X, G6M-04-03X, G6M-02-01X	244.7	247.2	-2.5	4.28E-03	4.17E-03	15.3	15.5	-0.2
Former North	G6M-04-22X, G6M-04-01X, G6M-04-11X	214.2	228.1	-13.9	4.86E-03	4.15E-03	14.3	15.5	-1.2
Former North	G6M-95-19X, G6M-03-01X, G6M-96-22A	241.7	207.7	34.0	1.90E-02	7.39E-03	7.3	11.6	-4.4
Former North	G6M-95-20X, G6M-04-10X, G6M-95-19X	217.3	230.0	-12.7	1.85E-02	5.21E-03	7.3	13.9	-6.5
Former North	G6M-95-19X, G6M-96-22A, G6M-95-20X	221.9	221.0	0.9	1.29E-02	8.44E-03	8.8	10.9	-2.1

Table E.3

Three-Point Gradient Method – Magnitudes and Directions

Post	Definition Monitoring Wells	Estimated Direction (degrees)	Calculated Direction (degrees)	Direction Difference[1,3] (degrees)	Estimated Magnitude	Calculated Magnitude	Transformed[2] Estimated Magnitude	Transformed[2] Calculated Magnitude	Transformed Magnitude Residual[3]
Former North	G6M-95-19X, G6M-04-10X, G6M-03-01X	229.6	224.5	5.1	2.21E-02	4.76E-03	6.7	14.5	-7.8
Former North	G6M-04-22X, G6M-04-11X, G6M-13-05X	220.8	226.8	-6.0	6.57E-03	3.69E-03	12.3	16.5	-4.1
Former North	30PZ-19-02, 30PZ-19-03, 30PZ-19-01	256.9	256.7	0.2	7.06E-03	6.63E-03	11.9	12.3	-0.4
Former North	30PZ-19-02, 30PZ-19-04, 30PZ-19-03	291.4	289.0	2.4	5.60E-03	5.27E-03	13.4	13.8	-0.4
Former North	30PZ-19-05, 30PZ-19-02, 30PZ-19-01	259.3	259.1	0.2	1.11E-02	1.02E-02	9.5	9.9	-0.4
Former North	31PZ-19-01, 31PZ-19-02D, 50PZ-19-07	336.0	304.3	31.7	1.71E-03	1.71E-03	24.2	24.2	0.0
Former North	MW-7_(IT), 50PZ-19-02, 30PZ-19-02	226.4	225.5	0.9	5.87E-03	6.01E-03	13.1	12.9	0.2
Former North	30PZ-19-02, G6M-18-01, 30PZ-19-04	274.2	269.8	4.4	5.16E-03	4.90E-03	13.9	14.3	-0.4
Former North	31PZ-19-01, 50PZ-19-07, 30PZ-19-04	276.2	279.4	-3.1	3.64E-03	2.74E-03	16.6	19.1	-2.5
Former North	G6M-18-01, 31PZ-19-01, 30PZ-19-04	277.6	279.9	-2.3	4.48E-03	3.13E-03	14.9	17.9	-2.9
Former North	50PZ-19-01, 50PZ-19-02, MW-7_(IT)	219.6	212.6	7.0	5.10E-03	4.76E-03	14.0	14.5	-0.5
Former North	50PZ-19-05, 50PZ-19-06, 50PZ-19-04	246.0	251.0	-5.0	6.44E-03	6.01E-03	12.5	12.9	-0.4

Notes:

[1] For calibration purposes the residual difference was calculated as the square root of the absolute value of the direction difference. The untransformed difference is tabulated here.

[2] Magnitude values were transformed for calibration purposes.
Transformation: square root of the reciprocal $\sqrt{\frac{1}{magnitude}}$

[3] The difference or residual value is calculated as the corresponding Estimated Value - Calculated Value.

Table E.4

Head Differences Across the Barrier Wall

Piezometer 1	Piezometer 2	Target Water Level Piezometer 1 (feet/MSL)	Target Water Level Piezometer 2 (feet/MSL)	Target Difference (feet)	Calculated Water Level Piezometer 1 (feet/MSL)	Calculated Water Level Piezometer 2 (feet/MSL)	Calculated Difference (feet)	Residual[1] (feet)
PZ-12-02	PZ-12-01	217.3	216.8	0.44	217.4	216.5	0.53	-0.09
PZ-12-04	PZ-12-03	217.9	216.8	1.12	217.8	216.6	0.99	0.13
PZ-12-06	PZ-12-05	218.1	217.1	0.96	218.1	216.7	0.96	0.003
PZ-12-08	PZ-12-07	218.8	217.1	1.74	218.7	217.2	1.64	0.10
PZ-12-10	PZ-12-09	219.6	217.9	1.66	219.5	218.3	1.53	0.13

Note:

[1] Residual is calculated as Target Difference - Calculated Difference.

Table E.5a

Soft Target Types - Surface Water Levels, Staff Gages and LIDAR Based

Surface Water Levels - Staff Gages					
Location	**Easting**	**Northing**	**Target Stage (feet/MSL)**	**Calculated Stage (feet/MSL)**	**Residual[1]**
SG-GP	634260.6	3026110.9	217.3	216.7	0.6
Staff_1	630628.0	3027223.0	216.5	216.3	0.2
SWEL-104	631343.6	3026803.0	216.1	216.3	-0.2
SWEL-105	626227.1	3027437.5	203.5	203.2	0.3
SWEL-106	630639.8	3028173.6	216.1	216.0	0.0
SWEL-107	630578.0	3028240.0	211.8	210.6	1.3
SWEL-108	630303.3	3028573.5	211.4	209.6	1.9
SWEL-109	629992.6	3028591.5	211.9	210.6	1.3
SWEL-110	630091.0	3029100.0	208.1	207.9	0.2
SWEL-111	630000.0	3029360.0	207.9	207.7	0.2
SWEL-112	628297.0	3028320.0	204.7	204.6	0.1
SWEL-16	627192.9	3025167.0	219.2	218.4	0.8
26M-14-SWEL1	614017.8	3008904.6	281.9	278.9	3.0
26M-14-SWEL2	614288.1	3008340.4	282.0	282.5	-0.5
26SWEL-17-01	613956.4	3008959.3	278.6	277.2	1.5
26SWEL-17-02	614309.5	3008598.4	282.2	281.5	0.7
SWEL-12	620746.2	3005451.1	225.3	219.9	5.5
SWEL-13	613870.3	2996919.9	237.2	236.4	0.8
CPSG-01swel	627621.7	3018744.8	244.1	244.5	-0.4
CPSG-02swel	629358.3	3018918.8	242.8	242.6	0.3
CSBSG-01swel	630022.5	3019399.0	234.5	233.1	1.3
MLSG-01swel	625779.1	3016884.8	241.6	240.2	1.4
RPSG-01swel	627951.3	3021370.2	244.6	243.4	1.2
SHSG-14-01Gswel	630568.5	3028212.9	210.5	210.6	0.0

Surface Water Levels - LIDAR Based						
Location	**Easting**	**Northing**	**Target Stage (feet/MSL)**	**Calculated Stage (feet/MSL)**	**Residual[1]**	**Description**
LIDAR01	629202.1	3018876.8	243.0	243.1	-0.1	Headwaters of Cold Spring Brook
OakHWLND	609571.6	3009282.2	371.0	370.0	1.0	Mapped wetland east of Oak Hill Pond
LIDAR10	621018.8	3016918.6	289.0	289.6	-0.6	Mapped water body west of Mirror Lake
LIDAR08	620972.8	3017758.7	314.3	315.9	-1.6	Mapped wetland west of Mirror Lake
LIDAR09	621893.5	3019446.4	347.7	349.8	-2.1	Mapped wetland west of Mirror Lake

Note:

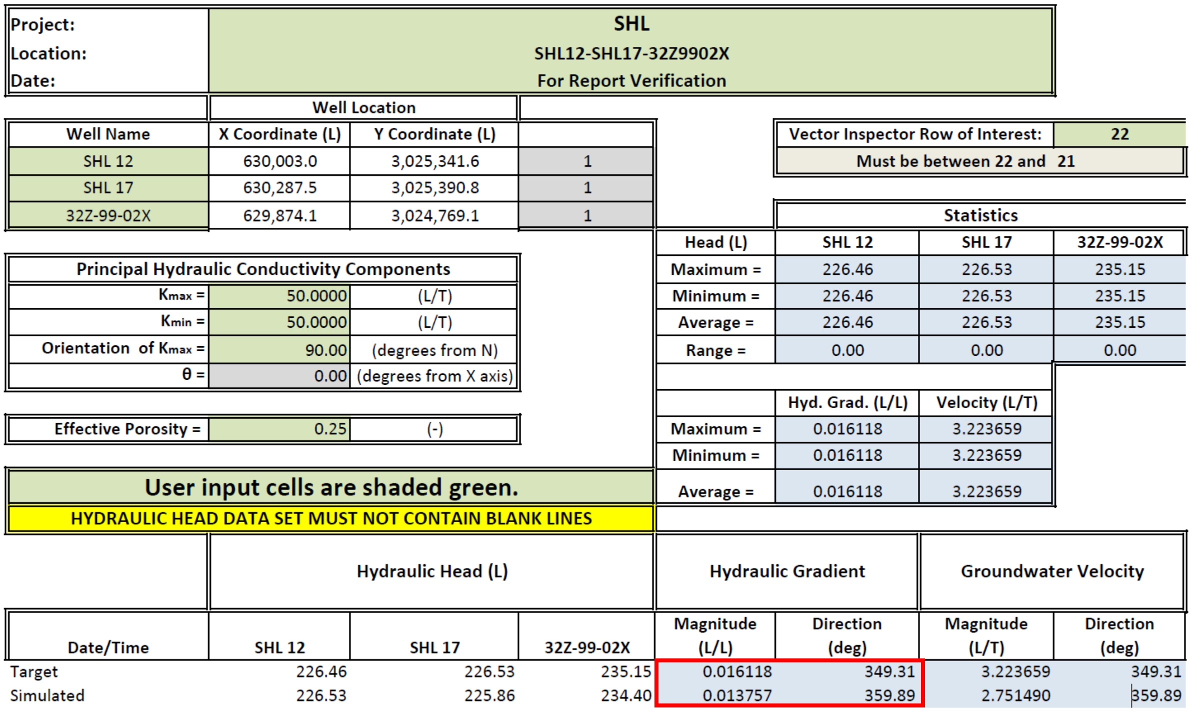
[1] Residual is calculated as Target Stage - Calculated Stage.

Table E.5b

Soft Target Types – Estimated Hydraulic Conductivity and Pumping Rate Reductions

Hydraulic Conductivity Constraint		
Short Name	**Estimated Hydraulic Conductivity (feet/day)**	**Model Hydraulic Conductivity (feet/day)**
Shabokin_Inactive	274.8	271.0
Shabokin Well	267.4	263.4
MacPherson Well	406.3	361.7
Patton Well	271.7	258.3
Grove Pond Well #1	327.1	308.6
Grove Pond Well #2	325.5	331.2
Grove Pond Well #6	328.4	336.4
Grove Pond Well #7	332.6	313.6
Grove Pond Well #8	327.9	317.3
EW-01	28.5	36.3
EW-04	32.2	29.1

Pumping Rate Reductions			
Short Name	**Specified Pumping Rate (gpm)**	**Actual Model Rate (gpm)**	**Rate Reduction**
Walker Well	94.1	92.6	2%
MCI Shirley GP Well 1	94.7	0.0	100%
MCI Shirley GP Well 2	66.6	18.6	72%
Primrose Car Wash	40.0	22.0	45%



Project:	SHL
Location:	SHL12-SHL17-32Z9902X
Date:	For Report Verification

	Well Location		
Well Name	X Coordinate (L)	Y Coordinate (L)	
SHL 12	630,003.0	3,025,341.6	1
SHL 17	630,287.5	3,025,390.8	1
32Z-99-02X	629,874.1	3,024,769.1	1

Vector Inspector Row of Interest:	22
Must be between 22 and 21	

Principal Hydraulic Conductivity Components		
K_{max} =	50.0000	(L/T)
K_{min} =	50.0000	(L/T)
Orientation of K_{max} =	90.00	(degrees from N)
θ =	0.00	(degrees from X axis)

Effective Porosity =	0.25	(-)

	Statistics		
Head (L)	SHL 12	SHL 17	32Z-99-02X
Maximum =	226.46	226.53	235.15
Minimum =	226.46	226.53	235.15
Average =	226.46	226.53	235.15
Range =	0.00	0.00	0.00

	Hyd. Grad. (L/L)	Velocity (L/T)
Maximum =	0.016118	3.223659
Minimum =	0.016118	3.223659
Average =	0.016118	3.223659

User input cells are shaded green.

HYDRAULIC HEAD DATA SET MUST NOT CONTAIN BLANK LINES

	Hydraulic Head (L)			Hydraulic Gradient		Groundwater Velocity	
Date/Time	SHL 12	SHL 17	32Z-99-02X	Magnitude (L/L)	Direction (deg)	Magnitude (L/T)	Direction (deg)
Target	226.46	226.53	235.15	0.016118	349.31	3.223659	349.31
Simulated	226.53	225.86	234.40	0.013757	359.89	2.751490	359.89

Figure E.1 Output from the USEPA 3PE Tool with the Calculated Magnitude and Direction for an Example Well Triad

Appendix F

Maps of Hydraulic Conductivity and Bedrock Thickness Scalar

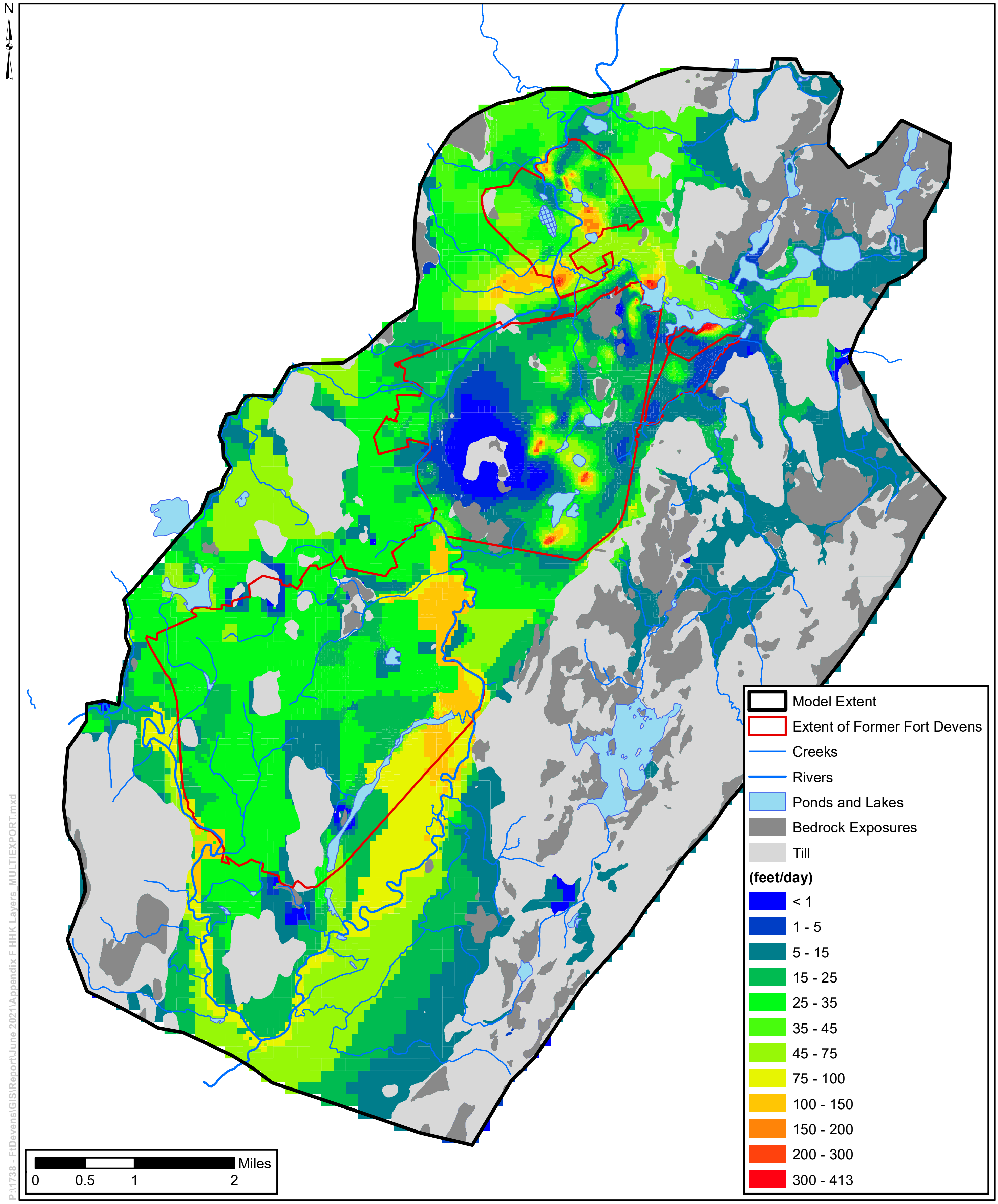


Figure F.1 Horizontal Hydraulic Conductivity - Overburden

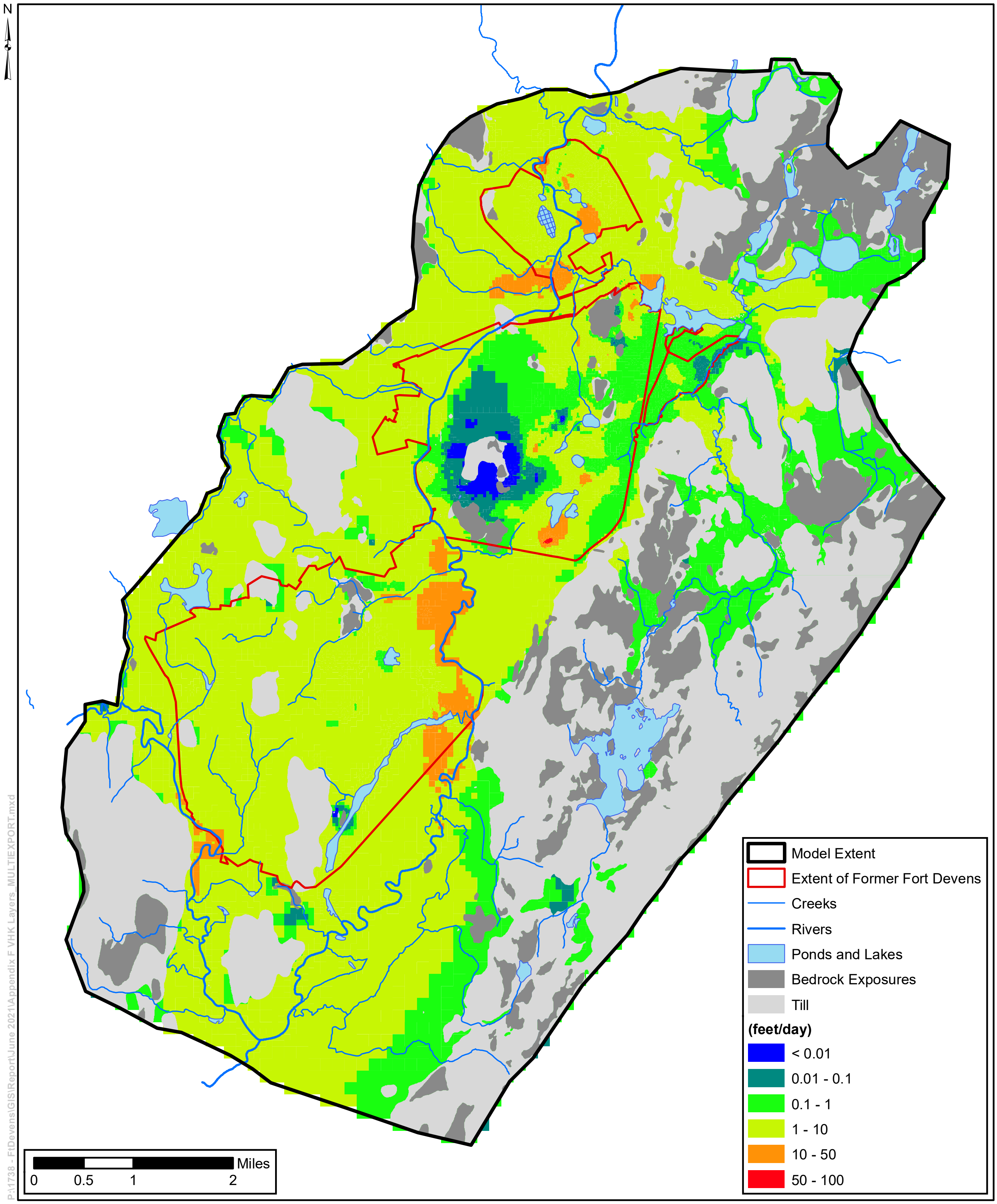


Figure F.2 Vertical Hydraulic Conductivity - Overburden

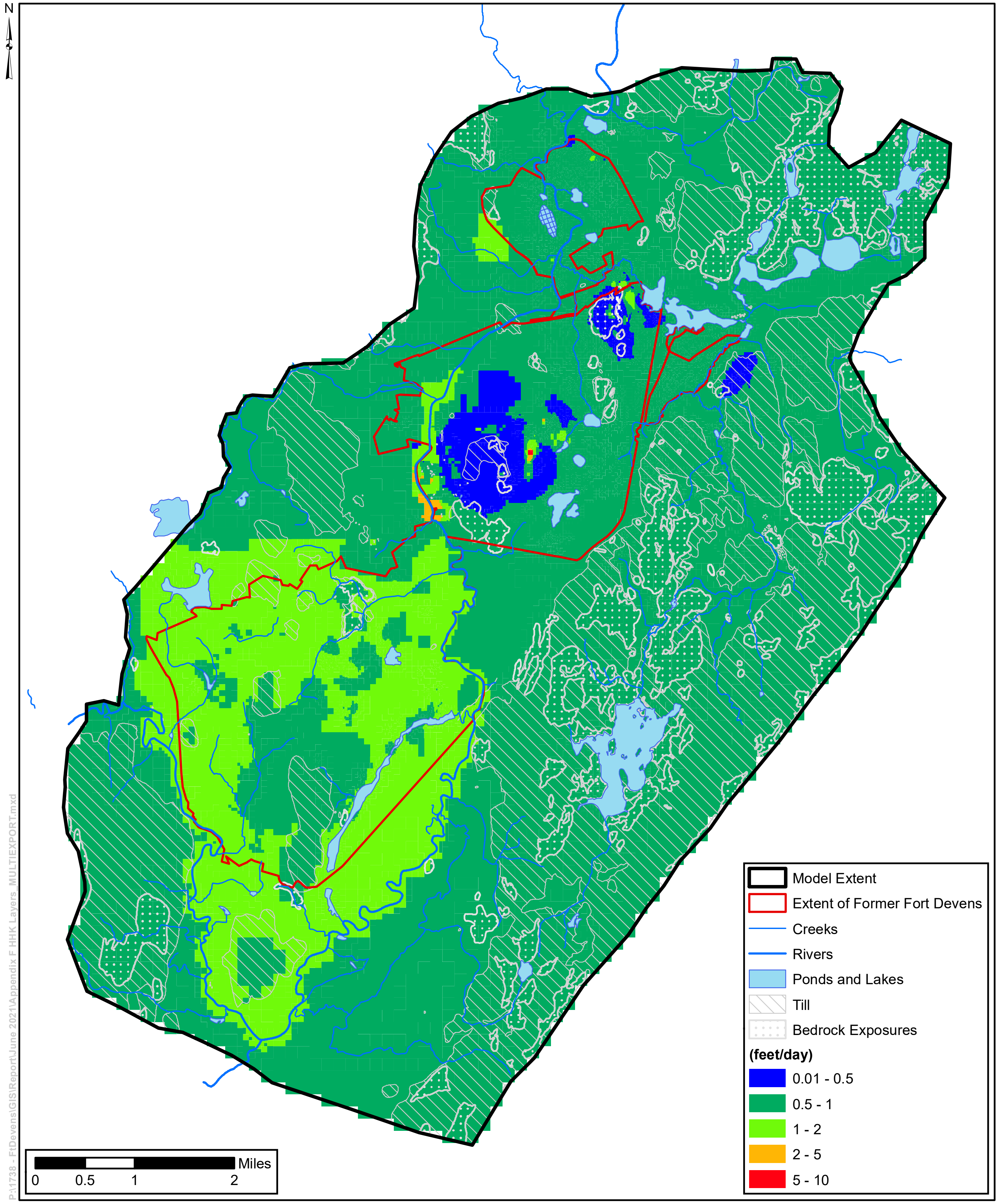


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Figure F.3 Horizontal Hydraulic Conductivity - Upper Bedrock

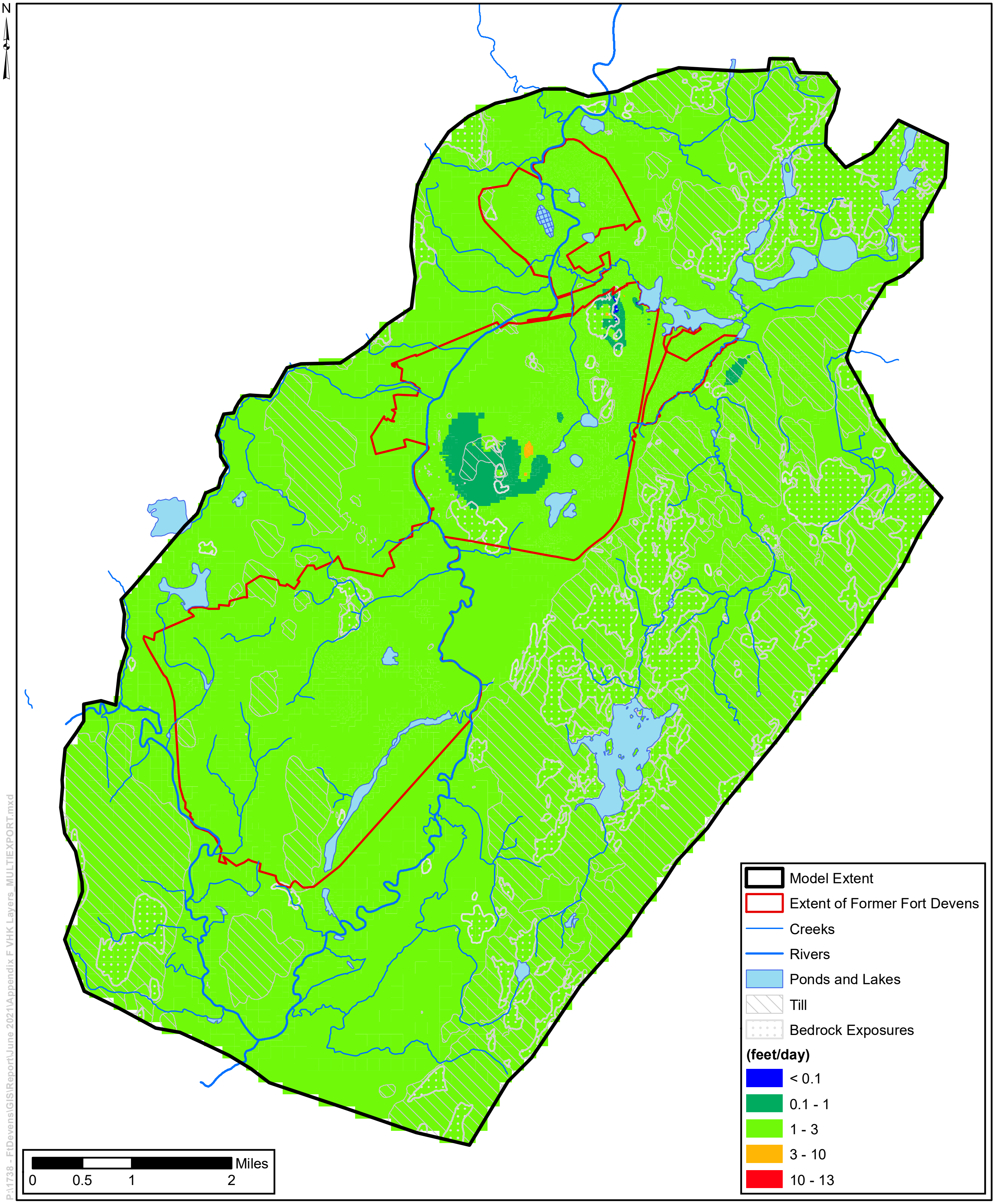

Figure F.4 Vertical Hydraulic Conductivity - Upper Bedrock

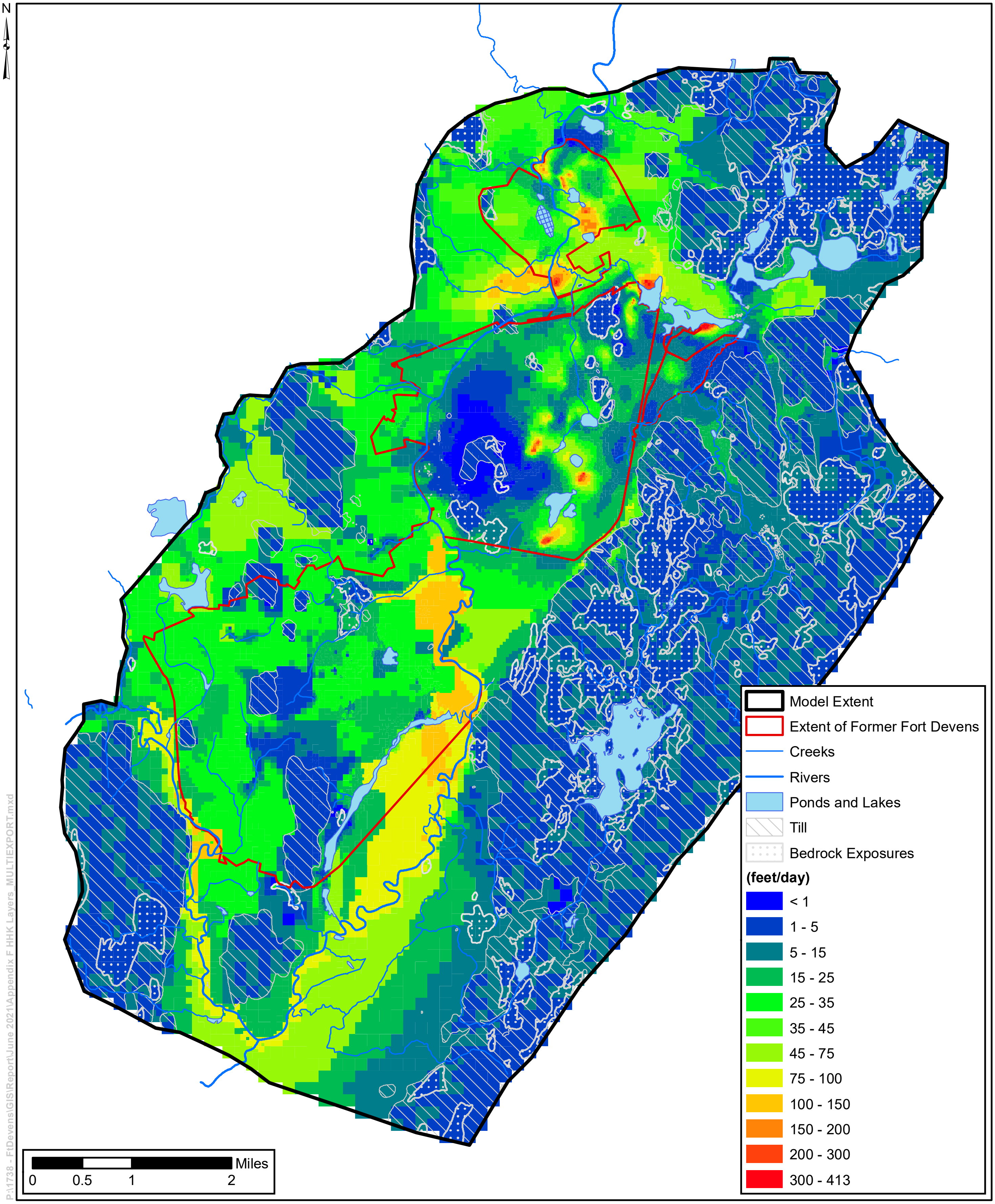

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Figure F.5 Horizontal Hydraulic Conductivity - Model Layer 1

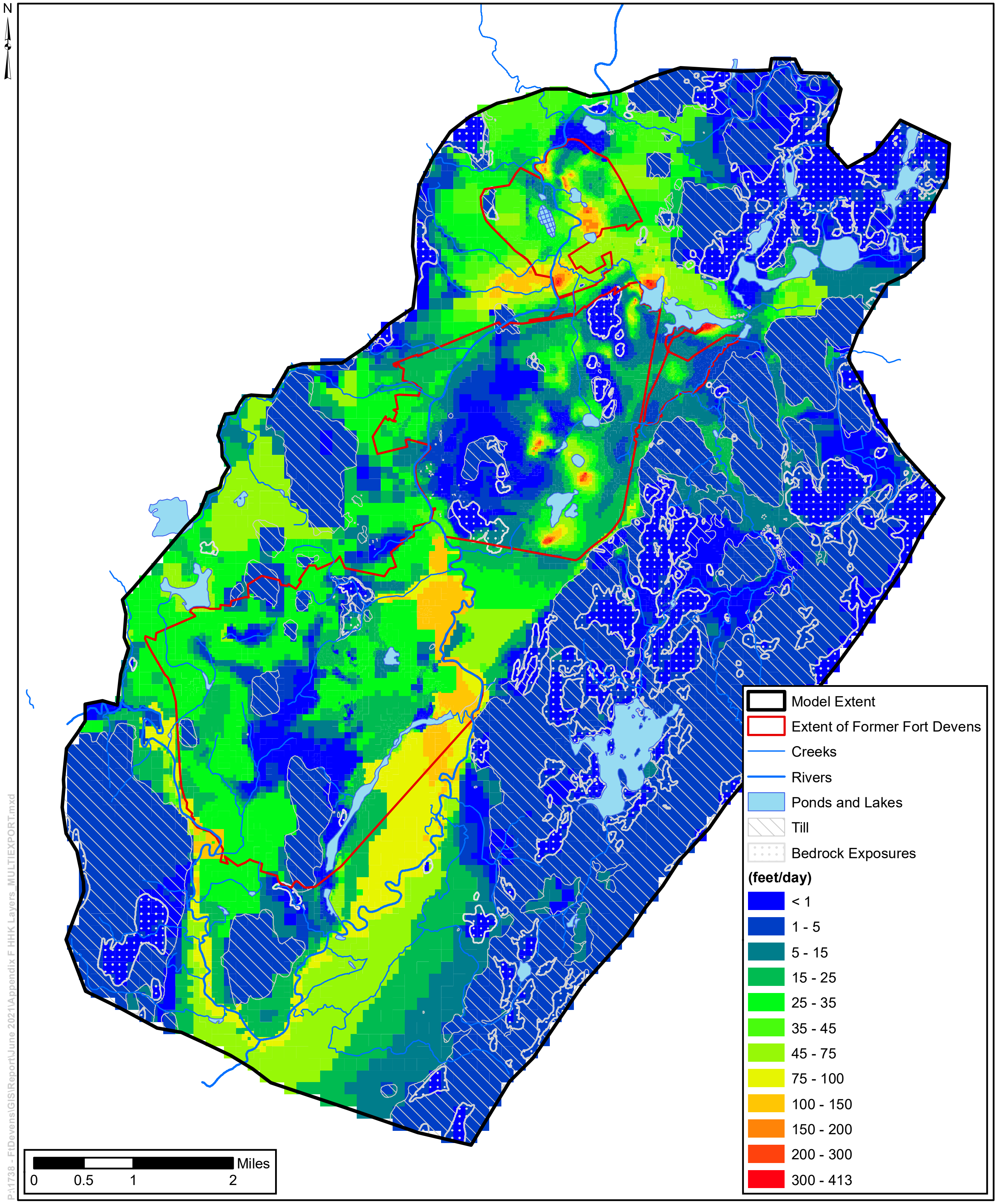

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Figure F.6 Horizontal Hydraulic Conductivity - Model Layer 2

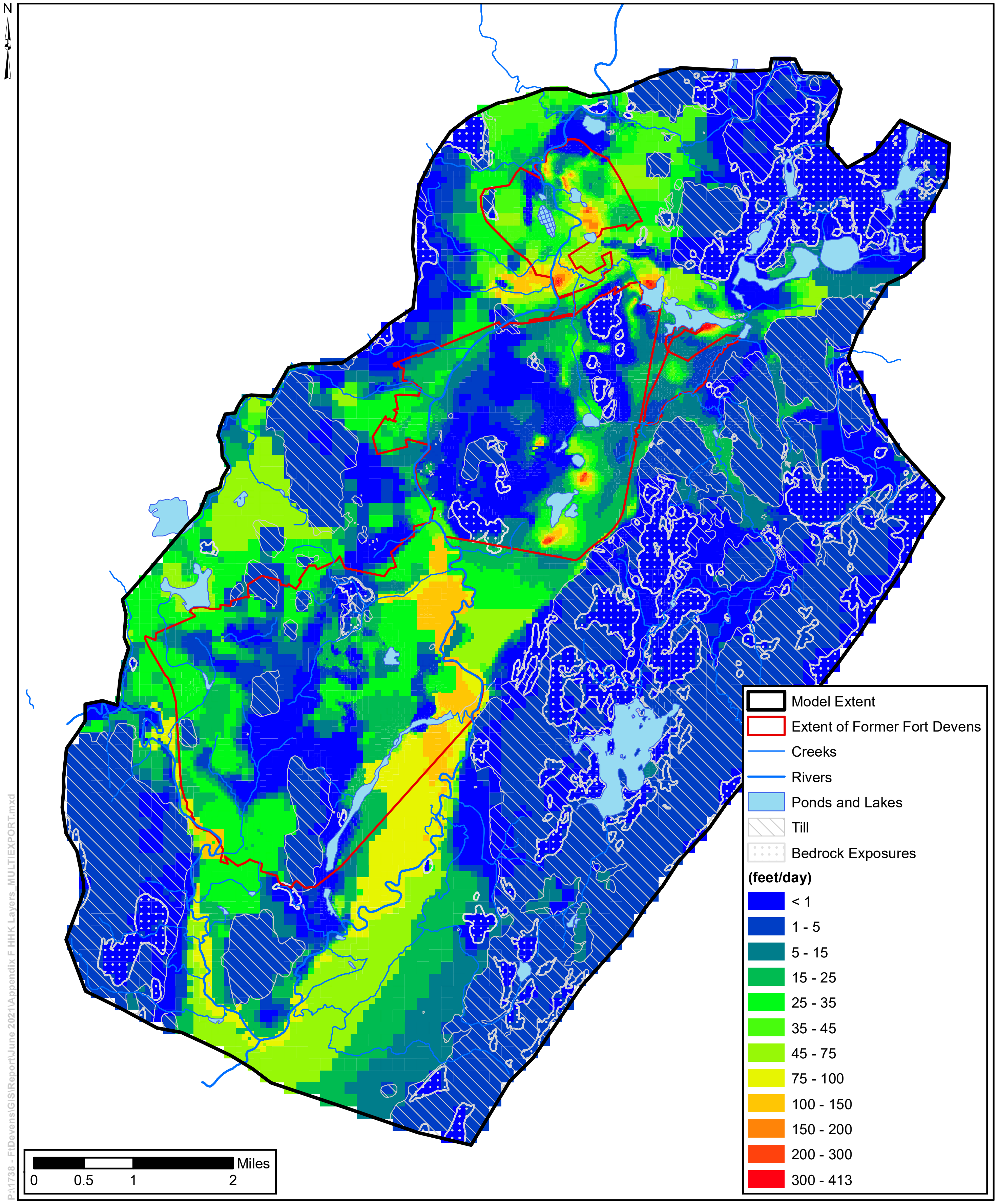

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Figure F.7 Horizontal Hydraulic Conductivity - Model Layer 3

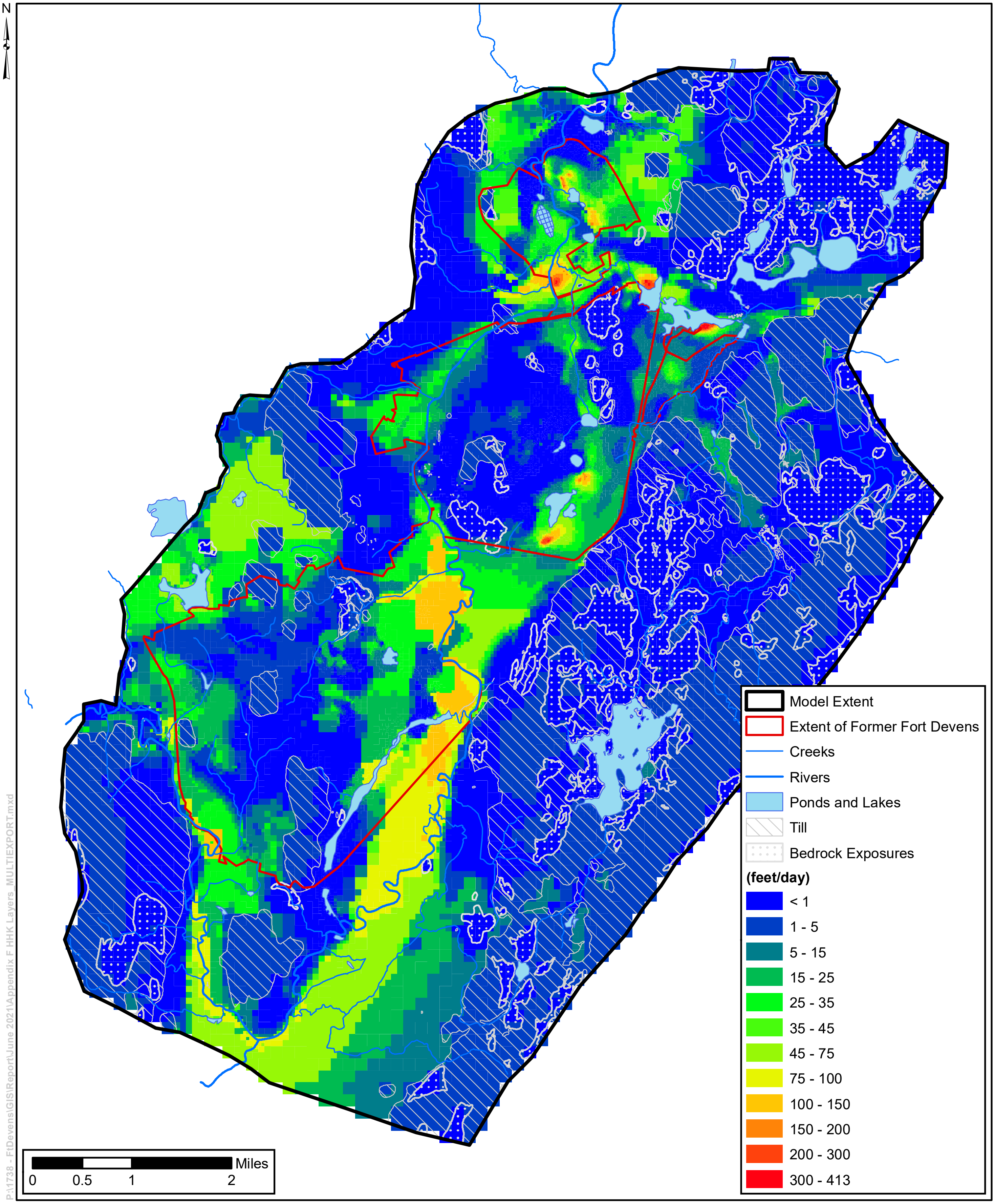

Figure F.8 Horizontal Hydraulic Conductivity - Model Layer 4

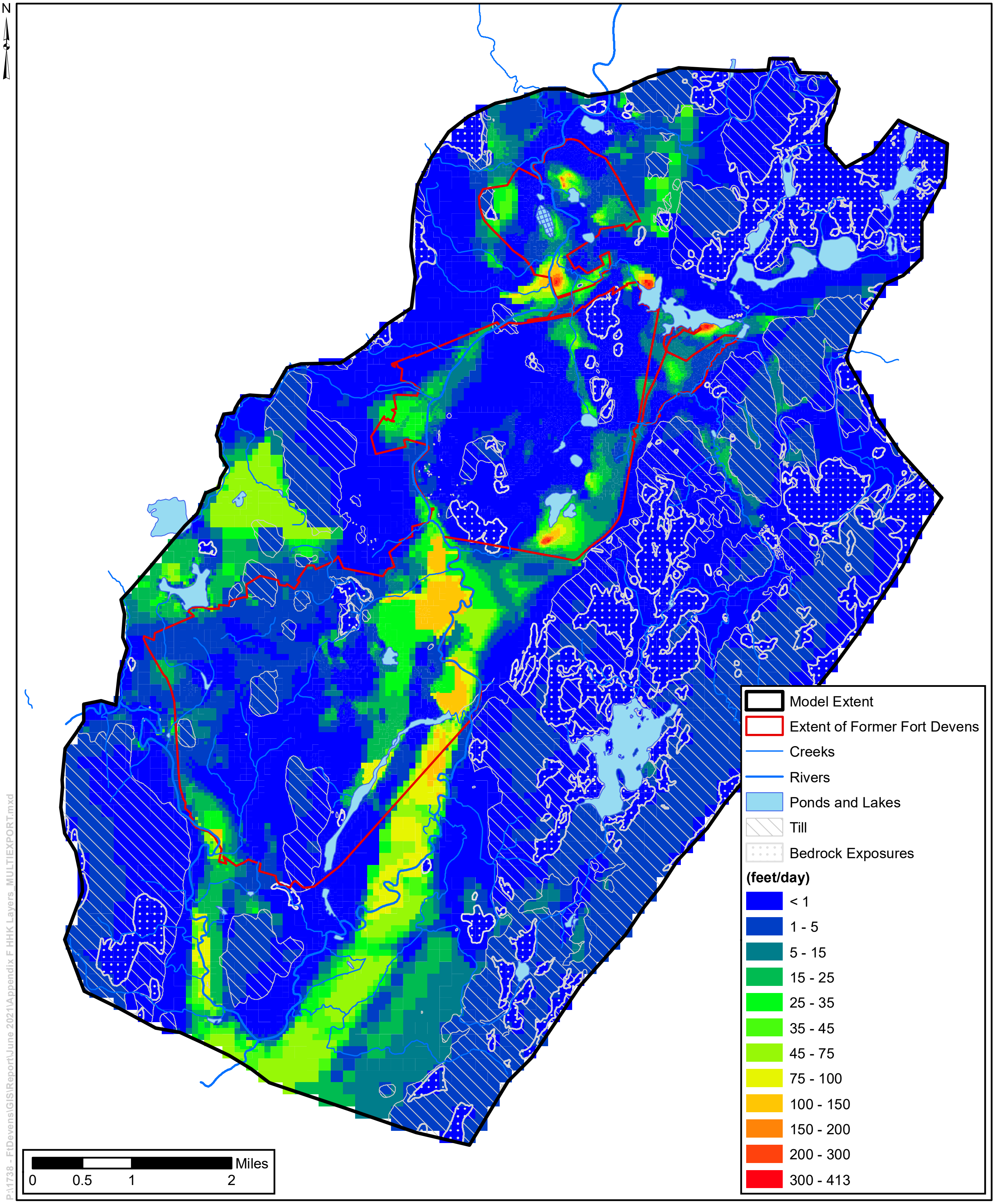

Figure F.9 Horizontal Hydraulic Conductivity - Model Layer 5

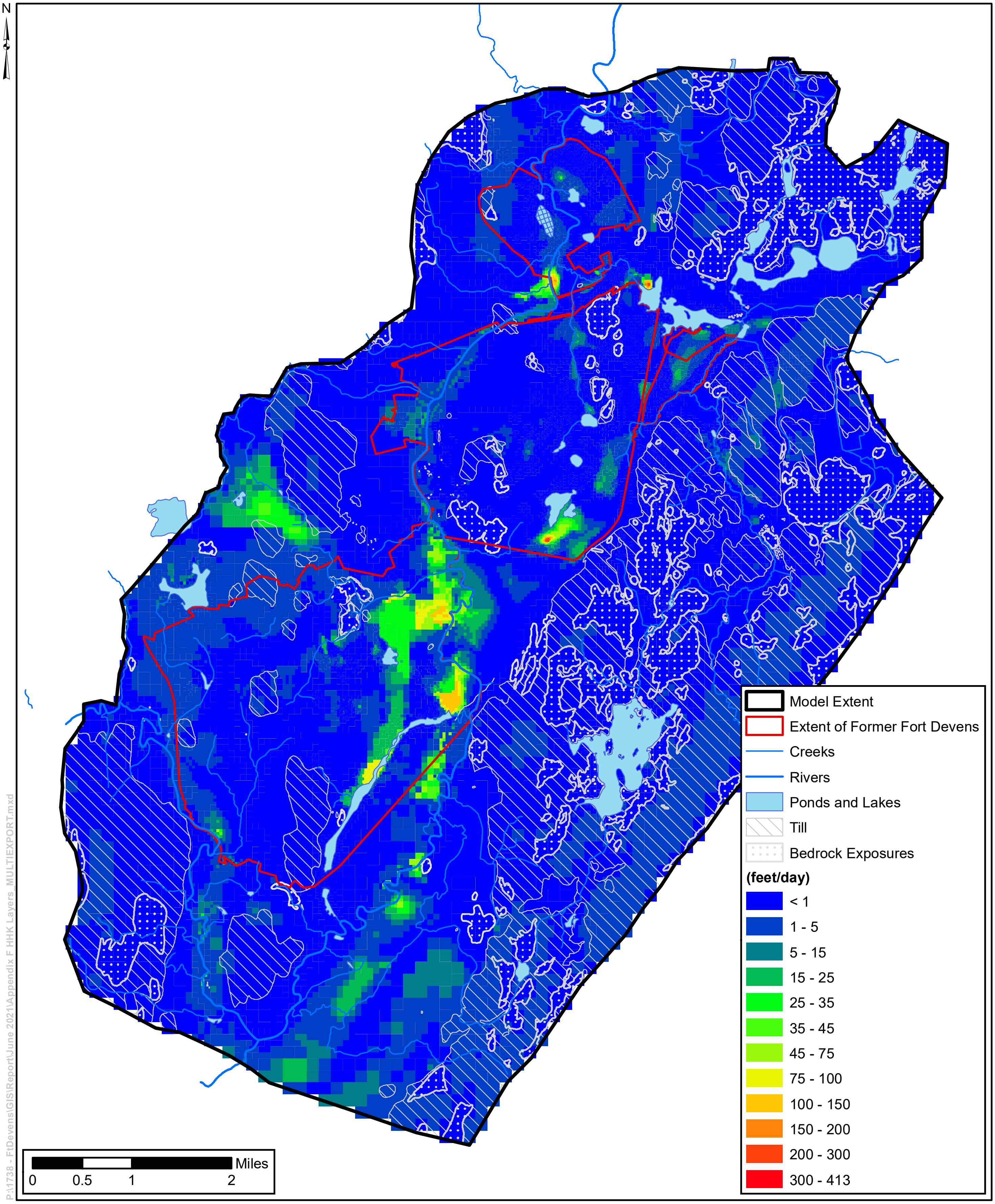

Figure F.10 Horizontal Hydraulic Conductivity - Model Layer 6

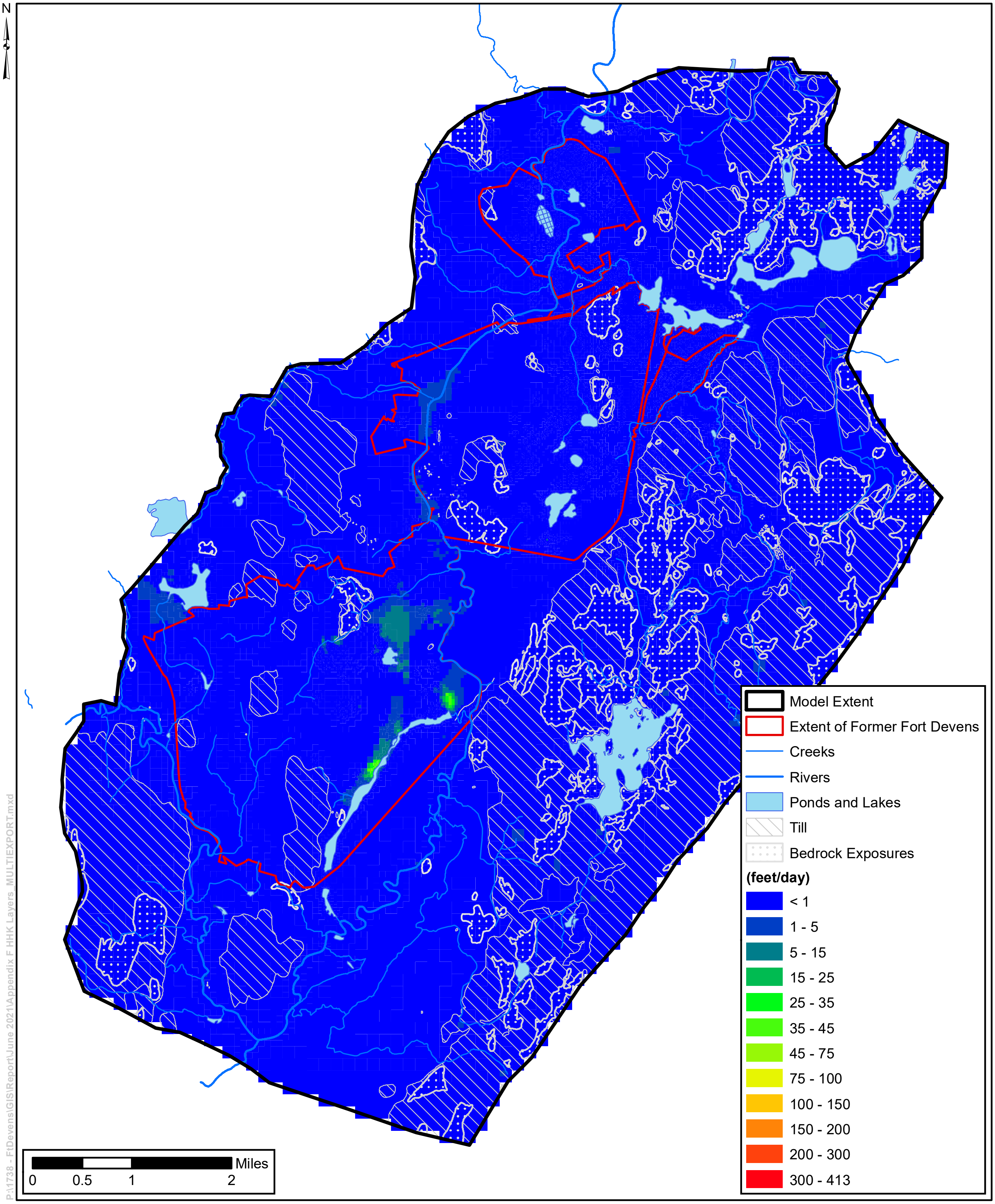

Figure F.11 Horizontal Hydraulic Conductivity - Model Layer 7

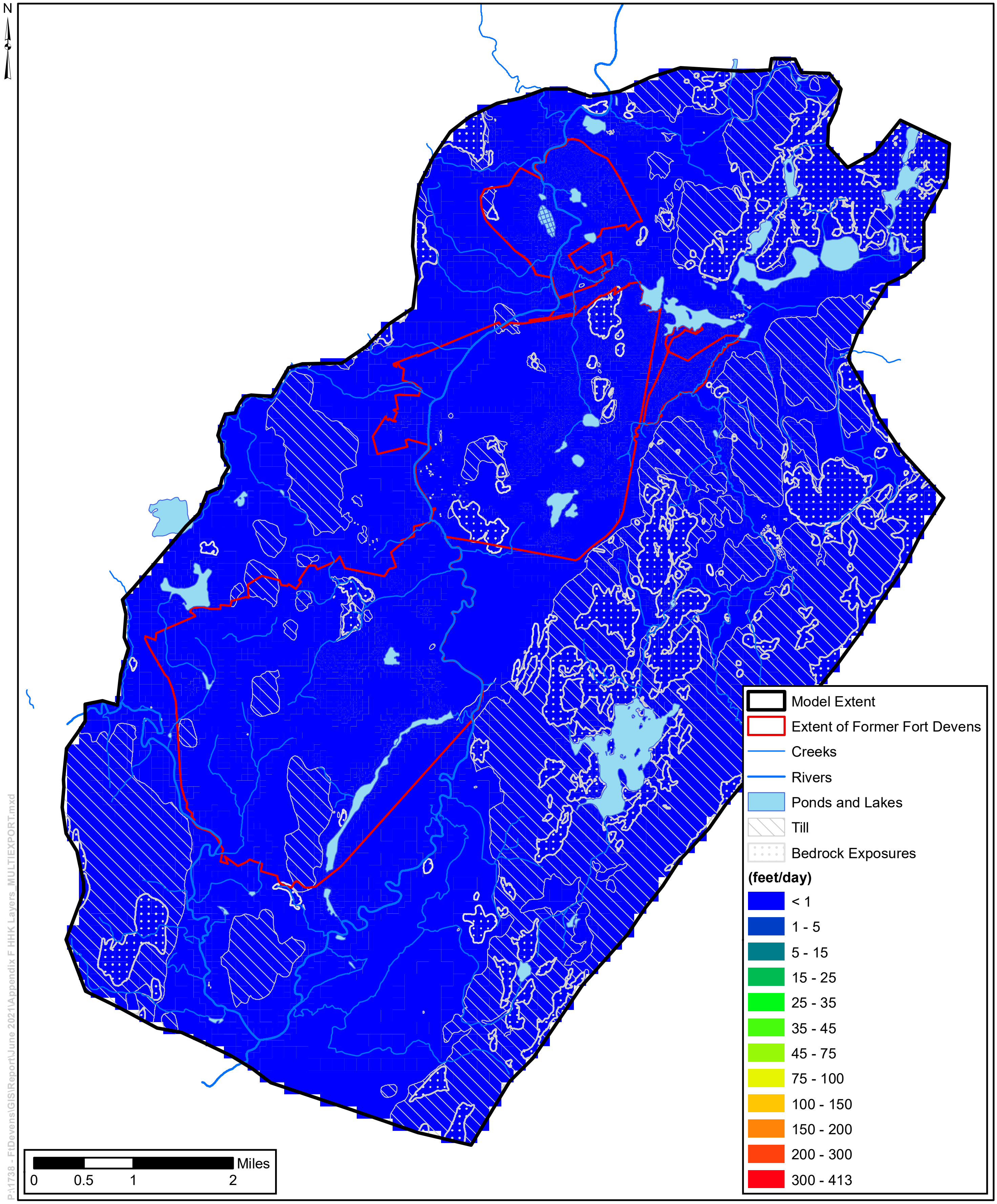

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Figure F.12 Horizontal Hydraulic Conductivity - Model Layer 8

