U.S. Army Corps of Engineers, Baltimore District

Final Preliminary PRB Design and Installation Work Plan

Fort Gregg-Adams, Virginia

March 2025

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Prepared For:

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March 2025

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Acronyms and Abbreviations

CAC	colloidal activated carbon
Cascade	Cascade Remediation Services, LLC
DoD	Department of Defense
DPT	direct push technology
FTA	fire training area
PDI	pre-design investigation
PFAS	per- and polyfluoroalkyl substances
PQAPP	Programmatic Uniform Federal Policy-Quality Assurance Project Plan
PRB	permeable reactive barrier
QAPP	Quality Assurance Project Plan
TCRA	Time-Critical Removal Action
TGI	technical guidance instructions
USEPA	United States Environmental Protection Agency

1 Introduction

Fort Gregg-Adams is approximately 5,907 acres and lies within the Virginia Coastal Plain within Prince George County, Virginia, west/southwest of the City of Hopewell and northeast of Petersburg (Figure 1 of Quality Assurance Project Plan [QAPP] Addendum #2). Per- and polyfluoroalkyl substances (PFAS) are present in groundwater within the vicinity of the Active and Former Fire Training Areas (FTAs; FTLE-7, FTLE 30, and FTLE-31) and there is evidence that groundwater impacts that extend to the southern boundary of the installation (Figure 2 of QAPP Addendum #2). PFAS-impacted groundwater has the potential to migrate off-post, which may pose a risk to off-post receptors. To mitigate off-post migration of PFAS, a time-critical removal action (TCRA) will be executed. The TCRA is a permeable reactive barrier (PRB) composed of colloidal activated carbon (CAC) along the southern installation boundary to reduce PFAS in groundwater to levels that are at or below residential risk screening levels at the point of treatment. This Work Plan describes the details of the CAC PRB design, implementation, and monitoring.

2 TCRA Implementation

In-situ containment of PFAS via sorption to injectable CAC will be used to address migration of PFAS in groundwater. This approach is based on the well-established use of activated carbon for ex-situ water treatment and utilizes low-micron size activated carbon particles that can be delivered to the subsurface via liquid injection. The low-micron size of the particles allows for delivery as a liquid suspension using traditional injection methods including injection wells and direct push technology (DPT). Once distributed within the pore space of the aquifer, target contaminants are sequestered within the activated carbon pores upon contact, thus mitigating ongoing migration of PFAS via groundwater. The selected remediation product for this application consists of CAC (ColloidalChem + Anchor™, commercially available from Cascade Remediation Services, LLC [Cascade]). The following sections describe the activities to be performed as part of this TCRA, including bench scale testing, potable water injection testing, well installation, CAC injection, and verification sampling.

2.1 Summary of Pre-Design Investigation

To properly design the CAC PRB, PFAS distribution and related hydrogeological and mass flux data are needed along the region of the southern boundary where groundwater PFAS impacts are present. The pre-design investigation (PDI) will be conducted along the southern installation boundary (Figure 2 of QAPP Addendum #2) and will consist of a targeted investigation to finalize the design and location of the PRB. The objectives of the PDI are as follows:

1. Confirm groundwater flow direction in the vicinity of FTAs and southern installation boundary.
2. Confirm lateral and vertical distribution of PFAS along southern installation boundary with a focus on the high PFAS concentrations migrating from the upgradient Active and Former FTAs.
3. Combine hydrostratigraphy and PFAS distribution data to generate a mass flux based conceptual site model to optimize the PRB location and design.
4. Evaluate geochemistry and co-contaminants (e.g., volatile organic compounds) in groundwater to confirm CAC loading during PRB design.

PDI activities will include installation and sampling of groundwater monitoring wells, and implementation and sampling of Hydraulic Profiling Tool/vertical aquifer profiling points. This work is described in further detail in QAPP Addendum #2.

2.2 Bench Scale Test

A bench scale test will be completed prior to injection of the activated carbon. Laboratory testing will be performed by Cascade. The bench test will identify potential interferences to sorption of PFAS and confirm the required loading of CAC (ColloidalChem + Anchor™) within the PRB to remove PFAS constituents from groundwater. Groundwater for the bench testing will be obtained during the PDI and will be sent to Cascade for testing.

CAC dosing will be determined through evaluation of target groundwater constituents, treatment goals, and related groundwater parameters that might affect treatment performance. The goal of these tests is to establish CAC dosing for PRB design. Laboratory testing does not attempt to mimic the full set of variables encountered in a field site and should be used as one of many inputs for dosing modeling.

Bench testing will involve batch testing using CAC and site groundwater. There will be two loadings of CAC during the first round, along with a blank sample and spiked controls (e.g. 100 parts per trillion control). Additional rounds of testing will be designed and performed depending on results of the first round. Samples will be centrifuged and filtered to remove treatment product, and water phase will be analyzed for PFAS by liquid chromatography/tandem mass spectrometry by a laboratory selected by Cascade. These data are not for regulatory purposes and are for remedy optimization only. In most cases, a few iterations of this type of batch testing are needed to address unexpected cross-contamination, analytical quality control issues, matrix interferences, and other challenges associated with non-routine parts per trillion-level analyses.

Results of the bench testing will be obtained prior to field application and if adjustments need to be made to the field plan for dosing, this will be communicated in a Field Change Report.

2.3 Potable Water Injection Test

An injection pilot test will be performed during the PDI fieldwork to validate the injection method used to deliver the injectable CAC product to the subsurface treatment area. The injection test will consist of up to four injection borings using DPT implemented over a one-day period. Injection borings will be spaced approximately 6 feet apart. Injection boring locations may be adjusted in the field as needed. The target vertical zone for injection is approximately 5 to 15 feet below ground surface and may be adjusted based on the results of the PDI. The vertical injection interval within each boring is approximately 5 feet, and there will be two injection intervals per boring.

Pilot test injections will be performed using DPT methods for injection of liquid remediation substrates. The top 5 feet of each boring will be hand cleared. Injection will be implemented using a “top down” approach in which DPT is used to advance injection tooling to the shallowest target interval. Once the injection tooling is at the shallowest injection interval, injection of potable water is performed. Injection pressure limits of 25 to 35 pounds per square inch will be utilized to avoid fracturing of the formation during injection. Pressure and flow rate will be monitored for each injection point throughout the injection. If the maximum pressure is reached and injection has not occurred, the pump will be shut down and the lines cleared. If a second attempt to inject at that interval is also unsuccessful, the tooling will be advanced to the next injection interval. Once the target volume has been injected at the first depth, direct push is used to lower the tooling down to the next injection interval. This process is repeated for each injection interval.

The expected injection volume is approximately 211 gallons per 5-foot injection interval for a total of approximately 422 gallons per injection boring. It is anticipated that potable water will be provided by the buffalo fill stand at Building 7118 (on the corner of 18th Street and Quartermaster Road) located near the injection area. A source blank was previously collected from this fire hydrant and analyzed for PFAS via United States Environmental Protection Agency (USEPA) Method 1633; results indicated that the concentrations of the Department of Defense (DoD) target PFAS were either non-detect or had detectable concentrations less than half the applicable tapwater risk screening levels (Arcadis 2022). Further information regarding source blank collection is provided in Section 17.6 of the QAPP Addendum #2.

The potable water will be transferred to a piping manifold equipped with flow control valves, flow meters, and pressure gauges to monitor and control the flow rate and pressure to each injection location. The potable water will be delivered to each injection location using temporary above grade transfer hoses.

Once injection procedures are complete, location abandonment will be completed by removing injection tooling and installing a 1-inch tremie pipe to the bottom of the borehole. Portland Type 1 cement or a bentonite slurry will be added to the borehole via pressure injection from the base of the location to ground surface. The area around the boring will be restored to match the ground surface immediately adjacent to the boring.

2.4 Installation and Development of Performance Monitoring Wells

To supplement three monitoring wells installed during the PDI (FTGA-TCRA-MW01 through FTGA-TCRA-MW03), seven monitoring wells will be installed prior to injection of the CAC PRB (FTGA-TCRA-MW04 through FTGA-TCRA-MW10), as shown on **Figure 1**. One well (FTGA-TCRA-MW04) will be installed approximately 25 feet upgradient of the CAC PRB, two wells (FTGA-TCRA-MW05 and FTGA-TCRA-MW06) will be installed within the anticipated ROI of the CAC PRB, and four wells (FTGA-TCRA-MW07 through FTGA-TCRA-MW10) will be installed approximately 10 to 20 feet downgradient of the CAC PRB.

Well installation will be completed using the appropriate drilling methods with a minimum outer casing size in accordance with state regulations. A DPT rig with auger attachment is anticipated to be used for installation of the new wells; if field conditions necessitate, an alternative drilling method will be used for the new well installation. All equipment and materials used during drilling and for well construction will be composed of non-PFAS-containing materials (e.g., including lubricants used for drill rod threads). Drilling water from a verified source may be introduced to the boreholes if difficult drilling conditions are encountered (which may include hard clays that are not part of a confining unit). However, based on drilling activities completed during previous investigations, the need for use of drilling water is not anticipated. No drilling in bedrock is planned.

Monitoring wells will be constructed using 2-inch polyvinyl chloride screens and polyvinyl chloride risers. Screen slot size and filter pack sand size will be determined based on the well installation completed during the PDI. Screen length will be nominally 10 feet, to be finalized based on observed lithology and PFAS concentration distribution. Filter packs will be washed quartz sand, extending from 1 foot below to 2 feet above the well screen unless conditions indicate otherwise. Downhole annular space material will be installed using a tremie pipe. Potential for bridging in the filter pack will be mitigated by performing pre-development before installing bentonite and grout. Pre-development will be performed by gently surging the well to settle the filter pack. Additional filter pack material will then be added if needed due to filter pack settlement during pre-development to achieve the specified filter pack thickness. Following pre-development, approximately 2 feet of hydrated bentonite will be placed above the filter pack. The well will then be pressure-grouted via a tremie pipe with bentonite cement grout beginning no more than 4 feet above the top of the aquifer or 4 feet above the top of the screen for wells with the top of screen positioned above the aquifer. Water used to make bentonite cement grout will be from a verified source (e.g., the buffalo fill stand at Building 7118, as discussed further in Section 17.6 of the QAPP Addendum #2) with acceptable concentrations of DoD target PFAS less than or equal to one half the applicable tapwater risk screening levels, and the amount of bentonite will not exceed 2 pounds of bentonite per 94-pound sack of cement. No more than 7 gallons of water will be used per 96 pounds of bentonite-cement mixture.. Each well will be completed with a minimum 2-foot by 2-foot and 4-inch-thick concrete pad. Well vaults will be locking and either traffic-rated flush-mount or steel stickup with three protective bollards. The monitoring wells will be constructed in accordance with state well construction standards and the PFAS-Specific Drilling and Monitoring Well Installation Technical Guidance Instructions (TGI; Attachment D of the Programmatic Uniform Federal Policy-Quality Assurance Project Plan [PQAPP; SERES-Arcadis 2024]).

Following construction, and after sufficient time has passed to allow for proper curing of the well seal/grout (typically 24 to 48 hours depending on the type of cement used), monitoring wells will be developed in accordance with the TGI for Monitoring Well Development (Attachment D of the PQAPP [SERES-Arcadis JV 2024]) using a combination of surging and pumping. Any water introduced to the well during development will be from a verified source (e.g., the buffalo fill stand at Building 7118) with acceptable concentrations of DoD target PFAS not equal to or greater than one half the applicable risk screening levels for tapwater. Well screens will undergo two cycles of surging, for approximately 15 to 30 minutes each time, followed by pumping or bailing to remove accumulated sediments. After the wells have been surged twice, the wells will be pumped at a relatively constant rate until indicator parameters (e.g., pH, specific conductance, and temperature) are stable for three consecutive readings spaced 3 to 5 minutes apart, and the extracted water is clear and free of sediment (i.e., with turbidity less than 50 nephelometric turbidity units). Water levels and depth to bottom will be measured before, during, and after well development. Development water will be temporarily containerized, treated by granular activated carbon, and discharged at an approved location by the installation.

Following completion, monitoring wells will be professionally surveyed.

2.5 Baseline Groundwater Sampling

Monitoring wells FTGA-TCRA-MW01 through FTGA-TCRA-MW10 will be sampled consistent with the methods described in Section 17.5.2 of QAPP Addendum #2. For the newly installed wells (FTGA-TCRA-MW04 through FTGA-TCRA-MW10), sampling will occur a minimum of 72 hours after well development. During sampling, the field team will complete gauging of monitoring wells from the established measuring point (i.e., typically the top of casing) using an electronic water level meter to within 0.01 foot.

Groundwater samples will be collected from approximately the center of the saturated screened interval using low-flow sampling methods (or bailer methods, if necessary, based on length of the water column or condition of the well, and if acceptable to the state, installation, and Headquarters of the Department of the Army). Groundwater samples will be analyzed for PFAS using USEPA Method 1633 as defined in Worksheet #15 of QAPP Addendum #2, and field parameters (temperature, pH, specific conductivity, DO, turbidity, and ORP) will be measured during purging and allowed to stabilize in accordance with the TGI for PFAS Sampling Procedures and Low-Flow Groundwater Purging for Monitoring Wells (Attachment D of the PQAPP [SERES-Arcadis 2024]).

2.6 Colloidal Activated Carbon Barrier Injection

CAC will be injected across an approximately 1,000-foot long transect of injection borings near the property boundary (**Figure 1**). Injection will be performed using DPT and the final design will be based on the results of the PDI, bench scale test, and potable water injection test. The CAC substrate will be ColloidalChem™, which is commercially available from Cascade. Following CAC injections, up to four DPT borings will be advanced to confirm injection radius and CAC distribution in the subsurface.

Target injection volumes are calculated using the target radius of influence, length of target injection interval, and estimated mobile fraction of the aquifer using the following equation for the volume of a conceptualized cylinder:

$$V = (ROI)^2 \times \pi \times h \times \theta_m \times 7.48$$

Where:

V = injection volume (gallons)

ROI = radius of influence (feet)

h = vertical target interval (feet)

θ_m = mobile fraction (unitless)

Current design assumptions for the CAC PRB include:

- Up to 637 injection points oriented in three parallel lines along the property boundary.
- Injection points will be spaced approximately 6 feet apart, targeting approximately a 3-foot ROI during injection.
- Barrier thickness is assumed to be 18 feet.
- Target injection zone is anticipated to be between 5 and 15 feet below ground surface with two 5-foot injection intervals per boring. PDI results will be evaluated to confirm the target depth before injections begin.
- Mobile fraction is assumed to be approximately 10 percent.
- Injection volume will be approximately 211 gallons per injection point. This includes approximately 72 pounds of ColloidalChem, and 29 pounds of Anchor™ material per injection point. Final CAC loading will be informed by the results of the PDI and bench scale testing.

Refinement to PRB design parameters, if necessary based on the results of the PDI, will be documented in a memorandum.

2.7 Verification Sampling

A verification sampling program will be performed to document changes in PFAS concentrations as a result of PFAS treatment at the CAC PRB.

Verification sampling at the CAC PRB will be focused on monitoring groundwater upgradient, within, and downgradient of the treatment area, including three existing monitoring wells installed during the PDI (FTGA-TCRA-MW01 through FTGA-TCRA-MW03) and seven new monitoring wells (FTGA-TCRA-MW03 through FTGA-TCRA-MW10) (**Figure 1**). Performance monitoring events will be completed at 3 months, 6 months, and 9 months following PRB installation at these ten monitoring well locations.

Analytes will include the following:

- PFAS by USEPA Method 1633
- Field parameters: pH, dissolved oxygen, temperature, oxidation-reduction potential, and specific conductance.

Groundwater samples will be collected as described in Section 2.5, above.

3 Reporting

PDI results will be presented in a letter report. These data will be used to review and verify design assumptions presented in this document. An After-Action Report will be developed to document the TCRA actions completed and will include the installation specifications for the PRB, including figures documenting the barrier injection and monitoring well locations and injection details (including injection rates, injection volumes, and CAC delivered). Draft, Draft Final, and Final After-Action Reports will be submitted.

Additionally, Verification Sampling Reports will be submitted to document PFAS concentrations following PRB installation. Verification Sampling Reports will include laboratory analytical data summary tables, figures, and validated laboratory analytical packages. Draft, Draft Final, and Final Verification Sampling Reports will be submitted for approval.

4 Permitting

An underground injection control permit application will be prepared and submitted to the USEPA Underground Injection Control Program. The permit will cover injection activities for the injection test and injection remedy. Considerations for an erosion and sediment control plan exemption and rationale for why a plan is not necessary for the PRB installation is documented in **Attachment 1**. It is anticipated that no additional permits will be required to perform the injection activities.

5 Decontamination and Investigation-Derived Waste Management

All non-dedicated sampling equipment used during the investigation will be decontaminated according to the procedures specified in Section 17.6 of QAPP Addendum #2 and TGI – Groundwater and Soil Sampling Equipment Decontamination (Attachment D of the PQAPP [SERES-Arcadis 2024]). Investigation-derived waste generated during PRB implementation (decontamination water) will be managed as described in Section 17.8 of QAPP Addendum #2.

6 References

Arcadis. 2022. Final Preliminary Assessment and Site Inspection of Per- and Polyfluoroalkyl Substances, Fort Lee, Virginia. June 23.

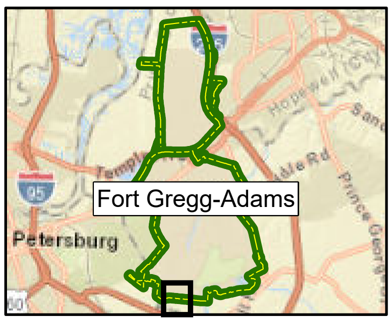
SERES-Arcadis. 2024. Final Programmatic UFP-QAPP, USAEC PFAS Remedial Investigations, Northeast Army Installations, USA. May.