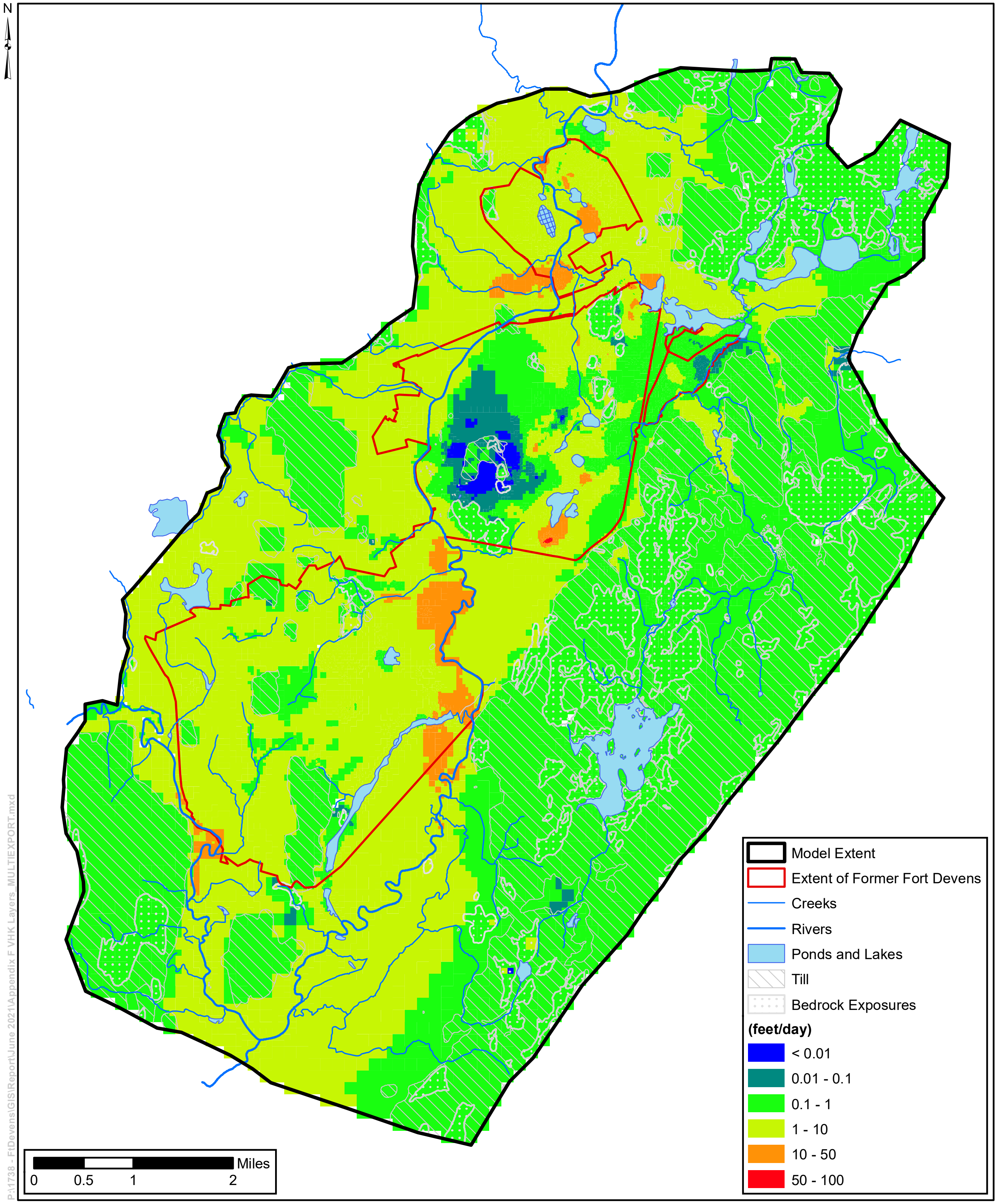

Figure F.13 Vertical Hydraulic Conductivity - Model Layer 1

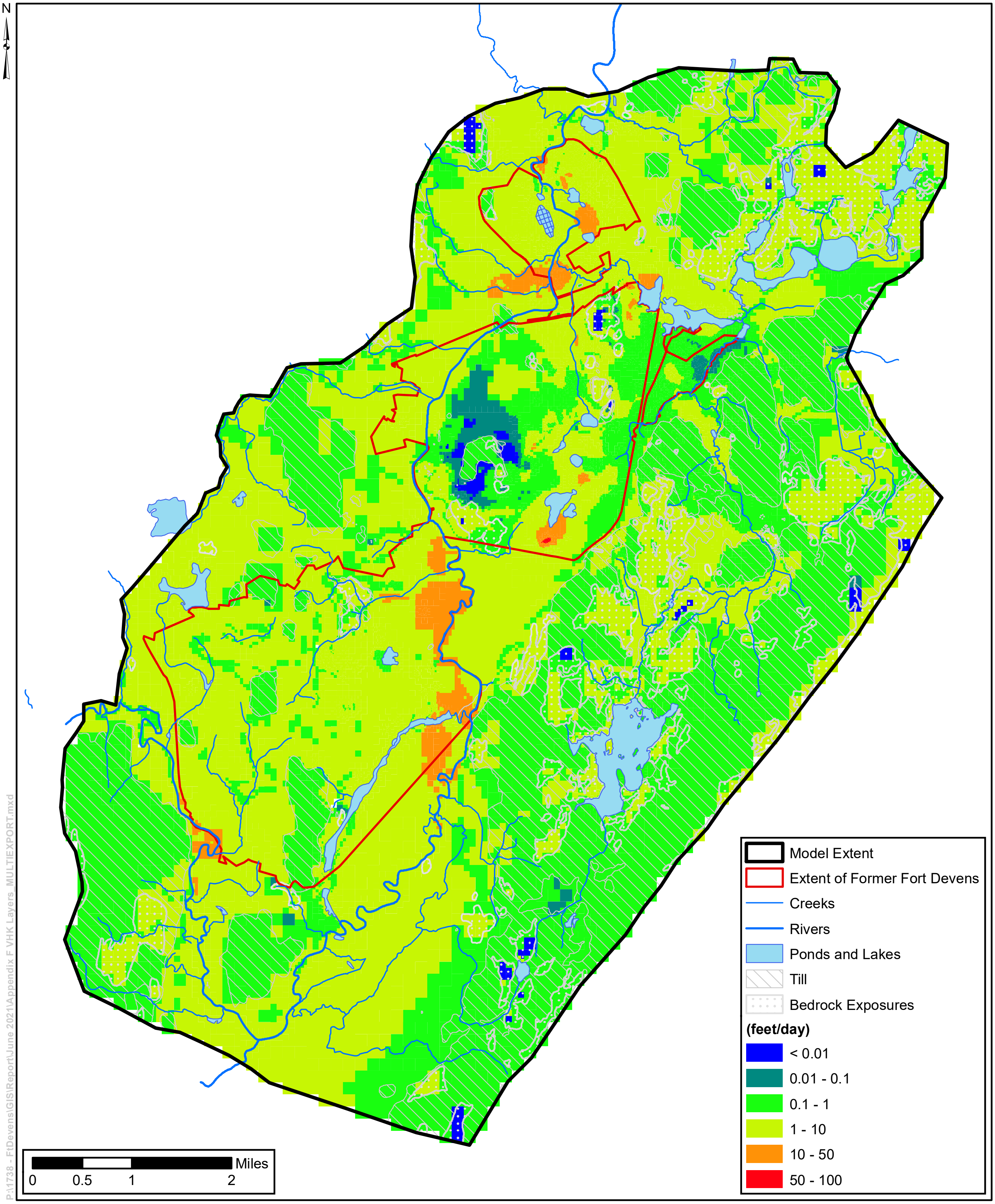

Figure F.14 Vertical Hydraulic Conductivity - Model Layer 2

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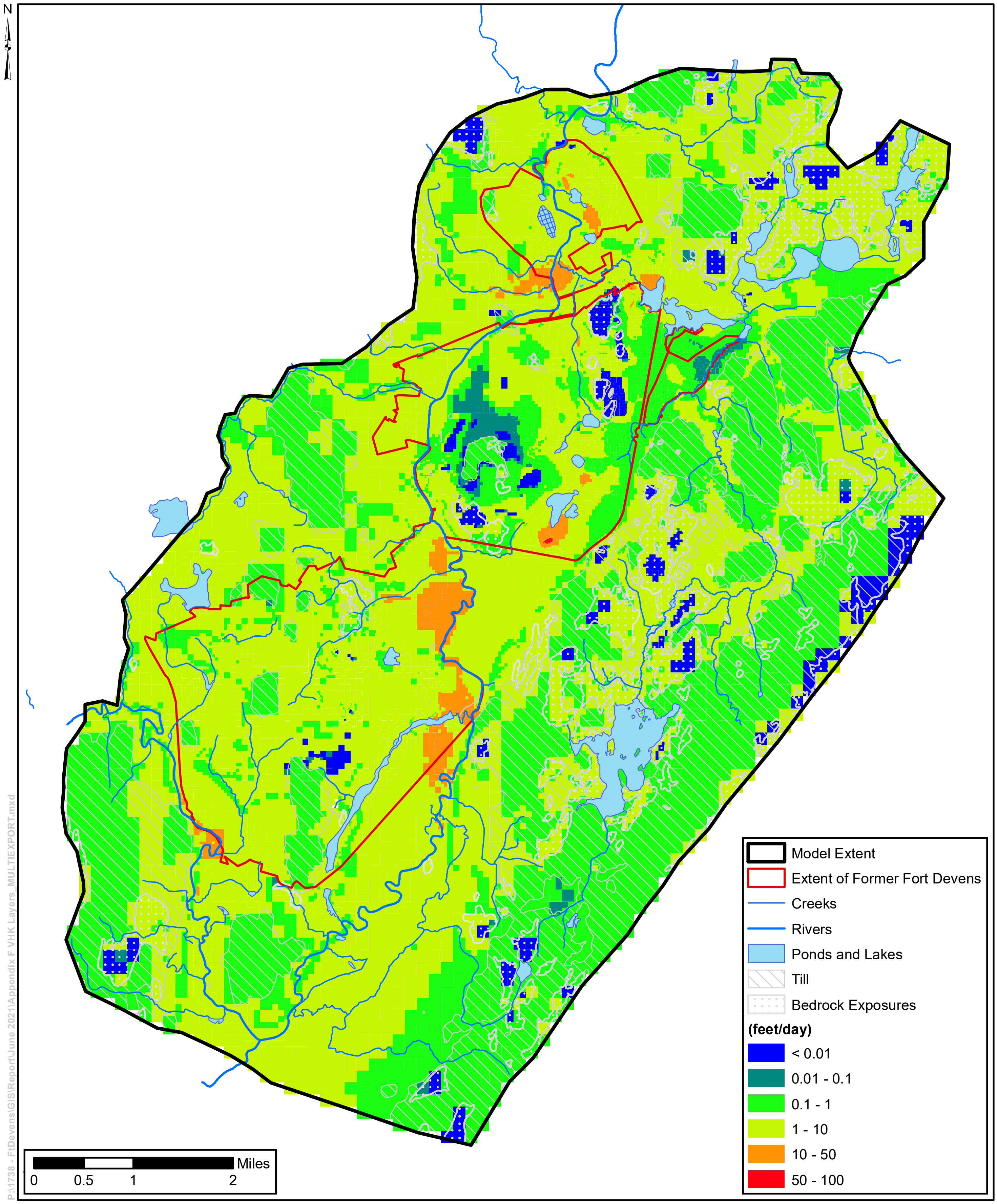

Figure F.15 Vertical Hydraulic Conductivity - Model Layer 3

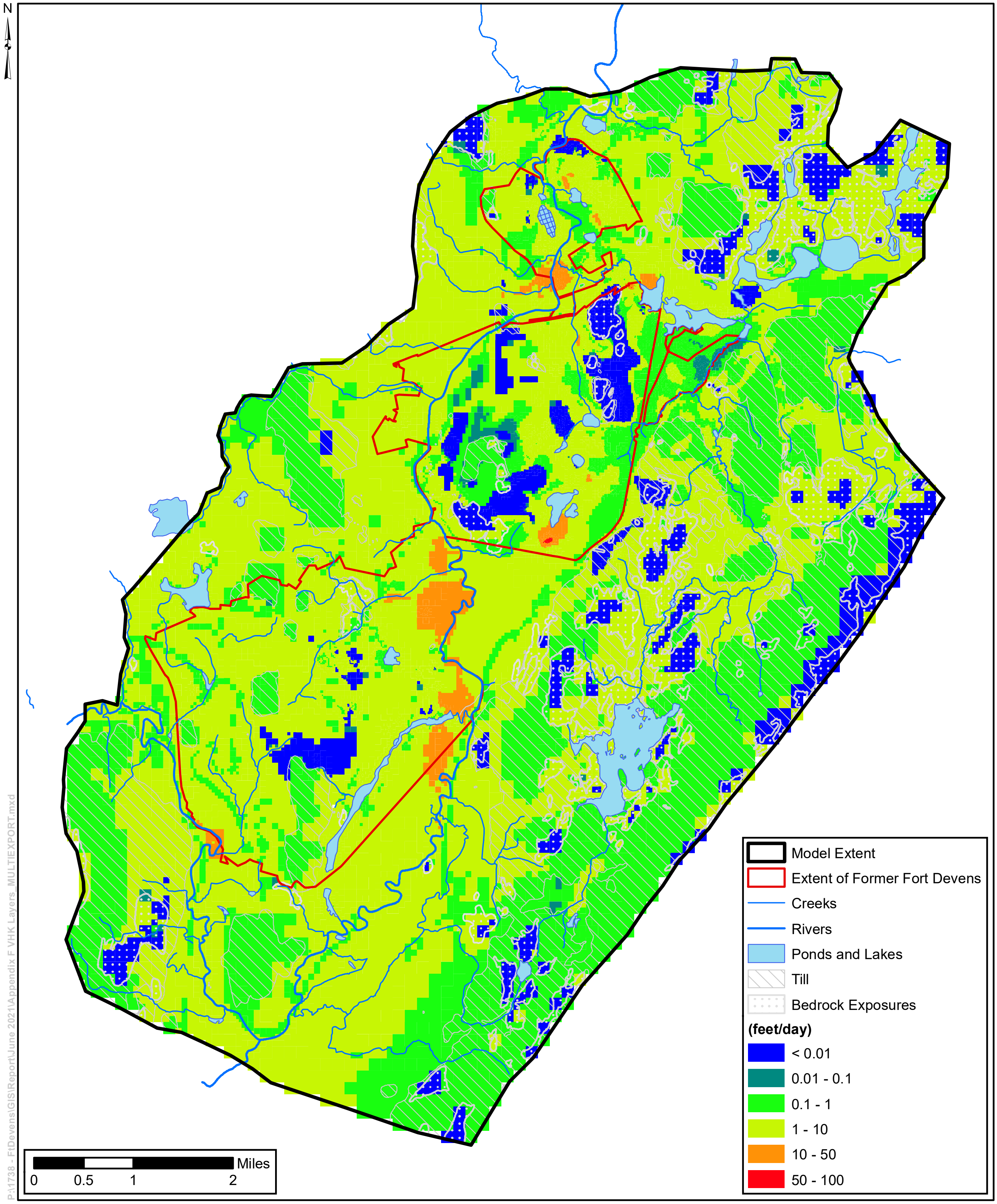

Figure F.16 Vertical Hydraulic Conductivity - Model Layer 4

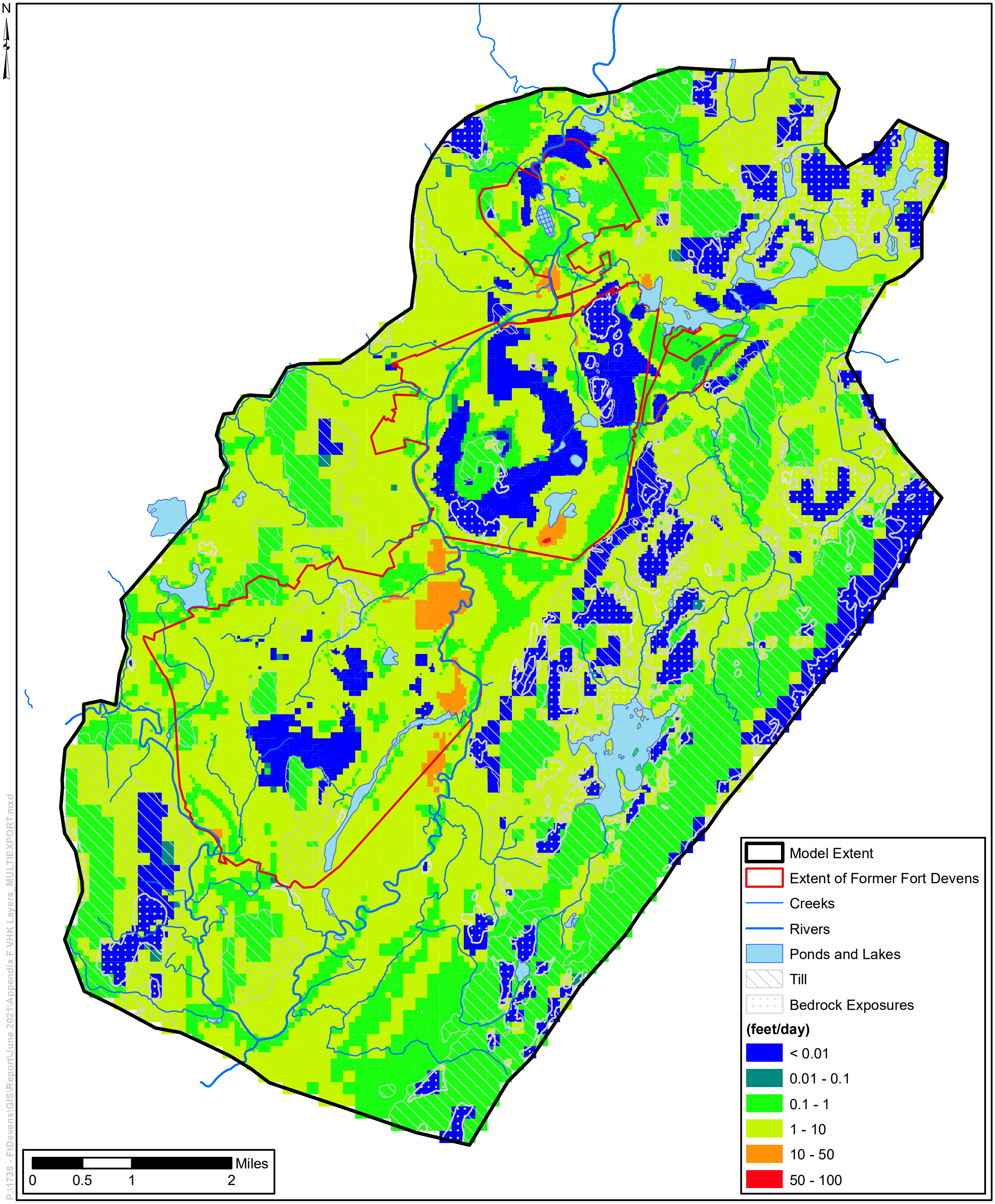

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Figure F.17 Vertical Hydraulic Conductivity - Model Layer 5

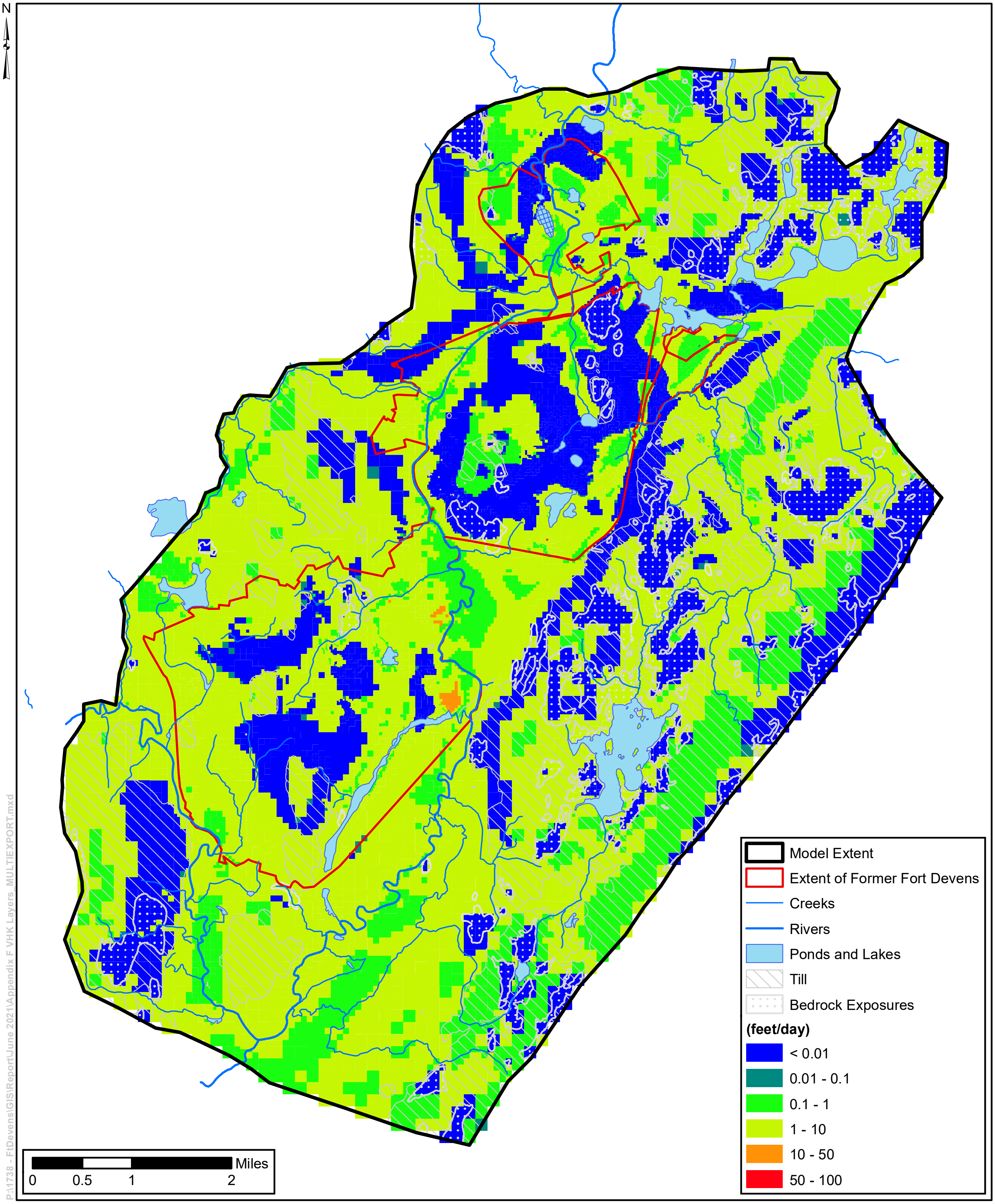

Figure F.18 Vertical Hydraulic Conductivity - Model Layer 6

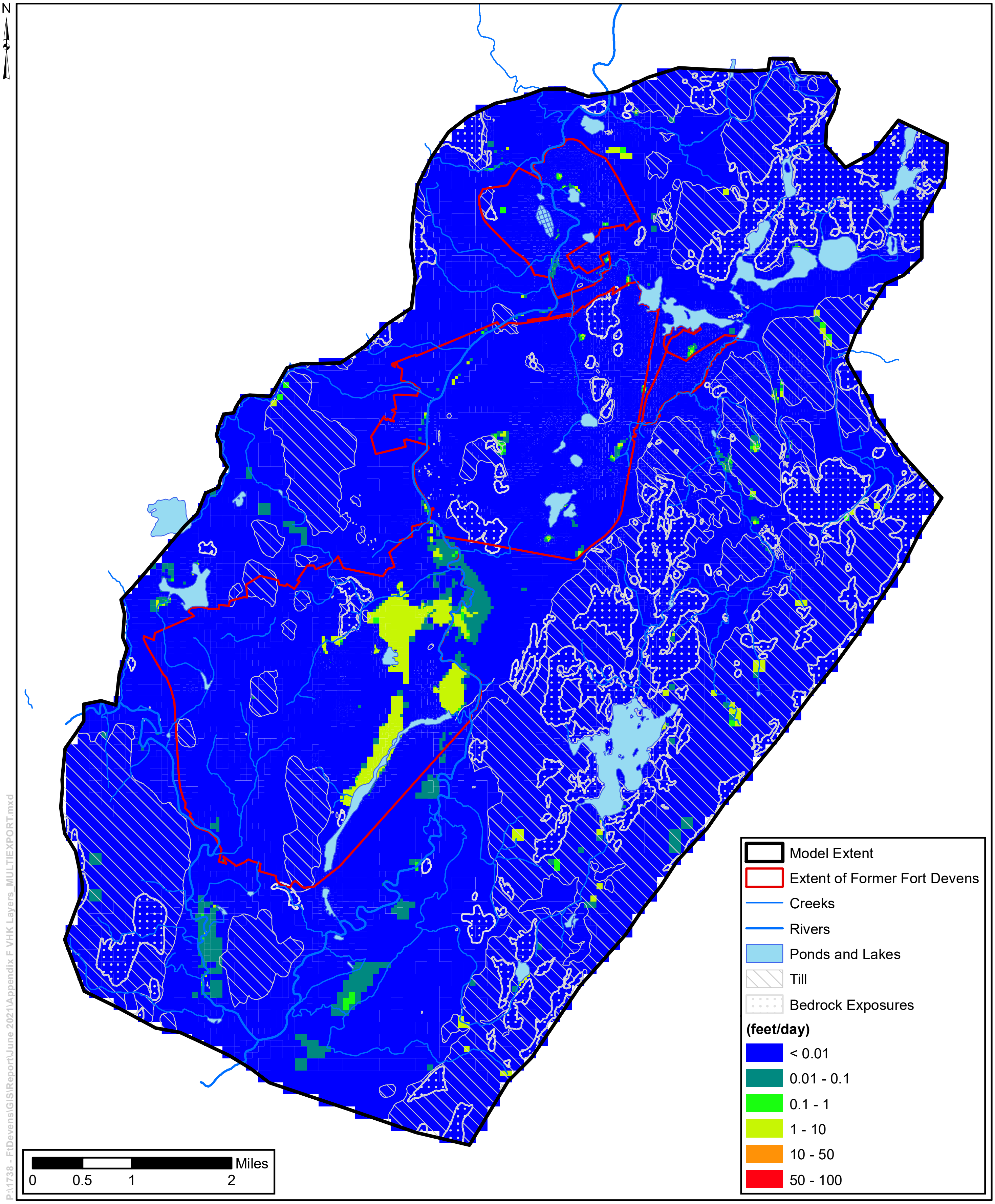

Figure F.19 Vertical Hydraulic Conductivity - Model Layer 7

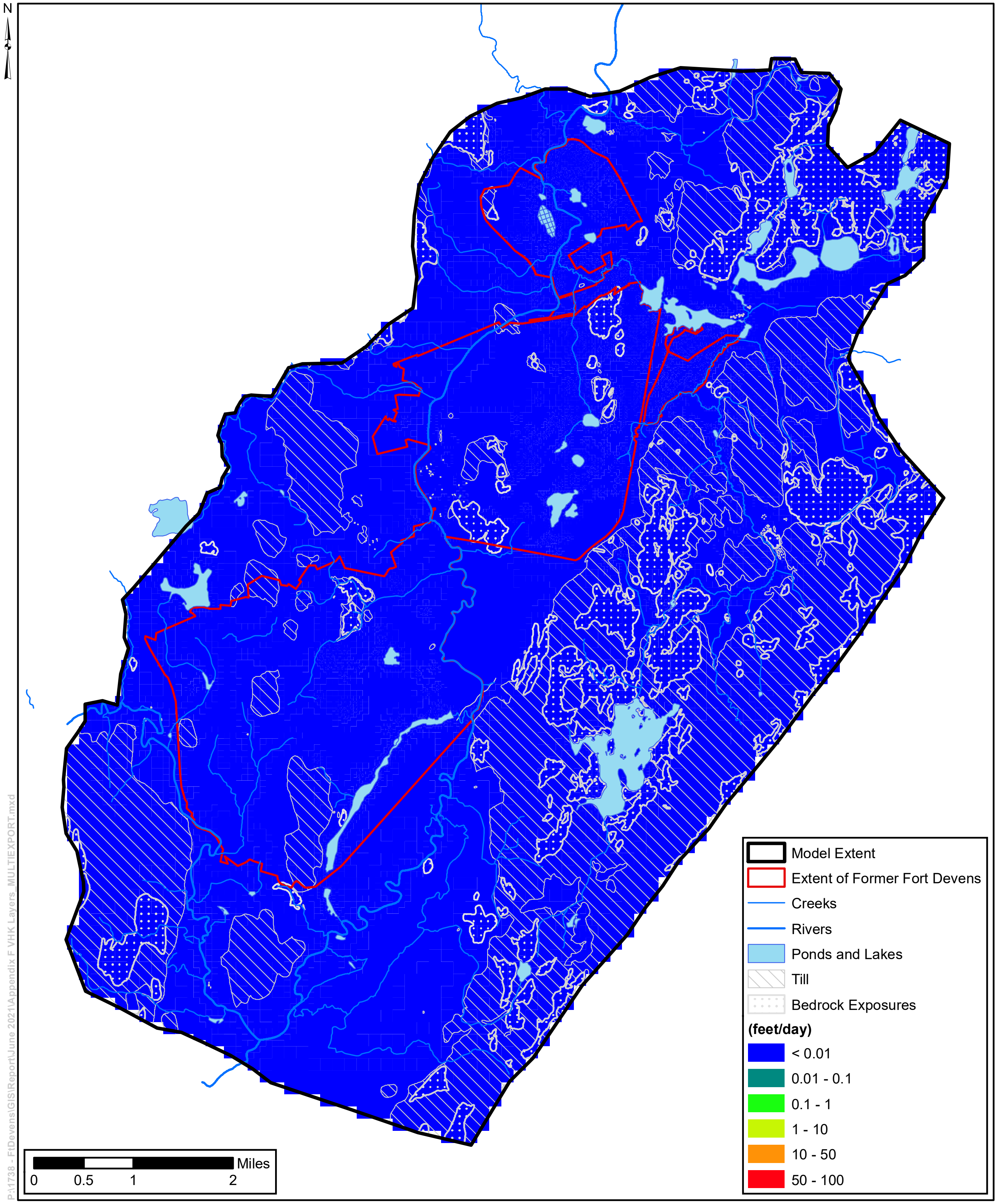

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Figure F.20 Vertical Hydraulic Conductivity - Model Layer 8

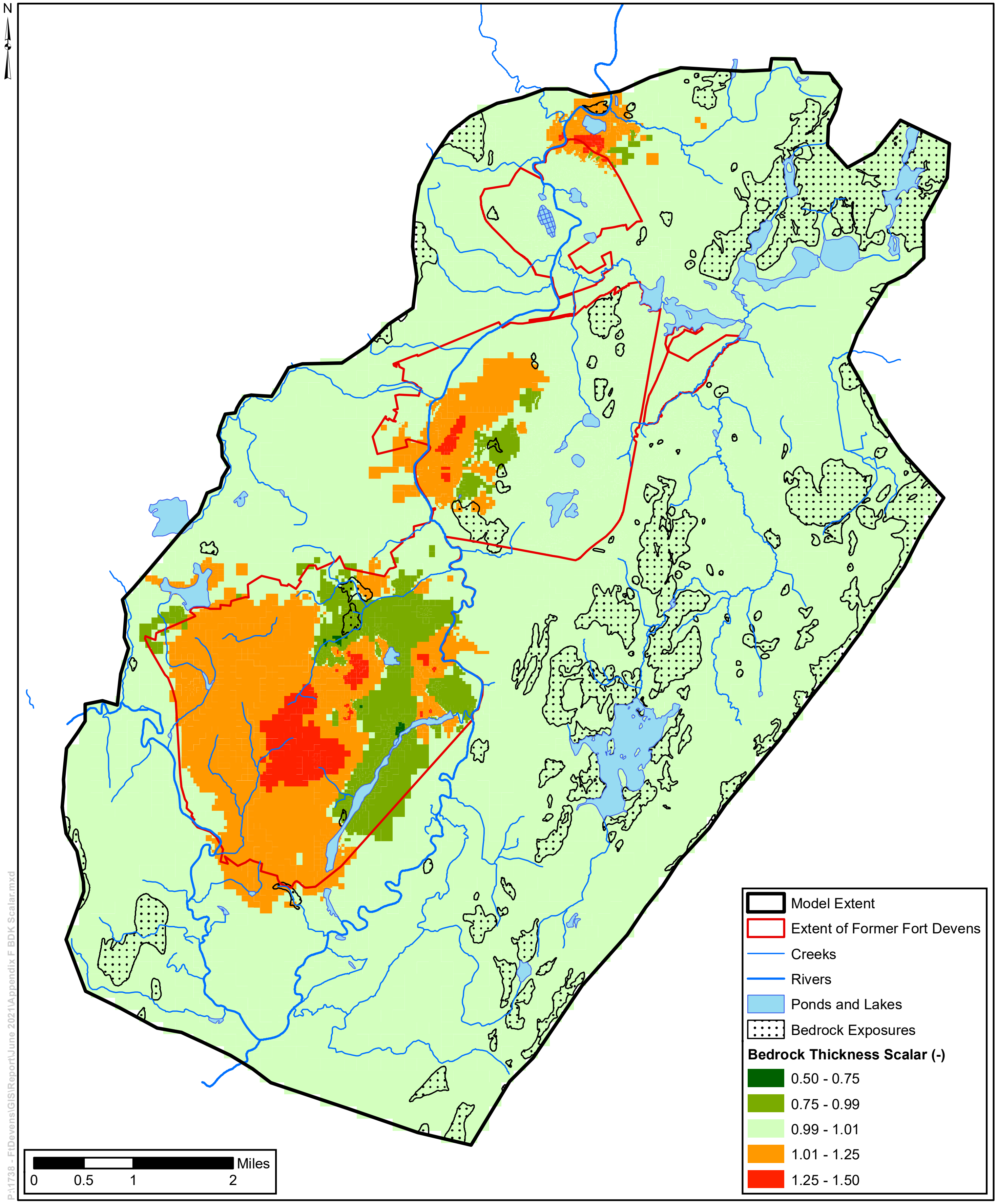

Figure F.21 Bedrock Thickness Scalar

Appendix G

Surface Water Properties

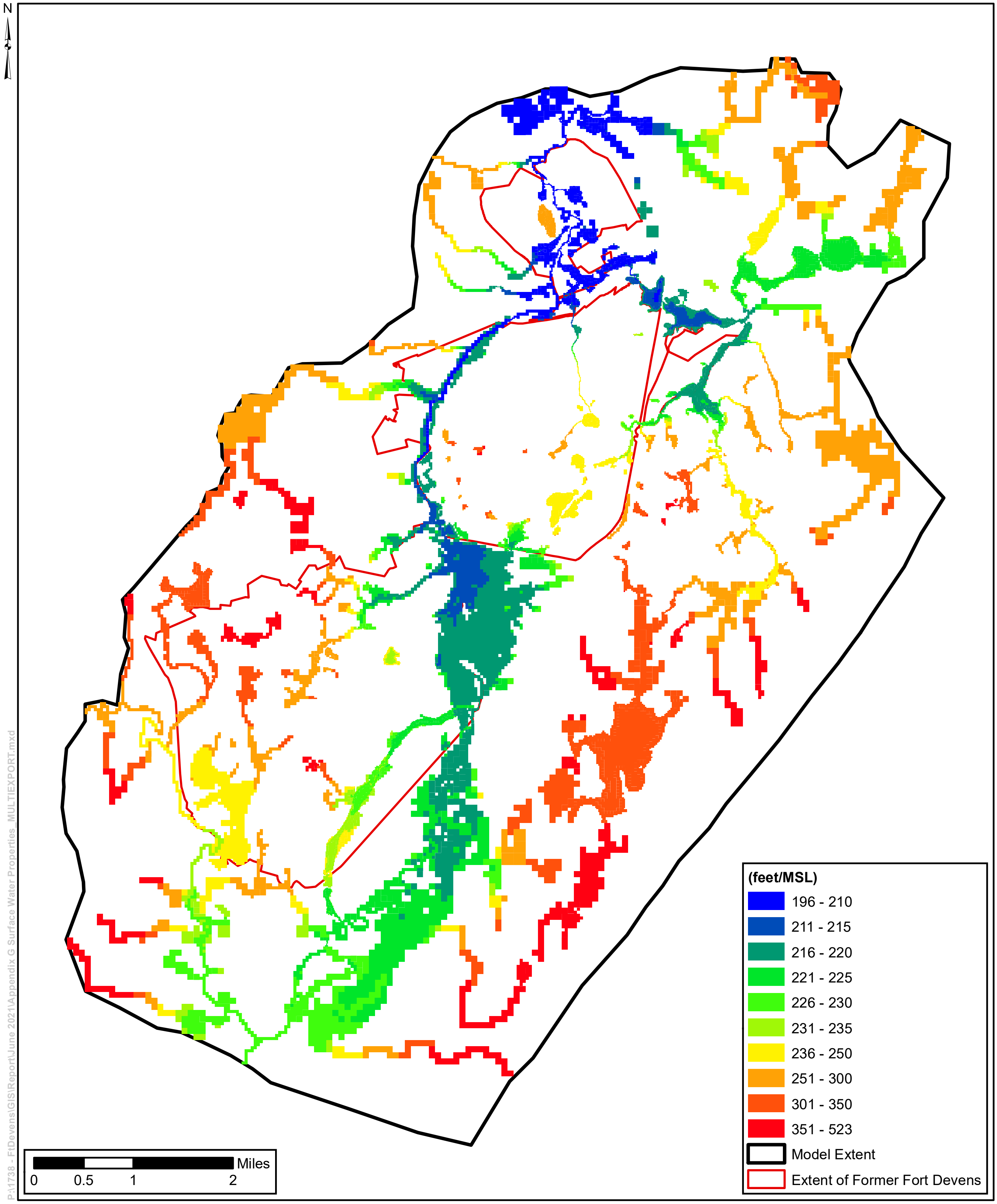

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Figure G.1 Surface Water Bed Elevation

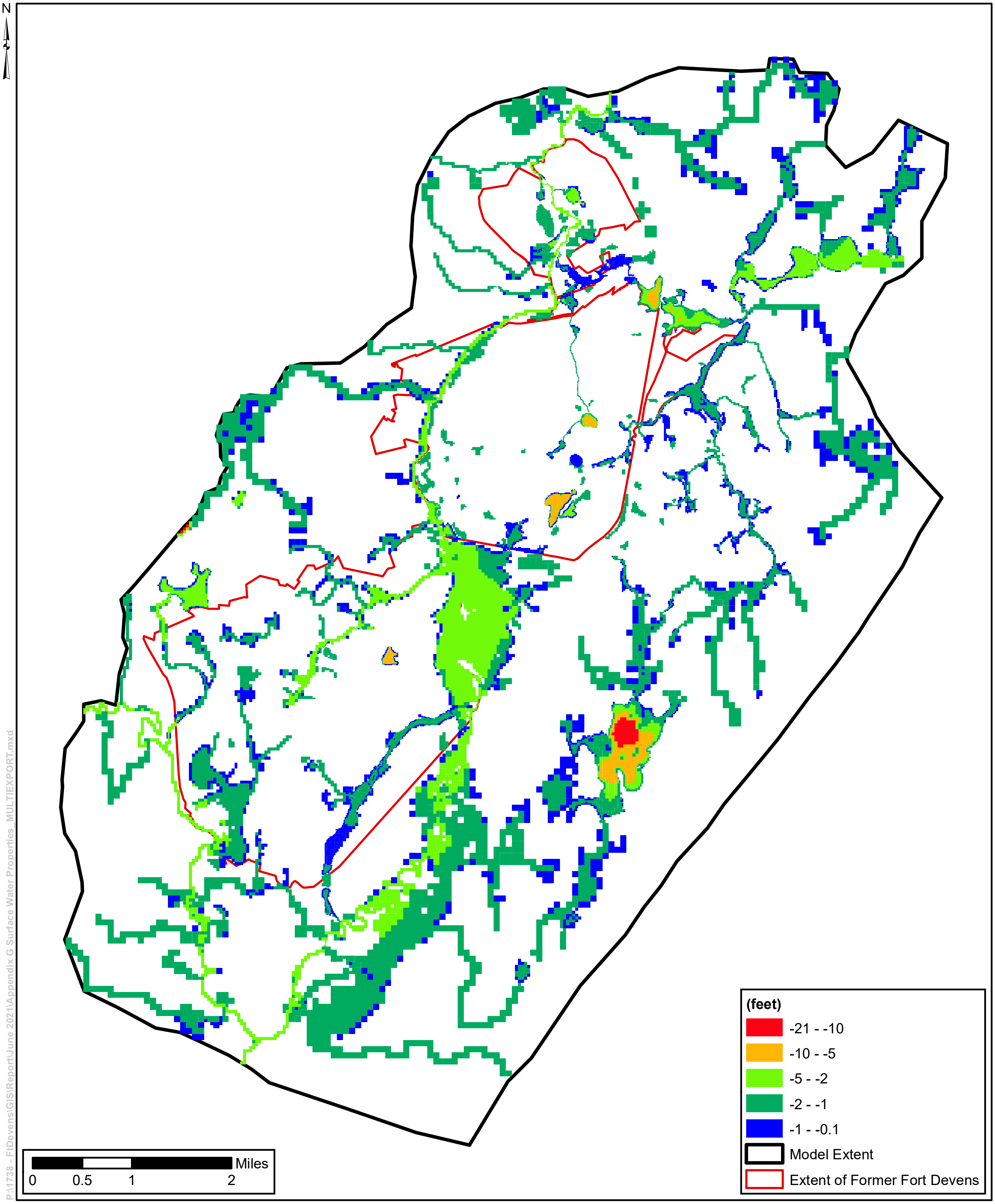

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Figure G.2 Surface Water Bed Offset

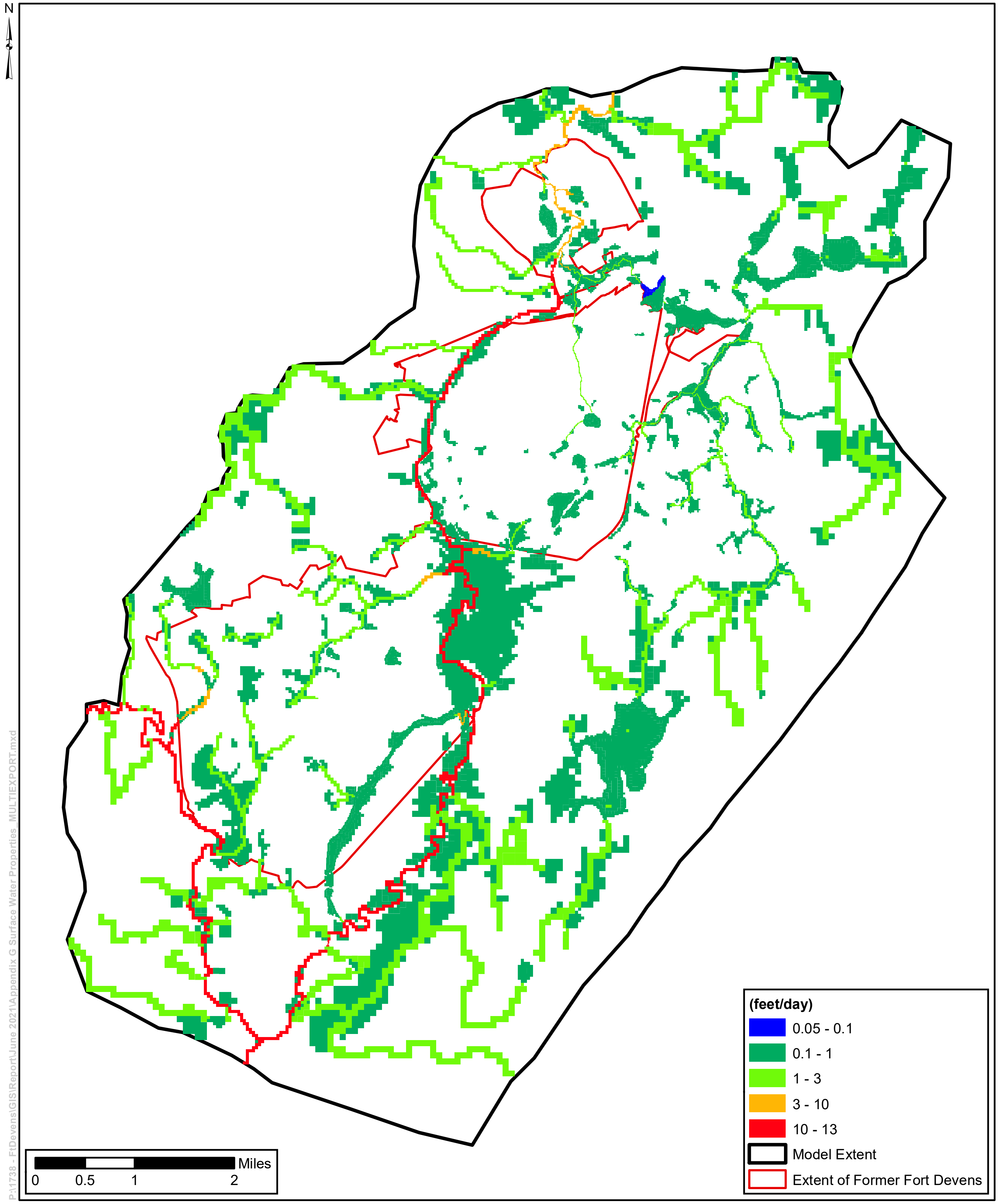

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Figure G.3 Surface Water Bed (Normalized) Vertical Hydraulic Conductivity

Appendix H

Surfaces Developed by Seres-Arcadis

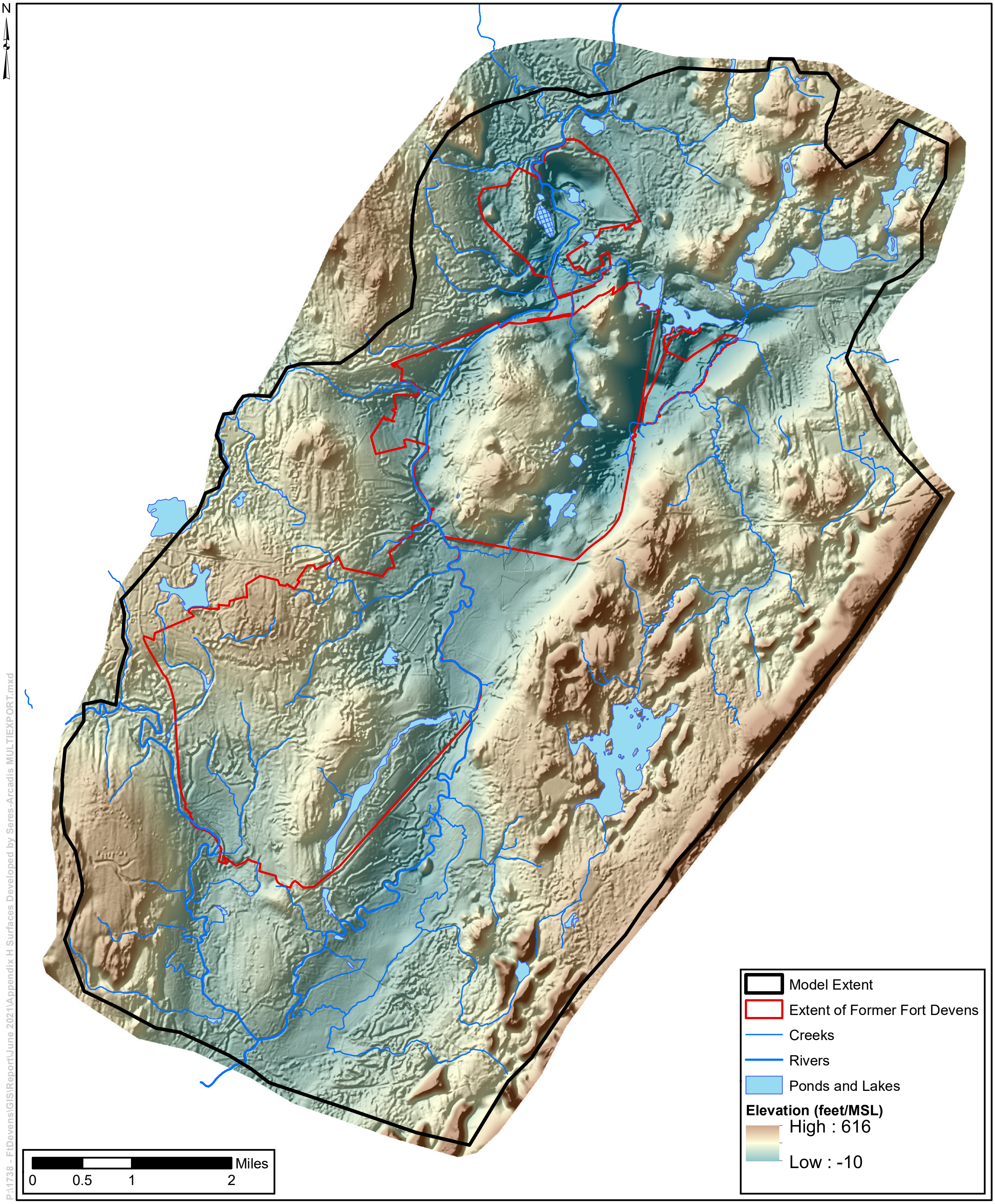

Figure H.1 Bedrock Surface

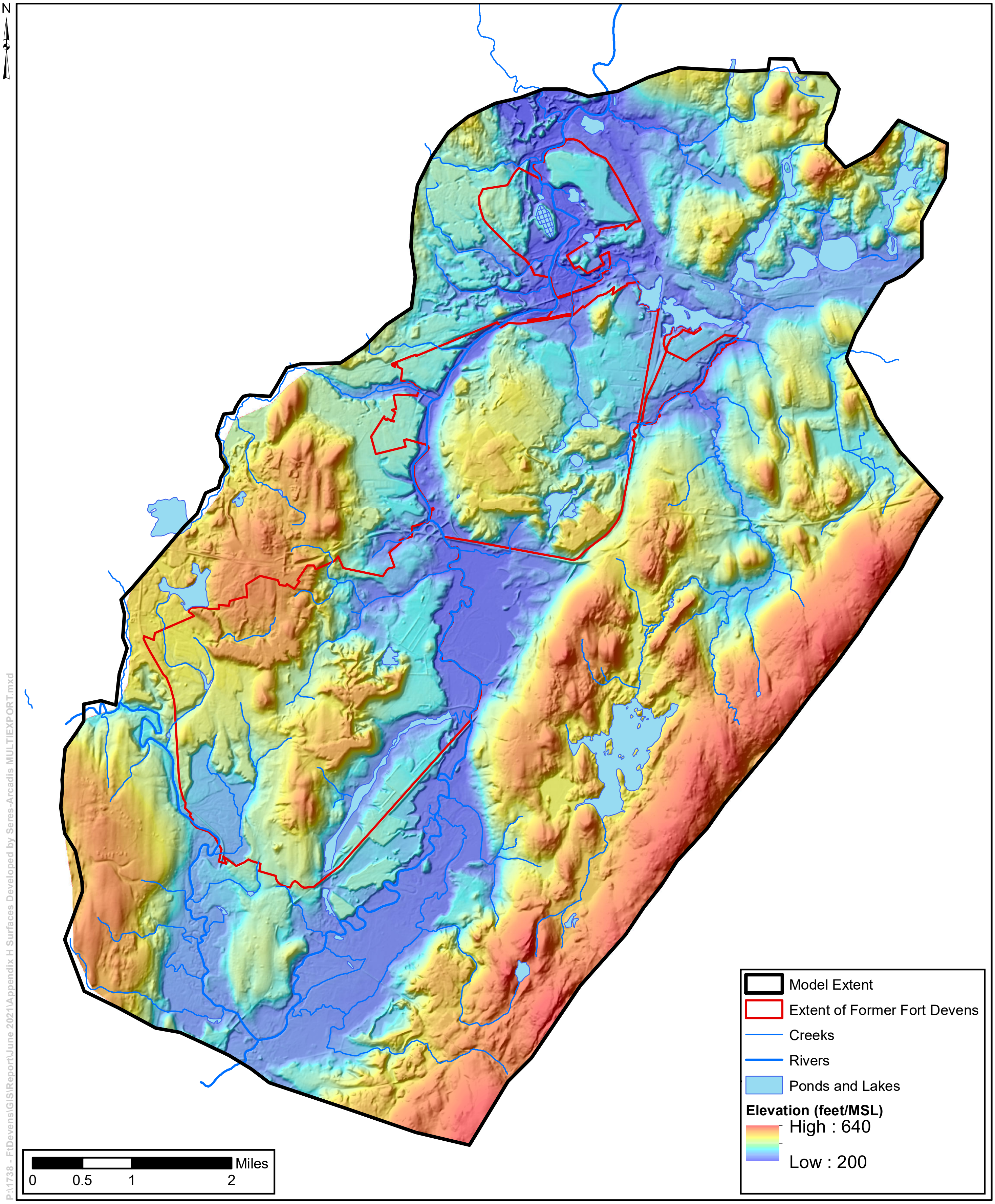

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Figure H.2 LIDAR Surface

Appendix I

Evapotranspiration Calculations from ETA (1995)

Appendix D

Evapotranspiration Calculations

MEMO

TO: File 93318.10

FROM: Donald Koch

DATE: March 15, 1994

SUBJECT: Estimation of Potential Evapotranspiration at Fort Devens

Potential evapotranspiration is an important hydrologic parameter that is used in developing estimates of recharge. Previous ground water modeling projects at Fort Devens have used potential evapotranspiration estimates calculated using the Blaney-Criddle equation and average temperatures for central Massachusetts. The annual value estimated, 42.4 inches/year, may be too large causing recharge to be underestimated.