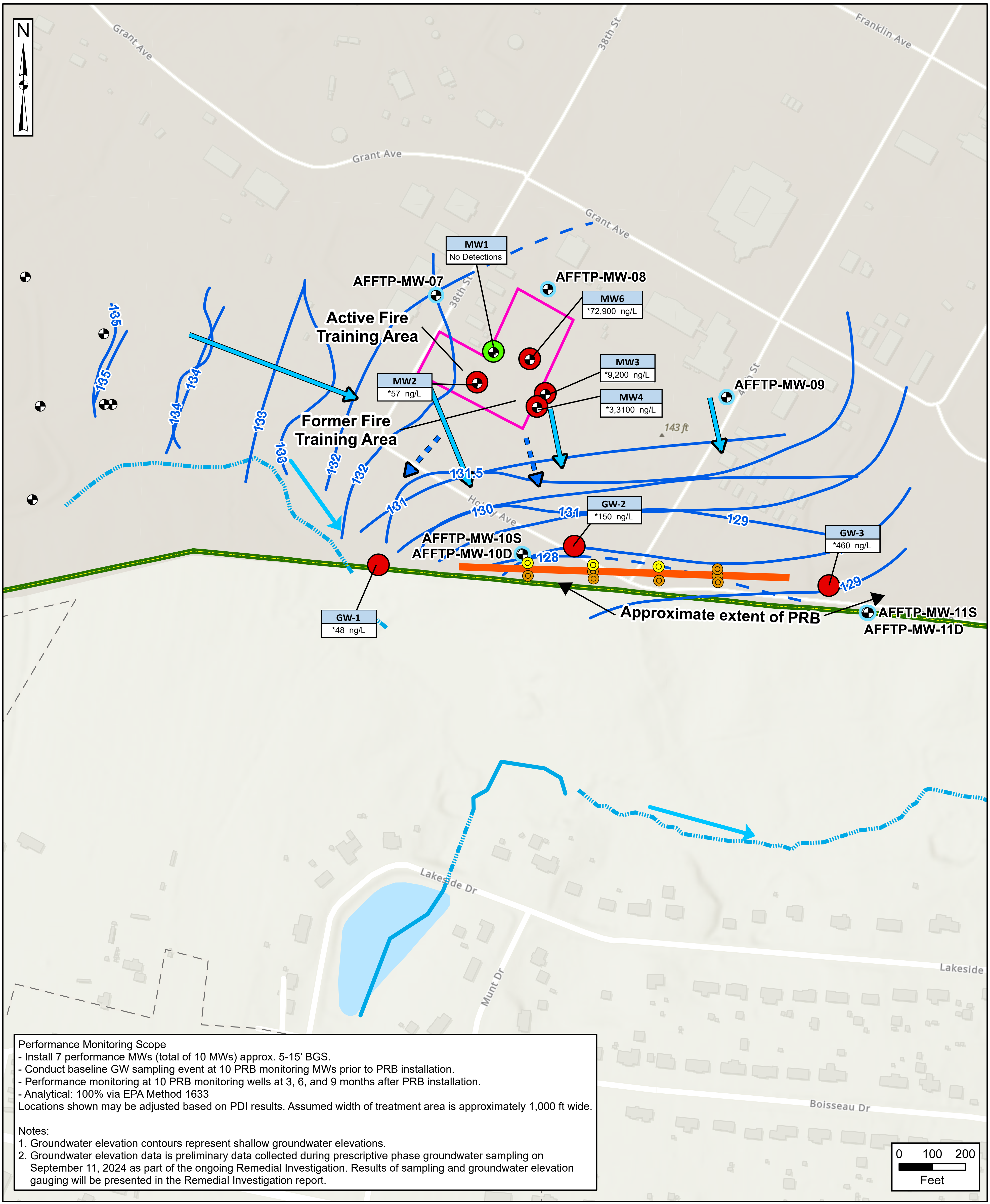
Figures

SERES Engineering & Services, LLC
ARCADIS
a joint venture

Quality Assurance Project Plan Addendum #2
PFAS Time Critical Removal Action
Fort Gregg-Adams, VA

Figure 1
Active and Former Fire Training Areas
Permeable Reactive Barrier and Performance Monitoring





Performance Monitoring Scope
- Install 7 performance MWs (total of 10 MWs) approx. 5-15' BGS.
- Conduct baseline GW sampling event at 10 PRB monitoring MWs prior to PRB installation.
- Performance monitoring at 10 PRB monitoring wells at 3, 6, and 9 months after PRB installation.
- Analytical: 100% via EPA Method 1633

Locations shown may be adjusted based on PDI results. Assumed width of treatment area is approximately 1,000 ft wide.

Notes:
1. Groundwater elevation contours represent shallow groundwater elevations.
2. Groundwater elevation data is preliminary data collected during prescriptive phase groundwater sampling on September 11, 2024 as part of the ongoing Remedial Investigation. Results of sampling and groundwater elevation gauging will be presented in the Remedial Investigation report.

Installation Boundary
AOI
Shallow Groundwater Flow Direction
Inferred Surface Runoff Flow Direction
Surface Water Flow Direction
River/Stream (Perennial)
Stream (Intermittent)
Groundwater Elevation Contour**

Monitoring Well
● Historical Groundwater Sampling Location with Risk Screening Level Exceedance
● Historical Groundwater Sampling Location with no Risk Screening Level Exceedances
Proposed Permeable Reactive Barrier

* = Sum of PFOA, PFOS, PFHxS, PFNA, PFBS, PFBA and PFHxA, as ng/L.
** Dashed where inferred

Sampling Locations
● Groundwater (To Be Sampled During RI)

Proposed Sample Locations
● PRB Performance Well installed prior to baseline sampling (7 total)
● PRB Performance Well installed during Pre-Design Investigation (3 total)

Data Sources:
Fort Gregg-Adams, GIS Data, 2019
USGS, NHD, Water Bodies, 2019
ESRI, ArcGIS Online, Topo Map

Coordinate System:
WGS 1984, UTM Zone 18 North

Attachment 1

Erosion and Sediment Control Plan Exemption Rationale

Attachment 1

Erosion and Sediment Control Exemption Rationale

The objective of this scope of work is to install a 1,000-foot permeable reactive barrier composed of colloidal activated carbon to reduce PFAS in groundwater to levels that are at or below residential risk screening levels at the point of treatment (**Work Plan - Figure 1**). To facilitate this objective, up to 637 injection borings will be installed along the 1,000-foot transect using direct push technology, and ten monitoring will be installed via hollow-stem auger to aid in the implementation design. Assuming a standard boring diameter of 5 inches, the area of total land disturbed is estimated to be 88 square feet. Therefore, an Erosion and Sedimentation Control Plan (E&SCP) is not required for this removal action because the area of total land disturbed is less than 2,500 square feet.

According to the conservation standards contained in the Virginia Erosion and Sediment Control Handbook (9VAC25-875), adopted by Prince George County, where the Site is located, land disturbing activities are nonregulated where the total disturbed land area is less than 2,500 square feet (specifically, within the James River watershed). Additionally, according to Prince George County Erosion and Sediment Control Ordinance, land disturbing activities that are confined wholly by federal lands are exempt from the provisions of the ordinance (Ord. No. O-01-003, § 10-94, 8-22-2001).

If the scope of work to be performed under this contract should change such that an exemption no longer applies, the JV will prepare an E&SCP using the sample outline provided below (**Exhibit 1**).

Exhibit 1 – Sample E&SC Plan Outline:

1 Project Description
2 Existing Site Conditions
3 Adjacent Property
4 Offsite Areas
5 Soils
6 Critical Erosion Areas
7 Erosion and Sediment Control Measures
8 Structural Practices
9 Vegetative Practices
10 Management Strategies
    10.1 Permanent Stabilization
    10.2 Stormwater Management
    10.3 Maintenance

Uniform Federal Policy-Quality Assurance Project Plan Addendum #2

Environmental Services for Per- and Polyfluoroalkyl Substances Impacted Areas Fort Gregg-Adams, Virginia

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Uniform Federal Policy-Quality Assurance Project Plan Addendum #2

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List of Acronyms and Abbreviations

%	percent
ºC	degrees Celsius
µg/L	micrograms per liter
AAR	After-Action Report
AES	atomic emission spectroscopy
AFFF	aqueous film-forming foam
AOI	area of interest
Arcadis	Arcadis U.S., Inc.
Army	United States Army
ASD	Assistant Secretary of Defense
bgs	below ground surface
B.S.	Bachelor of Science
CAC	colloidal activated carbon
CAS	Chemical Abstracts Service
CCB	continuing calibration blank
CCV	continuing calibration verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CPR	cardiopulmonary resuscitation
CSM	conceptual site model
DL	detection limit
DO	dissolved oxygen
DOC	dissolved organic carbon
DoD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
DQI	data quality indicator
DQO	data quality objective
DRO	diesel range organics
EB	equipment blank
EIS	extracted internal standard

ELAP	Environmental Laboratory Accreditation Program
ELLE	Eurofins Lancaster Laboratories Environmental
ESM	Environmental Support Manager
FB	field blank
FD	field duplicate
FID	flame ionization detector
FTA	fire training area
GC	gas chromatography
GC/FID	gas chromatography/flame ionization detector
GC/MS	gas chromatography/mass spectrometry
GIS	geographical information system
GRO	gasoline range organics
HazMat	hazardous material
HAZWOPER	Hazardous Waste Operations and Emergency Response
HDPE	high density polyethylene
HFPO-DA	hexafluoropropylene oxide dimer acid
HPT	Hydraulic Profiling Tool
IAR	ion abundance ratio
IC	ion chromatography
ICAL	initial calibration
ICB	initial calibration blank
ICP	inductively coupled plasma
ICP/AES	inductively coupled plasma/atomic emission spectroscopy
ICS	interference check solution
ICV	initial calibration verification
IDW	investigation-derived waste
installation	United States Army and Reserve installation
IS	internal standards
ISC	instrument sensitivity check
JV	SERES-Arcadis Small Business Joint Venture
LC/MS/MS	liquid chromatography/tandem mass spectrometry
LCS	laboratory control sample

LCSD	laboratory control sample duplicate
LLCCV	low-level calibration check standard
LLLCS	low-level laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MD	matrix duplicate
mg/L	milligram per liter
mL	milliliter
MPC	measurement performance criteria
M.S.	Master of Science
MS	matrix spike
MSA	Method of Standard Additions
MSD	matrix spike duplicate
N	normal (parent sample)
N/A	not applicable
NAPL	non-aqueous phase liquid
ng/L	nanogram per liter
NIS	non-extracted internal standard
NTU	nephelometric turbidity unit
OPR	ongoing precision and recovery
OPSEC	operational security
ORP	oxidation-reduction potential
OSHA	Occupational Safety and Health Administration
PA	preliminary assessment
Pace	Pace Analytical
PDI	pre-design investigation
PDS	post-digestion spike
PE	Professional Engineer
PFAS	per- and polyfluoroalkyl substances
PFBA	perfluorobutanoic acid
PFBS	perfluorobutanesulfonic acid

PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexane sulfonate
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PG	Professional Geologist
PM	Project Manager
PMP	Project Management Professional
POC	point of contact
PP	polypropylene
ppm	part per million
PQAPP	Programmatic Uniform Federal Policy-Quality Assurance Project Plan
PQL	Practical Quantitation Limit
PRB	permeable reactive barrier
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QP	quality procedure
QSM	Quality Systems Manual
RCRA	Resource Conservation and Recovery Act
RF	response factor
RI	Remedial Investigation
RPD	relative percent difference
RRT	relative retention time
RSD	relative standard deviation
RSE	relative standard error
RSL	Regional Screening Level
RT	retention time
SB	source blank
SERES	Seres Engineering & Services, LLC
SI	site inspection
SOP	standard operating procedure

SPE	solid phase extraction
SSHO	Site Safety and Health Officer
TBD	to be determined
TCRA	Time Critical Removal Action
TGI	technical guidance instructions
TOC	total organic carbon
TPH	total petroleum hydrocarbon
U.S.	United States
UFP	Uniform Federal Policy
USACE	United States Army Corps of Engineers
USAEC	United States Army Environmental Command
USEPA	United States Environmental Protection Agency
VAP	vertical aquifer profiling
VOC	volatile organic compound

INTRODUCTION

A Programmatic Uniform Federal Policy (UFP)-Quality Assurance Project Plan (QAPP) (herein referred to as the PQAPP; Seres Engineering & Services, LLC [SERES]-Arcadis U.S., Inc. [Arcadis] Small Business Joint Venture [JV] 2024a) was developed and submitted as final in May 2024. The PQAPP addresses the per- and polyfluoroalkyl substances (PFAS) Remedial Investigation (RI) sampling and objectives at active U.S. Army (Army) installations (installations) within the Northeast United States (U.S.). A site-specific QAPP Addendum was prepared for RI sampling and objectives at Fort Gregg-Adams and submitted as final in June 2024 (SERES-Arcadis 2024b). The purpose of this site-specific QAPP Addendum #2 is to supplement the PQAPP and QAPP Addendum, detail the planning processes for collecting data, and describe the implementation of the quality assurance (QA) and quality control (QC) activities developed for the sampling planned in support of a Time Critical Removal Action (TCRA) at Fort Gregg-Adams in Prince George County, Virginia. The TCRA involves a colloidal activated carbon (CAC) permeable reactive barrier (PRB) to be installed along the southern installation boundary to reduce PFAS concentration in groundwater to levels that are at or below residential risk screening levels after the point of treatment. The objectives of this QAPP Addendum #2 are to generate project data that are technically and legally defensible and useful in meeting the Army's PFAS TCRA project goals. Data collection efforts in support of the TCRA will include a pre-design investigation (PDI), baseline sampling prior to PRB implementation, and verification sampling following PRB implementation; these data collection efforts are described in this QAPP Addendum #2.

The goal of the PDI is to collect the hydrogeologic and analytical data needed to confirm the distribution and flux of PFAS along the southern installation boundary and identify the most effective location for the PRB. Final PRB design will be informed by the results of the PDI. Details regarding preliminary PRB design and implementation are presented as **Attachment 1**. Refinement to PRB design parameters, if necessary based on the results of the PDI, will be documented in a memorandum.

The Department of Defense (DoD) has adopted a policy to retain facilities in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process based on human health risk-based screening levels for PFAS in soil and groundwater (tap water), as described in memoranda from the Assistant Secretary of Defense (ASD) dated 24 August 2023 (ASD 2023) and 3 September 2024 (ASD 2024). These memoranda supersede previous policy memoranda, including the 15 October 2019, 15 September 2021, and 06 July 2022 versions (ASD 2019, 2021, 2022). The 24 August 2023 Memorandum: *Investigating PFAS within the DoD Cleanup Program* and the 3 September 2024 Memorandum: *Prioritization of DoD Cleanup Actions to Implement the Federal Drinking Water Standards for PFAS* are provided for reference as **Attachment 2**. The DoD guidance provides human health risk screening levels for PFAS with U.S. Environmental Protection Agency (USEPA), including enforceable individual Maximum Contaminant Levels (MCLs) for five PFAS in drinking water (perfluorooctane sulfonate [PFOS], perfluorooctanoic acid [PFOA], hexafluoropropylene oxide dimer acid [HFPO-DA], perfluorononanoic acid [PFNA], and perfluorohexane sulfonate [PFHxS]) and a hazard index MCL for mixtures of PFHxS, PFNA, PFBS, and HFPO-DA. For PFAS without MCLs, or for PFAS in soil, Regional Screening Levels (RSLs) calculated using the USEPA's RSL calculator for residential and industrial/commercial worker scenarios (USEPA 2024b) are used. Project screening levels based on DoD guidance are presented in **Worksheet #15** of this QAPP Addendum #2. In anticipation of changes and additions to risk-based screening levels, updates or additions to the list of PFAS to consider for evaluation during investigation will be maintained on the DoD's PFAS website at: https://www.acq.osd.mil/eie/eer/ecc/pfas/tf/policies.html.

The term PFAS will be used herein to encompass all PFAS constituents being evaluated by the selected analytical methods that will be utilized during the RI. The term "DoD target PFAS" will be used herein to encompass all PFAS constituents that will both be analyzed via the selected analytical method (i.e., USEPA Method 1633) and are specified on the DoD's PFAS website.

This QAPP Addendum #2 addresses three primary elements:

- Project management
- General conceptual site model (CSM) description
- Site-specific investigation design and data acquisition

The site-specific worksheets in this QAPP Addendum #2 for Fort Gregg-Adams supplement the general programmatic information provided in the PQAPP and the QAPP Addendum associated with the ongoing RI. A crosswalk between the PQAPP and the Fort Gregg-Adams QAPP Addenda is presented in **Table 1**. Site-specific details provided in this QAPP Addendum #2 include sampling locations, media, methodologies, and procedures. Should site conditions warrant deviation from the prescribed procedures in this QAPP Addendum #2, the stakeholders defined in **Worksheet #4** of this QAPP Addendum #2 will be consulted following the specific communication pathways described in **Worksheet #6** of the PQAPP before changes to the sampling plan are made. A non-conformance report will be used if a change is encountered in the field that results in inability to meet data quality objectives (DQOs). If necessary, a Field Change Report will be used to provide documentation for changes to the work proposed in the QAPP that do not affect data quality objectives. Any non-conformance reports or Field Change Reports will be attached as an appendix to the After-Action Report (AAR) following TCRA implementation, if necessary.

Table 1. Crosswalk: PQAPP to Fort Gregg-Adams QAPP Addenda

Optimized UFP-QAPP Worksheets		PQAPP	Fort Gregg-Adams QAPP Addendum (RI)	Fort Gregg-Adams QAPP Addendum #2 (TCRA)
1 & 2	Title and Approval Page	✓	✓	✓
3 & 5	Project Organization and QAPP Distribution	✓		
4, 7 & 8	Personnel Qualifications and Sign-off Sheet	✓	✓	✓
6	Communication Pathways	✓		
9	Project Planning Session Summary	✓	✓	✓
10	CSM	✓	✓	✓
11	Project/Data Quality Objectives	✓	✓	✓
12	Measurement Performance Criteria	✓		✓[1]
13	Secondary Data Uses and Limitations	✓	✓	✓
14 & 16	Project Tasks & Schedule	✓	✓	✓
15	Project Action Limits and Laboratory-Specific Detection / Quantitation Limits	✓	✓	✓[1]
17	Sampling Design and Rationale	✓	✓	✓
18	Sampling Locations and Methods	✓	✓	✓
19 & 30	Sample Containers, Preservation, and Hold Times	✓		✓[1]
20	Field QC	✓	✓	✓
21	Field Standard Operating Procedures (SOPs)	✓	✓	✓
22	Field Equipment Calibration, Maintenance, Testing, and Inspection	✓	✓	✓
23	Analytical SOPs	✓		✓[1]
24	Analytical Instrument Calibration	✓		✓[1]
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection	✓		✓[1]
26 & 27	Sample Handling, Custody, and Disposal	✓		
28	Analytical Quality Control and Corrective Action	✓		✓[1]
29	Project Documents and Records	✓		
31, 32 & 33	Assessments and Corrective Action	✓		
34	Data Verification and Validation Inputs	✓		
35	Data Verification Procedures	✓		
36	Data Validation Procedures	✓		✓[1]
37	Data Usability Assessment	✓		

[1] Worksheet completed due to the inclusion of analytical methods that were not covered under the PQAPP for the RI (SERES-Arcadis 2024a).