The Irrigation Water Requirements Committee of the American Society of Civil Engineers prepared a manual summarizing state-of-the-art techniques for estimation of evapotranspiration (ASCE, 1990). Computer software (REF-ET) is available to apply some of the techniques discussed (Utah State, 1989). Given the importance of potential evapotranspiration estimates to the ground water modeling at Fort Devens, new estimates of potential evapotranspiration were made using these state-of-the-art techniques.

Potential evapotranspiration "is the rate at which water, if available, would be removed from wet soil and plant surfaces expressed as the rate of latent heat transfer per unit area, or as a depth of water per unit time" (ASCE, 1990). This definition and the discussion in the ASCE manual (1990) differentiate between potential evaporation from a free water surface, potential evapotranspiration, and reference crop evapotranspiration, which is essentially evapotranspiration for a specific crop. Grass and alfalfa are the two widely used reference crops. For the purposes of ground water modeling at Fort Devens, potential evapotranspiration was defined as the reference crop evapotranspiration for grass. The differences are minor (ASCE, 1990). Potential evaporation is slightly larger because of the differing aerodynamic roughness and albedo of a free water surface (Penman, 1963 as cited in ASCE, 1990).

The REF-ET program (Utah State, 1989) uses averaged weather data to make the estimates. Data on diskettes was obtained from the National Climatic Data Center (1993). These Comparative Climatic Data are averages and normals for first order weather stations in the U.S. The nearest first order weather station to Fort Devens is at Worcester so these data were used. The following data were extracted into a file for use with REF-ET program.

Normal daily maximum temperature (1951-1980)
Normal daily minimum temperature (1951-1980)
Normal daily mean temperature (1951-1980)
Sunshine - average percent of possible for period of record at Boston, MA, since no data were available for Worcester (57 years of record)
Wind - average speed in miles per hour converted to miles per day (MPD) for period of record (29 years of record)
Relative Humidity - averages in percent for AM and PM - daily average was computed by averaging AM and PM values (37 years of record)

The following table shows the weather data used in the estimates.

Mon	Max Temp deg F	Min Temp deg F	Mean Temp deg F	% Sunshine	Avg RelHum %	Avg Wind MPD	Avg Precip in
1	30.9	15.6	23.3	53	65.0	285.6	3.82
2	32.9	16.6	24.8	56	64.0	278.4	3.29
3	41.1	25.2	33.1	57	62.0	273.6	4.16
4	54.5	35.4	45.0	56	58.5	264.0	3.90
5	65.9	45.5	55.7	58	60.0	240.0	3.86
6	74.4	54.8	64.6	63	64.5	213.6	3.46
7	79.0	60.7	69.9	65	66.5	201.6	3.58
8	77.0	59.0	68.0	65	69.0	199.2	4.42
9	69.4	51.3	60.3	63	71.0	206.4	4.25
10	59.3	41.3	50.3	60	67.0	225.6	4.21
11	46.9	32.0	39.5	50	69.0	244.8	4.43
12	34.7	20.1	27.4	52	68.5	261.6	4.22

all data is from Worcester first order station except % sunshine which is from Boston

Temperatures and Precipitation are 30 year normals for Worcester, remaining data are averages for period of record.

These data were used to calculate reference crop evapotranspiration (grass) by REF-ET. As previously mentioned, potential evapotranspiration was considered equal to this reference crop evapotranspiration for the ground water modeling purposes.

Monthly ET Estimates
by Various Procedures
(all values in inches)

Month	Pmon	KPen	FcPen	63Pen	Harg	FRad	FB-c	Avg	Avg w/o outliers
1	1.24	0.93	1.24	1.24	0.62	0.62	0	0.84	0.81
2	1.12	1.12	1.68	1.4	0.84	1.12	0.28	1.08	1.01
3	2.17	2.17	3.1	2.79	1.55	2.48	1.55	2.26	2.23
4	3.6	3.6	5.1	4.2	3	3.9	3.3	3.81	3.72
5	4.96	5.27	7.13	5.58	4.65	5.89	5.58	5.58	5.46
6	5.4	6.3	7.8	6.3	5.4	6.6	6.6	6.34	6.24
7	5.89	6.51	8.37	6.51	5.89	7.13	7.13	6.78	6.63
8	5.27	5.58	7.13	5.89	4.96	5.89	6.2	5.85	5.77
9	3.6	3.9	4.8	4.2	3.3	4.2	4.2	4.03	4.02
10	2.79	2.79	3.41	2.79	2.17	2.48	2.79	2.75	2.73
11	1.5	1.5	1.8	1.8	0.9	1.2	1.2	1.41	1.44
12	1.24	0.93	1.24	1.24	0.62	0.62	0	0.84	0.81
Total	38.78	40.6	52.8	43.94	33.9	42.13	38.83	41.57	40.86

All the procedures are documented in the ASCE Manual (1990) and the REF-ET documentation (Utah State, 1989). The procedures used and their abbreviations in the above table are:

Pmon -- Penman-Monteith (Allen et al, 1989, ASCE, 1990)
Kpen -- 1982 Kimberly Penman (Wright, 1982; 1987)
FcPn -- FAO-ID-24 Corrected Penman (Doorenbos & Pruitt, 1977)
63Pn -- 1963 Version of Original Penman (Penman, 1963)
Harg -- 1985 Hargreaves (Hargreaves et al, 1985)
FRad -- FAO-ID-24 Radiation (Doorenbos & Pruitt, 1977)
FB-C -- FAO-ID-24 Blaney-Criddle (Doorenbos & Pruitt, 1977)

The calculated potential evapotranspiration rates range from 33.9 inches/year to 52.8 inches/year with an average of the seven methods of 41.6 inches/year. Inspection of the results and review of the ASCE Manual indicated that the outliers, those of the corrected Penman and Hargreaves methods, were likely erroneous. An average of the five remaining methods resulted in an average potential evapotranspiration rate of 40.9 inches/year. This value and the associated average monthly rates are recommended for use at Fort Devens. The attached figure shows the five results of the five methods graphically. The estimate should be considered plus or minus about two inches/year.

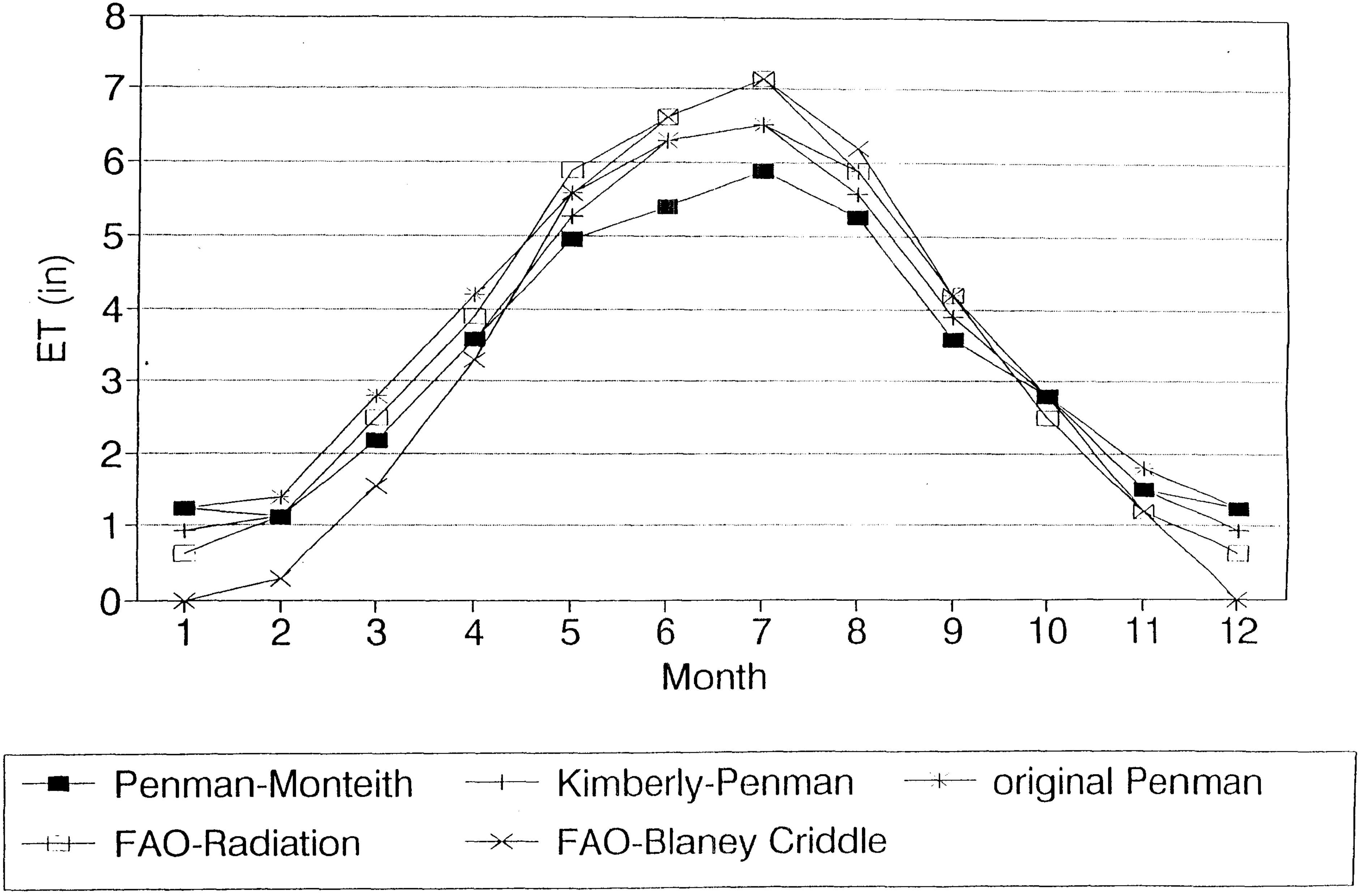
References

1. Utah State University, 1989, REF-ET, Reference Evapotranspiration Calculator Version 2.0, Computer program and documentation.

2. American Society of Civil Engineers, 1990, Evapotranspiration and Irrigation Water Requirements, Manual and Report on Engineering Practice No. 70.

3. National Climatic Data Center Comparative Climatic Data, 1993, diskettes and documentation.

Potential Evapotranspiration Estimates
Fort Devens, MA



Appendix J

Parameter Sensitivity

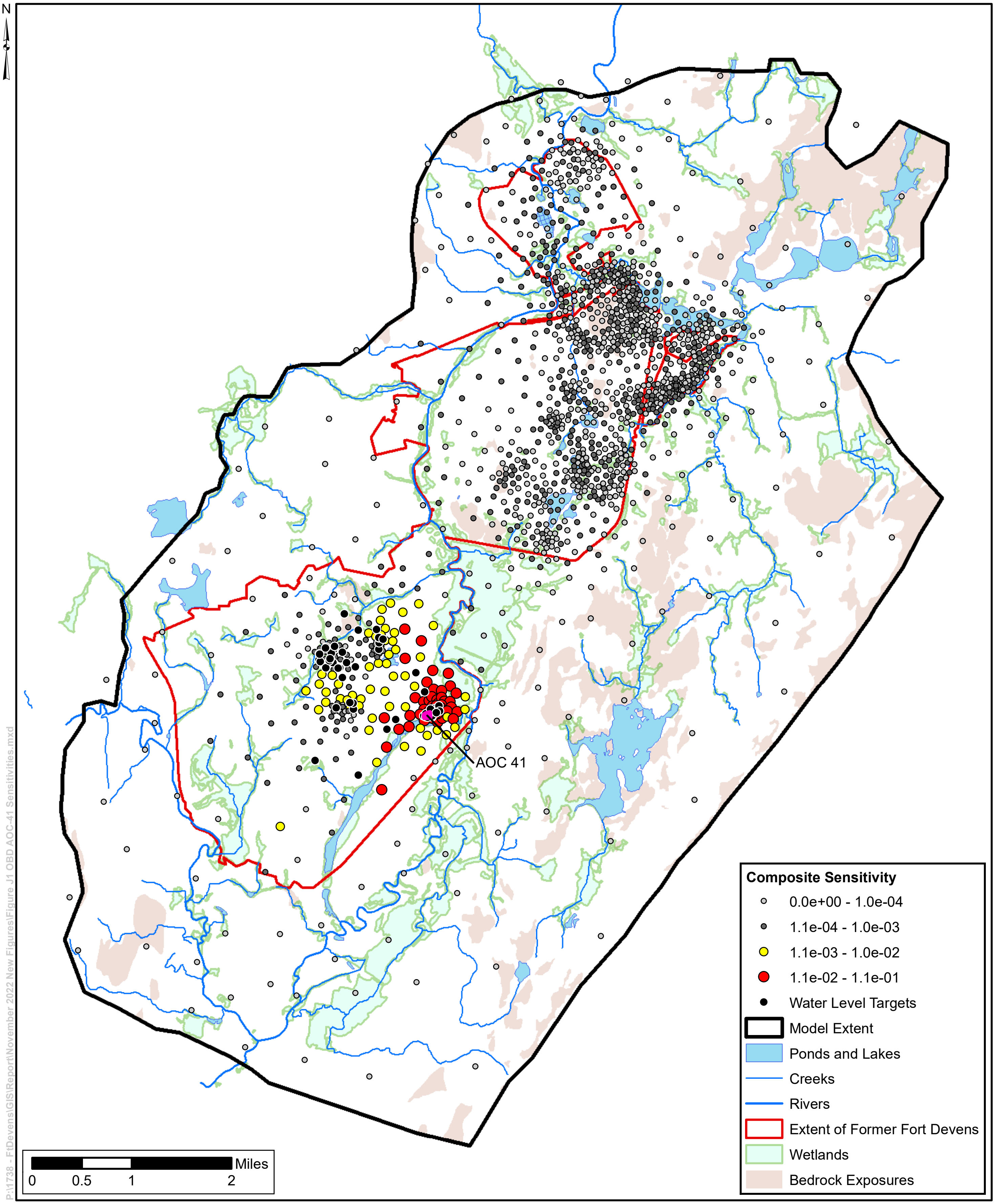


Figure J.1 Pilot Point Composite Sensitivity to AOC-41 Water-Level Targets
- Overburden Horizontal Hydraulic Conductivity

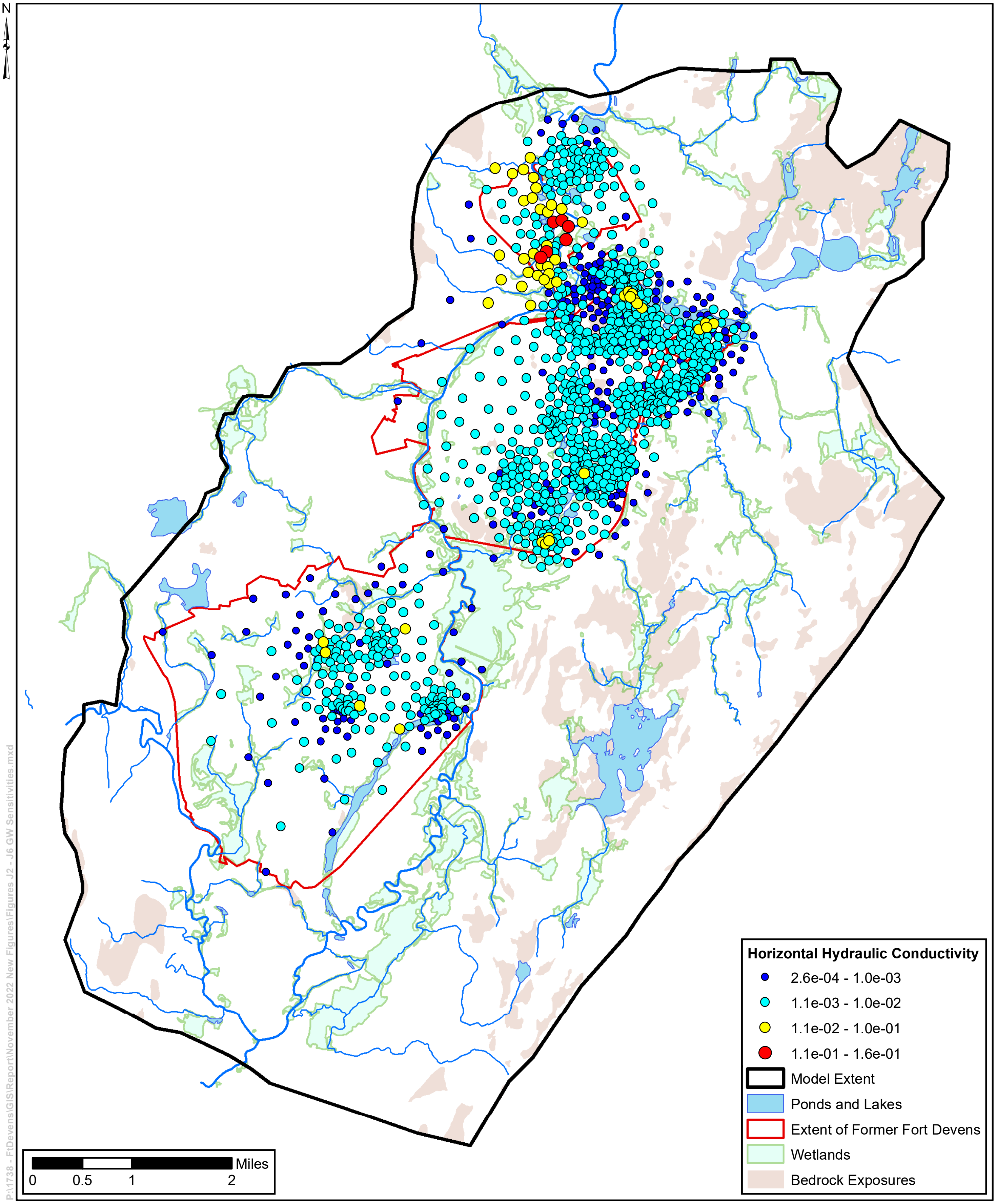


Figure J.2 Pilot Point Sensitivity - Overburden Horizontal Hydraulic Conductivity

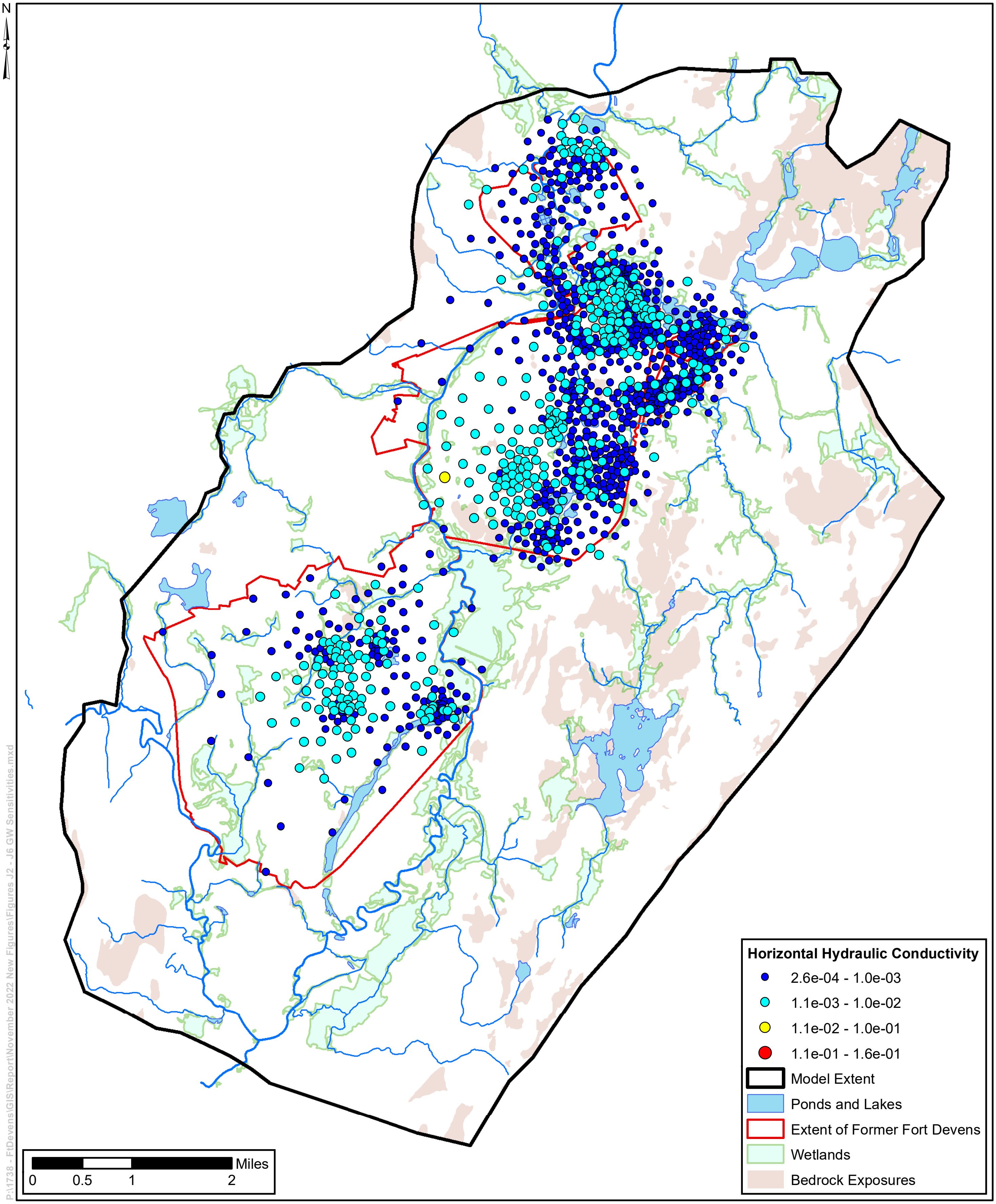


Figure J.3 Pilot Point Sensitivity - Weathered Bedrock Horizontal Hydraulic Conductivity

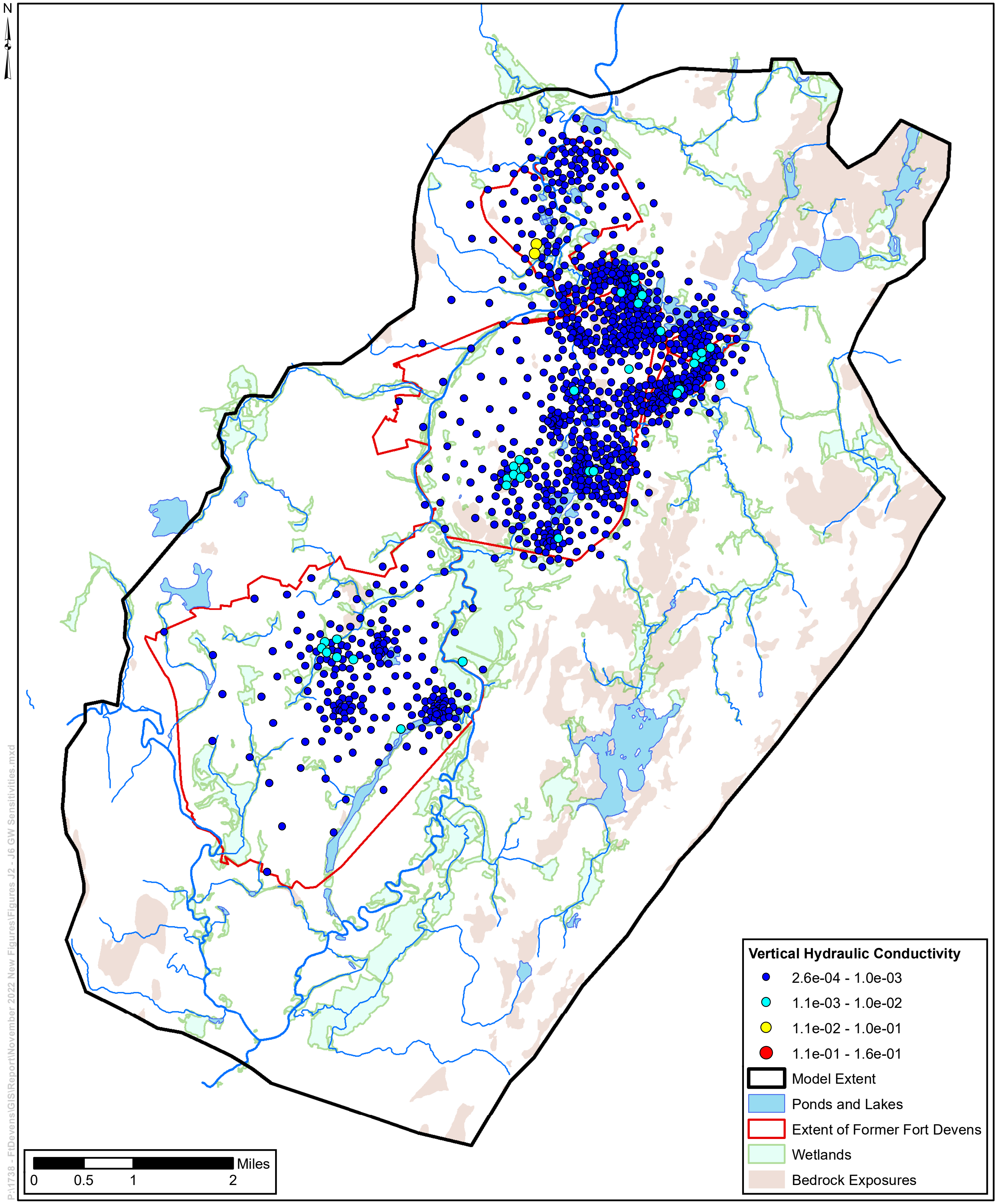


Figure J.4 Pilot Point Sensitivity - Overburden Vertical Hydraulic Conductivity

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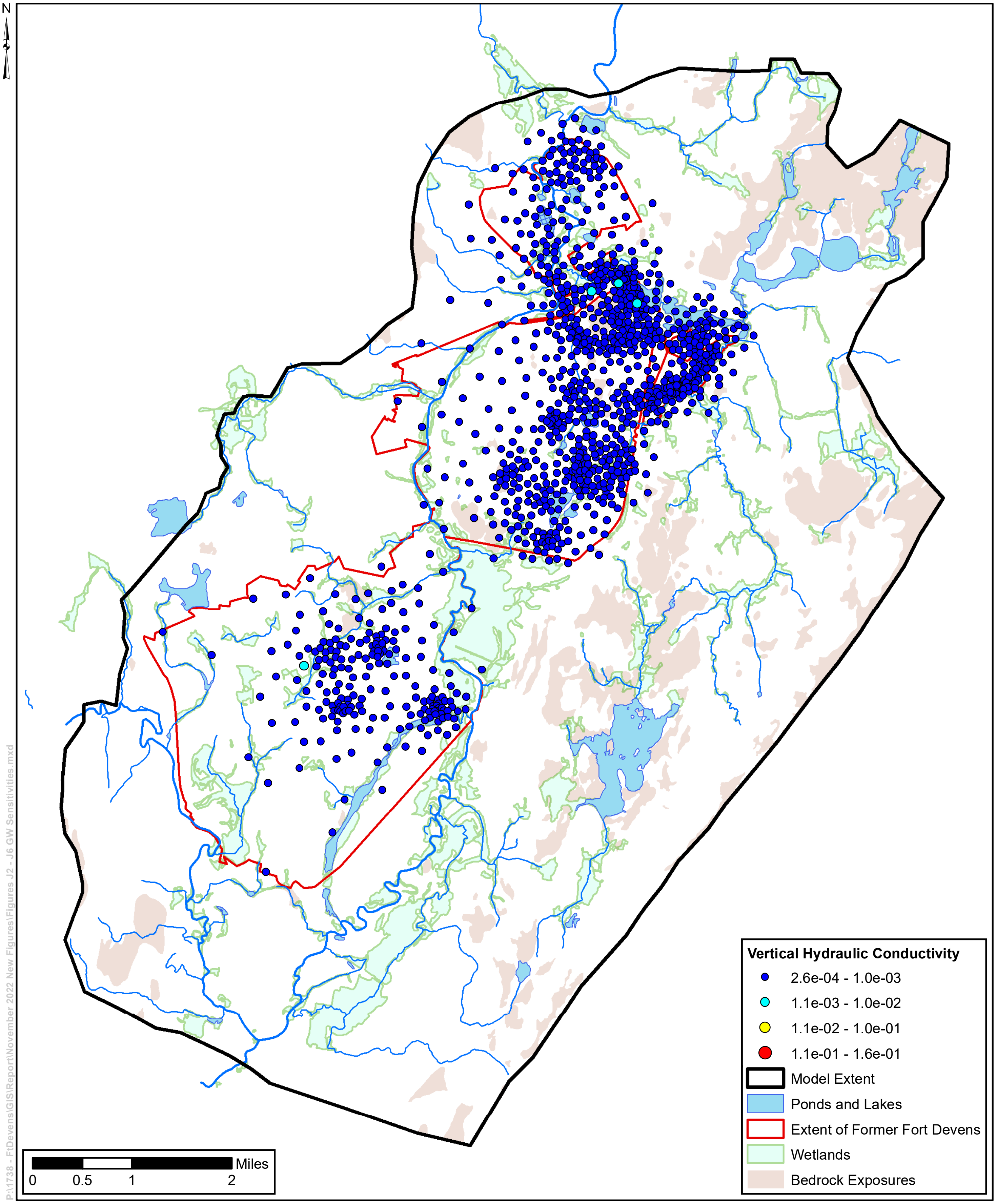

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Figure J.5 Pilot Point Sensitivity - Weathered Bedrock Vertical Hydraulic Conductivity

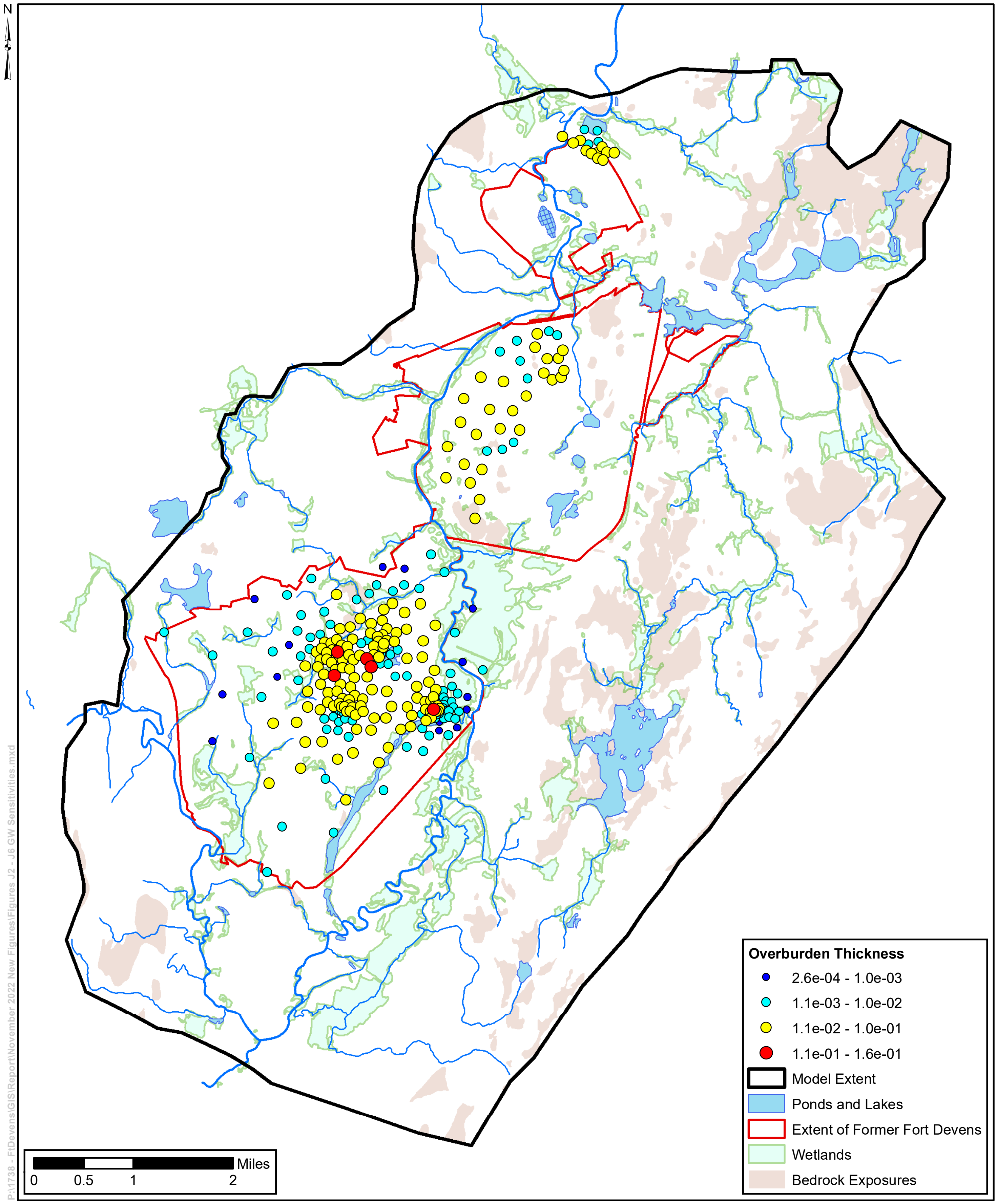

Figure J.6 Pilot Point Sensitivity - Overburden Thickness

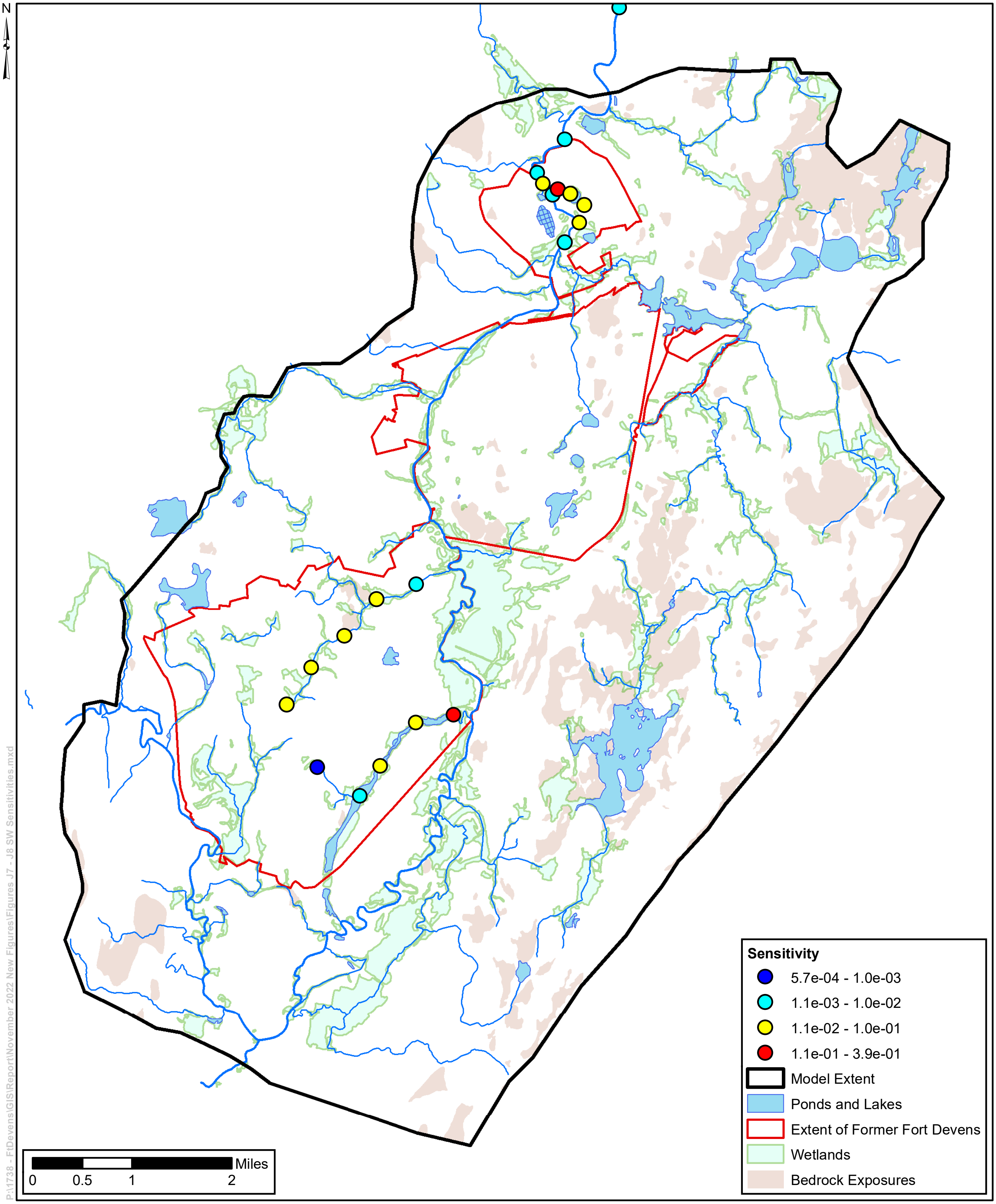

Figure J.7 Pilot Point Sensitivity - Surface Water Bed Elevation Offset

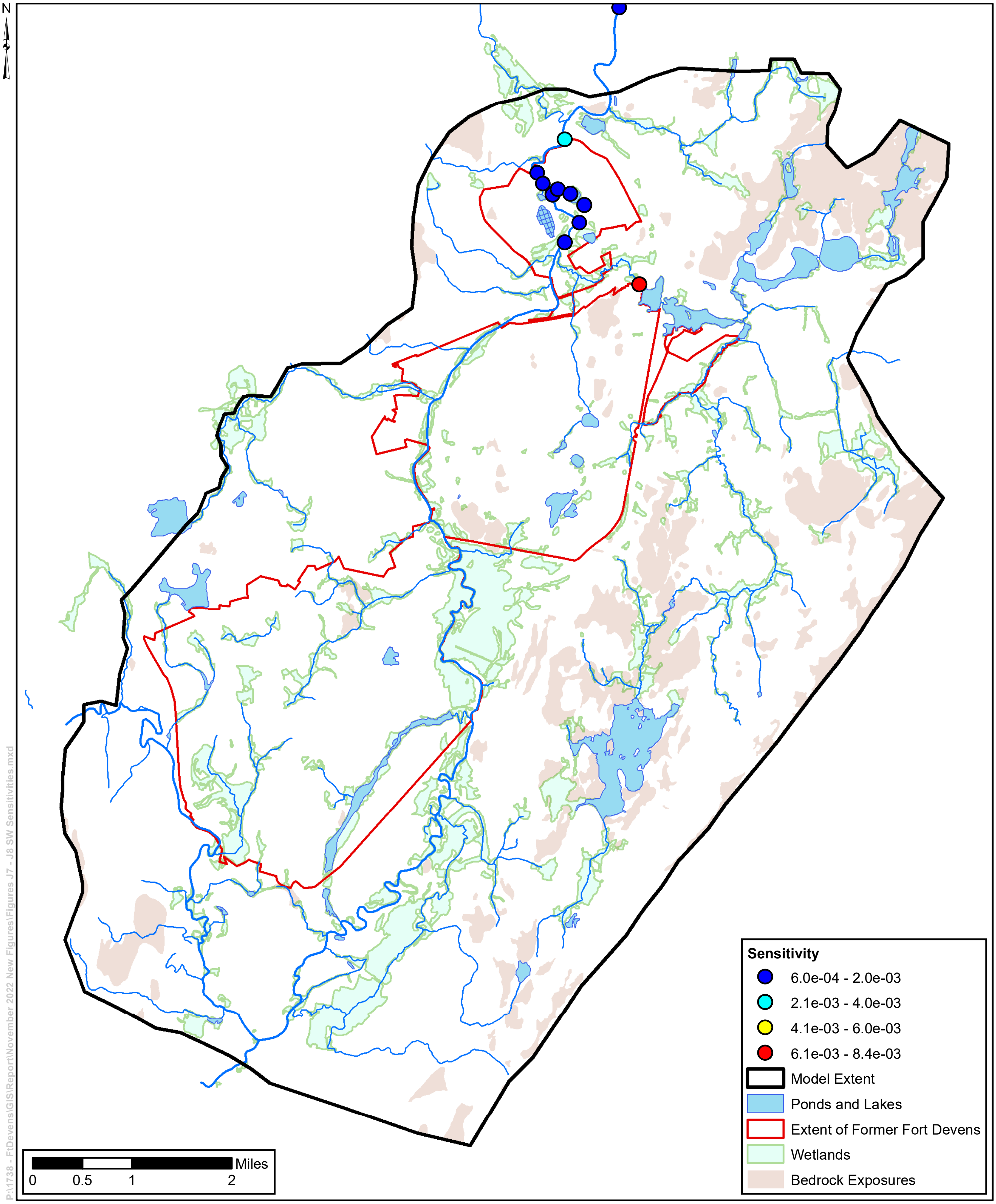

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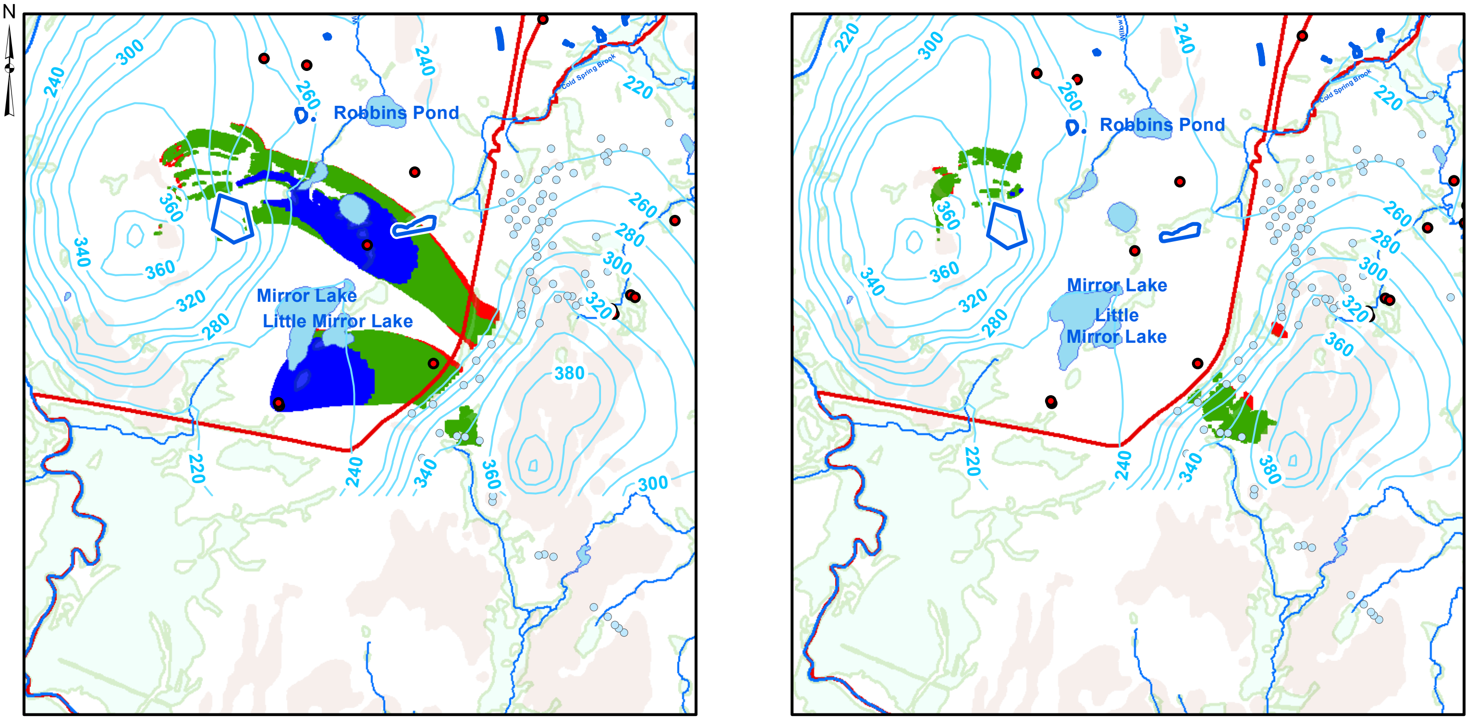
Figure J.8 Pilot Point Sensitivity - Surface Water Bed Conductance

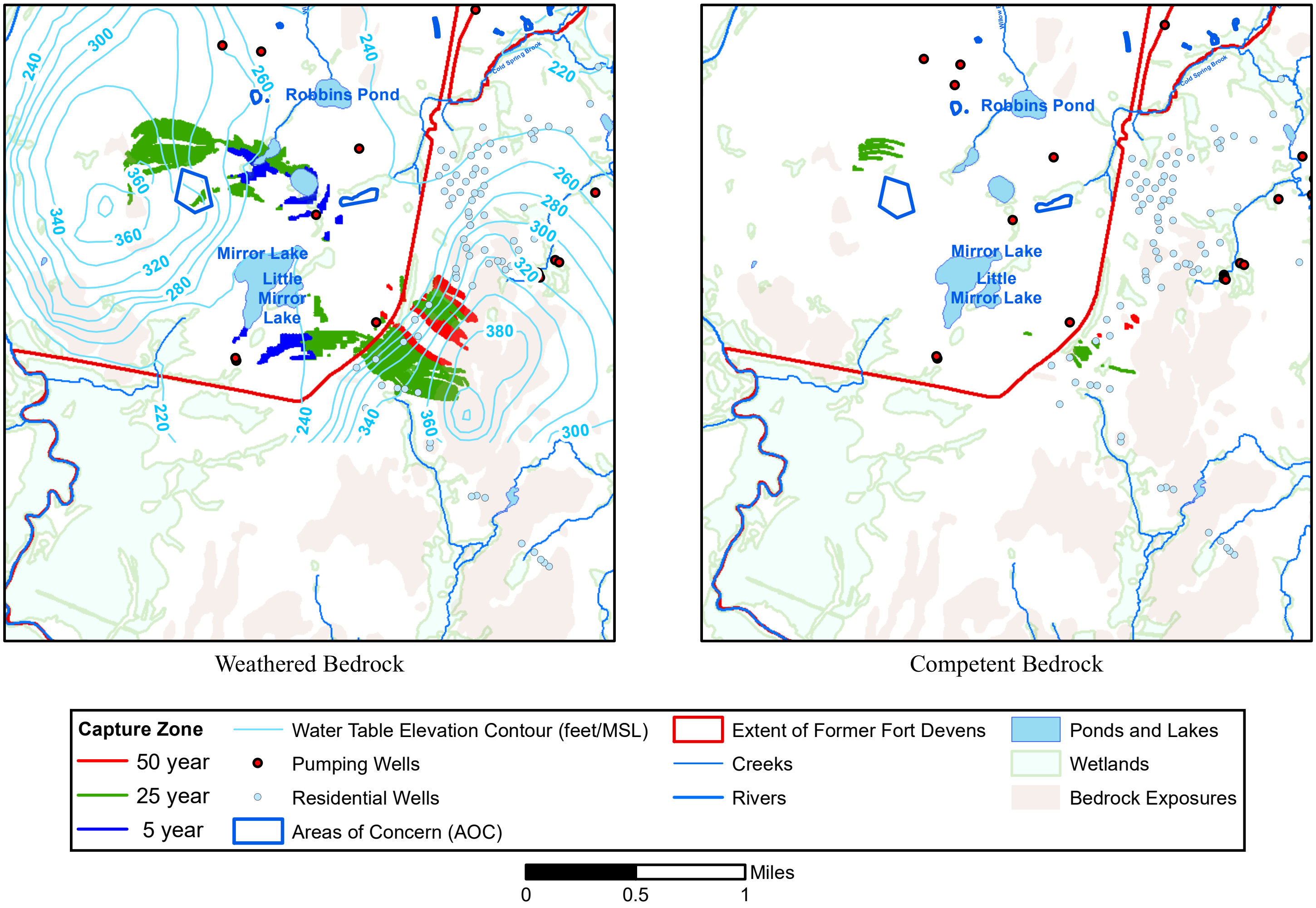
Appendix K

Capture Zones by Hydrostratigraphic Unit



Overburden

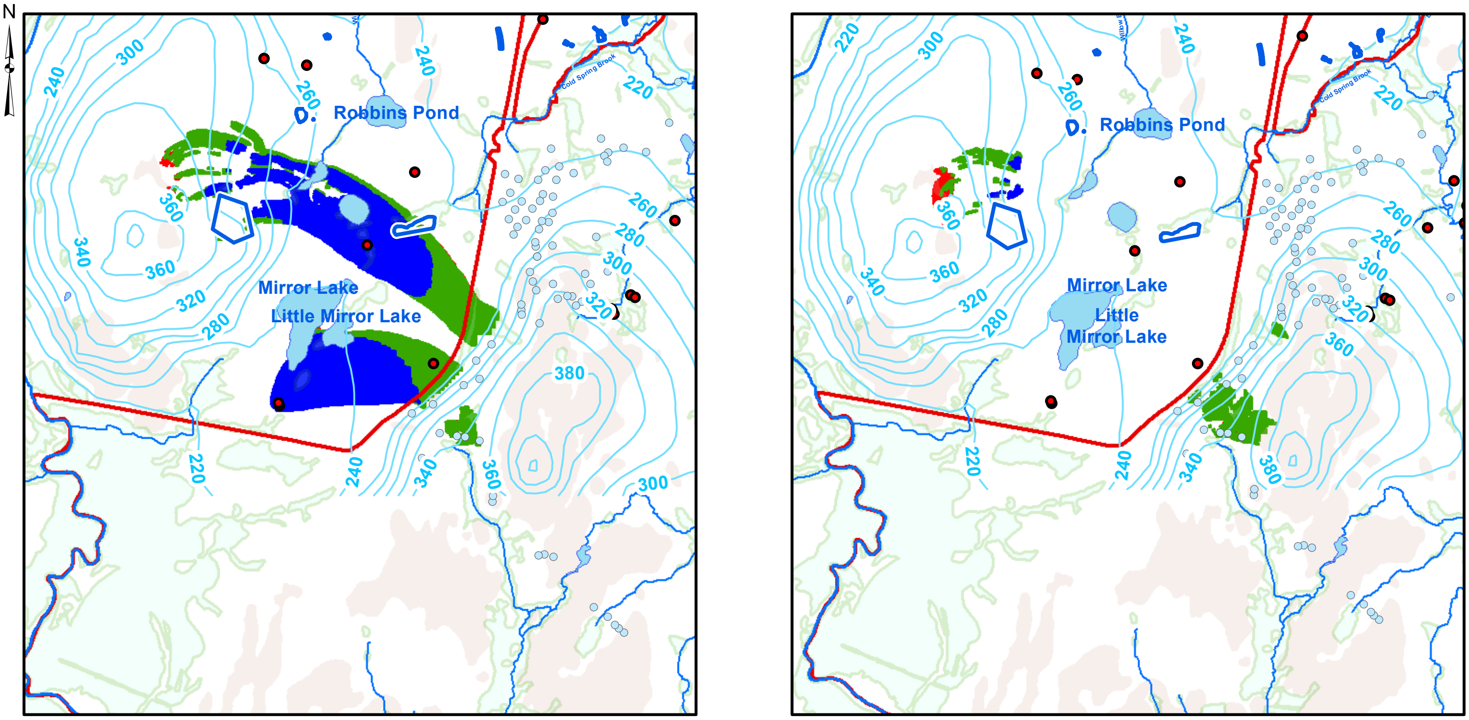
Till



Weathered Bedrock

Competent Bedrock

Figure K.1 Five-, Twenty-five-, and Fifty-year Capture Zones for Patton and Shabokin Wells – Base Effective Porosity



Overburden

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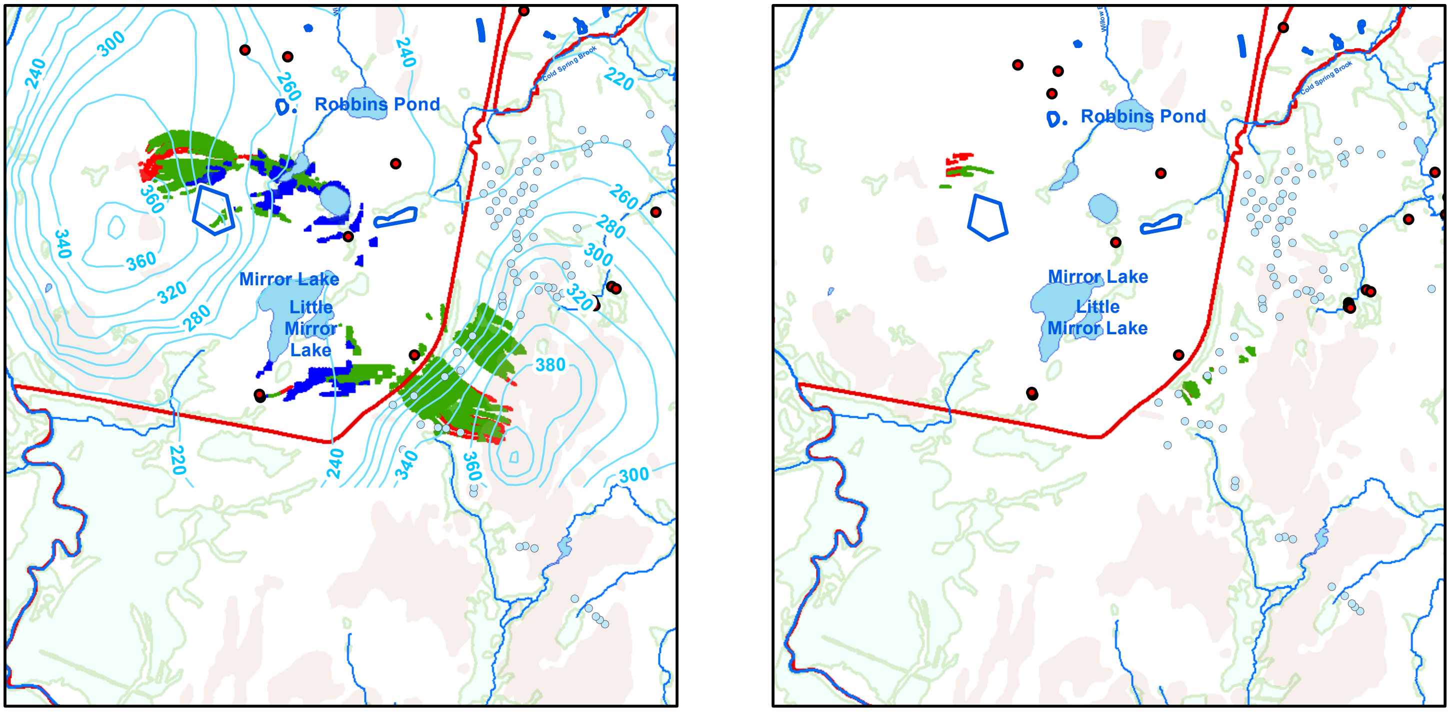


Weathered Bedrock

Competent Bedrock

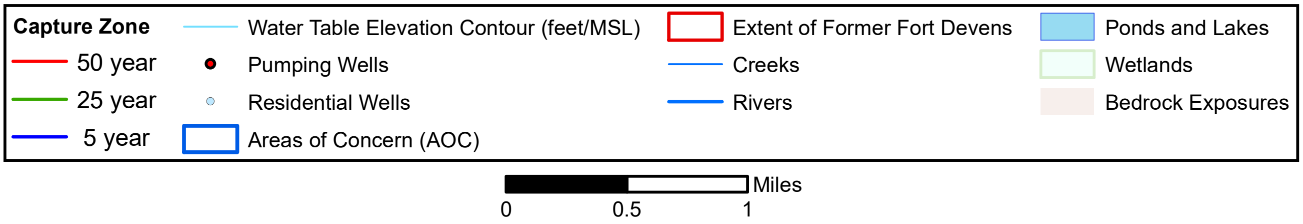
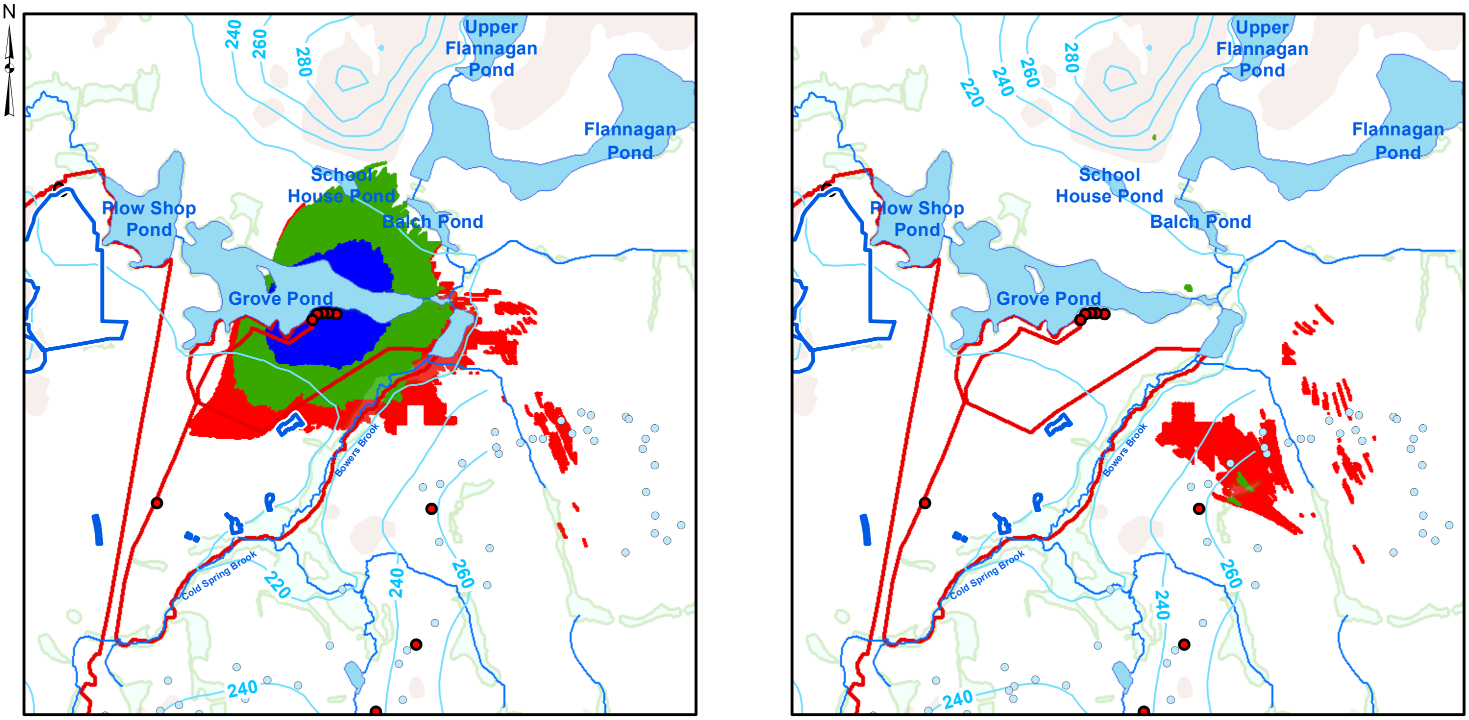
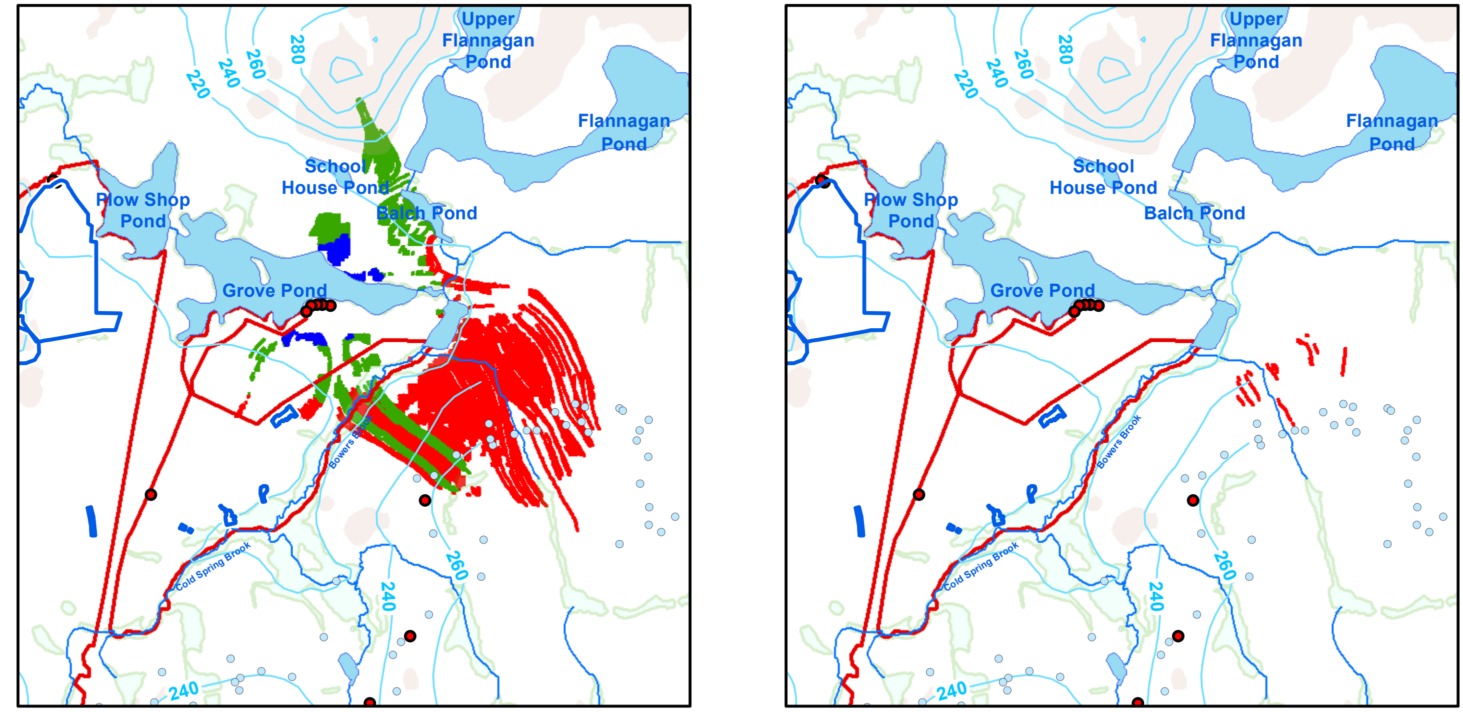


Figure K.2 Five-, Twenty-five-, and Fifty-year Capture Zones for Patton and Shabokin Wells – Alternate Effective Porosity



Overburden

Till



Weathered Bedrock

Competent Bedrock

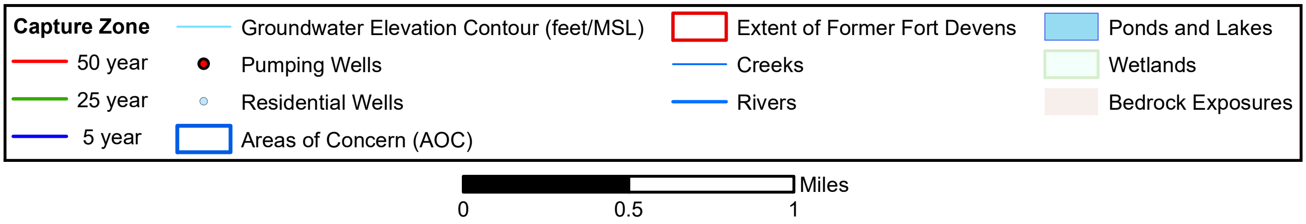
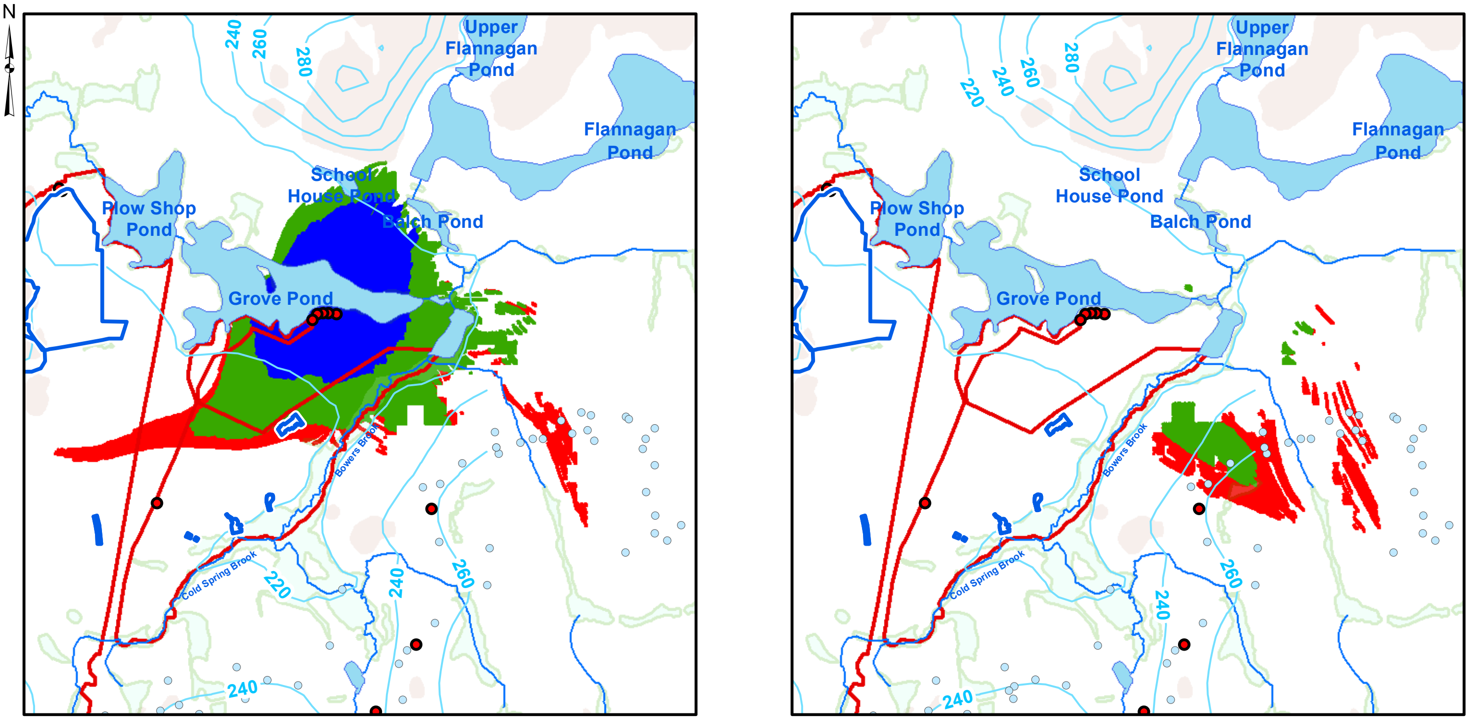
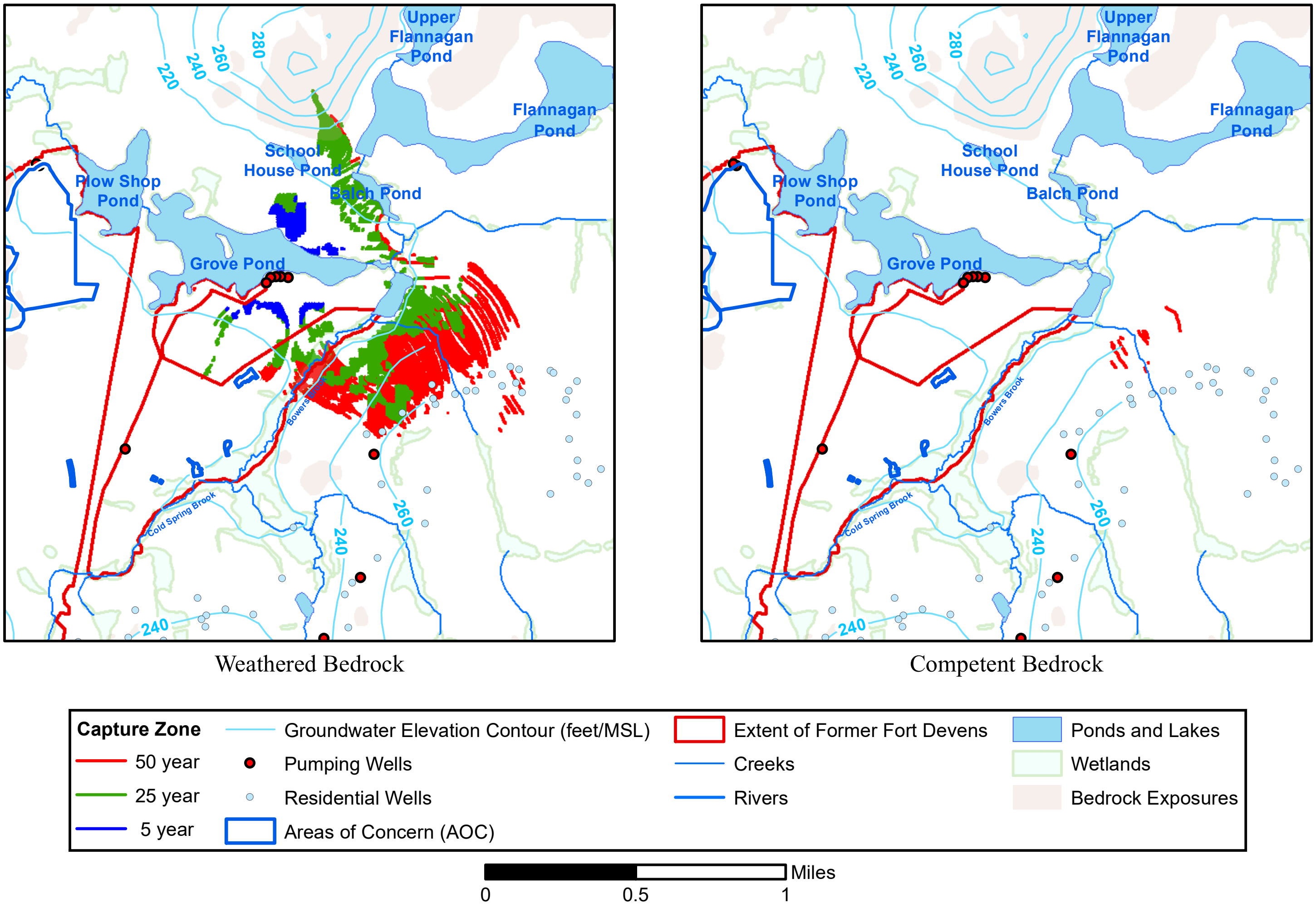


Figure K.3 Five-, Twenty-five-, and Fifty-year Capture Zones for the Grove Pond Well Field – Base Effective Porosity



Overburden

Till



Weathered Bedrock

Competent Bedrock

Figure K.4 Five-, Twenty-five-, and Fifty-year Capture Zones for the Grove Park Well Field – Alternate Effective Porosity

Appendix F

Area of Contamination-Specific Physical Characteristics and Hydrogeology

FINAL

United States Army Corps of Engineers
New England District

Appendix F – Area of Contamination-Specific Physical Characteristics and Hydrogeology

Phase II Remedial Investigation Work Plan and Quality Assurance Project Plan Addendum for Per- and Polyfluoroalkyl Substances

Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

Contract No. W912WJ-19-D-0014

Contract Delivery Order No. W912WJ-20-F-0022

Contents

Acronyms and Abbreviations

AOC	area of contamination
bgs	below ground surface
Devens	former Fort Devens Army Installation
PFAS	per- and polyfluoroalkyl substances
RI WP	Phase II Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances

1 Introduction

This appendix to the Phase II Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS) summarizes the key physical and hydrogeological characteristics within each area of contamination (AOC) identified within Area 1 at the former Fort Devens Army Installation (Devens), located in Devens, Massachusetts. From a regional perspective, both groundwater and surface water at Devens flow to the north and eventually discharge into the Nashua River north of Devens. Locally, however, groundwater and surface water flow dynamics vary across Area 1 in different cardinal directions due to the presence of local sources and sinks but ultimately culminate in the regional discharge to the north. The remainder of this appendix describes these dynamics for each AOC.

2 Former Vehicle Storage and Motor Repair Shops Site (AOC 57)

AOC 57 is located to the east of and immediately adjacent to Cold Spring Brook near its confluence with Bowers Brook. Surface topography across this AOC is generally flat in the upland region near Barnum Road where paving and development has occurred, and then slopes down to the east/southeast towards Cold Spring Brook in the wooded/undeveloped areas. Key findings for this area are:

- Relatively thick overburden (an average thickness of approximately 100 feet) occurs in this area with maximum thickness of approximately 150 feet observed at 5702MW-20-03A, where the bedrock surface dips below an elevation of 90 feet (North American Vertical Datum of 1988).
- Overburden generally comprises an unconsolidated sediment sequence—approximately 50 feet of sand with gravel overlying approximately 30 to 80 feet of silt to sandy silt, followed by a 4- to 8-foot-thick band of basal till—that conforms to the underlying bedrock.
- Surface topography on the opposite side of Cold Spring Brook (east/southeast) rises steeply, and the overburden thickness likely decreases accordingly as the bedrock (or till) and land surface increase in elevation further to the southeast.
- Bedrock consists of the Oakdale Formation (under AOC 57 Areas 2 and 3), and the Devens gneiss complex (under AOC 57 Area 1) with the contact between these formations running along a north/northeast direction. East and southeast of Cold Spring Brook, the bedrock transitions to the Ayer granite.
- The water table occurs entirely within the overburden, and groundwater flows from the local topographic highs near Barnum Road to the east/southeast (topographic lows) where it discharges to Cold Spring Brook and the surrounding wetlands. Cold Spring Brook flows into Grove Pond which eventually discharges to the Nashua River northwest of Area 1.
- Depth to groundwater ranges from about 20 feet below ground surface (bgs) in the upland areas (near Barnum Road) to less than 1 foot bgs in the lowlands/wetlands adjacent to Cold Spring Brook.
- Previous investigations have shown downward vertical hydraulic gradients within overburden in the upland areas where recharge likely occurs (near Barnum Road) that transition to upward vertical hydraulic gradients approaching and adjacent to Cold Spring Brook, indicating that Cold Spring Brook (and the surrounding wetlands) act as a discharge boundary for the overburden groundwater.

3 Barnum Road Firefighting Exercise Site (AOC 74)

AOC 74 is located approximately 1,500 feet northeast of AOC 57 and approximately 1,800 feet south of Grove Pond. The physical characteristics of AOCs 57 and 74 are similar. Surface topography across AOC 74 is generally flat across the paved and developed areas in the upland region near Barnum Road, and then slopes down to the east/southeast towards Cold Spring Brook. Two stormwater detention ponds located behind (east/southeast) former building 3773 drain into a swale that discharges to Cold Spring Brook. Key findings for this area are:

- Overburden thickness ranges from approximately 120 to 150 feet in the upland region near Barnum Road and then decreases to approximately 50 feet near Cold Spring Brook.
- Bedrock consists of the Oakdale Formation, while east/southeast of Cold Spring Brook, the bedrock transitions to the Ayer granite.
- The water table occurs entirely within the overburden, and groundwater primarily flows from the local topographic highs near Barnum Road to the east/southeast (topographic lows) where it discharges to Cold Spring Brook and the surrounding wetlands. Cold Spring Brook flows into Grove Pond which eventually discharges to the Nashua River northwest of Area 1.
- Observed water-level data also shows a groundwater divide in the overburden running through this area—so, in addition to the east/southeast flow component towards Cold Spring Brook, a northern flow component towards Grove Pond is observed in the upland area near Barnum Road.
- Depth to groundwater ranges from 20 to 30 feet bgs in the upland area near Barnum Road to less than 5 feet bgs approaching Cold Spring Brook.
- Vertical hydraulic gradients at AOC 74 are assumed to mirror those in AOC 57, with downward vertical hydraulic gradients within overburden in the upland area near Barnum Road where recharge likely occurs, transitioning to upward vertical hydraulic gradients immediately adjacent to Cold Spring Brook as overburden groundwater discharges to surface water.

4 Former Building T-1445 Warehouse Fire (AOC 75)

AOC 75 is located approximately 1,500 feet west (hydraulically and topographically upgradient) of AOC 57. Surface topography across AOC 75 is mostly flat, but gently slopes downward to the east towards Cold Spring Brook and its surrounding wetlands. Drainage swales run east to west along the northern edge of the property and north to south along the eastern edge of the property. These swales convey stormwater to a detention pond to the south, which eventually discharges to Cold Spring Brook. Key findings for this area are:

- This AOC lies above a deep bedrock valley and overburden thickness ranges from less than 30 feet in the far west (upland near MW75-19-01BR) to approximately 300 feet near Former Building T-1445 (75MW-19-02BR).
- To date, this AOC has the deepest depth to bedrock currently encountered within the Area 1 (elevation of approximately -50 feet North American Vertical Datum of 1988).
- Overburden consists of varying sequences of sand with gravel and silty sands overlying a basal till that conforms to the underlying bedrock.
- Bedrock consists of the Devens gneiss complex—to the east (between AOC 57 Areas 1 and 2) lies the contact with the Oakdale Formation.

- The water table occurs entirely within the overburden, and groundwater generally flows from west to east towards Cold Spring Brook where it eventually discharges. Cold Spring Brook flows into Grove Pond which eventually discharges to the Nashua River northwest of Area 1.
- Depth to groundwater ranges from approximately 20 feet bgs in the bedrock valley near Former Building T-1445 (75MW-19-02BR) to less than 5 feet bgs near Cold Spring Brook.
- Two bedrock monitoring wells (MW75-19-01BR and MW75-19-02BR) have been installed in this area, and depth to groundwater for these wells is approximately 20 feet bgs.
- Water-level data from well pairs show downward vertical hydraulic gradients in the upland areas (near Former Building T-1445) where recharge likely occurs that transition to upward vertical hydraulic gradients approaching Cold Spring Brook (75MW-19-04A and 75MW-19-04B), indicating that Cold Spring Brook (and the surrounding wetlands) acts as a discharge boundary for the overburden groundwater.

5 Grove Pond Wellfield Area: MAARNG Property & Former Building 3713 Area

Grove Pond wellfield is in the northeast portion of Area 1 approximately 1,500 feet north of AOC 74 and immediately adjacent to Grove Pond. Surface topography across the Massachusetts Army National Guard (MAARNG) and Army properties to the west/southwest is generally flat along the developed portions. North of these developed areas, the land steeply slopes down toward Grove Pond. Key findings for this area are:

- Overburden thickness in this area is relatively consistent only ranging from approximately 120 feet beneath the developed portions to approximately 100 feet near Grove Pond.
- Overburden stratigraphy consists of sand and gravel with occasional thin (less than 5 feet thick) silty sand sequences to approximately 60 to 80 feet bgs. This sand and gravel zone is underlain by poorly sorted sequences of silt, sand, gravel, and clay and finally a thin basal till (approximately 5 to 10 feet thick) that conform to the bedrock surface.
- The underlying bedrock consists primarily of the Devens gneiss complex with the Oakdale Formation contact boundary estimated to fall between AOC 74 and the Grove Pond wellfield.
- The water table occurs entirely within the overburden in this area with groundwater generally flowing from the upland areas south of Grove Pond (local topographic high) to the north towards Grove Pond (topographic low), where it eventually discharges to surface water that eventually joins the Nashua River to the northwest.
- A groundwater divide is present that generally follows Barnum Road—beneath the upland areas of AOC 74, overburden groundwater flows north towards Grove Pond; while east of Barnum Road, overburden groundwater flows east/southeast discharging to Cold Spring Brook where it eventually flows into Grove Pond.
- Depth to groundwater ranges from approximately 30 to 40 feet bgs in the upland developed areas where recharge likely occurs to less than 5 feet bgs approaching Grove Pond.

6 Cold Spring Brook Landfill (AOC 40) & Patton Water Supply Well Area

The Patton well/AOC 40 area is part of the remediated Cold Spring Brook Pond and is surrounded on the north, south, and west by the Red Tail Golf Course property, all portions of which are situated uphill of the area. Surface topography generally slopes towards Cold Spring Brook Pond, which drains into Cold Spring Brook. Key findings for this area are:

- Overburden thickness ranges from approximately 120 feet near the Patton well to approximately 60 to 80 feet near Cold Spring Brook to the northeast.
- Overburden stratigraphy consists of varying sequences of sand and gravel; silty sand; and poorly sorted mixes of sand, gravel, silt, and clay.
- Bedrock underlying the Cold Spring Brook Pond area is the Devens gneiss complex, while the contact boundary to the Oakdale Formation estimated to fall just west of this area, and the Ayer granite contact boundary just to the east.
    - To the east/southeast of Cold Spring Brook Pond, beyond the Devens property boundary, surface topography rises sharply as the overburden pinches out and the Ayer granite becomes exposed at the surface.
    - To the west/southwest, surface topography also rises in elevation, the overburden thins, and the Oakdale Formation becomes exposed near AOC 43J.
    - To the north, surface topography steepens in elevation, the overburden thins, and the Devens gneiss complex is exposed near Robbins Pond.
- The water table is present entirely in the overburden and groundwater generally flows from the surrounding topographic highs and converges at/discharges to Cold Spring Brook Pond/Cold Spring Brook. Because the Patton well is completed within, and draws water from, the overburden, operation of this supply well influences the local groundwater flow patterns. When this well is operating, local groundwater flow patterns are radial, indicating groundwater flow towards the pumping well from multiple directions and potentially capturing surface water (e.g., Mirror Lake and Cold Spring Brook Pond).
- Depth to groundwater varies from less than 10 feet bgs to more than 50 feet bgs depending upon the operational status of the Patton well—generally, depth to groundwater is deepest near the Patton well and relatively shallow near Cold Spring Brook Pond and Cold Spring Brook.
- Water-level data (from well pair IE-S/IE-D located near the outfall of Cold Spring Brook Pond) show an upward vertical hydraulic gradient, indicating that Cold Spring Brook Pond/Cold Spring Brook (and the surrounding wetlands) act as discharge boundaries for the overburden groundwater.

7 Shabokin Water Supply Well Area

The Shabokin water supply well is located just south of Mirror Lake at the intersection of Sheridan Road and Mirror Lake Road, approximately 4,000 feet southeast of AOC 43J and 4,000 feet southwest of Patton well/AOC 40. The Oxbow National Wildlife Refuge is located immediately to the south and consists of over 1,500 acres of upland, southern New England floodplain forest, and wetland communities along the Nashua River corridor. The surface topography of the Shabokin well area is generally flat and lower in elevation relative to the hilly areas to the east/northeast and west/northwest. Key findings for this area are:

- Previous investigations have not confirmed top of bedrock in this area, but overburden thickness near the Shabokin well is at least 100 feet based on the completion depth of the well and nearby borings.
- Thickness of the overburden decreases significantly to the west/northwest as surface topography increases in elevation towards AOC 43J and is estimated to be approximately 25 feet near SWMW-20-01A and SWPZ-20-01.
- Details regarding the lithology and stratigraphy are limited for this area but, given its proximity to wetland areas and floodplain deposits adjoining the Nashua River to the south and the available data, the overburden comprises a heterogeneous mix of sand, fine gravel, and silt.
- The underlying bedrock is the Oakdale Formation, but the north-south oriented contact boundary with the Devens gneiss complex is estimated to fall just to the east of Mirror Lake.
- The water table appears to occur entirely within the overburden; however, this is uncertain given the limited water-level data and that some previous investigative borings did not encounter groundwater (e.g., SWVP-19-02).
    - Based on the limited water-level data available for the area, overburden groundwater is interpreted to flow from the surrounding topographic highs to the west and east converging at/discharging to Mirror Lake, flowing through the lake, and then moving south towards the Shabokin well and wetlands.
    - Because the Shabokin well is completed within, and draws water from, the overburden, operation of this supply well influences local groundwater flow patterns—depending on the operational status of the Shabokin well, overburden groundwater will either be extracted by the well or will eventually discharge to the wetland areas adjoining the Nashua River and to the Nashua River itself.
    - Hydraulic interference between operation of the Patton and Shabokin wells also influences overburden groundwater flow patterns in this area as both wells compete for and capture water from Mirror Lake and the surrounding overburden aquifer.
- Where groundwater has been encountered in the overburden, depth to water ranges from approximately less than 5 feet bgs to more than 20 feet bgs—depending upon the operational status of the Shabokin well. In general, though, depth to groundwater is deepest in the lowlands (near the Shabokin well) while shallower in the uplands and the wetland areas to the south.

8 Historical Gas Station J (AOC 43J)

AOC 43J sits atop a local topographic high in the southwest corner of Area 1 just east of the Nashua River. Surface topography is generally flat across the paved areas, then gently slopes moving away from these areas in all directions, with steeper slopes encountered to the east towards Mirror Lake. The key findings for this area are:

- Overburden thickness generally varies between approximately 10 to 30 feet and consists primarily of sand with gravel overlying a basal till that conforms to the underlying bedrock topography.
    - The overburden is either not present or very thin in the upgradient portions (near XJM-93-04X where there is exposed or shallow bedrock).
    - Moving east and southeast, the overburden thickness increases where depth to bedrock becomes approximately 100 feet bgs near Mirror Lake and the Shabokin water supply well.

- Underlying bedrock consists of the Oakdale Formation, which is partially exposed at the ground surface in the upgradient areas.
- Where the overburden is not present or very thin in these upgradient portions, the water table occurs within the shallow bedrock, while moving away from this area, the overburden becomes present and is saturated (i.e., water table occurs within the overburden).
- Because AOC 43J is positioned on a topographic high, groundwater flows radially from this area.
  - To the east, groundwater generally flows toward the Patton water supply well.
  - To the southeast, groundwater generally flows towards Mirror Lake, where it discharges (and is thought to be captured by the Shabokin water supply well).
  - To the northeast, groundwater generally flows towards the Robbins Pond area where the water table becomes shallow moving towards wetland areas that slope and drain towards the pond via an unnamed tributary.
- Depth to groundwater generally ranges between 5 to 10 feet bgs under AOC 43J, while to the east/southeast, near Mirror Lake (SWPZ-20-02) and the Shabokin water supply well (SWPZ-19-01), where the overburden thickens considerably, the depth to groundwater is approximately 20 to 25 feet bgs.

Appendix G

Area of Contamination-Specific PFAS Fate and Transport

FINAL

United States Army Corps of Engineers
New England District

Appendix G – Area of Contamination-Specific PFAS Fate and Transport Preliminary Summary of Contamination

Phase II Remedial Investigation Work Plan and Quality Assurance Project Plan Addendum for Per- and Polyfluoroalkyl Substances

Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

Contract No. W912WJ-19-D-0014

Contract Delivery Order No. W912WJ-20-F-0022

Contents

Figures

Acronyms and Abbreviations

µg/kg	microgram per kilogram
AFFF	aqueous film-forming foam
AOC	area of contamination
bgs	below ground surface
Devens	former Fort Devens Army Installation
EtFOSAA	n-ethyl perfluorooctane sulfonamide
KGS	KOMAN Government Solutions, LLC
KOC	organic carbon-water coefficient
MAARNG	Massachusetts Army National Guard
ng/L	nanogram per liter
PFAS	per- and polyfluoroalkyl substances
PFAS6	the sum of perfluorooctanesulfonic acid, perfluorooctanoic acid, perfluoronanoic acid, perfluorohexanesulfonic acid, perfluoroheptanoic acid, and perfluorodecanoic acid
PFDA	perfluorodecanoic acid
PFHpA	perfluoroheptanoic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexanesulfonic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate, or perfluorooctanesulfonic acid
RI WP	Phase II Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances

1 Introduction

This appendix to the Phase II Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS) provides a preliminary summary of PFAS fate and transport for each area of contamination (AOC) identified within Area 1 at the former Fort Devens Army Installation (Devens), located in Devens, Massachusetts. Figures G-1 through G-6 show the PFAS fingerprints available from Phase I remedial investigation activities for soils, groundwater, and surface water at each AOC. A brief description of the primary PFAS in the source area (in soils and groundwater) relative to those detected in groundwater located hydraulically downgradient is included in the following sections, along with notes on the observed potential differential transport and/or PFAS transformation.

2 Former Vehicle Storage and Motor Repair Shops Site (AOC 57)

The primary sources of PFAS contamination in AOC 57 are related to historical vehicle storage and repair activities that also resulted in AOC contamination with non-PFAS organic constituents (i.e., hydrocarbons and polychlorinated biphenyls), as well as migration of PFAS from upgradient AOC 75 and area of Former Building 3713 (discussed as part of the Grove Pond Wellfield Area). Multiple releases are identifiable by differing PFAS fingerprints in groundwater in different areas of the AOC.

At AOC 57, soil samples were collected for PFAS from Area 2, southwest of the building, and Area 3, east of the building, from locations where known releases are associated with former activities; no soil samples were collected in Area 1. At Area 2, naphthalene and total petroleum hydrocarbon content were detected in surface soils, and fingerprint analysis of soil indicated contaminated soil was most likely derived from lubricating oil, possibly from the release of vehicle crank case oil (KOMAN Government Solutions, LLC [KGS] 2020). Area 3 soils were impacted by releases of materials containing polychlorinated biphenyls and hydrocarbons (KGS 2020). Groundwater samples were collected in all three areas of the AOC, including Area 1 in the southwestern most portion of the AOC, as well as upgradient of Area 3 to the northwest of the building near Barnum Road.

PFAS fingerprints for AOC 57 soil and groundwater are shown on Figure G-1. The data indicate:

- The former vehicle storage yard for the former motor repair shops appears to be the biggest PFAS source in AOC 57: the maximum soil detections of PFAS (43 micrograms per kilogram [µg/kg] of perfluorodecanoic acid [PFDA] and 17 µg/kg of perfluorooctane sulfonate [PFOS]) were measured at 5720SB-19-07 from 0 to 0.5 foot below ground surface (bgs), in the eroded drainage ditch adjacent to the former repair shops (KGS 2020). PFAS concentrations in groundwater are also elevated in this area and were the highest detected in AOC 57. The greatest detection of PFAS was 2,400 nanograms per liter (ng/L) of perfluorooctanoic acid (PFOA) at monitoring well 5702MW-20-05A, screened from 30 to 40 feet bgs and located hydraulically downgradient of the Area 2 release area. The groundwater samples in this area have a higher proportion of perfluorohexanesulfonic acid (PFHxS) than the groundwater samples to the north and northeast (Area 3), suggesting a different source in this area. PFHxS in this area may be partially derived from upgradient AOC 75 groundwater.
- In Area 3, PFAS were detected in soil samples and in groundwater at elevated concentrations, but at lower concentrations than in AOC 57 Area 2. The highest concentration groundwater samples predominantly contained perfluoroalkyl carboxylates, including PFOA, perfluoroheptanoic acid (PFHpA), and

perfluorohexanoic acid (PFHxA) (Figure G-1). 5703MW-20-02A screened from 30 to 40 feet bgs contained the maximum PFAS detection in Area 3 (870 ng/L PFOA in February 2020). Upgradient detections to the northwest of the building near Barnum Road. contained similar PFAS constituents PFHpA and PFHxA and at more elevated concentrations than the samples in Area 3, suggesting a PFAS source upgradient of the building that flows towards Cold Spring Brook.

- In Area 1, in the southwestern most portion of the AOC, maximum PFAS detections in groundwater are much lower than in Areas 2 and 3 (i.e., less than 100 ng/L total PFAS), and contain a similar PFAS fingerprint to groundwater in upgradient AOC 75. AOC 75 appears to be the source of PFAS contamination in Area 1 groundwater.

Soil and groundwater data, along with historical release information and water level measurements collected during Phase I activities indicate that the source of PFAS in groundwater at AOC 57 Areas 2 and 3 are releases to ground surface in areas previously characterized for other contaminants of concern. This is evident because the greatest PFAS detections are in the top 6 inches of soil in the swale adjacent to the parking lot in Area 2 and along the perimeter of the previous excavation performed, adjacent to the parking lot, in Area 3, as well as and the distribution in the magnitude of PFAS detections in groundwater in those areas. Based on water level measurements and vertical profile sampling data, groundwater containing PFAS flows to the south-southeast and discharges to Cold Spring Brook. Sampling of soil and groundwater at AOC 57 Area 1 indicate no local release of PFAS to that area. The PFAS fingerprint at that location matches that of AOC 75.

3 Barnum Road Firefighting Exercise Site (AOC 74)

The use of aqueous film-forming foam (AFFF) for firefighter training to the southeast of Building 3773 is the presumptive primary source of PFAS in AOC 74; some PFAS constituents that are atypical to AFFF in this area suggest another source type may have also affected the area. The highest soil PFAS concentrations are observed adjacent to the parking lot where AFFF was released, and the highest PFAS groundwater concentrations are also observed in and near this location. PFAS fingerprints for AOC 74 soil and groundwater are shown on Figure G-2. The data indicate:

- The highest concentration PFAS measured in AOC 74 soil are, in order of maximum concentration: n-ethyl perfluorooctane sulfonamide (EtFOSAA), PFDA, and PFOS. The greatest detection of PFAS was 12 µg/kg of EtFOSAA at 74SB-19-03 from 0 to 0.5 foot bgs. This location is adjacent to the rear of the parking lot where AFFF products were released to the ground surface. PFOS is a primary ingredient in AFFF, and EtFOSAA and PFDA are both possible impurities in AFFF and have similar organic carbon-water coefficient (KOC) values (Interstate Technology and Regulatory Council 2020). EtFOSAA is also a known precursor to PFOS. The presence of EtFOSAA in multiple soil samples in this area is surprising based on the current understanding of AFFF ingredients, and it is possible that an additional non-AFFF based PFAS source has affected this area.
- The highest concentration PFAS measured in AOC 74 groundwater are, in order of maximum concentration: PFOA, PFHxA, and PFHpA. The greatest detection of PFAS was 2,270 ng/L of PFOA at 74VP-18-05 from 52 to 56 feet bgs. This location is adjacent to the source area, and the three highest concentration compounds (PFOA, PFHxA, and PFHpA) are all major breakdown products of fluorotelomer-based AFFF and are more mobile PFAS than those detected in soils.

The greatest concentrations of PFAS detected in soil and groundwater are in and adjacent to the documented AFFF release area, to the rear of the parking lot and immediately hydraulically downgradient to the northeast, toward the Grove Pond wellfield. Generally, PFHxA is more enriched in groundwater located hydraulically downgradient from the source area, as it has the lowest KOC and is the most mobile in groundwater compared to PFOA and PFHpA.

Soil and groundwater data, along with historical release information and water level measurements collected during Phase I activities, indicate that the source of PFAS in groundwater at AOC 74 is a discharge of AFFF to ground surface in or adjacent to the parking lot behind the building. This source area/release location is evident because the highest historical PFAS detections in soil are within the top 6 inches to 3 feet of soil just south of the parking lot. In addition, the observed distribution of PFAS throughout the vadose zone (hydraulically downgradient) is indicative of leaching (potentially facilitated by stormwater runoff) over time from the release location into groundwater. Based on water level measurements and vertical profile sampling data, groundwater containing PFAS flows to the southeast and discharges to Cold Spring Brook, as well as flowing to the northeast toward the Grove Pond wellfield.

4 Former Building T-1445 Warehouse Fire (AOC 75)

The primary source of PFAS in AOC 75 was the use of a large quantity of AFFF to suppress a warehouse fire. PFAS fingerprints for AOC 75 soil and groundwater are shown on Figure G-3. The data indicate:

- The highest concentrations of PFAS measured in AOC 75 soil are, in order of maximum concentration: PFOS, PFOA, and PFDA. The greatest detection of PFAS was 2.0 µg/kg of PFOS and 1.2 µg/kg of PFOA at 75SB-19-09 from 0 to 0.5-foot bgs. This location is adjacent to the location of the Building T-1445 warehouse fire, where AFFF is documented to have been released.
- The highest concentrations of PFAS measured in AOC 75 groundwater are, in order of maximum concentration: PFOS, PFHxS, and PFOA. The greatest detection of PFAS was 1,160 ng/L of PFOS at 75VP-18-07 from 62 to 66 feet bgs. This location is adjacent to the soil sample location identified above that contained the highest concentrations of PFAS (75SB-19-09).

The greatest concentrations of PFAS in and adjacent to the AOC 75 source area are that of PFOS, known to be a primary ingredient in 3M-branded AFFF formulations that were approved for use by MilSpec. Downgradient from the source area/release location in groundwater (at 75MW-19-04A for example), PFHxS is the dominant compound in the PFAS fingerprint. PFHxS is a minor component of the PFAS fingerprint in soil because it is readily desorbed to water. PFHxS is both an ingredient of and breakdown product of precursors found in 3M-branded AFFF formulations. PFOA is found in relatively similar ratios in both soil and groundwater, is a breakdown product and/or constituent of AFFF, and is more mobile (has a lower estimated KOC) than PFOS.

Soil and groundwater data, along with historical release information and water level measurements collected during Phase I activities indicate that the source of PFAS in groundwater at AOC 75 is discharge of AFFF to ground surface to extinguish the T-1445 warehouse fire. However, there is no detailed information available on AFFF discharge during or following the fire. Phase I soil concentration data for this location indicate very low concentration detections through the area. This may be due to redevelopment of the area over time. The greatest dissolved detection of PFAS in a vertical profile location is at 75VP-19-01 (2,052 ng/L the sum of perfluorooctanesulfonic acid, perfluorooctanoic acid, perfluoronanoic acid, perfluorohexanesulfonic acid, perfluoroheptanoic acid, and perfluorodecanoic acid [collectively referred to as PFAS6]), adjacent to the location of former T-1445. Based on water level measurements and vertical profile sampling data, groundwater containing PFAS flows to the east and southeast, discharging to Cold Spring Brook.

Shallow soil and groundwater data collected to date at AOC 75 indicate that the source of PFAS to groundwater, and ultimately to surface water (Cold Spring Brook), has been identified adjacent to the location of the Building T-1445 warehouse fire.

5 Grove Pond Wellfield Area: Massachusetts Army National Guard Property and Former Building 3713 Area

The primary sources of PFAS in the Grove Pond wellfield are multiple releases related to vehicle maintenance and storage areas. Groundwater pumping in the wellfield enhanced PFAS movement towards the wells relative to what would have occurred under natural flow conditions. PFAS fingerprints for the Grove Pond wellfield area soil and groundwater are shown on Figure G-4. The data indicate:

- Elevated soil PFAS detections were found across the Grove Pond AOC. The highest concentration PFAS measured in Grove Pond wellfield area soil are, in order of maximum concentration: PFDA, PFOS, and EtFOSAA. The greatest detection of PFAS was 32 µg/kg of PFDA at GPSB-19-08 from 0 to 0.5 foot bgs. This sample was collected from surface soils located adjacent to the former buildings associated with the former vehicle maintenance repair, rebuilding, and cannibalization facility.
- The highest groundwater PFAS concentrations were measured in the northern part of the AOC, downgradient of the highest soil detections. The highest concentration PFAS measured in Grove Pond wellfield area groundwater are, in order of maximum concentration: PFHxA, PFHpA, PFOA, and PFOS. The greatest detection of PFAS was 1,200 ng/L of PFHxA at GPVP-19-05 from 82 to 86 feet bgs and appears to be related to upgradient AOC 74 releases. Most groundwater samples in the Grove Pond AOC are PFOA, PFHpA, and PFHxA dominant. GPVP-18-12, adjacent to the former pump house, contains a higher percentage of PFOS (30%, 510 ng/L PFOS) than surrounding samples and also contains the highest total PFAS concentration of any groundwater sample collected in the AOC.

In soils, PFDA was also the PFAS with the greatest detection at AOC 57 Area 2, where similar activities of vehicle storage, repair, and maintenance occurred. Detections of PFAS in soils across the area indicate that there may have been several discrete releases of similar materials to ground surface over time throughout the Grove Pond area, as all soil samples contained a similar fingerprint of predominantly PFDA, PFOS, and EtFOSAA.

Three vertical profile locations (5702VP-19-06, -07, and -09) sampled as part of AOC 57 work during Phase I, to the west of the 112 Barnum Road building, exhibit PFAS with a fingerprint similar to that of 5702VP-18-01 (located in the drainage ditch to the southwest of 112 Barnum Road), but PFAS in groundwater at these locations appears to be from a source that may be related to activities at the Former Building 3713, which were similar to those on the Massachusetts Army National Guard (MAARNG) property to the east.

Soil and groundwater data, along with historical use information and water level measurements collected during Phase I activities indicate that the source of PFAS in groundwater across the Grove Pond wellfield area are multiple releases of PFAS-containing materials associated with storage, maintenance, and cannibalization/rebuilding of motor vehicles. Phase I soil data indicate multiple small volume independent releases to ground surface occurred across the MAARNG property. Past use of the Former Building 3713 area was similar to that on the MAARNG property. Based on water level measurements, monitoring well data, and vertical profile sampling data, groundwater containing PFAS flows to the northeast toward Grove Pond and the Grove Pond wellfield, depending on the location. The Former Building 3713 area is on top of a groundwater divide where groundwater is also observed to flow southeast to Cold Spring Brook.

6 Cold Spring Brook Landfill (AOC 40) and Patton Water Supply Well Area

The primary source of PFAS in the Patton Water Supply Well Area/ AOC 40 Cold Spring Brook Landfill AOC is the former landfill. Maximum soil and groundwater PFAS detections occur immediately to the southeast of the former landfill. PFAS fingerprints for the Patton water supply well and AOC 40 area soil and groundwater are shown on Figure G-5. The data indicate:

- The highest concentration PFAS measured in soils collected at AOC 40 are for, in order of maximum concentration: PFOS, PFOA, and PFHxS. The greatest detection of PFAS was 4.3 µg/kg of PFOS at PWSB-19-02 from 0 to 0.5 foot bgs. This location is adjacent to the southeast of the former landfill. These concentrations are relatively low, which can be attributed to previous excavation and removal of landfill waste when Cold Spring Brook Pond was restored between 2000 and 2002 (KGS 2020).
- The highest concentration PFAS measured in AOC 40 and Patton water supply well area groundwater are, in order of maximum concentration: PFOA, PFHxA, and PFHpA. The greatest detection of PFAS was 380 ng/L of PFOA at PWVP-19-04 from 22 to 26 feet bgs. This location is adjacent to the southwest corner of the former landfill at AOC 40.

PFOS is dominant in soils and PFOA is dominant in groundwater due to PFOA's greater mobility (lower KOC) in both soils and groundwater. The ratio of PFHxA (six carbons) increases with increasing distance from the source area/release location, as groundwater travels hydraulically downgradient to vertical profiling locations PWVP-19-13 (to the southwest) and PWVP-19-06 (to the northeast), following the natural groundwater divide that separates the area.

Soil and groundwater data, along with historical release information and water level measurements collected during Phase I activities indicate that the source of PFAS in groundwater in the Patton water supply well area is AOC 40, a former landfill constructed at Cold Spring Brook Pond and later removed as a remedial action. The greatest concentrations of PFAS in soil identified during Phase I activities were in samples collected from 0 to 6 inches bgs along the southeast edge of Cold Spring Brook Pond. The greatest groundwater PFAS concentration was detected in a sample collected from PWVP-19-04 located near the southwest corner of Cold Spring Brook Pond, the former location of the AOC 40 landfill. Based on water level measurements and vertical profile sampling data, groundwater containing PFAS from AOC 40 flows both to the northeast along Cold Spring Brook (Cold Spring Brook Pond is the beginning of Cold Spring Brook) and to the southwest toward Patton water supply well and Mirror Lake (Figure G-5).

Less information is available regarding a potential source of PFAS in the Queenstown Road area between the Devens Consolidated Landfill and AOC 43G. Groundwater samples collected southeast/hydraulically downgradient of Queenstown Road in this area exhibit low concentrations of PFAS (typically less than 100 ng/L PFAS6). A monitoring well pair will be installed upgradient of this area to better understand the source of the dilute PFAS plume to the west-northwest of the Patton water supply well.

7 Historical Gas Station J (AOC 43J) and Shabokin Water Supply Well Area

The source of PFAS in the Shabokin Water Supply Well/AOC 43J Historical Gas Station J AOC has not been confirmed. Existing PFAS detections in this AOC are relatively low compared to the other Area 1 AOCs and are not indicative of a major point source: the greatest groundwater detection of PFAS was 29 ng/L of PFOA at AOC 43J monitoring well XJM-94-07X, screened from 3.7 to 13.7 feet bgs. This shallow monitoring well is located just hydraulically downgradient of the parking lot of AOC 43J, where USTs and former dry wells and cesspools were in place in the past to support gas station, motor pool, and vehicle storage and maintenance at the property. The highest concentration PFAS measured in groundwater are, in order of maximum concentration: PFOA, PFHxS, and PFOS. PFAS fingerprints for AOC 43J and the Shabokin water supply well area groundwater area shown on Figure G-6.