QAPP WORKSHEET #1 & #2: TITLE AND APPROVAL PAGE

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

1. Project Identifying Information:
    a. Site name/project name: Environmental Services for Per- and Polyfluoroalkyl Substances Impacted Areas at Fort Gregg-Adams, Virginia
    b. Site location/number: Fort Gregg-Adams, Virginia
    c. Contract/work assignment number: W912DR-19-D-0009/ W912DR24F0232
2. Lead Organizations: U.S. Army Corps of Engineers (USACE), U.S. Army Environmental Command (USAEC), and Fort Gregg-Adams
    a. USACE Project Manager (PM), Baltimore District
       Nicole Walworth
    b. USACE Regional Point of Contact (POC), Norfolk District
       Matthew McKeehan
    c. Fort Gregg-Adams USAEC Environmental Support Manager (ESM)
       Hector Anchondo
    d. Fort Gregg-Adams Environmental Chief
       James (Alan) Mills
3. List plans and reports from previous investigations relevant to this project:

Title	Date
Final UFP-QAPP Addendum, RI for PFAS-Impacted Areas at Fort Gregg-Adams	June 2024
Final PQAPP, RIs for PFAS-Impacted Areas at U.S. Army Installations in the Northeast Region	May 2024
Accident Prevention Plan, Remedial Investigations for PFAS Impacted Areas at Army Installations in the Northeast	August 2022
Final Preliminary Assessment (PA)/Site Inspection (SI) of PFAS, Fort Lee, Virginia, USAEC PFAS PA/SI at Active Army Installations, Nationwide, USA	June 2022
Final PQAPP, USAEC PFAS PA/SI, Active Army Installations, Nationwide, USA	October 2019
Final UFP-QAPP Addendum, USAEC PFAS PA/SI, Fort Lee, Virginia	May 2020
Final Accident Prevention Plan: A-E Services, PFAS Contamination in the Cleanup/Restoration Programs at Active Army Installations – Nationwide.	March 2018
Final Site Safety and Health Plan, USAEC PFAS PA/SI, Fort Lee, Virginia	May 2020

Title	Date
ASD Memorandum: Investigating PFAS within the DoD Cleanup Program.[1]	August 2023 July 2022 September 2021 October 2019
ASD Memorandum: Monitoring of PFAS Sampling for Installations with Non-DoD Drinking Water Systems.	July 2020
Army Guidance for Addressing Releases of PFAS	September 2018
USEPA Occurrence Data for the Unregulated Contaminant Monitoring Rule: UCMR3 (2013-2015) Occurrence Data.	January 2017

1. ASD Memoranda dated 2019, 2021, and 2022 have been superseded by the ASD Memorandum dated August 2023.

QAPP WORKSHEET #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 is used to identify key site-specific personnel for each organization performing tasks defined in this QAPP Addendum #2.

LEAD ORGANIZATIONS: USACE, USAEC, and Fort Gregg-Adams

Name	Agency	Project Title/Role	Signature[1] (check box)
Nicole Walworth	USACE - Baltimore	Project Manager / COR	☐
Matthew McKeehan	USACE - Norfolk	Project Manager	☐
Hector Anchondo	USAEC	ESM	☐
Alan Mills	Fort Gregg-Adams	Directorate of Public Works Environmental Chief	☐
Craig Norris	Fort Gregg-Adams	Directorate of Public Works Environmental Compliance Chief	☐

Notes:
[1] Signature check boxes indicate personnel have read and agree to implement this QAPP Addendum #2 as written.
COR = Contracting Officers Representative
ESM = Environmental Support Manager
POC = point of contact
USACE = U.S. Army Corps of Engineers
USAEC = U.S. Army Environmental Command

ORGANIZATION: SERES-Arcadis JV

Name	Project Title/Role[1]	Education/Experience	Specialized Training/Certifications	Signature[2] (check box)
Rhonda Stone, PMP	PM	Education: B.S., Environmental Science. Experience: 27 years of experience in Hazardous, Toxic and Radioactive Waste Project and Program Management. Program Manager for the Army's PFAS PA/SIs and RIs.	• PMP • Arcadis Certified PM • OSHA: Initial 40-Hour HAZWOPER OSHA: HAZWOPER 8-Hour Refresher 29 CFR 1910.120I(8)	☒
Livi Miller, PG	Deputy PM	Education: B.S. Environmental Science, M.S. Geology. Experience: 9 years; managed environmental investigation projects; CERCLA reporting and CSM development; led field events for site characterization, multi-media sampling, drilling oversight, and monitoring well installation.	• PG (Texas) • OSHA: Initial 40-Hour HAZWOPER • OSHA: 8-Hour Refresher • OSHA: 8-Hour Site Supervisor • OSHA: 30-Hour Construction Safety • First Aid/CPR	☒
Catherine Coffey	Project Controls/Project Manager	B.S. Environmental Science. Experience: 20 years; environmental site investigation and remediation. Over 18 years in environmental remediation and construction project management including planning and oversight of field work and environmental construction activities. RCRA and CERCLA experience including site characterization through groundwater, soil, surface water, sediment sampling and vapor intrusion, CSM development, and reporting. Experience also includes program-level support and installation-level management of PFAS PAs and SIs for the Army.	• OSHA: Initial 40-Hour HAZWOPER • OSHA: HAZWOPER 8-Hour Refresher 29 CFR 1910.120(e)(8) • OSHA 30-Hour Construction Safety – 2016 • OSHA Site Supervisor – 2006 • DOT Hazmat #1: DOT/International Air Transport Association Shipping and Transportation – 2019 • First Aid/CPR – 2018 • OPSEC Awareness • Anti-Terrorism Level 1 Training • iWATCH Training	☒

Name	Project Title/Role[1]	Education/Experience	Specialized Training/Certifications	Signature[2] (check box)
Jessica Travis, PE	QC Manager	Education: B.S., Environmental Engineering. Experience: 24 years; managed environmental investigation remediation projects; provide project QC on PFAS investigations for Active Army installations.	• PE (Delaware) • USACE Construction Quality Management for Contractors • OSHA: Initial 40-Hour HAZWOPER • OSHA: HAZWOPER 8-Hour Refresher 29 CFR; OSHA 40-Hour HAZWOPER • OSHA: 8-Hour Site Supervisor • OSHA: 24-Hour Supervised Field Work	☒
Joe Quinnan, PE, PG	Technical Manager	Education: B.S. Geological Engineering, M.S. Geological Engineering. Experience: 29 years of experience. Global lead for site characterization, North American lead for emerging contaminants.	• PE (Michigan) • PG (Michigan)	☒
Christelle Newsome	Project Chemist	38 Yrs. Exp. MS/Toxicology BS/Chemistry & Biology Experience: 38 Years experience with more than 25 years managing NAVFAC, AFCEE, USACE, DOE and USEPA federal program chemistry. Specializes in providing analytical and technical guidance support to project teams to ensure data quality objectives are met.	• OSHA: Initial 40-Hour HAZWOPER • OSHA: HAZWOPER 8-Hour Refresher 29 CFR 1910.120(e)(8) • ISO/IEC 17025:2017 Lead Assessor • DOD/ELAP Lead Assessor • NQA –1 Lead Assessor	☒

Name	Project Title/Role[1]	Education/Experience	Specialized Training/Certifications	Signature[2] (check box)
Justin Coffey	SSHO	Education: B.S. History. Experience: 14 years. This experience includes environmental cost estimating and procurement of goods and services for multiple clients including Federal. Task manager for commercial and federal performance-based projects. CERCLA reporting; site characterization through soil, sediment, surface water, and groundwater sampling; and CSM development. 10 years of experience in groundwater investigation oversight and safety, including leading safety tailgate meetings, writing health and safety plans, and drilling for sampling and installation of wells.	• OSHA: Initial 40-Hour HAZWOPER • OSHA: HAZWOPER 8-Hour Refresher 29 CFR 1910.120(e)(8) • OSHA: 8-Hour Site Supervisor • OSHA: 30-Hour Construction Safety • First Aid/CPR/automated external defibrillator/bloodborne pathogens • OPSEC Awareness • Anti-Terrorism Level 1 Training • iWATCH Training	☒
Eric Fowler[3]	Alternate SSHO	Education: B.S. Geology. Experience: 8 years; led field events for site characterization, multi-media sampling, and drilling oversight; environmental inspector for industrial demolition projects.	• OSHA: Initial 40-Hour HAZWOPER • OSHA: HAZWOPER 8-Hour Refresher 29 Code of Federal Regulation 1910.120(e)(8) • OSHA: 8-Hour Site Supervisor • OSHA: 30-Hour Construction Safety • First Aid/CPR	☒

Notes:

[1] Field sampling personnel may be subject to change based on staff availability.
[2] Signature check boxes indicate personnel have read and agree to implement this QAPP Addendum #2 as written.
[3] An alternate SSHO may need to be identified for future field events to accommodate schedules. If an alternate SSHO is utilized, they will have the trainings/certifications listed above for the SSHO, at a minimum.

Arcadis = Arcadis U.S., Inc.
B.S. = Bachelor of Science
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CFR = Code of Federal Regulations
CPR = cardiopulmonary resuscitation
CSM = conceptual site model
DOT = Department of Transportation

HazMat = hazardous material
HAZWOPER = Hazardous Waste Operations and Emergency Response
M.S. = Mater of Science
OPSEC = operational security
OSHA = Occupational Safety and Health Administration
PA = Preliminary Assessment
PE = Professional Engineer
PFAS = per- and polyfluoroalkyl substances
PG = Professional Geologist
PM = Project Manager
PMP = Project Management Professional
QC = quality control
RCRA = Resource Conservation and Recovery Act
RI = remedial investigation
SI = site inspection
SSHO = Site Safety and Health Officer
USACE = U.S. Army Corps of Engineers

QAPP WORKSHEET #9: PROJECT PLANNING SESSION SUMMARY

(UFP-QAPP Manual Section 2.5.1)
(USEPA 2106-G-05 Section 2.2.5)

The Project Planning Session Summaries presented below are specific to the TCRA activities at Fort Gregg-Adams. Meeting materials and/or minutes for the Project Planning Sessions are included in **Attachment 3**, as available. The Project Planning Sessions are described further below. The key participants who were involved in the Fort Gregg-Adams TCRA Planning Session are listed below.