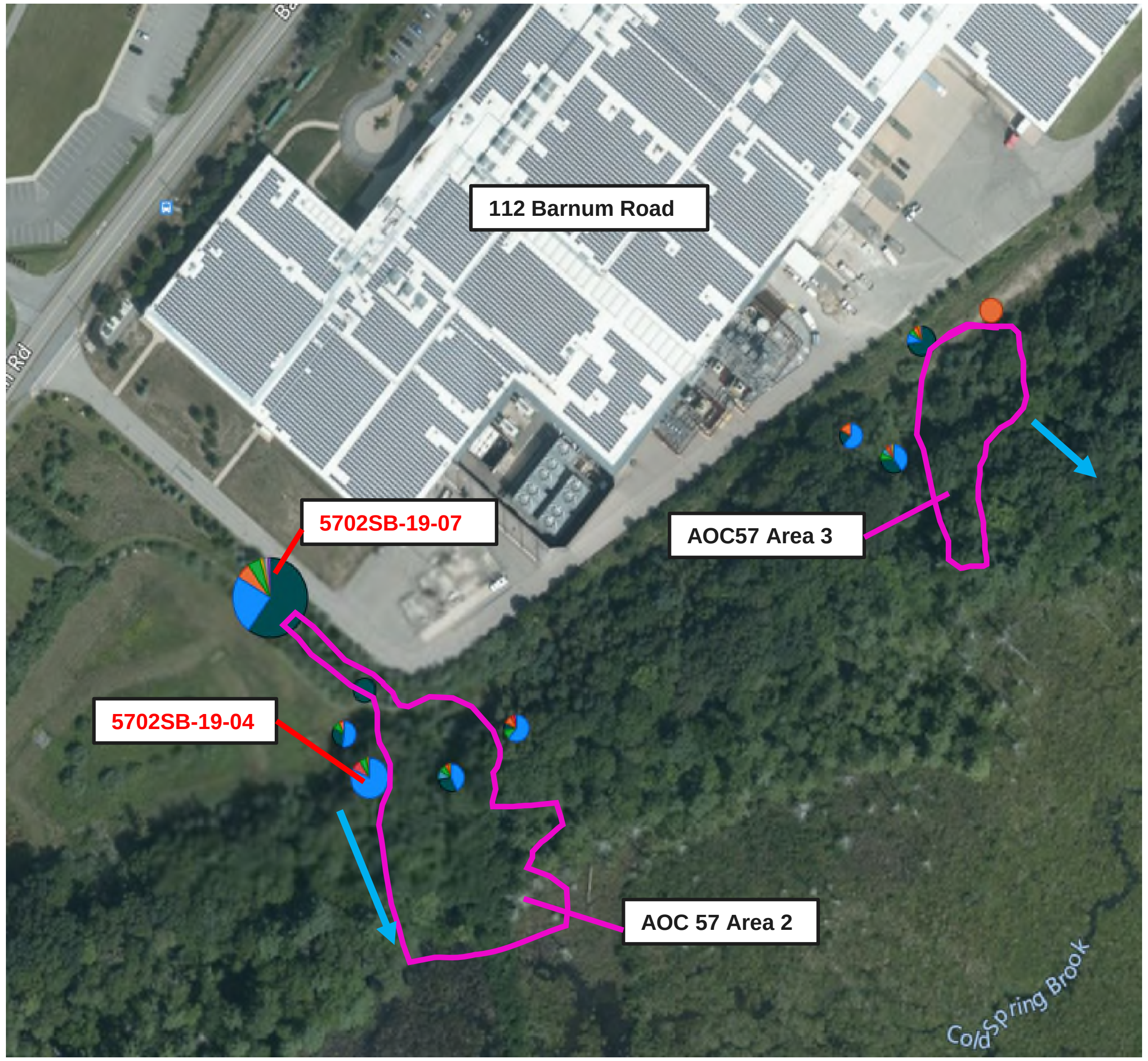
Groundwater data, historical release information, and water level measurements collected during Phase I activities indicate that the source of PFAS in groundwater in the Shabokin water supply well area is most likely AOC 43J, though as mentioned above, the PFAS detections in groundwater at this location are low in concentration both at and immediately downgradient of AOC 43J and throughout the entire Shabokin supply well area, and do not point to an ongoing source. Based on water level measurements and vertical profile sampling data, groundwater containing PFAS from AOC 43J flows both south and southeast to discharge to Mirror Lake. The Shabokin water supply well draws groundwater that originates from Mirror Lake, as well as groundwater from the east and west of Mirror Lake. As noted above, groundwater from AOC 40 discharges to Mirror Lake and to Cold Spring Brook Pond. Because of this, it is possible that there may be a contribution to Mirror Lake from AOC 40, and relatedly, a contribution from AOC 40 to the Shabokin supply well, particularly during periods when the Patton supply well may have been offline. Concentrations of PFAS6 in monitoring wells and vertical profile samples across this area are relatively low, generally ranging from 30 to 50 ng/L PFAS6.

8 References

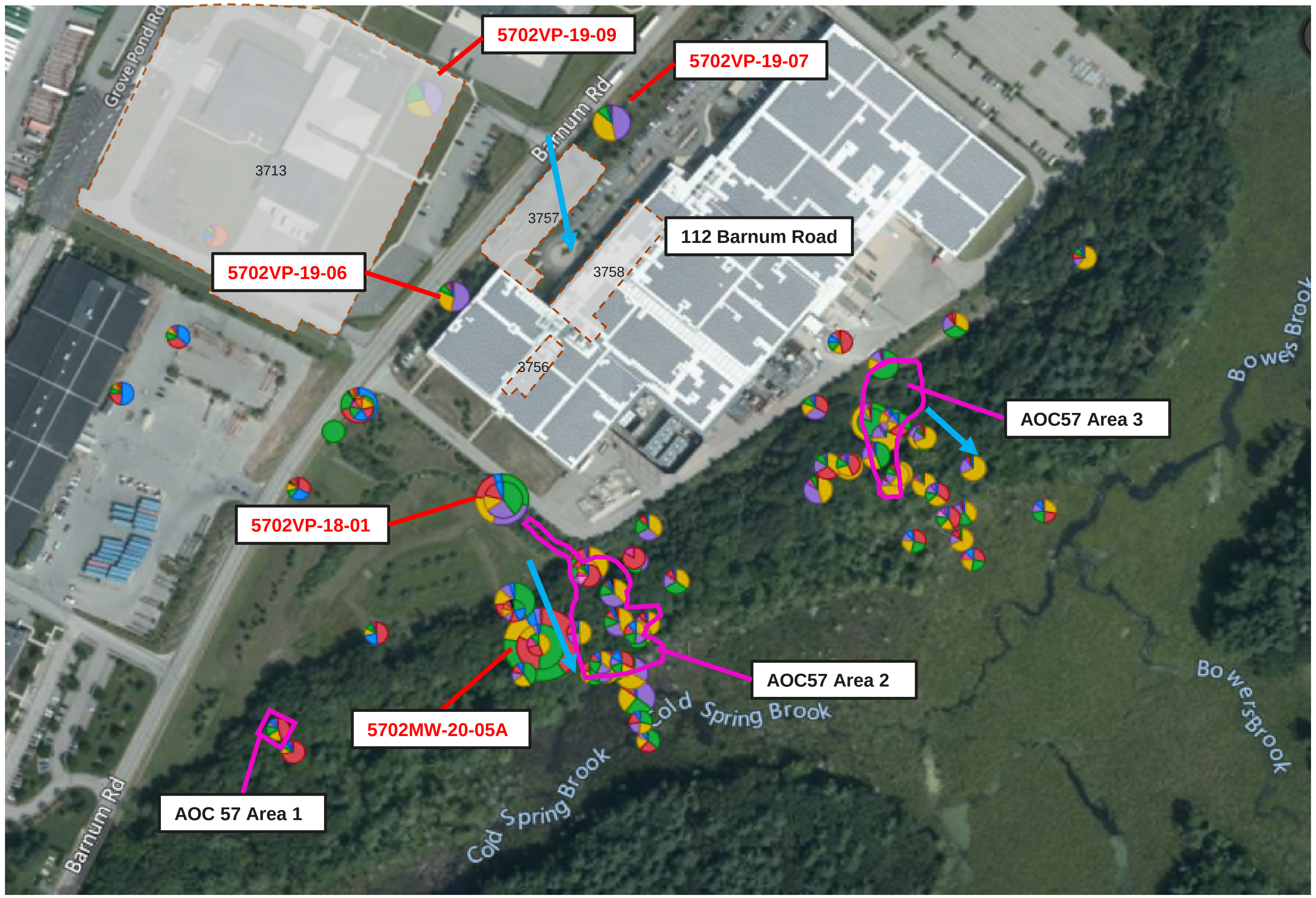
Interstate Technology and Regulatory Council. 2020. ITRC. 2020b. PFAS Technical and Regulatory Guidance Document. Available online at: https://pfas-1.itrcweb.org/. September.

KGS. 2020. Area 1 Preliminary Site Characterization Summary Per- and Polyfluoroalkyl Substances (PFAS) Remedial Investigation, Former Fort Devens Army Installation, Devens, MA. June.

Figures



Maximum Detection of PFAS in Soil



Maximum Detection of PFAS in Groundwater and Surface Water

Analyte

● 6:2 FtS
● 8:2 FtS
● EtFOSAA
● MeFOSAA
● PFBS
● PFDA
● PFHpA
● PFHxA
● PFHxS
● PFNA
● PFOA
● PFOS

Acronyms

1. 6:2 FtS = 6:2 fluorotelomer sulfonate
2. 8:2 FtS = 8:2 fluorotelomer sulfonic acid
3. EtFOSAA = N-ethyl perfluorooctane sulfonamidoacetic acid
4. NMeFOSAA = N-methylperfluorooctane sulfonamidoacetic acid
5. PFBS = perfluorobutanesulfonic acid
6. PFDA = perfluorodecanoic acid
7. PFHpA = perfluoroheptanoic acid
8. PFHxA = perfluorohexanoic acid
9. PFHxS = perfluorohexanesulfonic acid
10. PFNA = perfluorononanoic acid
11. PFOA = perfluorooctanoic acid
12. PFOS = perfluorooctanesulfonic acid

Note

The size of the pie chart is proportional to the sum of the PFAS concentrations. Larger pie charts indicate higher total PFAS concentrations.

→ Interpreted Groundwater Flow Direction

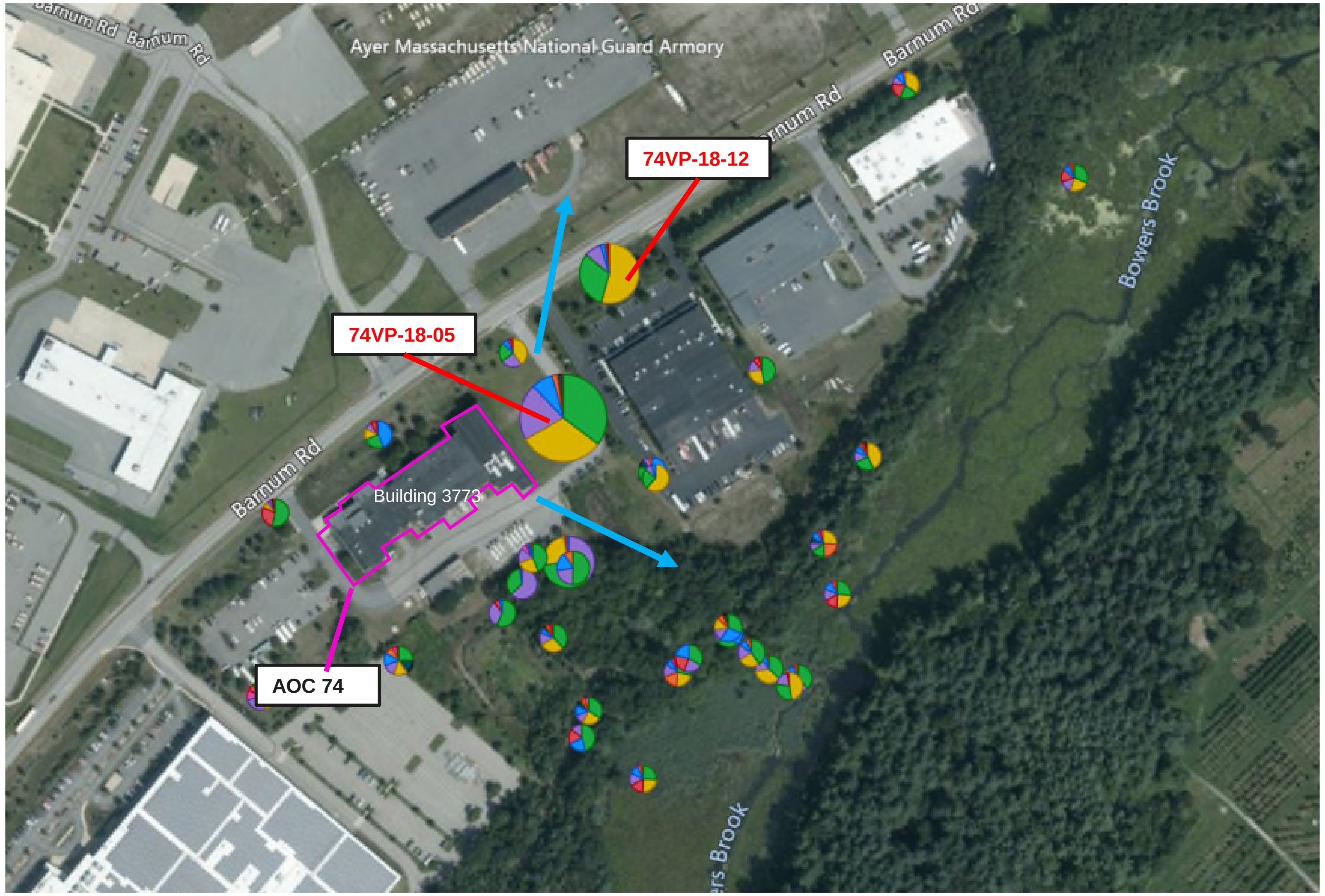
PHASE II REMEDIAL INVESTIGATION WORK PLAN - AREA 1
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

FORMER VEHICLE STORAGE AND MOTOR REPAIR SHOPS (AOC 57) PFAS COMPOSITION

SERES
Engineering & Services, LLC
ARCADIS
a joint venture

FIGURE
G-1

Maximum Detection of PFAS in Soil



Maximum Detection of PFAS in Groundwater and Surface Water

Analyte

- ● 6:2 FtS
- ● 8:2 FtS
- ● EtFOSAA
- ● MeFOSAA
- ● PFBS
- ● PFDA
- ● PFHpA
- ● PFHxA
- ● PFHxS
- ● PFNA
- ● PFOA
- ● PFOS

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6. PFDA = perfluorodecanoic acid
7. PFHpA = perfluoroheptanoic acid
8. PFHxA = perfluorohexanoic acid
9. PFHxS = perfluorohexanesulfonic acid
10. PFNA = perfluoranonaic acid
11. PFOA = perfluorooctanoic acid
12. PFOS = perfluorooctanesulfonic acid

Note

The size of the pie chart is proportional to the sum of the PFAS concentrations. Larger pie charts indicate higher total PFAS concentrations.

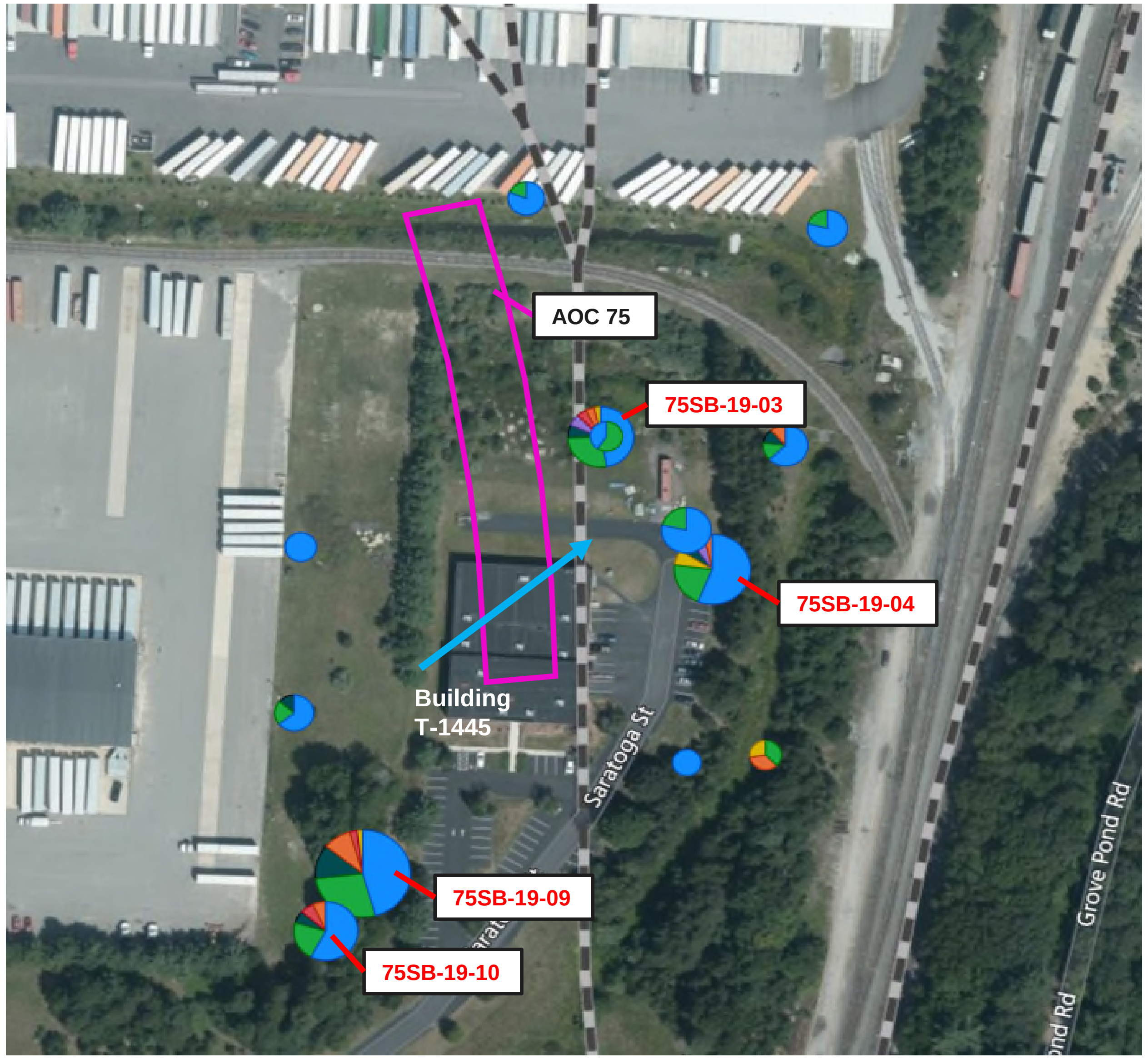
→ Interpreted Groundwater Flow Direction

PHASE II REMEDIAL INVESTIGATION WORK PLAN - AREA 1
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

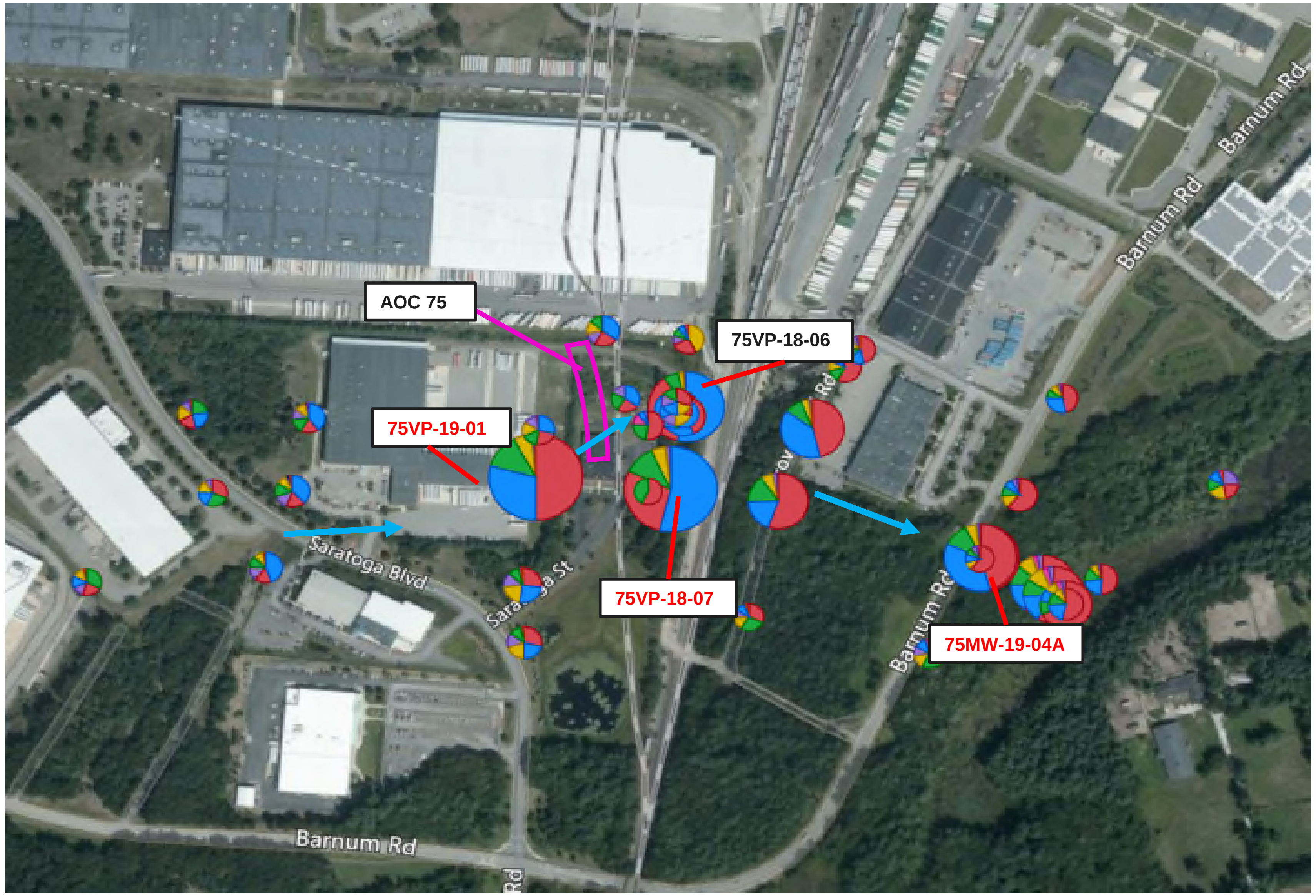
BARNUM ROAD FIREFIGHTING EXERCISE SITE (AOC 74) PFAS COMPOSITION

SERES Engineering & Services, LLC
ARCADIS
a joint venture

FIGURE
G-2



Maximum Detection of PFAS in Soil



Maximum Detection of PFAS in Groundwater and Surface Water

Analyte

- ● 6:2 FtS
- ● 8:2 FtS
- ● EtFOSAA
- ● MeFOSAA
- ● PFBS
- ● PFDA
- ● PFHpA
- ● PFHxA
- ● PFHxS
- ● PFNA
- ● PFOA
- ● PFOS

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6. PFDA = perfluorodecanoic acid
7. PFHpA = perfluoroheptanoic acid
8. PFHxA = perfluorohexanoic acid
9. PFHxS = perfluorohexanesulfonic acid
10. PFNA = perfluorononanoic acid
11. PFOA = perfluorooctanoic acid
12. PFOS = perfluorooctanesulfonic acid

Note

The size of the pie chart is proportional to the sum of the PFAS concentrations. Larger pie charts indicate higher total PFAS concentrations.

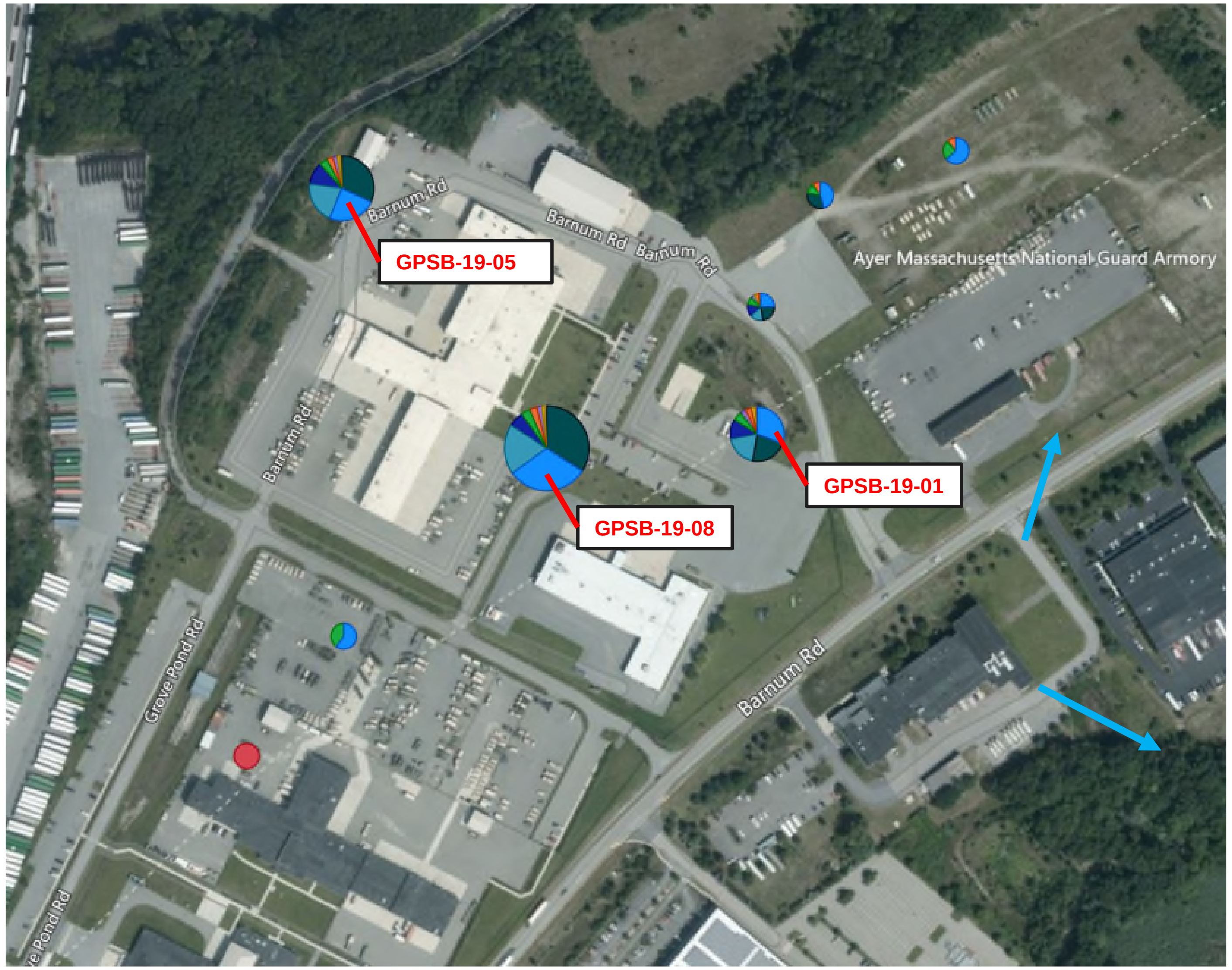
→ Interpreted Groundwater Flow Direction

PHASE II REMEDIAL INVESTIGATION WORK PLAN - AREA 1
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

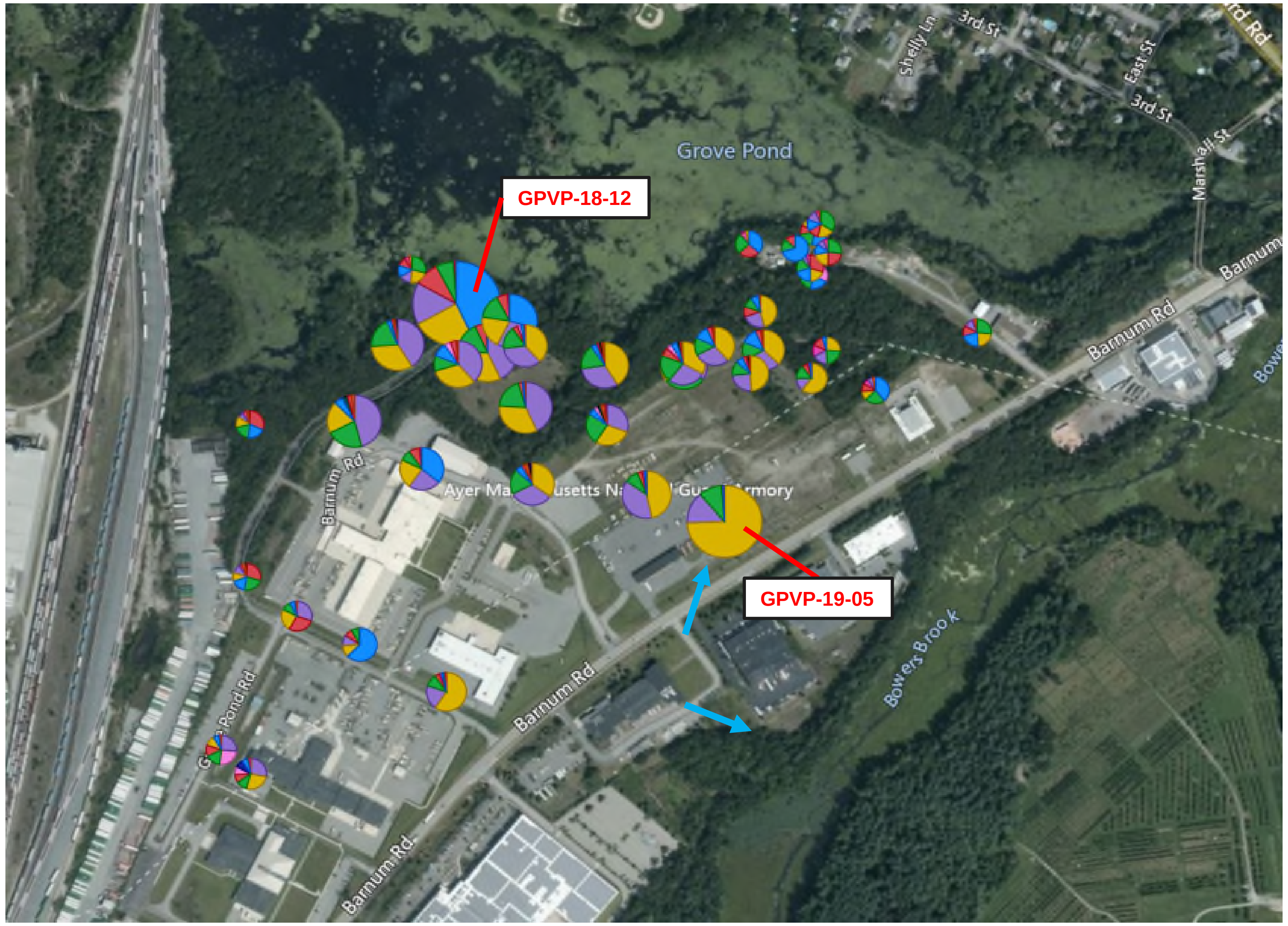
FORMER BUILDING T-1445 WAREHOUSE FIRE (AOC 75) PFAS COMPOSITION

SERES Engineering & Services, LLC
ARCADIS
a joint venture

FIGURE
G-3



Maximum Detection of PFAS in Soil



Maximum Detection of PFAS in Groundwater and Surface Water

Analyte

- ● 6:2 FtS
- ● 8:2 FtS
- ● EtFOSAA
- ● MeFOSAA
- ● PFBS
- ● PFDA
- ● PFHpA
- ● PFHxA
- ● PFHxS
- ● PFNA
- ● PFOA
- ● PFOS

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7. PFHpA = perfluoroheptanoic acid
8. PFHxA = perfluorohexanoic acid
9. PFHxS = perfluorohexanesulfonic acid
10. PFNA = perfluorononanoic acid
11. PFOA = perfluorooctanoic acid
12. PFOS = perfluorooctanesulfonic acid

Note

The size of the pie chart is proportional to the sum of the PFAS concentrations. Larger pie charts indicate higher total PFAS concentrations.

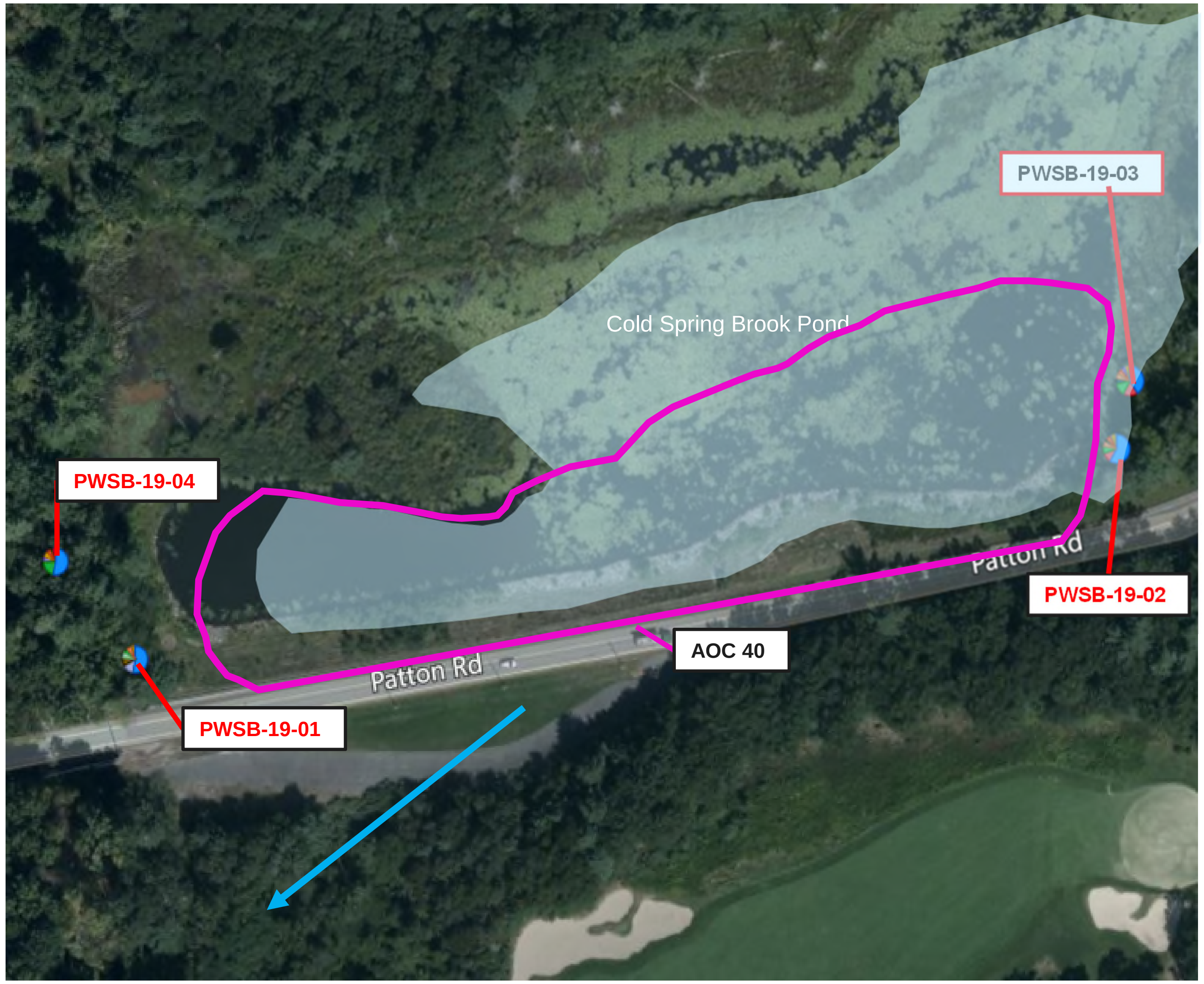
→ Interpreted Groundwater Flow Direction

PHASE II REMEDIAL INVESTIGATION WORK PLAN - AREA 1
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

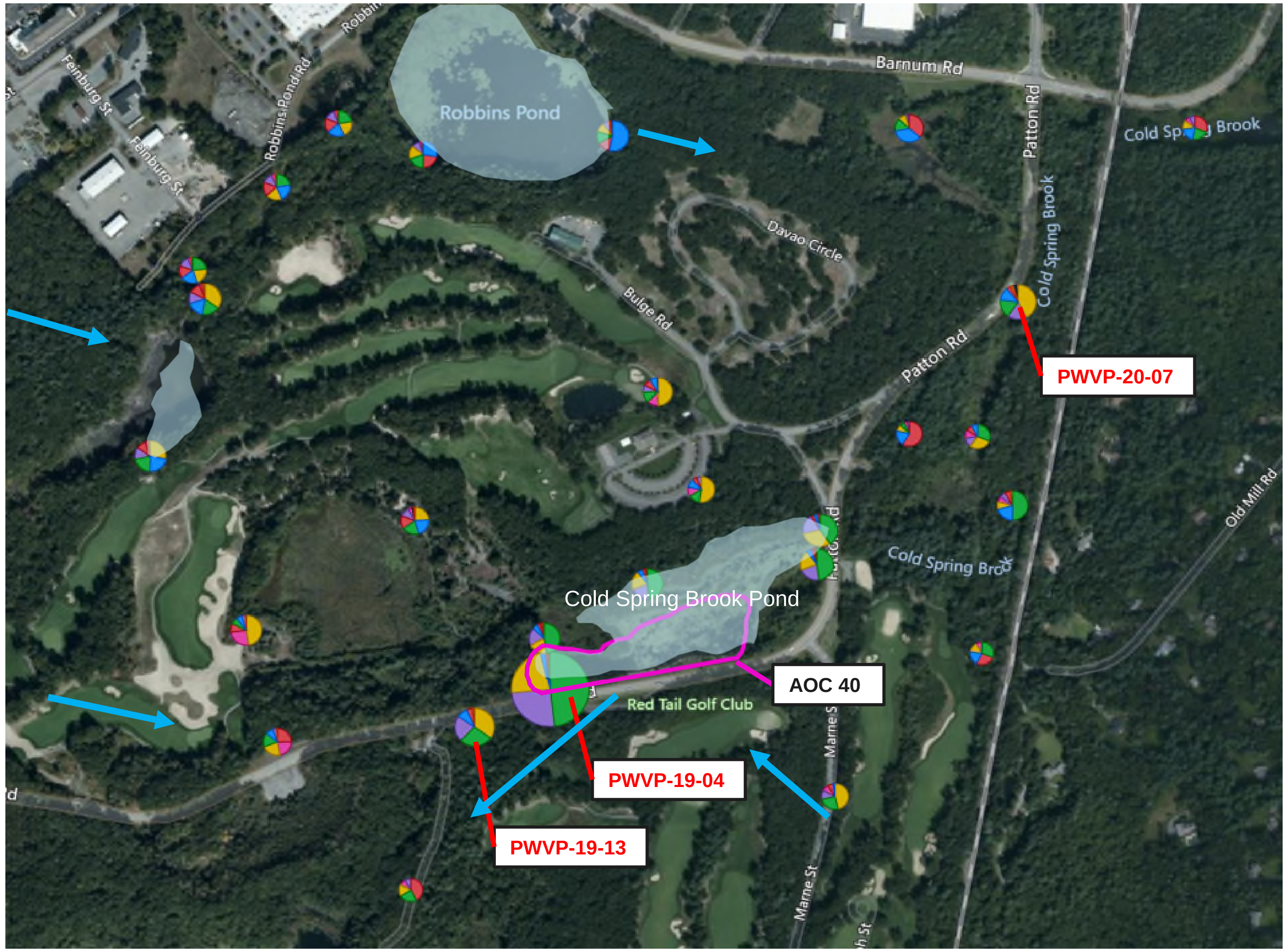
GROVE POND WELLFIELD AREA
PFAS COMPOSITION

SERES Engineering & Services, LLC
ARCADIS
a joint venture

FIGURE
G-4



Maximum Detection of PFAS in Soil



Maximum Detection of PFAS in Groundwater and Surface Water

Analyte

● 6:2 FtS
● 8:2 FtS
● EtFOSAA
● MeFOSAA
● PFBS
● PFDA
● PFHpA
● PFHxA
● PFHxS
● PFNA
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8. PFHxA = perfluorohexanoic acid
9. PFHxS = perfluorohexanesulfonic acid
10. PFNA = perfluoronanoic acid
11. PFOA = perfluorooctanoic acid
12. PFOS = perfluorooctanesulfonic acid

Note

The size of the pie chart is proportional to the sum of the PFAS concentrations. Larger pie charts indicate higher total PFAS concentrations.

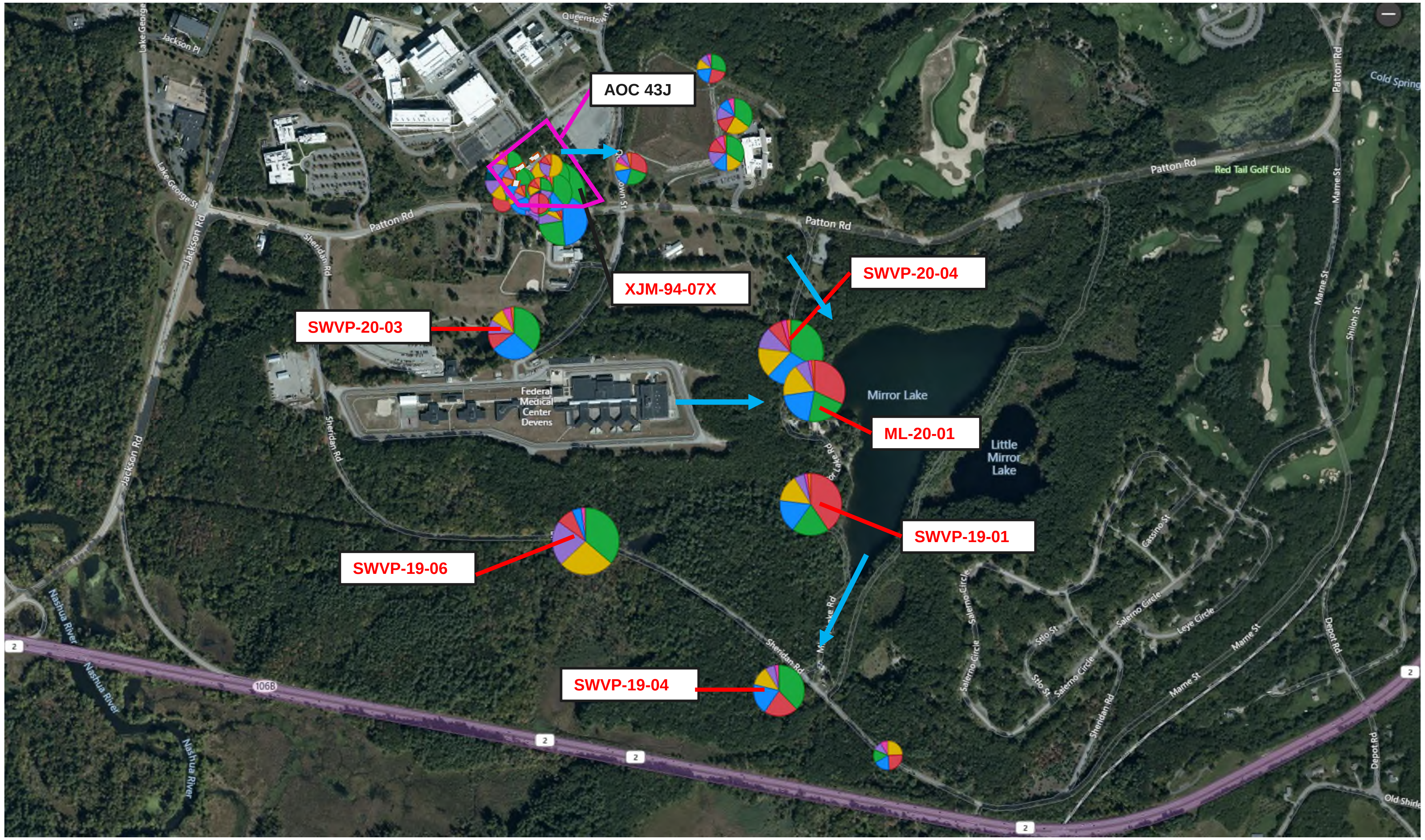
→ Interpreted Groundwater Flow Direction

PHASE II REMEDIAL INVESTIGATION WORK PLAN - AREA 1
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

COLD SPRING BROOK LANDFILL (AOC 40) & PATTON WATER SUPPLY WELL AREA PFAS COMPOSITION

SERES Engineering & Services, LLC
ARCADIS
a joint venture

FIGURE
G-5



Maximum Detection of PFAS in Groundwater and Surface Water

Analyte

● 6:2 FtS
● 8:2 FtS
● EtFOSAA
● MeFOSAA
● PFBS
● PFDA
● PFHpA
● PFHxA
● PFHxS
● PFNA
● PFOA
● PFOS

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8. PFHxA = perfluorohexanoic acid
9. PFHxS = perfluorohexanesulfonic acid
10. PFNA = perfluorononanoic acid
11. PFOA = perfluorooctanoic acid
12. PFOS = perfluorooctanesulfonic acid

Note

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→ Interpreted Groundwater Flow Direction

PHASE II REMEDIAL INVESTIGATION WORK PLAN - AREA 1
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

HISTORICAL GAS STATION J (AOC 43J) & SHABOKIN WATER SUPPLY WELL AREA PFAS COMPOSITION

SERES Engineering & Services, LLC
ARCADIS
a joint venture

FIGURE
G-6

Maximum Detection of PFAS in Groundwater and Surface Water

Analyte

- ● 6:2 FtS
- ● 8:2 FtS
- ● EtFOSAA
- ● MeFOSAA
- ● PFBS
- ● PFDA
- ● PFHpA
- ● PFHxA
- ● PFHxS
- ● PFNA
- ● PFOA
- ● PFOS

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6. PFDA = perfluorodecanoic acid
7. PFHpA = perfluoroheptanoic acid
8. PFHxA = perfluorohexanoic acid
9. PFHxS = perfluorohexanesulfonic acid
10. PFNA = perfluoronanoic acid
11. PFOA = perfluorooctanoic acid
12. PFOS = perfluorooctanesulfonic acid

Note

The size of the pie chart is proportional to the sum of the PFAS concentrations. Larger pie charts indicate higher total PFAS concentrations.

→ Interpreted Groundwater Flow Direction

PHASE II REMEDIAL INVESTIGATION WORK PLAN - AREA 1
FORMER FORT DEVENS ARMY INSTALLATION
DEVENS, MASSACHUSETTS

HISTORICAL GAS STATION G (AOC 43G) PFAS COMPOSITION

SERES Engineering & Services, LLC
ARCADIS
a joint venture

FIGURE
G-7

Appendix H

Remedial Investigation Implementation Methodology

FINAL

United States Army Corps of Engineers
New England District

Appendix H – Remedial Investigation Implementation Methodology

Phase II Remedial Investigation Work Plan and Quality Assurance Project Plan Addendum for Per- and Polyfluoroalkyl Substances

Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

Contract No. W912WJ-19-D-0014

Contract Delivery Order No. W912WJ-20-F-0022

Contents

Figures

Acronyms and Abbreviations

2D	two dimensional
Devens	former Fort Devens Army Installation
DO	dissolved oxygen
gpm	gallon per minute
gpm/foot	gallon per minute per foot
JV	joint venture
LLC	Limited Liability Company
ORP	oxidation-reduction potential
PFAS	per- and polyfluoroalkyl substances
PSW	passive surface wave
PVC	polyvinyl chloride
QAPP Addendum	Addendum for Phase II to the I Uniform Federal Policy for Quality Assurance Project Plan, Remedial Investigation for Per- and Polyfluoroalkyl Substances (PFAS)
Refraction	P-wave refraction
RI WP	Phase II Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances
SERES-Arcadis JV	SERES-Arcadis Joint Venture, Limited Liability Company
SPAC	spatial autocorrelation
TGI	technical guidance instruction

1 Introduction

This appendix to the Phase II Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances (PFAS) describes the remedial investigation (RI) and implementation methodology for field activities for Area 1 at the former Fort Devens Army Installation (Devens), located in Devens, Massachusetts. Field activities will be conducted in accordance with the following technical guidance instructions (TGIs), which are included in the Addendum for Area 1 – Phase II to the I Uniform Federal Policy for Quality Assurance Project Plan, Remedial Investigation for Per- and Polyfluoroalkyl Substances (PFAS) (QAPP Addendum; provided as Appendix A):

- TGI - Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling (all media) Guidance
- TGI – PFAS Sampling Procedures and Low-Flow Groundwater Purging for Monitoring Wells
- TGI - Equipment and Reagent Blank Sample Collection for PFAS Analysis
- TGI – Utility Location
- TGI - PFAS Drilling and Well Installation
- TGI – Monitoring Well Development
- TGI - Manual Water-Level Monitoring
- TGI - In-Situ and Ex-Situ Water Quality Parameters
- TGI - Sample Chain of Custody
- TGI - Investigation-Derived Waste Handling and Storage
- TGI – Groundwater and Soil Sampling Equipment Decontamination
- TGI – Soil Description
- TGI – Sediment, Surface Water, and Stormwater Sample Collection for PFAS Analysis
- TGI – Vertical Aquifer Profiling
- TGI – Fish Sampling Procedures
- TGI – Field Processing for Fish Samples Procedures
- TGI - Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells.

2 Site Preparation

Before any intrusive activities, the SERES-Arcadis Joint Venture (JV), Limited Liability Company (LLC)[1] (hereafter referred to as the SERES-Arcadis JV) will implement the following utility locating procedures:

- Notify the Massachusetts Digsafe System a minimum of 72-hours before any intrusive field work for underground utility clearance.
- Clear each drilling location of utilities with ground-penetrating radar.
- Conduct a detailed visual site inspection and review existing plans for possible utilities that potentially conflict with the planned activities.

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[1] The SERES-Arcadis JV is composed of protégé firm SERES Engineering & Services, LLC and its mentor, Arcadis U.S., Inc.

- Use a soft dig method to a depth of 5 feet bgs to further clear the proposed locations before advancing any borings.

In addition to the utility location, each property owner will be notified of the planned field activities a minimum of 30 days before the start of intrusive activities. As described in the sections below, several locations are anticipated to be located in public rights-of-way or on private property. For these locations, access agreements will be pursued, and no work will be conducted until a signed access agreement is executed by the property owner(s), SERES-Arcadis JV, and U.S. Army Corps of Engineers. For any locations on or adjacent to public rights-of-way, the SERES-Arcadis JV will complete a traffic safety assessment and use a police detail if needed.

SERES-Arcadis JV field personnel will complete the site-specific munitions and explosives of concern awareness training with the Devens Fire Department before the start of field activities. Field personnel will also have current health and safety training as required by state/federal regulations, such as 40-hour Hazardous Waste Operations and Emergency Response training. Additional requirements are outlined in the SSHP. Personnel responsible for overseeing drilling operations will have at least 5 years of prior relevant drilling experience.

3 Seismic Profile Surveying

The SERES-Arcadis JV has incorporated the available information on bedrock into the Area 1 conceptual site model, and some uncertainty remains regarding bedrock topography and depth to competent bedrock. To properly site the locations of monitoring wells and improve the overall conceptual site model, the SERES-Arcadis JV will complete a seismic geophysical survey. Seismic methods are sensitive to the density, compressional, and shear strengths of the soil and rock. The contrast between the crystalline bedrock and the overlying alluvium makes seismic technologies particularly suitable.

One of two seismic methods will be employed, depending on site conditions. For areas where linear, unobstructed pathways of between 2000 and 4000 feet in length are available (length depends on the depth to bedrock), standard P-wave refraction (refraction) will be completed as the preferred means to determine depth to bedrock. The P-wave velocities of the alluvium and bedrock, which are the outputs from the Refraction method, are directly relatable to the rock strength, which in this case is directly related to the competence of the crystalline bedrock. Lithology and/or degree of fracturing in the bedrock may be revealed by variations of the bedrock's P-wave velocity. However, because much of the site does not meet the requirements for Refraction due to limited access to straight pathways of sufficient length caused by wooded areas, streams and wetlands, the passive surface wave (PSW) method is a good alternative method to Refraction. PSW seismic data will be gathered using the two-dimensional (2D) spatial autocorrelation (SPAC) method. The analysis of the data will be dependent on the actual location and length of the profile lines.

3.1 Seismic Methods

For Refraction surveys, the seismic energy used for analysis is in the form of actively controlled percussive blows to the ground surface which sends body waves through the subsurface (body waves travel in all directions within the subsurface). The rate of travel of the seismic body waves (i.e., the velocity) varies with material type and relative condition of the material (e.g., massive vs. fractured rock). When the body wave encounters a material of differing, higher velocity, some of the seismic energy is refracted along the top of the deeper layer. The most common boundaries of this type are the water table and the top of bedrock. The fastest moving body wave, the P-wave, always arrives first, followed by the slower S-wave, and finally by a train of slow-moving surface waves (i.e., waves that radiate along the ground surface. The seismograph can record the entire train of body and surface waves, although the objective is to assure capture of the body waves for analysis. By measuring how long the refracted P-waves travel in the subsurface using a series of evenly spaced geophone sensors placed in a straight line, analysis can determine the elevation of the bedrock interface and the velocity of the soil and bedrock. Survey design is based on the anticipated depth to bedrock – the deeper bedrock is, the longer the refraction layout must be. The final output is a 2D cross-section of the seismic strata (generally two layers, alluvium and bedrock).

As noted above, much of the site is not appropriate for Refraction method due to site conditions. The alternative means to determine depth to bedrock is to record the naturally occurring (passively generated) train of surface waves. In this case, the combined ground motions created by traffic, railroads, machinery, and other manmade, non-directional sources of seismic surface wave energy can be used to assess the depth to bedrock. The PSW method is an effective way of obtaining the seismic stratigraphy (essentially two layers, alluvium, and bedrock). Using the same geophones and seismograph used for Refraction, the PSW data are passively recorded over a larger time window (up to several minutes) to obtain ambient vibrations. Generally, a circular group of sensors is place around a selected point to gather the surface wave energy. The analysis of the PSW data is used to create a series of one-dimensional models of the seismic stratigraphy.

One of two seismic methods will be employed, depending on site conditions. For areas where linear, unobstructed pathways of between 2,000 and 4,000 feet in length are available (length depends on the depth to bedrock), standard P-wave Refraction (Refraction) will be completed as the preferred means to determine depth to bedrock. The P-wave velocities of the alluvium and bedrock, which are the outputs from the Refraction method, are directly relatable to the rock strength, which in this case is directly related to the competence of the crystalline bedrock. Lithology and/or degree of fracturing in the bedrock may be revealed by variations of the bedrock's P-wave velocity. However, because much of the site does not meet the requirements for Refraction due to limited access to straight pathways of sufficient length caused by wooded areas, streams and wetlands, the PSW method is a good alternative method to Refraction. PSW seismic data will be gathered using the 2D SPAC method. Regardless of which of the two seismic methods, the same data recording equipment will be used, and the main difference is in the way data is collected. Note that in the SPAC method an active energy source is not required, whereas with Refraction the active energy source is essential. The follow sections explain the methods, equipment, field procedures and data processing steps.

Seismic geophysical methods provide image about the subsurface using the physical motion in water, soil or rock trigger by the release of mechanical energy at or below the ground surface (the source is commonly referred to as a "shot"). The entire wave train radiating from the energy source operates in two distinct modes – body waves and surface waves. Body waves (called P-waves and S-waves) travel outwards from the source in three dimensions all directions from the location of the energy release. Following behind the fast-moving body waves, and traveling at the slowest speeds are surface waves, which travel along the ground surface in a 2-dimensional spread parallel to the ground surface. Figure H-1 below illustrates the wave train.

The most common natural sources of seismic energy are earthquakes, thunder, wind, and rock falls. For shallow (hundreds to thousands of feet in depth) near surface studies, the value of naturally occurring sources of energy is difficult to plan for because the timing of these events is nearly unpredictable at a practical scale[2]. Rather, for shallow subsurface imaging using a controlled, active source of mechanical energy (e.g., percussive blow from a hammer or heavy weight, explosives, or release of compressed air in aquatic settings) is synchronized

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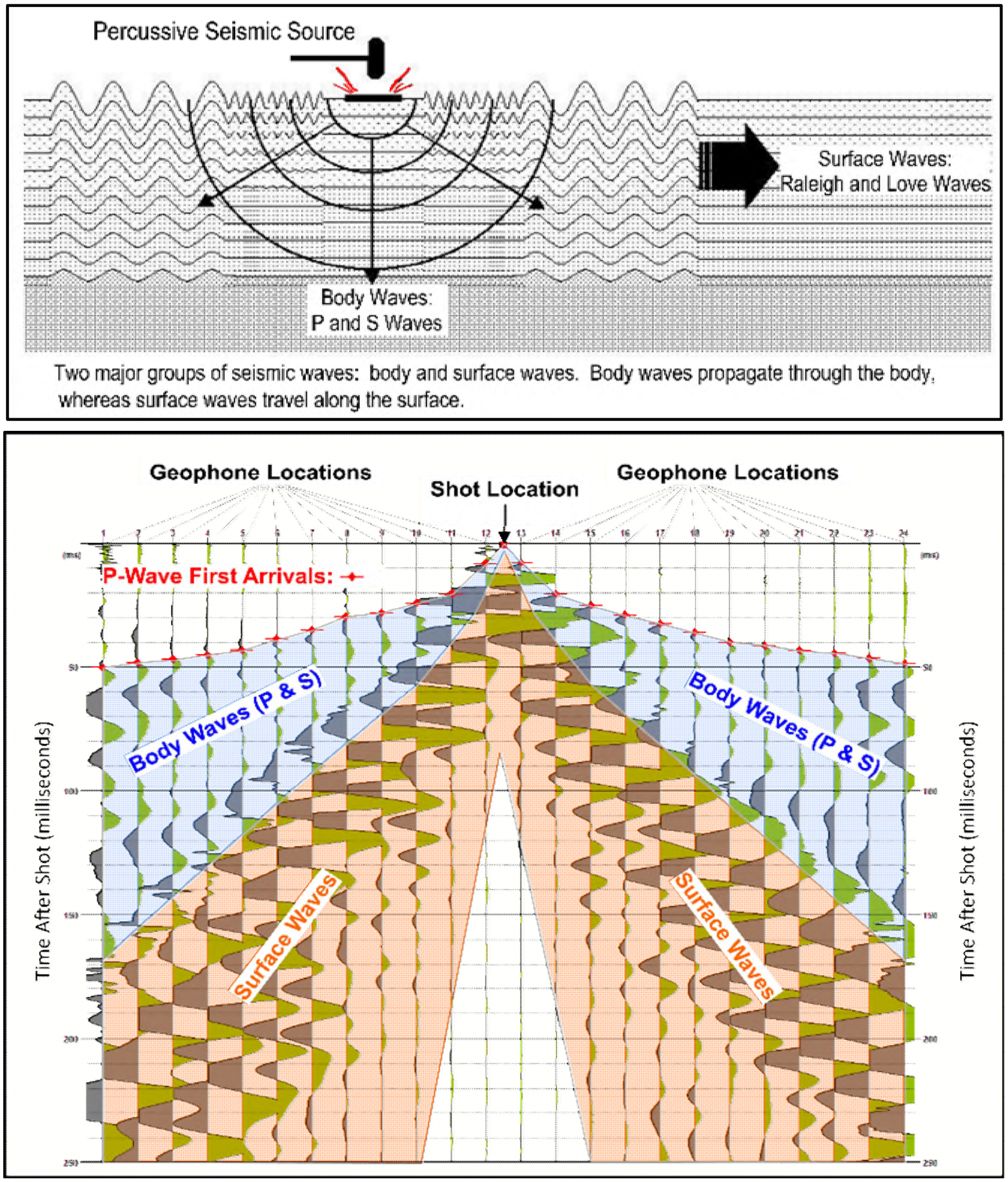
[2] Large earthquakes, however, are extremely valuable to earth scale studies and have allowed geophysicists to develop a detailed understanding of the nature of the earth's interior.

(“triggered”) with the start of data collection. Since the data collection is closely tied in space and time to the energy source, some of the most accurate and useful seismic methods take advantage of the fastest moving of the seismic waves (the leading wave of a seismic wave train is known as a P-wave). The P-wave travels through the earth radially from the energy source and when a boundary of differing materials is encounter some of the energy is reflected back to the surface, some is refracted along the layer boundary, and the rest of the energy passes into the deeper layer and continues into the earth until another layer boundary is reached. The methods known as Seismic Reflection and Seismic Refraction use the P-wave energy from controlled sources, although for relatively simple, shallow bedrock surface mapping Seismic Refraction is more than adequate. Seismic reflection is generally far more expensive and time consuming, requiring much more elaborate data processing and is usually only justified in situations where much deeper (thousands to tens of thousands of feet of penetration are needed). The largest used of Seismic Reflection is in the oil and gas industry.

Because the source of energy is synchronized and the timing can be set with great precision, the amount of time needed to record the body waves is on the scale of a few hundred milliseconds. Both methods have rigid requirements in terms of data collection in that they both need the data sensors (geophones) to be evenly spaced along straight-line pathways. Moreover, both methods suffer from the presence of elevated amounts of unwanted, randomly occurring natural and anthropogenic energy sources. To be successful in noisy environments a combination of higher energy per shot and repetition of shots (“stacking”) is required. In the most extreme noisy environments, it may not be possible to generate enough controlled percussive energy to overcome the background noise.

To cope with site conditions which either do not allow data collection along well-defined straight-line paths and or where excessive noise may obviate the use of active sources, a second family of seismic methods is available using the slower moving, random natural and anthropogenic surface waves. Known as passive seismic methods, the intent is to record ground motion over a relatively long period of time (many minutes) with the assumption that the random seismic energy (surface waves) is approaching the recording site from multiple directions. In this case it is only the surface waves (known as Raleigh and Love Waves) that are used in data analysis. Rather than a direct recording of a refracted or reflect wave, these methods rely on how earth layering modifies the nature of the surface waves as they travel along the surface. There is no need for an active source, which simplifies data collection, but the analysis of the surface waves is more complex and requires more processing time and experience. Nevertheless, this method is a good substitute for the body wave methods where site conditions preclude their use.



Two major groups of seismic waves: body and surface waves. Body waves propagate through the body, whereas surface waves travel along the surface.

Figure H-1. Seismic Waves Created by Percussive Energy Sources.

Note: Top diagram shows the relationship of the two principal types of seismic waves, body waves and surface waves. The lower diagram illustrates an actual seismic record gathered during a refraction survey. The first arrivals of the fastest P-waves are used to model stratification. In this case three seismic layers are interpretable. Beneath the first arrivals in time are other body waves (blue shading). In orange shading are the surface waves which are the slowest moving seismic waves. The SPAC method performs analysis on the surface waves that are randomly generated by various noise sources such as vehicles and machinery, resulting in seismic stratification.

3.1.1 Seismic Refraction

As shown in the lower half of Figure H-2 below, for refraction surveys, the seismic energy in the form of percussive blows to the ground surface radiates body waves through the subsurface. The rate of travel of the seismic body waves (i.e., the velocity) varies with material type and relative condition of the material (e.g., massive vs. fractured rock). When the body wave encounters a material of differing, higher velocity, some of the seismic energy is refracted along the top of the deeper layer. The most common boundaries of this type are the water table and the top of bedrock. The fastest moving body wave (the P-wave) always arrives at the geophones first, followed closely by the slower S-wave, and then surface waves (Raleigh and Love waves) arrive later in time. The seismograph is set to record enough of the wave train to fully capture the P-wave arrivals. By measuring how long the refracted P-waves travel in the subsurface using a series of evenly spaced geophone sensors, analysis can determine the elevation of the bedrock interface and the velocity of the materials (see graph on the upper portion of Figure H-2 below).

Seismic refraction data gathered along a continuous series of lines can assist in the construction of a detailed diagram of the top of bedrock. Seismic refraction will provide the P-wave velocity – that is the first “wiggle” on the plot as shown in the upper portion of Figure H-1 above. Each “wiggle trace” represents information gathered at a geophone, and the vertical dimension is time after the initial percussive impact as shown in the lower portion of Figure H-1 above. The timing of the first arrivals is transferred to a database and analyzed using one of several refraction analysis methods.

The shot offset and geophone spacing for a given site will vary depending on the expected depth to bedrock, that is, the deeper the bedrock, the longer the layout.

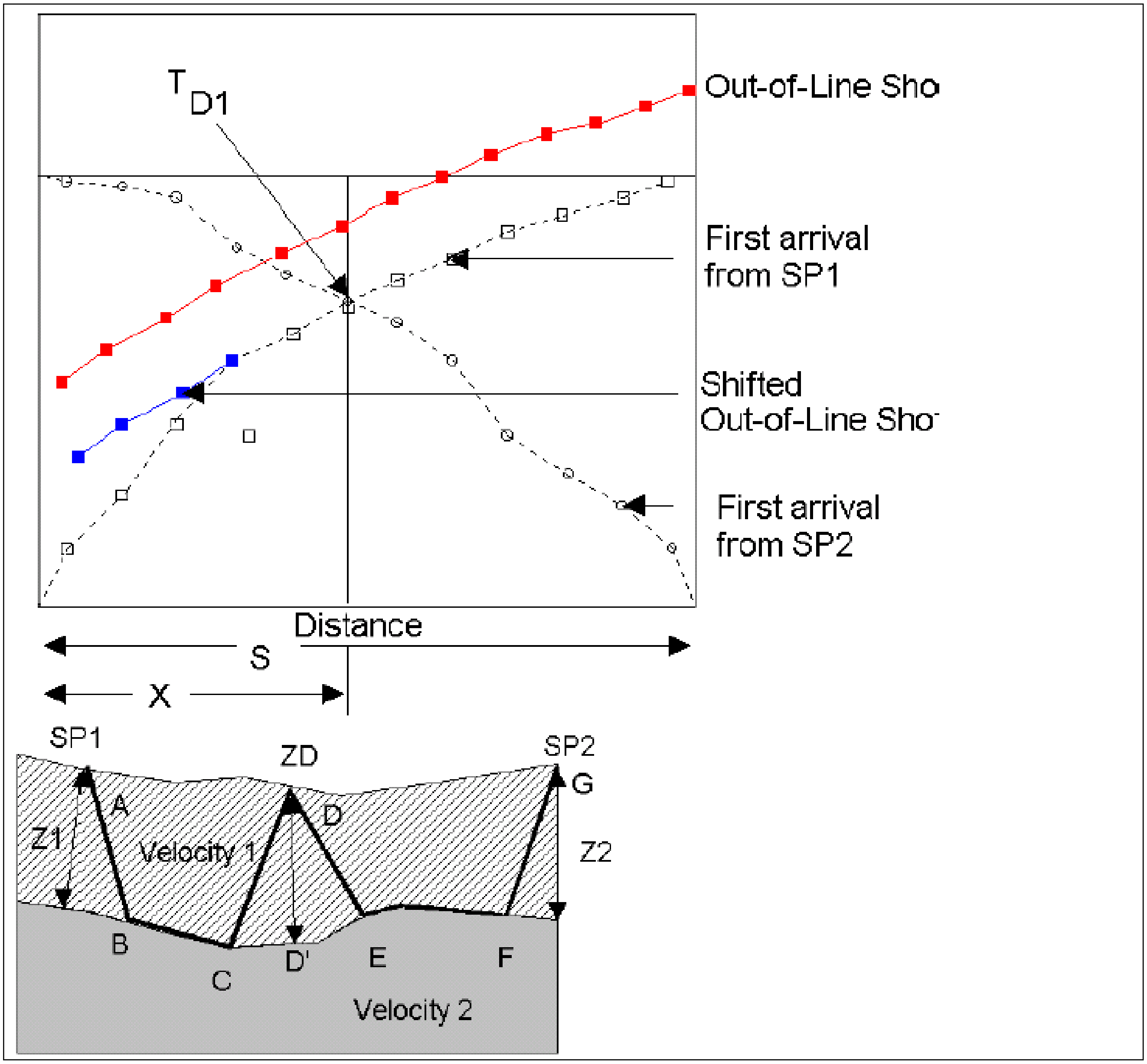


Figure H-2. Seismic Refraction Method

3.1.2 Passive Surface Wave Method

The most broadly applicable and useful of the PSW methods is called SPAC. Data collection is performed at essentially a single point by placing geophones in a radial, circular array rather than a straight line. The chain of geophones is attached to the seismograph and data collection is performed by setting the seismograph to record ground motions over many minutes (see Figure H-1 above for an image of surface waves). No active energy source is used, but rather the seismograph records surface waves arriving at the data collection point from random directions. The collected data is subsequently analyzed by determining the surface wave velocities over a range of surface wave frequencies. The earth acts as a filter of surface waves with depth resulting in what is known as a dispersion of energy. Essentially the wave frequency is inversely related to depth. The velocity of the various frequency waves is governed by the S-wave stratigraphy of the earth. The transition from alluvium to crystalline bedrock marks a sharp increase in shear strength of the earth which translates to a higher S-wave velocity. An inversion modeling process is used to derive the S-wave depth model, and the depth to bedrock is revealed at the depth where the S-wave velocity sharply increase.

3.1.3 Seismic Equipment

Seismic equipment for all types of seismic surveys requires, at a minimum, motion sensors (geophones) which are placed on the ground surface (firmly attached using a small spike which penetrates a few inches into the ground). Geophones are attached to special cables which create an electronic connection between the geophones and the seismograph. The individual geophones have a suspended magnet placed within a coil of wire, and through the process of induction, the up and down or side to side motion of the magnet generates a small electrical current. The amount of energy arriving at a particular geophone is captured in the maximum absolute value of the generated voltage (this is known as amplitude). The frequency of the seismic wave is captured by the rate at which the voltage oscillates from positive peak voltage to negative peak voltage (for example, upward movement would be positive and downward movement negative). When captured by the seismograph, the oscillations appear as the wiggle traces as illustrated in Figure H-1 above. Data collection is either manually started in the case of passive methods or is automatically started (triggered) in the case of active methods.

In the specific case of active methods, a seismic source (typically a sledgehammer or other impact device) with an impulse trigger connected to the handle of the hammer is connected by a wire to the seismograph. The hammer blow closes the impulse trigger at the moment of impact and sends a “zero” time to the seismograph and causes it to start recording geophone signals at the moment of the hammer blow. In active surveys the total time window is preset to assure recording of all P-wave arrivals at all geophones and during recording the geophone voltage is discretely sampled at a high enough rate to fully capture the true ground motion. For refraction, five shot locations are typically placed in a given geophone layout - one short offset and one long offset at each end of the geophone layout and one in the center of the layout.

3.2 Seismic Data Processing and Presentation

The SERES-Arcadis JV geophysicists will use interactive seismic data processing programs for analysis of either the Refraction or PSW data. For Refraction, the initial step will be to pick first breaks (i.e., P-wave arrivals) and to analyze the resulting first break data. This analysis will be conducted using software that incorporates several methods, including: the slope-intercept method, parts of the Plus-Minus Method of Hagedoorn (1959), Time-Delay Method, and features the Generalized Reciprocal Method of Palmer (1980). It is assumed a combination of the time-delay method and the slope-intercept methods will be used for this project. The Generalized Reciprocal Method will only be applied where complexities dictate. Output from the Refraction processing will result in a continuous seismic cross-section assumed to consist mainly of two layers, alluvium, and bedrock.

For the PSW data, the analysis of the PSWs recorded at discrete points along the proposed routes using the 2D SPAC method (Aki 1957), which assumes ambient ground motions reach the recording location from all directions. By gathering a series of PSW measurements along the proposed route, a number of estimates of depth to bedrock can be created, the quantity of which is a function of the length of the route.

4 Vertical Profiling

Shallow vertical profile locations will be installed using direct-push methods. Groundwater samples will be collected via a retractable well screen, which is advanced with 1-inch steel drilling rods (SP-22 or similar). Groundwater samples will be collected using the "top-down" approach (i.e., samples collected as the borehole is drilled to minimize any potential for cross-contamination).

Due to the presence of flowing sands, refusal encountered in some historical vertical profile locations, and deeper groundwater levels in some areas of Area 1, it is anticipated that deeper vertical profile locations will need to be installed using sonic drilling methods. Drilling water will be obtained from the Devens municipal water supply and dyed with an inert tracer (fluorescein or similar) to allow the SERES-Arcadis JV to confirm that all drilling water has been removed from vertical profile test interval before sampling. Packer isolation sampling methods will be used to collect groundwater samples. This method involves deploying a stainless-steel screen and packer assembly setup inside the outer override sonic casing; 4-inch-diameter screens will be used to allow for higher purge rates and greater sample depths.

Each vertical profile location will be abandoned using tremie-grout techniques following the completion of sampling unless permanent monitoring wells are installed. All drilling will be completed by a licensed Massachusetts driller under the oversight of a SERES-Arcadis JV geologist and will be conducted in accordance with all promulgated state and federal laws.

5 Overburden Monitoring Well Installation

Overburden monitoring wells will be installed using direct-push (shallow piezometers), sonic or drive-and-wash techniques, depending on the specific drilling location. Each of the drilling methods (with the exception of direct-push) requires the addition of drilling water to the borehole. Inert dye (fluorescein or similar) will be introduced into the drilling water to allow the SERES-Arcadis JV to confirm that all drilling water has been removed from the screened interval, and that future groundwater samples are representative.

Piezometers and permanent monitoring wells will be constructed of 1- or 2-inch-diameter schedule 40 polyvinyl chloride (PVC) with 10-foot long screen (10-slot size [0.010-inch]). Deeper wells may require schedule 80 PVC and/or 4-inch diameter well materials. Screen depths will be selected based the following:

- Overburden wells: Installed to target highest PFAS concentrations (if PFAS is detected) and/or specific hydrostratigraphic units.
- Weathered rock wells: Installed to target shallow weathered rock hydrostratigraphic unit.

Filter packs, seals, and surface completions will be completed consistent with Massachusetts guidance. The wells will be completed flush with the surface grade encased by a 2-foot by 2-foot concrete pad and secured using an 8-inch protective roadbox or 4-inch-diameter steel standpipe. Well construction details (included the materials used) will be recorded by a SERES-Arcadis JV field geologist. The measuring points and well labels will be marked with an indelible ink pen on both the inner and outer well casings or inside the roadbox lid. All drilling and well construction will be completed by a licensed Massachusetts driller under the oversight of a SERES-Arcadis JV geologist and will be conducted in accordance with all promulgated state and federal laws. All well locations will be surveyed by a licensed Massachusetts surveyor for northing, easting, and ground/top of casing elevations.

6 Bedrock Well Drilling

Bedrock wells will be drilled following one of two approaches:

- Potential source/plume locations, completed onsite and within areas of known PFAS detections in the overburden to evaluate whether PFAS has migrated into bedrock.
- Post boundary/off-post locations, to be completed at a distance from the known sources and between PFAS sources and potential off-post receptors to evaluate whether off-post PFAS transport is occurring.

The drilling approaches for each well type are described below.

6.1 Potential Source/Plume Bedrock Well Drilling Approach

Potential source/plume locations will be completed as single-screened monitoring wells targeting the first water-bearing fracture zone encountered in competent bedrock. Wells are planned to be no greater than 100 feet below the bedrock surface, but may be extended to 200 feet if needed for vertical delineation. Wells may be terminated at a shallower depth if drilling observations indicate that a significant fracture has been encountered. Final determination of screened intervals will be based on geophysical logging. Packer tests will only be completed if multiple fracture zones are observed, and the tests will help select most appropriate interval.

6.2 Post Boundary/Off-Post Bedrock Well Drilling Approach

Post boundary/off-post locations will be completed to at least 200 feet below the bedrock surface. Depending on fractures encountered, the boreholes may be completed with two nested wells, screened at different intervals. Boreholes may also be extended deeper if needed for vertical delineation. Final determination of screened intervals will be based on geophysical logging and packer test results.

6.3 Bedrock Drilling Methodology

All bedrock wells will be double-cased. Drilling through overburden will be completed using either sonic or hollow-stemmed augers to the bedrock surface. Air rotary or air-hammer drilling will be used to drill approximately 5 feet into rock to create a socket for the surface casing. Surface casing will be constructed of 8-inch diameter steel. Casing will be grouted in place and allowed to cure for a minimum of 24 hours before drilling resumes.

Bedrock boreholes will be drilled to either 6- or 8-inch diameter by air-rotary methods. Drillers will use un-dyed potable water as a drilling fluid (if needed, for dust suppression purposes). While drilling, the field geologist will log changed drilling conditions include water-production, drilling rate, increased “chatter”, or changes in drilling return water color or turbidity. The driller will maintain an estimate of drilling water lost to the formation, if any. Rock cuttings will not be logged for lithology.

Borehole yield tests will be conducted at key decision points to determine if the drilled section of the borehole has encountered water bearing fractures of sufficient yield to test or build monitoring wells. Tests will be completed as drilling-water falling head tests. With the tools removed from the borehole, water will be added to the top of casing. The water level in the borehole will be manually measured for 10 minutes. The rate of recovery (gallons per minute [gpm]) and specific capacity (gallons per minute per foot [gpm/foot]) will be estimated based on the casing diameter and volume. The recovery rates will be evaluated as follows:

- A total borehole recovery rate of less than 0.25 gpm will be considered insufficient yield for testing or well construction. If a location is at a decision point for drilling deeper, drilling will continue. If a location is at its maximum planned depth, the location will be abandoned.

- A total borehole recovery rate of greater than 0.25 gpm will be considered sufficient yield for testing. Geophysics and packer testing would then be performed. The final decision on whether to construct a well would then be based on the results of that testing, as described in the sections below.

After each borehole is drilled, the driller will flush the borehole until clear of cuttings. The borehole will be left open temporarily to allow geophysical logging and packer testing, as described below.

6.4 Borehole Geophysics

Geophysics work will be completed by a SERES-Arcadis JV geophysics subcontractor at each new bedrock borehole. Borehole geophysical logging will be completed a minimum of 24 hours after drilling is completed to allow the water-column to equilibrate and any turbidity to settle.

The logging suite is anticipated to include tools to evaluate the nature of the bedrock, the depths and orientation of fractures, and relative groundwater yield of the fractures encountered. The logging suite will include natural gamma, induction conductivity, fluid temperature/resistivity, three-arm caliper, acoustic and optical televiewers, and heat-pulse flowmeter. Flow meter logging will be completed first under ambient (unstressed) conditions, and then under dynamic (pumping) conditions. For dynamic flow logging, a submersible pump will be deployed at the top of the water column and pumped at a rate sufficient to created steady drawdown and induce upward flow within the water-column. Pumping and drawdown data will also be used to estimate the specific capacity of the full borehole.

If significant ambient vertical flow is observed (i.e., exceeding 0.25 gpm) and the well is expected to remain open for greater than 2 weeks, temporary packers will be deployed to separate the fracture zones contributing to vertical flow.

6.5 Packer Testing

Packer testing will be completed at boreholes where multiple hydraulically active fracture zones were observed in the geophysical logging and where the data leave uncertainty about well construction. If geophysical logging has identified only one zone (for first water locations) or two zones (for deep borehole locations), then packer testing may not be needed to decide well construction, and water-quality data from the target zones will be evaluated after the well is constructed and developed. In those cases, packer testing would only be completed if geophysical logging data leaves uncertainty about whether the zones have sufficient yield to support a monitoring well.

Packer testing intervals will be selected based on review of the geophysical logs and will target zones with evidence of groundwater yield. The number of zones tested will be based on number of hydraulically active zones observed but is estimated to be no greater than two intervals per 100 feet of open borehole. Packer testing will be conducted in the following manner:

- A water level measurement will be measured in the open borehole before testing starts to establish equilibrium conditions.
- A 10- or 15-foot double-packer assembly will be lowered to straddle the target interval and then inflated to isolate the interval. Packer testing will begin from the shallowest interval, moving sequentially deeper.
- Once the packers have been inflated, baseline water levels will be manually recorded outside and inside of the packer assembly for a minimum of 10 minutes to confirm that the packers are maintaining a proper seal. Transducers will be used to record water levels, supplemented by manual measurements.
- Once the water levels have stabilized, a submersible pump will be installed and started with a rate of 1 gpm. Flow and drawdown will be monitored during the purging process to establish the specific capacity of the

interval. The minimum acceptable yield to complete a test will be 0.25 gpm with 25 feet of drawdown (i.e., specific capacity of 0.01 gpm/foot). Pumping flow rate adjustments will be made quickly at the start of the test to limit drawdown beyond 25 feet. If the yield of an interval is below the threshold described above, the test will be stopped and no groundwater sample will be collected.

- If the yield of an interval is sufficient for the collection of groundwater samples, the packer test will continue until three volumes of water have been removed from the borehole. The volume of water for one volume will include the water contained within the standpipe and the packer interval.
- Once the pre-determined volume has been removed, a groundwater sample will be collected and field parameters (including pH, conductivity, oxidation-reduction potential [ORP], and dissolved oxygen [DO]) will be recorded.
- Groundwater samples will be sent to for PFAS analysis under appropriate chain-of-custody procedures.

6.6 Bedrock Monitoring Well Construction

Selection of bedrock monitoring well screened intervals will be made based on borehole geophysics and packer testing results. Wells will only be completed in zones with a minimum estimated yield of at least 0.25 gpm with 25 feet of drawdown (i.e., specific capacity of 0.01 gpm/foot). Where multiple zones meet the flow criteria, selection priority will be given to zones of highest yield and highest PFAS concentrations. For deep boreholes where multiple intervals may be selected, priority will be given to vertical separation (e.g., placing a shallow well in the upper 100 feet and deeper well in the bottom 100 feet).

Where screened intervals are above the base of the borehole, the borehole will be grouted back to within 20 feet of the screened interval. After the grout has set, bentonite chips will be used to backfill any remaining depth to within approximately 2 feet of the base of the screen, where the filter pack will start.

Monitoring wells will be constructed of 2-inch-diameter schedule 40 PVC with 10-foot long screens (10-slot size [0.010-inch]). Deeper wells may require schedule 80 PVC well materials. Filter packs, seals, and surface completions will be completed consistent with Massachusetts guidance. The wells will be completed flush with the surface grade encased by a 2-foot by 2-foot concrete pad and secured using an 8-inch protective roadbox or 4-inch-diameter steel standpipe. Well construction details (included the materials used) will be recorded by a SERES-Arcadis JV field geologist. The measuring points and well labels will be marked with an indelible ink pen on both the inner and outer well casings or inside the roadbox lid. Well construction will be completed by a licensed Massachusetts driller under the oversight of a SERES-Arcadis JV geologist and will be conducted in accordance with all promulgated state and federal laws. All well locations will be surveyed by a licensed Massachusetts surveyor for northing, easting, and ground/top of casing elevations.

7 Monitoring Well Development

Each overburden monitoring well will be developed using a submersible pump and surge block to remove fines and improve the hydraulic connection of the well with the native formation. Where drive-and-wash drilling methods are used (and drilling water is introduced into the formation), well development will also recover any drilling fluids.

Each open bedrock borehole will be initially developed with the drill rig using air-lift methods to remove any remaining sediment and rock flour generated during the drilling process. This development will ensure hydraulic communication of any fractures encountered with the borehole. After permanent PVC wells are installed within the open boreholes, the same well development procedures described above for overburden well development will be used.

8 Groundwater Sampling and Water Level Measurements

Groundwater samples will be collected during the installation of vertical profile borings in a manner similar to that of previous vertical profile samples collected by KGS. Groundwater samples will be collected in 10-foot intervals (starting at the water table) with a peristaltic or bladder pump setup with dedicated tubing. Samples will be collected after a minimum of three casing volumes have been purged from within the drilling rods.

Groundwater samples will also be collected from all newly installed monitoring wells in addition to a subset of existing monitoring wells in each investigation area during the spring (April/May; higher water table) and fall (October/November; lower water table) timeframes; samples will be collected in accordance with low-flow guidance. All sampled monitoring wells and piezometers will also be gauged, and water level measurements recorded to evaluate groundwater flow direction and horizontal/vertical hydraulic gradients, where appropriate.

During sampling, water quality parameters will be collected with each vertical profile location and monitoring well location and will include DO, ORP, specific conductance, temperature, turbidity, and pH. Field parameter stabilization requirements will be followed for each monitoring well location, but stabilization is not a requirement for vertical profile sampling.

9 Surface Water Sampling

Because of the tendency for PFAS to accumulate at the air/water interface, as a conservative measure and consistent with recommendations from the Interstate Technology and Regulatory Council (https://pfas-1.itrcweb.org/11-sampling-and-analytical-methods/), surface water samples will be collected from immediately below the water surface using the procedures appropriate given site conditions and may include direct collection in the sample jar and/or use of a peristaltic pump. Surface water samples will be analyzed for the PFAS suite specified in the QAPP Addendum (Appendix A) and for total organic carbon and dissolved organic carbon. Water quality parameters will be collected from each sampling location including DO, ORP, specific conductance, temperature, turbidity, and pH.

10 Fish Tissue Sampling

Fish tissue samples will be collected and analyzed to evaluate potential angler exposure via fish consumption. Fish will be collected using the appropriate sampling method(s) for the individual waterbody, which may include electrofishing, seining, gillnetting, trap netting (fyke/hoop nets), or angling. The work will be conducted under a Massachusetts Division of Fisheries and Wildlife Commercial Scientific Collection Permit. State personnel (typically a conservation officer) will be notified of the sampling before going into the field as required by the permit.

As detailed in the QAPP Addendum (Appendix A), sampling will include five locations (Plow Shop Pond, Cold Spring Brook Pond, Mirror Lake, Robbins Pond, and Nashua River), and will target species and sizes of fish that are relatively common in the surface water bodies and may be consumed by human receptors. Target species may include largemouth bass, bullhead, chain pickerel, or additional species (based on availability). Each sample will be a composite of up to five individuals, and samples will be analyzed as edible fillet portions.

11 PFAS-Specific Field Guidance

In accordance with various available protocols, the SERES-Arcadis JV has developed a TGI specific for field sampling on PFAS projects. Special considerations will be made throughout each of the above field activities regarding PFAS-containing materials and cross-contamination potential. All field staff will be provided with a summary of materials (clothing, notebook, pens/markers, etc. that are prohibited for use when collecting PFAS samples) and field equipment approved for field investigation efforts, and recommendations will be provided on any materials that are prohibited for the collection of PFAS samples (i.e., Teflon or low-density polyethylene supplies). The SERES-Arcadis JV will confirm with the laboratory analyzing samples (Eurofins) that sampling containers are high-density polyethylene with unlined polypropylene caps. Wet ice will be used to pack sample containers for shipment, and PFAS samples will be stored in coolers separate from other types of samples (if necessary).

Non-dedicated sampling equipment and drilling rods will be rinsed with Alconox or Liquinox cleaning solution, followed by a distilled or deionized water rinse. If necessary, a decontamination pad will be set up in a central area of the site in order to clean/rinse drilling augers.

12 Waste Management

Investigation-derived waste generated during the proposed activities will include purged groundwater and drill cuttings, as well as general site refuse. Investigation-derived waste management procedures are presented in Worksheet #17-12 of the QAPP and will be managed in accordance with standard operating procedure RI-SOP-09 and previous waste management practices at Devens.

Drill cuttings generated during the installation of vertical profile locations and monitoring wells will be returned to the ground adjacent to the site of generation or moved to nearby wooded areas located within the boundaries of Devens. Groundwater generated (including drilling water, rinsate water, and well development water) will be discharged to the ground surface at the site of generation. Where drilling will take place along public rights-of-way or on private property east of Cold Spring Brook, drill cuttings and purge water will be containerized and transported to a central staging area for subsequent characterization.

13 Surveying

All sampling locations will be surveyed for the location, elevation of the ground surface, and top of well casing if a monitoring well was installed. In locations where monitoring wells are not being installed, locations will be marked and/or staked after drilling activities have been completed to ensure the accuracy of the survey. Surveying will be measured to the nearest 0.1 foot horizontally and 0.01 foot vertically, and a reference point will be indicated by a notch or permanent marker. A Massachusetts-licensed surveyor will be contracted to perform surveying in accordance with the Massachusetts State Plane Coordinate System of the North American Datum of 1983 and vertically on the North American Vertical Datum of 1988. All measurement units will be in feet.

14 References

Aki K. 1957. Space and time spectra of stationary stochastic waves, with special reference to microtremors, *Bull. Earthq. Res. Inst.* 35:415-457.

Hagedoorn, J.G. 1959. The plus-minus method of interpreting seismic refraction sections. *Geophysical Prospecting* 7(2):158-182. June.

Palmer, D. 1980. The generalized reciprocal method of seismic refraction interpretation. Published by the Society of Exploration Geophysicists. January.

Appendix I

Response to Regulatory Comments on Draft and Draft-Final Phase II Area 1 Remedial Investigation Work Plan

Project Name:	**Former Fort Devens Army Installation**	**Location:**	**Devens, Massachusetts**
Document Name:	**DRAFT Phase II Remedial Investigation Work Plan and Quality Assurance Project Plan Addendum for Per- and Polyfluoroalkyl Substances (PFAS) Groundwater Operable Unit – Area 1**		
Prepared By:	**Seres Arcadis 8(a) JV**		

No.	Ref. Page / Para.	COMMENTS	RESPONSE	BACKCHECK	BACKCHECK RESPONSE
USEPA COMMENTS – JUNE 22, 2022 / OCTOBER 25, 2022 (BACKCHECK)					
		GENERAL COMMENTS			
1.		The Work Plan includes a lot of useful information on procedures for the collection of PFAS from aqueous systems. However, sample collection procedures should reflect the ability to satisfy the stated objectives of the program. Many of the comments below recommend specific changes to or expansion of the currently proposed sampling program for improved delineation of PFAS contamination and characterization of source areas. EPA requests that Army's responses to the comments outlined below either (1) explain why the requested change wasn't implemented or (2) identify where within the draft final Phase 2 Area 1 draft Work Plan the requested change is addressed/memorialized.	The Army's responses have been structured per the comment.	NA	NA
2.		On May 18, 2022, EPA published updates to its Regional Screening Levels (RSL) and Regional Removal Management Levels (RML) tables including the addition of five per- and polyfluoroalkyl substances (PFAS) analytes. Changes to the EPA Regional Screening Levels (RSL) include updated toxicity values for PFAS, resulting in new screening levels for PFAS and screening levels for PFNA, PFHxS and HFPO-DA (GenX) compounds. The attached tables were generated by EPA Region 1 to replace the Site-specific Screening Levels (SSL) tables developed for Devens in 2018 (for Perfluorooctanoic acid (PFOA), Perfluorooctane sulfonate (PFOS), Perfluorobutane sulfonate (PFBS)) and present the new SSLs developed for Perfluorononanoic acid (PFNA), Perfluorohexanesulfonic Acid (PFHxS), and hexafluoropropylene oxide dimer acid and its ammonium salt (HFPO-DA (GenX)). SSLs were updated and developed for the groundwater and soil exposure pathways for a child resident, and for a recreational child who may be exposed to surface water or sediment. SSLs were also generated for the groundwater and soil exposure pathways for a construction worker, and the soil exposure pathway for a commercial worker. In addition, SSLs were produced for fish consumption for an adult and child. All of the SSLs were calculated using the EPA Regional Screening Level (RSL) calculator https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search. The calculator used the new oral Reference Doses (RfDs) for PFAS listed below: Chemical | Tox Value Source | RfD (mg/kg-day)	In accordance with the attached July 6, 2022 Memorandum from the Office of the Assistant Secretary of Defense (OSD), the Army will utilize the SSLs and risk assessment methodology provided with the comment. These changes will be reflected in the Draft Final Work Plan and data screened appropriately.	NA	NA

<table>
<tr><th>No.</th><th>Ref.
Page / Para.</th><th>COMMENTS</th><th>RESPONSE</th><th>BACKCHECK</th><th>BACKCHECK RESPONSE</th></tr>
<tr><td></td><td></td><td>
<table>
<tr><td>PFOA</td><td>ATSDR</td><td>3.0E-06</td></tr>
<tr><td>PFOS</td><td>ATSDR</td><td>2.0E-06</td></tr>
<tr><td>PFBS</td><td>PPRTV</td><td>3.0E-04</td></tr>
<tr><td>PFNA</td><td>ATSDR</td><td>3.0E-06</td></tr>
<tr><td>PFHxS</td><td>ATSDR</td><td>2.0E-05</td></tr>
<tr><td>HFPO-DA (GenX)</td><td>OW</td><td>3.0E-06</td></tr>
</table>

For the child resident, the RSL calculator used all default exposure assumptions to obtain SSLs. The SSLs for the recreational child were calculated using mostly default values, except for exposure frequency (days/year), exposure events per day, and exposure time per event (hours/event) (USEPA, 2014a). The calculator requires that these three exposure parameters be entered as site-specific values. The exposure frequency was set at 45 days per year for surface water and 75 days per year for sediment, based on the default values used in the Risk Assessment Information System Tool (https://rais.ornl.gov/tools/rais_chemical_prg_guide.html). The other two exposure parameters were set at one event per day and one hour per event. Additionally, the default parameter for surface area was modified to reflect a wading child and was calculated as a time-weighted average of the surface area of legs and feet for children ages 0 to 6.

For fish consumption, default exposure assumptions for adult and child were used in the calculator, except for fish ingestion rate (IRF) which does not have a default value (USEPA, 2014a). The IRF values used for the adult and child were based on data from NHANES, which is a program that periodically estimates food consumption rates nationwide for different regions and socioeconomic groups (NHANES 2003-2010) (USEPA, 2014b). For the construction worker and the commercial worker, SSLs were calculated manually using the RSL equations and default exposure parameters. Copies of the RSL calculator outputs are provided with this memorandum.

The SSLs should be used to identify chemicals of potential concern in the human health risk assessment. Because there are likely to be multiple chemicals present at the AOCs/Sites evaluated in the PFAS RI, SSLs are developed as the concentration associated with a Hazard Quotient (HQ) of 0.1 (to ensure that multiple chemicals contributing to non-cancer risks are included in the risk assessment). Where there is only one chemical at a site, it would be appropriate to set the screening level at HQ = 1. If there are multiple chemicals present, it is important to screen at a HQ of 0.1 to ensure that the cumulative hazard quotient of multiple non-carcinogens is considered.
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No.	Ref. Page / Para.	COMMENTS	RESPONSE	BACKCHECK	BACKCHECK RESPONSE
		The SSLs and exposure assumptions for the child resident are summarized in Table 1. Table 2 provides the SLs and exposure assumptions for the recreational child, and Table 3 provides SLs and exposure parameters for the commercial worker. Additionally, the SLs and exposure assumptions for fish ingestion are summarized in Table 4, and Table 5 provides the SLs and exposure parameters for the construction worker.			
3.		Please amend the draft Work Plan (text and figures), as/if warranted, to reflect the new, updated Devens SSLs.	See response to General Comment No. 2.	NA	NA
4.		The Work Plan should be expanded to include an assessment of ecological risks. Specifically, a screening-level ecological risk assessment should be performed using the PFAS ecological screening values (ESVs) for the media and receptors presented in the September 2021, “Derivation of PFAS Ecological Screening Values Report” prepared by Argonne Laboratory on behalf of DoD, for use at DoD installations where PFAS have been detected in soils and surface waters.	The Work Plan will be revised to include the methodology for a Screening-Level Ecological Risk Assessment (SLERA). The SLERA will include the ESVs noted in the comment, as appropriate.	NA	NA
5.		The reference to Area 1 as the “PFAS GW OU” is premature. The suggestion that PFAS impacts exist in groundwater only and that no source soils remain is inconsistent with and unsupported by the limited soil data available. The scope of the Phase 2 RI must be expanded to include the collection of soil samples from the three Area 1 AOCs not sampled during the Phase 1 RI, and from the five, previously sampled Area 1 AOCs where PFAS was detected above the updated SSLs (see attached Tables 1-5).	The reference to GW OU will be removed. As noted herein, soil sampling will be added to the Work Plan scope.	NA	NA
6.		The extent of contamination has not been adequately characterized and/or delineated at many Area 1 AOCs. Specifically, as stated in EPA’s comments on the Phase 1 PSCS, sample locations with elevated soil concentrations and groundwater results above screening criteria must be surrounded by non-detects or sampling results below Devens SSLs, EPA Final and/or Interim Lifetime Health Advisories (HLAs), and/or the Massachusetts GW-1 standard (GW-1) for the sum of six PFAS compounds.	Soil sampling and additional groundwater sampling to characterize the extent of PFAS exceeding the May 2022 Devens SSLs will be added to the Work Plan. The Interim Lifetime Health Advisories are not considered to be screening levels at this time but will be considered by the Army in the assessment of the extent of contamination. The Massachusetts GW-1 standard for the sum of six PFAS compounds will be included in the screening.	NA	NA
		PAGE-SPECIFIC COMMENTS			
1.	Page ES-1, Objectives	For reasons discussed above, please delete the last sentence. The reference to Area 1 as the “PFAS GW OU” is premature.	See response to General Comment No. 5.	NA	NA
2.	Page 5, Exhibit 1-1	The purpose of the Exhibit is unclear. As currently formatted, the Exhibit implies that a Phase 2 RI will not be conducted at sites with previously confirmed PFAS detections. Also, EPA recommends that it be replaced with an Exhibit that presents information specific to Area 1 or that it be reformatted (i.e., color-coded). Also, please clearly identify, Phase 1 Area 1 sites not proposed for investigation in Phase II.	The purpose of Exhibit 1-1 is to summarize previous PFAS investigations by site and the evolution of PFAS investigations at Devens. To clarify this summary, color-coding will be added, and Phase 1 Area 1 sites not proposed for investigation in Phase II will be identified.	NA	NA

No.	Ref. Page / Para.	COMMENTS	RESPONSE	BACKCHECK	BACKCHECK RESPONSE
3.	Page 5, § 1.1.3	On June 15, 2022, EPA's Office of Water released Final Health Advisories (HAs) for PFBS and GenX and Interim Updated HAs for PFOA and PFOS. Due to the interim nature of the newly released HAs for PFOA and PFOS, which are based on data and draft analyses still undergoing EPA Science Advisory Board review, the Region 1 Superfund program will continue to use the toxicity values recently incorporated in the Regional Screening Level (RSL)/Removal Management Level (RML) tables and the resultant RSLs/RMLs of May 18, 2022 and site-specific screening levels (SSLs), where/if available, to determine if more evaluation is warranted at Superfund sites in the Region. At such a time that the Office of Water Health Advisories for PFOA and PFOS become final, the Superfund program will determine what steps are appropriate regarding evaluating sites in light of the Health Advisories. Please be sure that the draft final Work Plan includes reference to the final and interim PFAS HAs.	A reference to the final and interim PFAS HAs will be added to the text. However, the Army notes that, per Department of Defense (DoD) policy, it will conduct the investigation in accordance with the OSD directives in place at the time of the work.	NA	NA
4.	Page 7, § 1.2, ¶ 2	The draft Work Plan states that "No soil samples collected exceeded the applicable site-specific soil SLs for PFAS." Please compare existing (PA/SI and Phase 1) soil data to the recently updated Devens PFAS SSLs and amend the sentence as/if necessary.	This comparison and update to the text will be performed.	NA	NA
5.	Page 7, § 1.2, ¶ 4	The second sentence states "Of the 143 off-post wells sampled, the combined concentrations of PFOA and PFOS from all wells were below the USEPA LHA of 70 ng/L." Please confirm that *the combined concentrations of both compounds from all 143 wells* is accurate and amend/reword, if not.	For clarity, the text will be revised to state, "*… the summed concentration of PFOA and PFOS at each of the 143 wells …*"	NA	NA
6.	Page 7, § 1.3	Please explain how it was determined (i.e., identify media sampled) that contaminated groundwater discharges (i.e., upwells) to surface water bodies. Were lake, pond and/or brook bed water samples or porewater samples collected to confirm locations of upwelling groundwater? If not, please amend the draft Work Plan to include this sampling.	The discharge points to surface water were, and will be, identified based on upward vertical hydraulic gradients observed at monitoring well pairs adjacent to surface water bodies, and comparison of PFAS mixtures detected in groundwater in the adjacent AOC and surface water to assess if a correlation exists. AOC-specific assessments of groundwater discharge locations are included in Section 3.5.2 (now Section 3.5.3), Exhibit 3-2 (now Exhibit 3-3). Additional AOC-specific details regarding discharge locations are included in Appendix G. The work plan includes sufficient investigation of vertical and horizontal gradients on both sides of Cold Spring Brook to evaluate whether underflow is occurring, therefore, porewater sampling is not necessary to confirm discharge or the points of discharge. Discharged groundwater is captured by the series of surface water samples collected and proposed.	Army's reliance on surface water samples and upward vertical hydraulic gradient measurements in monitoring wells adjacent to surface water bodies to confirm locations of upwelling groundwater in surface water bodies is unacceptable due to the increased likelihood that PFAS concentrations will be diluted upon mixing with surface water and the fact that hydraulic gradients, while useful tools in evaluating possible underflow, cannot confirm/verify that groundwater discharge is (or isn't) occurring. Please amend the work plan to include porewater sampling to confirm locations of undiluted contaminant transport and concentrations of PFAS in groundwater discharging to surface water bodies evaluated in the Phase 2 Area 1 PFAS RI (i.e., Cold Spring Brook, Grove Pond, Plow Shop Pond, Robbins Pond, Mirror Lake, etc.).	There are no EPA guidance values or screening levels applicable to porewater alone. The analysis of porewater is not required under CERCLA to evaluate risks to human health and the environment - which is performed by evaluating the nature and extent of contamination in media through which receptors could be exposed to contaminants (i.e., groundwater, surface water, soil, and/or sediment) and comparing those data to promulgated toxicological guidelines. The Army has added in-stream piezometers to the Work Plan in accordance with the comment. These additional piezometers, along with the proposed surface water, sediment, and groundwater sampling in and around Cold Spring Brook will provide sufficient lines of evidence to evaluate groundwater / surface water interaction.
7.	Page 7, § 1.3	The draft Work Plan concludes that while there were low levels of PFAS detected in some locations within or near suspected PFAS release areas, there are "no obvious continuing soil source areas within Phase 1 Area 1." This statement is inconsistent with EPA's supplemental (February 10, 2022) comments on the draft June 2020, Phase 1 Area 1 Preliminary Site Characterization Summary (PSCS), Per-and Polyfluoroalkyl Substances (PFAS),	Additional soil sampling will be performed as needed in areas where there are PFAS concentrations that exceeded the May 2022 Devens SSLs during Phase 1 (AOC 43G, AOC 57 Area 2, and the Grove Pond Wellfield Area) and these results are not bounded laterally. All PFAS results in soil that exceed the May 2022 child recreator SSL for soils are bounded vertically. PFAS results for soils did not	NA	NA

No.	Ref. Page / Para.	COMMENTS	RESPONSE	BACKCHECK	BACKCHECK RESPONSE
		which identified numerous data gaps in the investigation and delineation of PFAS-impacted soils and groundwater. Specifically, locations of confirmed surface soil detections were not sampled at depth nor were samples collected from the areas in close proximity to these locations. Also, areas upgradient of confirmed groundwater detections were not identified/investigated as potential PFAS sources. The scope of the proposed Phase 2 RI must be expanded to adequately address the Phase 1 data gaps identified in EPA's October 26, 2020, comments and February 10, 2022, supplemental comments on the Phase 1 Area 1 PSCS and ensure that conclusions in the Area 1 PFAS RI Report are supported by site-specific sample data.	exceed the May 2022 SSLs at any location sampled at AOC 74 or AOC 75. As such, additional sampling is not proposed for soils at AOC 74 and AOC 75. An Excel file including Area 1 soil results for PFAS screened against the May 2022 SSLs is attached to this response to comments document for reference. Where the May 2022 child recreator soil SSL was exceeded, results indicate: • At AOC 43G, samples collected at two soil borings out of the eight sampled exceeded the SSL: o The PFOS SSL was exceeded at 43GSB-19-02 from 0.5 to 3 ft bgs. This result is bounded vertically by samples at 3 to 7 ft bgs and deeper. o The PFOS SSL was exceeded at 43GSB-19-03 from 0.5 to 3 ft bgs. This result is bounded vertically by samples at 3 to 7 ft bgs and deeper. o The PFOA SSL was exceeded at 43GSB-19-03 at 7 to 15 ft bgs. This result is bounded vertically by samples at 3 to 7 ft bgs and shallower, and 23 to 25 ft bgs. • At AOC 57, samples collected at two soil borings out of the 13 sampled exceeded the SSL: o The PFOS SSL was exceeded at 5702SB-19-04 and 5702SB-19-07 from 0 to 0.5 ft bgs. These results are bounded vertically by samples at 0.5 to 3 ft bgs and deeper at both locations. • In the Grove Pond Wellfield Area, samples collected at three soil borings out of the nine sampled exceeded the SSL: o The PFOS SSL was exceeded at GPSB-19-01 from 0 to 0.5 ft bgs. This result is bounded vertically by samples at 0.5 to 3 ft bgs and deeper. o The PFOS SSL was exceeded at GPSB-19-05 from 0 to 0.5 and 0.5 to 3 ft bgs. These results are bounded vertically by samples at 3 to 7 ft bgs and deeper. o The PFOS SSL was exceeded at GPSB-19-08 from 0 to 0.5 and 0.5 to 3 ft bgs. These results are bounded vertically by samples at 3 to 7 ft bgs and deeper.		
8.	Page 7, § 1.3, ¶ 1	The statement that "The soil data collected during the Phase 1 Area 1 investigations confirmed that low levels of PFAS are present in some locations within or near suspected PFAS release areas, but there are no obvious continuing soil source areas within the Phase 1 Area 1" is inconsistent with the TOP assay sample	TOP assay provides concentrations of the maximum amount of PFAS that may be generated given extremely oxidizing conditions, which are not naturally occurring. Some PFAS compounds in groundwater can transform with time and/or distance from the source area but would	NA	NA

No.	Ref. Page / Para.	COMMENTS	RESPONSE	BACKCHECK	BACKCHECK RESPONSE
		results presented in § 3.3.2.3. Specifically, groundwater data from AOCs 57, 74, 75, and the Grove Pond Area are indicative of an upward trend in PFAA concentrations over time, both within and downgradient of these areas. In addition, PFAS concentrations in Grove Pond area and AOC 40 soil samples suggest the potential presence of source areas at these locations.	not in themselves be considered "sources." Though several soil sampling locations do exceed the new May 2022 SSLs, these locations are shallow, and each exceedance is bounded vertically by a sample or samples that do not exceed the SSLs. Additional soil sampling to characterize these locations is proposed, as noted in the response to EPA Page-Specific Comment 7.		
9.	Page 7, § 1.3, 5th sentence	In light of the fact that PFAS was detected in surface soils within areas formerly excavated (see Phase 1 PSCS, Figures 3-14 and 3-15), the statement that presence of continuing soil source areas is unlikely "because prior environmental restoration activities performed to remove soils containing other contaminants resulted in the removal of PFAS-containing soils," is inaccurate and should be deleted.	The statement will be revised to indicate that prior environmental restoration activities performed to remove soils containing other contaminants would have also resulted in the removal of some PFAS-containing soils if commingled, rather than potentially implicating that all PFAS-containing soils were removed.	NA	NA
10.	Pages 7, § 1.3.1	The work proposed in the Phase 2 RI Work Plan is inadequate to accomplish the stated goals and objectives on the previous page. Specifically, for reasons previously discussed, the Work Plan must be expanded to include additional soil, groundwater, sediment, and surface water sampling and evaluation of risks to ecological receptors.	The Work Plan will be revised to reflect additional characterization of these media considering the May 2022 SSLs. The Work Plan will also be updated to include a description of the proposed SLERA. However, based on the Devens SSLs, surface water and sediment samples collected as part of Phase 1 did not exceed the most stringent SSLs for child recreator.	NA	NA
11.	Pages 8, § 1.3.1	The second bullet states that the work proposed includes "Confirmation of discharge to groundwater containing PFAS to, and interaction with, surface water receptors, including Grove Pond, Cold Spring Brook, Robbins Pond and Mirror Lake." To accomplish this, streambed piezometers must be installed, vertical head gradients must be confirmed, and samples must be collected to confirm where discharge is occurring. Please identify where within the draft Work Plan the specific activities proposed to accomplish these objectives are discussed.	Vertical head gradients will be confirmed using both monitoring wells adjacent to surface water bodies and staff gages. This is discussed in Section 3.5.2 (now 3.5.3) Exhibit 3-2 (now Exhibit 3-3)("Discharge Location and Receptor" rows) and in Section 4.2.1(now Section 4.2.3) Exhibit 4-1 (now Exhibit 4-3)("Data Gap to be Addressed" column). Surface water samples at suspected groundwater discharge locations were sampled during Phase I and will be resampled during Phase II, per Work Plan Section 4.2.4 (now 4.2.6) and as shown on Figure 4-6 (now Figure 4-12). The scope will be adjusted per comment responses included in this document. As discussed in the response to Specific Comment #6, porewater and/or streambed piezometer sampling is not necessary to confirm discharge, or the points of discharge. Discharged groundwater is captured by the series of surface water samples collected and proposed, and as mentioned in the response to Specific Comment #10, there presently has been no exceedance of the most stringent (child recreator) SSL.	For reasons stated above, please amend the work plan to include porewater sampling and installation of streambed piezometers to confirm locations of undiluted contaminant transport and concentrations of PFAS in groundwater discharging to surface water bodies evaluated in the Phase 2 Area 1 PFAS RI (i.e., Cold Spring Brook, Grove Pond, Plow Shop Pond, Robbins Pond, Mirror Lake, etc.).	See response to Page-Specific Comment No. 6 Backcheck.
12.	Pages 8, § 1.3.1	The third bullet indicates that high resolution sampling will be performed to identify high concentration areas. However, the VP sampling proposed (every 10 ft using a 4 ft screen) is too coarse near the surface to identify leaching from soils. EPA recommends near continuous profiling for the upper 15 ft with three samples total and advancement every 5 ft. After that, the proposed 10 ft resolution is acceptable.	Concentrations of PFAS in soils and concentrations of PFAS at and below the water table provide the data needed to understand where leaching potentially occurred in the past or may occur from soils. The Army does not agree that additional resolution in the upper 15 ft is necessary to understand leaching potential in addition to the required soil data and groundwater sampling every 10 ft.	EPA remains concerned that the coarse frequency specified may miss leachate. As currently proposed, soil samples will not be collected in areas where the water table is less than 10 ft. Adjustments to the set frequency should be made based on anticipated depth to the water table.	The Army has revised the VP sampling protocols to include the collection of one additional sample per boring in the upper 15 feet (one at the water table and one 10' below the water table) to achieve the requested sampling frequency.