Name	Organization	Title/Role	Email
Nicole Walworth	USACE - Baltimore	PM	nicole.u.walworth@usace.army.mil
Erica Steiner	USACE - Baltimore	Contract Specialist	Erica.J.Stiner@usace.army.mil
Kent (Hap) Gonser	USAEC	Northeast and Europe Division, Chief	kent.r.gonser.civ@army.mil
Ruby Crysler	USAEC	Program Manager	ruby.l.crysler.civ@army.mil
Hector Anchondo	USAEC	ESM	hector.l.anchondo.civ@army.mil
Craig Norris	Fort Gregg-Adams	Installation Restoration Program Manager	craig.a.norris10.civ@army.mil
Rhonda Stone, PMP	SERES-Arcadis JV	PM	Rhonda.stone@arcadis.com
Catherine Coffey	SERES-Arcadis JV	Project Controls/PM	catherine.coffey@arcadis.com
Jen Mayers	SERES-Arcadis JV	Program Manager	jennifer.buckelsmayers@arcadis.com
Joe Quinnan	SERES-Arcadis JV	Senior Scientist	joseph.quinnan@arcadis.com
Jessica Travis, PE	SERES-Arcadis JV	QC Manager	jatravis@seres-es.com
Eric Killenbeck	SERES-Arcadis JV	Program Technical Lead	Eric.killenbeck@arcadis.com
Aubrey Thomas	SERES-Arcadis JV	Task Manager	Aubrey.thomas@arcadis.com

Note: N/A = not applicable

Date of Planning Session #1: 17 July 2024
Location: Teleconference
Purpose: Environmental Services for PFAS Impacted Areas (TCRA) – Fort Gregg-Adams Kick-off Call (Internal Army Call)

Summary of discussion topics: Project team introduction, roles and responsibilities, lines of communication, quality monitoring, and project schedule.

Documented Changes since Planning Session: At the request of USACE and USAEC, the project schedule was modified to start field work in the fall of 2024 and mitigate schedule risks for TCRA implementation. It was agreed upon by USACE, USAEC, and the SERES-Arcadis JV that the QAPP for this project would be submitted as an addendum to the existing RI QAPP to facilitate timely mobilization to the field.

QAPP WORKSHEET #10: CONCEPTUAL SITE MODEL

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

The scope of work included in this QAPP Addendum #2 will take place in the vicinity of the Active and Former Fire Training Areas (FTAs) at Fort Gregg-Adams (FTLE-7, FTLE 30, and FTLE-31). A preliminary CSM for the Active and Former FTAs at Fort Gregg-Adams is presented below. For additional details regarding the installation-wide CSM, refer to the PQAPP (SERES-Arcadis 2024a). Data collected during the completion of the PDI sampling scope of work within this QAPP Addendum #2 will be used to further develop the CSM for the Active and Former FTAs at Fort Gregg-Adams.

Location and Physical Setting

Fort Gregg-Adams lies within the Virginia Coastal Plain within Prince George County, Virginia, west/southwest of the City of Hopewell and northeast of Petersburg. The installation is bounded to the north by the Appomattox River and to the west, east, and south by residential and light commercial development and Petersburg National Battlefield Park (**Figure 1**). The Active and Former FTAs are located near Hobby Avenue and 38th Street on the southern portion of the installation (**Figure 2**). The area of interest (AOI) encompasses three separate FTAs (one active and two inactive). The location of one inactive FTA is displayed on **Figure 2**. There is general uncertainty regarding the location of the other inactive FTA and extent of aqueous film-forming foam (AFFF) use; these data gaps are being evaluated as part of the ongoing RI.

Active and Former FTA Background and Land Use

The Active FTA consists of three propane-fed and concrete-lined pits that are used for fire simulations during training activities. Prior to the concrete pit construction, the area was an earthen dike with a metal pan (burn pad) on bottom where diesel fuel was ignited. A metal pipe with a valve was also installed through the dike for drainage. According to installation personnel, the concrete pit area was constructed on top of the old burn pad site. Drainage from the active pit is to the southeast (ECC 2008). Sodium bicarbonate (baking soda) and water and Universal Green (a PFAS-free training foam) are currently used for fire suppression during training exercises in this area. Purple K was previously used on a tactical fire training trailer until the 1990s. The trailer was reportedly not set up to use AFFF and used nitrogen cylinders, according to the installation Compliance Chief. Land use at the Active FTA is not expected to change in the foreseeable future.

The Former FTAs were reportedly operational from the 1960s through the early 1980s. An unknown volume of AFFF was reportedly used at the Former FTAs (unlined pits) during that time. For the oldest Former FTA, no historical documents are available, and the location of the pit is estimated based on historical aerial imagery in the northern portion of the AOI boundary (north of MW-03).

The more recent former burn pit (FTLE-31) is located east of the Active FTA's concrete pits in the forested area around MW-05, where known excavations have occurred during previous environmental investigations to address contamination from fuels. It is assumed that the inactive pit was constructed similarly to the Active FTA prior to the concrete construction (ECC 2008). In 2009, soil was excavated from an area estimated to be approximately 40 by 60 feet to the depth of groundwater (approximately 16 feet) for a total excavation of approximately 2,081 tons of soil (ECC and Arcadis Malcom Pirnie, Inc. 2012a). Visually stained soil or soil exceeding applicable field screening criteria was removed and taken offsite for disposal at the East End Landfill located in Richmond, Virginia. It is uncertain if soil considered clean based on field screening was placed back in the excavation as anticipated in the work plan documents (ECC and Arcadis Malcom Pirnie, Inc. 2012b). However, it has also been reported that soil from the Fort Gregg-Adams borrow pit (unspecified location) was used for backfill. Following the soil excavation and removal, forty pounds of Regenesis Oxygen Release Compound Advanced™ amendment was applied to the base of the excavation as a supplemental/tertiary treatment to enhance degradation of residual fuel contamination possibly remaining in the smear zone and groundwater (ECC and Arcadis Malcom Pirnie, Inc. 2012b).

Surrounding Land Use

The on-post areas to the north, east, and west of the Active and Former FTAs are used for military training purposes, with undeveloped woodlands to the southwest. The southern installation boundary is located approximately 400 feet south of the Active FTA. Land use off-post to the south of the installation boundary is undeveloped woodlands followed by low-density residential development.

Topography and Climate

The land surface in the vicinity of the Active and Former FTAs is at an elevation of approximately 145 feet above mean sea level and slopes gently to the south. A stormwater retention pond and intermittent stream are located approximately 760 feet south of the Active FTA and act as a tributary to Blackwater Swamp (U.S. Geological Survey 2022). The Active and Former FTAs are located south of local topographic high points along 38th Street and near the intersection of 40th Street and Grant Avenue. Surface water drainage north and east of these high points is directed toward Bailey Creek and Blackwater Swamp, respectively.

The installation receives an average of 43.6 inches of precipitation annually. Summer months are reported to have the highest number of days with precipitation as well as the highest average precipitation rates. Fort Gregg-Adams also receives around 10.3 average inches of snowfall annually, with January having the highest averages for the year. The climate in this area is classified as humid subtropical and is characterized by hot, humid summers and mild to cool winters. The average annual temperature is 58.8 degrees Fahrenheit, with the warmest month of July and the coolest month of January (Weatherbase 2020).

Hydrology

The dominant surface water features near the Active and Former FTAs are Bailey Creek to the north and Blackwater Swamp to the east.Fort Gregg-Adams has approximately 511 acres of jurisdictional wetlands (the bulk of which are in three main areas: Bailey Creek, Blackwater Swamp, and the Range Complex, which encompasses the Bullhill Run and Cabin Creek headwaters). All are non-tidal, and some are isolated, but most of the wetlands are forested wetlands associated with stream channels and river headwaters (Fort Lee 2020).

- Blackwater Swamp is located approximately 0.5 miles east of the Active and Former FTAs and drains towards the east where it eventually becomes the Blackwater River, a more southerly watershed that ultimately feeds the Albemarle Sound in North Carolina. Blackwater Swamp is part of the Blackwater Watershed (Fort Lee 2020).

- Bailey Creek, a drainage of the James River and the principal natural drainage feature of Fort Gregg-Adams, essentially bisects the Cantonment area of Fort Gregg-Adams with its headwaters starting at the southwestern edge of the installation, approximately 0.9 miles north of the Active and Former FTAs. The creek flows to the northeast of the installation, approximately 7 miles to the James River. Bailey Creek drains approximately 2,400 acres of Fort Gregg-Adams and is part of the James River Watershed. Wetlands are mostly riparian in nature and associated with forested intermittent stream channels and drainages that feed Bailey Creek (Fort Lee 2020).

Geology and Hydrogeology

The Virginia Coastal Plain is composed of unconsolidated clay, sand, and gravel units with occasional bituminous shale, limestone, and sandstone lenses that extend from land surface to an approximate depth of 700 feet below ground surface (bgs) and are underlain by bedrock of Precambrian and Paleozoic age (Fluor Daniel, Inc. 1997).

Numerous surface water features impart complex hydrology and groundwater flow directions at Fort Gregg-Adams. Three aquifers are present in the vicinity of Fort Gregg-Adams: the surficial aquifer, the Yorktown-Eastover aquifer, and the Potomac aquifer. The scope of work included in this TCRA will address the surficial aquifer only. The surficial aquifer in the vicinity of Fort Gregg-Adams is unconfined and is located from 5 to 40 feet bgs. The surficial aquifer consists mainly of sands with isolated clay and silt beds which may cause locally perched water conditions in shallow sediments (Fluor Daniel, Inc. 1997). Estimated groundwater velocity in the surficial aquifer is approximately 0.6 ft/day (Add Reference).

The hydraulic gradient in this region is generally low at 0.009 foot per foot. Data from the ongoing RI indicates a southeasterly groundwater flow direction in the vicinity of the Active and Former FTAs (**Figure 3**); this observation matches observations from the recent SI and a historical petroleum release RI regarding groundwater flow direction (Arcadis 2022; Montgomery 1992). However, a shallow groundwater divide may occur along a northeast-southwest line extending though the middle of the FTAs, based on results from limited electronic cone penetration testing (ECC and Arcadis Malcom Pirnie, Inc. 2012b).

Drinking Water Sources and PFAS Relevance

There are no known in-use drinking water wells on-post. An off-post drinking water well evaluation was completed to assess whether in-use private drinking water wells exist near the installation. The evaluation area included parts of Prince George County, the City of Petersburg, and the City of Hopewell adjacent to the installation. Geographical information system (GIS) data from Prince George County indicated that public water service lines cover much of the off-post evaluation area. This water is sourced from the Appomattox River. Several residential wells were identified downgradient of the FTAs to the south and southeast; preliminary sampling results identified PFOS and PFOA at concentrations in single digit nanograms per liter (ng/L.

Known or Suspected Chemicals of Concern

PFAS sampling activities conducted at the Active and Former FTAs during the prior investigations are discussed below. Historical data for PFOS, PFOA, perfluorobutanesulfonic acid (PFBS), perfluorononanoic acid (PFNA), perfluorohexanesulfonic acid (PFHxS), perfluorobutanoic acid (PFBA), and perfluorohexanoic acid (PFHxA), as available, are shown on **Figure 2** for the FTAs. Hexafluoropropylene oxide dimer acid

(HFPO-DA) has not been analyzed in historical samples (collected during the SI and prior to the SI). While HFPO-DA is not considered part of the CSM at the installation, it will continue to be analyzed for all samples collected during the TCRA.

PFAS Investigations before the SI:

In 2014, PFOS and PFOA were sampled from existing monitoring wells at the Active and Former FTA AOI and analyzed by USEPA Modified Method 537. Information detailing the sampling procedures is not available. The results of this sampling indicated the presence of PFOS and PFOA at maximum concentrations of 8,330 ng/L and 6,840 ng/L, respectively (i.e., at MW-06); however the analytical data were not validated.

SI Sampling Results:

Based on the findings of the PA, eight areas of potential interest, including the Active and Former FTAs, were sampled during the SI at Fort Gregg-Adams to identify presence or absence of PFOS, PFOA, and PFBS. SI sampling was conducted in 2020 and supplemental samples were collected in 2021. The groundwater sampling data were re-screened using the updated risk screening levels per the 24 August 2023 ASD Memorandum. PFOS, PFOA, PFBS, PFNA, PFHxS, and PFHxA were identified in groundwater at concentrations greater than the applicable risk screening levels (**Figure 2**). PFAS concentrations (sum of reported PFAS) greater than 60,000 ng/L are present in groundwater at and near the FTAs and decrease significantly to between approximately 50 ng/L to the south and 500 ng/L to the east/southeast along the southern installation boundary. Off-post residential wells to the south and southeast of the FTAs have single digit ng/L PFAS concentrations. Based on the sampling results, the Active and Former FTAs is included in the ongoing RI.

Potential Receptors and Exposure Pathways

The sources of PFAS at the Fort Gregg-Adams AOIs include intentional and accidental releases of AFFF to soil and/or paved surfaces associated with firefighter training, equipment and nozzle testing, AFFF storage, and potential disposal of soil that may have contained residual AFFF. The primary exposure pathways relevant to the TCRA at the Active and Former FTAs are ingestion or dermal contact with groundwater used as a potable water source for off-installation drinking water users to the south of the FTAs. As previously referenced, public water service lines cover much of the off-installation area to the south of the FTAs; however, several residential wells were identified in this area and sampled for PFAS. Preliminary sampling results identified PFOS and PFOA at concentrations below 10 ng/L (**Figure 3**). The water supply at Fort Gregg-Adams is provided through two major surface water treatment plants which source water several miles away from the FTAs (Lake Chesdin and the Appomattox River). There are no known in-use drinking water wells on-post.

Data Gaps

Prior to TCRA implementation, a PDI will be conducted to collect data needed to support the final design of the TCRA. The objectives for the PDI are as follows: 1) Confirm groundwater flow direction in the vicinity of FTAs and southern installation boundary; 2) Confirm the lateral and vertical distribution of PFAS along the southern installation boundary with a focus on the high PFAS concentrations migrating from the upgradient Active and Former FTAs; 3) Combine hydrostratigraphy and PFAS distribution data to generate a mass flux based CSM to optimize the TCRA location and design; and 4) Evaluate geochemistry and co-contaminants (e.g., volatile organic compounds [VOCs]) in groundwater to inform CAC loading during PRB design. Data collected during the PDI will inform the final PRB design, including the length, width, and thickness of the PRB; number of injection points; injection radius of influence; and required mass of CAC. Additionally, the results of the PDI will allow for targeted application of CAC to account for site-specific flux of PFAS as well as other non-target constituents that may sorb to the CAC (e.g., VOCs). Sample locations for the PDI are presented on **Figure 4**. **Worksheet #17** of this QAPP provides the rationale and sampling design for the PDI sampling scope of work to address the above data gaps, as well as baseline and verification sampling after PRB implementation. **Worksheets #18** and **#20** of this QAPP list the planned sample identifications and required QC samples for each medium for the PDI and subsequent sampling phases.

QAPP WORKSHEET #11: PROJECT/DATA QUALITY OBJECTIVES

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

This worksheet describes the general DQOs using USEPA's seven-step DQO process: Guidance on Systematic Planning Using the DQOs Process, USEPA QA/G-4, USEPA/240/B-06/001 (USEPA 2006). The selected investigation design is presented on **Worksheet #17**. This worksheet will state the problem, identify the goal of the study in accordance with the environmental questions being asked, identify information inputs, define the boundaries of the sampling, develop a decision rule/analytic approach, specify performance or acceptance criteria, and develop the plan for obtaining data. Each of these steps is described below.

Step 1: State the Problem
PFAS are present in groundwater within the vicinity of the Active and Former FTAs (FTLE-7, FTLE 30, and FTLE-31) and the region downgradient of these FTAs where there is evidence that these groundwater impacts extend to the southern installation boundary. PFAS-impacted groundwater has the potential to migrate off-post and may pose a risk to off-post receptors located to the south and southeast of the FTAs. To mitigate future off-post migration, a TCRA will be executed as part of this work. The TCRA consists of a CAC PRB installed along the southern boundary to reduce PFAS levels in groundwater to levels that are at or below residential risk screening levels after the point of treatment. To properly design this PRB, data gaps regarding the PFAS contaminant distribution and related hydrogeological and mass flux data along the southern installation boundary will be evaluated during the PDI. For the Army PA/SIs, the 2021 and/or 2022 ASD Memorandum and its associated human health risk screening levels were used as the basis for recommending further investigation in the RI phase. Risk-screening levels presented in the updated ASD Memoranda, released 24 August 2023 and 3 September 2024 (**Attachment 2**; i.e., RSLs and MCLs) were used as project screening levels for this TCRA (see **Worksheet #15**).
Step 2: Identify the Goal of the Study
The primary goal of this work is to mitigate future off-post migration of PFAS via implementation of a TCRA at Fort Gregg-Adams. A PDI will be conducted prior to the PRB design and implementation. Specific goals of the PDI are to determine 1) groundwater flow directions between the Active and Former FTAs (FTLE-7, FTLE 30, and FTLE-31) and the southern installation boundary; 2) the hydrogeological and geochemical properties of the subsurface environment and 3) the PFAS levels and distribution in groundwater along the southern boundary of the facility. This information will be synthesized to create a flux-based CSM that will be used as the basis for the design and implementation of the PRB.

Prior to PRB implementation, a baseline sampling event will be conducted to generate a pre-TCRA baseline groundwater quality data set. This work includes the installation of a PRB performance monitoring well network followed by groundwater sampling and analysis for PFAS.

Subsequent to PRB installation, verification groundwater sampling and analyses for PFAS will be conducted to demonstrate the effectiveness of the PRB.

This TRCA work will be conducted in accordance with CERCLA guidance for field investigations and in compliance with the U.S. Department of the Army requirements and guidance for addressing PFAS at Army installations.

Step 3: Identify Information Inputs

The data needed to accomplish the goals of the sampling and analysis activities for this project are as follows:

- Previously collected analytical data for PFAS at the Active and Former FTAs (FTLE-7, FTLE 30, and FTLE-31). These data will be used in conjunction with information inputs summarized below to meet the goals in Step 2. The PA/SI Report completed for Fort Gregg-Adams contains analytical results for 18 PFAS compounds in soil, groundwater, surface water and/or sediment from the FTAs.
- Analytical data from source water samples collected during an Expanded SI sampling event that was performed under the SI QAPP (Arcadis 2020).
- GIS data from existing well locations and AOI spatial data.
- Aerial imagery to evaluate relevant structures and sampling locations.
- Hydrogeological information, derived from both soil coring/logging and Hydraulic Profiling Tool (HPT) results to evaluate groundwater flow and transport pathways along the subject region of the southern boundary.
- Sampling and analyses of groundwater samples and per the methods and sampling plan design and rationale summarized in **Worksheet #17**.
- Groundwater elevation data collected during the scope outlined in **Worksheet #17**.
- Field parameters including temperature, pH, conductivity, oxidation-reduction potential (ORP), dissolved oxygen (DO), and turbidity.