No.	Ref. Page / Para.	COMMENTS	RESPONSE	BACKCHECK	BACKCHECK RESPONSE
13.	Page 9, § 1.3.3	As shown in Figures 1-3, 3-3, and C-1, AOC 43G is the apparent source of PFAS extending along the western edge of Area 1 upgradient of the Patton well and AOC 75. Accordingly, AOC 43G should be included in the Area 1 evaluation, or additional investigation should be conducted to identify the source of PFAS contamination in the area upgradient of the Patton well and AOC 75.	AOC 43G will be added to Area 1. The investigation will also evaluate the connection between AOC 43G and AOC 75, if any.	NA	NA
14.	Page 9, § 1.3.3	The text notes that local-scale watersheds were delineated and references Section 3.2. EPA recommends that a figure representing these local-scale watersheds be included in the Figures section of the draft Work Plan.	A figure (new Figure 1-4) showing the local-scale watersheds will be added to the Work Plan.	NA	NA
15.	Page 9, § 1.3.3, ¶ 1 (and Page 19, § 3.2, ¶ 1)	The draft Work Plan states that the boundaries of Area 1 are defined by areas of overburden groundwater that discharge to surface water flow boundaries. It is unclear how Army arrived at this conclusion when there is very limited data from the bedrock aquifer system (including private supply wells) to support this supposition. EPA raised similar concerns in its June 2020 comments on the Area 1 PSCS, specifically with regards to Army's position that groundwater doesn't underflow Cold Stream Brook. The proposed Phase 2 sampling program should be expanded to ensure that sufficient bedrock data is collected to support Army's predictions and resolve outstanding concerns regarding Area 1 groundwater flow. (See Page- Specific Comment on Page 40, Section 4.2.3, and Exhibit 4-3.)	As detailed in Exhibit 4-2 (now Exhibit 4-4) and shown on Figure 4-2 (now 4-8), the Army will be installing six VAPs, six overburden wells, four bedrock wells, and two piezometers east of Cold Spring Brook/east and southeast of AOC 40 to improve the understanding of the CSM.	The four bedrock wells indicated in the response should assist with evaluation of bedrock with respect to PFAS impacts and provide a better understanding of bedrock hydrogeology. The proposed overburden wells CSMW-21-02 and CSMW-21-05 on the southeast side of Cold Spring Brook from AOC 57 should be as close to Cold Spring Brook as accessibility allows. In addition, a key purpose of these wells should be to determine whether impacted groundwater from AOC 57 flows under the brook in the shallow, intermediate, and deep overburden deposits. Proposed vertical profiling (CSVP-21-02 and -21-03) may answer this question. If this is not sufficient, consider installing nested monitoring wells (or multilevel sampling systems such as FLUTe liners) at CSMW-21-02 and CSMW21-04. Similarly, proposed staff gauge CSSG-21-02 appears to be located between CSB and a tributary brook, on dry land. This is probably a map scale issue.	The locations of monitoring wells CSMW-21-02, CSMW-21-05, and CSSG-21-02 have been adjusted be closer to Cold Spring Brook and Bowers Brook, respectively. The actual locations will depend on approval by private landowners.
16.	Page 13, § 2.2.5	Please insert a subsection outlining the decision criteria for soils.	A subsection outlining the decision criteria for soils will be added to this section.	NA	NA
17.	Page 13, § 2.2.5.1	Please amend the discussion to reflect the recently updated PFAS SSLs for Devens and DOD's ESVs for evaluating ecological risks.	The discussion will be revised to include the May 2022 SSLs and the ESVs.	NA	NA
18.	Page 13, § 2.2.5.2	Several statements are offered relative to decisions or conclusions based upon Phase II results including laboratory results reported less than the LODs for PFAS6 and PFBS "…will be considered not to be present". This assumes the LODs are not elevated, and the data are judged to be acceptable through validation. Additional statements are offered including that if PFAS6 and PFBS are detected at concentrations less than the MCP GW-1 PFAS6 standard and site-specific SL for PFBS then "no further investigative action will be required". Please clarify if this applies only to the spatial extents of the investigation locations. The possibility remains that additional investigation effort may be required based on the comparison of Phase 1 and 2 data to	The decision statement will be amended to state: "If PFAS6 and PFBS are not detected at concentrations greater than the LODs, the LODs are less than or equal to the appropriate screening value, and the data are judged to be acceptable through validation that has occurred, then they will be considered to not be present. In this case, no further investigation will be required." The reference to the decision criteria for no further investigative action for PFAS6 and PFBS detected at concentrations less than the MCP GW-1 PFAS6 standard and SSL for PFBS applies to the spatial extents of the	NA	Based on updated PFAS screening values, the text was revised further: "If PFOA, PFOS, PFBS, PFNA, PFHpA, PFDA, and PFHxS are not detected at concentrations greater than the LODs, the LODs are less than or equal to the appropriate screening value, and the data are judged to be acceptable through validation that has occurred, then they will be considered to not be present, and no further investigation will be required."

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		recently updated Devens' SSLs and incorporation of Phase 2 data into the conceptual site model (CSM).	investigation locations. However, since the May 2022 SSLs will be used in the evaluation of the data, the Army does not envision a scenario where additional investigation would be required for a different reason.		
19.	Page 15, § 2.2.7	Two of the bullets in this section describe data gaps in evaluating the hydraulic relationship and PFAS detections between the PFAS GW OU Area 1 and private drinking water wells east and southeast of Cold Spring Brook. A similar evaluation should be undertaken relative to any/all private wells where PFAS compounds have been detected.	The hydrogeologic relationship between the PFAS in groundwater in Area 1 and private drinking water wells adjacent to Area 1 where PFAS have been detected above the MMCL will be evaluated.	NA	NA
20.	Page 18, § 3.1.2.1	Because it is not a common term, "relative transmissivity" should be defined/explained in draft final Work Plan.	The term "relative transmissivity" will be explained in the text.	NA	NA
21.	Page 18, § 3.1.2.1	Please clarify the statement that existing overburden/bedrock well pairs do not yield enough lateral resolution to fully characterize vertical gradients in key locations throughout Area 1. Although this section is CSM, not Work Plan, a discussion of general data gap locations would be helpful here. Does this mean that there are insufficient pairs of overburden/ bedrock wells for evaluation, or that more vertical resolution is needed, e.g., more depths per given location?	The text will elaborate on this data gap and refer the reader to later sections where this is covered in more detail (Section 3 Exhibit 3-2 (now Exhibit 3-3)["Discharge Location and Receptor" rows] and Section 4 Exhibit 4-1 (now Exhibit 4-3)["Data Gap to be Addressed" column]).	NA	NA
22.	Page 18, § 3.1.2.2	Please define "exposed till" in the first sentence. Is the text implying that the till exposed at surface has a lower hydraulic conductivity than the till unexposed or overlain by other deposits? If that is the case, are there data to support this? Is it weathering related?	The statement is implying that the till has a lower transmissivity than the glacial meltwater deposits that constitute the primary overburden aquifer at Fort Devens. This text is consistent with previously approved reports concerning the hydrogeology.	Army's response does not address the use of the word "exposed." In fact, the response does not address the question. Please amend the response to respond to the comment and include citations for "the previously-approved reports concerning the hydrogeology of Fort Devens" referenced in Army's response	The descriptor, "exposed," was taken from a previous summary of site hydraulic conductivities in the Final Area 1 Preliminary Site Characterization Summary (PSCS) (KGS 2020a), which was submitted on June 3, 2020 . The Army will remove the word exposed as requested from this report.
23.	Page 18, § 3.1.2.2	The last sentence states that "… bedrock supply wells across the area typically yield less than 2 gpm." Please identify these bedrock supply wells and describe their locations.	The text was based on the limited daily pumping rate data available from adjacent private wells and will be revised to state that "domestic bedrock wells on hilltops in crystalline rock in Massachusetts, such as those in the Devens area, have yields averaging 6 gpm (USGS 1994).	NA	NA
24.	Page 18, § 3.1.2.2, last ¶	The second sentence states that "the combination of much higher overburden permeability and a limited fracture network in the bedrock… likely impedes vertical migration of potential contaminants." This doesn't seem feasible if the shallow fractures are vertical. What does the borehole geophysics indicate is the dip angle on the shallow fractures?	Available information from previous investigations, including the Devens Pathfinder Wells, along with the presence of overburden water supply wells in the area support this statement. However, as discussed in the Work Plan, bedrock monitoring wells are being installed to evaluate the vertical migration pathway as part of the Phase II RI. Borehole geophysics and packer testing to evaluate bedrock hydraulic characteristics is included in the scope of the bedrock monitoring well installation.	NA	NA
25.	Page 19, § 3.2, ¶ 7	The text suggests that there is "an apparent groundwater divide" associated with Robbins Pond. However, the local groundwater contours indicate groundwater flow in the vicinity of the pond is to the east as well as to the north (see Figure 4-4a). Please identify/discuss the site-specific data relied upon to develop this discovery. Also, please explain why the high PFAS concentrations (more than 500 ng/L in some samples) west of Robbins Pond are not being investigated as part of Area 1 PFAS Phase 2 RI.	As indicated on the figure, the overburden groundwater contours were generated from the March 2020 site-wide gauging event. The divide is consistent with both the surface topography and bedrock surface topography. AOC 43G will be investigated as a part of the Area 1 WP.	Please show the divide on the contour map.	The divide has been added to the figure.

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26.	Page 20, § 3.2	The reference to a "sparse fracture network" in the first sentence is speculative and unsupported by available data. Please delete.	The information is based on data from the Devens Pathfinder Wells. See Section 3.1.2.2 of the Work Plan, which summarizes data from these wells. As discussed in the Work Plan, additional information on the nature of the bedrock will be collected as part the RI.	NA	NA
27.	Page 20, § 3.2, ¶ 2	The first sentence states that insufficient data exists to fully characterize vertical gradients but then the following sentences concluded that upward flow occurs and the Brook acts as a regional sink. Please explain the contradiction and amend the text as necessary.	The subject text states: "While the existing overburden/bedrock well pairs do not provide sufficient resolution to fully characterize vertical gradients, data collected from previous investigations performed within PFAS GW OU Area 1 have shown downward vertical hydraulic gradients (from the overburden to bedrock) in the upland areas where recharge likely occurs." This is not a contradiction, but a qualification of the data, which will be confirmed through the RI.	NA	NA
28.	Page 20, § 3.3	Please amend the first sentence to state that PFAS has been used since the 1940s. (see USGS CIRCULAR # 1490).	The sentence will be revised per the comment.	NA	NA
29.	Page 23, § 3.3.4	The "preliminary summary of contamination" includes statements regarding groundwater flow and extent of contamination that have yet to be substantiated with site-specific field data. EPA raised these concerns in comments on draft annual LTM reports, Five-Year Review (FYR) Reports, the Phase 1 Area 1 RI Work Plan (and associated Field Sampling Plan Addendums) and the Area 1 Preliminary Site Characterization Summary (PSCS). As noted in the February 2022 comments generated by EPA's Federal Facility Restoration and Reuse Office (FFRRO) technical support contractor, figures in the Area 1 PSCS revealed soil and groundwater sample locations where PFAS detections exceeded applicable screening criteria, WITH no surrounding sample data that were non-detect or below Massachusetts GW-1 standard (GW-1) for the sum of six PFAS compounds or the Devens SSLs. For delineation of the horizontal extent of contamination, all of the locations depicted in figures with one or both red half-circles should be bounded by locations with yellow or green half circles. Also, based on the cross-sections, there are some locations where the vertical extent of contamination has not been delineated. In addition, for soil, the extent of contamination in the vicinity of 5702SB-19-07, 5702SB-19-04, and 5702SB-19-06, has not been delineated at multiple depths (Figure 3-14). Also, surface contamination has not been delineated near 5702SB-19-05 or 5702SB-19-02. There are similar issues on Figure 3-15 (of the Area 1 PSCS), where the extent has not been delineated near 5703SB-19-02 (multiple depths) or near 5703SB-19-04 (surface contamination). Finally, it is unclear why PFAS surface contamination is present within the areas formerly excavated (both soil figures). Please ensure that the draft Area 1 Phase 2 Work Plan acknowledges, addresses, and resolves these data gaps.	The proposed groundwater investigation scope has been designed to address both horizontal and vertical gaps in characterization of PFAS, as well as to improve the overall understanding of the CSM and groundwater flow. As noted in Section 4.2 and Figure 4-2 (now Figure 4-8), in several cases the Phase II scope of work extends beyond the former Fort Devens boundary (i.e., to the east of Cold Spring Brook and to the east of Red Tail Golf Course/AOC 40 along Blanchard Road). Additional soil sampling will be performed as needed in areas where PFAS concentrations exceed the May 2022 Devens SSLs (AOC 43G, AOC 57 Area 2, and the Grove Pond Wellfield Area). Soil sampling will also be proposed at AOC 43J, the former pump house area located in the northeast corner of the Grove Pond Wellfield Area, the Building 3713 area, and upgradient of AOC 75. Note, it is inaccurate to state that soils were not delineated vertically. As included in the response to EPA Page-Specific Comment #7, samples collected at two soil borings (5702SB-19-04 and 5702SB-19-07) out of the 13 sampled exceeded the SSL at 0 to 0.5 ft bgs, and these results are bounded vertically by samples at 0.5 to 3 ft bgs and deeper at both locations.	NA	NA

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30.	Page 23, § 3.3.4	This section contains the major conclusions on PFAS transport. Most of the conclusions rely on potential receptor locations having similar PFAS mixtures (fingerprints) as upgradient or source location mixtures. Additional confidence in stated conclusions would require an expanded fingerprint analysis including use of other compounds besides PFAS, such as general chemistry, environmental or stable isotope to identify water type and flowpath analysis.	The groundwater samples collected during Phase 2 will be analyzed using EPA Method 1633, which will provide an expanded list of PFAS parameters. Field parameters will also be collected during sampling. This will be combined with other proposed activities (seismic surveying, borehole geophysics, packer testing, synoptic water level gauging) to improve the overall CSM. General water chemistry parameters will be measured and recorded during groundwater sampling.	NA	NA
31.	Page 24, § 3.3.4	For reasons similar to those discussed above for AOC 57, the extent of groundwater contamination has not been fully delineated at AOC 74. All of the locations (see Area 1 PSCS, Figure 4-5) with one or two red semicircles (exceedances) are not bound by locations with two yellow or green semicircles (below screening levels or non-detect). It is noted that the downgradient section of AOC 74 is adjacent to the Grove Pond plume (see Area 1 PSCS, Figure 6-2). Also, based on the cross-sections, there are some locations where the vertical extent of contamination has not been delineated. For soil contamination, there is a line of borings (on Area 1 PSCS, Figure 4-9) extending from 74SB-19-02 in the southwest to 74SB-19-03 in the northeast where the extent of contamination has not been delineated to the northwest (toward the building) at multiple depths. In addition, the extent of contamination northwest, south, and southeast of 74VP-18-03 has not been delineated. Finally, the extent of surface contamination in the vicinity of 74SB-19-07 has not been delineated. Please ensure that the draft Area 1 Phase 2 Work Plan acknowledges, addresses, and resolves these data gaps.	An additional VAP and monitoring well will be installed northeast of AOC 74. Several locations (VAPs and wells) are proposed across (to the east of) Cold Spring Brook from AOC 74, to address data gaps and improve the overall understanding of the CSM. Especially in the northeastern portion of Area 1, concentrations of PFAS from more than one AOC are present in groundwater between AOCs, such as between 74VP-18-03, AOC 57 Area 3, and the upgradient Building 3713 area. The number of plumes and origins of contamination in this area necessitate a wholistic investigative approach, with a focus on characterization of migration pathways and potential risk. Additional groundwater sampling in areas that have already been confirmed to be above the May 2022 SSLs (such as between 74VP-18-03, 74VP-19-01, and 5703VP-19-01) is not proposed. Soil samples collected during Phase 1 activities at AOC 74 do not exceed the May 2022 SSLs. Five soil samples were collected vertically at each of the seven AOC 74 borings. Additional soil sampling at this AOC is not planned at this time.	NA	NA
32.	Page 24, § 3.3.4	For reasons similar to those discussed above for AOCs 57 and 74, the extent of groundwater contamination has not been fully delineated at AOC 75. Referring to figures in the Area 1 PSCS, neither the locations with elevated soil concentrations nor the groundwater sampling locations with results above screening criteria are surrounded by locations with non-detects or low concentrations. All of the locations with one or two red semicircles are not bounded by locations with two yellow or green semicircles apart from 75MW-19-01BR (Figure 5-5). Also, based on the cross-sections, there are some locations where the vertical extent of contamination has not been delineated. There is one location where the extent in surface soil has not been delineated (75SB-19-09). Also, the conceptual site model (CSM) for this site is unclear as there are several upgradient locations with PFAS concentrations above screening criteria. Contamination usually does not disperse significant distances upgradient, so it is possible that PFAS-contaminated surface water or leaks from storm drains and/or sanitary sewers spread	As described in Section 4.2 and shown on Figure 4-3b (now 4-9b), one monitoring well (75MW-21-01) is proposed to be installed in the former source area associated with AOC 75 (Section 4.2.1 (now Section 4.2.3) and Figure 4-3b) (now 4-9b). The vertical extent of PFAS in groundwater at this AOC was confirmed through installation of 75MW-19-01BR. Additional wells are proposed to the east of the presumed discharge point (Cold Spring Brook; Figure 4-5 [now Figure 4-11]) and in the Patton Well area to the south (Section 4.2.2 [now Section 4.2.4] and Figure 4-5 [now Figure 4-11]). Additional VPs and MWs will be proposed at this AOC to resolve remaining data gaps. Soil samples collected during Phase I activities at AOC 75 do not exceed the May 2022 SSLs. Four to five soil samples (depending on depth to water) were collected vertically at each of the 10 AOC 75 borings. Additional	NA	NA

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		PFAS contamination. In addition, it should be noted that the surface water runoff direction is unclear. Please ensure that the draft Area 1 Phase 2 Work Plan acknowledges, addresses, and resolves these data gaps. In addition, the CSM should be amended to explain why groundwater contamination would be present upgradient of a suspected/confirmed source area.	soil sampling at this AOC is not planned at this time. Soil sampling will be performed upgradient (west) of AOC 75 to improve understanding of this area.		
33.	Page 24, § 3.3.4	Contamination in the area east of the Cold Spring Brook has not been delineated. Although there is evidence that shallow groundwater may discharge to the wetland that flanks Cold Spring Brook, this has not yet been conclusively demonstrated nor has the possibility that impacted groundwater is migrating beneath the Brook to the east been adequately addressed. As discussed in EPA's comments on the Area 1 PSCS, the Brook could be perched above low permeability materials, and groundwater could flow beneath the Brook. Numerous sampling locations adjacent to Cold Spring Brook with exceedances above State and EPA screening levels are not bound by "non-detect" or confirmed detections below human health and/or ecological risk screening values. The Work Plan must be revised to acknowledge this data gap and propose collection of groundwater samples from the area east and downgradient of Cold Spring Brook to confirm/deny whether contaminated groundwater flows beneath the brook. The Work Plan assumes that groundwater is the source for PFAS found in surface water samples but other mechanisms for PFAS reaching the sample locations (i.e., airborne deposition and dispersion or overland flow) should be identified/evaluated as potential PFAS "sources." Please amend the Work Plan to include a discussion of these other mechanisms.	Please refer to Section 4-2 (Exhibit 4-2 [now Exhibit 4-4]) and Figure 4-5 (now Figure 4-11), which discuss/present the installation, sampling, and/or gauging of VAPs, overburden wells, and bedrock wells that are proposed in the area east of Cold Spring Brook to address this data gap. The Army will add a discussion of the potential for overland flow from known/suspected PFAS source areas. Although airborne deposition of PFAS is not considered to be a potential release mechanism that is relevant to Area 1, general text concerning aerial deposition will be added.	NA	NA
34.	Page 24, § 3.3.4	For Grove Pond wellfield, it appears that all of the sources of groundwater contamination in this area have not been identified (i.e., the upgradient extent has not been fully delineated and the source of contamination in cross-gradient location with elevated PFAS concentrations like GPVP-18-12 has not been identified). The horizontal extent of groundwater contamination has not been delineated as the sampling locations with results above screening criteria are not surrounded by locations with non-detects or concentrations below GW-1 (Figure 6-2). The cross-sections indicate that the vertical extent (above the GW-1) has not been delineated, and samples have not been collected from bedrock (i.e., based on concentrations in the deepest samples, it appears that groundwater in bedrock may be contaminated with PFAS). Also, due to the potential that contaminated groundwater discharges into Grove Pond, an insufficient amount of surface water and sediment samples have been collected. In addition, the extent of soil contamination is not delineated at multiple depths and at the surface (Figure 6-8). For example, GPSB-19-05 and GPSB-19-08 had detections above the PFAS criteria for every depth sampled, but additional sampling has been completed to	Additional soil sampling will be performed as needed in areas where PFAS concentrations exceed the May 2022 Devens SSLs (AOC 43G, AOC 57 Area 2, and the Grove Pond Wellfield Area). Soil sampling will also be proposed at AOC 43J, the former pump house area located in the northeast corner of the Grove Pond Wellfield Area, the Building 3713 area, and upgradient of AOC 75. As described in the Work Plan, permanent overburden and bedrock wells are proposed to be installed in the Grove Pond wellfield area, included in areas adjacent to GPVP-18-12. Surface water samples and fish tissue samples are also proposed to be collected from Grove Pond (see Figure 4-6 [now Figure 4-12] and Section 4.2 of the Work Plan). Five sediment samples were collected from Grove Pond in 2018. These data should be sufficient for characterizing human health and ecological risk. The sediment sample	NA	NA

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		delineate the extent of impacted areas. It is also noted that surface water runoff from soil surface contamination could lead to increased concentrations of PFAS sediment and surface water in Grove Pond. Ensure that future Work Plans acknowledge and address these data gaps.	results were all non-detect for PFBS, PFOS, and PFOA, and the reporting limits are less than the May 2022 Devens SSLs. As such, additional sediment sampling in Grove Pond is not necessary as part of this Work Plan. As included in the response to EPA Page-Specific Comment #7, the May 2022 child recreator soil SSL for PFOS was exceeded at three soil borings out of the nine sampled. Exceedances occurred from 0 to 0.5 or 0 to 3 ft bgs, and these results are bounded vertically by additional samples collected at each location. Additional sampling to characterize the lateral extent of the exceedances will be proposed in the revised Work Plan.		
35.	Page 25, § 3.3.4	For reasons similar to those described in the preceding comments, the extent of contamination has not been delineated in the vicinity of Patton Well/AOC 40. Neither the locations with elevated soil concentrations nor the groundwater sampling locations with results above screening criteria are bounded by locations with non-detects or concentrations below GW-1 (see Area 1 PSCS, Figures 7-5 and 7-8). Also, no surface water and sediment samples have been collected near PWSB-19-02 and PWSB-19-03 where exceedances were the highest in soil samples (Figure 7-9). Please ensure that the draft Area 1 Phase 2 Work Plan acknowledges, addresses, and resolves these data gaps.	Soil samples collected during Phase 1 activities at AOC 40 do not exceed the May 2022 Devens SSLs. Four to five soil samples (depending on depth to water) were collected vertically at each of the 10 AOC 75 borings. Additional soil sampling at this AOC is not planned at this time. Please refer Work Plan Exhibit 4-1 and Exhibit 4-2(now Exhibit 4-3 and 4-4), as well as Figure 4-4a (now Figure 4-10a), which show the investigation locations proposed in the Patton Well/AOC 40 area (including overburden and bedrock well installation) and in off-post areas to the east. Surface water samples are proposed to be collected from Cold Spring Brook Pond (Figure 4-6 [now Figure 4-12]). An additional two locations of surface water and collocated sediment samples will be added to the work plan in the southwest and southeastern corners of Cold Spring Brook Pond, as requested, though the Army would like to note that soils, surface water, and sediment collected at AOC 40 do not exceed the May 2022 SSLs.	NA	NA
36.	Page 25, § 3.3.4, 1st bullet	The text appears to imply a potential off-site source of PFAS (different PFAS mixture). This should be stated as a possibility or another potential explanation for the difference should be provided.	The first bullet, which discusses the PFAS mixture at the Grove Pond supply wells, is meant to imply an on-site source as it states that "…that groundwater from the Grove Pond wellfield area reaches the supply wells." The second bullet compares the PFAS mixture on-site to that of the mixture off-site, which differs. Text will be added to the second bullet indicating that there is a potential off-site source of PFAS that impacts the off-post private supply wells.	NA	NA
37.	Page 25, § 3.3.4	For reasons similar to those discussed above, the extent of contamination has not been delineated in the vicinity of the Shabokin Well area, The source of PFAS is not known, and most groundwater sampling locations with results above screening criteria are not bounded by locations with non-detects or concentrations below GW-1 (see Area 1 PSCS, Figure 8-5). Also,	Please refer to Work Plan Exhibit 4-1 (now Exhibit 4-3) and Figure 4-4b (now Figure 4-10b), which show investigation locations proposed in the Shabokin area and downgradient of AOC 43J (including overburden and bedrock well installation). These activities will continue characterization of the area.	NA	NA

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		a sufficient number of surface water and sediment samples have not been collected. Ensure that future Work Plans acknowledge and address these data gaps. Please ensure that the draft Area 1 Phase 2 Work Plan acknowledges, addresses, and resolves these data gaps.	An additional three surface water and sediment sampling locations will be added to the Work Plan for Mirror Lake, for a total of four locations. Surface water will also be collected from a spring to the southwest of Mirror Lake (Figure 4-6 [now Figure 4-12]). Sediment samples will be collected at surface water sampling locations that have not previously been sampled for sediment.		
38.	Page 25, § 3.3.4, 5th bullet	Is it possible that conclusions regarding the potential sources of PFAS and the Shabokin supply well could be explained by compound partitioning and differential transport as referenced in Sections 3.3.2.1 through 3.3.2.3? Further discussion is warranted.	The general hydraulic upgradient and downgradient directions of the PFAS source location can be identified based on the locations of detections and PFAS mixture changes along the flow path due to differential transport. Additional discussion on these details will be added to the text. AOC 43J is the suspected source area; soil sampling in this area will be added to the Work Plan.	NA	NA
39.	Page 26, § 3.3.4	The last sentence in the bullet at the top of the page states that "It appears that groundwater flow in the Blanchard Road and Old Mill Road area is toward Devens and toward Cold Spring Brook, rather from Devens to off-post." This statement is confusing and speculative, pending results of the Phase 2 bedrock investigation. Please delete.	The Army disagrees that the statement is confusing or speculative, based on the topography and bedrock surface elevations in the area. However, the text will be deleted as the proposed investigation scope will address the question directly.	NA	NA
40.	Page 26, § 3.4.1, ¶ 3	While residential use of property located in Area 1 may not be a "realistic future scenario", zoning by-laws and reuse plans are insufficient to serve as land use controls, and an unrestricted use/unlimited exposure (UU/UE) scenario must be evaluated. Consequently, the human health risk assessment must include evaluation of the residential use/exposure scenario.	A hypothetical future residential scenario (i.e., exposure to soil and groundwater used as a source of drinking water) will be included to evaluate unrestricted use/unlimited exposure (UU/UE). The text will be modified accordingly.	NA	NA
41.	Page 27, § 3.4.1, ¶ 1	The statement: "…the groundwater exposure pathway for drinking water users is incomplete and will not be evaluated further," is unacceptable. This pathway must be evaluated in the human health risk assessment, as required per EPA Risk Assessment Guidance for Superfund, and reasons discussed below: • although engineering controls have been implemented to limit human exposure to PFAS in drinking water produced from the Town of Ayer Grove Pond well field and Devens Patton and Shabokin wells, these interim actions do not obviate the CERCLA requirement to evaluate drinking water pathways connecting groundwater drawn from the wells to human receptors supplied by these wells. The results from the Phase 1 RI confirm that groundwater drawn from the wells is contaminated with PFAS above applicable MassDEP MCLs. CERCLA requires that current and future, potential human health exposure pathways be evaluated in the forthcoming PFAS RI/FS. A remedy will be selected to address the risks posed via this pathway after the remedial investigation and feasibility study are completed. Accordingly, the drinking water pathway connecting	Potential future use of the aquifer groundwater as a source of potable water will be evaluated in the BHHRA. The text will be modified accordingly.	NA	NA

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		groundwater drawn from these supply wells to current and future human receptors must be evaluated in the human health risk assessment; and, • although administrative controls (e.g., deed restrictions) restricting the use of groundwater may be imposed on Devens properties, these controls do not eliminate the drinking water pathway connecting groundwater in state-designated Current and Potential Drinking Water Source Areas to current and potential future users of groundwater from these areas. Administrative controls cannot be used to change the classification of groundwater in these areas [310 CMR 40.1012(4)(a)]. Accordingly, the drinking water pathway connecting groundwater in these areas to potential human receptors must be evaluated in the human health risk assessment.			
42.	Page 27, § 3.4.2	As discussed above, the Work Plan must be expanded to include an assessment of ecological risks. Specifically, a screening-level ecological risk assessment should be performed using the PFAS ecological screening values (ESVs) for the media and receptors presented in the September 2021, "Derivation of PFAS Ecological Screening Values Report" prepared by Argonne Laboratory on behalf of DoD, for use at DoD installations where PFAS have been detected in soils and surface waters.	The Work Plan will be revised to include a proposed SLERA. See response to General Comment No. 4.	NA	NA
43.	Page 28, § 3.5	Please see comments above and below that identify additional Phase 1 PFAS RI data gaps to be addressed in the Phase 2 RI. Specifically, all Phase 1 data must be screening against the new SSLs and additional sampling must be proposed in Area 1 AOCs with detections that exceed the updated values.	Phase 1 data will be reviewed considering the revised SSLs and additional data gaps based on the review, if any, will be added to the section.	NA	NA
44.	Page 30, Exhibit 3-2,AOC 74, Discharge Locations and Receptors	It is important to identify/sample upgradient surface waters that do not have the same chemical composition (i.e., PFAS fingerprint) to confirm that groundwater is discharging to surface waters along designated reaches. Please amend the draft Work Plan accordingly.	Surface water sampling locations will be added where surface water flows into Area 1 from upgradient locations (i.e., at Bowers Brook and the Nashua River). Please refer to Section 4.2.4 (now Section 4.2.6) and Figure 4.6 (now Figure 4-12) for currently proposed surface water sampling locations. Sediment samples will be collected at surface water sampling locations that have not previously been sampled for sediment.	NA	NA
45.	Page 33, § 3.5.3	EPA agrees that additional data collection is necessary to adequately define the nature and extent of PFAS contamination and effectively evaluate current and potential human health and ecological risks in Area 1. Please amend the existing discussion to include a comparison of Phase 1 data to the updated Devens PFAS SSLs.	The Work Plan proposed scope will be amended to reflect changes needed to characterize these media considering the May 2022 Devens SSLs.	NA	NA
46.	Page 35, § 4.2, ¶ 1	The text refers to Appendix H, which focuses on the methods to be used, not the rationale. This should be specifically outlined in the text.	As stated in Appendix H, Section 3, the rationale for the seismic survey is to properly site the location of monitoring wells and improve the overall CSM. A table including the rationale for each seismic transect will be added to Appendix H.	NA	NA

No.	Ref. Page / Para.	COMMENTS	RESPONSE	BACKCHECK	BACKCHECK RESPONSE
47.	Page 35, § 4.2	The text refers the reader to Appendix H for "details on the seismic profile methodology." While Appendix H and Figure 1 provide details regarding the locations where seismic profile surveying will be performed, they do not provide the rationale for selection of specific locations. Please expand the discussion in the text to include this information.	Please see response to previous comment.	NA	NA
48.	Page 35, § 4.2	The draft Work Plan must be expanded to include collection of additional sediment samples. The data collected to date is insufficient to demonstrate that PFAS in sediment does not pose unacceptable risk to human and ecological receptors.	All sediment samples collected during the Phase 1 investigation work had PFAS concentrations below the May 2022 SSLs. Re-sampling of these locations is not proposed at this time. Sediment samples will be collected at proposed surface water sampling locations that have not previously been sampled for sediment.	NA	NA
49.	Page 35, § 4.2	The draft Work Plan must be expanded to include the collection of soil samples to identify/investigate areas of Phase 1 PFAS soil detections and confirm the absence/presence of additional groundwater source areas.	Soil sampling will be added to the proposed work plan to characterize SSL exceedances where they have been detected (see response to EPA Page-Specific Comment #7) and in areas that have not yet been sampled (AOC 43J, the former pump house area located in the northeast corner of the Grove Pond Wellfield Area, the Building 3713 area, and upgradient of AOC 75).	NA	NA
50.	Page 35, § 4.2.1 (Exhibit 4-1)	An additional monitoring well is necessary in the vicinity of Patch Road, where elevated PFAS concentrations were detected.	AOC 43G will be added into the Work Plan. Proposed vertical profile PWVP-21-01, overburden well PWMW-21-05, and bedrock well PWMW-21-05BR are located upgradient of this area to improve characterization of groundwater flowing into the Patch Road area.	NA	NA
51.	Page 35, § 4.2 (Exhibit 4-1)	Additional vertical groundwater profiling should be conducted east of the southern portion of Building T-1445 to help define the plume in this area.	As presented in Section 4-2 and Figure 4-3b (now Figure 4-9b), the Army has proposed to install wells upgradient (75MW-21-01) and downgradient (5702MW-21-01) of Building T-1445 for this purpose.	NA	NA
52.	Page 35, § 4.2 (Exhibit 4-1)	The scope of the proposed Phase 2 RI should be expanded to include the collection of soil samples from near Building 3713/AOC 44/52 and near the Former Pump House in Grove Pond to confirm/deny the presence of PFAS contamination in these areas.	Please see the response to EPA Page-Specific Comment #49. The groundwater model will also be used to assess what areas may have contributed to locations with elevated PFAS concentrations in groundwater, and soil sampling will be proposed in those areas, if not already performed.	NA	NA
53.	Page 36, § 4.2 (Exhibit 4-1)	Please explain why the proposed sampling program isn't confirming the depths of high permeability pathways prior to the selection of screen interval depths. Are these proposed, estimated screen intervals? Coring or borehole geophysical logging should be performed prior to screen placement.	A portion of the proposed overburden wells have pre-determined screen depths, based on PFAS concentrations in previously installed VAP locations. Screen intervals for bedrock wells will be determined based on overburden groundwater conditions and the results of geophysical logging, and packer testing. Please refer to Exhibit 4-1, Exhibit 4-2, and Exhibit 4-6 (now Exhibits 4-3, 4-4, and 4-8).	NA	NA
54.	Page 39, § 4.2.2 (Exhibit 4-2)	An overburden monitoring well should be installed north of Grove Pond to determine the extent of potential underflow beneath the pond.	Four VAP locations were installed in 2018 to the north of Grove Pond, with a maximum PFAS6 concentration of 31.3 ng/L. The Army believes that this sampling addressed concerns about the degree of potential underflow, if any. The groundwater model shows groundwater from the area	NA	NA

No.	Ref. Page / Para.	COMMENTS	RESPONSE	BACKCHECK	BACKCHECK RESPONSE
			northeast of Grove Pond would flow southwest to discharge to Grove Pond.		
55.	Page 40, 4.2.3 (and Exhibit 4-3)	The draft Work Plan states that "The installation of four of the 11 locations will be contingent upon PFAS concentrations in overburden groundwater." Please define the contingency or criteria for concentrations in the overburden that will lead to installing a bedrock well at the location. The statement implies that one of more of the four locations in question may be eliminated if PFAS concentrations in overburden groundwater are below a certain threshold(s). Conversely, the proposed program should also allow for bedrock wells at more than four locations if the overburden threshold is exceeded at more than the four locations listed in Exhibit 4. Similarly overburden results may indicate that bedrock wells near OU1 boundaries or corners may be needed at more than the three locations shown in the Exhibit. Please address.	Please review the criteria and study questions described in Section 4.3. The comment is correct that bedrock wells will not be installed in these "contingent" areas where overburden groundwater concentrations are less than the screening criteria. If required to address data gaps, additional bedrock wells would be proposed in a future Work Plan Addendum, pending the results of the Phase 2 investigation.	NA	NA
56.	Page 42, § 4.2.3 (Exhibit 4-4)	How will the vertical extent of PFAS be confirmed if drilling is stopped at the first water bearing zone? A cluster of wells should be installed where the first bedrock well stops at the first water bearing zones; another cases through that section and drills to the next water-bearing zone.	As described in the study questions and Exhibit 4-4 now Exhibit 4-6), the objective of the bedrock well installations within Area 1 is to determine if PFAS detected in overburden and/or weathered bedrock exceeding the SSLs extends into competent bedrock at concentrations exceeding the SSLs. If PFAS is detected in the shallow bedrock groundwater at concentrations exceeding the SSL, additional deeper bedrock monitoring wells will be proposed in a future Work Plan Addendum. Note that deeper bedrock wells are proposed to be installed along the Devens boundaries and in off-post areas to evaluate potential concentrations/ sources of PFAS in those areas.	NA	NA
57.	Page 44, § 4.2.4 (Exhibit 4-7)	Surface water samples should be collected from areas of suspected/likely groundwater discharge to Grove Pond (i.e., east and west of GP-18-04) to evaluate the extent of potential surface water impacts.	Please refer to Section 4.2.4 (now Section 4.2.6) and Figure 4-6 (now Figure 4-12). Surface water sampling is proposed in a total of eight surface water bodies within and surrounding Area 1, including Grove Pond. Surface water samples collected to date (including at GP-18-04) do not exceed the SSLs.	NA	NA
58.	Page 44, § 4.2.4 (Exhibit 4-7)	Please describe how surface water sampling will be performed. Will grab samples be collected? Will concurrent flow measurements be made?	Please refer to Appendix H, Section 10 and/or the QAPP, Attachment A for a discussion of surface water sampling methodology. Estimates of surface water flow will be incorporated into the RI based on stream gauge data and bathymetry estimates, but these estimates may not be concurrent with surface water sampling.	NA	NA
59.	Page 44, § 4.2.4 (and Exhibit 4-7)	Please include an additional surface water sample where the eastern stream enters the pond. If Army believes this location is effectively covered by RP-18-01, then the additional sample should be located on the eastern edge of the pond (between RP-18-01 and RP-18-03).	Please refer to Exhibit 4-7 (now Exhibit 4-9) and Figure 4-6 (now Figure 4-12). Location RP-18-02 is already proposed to be collected on the eastern edge of Robbins Pond between RP-18-01 and RP-18-03, and three samples are proposed to be collected from the unnamed tributary entering Robbins Pond (at UT-18-01 through -03). Note that additional surface water samples will be collected from Willow Brook to the north of Robbins Pond as a part of the Area 2 Phase 2 RI Work Plan.	NA	NA

No.	Ref. Page / Para.	COMMENTS	RESPONSE	BACKCHECK	BACKCHECK RESPONSE
60.	Page 45, § 4.2.4	The groundwater model report (Appendix E, section 7) notes that baseflow estimated from surface water flow estimates would provide a direct measurement of recharge and help constrain the model, particularly with respect to hydraulic conductivity. Surface water flow measurements should be incorporated into the proposed surface water sampling program, including Cold Spring Brook (close to Cold Spring Pond, before the confluence with Bowers Brook, and after the confluence with Bowers Brook), the stream east of Robbins Pond, and any major tributaries entering or exiting Grove Pond. (Surface water flow estimates will also be useful in determining contaminant load.)	Estimates of surface water flow will be incorporated into the RI based on stream gauge data and bathymetry estimates. As noted in other comments, the potential for underflow of Cold Spring Brook is being investigated during the RI, which will provide confirmation of Cold Spring Brook as a discharge boundary. Updates to the model will be considered after further data collection.	The response is acceptable. However, the language in the text suggests a bias toward a particular outcome: "will provide confirmation of Cold Spring Brook as a discharge boundary." An objective investigation needs to be designed and conducted without pre-judging the outcome. Also, the investigation must be sufficiently robust as to answer the question as to whether impacted groundwater is transported to the far side of the Brook. For example, it is plausible that shallow groundwater discharges to the Brook while intermediate and deep groundwater flow beneath the Brook. It is also plausible that these conditions might shift with seasons, flow conditions, etc.	Comment noted. The Army will review the revised text per the comment to verify that the language does not indicate a pre-determined outcome for the investigation.
61.	Page 45, § 4.2.5	As indicated in Figure 4-6, the text should be amended to indicate that fish samples will also be collected from Grove Pond.	The text will be amended to reflect the planned fish tissue sampling in Grove Pond. In addition, the text will be revised to include fish tissue sampling from Cold Spring Brook Pond.	NA	NA
62.	Page 45, § 4.3	This brief overview of the proposed baseline human health risk assessment is insufficient. Please identify and briefly discuss the components of a baseline HHRA (i.e., exposure assessment (e.g., potential pathways, receptors, and exposure levels), toxicity assessment (e.g., effects, toxicity values, and uncertainties), and risk characterization (e.g., scenarios, exposure assumptions, and risk calculations).	The Work Plan will be revised to briefly discuss the BHHRA components: data evaluation/hazard identification, exposure assessment, toxicity assessment, and risk characterization.	NA	NA
63.	Page 45, § 4.3	Please expand the discussion to include elements of the screening-level ecological risk assessment. Specifically, the text should identify PFAS ecological screening values (ESVs) for the media and receptors presented in the September 2021, "Derivation of PFAS Ecological Screening Values Report" prepared by Argonne Laboratory on behalf of DoD, for use at DoD installations where PFAS have been detected in soils and surface waters and discuss the ecological screening process described therein.	The Work Plan will be revised to include the methodology for a SLERA. See response to General Comment No. 4.	NA	NA
64.	Page 50, § 6.0	Please provide details regarding the phasing/sequencing of the fieldwork in Section 6 (or elsewhere in the document). For example, will the seismic survey influence the location or construction details for the bedrock wells, and will the proposed VP locations be used to site permanent monitoring wells? A few dependencies are implied (such as certain bedrock locations being dependent on PFAS concentrations in overburden) but should be spelled out.	Text regarding the general sequencing will be added to Section 4. The phasing/sequencing of the planned RI implementation is detailed in Appendix H. Additional details regarding rationale for the proposed VP and proposed overburden wells associated with the VP locations is presented in Section 4.2 and the figure set.	NA	NA
		TABLES			
65.	Table 1-2	Please revise the table to reflect the new, updated Devens SSLs recently developed by EPA Region 1 and presented in attached Tables 1-5.	The Work Plan tables will be updated to include the Devens SSLs recently developed by EPA Region 1.	NA	NA
66.	Table 3-1	The "Devens PFAS RI Sample Review to Support Human Health Risk Assessment" appears to be missing from the report. Please include.	Table 3-1 will be included.	NA	NA

No.	Ref. Page / Para.	COMMENTS	RESPONSE	BACKCHECK	BACKCHECK RESPONSE
		FIGURES			
67.	Figure 3-3 – Overburden Water Level Elevation Contours	• The contours by this bedrock knob are unrealistic. They show flow going through this area as if the overburden is contiguous, but flow is likely to go around this knob not through it. Further discussion is warranted. • The legend includes bedrock monitoring wells. If the wells were not used to develop the overburden water level elevations, they should be removed from the figure. Were these wells used to develop the overburden water level elevations? If not, recommend removing from the figure. Also, please explain the rationale for relying on bedrock data when there is adequate overburden coverage in this area. • The groundwater elevation contour lines along the western edge of the study area should be dashed, as no data appear to anchor the interpretation.	• The contours (and lack of shading) around the bedrock knob are not meant to imply through-flow; rather that the exposed bedrock presents a barrier to overburden flow. The figure will be revised to clarify. • Bedrock monitoring wells are shown for reference only and were not used to generate contours. A note will be added to the revised figure. • The groundwater elevation contour lines along the western edge of the study area will be revised to be dashed.	NA	NA
68.	Figure 3-4 – PFAS Groundwater Operable Unit Area 1 and Off-Post Mixtures	• To better inform the CSM discussion, EPA recommends splitting up this figure into multiple figures on a smaller scale.	Additional smaller scale figures will be added to the work plan.	NA	NA
69.	Figure 4-1 – Seismic Profile Surveying Location	• Figure 2-5 in the Area 1 PSCS (Appendix B) reveals that relatively few confirmed bedrock data points existing in the vicinity of Mirror Lake and the Shabokin Well. The proposed geophysics lines east and southeast should be extended near Mirror Lake and the Shabokin well to provide additional coverage and better evaluate overburden ground flow in this area. • Another seismic line should be run, aligned north-south and extending from the northeastern corner of Mirror Lake to at least a few hundred feet north of the Patton Well, intercepting the western end of the proposed east-west seismic line in this area. This would provide additional details regarding the bedrock topography in an area with potentially high PFAS concentrations. • Please shows locations with PFAS exceedances above site-specific screening criteria on the figure to provide context for the seismic line selection. • Please show all bedrock water supply wells, including private wells, on this figure. • Please add confirmed bedrock locations (as seen in Figure 2-5 in Appendix B) to the figure to show areas of relative bedrock information.	The proposed geophysics (seismic survey) lines will be adjusted to include areas in the vicinity of Mirror Lake and the Shabokin Well. A table with the rationale for each seismic transect will be added to the main text as Exhibit 4-1. Existing bedrock wells are already shown on Figure 4-1. Existing bedrock water supply wells and the areas with PFAS above screening criteria will be added to the figure.	NA	NA

No.	Ref. Page / Para.	COMMENTS	RESPONSE	BACKCHECK	BACKCHECK RESPONSE
70.	Figure 4-2	Elevated PFAS concentrations were detected in groundwater southwest of Robbins Pond (PWVP-19-01, PWVP-19-08, and PWVP-20-07). This area should be shaded in orange on the Figure.	The orange boundaries represent the extent of areas exceeding the EPH LHA. As detailed in the PSCS, the three referenced PWVP locations did not exceed the LHA but did exceed the PFAS6 MMCL. Therefore, the current yellow shading is accurate.	NA	NA
71.	Figure 4-2	This figure should identify the location of the 13 off-base (outside of Area 1) private wells reported to have PFAS in groundwater at levels above the MADEP PFAS6 GW-1 standards. Well construction for these 13 private supply wells should be provided to allow for more detailed hydraulic analysis.	The locations of the referenced private wells will be added to the figure. The Army will review available well construction records and bedrock elevations compiled in the PSCS and add to the table set.	NA	NA
72.	Figure 4-2	Please amend the figure to include all locations with PFAS exceedances above the updated SSLs.	Figure 4-2 (now Figure 4-8) will be updated to reflect locations that exceed the May 2022 Devens SSLs.	NA	NA
73.	Figure 4-3a, Northeast Portion of Operable Unit	Previous soil sampling results indicate that potential PFAS sources exist near the former location of Building 3713/AOC 44/52 and near the Former Pump House. Please explain why additional soil sampling was not performed in the Phase 1 RI. Regarding the Former Pump House, the plan should identify the material that was pumped at this location (e.g., water, gasoline, diesel, etc.). Could pumping of the nearby Army supply wells located here explain the high levels of PFAS reported in the samples collected from VP-18-12? When were the Army wells active?	Additional soil sampling will be performed in areas where there are PFAS concentrations exceeding the May 2022 Devens SSLs. Soil sampling will also be proposed at AOC 43J, the former pump house area located in the northeast corner of the Grove Pond Wellfield Area, the Building 3713 area, and upgradient of AOC 75. As described in the Work Plan Section 4.2, and Figure 4-3a (now Figure 4-9a), permanent overburden and bedrock wells are proposed to be installed in the Grove Pond wellfield area, including areas adjacent to GPVP-18-12. Available information on the use date(s) and purpose of the Former Pump House will be added to the text.	NA	NA
74.	Figures 4-3a and 4-3b	These figures depict slightly different areas but are both entitled "Northwest Portion of Operable Unit." Please revise the figure titles for clarity.	These figures are showing different parts of the Northeast Area, hence being numbered as 4-3a and 4-3b (now Figure 4-9a and 4-9b).	NA	NA
75.	Figure 4-4a, Southwest Portion of Operable Unit	Elevated PFAS concentrations were detected in groundwater southwest of Robbins Pond (PWVP-19-01, PWVP-19-08, and PWVP-20-07). This area should be delineated on the figure.	As detailed in previous comments, the PFAS concentrations exceeded the PFAS6 criteria but not the EPA LHA.	NA	NA
76.	Figures 4-4a and 4-4b	These figures depict slightly different areas but are both entitled "Southwest Portion of Operable Unit." Please revise the figure titles for clarity.	These figure titles will be modified to be more specific to the area(s) that is shown.	NA	NA
77.	Figure 4-4a and Figure 4-6	Please add an additional surface water sample where the eastern stream enters the pond. Also, an additional sample should be collected from the eastern edge of the pond (between RP-18-01 and RP-18-03) and a monitoring well should be installed in the vicinity of Patch Road, where elevated PFAS concentrations were detected.	Please refer to Exhibit 4-7 (now Exhibit 4-9) and Figure 4-6 (now Figure 4-12). Location RP-18-02 is already proposed to be collected on the eastern edge of Robbins Pond, and three samples are proposed to be collected from the unnamed tributary entering Robbins Pond. Patch Road no longer appears to be present south of Feinburg St, and north of Feinburg St., PFAS is associated with releases at AOC 43G (to be verified). Proposed vertical profile PWVP-21-01, overburden well PWMW-21-05, and bedrock well PWMW-21-05BR are located upgradient of this area to improve characterization of groundwater flowing into the Patch Road area.	NA	NA

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78.	Figure 6-1	The project schedule is not provided.	The project schedule will be included in the final Work Plan.	NA	NA
		APPENDICES			
		Appendix A – Addendum for Groundwater Operable Unit Area 1 to UFP-QAPP for Remedial Investigation for PFAS	**Now revised to Appendix A – Addendum for Phase II Area 1 to UFP-QAPP for Remedial Investigation for PFAS**		
79.	Analytical Parameters	Please confirm that only PFAS samples will be collected for laboratory analysis. Appendix H, Section 9 for Surface Water Sampling also lists total organic carbon and dissolved organic carbon. Are there any other parameters that could aid in the feasibility study deliverable that would be helpful to collect at this time?	TOC and/or DOC will be collected from a subset of aqueous and soil/sediment samples. No additional parameters are proposed to be collected during the RI implementation.	NA	NA
80.	Data reporting	Please confirm how the results will be reported. Will values below the LOQ (listed as level of quantitation in the acronym list and as limit of quantitation on WK#15) be reported to the LOD (limit of detection) or the detection limit (DL)? All LOQ values are significantly less than the Project Action Limits (PALs). The approach should be confirmed with the laboratory. It seems that the LOD should be used rather than the DL. Values between the LOQ and LOD would be qualified as estimated “J”. (WK#15 and WK#37)	Per DoD requirements, non-detected results will be reported at the LOD. Results between the LOQ and DL will be reported as estimated “J”.	NA	NA
81.	Fish tissue results	Please explicitly state how the fish tissue results will be reported. Are the results based on wet or dry weight? Will percent lipids be measured? The lab SOP for lipids was provided. (WK#15-3)	The Work Plan will be revised to indicate that fish tissue results will be reported on a wet-weight basis. Fish tissue samples will not be analyzed for lipids, the lab SOP for lipids will be removed.	NA	NA
82.	Quality Control Samples	Wk#12 indicates criteria for Laboratory Control Sample Duplicates (LCSD). Please note that no LCSD analyses are planned because Matrix Spike/Matrix Spike Duplicates (MS/MSD) will be collected and analyzed for all matrices.	Noted. The worksheets will be revised.	NA	NA
83.	Surface Water Sampling (WK#17)	Please explain how it was determined that “immediately below the water surface” is the optimal location for collecting the surface water sample?	Language will be updated to be consistent with the surface water sampling SOP.	NA	NA
84.	Fish Sample Containers (WK #19&30)	Please expand on the fish sample preparation. Will the tissue sample be prepared by the field team, or will whole fish be shipped to the laboratory for preparation? Is a 4.5-ounce plastic bottle appropriate? The field SOPs, SOP-16 and SOP-17 are consistent with shipping the fish to the lab for preparation.	The Work Plan will be revised to state that whole-body fish tissue samples will be shipped to the laboratory for processing, and that fish tissue samples will be wrapped in aluminum foil and then placed in zip-loc bags (not plastic bottles).	NA	NA
85.	WK#19&30:	Please reconcile the aqueous holding time with the lab SOP. The lab SOP states 14 days for preparation and 28 days for analysis. (The fish tissue holding times match the SOP.)	The holding time for aqueous samples is 28 days to extraction and 28 days to analysis.	NA	NA
		Appendix D- USEPA Region 1 Site-Specific Screening Levels			
86.		Please replace the current materials with the recently updated PFAS SSL information contained in attached Devens SSLs Tables 1-5.	The 2018 Devens SSLs will be replaced with the 2022 Devens SSLs.	NA	NA

No.	Ref. Page / Para.	COMMENTS	RESPONSE	BACKCHECK	BACKCHECK RESPONSE
		Appendix E – Regional Groundwater Flow Model of the Former Fort Devens, Massachusetts			
		GENERAL COMMENTS			
1.		The adequacy of the regional model to assess flow paths requires additional information on parameter sensitivities and confidence intervals. While the overburden system appears to be adequately represented in the model, the underlying bedrock requires some additional modifications to ensure better representation.	*EPA Appendix E General Comments 1, 2, 3, and 8, and Appendix E Page-Specific Comments 3 and 16 concern the representation of the bedrock in the model.* The suggestions regarding the thickness of bedrock and the associated transmissivity, as well as the fractured nature of the bedrock, are reasonable and appropriate for this hydrogeologic setting. However, the approach for incorporating the bedrock in the regional model was dictated by the following objectives: • Model development based on previous modeling studies, considering an equivalent porous media (EPM) approach and 50 feet of weathered bedrock underlain by at least 200 feet of competent bedrock. • Focus on groundwater flow paths within the overburden sands throughout the facilities, where contamination is found based on available sampling data. • Model refinements and re-evaluation of model structure particularly in the bedrock, if/when data collected as part of the RI suggest contaminant migration in the bedrock The representation in the model using the EPM approach and 50 feet of weathered bedrock underlain by at least 200 feet of competent bedrock, was used because it was consistent with the data available at the time the model was developed and previous modeling studies. Further, this representation is appropriate for the primary purpose of the model which is to “calculate groundwater flow paths within the overburden sands throughout the facilities.” The critical parameter controlling the flow of groundwater between the overburden and the bedrock is the vertical hydraulic conductivity assigned to the bedrock. Regardless of the thickness or the number of layers used to represent the bedrock, this parameter value will always include surrogate effects because the bedrock cannot be perfectly characterized. What the model tells us though, is that given our assumptions and simplifications the vertical hydraulic conductivity currently assigned is necessary to support the water levels observed in the overburden given the amount of recharge specified. There is little data to constrain a more detailed representation currently. The bedrock will be revaluated when additional data is collected during future phases of investigation.	Army’s response does not address EPA’s comment/concern. While the first bullet indicates that the regional model was developed “based on previous modeling studies,” these previous models were typically smaller areally and the interaction of shallower and deeper flowpaths was less critical. As such, citing those dimensions is not adequate justification for representing the underlying bedrock in the regional model. As noted in EPA’s comments on the SHL groundwater model update, the limitations of a regional model to provide answers to local groundwater issues should always be considered whenever such a model is used for a given purpose. To help resolve the apparent difference in opinion on the simulation of the bedrock thickness for this model, EPA would like to see additional information on bedrock wells in the area and their depths. While EPA does not disagree that vertical hydraulic conductivity is a critical parameter, simulating a shallower bedrock flow system than what maybe participating in the local flow system has critical consequences. The active bedrock flow system should be guided by well depths of withdrawal wells in the area. Well depths are available from other outside sources of information such as MassMapper (see below). https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html	Because data on bedrock, and fractured bedrock in particular, are limited at the site and across the model domain, the bedrock is being investigated separately as detailed in the Phase 2 Remedial Investigation Work Plan and Quality Assurance Project Plan Addendum for Per- and Polyfluoroalkyl Substances (PFAS) Groundwater Operable Unit – Area 1. Evaluation of the available data, though, suggests that, relative to the overburden, fractured bedrock does not act as a primary transport pathway at the site. Should the results of the upcoming Phase 2 Remedial Investigation work indicate that fractured bedrock does present a pathway risk, the numerical groundwater model can be updated accordingly. At this point, however, it would be premature to devote time/effort modeling the fractured bedrock system until additional information is obtained and data gaps have been adequately evaluated.

No.	Ref. Page / Para.	COMMENTS	RESPONSE	BACKCHECK	BACKCHECK RESPONSE
2.		The model simulated thickness in the bedrock should align with drilled residential bedrock wells in the area. The reason is that water-bearing fractures occur at depths that correspond to drilled well depths. Further, Hansen and Simcox (1993) found permeable water-bearing zones at depth in the bedrock. Omission of these water-bearing zones will cause the model to overcompensate and assign a model hydraulic conductivity higher for the shallower rock than actually occurs.	See response to EPA Appendix E General Comment 1.	NA	NA
3.		There is no anisotropy assigned to the bedrock despite preferred orientations measured (Kopera, 1978). The strike and dip of fractures shows preferred orientations that will impact the bulk flow and flow paths significantly. Dip patterns in particular show clustered distribution per rock type. Several shear zones are mapped that will likely affect hydraulic conductivity. Ideally, pump test in bedrock would be used as calibration to help compute anisotropy, which was not done. Typically, geologic maps are used to guide zonation of hydraulic conductivity of the bedrock. It's unclear how spatial variation of hydraulic conductivity was treated in the bedrock and what was used to guide variations besides pilot points. It's difficult to digest the spatial residual errors in the rock (and zonation implications) since hydrostratigrahic units were not differentiated on any of the residual plots (Figure 13). Figure 14 shows that variations in hydraulic conductivity were computed but primarily show a dominant single value per area. Figure F.3. shows variations in the upper bedrock that are not referenced to rock type.	See response to EPA Appendix E General Comment 1.	This comment is not addressed in GC 1. Please respond to the comment.	Please see response to Backcheck Comment GC 1.
4.		Parameters should be listed in the table with final values and confidence intervals. Placing confidence intervals on Fig. 14 would also be helpful. Composite scaled sensitives should be reported in a graph to identify most sensitive parameters.	Confidence intervals cannot be calculated when regularized inversion is used (Doherty, 2015). Moreover, because recharge and hydraulic conductivity are highly correlated and recharge was not calibrated as part of this effort, estimates of parameter value confidence intervals would not include the contribution from this parameter type. For this reason, the appropriateness of the calibrated values for hydraulic conductivity are assessed qualitatively against the expected values determined from the previous modeling efforts and encapsulated in the model inversion as prior information. The comparison with expected values is shown in Figures 14a and 14b. Classed post maps of parameter sensitivities will be included in an Appendix in the final report.	Please insert the response into the text of the report	Language from the response will be included in the revised text in Section 4.5, third paragraph.
5.		There are no computed water budgets presented nor zone budgets to assess model computed flow. Further, comparison of flow from preexisting model boundaries to the regional model boundaries would help understand flow and where differences exist.	Groundwater budgets per HSU will be included in the final report.	NA	NA
6.		Collection of baseflow data would help constrain model calibration. There are two USGS gages on the Nashua River where baseflow separation could be done on the streamflow record however the drainage area is much larger than the model	Estimates of baseflow would certainly help constrain the model calibration. Data from the two USGS gages as well as other gauges were considered during model construction, however issues such as drainage area versus	River leakage could be measured during baseflow conditions to help constrain the model.	Comment noted.

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		area. The two gages are 01095503 and 01095500. Other measurement stations could be added to assist in baseflow computation.	model area or dam releases between gauges prevented detailed baseflow separation. As noted in the EPA's Page Specific Comment 60 on the main document, estimates of surface water flow will be incorporated into the RI based on stream gauge data and bathymetry estimates. These estimates can then be used in future groundwater model updates.		
7.		Particle tracking simulations were made for the Shabokin and Patton wells. Why was this not performed for the Grove Pond well field?	A capture zone for the Grove Pond wellfield will be added to the report.	Acknowledged. However, understanding receptor locations is also important.	Comment noted.
8.		The model uses an equivalent porous media (EPM) approach for bedrock and assigns a low hydraulic conductivity to that zone. Has there been any evaluation of fracture flow in the bedrock aquifer? Have tendencies been replicated to improve the representation of simulation (i.e., simulating a fault zone as a linear high hydraulic conductivity zone in the model)?	See response to EPA Appendix E General Comment 1.	NA	NA
9.		Table B-1 lists hydraulic conductivity and transmissivity values at select pumping wells. Presumably those wells are located in relatively high-yielding zones within the overburden, which may not be applicable for other portions of the study area. While the hydraulic conductivities in the most recent model were based on previous models, given the scale of this larger model it is reasonable to "ground truth" the estimates for this critical parameter. Recommend conducting hydraulic conductivity (slug) tests for representative overburden and weathered bedrock units and incorporating data from the planned bedrock packer testing to refine the hydraulic conductivity for the model.	Hydraulic conductivity and transmissivity values used in the model were based on the information extracted from previous modeling efforts. Model calibration adjusted the hydraulic conductivity field resulting from those models to provide the reported fit to the data. Additional data, including hydraulic conductivity testing of select overburden and weathered bedrock wells, will be collected as part of the RI and will be used to constrain hydraulic conductivity in future versions of the model.	NA	NA
		PAGE-SPECIFIC COMMENTS			
1.	Page 2-1, § 2.2, 2nd sentence	The lowland areas are mentioned as containing eroded bedrock, whereas the hillsides are not mentioned as containing eroded bedrock. It suggests there was no erosion from the glacier of bedrock on the hillsides, which is not the case. Please amend.	This sentence will be modified to read as follows: The bedrock surface is an eroded and irregular surface. It includes elevated upland areas with exposed or nearly exposed bedrock, and lowland areas where the eroded bedrock surface has been overlain by fluvial, glaciofluvial, and glacial sediments.	NA	NA
2.	Page 3-1, § 3	Please identify/describe the "standard features in USG-Transport" implemented.	These features are described in Section 3.2 Boundary Conditions. Text in the report will be edited to clearly point to that Section.	NA	NA
3.	Page 3-2, § 3.1.2, Layering	While the modified approach represents the overburden system adequately, there may be some solution accuracy problems based on the lack of discretization in the bedrock. For example, resolution differences may exist between 1) areas where the overburden makes up 6 layers, and only 2 bedrock layers are available for simulation, and 2) areas with 4 overburden layers that have 4 bedrock layers. Further, because all bedrock wells are cased off in the upper 10-20 ft of hitting rock, there should be at least one bedrock layer with no wells assigned to it particularly	See response to EPA Appendix E General Comment 1.	This comment is not addressed in GC 1. Please respond to the comment.	Please see response to Backcheck Comment GC 1 and below. As illustrated in Figures A.1 through A.8 of Appendix A, there are at least three layers representing the bedrock within over 90% of the model domain. The majority of residential wells are located in areas where there are at least five layers of bedrock, while all residential wells are within areas with at least three layers of bedrock. In addition,

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		for pumping wells. This omission may cause issues with estimation of vertical hydraulic conductivity of the shallow rock.			Table B.2 – Residential Well Details – lists the depths of residential wells available at the time of model construction. Of the 127 wells listed, only 38 had reported depths.
4.	Page 3-3, § 3.2.1	A schematic illustration showing differences in surface-water interaction using the packages selected is needed. A reviewer cannot clearly follow the current specification without more information.	A figure providing this schematic illustration will be added to the report.	NA	NA
5.	Page 3-5, § 3.2.1.2.1	The vertical hydraulic conductivity of the riverbed is set at 130 ft/d, which is very high. Are there any independent measurements or references that can be cited?	Section 3.2.1.2.1 states the vertical hydraulic conductivity of the riverbed is 13 feet/day; 130 feet/day is the normalized vertical hydraulic conductivity as defined in the report and listed to compare conductance terms between previous models and this one.	The response does not respond to the question. Specifically, is there independent measurements of riverbed conductance?	These data are not available to our knowledge. Available estimates of bed conductance are based on model calibration, e.g., de Lima (1991), which was the basis for the normalized vertical hydraulic conductivity used by ETA (1993, 1994, and 1995), which were subsequently the basis for this model.
6.	Page 3-6, § 3.2.1.3.1	It's stated that surface-water stage has no effect on interchange, which is counterintuitive. Please demonstrate in an equation how this is so.	Section 3.2.1.3.1 was intended to convey that the conductance term can account for the approximate calculated stage in the calculation of seepage face flow, and that, where this interchange occurs, it is controlled by the bed elevation. This sentence will be modified in the final report to read as follows: Although bed width is an important property in calculating stream stage within the CLN network, the modeling focus here is on groundwater flow paths for which the flow exchange between the stream and the aquifer is important, including where this exchange occurs, which is determined by the bed elevation.	NA	NA
7.	Page 3-7, § 3.2.2	Not simulating withdrawals from residential wells is incorrect and problematic for assessment of receptor vulnerability. A rule of thumb is 0.2 gpm per residential well. Please amend.	Pumping from the residential wells, even at the rule of thumb rate provided, would only marginally alter flow conditions and therefore, the calculated flow directions in the overburden, which is the focus of this modeling effort. However, this rate can be considered in a future version of the model.	NA	NA
8.	Page 3-8, § 3.2.3	Please explain how a net recharge of 1.8 in/yr was computed for open surface water features.	The relevant calculations and assumptions by ETA, 1995 will be summarized in an Appendix in the final report.	NA	NA
9.	Page 3-9, § 3.3	A 1:10 vertical to horizontal ratio is not appropriate for fractured-rock aquifers where fractures are steeply dipping. Rather a 1:1 ratio should be the norm. Please amend.	The ratio is 10:1 or 1:1 for the weathered component of the bedrock. The competent bedrock is specified as 1:10. Flow in the overburden is largely insensitive to the horizontal hydraulic conductivity of the competent bedrock a 1:1 ratio can be evaluated in a future version of the model.	NA	NA
10.	Page 4-2, § 4.2.2	A proof is needed to validate the use of custom programs.	The proof will be provided as an Appendix in the final model report.	NA	NA
11.	Page 4-6, § 4.5	Please compile/present the observed water level values and dates in a table to be included in Appendix E.	This table will be provided in Appendix E in the final report.	NA	NA
12.	Page 4-7, § 4.5.1	There is a bimodal head distribution because there are several local highs in the calculated heads.	These local highs result in a divide as stated in the report.	NA	NA

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13.	Page 4-7, § 4.5.1	There is a lack of observed heads on the east side of New Cranberry Pond. Additional water level data are necessary to resolve this issue.	The calibration approach, in which the South Post, former Main Post, and former North Post were calibrated independently, demonstrates that calibration to additional water level data on the South Post will not affect the calibration on the North Post and, therefore, will not change the flow directions calculated for the former North Post.	The response indicates that the model is insensitive to water levels on the east side. However, no details have been provided to support this statement. Please explain.	A new figure (Appendix J, Figure J.1) and text to support this statement have been included in the report.
14.	Page 4-7, § 4.5.1	The computed vertical hydraulic conductivity of the upper bedrock is relatively high (computed at 1.5-2.2 ft/d).	These values are consistent with the values used in the SHL model. The previous modeling of the South Post did not explicitly represent the bedrock. It was treated implicitly as a no-flow boundary at the base of the model.	NA	NA
15.	Page 4-7, § 4.5.1	The calibration supports heterogeneity in the overburden but not the upper bedrock. Confidence intervals should be placed on the reported values per area.	There is little to no data available to constrain calibration of bedrock parameter values except as they pertain to vertical hydraulic conductivity to support the water levels in the overburden given the simplifying assumptions made to represent it. As such, variation in the bedrock properties (thickness and horizontal hydraulic conductivity) are indicative of areas where bedrock is identified at or near the surface and may affect nearby water levels in the overburden (Figure F.3). Regarding confidence intervals, see response to EPA Appendix E General Comment 4.	NA	NA
16.	Page 4-7, § 4.5.2	The large residuals mostly show underestimate of model-computed heads near rock outcrop, which suggest possible overestimate of hydraulic conductivity in the rock or underestimate of flow in the rock. Please amend.	See response to EPA Appendix E General Comment 1.	This comment is not addressed in GC 1. Please respond to the comment.	Please see response to Backcheck Comment GC 1 and below. As indicated in Section 4.5.2. of the report and illustrated in Figure D.3, there is significant variability in water level residuals near bedrock outcrops, comprising both negative and positive values of similar magnitudes. This variability is attributed to apparent weathered bedrock variability.
17.	Pages 4-7 to 4-8, §§ 4.5.1 - 4.5.3	Residual statistics should include the number of wells.	The number of wells for each Post are listed in Section 4.2.1.	NA	NA
18.	Page 5-1, § 5	Please provide references to the porosity values for similar rock types.	This paragraph will be modified to read as follows: The base estimates of effective porosity specified for the particle tracking analyses were taken from Geosyntec (2020) for the SHL model – 30% for the overburden, 25% for the till, and 0.1% for the bedrock units. Like other aquifer properties, the effective porosity in each model cell was calculated as the thickness weighted average of the effective porosities of each HSU within it. Effective porosity is a scalar on particle travel time. A range in potential travel times for each area was calculated by using an alternate set of effective porosities: 15% for the overburden and till units, 10% in the upper bedrock, and 2% in the competent bedrock. This alternate set of	NA	NA

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			effective porosities reflect our professional judgement of the best estimate based on our experience and is consistent with differences between effective porosity estimated from textural data (e.g., grain size and moisture retention) and field calibrated values to a tracer test reported by Stephens et al. (1998). Stephens et al. (1998) concluded that porosities derived from textural data resulted in effective porosity estimates that were between 50 and 90% larger than an estimate resulting from a calibration to a field tracer test for a sand and gravel aquifer. The base overburden porosity is 90% larger than the alternate value, and 67% larger for the till. The alternate porosities for the bedrock units are consistent with values discussed by Fetter (1994) for fractured crystalline bedrock. Retardation was assumed to be negligible, and thus specified as 1.		
19.	Page 5-1, § 5	Index maps should be included in Appendix F to reference locations in Figures 15a–15d.	An index map will be included in the final report.	NA	NA
20.	Page 5-1, § 5	Please explain how weak sinks are treated in particle tracking. How many particles were used?	Weak sinks are handled in two ways: 1) Grid refinement in the vicinity of pumping wells to preclude weak sinks, and 2) mod-PATH3DU was used, in part, because it includes an analytic correction to account for weak sinks.	NA	NA
21.	Page 5-2, § 5, ¶ 3	Capture zones should not be calculated using backward particle tracking analysis. Capture zones for the Shabokin and Patton wells should be calculated from forward tracking of particles from all water-table locations by designating codes to illustrate capture areas. Please recalculate and show the resulting capture zones in new figures in Appendix A.	Forward particle tracking can be a more appropriate approach when sufficient particles are released for comprehensive capture-zone delineation, however, backward tracking is sufficient and appropriate here for delineating the general shape and extent of the associated capture zones for the pumping wells. The model cells from which these two wells are pumping are both 10 feet square. For the backward tracking analysis, a circle of particles was released around each of these two wells at a radius of 7 feet from the cell center. Particles were released at 1 degree intervals (1.2 feet between particles) at 9 vertical release points per layer in which a well was screened. Vertically, particles were released every 10 % of a cell's thickness from 10% through 90%. At these intervals 3240 particles are released per model layer a well is screened within. The Shabokin Well is screened in model layers 4 and 5, thus 6480 particles were used to delineate its capture zone, while Patton Well is screened in model layer 3 and its capture zone was delineated using 3240 particles. We will include this description of the particle releases in the final report.	NA	NA
22.	Page 6-1, § 6, ¶ 2, last sentence	Without flow per model layer information, the statement that "Flow in the underlying crystalline bedrock is limited to non-existent" is unsubstantiated. Please provide this information or	Groundwater budgets per HSU will be included in the final report.	NA	NA

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		revise/omit this conclusion. (Please note: Hansen and Simcox (1993) report high yielding bedrock wells in Mass. below 600 feet.)			
23.	Page 6-1, § 6, ¶ 3	Please provide results of the post calibration comparison performed to show model computed hydraulic conductivity to pre-existing estimates of hydraulic conductivity.	The results of the post calibration comparison are provided in Figure 14a for the overburden, and Figure 14b for the upper bedrock.	NA	NA
24.	Page 7-1, § 7, ¶ 1, 1st sentence	Please define “optimized” flow directions within the context of the sentence.	The term “optimized” refers to flow directions resulting from an optimization (i.e., calibration) to available water levels and corresponding flow gradients.	NA	NA
25.	Page 7-1, § 7, ¶ 4, 2nd sentence	The text states that the use of pilot-points provided a “robust mechanism to evaluate sensitivity through the model domain” but sensitivity and confidence intervals were not presented in the report. Please provide this information necessary to evaluate/support this statement.	The methods employed by PEST use sensitivities to calculate the optimized parameter values. The Jacobian matrix encapsulates these sensitivities at each pilot-point location. The use of pilot-points is robust because they are point estimates of the sensitivity and do not incur the lumped bias within an area that zones do.	NA	NA
26.	Appendix A, Figure 15	Please describe how the planar maps were generated (i.e., from projecting from all layers?). Also, a breakdown per model layer is needed to identify, qualitatively, vertical flow.	The planar maps in Figure 15 were generated by projecting from all layers. Breakdown per layer will be included in the final report. In Appendix A, the planar maps were generated by calculating the relative proportion of bedrock in each model cell, based on its top and bottom elevation and the bedrock surface elevation in that cell (if present) and the assumed thickness. A note to this effect will be added in the final report for these figures.	NA	NA
27.	Appendix D	Please include a table with observed water level values and dates.	This table will be provided in Appendix E in the final report.	NA	NA
28.	Appendix F	Please include index maps to reference locations in Figures 15a – 15d.	An index map will be included in the final report.	NA	NA
MassDEP COMMENTS – MARCH 28, 2022					
		GENERAL COMMENTS – NONE			
		PAGE SPECIFIC COMMENTS			
1.	Section 1.2, ¶ 4	The statement indicating there were no exceedances of screening criteria reported in the previously collected soil samples is misleading. As indicated, the Phase 1 soil sample results were screened against MCP Method 1 Standards. However, in apparent contradiction to the concluding statement, there were numerous exceedances of the Method 1 Standards. In addition, concentrations in soil indicative of potential source areas were reported in soil samples collected from the Grove Pond Area and AOC 40 (Appendix C). Presumably, the cited “applicable site-specific soils SLs” cited are the EPA screening levels listed in Table 2-1, rather than the MCP Method 1 Standards mentioned here. As explained below in Comment 3, MassDEP cannot accept these screening levels because they are less stringent than screening levels that would be generated using state-promulgated standards and/or criteria. Accordingly, MassDEP will consider soil a medium of concern requiring further evaluation until screened-out using acceptable screening levels or shown to not pose significant risk by an acceptable risk assessment.	Soil sampling required to characterize the extent of PFAS exceeding the May 2022 Devens SSLs will be added to the Work Plan, per technical guidance included in the July 6, 2022 Office of the Assistant Secretary of Defense Memorandum (July 2022 ORD Memo).	NA	NA

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2.	Section 1.3	The statement indicating that no obvious continuing sources of PFAS were identified during the Phase 1 remedial investigation is inconsistent with the results from TOP assay sample results discussed in Section 3.3.2.3: "The presence of precursors in soil and to a lesser extent groundwater in the select areas mentioned above [AOC 57, AOC 74, AOC 75, and Grove Pond Area] indicates a potential to observe increasing concentrations of PFAAs both over time and, relatedly, with distance from a PFAS source area." In addition, PFAS concentrations in soil indicative of potential source areas were reported in soil samples collected from the Grove Pond Area and AOC 40 (Appendix C).	Soil sampling required to characterize the extent of PFAS exceeding the May 2022 Devens SSLs will be added to the Work Plan, per the July 2022 ORD Memo. Please see response to EPA Page-Specific Comment #8 with respect to TOP assay results and potential sources due to transformation processes.	NA	NA
3.	Sections 1.3.2 and 2.2.5, Table 2-1, and Worksheet #15 (Appendix A)	To satisfy more stringent state PFAS requirements, screening levels for groundwater, soil, surface water, sediment, and fish tissue should be: (1) identified for each of the six state-regulated PFAS compounds, and (2) determined using the state PFAS reference dose (RfD) [310 CMR 40.0993(6)(f)]. Note that MCP Method 1 soil and groundwater standards can be used to meet these requirements, and the soil standards can be adjusted to direct contact values because soil leaching need not be taken into account for risk assessment purposes. Also, calculation of surface water and sediment screening levels may not be necessary if sample concentrations do not exceed the groundwater and soil standards. Post-screening risk estimates should be calculated using the more stringent state PFAS RfD and compared to the state risk 2 thresholds [310 CMR 40.0993(10)]. In addition, the state PFAS MCL should be acknowledged as an applicable standard for assessment of drinking water exposure (as requested in MassDEP's October 28, 2020 letter to the Army). Current and Potential Drinking Water Source Areas (categorized GW-1) should be identified in accordance with the MCP (310 CMR 40.0006).	Per OSD guidance, the May 2022 Devens SSLs will be used for the RI exposure evaluations. Current and Potential Drinking Water Source Areas (GW-1) at Area 1 are presented on Work Plan Figure 1-1.	NA	NA
4.	Section 1.3.3	As shown in Figures 1-3, 3-3, and C-1, AOC 43G is the apparent source of PFAS extending along the western edge of Area 1 boundary upgradient of the Patton well and AOC 75. Accordingly, AOC 43G should be included in the Area 1 evaluation, or additional investigation should be conducted to identify the source of PFAS contamination in the area upgradient of the Patton well and AOC 75.	AOC 43G will be added to the Area 1 Work Plan.	NA	NA
5.	Section 2.2.5.3	The MCP GW-3 standards should not be used to screen surface water sample results for human health risks. These standards apply to groundwater and are intended to protect ecological receptors. Surface water screening levels for human health should instead be developed as outlined in Comment 3. Note that recreational use of surface water in Area 1 includes swimming at Mirror Lake.	Please see the response to Page-Specific Comment 3. Per OSD guidance, the May 2022 Devens SSLs will be used for RI exposure evaluations.	NA	NA
6.	Section 2.2.5.4	Sediment screening levels for human health should be developed as outlined in Comment 3.	Please see the response to Page-Specific Comment 3. Per OSD guidance, the May 2022 Devens SSLs will be used for RI exposure evaluations.	NA	NA

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7.	Section 2.2.5.5	Fish tissue screening levels for human health should be developed as outlined in Comment 3.	Please see the response to Page-Specific Comment 3. Per OSD guidance, the May 2022 Devens SSLs will be used for RI exposure evaluations.	NA	NA
8.	Section 3.3.1	This generic discussion of PFAS in the environment should be enhanced to note the extensive use and release of PFAS-containing materials at military facilities. Military facilities are not typical industrial operations, and they involve more than typical use of commercial products containing PFAS. In particular, AFFF was an essential tool for maintaining safety at facilities like Devens with numerous operations that involve petroleum-based fuels (e.g., fire training areas, airfields, fuel distribution facilities, fueling stations, fire stations, storage areas, and disposal areas), and transportation operations involving large quantities of PFAS-containing fluids are common at facilities like Devens.	Additional detail regarding the nature of activities at military facilities will be added to the text. However, the Army disagrees with the generalization that all military facilities involve "more than the typical use of commercial products containing PFAS."	NA	NA
9.	Section 3.4.1, ¶ 3	While residential use of property located in Area 1 may not be a "realistic future scenario", zoning by-laws and reuse plans are insufficient to serve as land use controls, and an unrestricted use/unlimited exposure (UU/UE) scenario should be evaluated. Consequently, the human health risk assessment should include an evaluation of a residential scenario.	A hypothetical future residential scenario (i.e., exposure to soil and groundwater used as a source of drinking water) will be included to evaluate unrestricted use/unlimited exposure (UU/UE).	NA	NA
10.	Section 3.4.1, ¶ 4	As indicated in Section 10.6.1 of the QAPP Addendum (Appendix A), subsurface soil extends to a depth of 15 feet for risk assessment purposes [310 CMR 40.0933(4)(c)].	The text will be revised to state that subsurface soil extends to 15 feet below ground surface (bgs) for risk assessment purposes.	NA	NA
11.	Section 3.4.1, ¶ 5	This statement: "…the groundwater exposure pathway for drinking water users is incomplete and will not be evaluated further," is not acceptable. This pathway must be evaluated in the human health risk assessment: • As noted here, engineering controls have been implemented to limit human exposure to PFAS in drinking water produced from the Grove Pond well field, Patton well, and Shabokin well; however, these interim actions did not eliminate the drinking water pathway connecting groundwater drawn from the wells to human receptors supplied by these wells. The results from the Phase 1 remedial investigation indicate that groundwater drawn from the wells is contaminated with PFAS. Interim actions have been taken to protect current users from this contamination. The associated human health risks must be assessed during the on-going remedial investigation and a feasibility study will follow to develop alternatives to address unacceptable risks. A remedy will be selected to address the risks posed via this pathway after the remedial investigation and feasibility study are completed. Accordingly, the drinking water pathway connecting groundwater drawn from these supply wells to current and future human receptors must be evaluated in the human health risk assessment. • As noted here, administrative controls (e.g., deed restrictions) restricting the use of groundwater have been imposed on Devens properties; however, these controls did not eliminate	Potential future use of the aquifer groundwater as a source of potable water will be evaluated in the BHHRA.	NA	NA

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		the drinking water pathway connecting groundwater in state-designated Current and Potential Drinking Water Source Areas to current and 3 potential future users of groundwater from these areas. Administrative controls cannot be used to change the classification of groundwater in these areas [310 CMR 40.1012(4)(a)]. Accordingly, the drinking water pathway connecting groundwater in these areas to potential human receptors must be evaluated in the human health risk assessment.			
12.	Section 3.4.1, final ¶	Groundwater at Devens is used for non-drinking water purposes, including commercial activities and irrigation of recreational and commercial areas (e.g., golf course, car wash, hotels, and 57 Barnum Road). Consequently, the potential risks resulting from exposure to PFAS in groundwater used for non-drinking uses should be evaluated in the risk assessment.	Potential future use of the aquifer groundwater as a source of potable water (i.e., drinking water) will be evaluated in the BHHRA. This evaluation is more conservative and health-protective than a non-potable use scenario. Therefore, the human health risk from non-potable use of the aquifer groundwater need not be quantified.	NA	NA
13.	Section 3.4.2	The remedial investigation will not be complete if ecological exposures are not evaluated (USEPA, 1988). As acknowledged here, terrestrial habitat and aquatic ecological receptors may be exposed to PFAS in soil, surface water, and sediment, and DOD and EPA recently published ecological screening values. Accordingly, at a minimum, a screening level ecological risk assessment should be conducted.	The Work Plan will be revised to include the methodology for a SLERA using the ESVs noted in the comment.	NA	NA
14.	Section 3.5.3	The plan should explain why additional sediment samples are not needed to complete the remedial investigation. Has an assessment of previously collected sediment samples demonstrated that PFAS in sediment does not pose unacceptable risk to human and ecological receptors? Has the extent of PFAS contamination in sediment been delineated adequately? If additional sediment sampling is not required, then the plan should include or cite an appropriate demonstration, or if necessary, additional sampling should be proposed to acquire sufficient data to complete the risk assessments.	All sediment samples collected during the Phase I investigation work had PFAS concentrations below the May 2022 SSLs. Sediment samples will be collected at surface water sampling locations that have not previously been sampled for sediment.	NA	NA
15.	Section 4.2.5	As indicated in Figure 4-6, text should be amended to indicate that fish samples will also be collected from Grove Pond.	The text will be updated to be consistent with the figure.	NA	NA
16.	Section 4.3	This brief overview of the proposed baseline human health risk assessment is insufficient for review. A more detailed presentation, including exposure assessment (e.g., potential pathways, receptors, and exposure levels), toxicity assessment (e.g., effects, toxicity values, and uncertainties), and risk characterization (e.g., scenarios, exposure assumptions, and risk calculations) should be included in the plan, or the details should be presented in a separate risk assessment Work Plan. Regarding assessment of groundwater, Current and Potential Drinking Water Source Areas should be identified in accordance with the MCP (310 CMR 40.0006). Also, as noted in Comment 13, at a minimum, a screening level ecological assessment should also be completed.	The Work Plan will be revised to briefly discuss the BHHRA components: data evaluation/hazard identification, exposure assessment, toxicity assessment, and risk characterization. Current and potential drinking water source areas will be identified in the human health CSM. The Work Plan will be revised to include the methodology for a SLERA.	NA	NA

No.	Ref. Page / Para.	COMMENTS	RESPONSE	BACKCHECK	BACKCHECK RESPONSE
		TABLES			
17.	Table 4-1	To facilitate review, the table should also list well screen elevations.	Well screen elevations will be added to Table 4-1.	NA	NA
		FIGURES			
18.	Figure 4-3a	Sample results indicate that potential PFAS sources are located near the former location of Building 3713/AOC 44/52 and near the Former Pump House. The plan should explain why soil samples were not proposed to evaluate these areas (soil samples were not collected from these locations during Phase I), or samples should be proposed to characterize them during Phase II. Regarding the Former Pump House, the plan should identify the material that was pumped at this location (e.g., water, gasoline, diesel, etc.). Could pumping of the nearby Army supply wells located here explain the high levels of PFAS reported in the samples collected from VP-18-12? When were the Army wells active?	Additional soil sampling will be performed in areas where there are PFAS concentrations exceeding the May 2022 Devens SSLs. Soil sampling will also be proposed at AOC 43J, the former pump house area located in the northeast corner of the Grove Pond Wellfield Area, the Building 3713 area, and upgradient of AOC 75. As described in the Work Plan Section 4.2, and Figure 4-3a (now Figure 4-9a), permanent overburden and bedrock wells are proposed to be installed in the Grove Pond wellfield area, including areas adjacent to GPVP-18-12. Available information on the use date(s) and purpose of the Former Pump House will be added to the text.	NA	NA
19.	Figure 4-3b	The AOC 57 (Areas 1, 2, and 3) and Building 3713 boundaries should be identified.	AOC 57 and Building 3713 will be identified on Figure 4-3b (now Figure 4-9a).	NA	NA
20.	Figure 4-4a	The AOC 43G boundary and AOC 43G PFAS plume should be identified.	AOC 43G and the associated plume will be added to the Work Plan and figure set.	NA	NA
21.	Figure 4-6	Please confirm/correct Cold Spring Brook Pond sample IDs GP-20-01 through -03 (should be CP-20-01 through -03?).	The sample IDs will be corrected.	NA	NA
		APPENDICES			
		Appendix A – Addendum for Groundwater Operable Unit Area 1 to UFP-QAPP for Remedial Investigation for PFAS			
22.	WK #15	Project Action Limits should be determined as outlined in Comments 3 and 5.	See Responses to Comments 3 and 5.	NA	NA
23.	WK #18	As indicated in Figure 4-6, fish samples will also be collected from Grove Pond.	The Work Plan and QAPP will be updated to indicate the correct # of fish tissue samples.	NA	NA
24.	Attachment E	The Massachusetts laboratory certification should be updated.	The certification will be updated.	NA	NA
		Appendix C			
25.	Figure C-9	Figure C-9 should identify the locations of AREE 61I and AREE 61H.	The locations of AREE 61I and 61H will be added to Figure C-9.	NA	NA
		Appendix E – Regional Groundwater Flow Model of the Former Fort Devens, Massachusetts			
26.	Figure H-1 (Bedrock Surface)	Please explain how this figure, which appears to show the bedrock surface at higher resolution than a contour map of bedrock elevations could, was prepared. Please identify any data other than bedrock elevations that was used to prepare the map (e.g., LIDAR) and explain how that other data was integrated with the bedrock elevations to prepare the figure.	The bedrock surface was derived from multiple lines of evidence/data source. These included, LIDAR, elevation of the top of bedrock (or lack thereof) from the KGS Phase 1 investigation, the elevation of top of bedrock from previous investigations at Fort Devens, and information from regional geological and/or water supply studies.	NA	NA
		END OF COMMENTS			

Appendix E Response References

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US Army Corps
of Engineers®

New England District
696 Virginia Road
Concord, Massachusetts
01742-2751

Project Name: **Former Fort Devens Army Installation** | **Location:** **Devens, Massachusetts**

Document Name: **DRAFT FINAL Phase II Remedial Investigation Work Plan and Quality Assurance Project Plan Addendum for Per- and Polyfluoroalkyl Substances (PFAS) – Area 1**

Prepared By: **Seres Arcadis 8(a) JV**

No.	Ref. Page / Para.	COMMENT	RESPONSE
1.	WP	**Table 2-1, Site-Specific Screening Levels**: As the Army is keenly aware, the emerging science around PFAS and its effects on human health and the environment is dynamic and rapidly evolving. This unfortunately poses continuing challenges for both federal/state regulatory agencies and the regulated community as efforts are made to determine the nature and extent of PFAS in the environment at sites and to implement any remedial actions necessary to protect humans and ecological receptors. Since EPA last provided the Army multimedia site-specific screening levels (SSLs), non-cancer RfDs have become available for PFHxA and PFBA. As a result, EPA has updated the Ft. Devens screening levels to include these two additional PFAS. The updated **June 2023 Ft Devens SSL Summary Table** is included as an attachment to this letter. Please update Table 2-1 to reflect these latest SSLs. The updated SSL table will require global editorial revisions to the work plan and applicable appendices to account for the addition of PFHxA and PFBA. As an example, Section 2.2.5 presents decision rules to be applied to the data collected as part of this work plan. These decision rules are based on the previous SSL table provided by EPA.	Table 2-1 has been revised to include the June 2023 SSLs provided with the comment letter. The Work Plan and QAPP text has been revised to reflect the addition of the new SSLs for PFHxA and PFBA.
2.	WP	**Section 1.3.1, ¶1**: Editorial Comment - This Phase II RI work plan also aims to address data gaps as described in Exhibits 4-4, etc. The following edits are proposed: "The goal of the Area 1 Phase II PFAS RI is *to address data gaps and* identify exposure pathways and assess risk to human and ecological receptors associated with the presence of PFAS in Area 1.	The proposed text has been incorporated into the Work Plan.

No.	Ref. Page / Para.	COMMENT	RESPONSE
3.	WP	**Section 2.1, ¶1**: Editorial Comment - The section discusses the work plan approach and in particular the data gaps for soil and ground water. Because this document also discusses the work plan for sediment surface water, and fish tissue, please add a sentence to paragraph to reflect all the work plan's sampling efforts.	The text has been revised per the comment.
4.	WP	**Section 2.2.2, ¶2**: Editorial Comment – Please see comment #2 above.	The proposed text has been incorporated into the Work Plan.
5.	WP	**Section 2.2.5**: Decision rules for data are limited to MMCLs and SSLs yet additional PFAS analytes will be analyzed and reported as part of Method 1633. It is suggested that additional text be included in this section to state that while chemical- specific ARARs, TBCs, and/or risk-based levels are not currently available for all the analytes that will be reported, it is anticipated that new toxicity assessments for these other PFAS may become available in the future and will need to be considered as part of the ongoing site characterization and risk evaluation process. These data may also be helpful in further "fingerprinting" sources associated with historical Army releases of these chemicals to the environment as well as identifying other sources of PFAS contamination that may not be the responsibility of the Army.	The text has been revised per the comment. The Army agrees that the additional data will be helpful in the evaluation of the potential sources of PFAS contamination at the site.
6.	WP	**Section 4.3.1.2.3, ¶1, 4th Sentence**: Please note that RME scenario is what the risk assessment is based on. CTE analyses are typically presented as companion to the RME in the RAGs D portion of a HHRA. The text implies that the CTE estimate could be used (over the RME scenario) as the basis for determining unacceptable risk, which is not the case. Use of CTE can inform the variance between RME and CTE, but it is not used in place of RME scenario for risk management decisions. Please revise the text to make clear the role of the RME and CTE in the risk assessment.	The text has been revised per the comment.

No.	Ref. Page / Para.	COMMENT	RESPONSE
7.	WP	**Section 4.2.7**: Consideration should be given to also collecting small, whole-body fish from each of the water bodies to be sampled as part of this work plan. This data would better support the completion of the SLERA.	The collection of fish tissue samples is limited to the edible portions of the fish for use in human health risk assessment via the fish consumption pathway, and whole-body fish tissue samples to evaluate ecological risks are not proposed at this time. As described in the work plan, the SLERA will evaluate ecological risks based on a comparison of detected PFAS concentrations in site media to corresponding ESVs. Although food web modeling may be used to evaluate potential risks for birds and mammals, the food web models are expected to use modeled concentrations of PFAS in dietary items (e.g., fish) based on literature values. If HQ values from the food web models indicate potential risk, then additional site-specific studies such as the collection of whole-body fish samples may be considered as part of the BERA (if necessary).
8.	QAPP	**Worksheets 15-2, 15-5, and 15-6**: Please add footnotes to indicate if the results will be reported on a dry weight or wet weight basis.	The footnotes have been added to the worksheet text.
9.	QAPP	**Worksheets 19 & 30**: Please correct the analysis holding times. The analytical SOP for each medium indicates that samples must be analyzed within 28 days of extraction.	The holding times have been corrected.
10.	QAPP	**Worksheet 23**: Please add the analytical SOPs for TOC and grain size to this worksheet and attach them to the QPP.	The SOPs have been added.
		END OF COMMENTS	

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Project Name: Former Fort Devens Army Installation	Location: Devens, Massachusetts
Document Name: FINAL Phase II Remedial Investigation Work Plan and Quality Assurance Project Plan Addendum for Per- and Polyfluoroalkyl Substances (PFAS) Groundwater Operable Unit – Area 1	
Prepared By: Seres Arcadis 8(a) JV	

No.	**Ref. Page / Para.**	**COMMENTS**	**RESPONSE**
		GENERAL COMMENTS	
1.	General	This in depth report contains extensive information, including historical data, maps, tables and figures with a focus on Area 1, as the priority remedial issue. PACE continues to be concerned about the extremely high levels of PFAS at the MAAF (AOC 50, AOC 30 and especially AOC 31), which is apparently in line to go through this lengthy CERCLA process as part of Area 3- well into the future. We believe that the highly concentrated plume at the AOC 31, the Fire Training Area should be addressed ASAP in order to contain and/or remove PFASs in order to prevent its spread into the environment, particularly the Nashua River.	Actions to address PFAS at AOC 31 are in progress (additional design data collection and assessment, treatability testing of PFAS treatment technologies, and preparation of pilot study work plans in 2024). Area 3 will be the focus of the next Phase II Remedial Investigation Work Plan.
2.	General	As active and ongoing research increasing our knowledge on PFAS' fate, transport and the potential ability to break down are constantly evolving, our understanding of how to best address these complex remediation sites at Devens must likewise evolve. A PFAS webinar I recently attended presented new information about how certain PFAS chemicals change form much more readily than we had thought, making those pie charts showing the 'fingerprints" of various levels of PFAS not as telling as we had thought. For example, at the Spectacle pond area In Ayer and Littleton, the mix of PFASs found in each town well was thought to be unrelated because their fingerprints were quite different. However, now, this seems inconclusive. With this new information on fate and transport, it is clear that a more thorough investigation is warranted to determine what is happening, as the original source of PFAS migrates in soil and groundwater.	We agree that the science about PFAS is changing/improving rapidly. The project team does monitor the literature quite carefully to make sure we are bringing the most up-to-date perspectives to our investigations and our data interpretation, New information regarding PFAS mixtures and potential transformation products of precursors is taken into account during remedial investigation scoping, and will be taken into account when evaluating the data to be collected during Phase II.

No.	Ref. Page / Para.	COMMENTS	RESPONSE
		This evolving science needs to be taken into careful consideration, as our understanding of the family of PFAS chemicals grows.	
		PAGE-SPECIFIC COMMENTS	
1.	Sections 1.2. & 1.3, p.8.	We agree with MA DEPs comment 1; the statements made are misleading and inconsistent with results found earlier and precursors that had been identified. Also, we agree that the more stringent MADEP screening levels for groundwater, soil, surface water, sediments and fish tissue, as described in comment 2 should be used.	The referenced comment was made on the Draft Work Plan and referred comparison of soil data to MADEP Method 1 Standards. Subsequent to that comment, the EPA released Regional Screening Levels (RSLs) that were as low or lower than the MADEP Standard 1 levels, which resolved the issue. It should be noted that the Army is required to use federal standards and screening criteria under CERCLA, so the statement concerning soil results were not misleading in that they referred to EPA standards in place at the time. MassDEP guidance is, and will continue to be, taken into account when planning activities and reviewing data. The comment was further addressed by the Army through the addition of soil sampling to characterize the extent of soil impacts that exceeded the new RSLs
2.	Section 1.2.	Refers to Table 1-1- private wells in Harvard that had PFAS6 greater than 20 ng/L should include what those levels were, not just the construction details of the wells.	The Army is not allowed to publicly release private well sampling data.
3.	Section 1.3. p.8.	EPA Comment 6. Has the Army's offer to add in-stream piezometers to the WP met the concerns of EPA re: dilution of gw samples of surface water to confirm underflow? This is important for the private wells found in Harvard to contain PFAS.	Underflow will be evaluated using piezometers at Cold Spring Brook and on-site, as well as by collecting groundwater samples for analysis of PFAS at off-site vertical aquifer profile locations and monitoring wells to be installed southeast of Cold Spring Brook. This approach was accepted by EPA. It should be noted that the majority of off-installation private wells containing PFAS are located well southeast of Cold Spring Brook and are not part of the underflow investigation.
4.	Section 1.3. p.8.	EPA Comment 7. Army states additional soil sampling is not needed because, in all sites, the soils are "bounded vertically". Please explain what that means and how it addresses concerns of	This comment response was with respect to characterizing the depth to which PFAS exceeded the screening levels. The depth of PFAS exceeding the screening levels below ground has been

No.	Ref. Page / Para.	COMMENTS	RESPONSE
		EPA. We are particularly concerned with Grove Pond well-field area.	characterized at several sites with sampling data collected during Phase I. As discussed in Sections 3.5.1 and 4.2.2, and shown on Figure 4-6, additional soil sampling is planned upgradient (south) of the Grove Pond wellfield.
5.	Figure 1-4, p.11,	Delineating gw flow patterns and local scale watersheds is missing. This is imp info. Please include copies for public review.	Figure 1-4 depicts watershed boundaries and groundwater flow contours, but does not include arrows depicting inferred groundwater flow directions. These features will be added to figures when presenting information publicly. To aid in your review, we have attached an updated version of the Figure with the flow arrows.
6.	Section 3. CSM.	The figures identified in the text to not align with the figures in the report. It appears that many figures were added during the comment time. Please do NOT remove any of the figures – they are all helpful and important. However, the reader is confused by the references that do not match the figures. In particular, I find no figure that seems to match descriptions given in 3.1.1: Figure 3-1.	Figure 3-1 shows the information described in Section 3.1.1, but due to the size of the figure (22 inches by 17 inches), it may have been inadvertently missed in the provided printed copy of the document. It is available electronically on Page 101 of the PDF file.
7.	Section 3. CSM.	The figures referred to in the EPA Comments/Army responses to not match with the figures In the report. This makes it very difficult to follow closely the discussions.	EPA Comment #25 on the Draft version of the work plan mistakenly referred to Figure 4-4a; they meant to refer to Figure 3-3.
8.	EPA Comment 48.	EPA requests for expansion of the number of sediment samples. Army response, refusing to do additional sampling at this time, should be reviewed by the BRAC team to ensure it is acceptable.	At locations where sediment was collected in 2018 and 2020, the data provide adequate characterization of nature and extent of PFAS and are sufficient in number for use in risk assessments. However, sediment samples will be collected from an additional eight locations where surface water samples will now be collected. The response to EPA Comment 48 was approved by EPA.
9.	EPA Comment 49-51, 54, 57,59.	EPA has requested additional sampling in specific locations and with soil sampling. Army responded with numerous additional sampling programs in the WP. Have these new sampling plans been reviewed by the BRAC team? Are they now adequate in chosen location, depth and quantity?	The revised proposed soil sampling program was reviewed by EPA and was approved.

No.	Ref. Page / Para.	COMMENTS	RESPONSE
10.	Section 4:	General Comment: Many of the EPA comments express concerns about the proposal to address data gaps and to assess migration pathways, including the installation of wells, vertical extent of drilling, the number of wells or their in specific locations. I do not have the knowledge to comment on the adequacy of these, but clearly, these are key decision points. I ask that the BRAC Team, together, carefully review these, with special highlights on those that most impact the Ayer Grove Pond water supply, and seek agreement with Army's plan to ensure data gaps are fully addressed.	The Army added additional soil sampling locations in the area upgradient of the Grove Pond wells in response to EPA's comment. The revised proposed soil sampling program was reviewed by EPA and was approved.
11.	Figure 4-9b.	Please add labels to this map for several identifiable reference points to assist with orientation by identifying the larger building(s) or parking areas.	When figures are prepared for the RI report and other presentations, care will be taken to ensure labels are included to assist with orientation of the reader/reviewer.
12.	Section 4.2.6.	For Grove Pond sampling sites GP-18-01 through GP-18-05, please take both sediment and surface water samples at these locations as you are at Mirror Lake. Grove Pond is an increasingly popular sport fishing and recreations location for Ayer and others in the region. With the water chestnut removal project I have been leading for the past 2 summers, I have witnessed the frequent use of the pond, and anticipate this will increase over time, as the invasive plants are removed. I ask that as much data as possible be collected from Grove Pond. Likewise, please consider sampling the fish tissue in two separate locations at Grove Pond. Extensive fishing (esp. for large mouth bass) occurs at the walking bridge on the northeast, close to GP-18-01.	Sediment samples previously collected from Grove Pond have been reviewed and are adequate to use for characterization of risk to human health. As noted in the work plan, additional surface water samples are being collected and where sediment has not been collected, it will be. Though fish are likely to move around within a small water body with no barriers, the Army can focus the sampling area on the vicinity of the fishing access area and extend outward as necessary to meet the required sample sizes.
13.	Section 5. Deliverables.	Please add reference to Figure 6-1 to identify the estimated timeline for the completion of the RI/FS (or show a condensed version of it here).	The schedule will be updated as the project progresses and communicated to the RAB.

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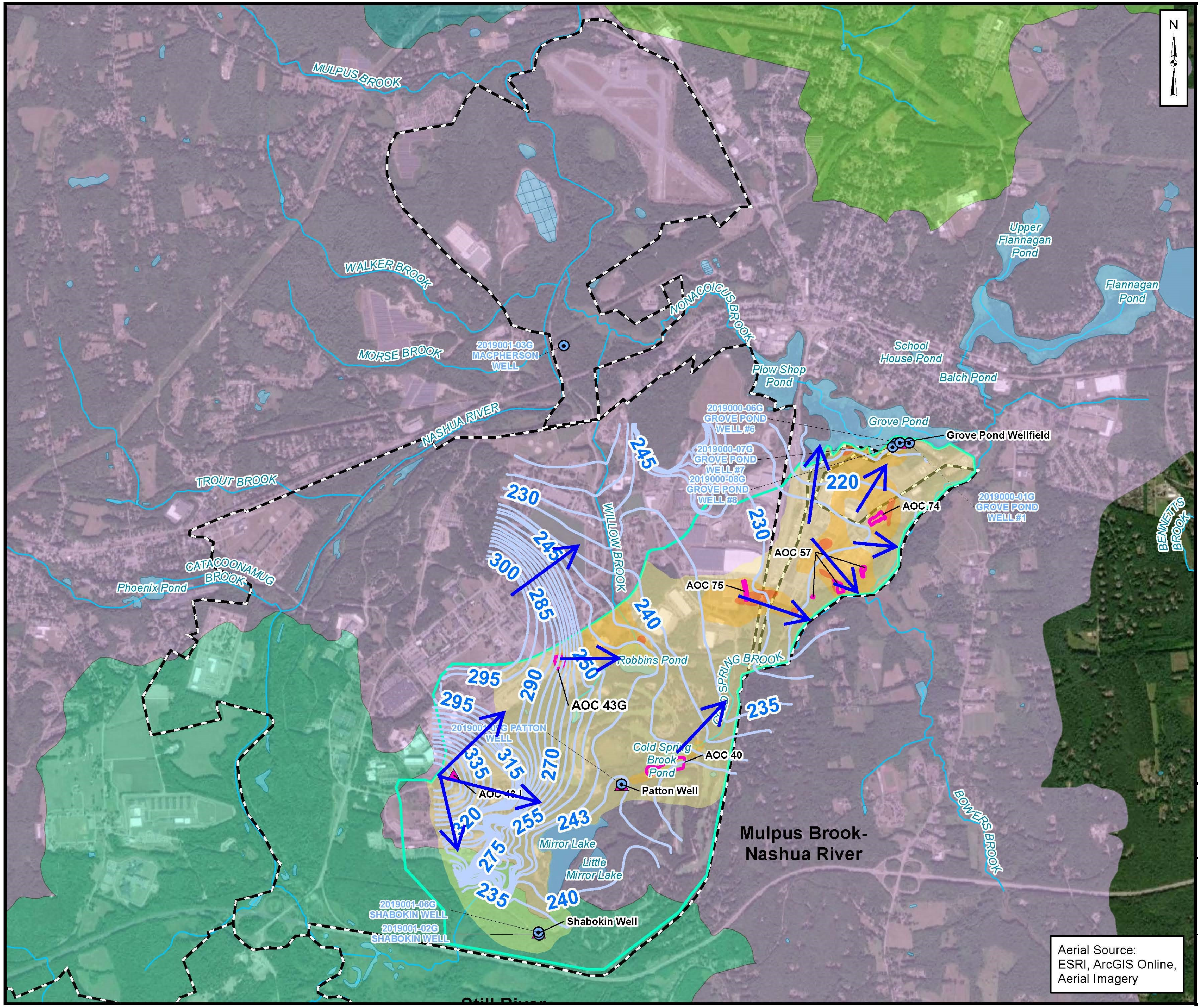
14.	Section 5.1.2.3.	Please elaborate on how Army plans to reach Community Acceptance. This should include robust and clear plans to outreach with at least two public forums or public hearings in the communities impacted, Ayer and Harvard in particular. It should also include extensive outreach through social media, local newspapers, local TV stations and direct contact with local Select Boards, Board of Health, and Conservation Commissions. Releasing electronic information, such as this report and/or fact sheets will not be sufficient.	Community Acceptance is part of the FS evaluation criteria. This process is governed by EPA requirements and will be implemented via the ongoing Community Involvement Program and Restoration Advisory Board.
		END OF COMMENTS	



Legend

- ⬚ Former Fort Devens Boundary
- ▲ AOC Location
- ◉ Water Supply Well
- ▭ AOC Area
- ▭ PFAS Groundwater Operable Unit Area 1
- 〰 Stream
- ▨ Waterbody
- 🟨 Approximate extent of the Area exceeding the Site-Specific Screening Levels (SSSLs)
- 🟧 Approximate extent of the Area > 10x SSSLs
- 🟥 Approximate extent of the Area > 100x SSSLs

Watershed Boundary

- ▨ Mulpus Brook-Nashua River
- ▨ Still River-Nashua River
- 🟩 Unkety Brook-Nashua River
- ▨ Witch Brook-Squannacook River

AOC = area of contamination

→ Inferred Direction of Groundwater Flow (approximate)

0 1,500 3,000
Feet

Aerial Source:
ESRI, ArcGIS Online,
Aerial Imagery

Phase II Remedial Investigation Work Plan - Area 1
Former Fort Devens Army Installation
Devens, Massachusetts

Local-Scale Watersheds

SERES Engineering & Services, LLC
ARCADIS
a joint venture

Figure
1-4

T:_ENV\Devens_RFTA\Seed_Task_Order\MXDs\Area 1 Phase 2 Work Plan\UPDATE\Update_Fig_Numbers\2023\Figure 1-4 - Local-Scale Watersheds.mxd 1/16/2023 6:33:10 PM User Name: ski01076