Step 4: Define the Boundaries of the Sampling

The physical boundaries of the TCRA work are limited to region of the Active and Former FTAs (FTLE-7, FTLE 30, and FTLE-31) and the installation boundary to the south of the FTAs. The field work is anticipated to be performed according to the schedule presented in **Worksheets #14 & #16**.

Step 5: Develop the Analytic Approach

Groundwater samples collected during the TCRA work for PFAS analyses will be submitted to a DoD Environmental Laboratory Accreditation Program (ELAP)- accredited laboratory to the requirements of the Quality Systems Manual (QSM) for Environmental Laboratories Version 5.4 (or later versions). Pace Analytical (Pace; South Carolina) is the laboratory selected for analysis of PFAS via USEPA Method 1633.

Groundwater samples will also be analyzed for the following parameters:

- In-field parameters, collected as part of the groundwater sampling procedure, as indicated in Step 3 above and
- Additional water quality parameters including anions via USEPA Method 300 (bromide, chloride, fluoride, nitrate, nitrite, and sulfate), carbonate/bicarbonate alkalinity by Standard Methods for the Examination of Water and Wastewater 2320, total organic carbon (TOC) and dissolved organic carbon (DOC) by USEPA Method 9060a, total and dissolved metals by USEPA Test Methods for Evaluating Solid Waste: Physical Chemical Methods (SW846) Method 6010, total petroleum hydrocarbons (TPH) by USEPA SW846 Method 8015, and VOCs by USEPA SW846 Method 8260. These data will be used to support the PRB remedy design. The total and dissolved values for the organic carbon and metals will be derived from unfiltered and filtered groundwater samples, respectively. Pace (South Carolina) is the laboratory selected for these analyses. In the event that Pace cannot perform said tasks, Eurofins (Lancaster), PA is the selected secondary laboratory.

Specific details regarding analyte lists and the laboratory's limits of detection (LODs), limits of quantitation (LOQs), and detection limits (DLs) are identified in **Worksheet #15**. QA/QC samples will be collected as defined in **Worksheet #20**. A listing of the laboratory SOPs is provided in **Worksheet #23** along with the levels of data quality.

Worksheets #17 and **#18** further identify project objectives and rationale for sampling and analysis.

The final waste characterization and disposal plan for investigation-derived waste (IDW) will be conducted in accordance with U.S. Army guidance, state/local regulations, and installation management practices. Disposal of IDW will be discussed in **Worksheet #17**.

Step 6: Specify Performance or Acceptance Criteria

Measurement performance criteria (MPC) for precision and accuracy are provided in **Worksheets #12 and #28**. Field monitoring and detection equipment will be routinely calibrated, as detailed on **Worksheet #22**, which confirms that equipment used is of the proper type, range, accuracy, and precision to provide data compatible with the specified requirements and desired results. The data usability assessment process is described in **Worksheet #37** of the PQAPP (SERES-Arcadis 2024a).

Step 7: Develop the Plan for Obtaining Data
The details of the sampling plan are provided on **Worksheet #17**. Sampling plans may be revised based on field conditions or site planning meetings, with appropriate notification and concurrence of USACE, USAEC, and Fort Gregg-Adams. Deviations from this QAPP Addendum #2 will be documented in the Fort Gregg-Adams TCRA AAR.

QAPP WORKSHEET #12: MEASUREMENT PERFORMANCE CRITERIA

(UFP-QAPP Manual Section 2.6.2)

(USEPA 2106-G-05 Section 2.2.6)

12.1 Measurement of Performance Criteria – PFAS in Groundwater

Matrix: Groundwater
Analytical Group/Method/SOPs: PFAS per USEPA Method 1633, or later versions compliant with DoD QSM 5.4 Table B-24/ Pace ENV-SOP-WCOL-0158
Concentration Level: Low

DQI	QC Sample or Measurement Performance Activity	MPC
Precision	FD	RPD ≤ 30%
Accuracy/Bias (contamination)	MBs and/or EBs as appropriate	No analytes detected >1/2 LOQ or >1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater.
Analytical Accuracy/Bias (laboratory)	OPR standards	%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 OPR
Analytical Precision (laboratory)	OPR duplicate 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	Instrument Sensitivity Check, LOQ verification sample (spiked at concentration of lowest calibration standard)	Recovery within ±30% of true value
Completeness	Useable data vs collected data	≥ 90%

Notes:
The table above complies with the requirements of USEPA Method 1633, or later versions, compliant with DoD QSM 5.4 Table B-24.
% = percent
DQI = data quality indicator
EB = equipment blank
EIS = extracted internal standard
FD = field duplicate
LOQ = limit of quantitation
MB = method blank
MPC = measurement performance criteria
MS = matrix spike
MSD = matrix spike duplicate
OPR = ongoing precision and recovery
QC = quality control
RPD = relative percent difference

PFAS Accuracy Limits – USEPA Method 1633 compliant with DoD QSM 5.4 Table B-24			
Analyte	**Acronym**	**CAS Number**	**Accuracy Limits (%R)[1]**
PFAS – Groundwater and Surface Water USEPA 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
Perfluorooctanesulfonamide	PFOSA	754-91-6	40-150

PFAS Accuracy Limits – USEPA Method 1633 compliant with DoD QSM 5.4 Table B-24			
Analyte	**Acronym**	**CAS Number**	**Accuracy Limits (%R)[1]**
PFAS – Groundwater and Surface Water USEPA Method 1633 compliant with DoD QSM 5.4 Table B-24			
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

Notes:

[1] The control limits were supplied by the laboratory August 2024. The laboratory will update their control limits quarterly as required by USEPA Method 1633.

CAS = Chemical Abstracts Service
DoD = Department of Defense
PFAS = per- and polyfluoroalkyl substances
QSM = Quality Systems Manual
USEPA = U.S. Environmental Protection Agency

12.2 Measurement of Performance Criteria – VOCs in Groundwater

Matrix: Groundwater
Analytical Group/Method/SOPs: VOCs / SW 846 8260D / Pace ENV-SOP-WCOL-0107
Concentration Level: Low

DQI	QC Sample or Measurement Performance Activity	MPC
Contamination	EB	No analytes detected >1/2 LOQ
Contamination	Trip Blank	No analytes detected >1/2 LOQ
Overall Precision	FD	RPD ≤ 30%
Precision	LCSD[1]	See **Worksheet #28** for additional information
Accuracy	LCS	See **Worksheet #28** for additional information
Precision / Accuracy	MS/MSD	See **Worksheet #28** for additional information
Accuracy	Surrogate Compounds	See **Worksheet #28** for additional information
Accuracy	MB	No Target Compounds >1/2 LOQ; No common lab contaminants > LOQ; or >1/10 the amount measured in any sample or >1/10 the regulatory limit (whichever is greater)
Completeness	Data completeness check; evaluated during data quality assessment	N/A

Notes:
% = percent
DQI = data quality indicator
EB = equipment blank
FD = field duplicate
LCS = laboratory control sample
LCSD = laboratory control sample duplicate
LOQ = limit of quantitation
MB = method blank
MS = matrix spike
MSD = matrix spike duplicate
N/A = not applicable
QC = quality control
RPD = relative percent difference

12.3 Measurement of Performance Criteria – GRO/DRO in Groundwater

Matrix: Soil/Water
Analytical Group/Method: Gasoline Range Organics or Diesel Range Organics 8015C
Concentration Level: Low

DQI	QC Sample and/or Activity Used to Assess Measurement Performance	MPC
Contamination	EB	No Target Compounds >1/2 LOQ; or >1/10 the amount measured in any sample or >1/10 the regulatory limit (whichever is greater)
Contamination	Trip Blank (If provided, GRO only)	No Target Compounds >1/2 LOQ; or >1/10 the amount measured in any sample or >1/10 the regulatory limit (whichever is greater)
Overall Precision	FD	RPD <30%
Precision	LCSD[1]	RPD <20%
Accuracy	LCS	See **Worksheet #28** for additional information
Precision / Accuracy	MS/MSD	See **Worksheet #28** for additional information
Accuracy	Surrogate Compounds	See **Worksheet #28** for additional information
Accuracy	MB	No Target Compounds > 1/2 LOQ; or >1/10 the amount measured in any sample or >1/10 the regulatory limit (whichever is greater)
Completeness	Data completeness check; evaluated during data quality assessment	90%

Notes:
[1] LCSDs are not a method requirement; however, if this information is provided, it will be evaluated.

% = percent
DQI = data quality indicator
EB = equipment blank
FD = field duplicate
GRO = gasoline range organics
LCS = laboratory control sample
LCSD = laboratory control sample duplicate
LOQ = limit of quantitation
MB = method blank
MS = matrix spike
MSD = matrix spike duplicate
QC = quality control
RPD = relative percent difference

12.4 Measurement of Performance Criteria – Total and Dissolved Metals in Groundwater

Matrix: Groundwater
Analytical Group/Method/SOPs: Metals / SW 846 6010D / Pace ENV-SOP-WCOL-0032
Concentration Level: Low

DQI	QC Sample or Measurement Performance Activity	MPC
Contamination	EB	No Target Compounds > 1/2 LOQ
Overall Precision	FD	RPD <30%
Precision	LCSD[1]	See **Worksheet #28** for additional information
Accuracy	LCS	See **Worksheet #28** for additional information
Precision / Accuracy	MS/MSD	See **Worksheet #28** for additional information
Accuracy	MB	No Target Compounds > 1/2 LOQ or > 1/10th the amount measured in any sample or >1/10 the regulatory limit (whichever is greater).
Accuracy	Interference Check	See **Worksheet #28** for additional information
Completeness	Data completeness check; evaluated during data quality assessment	90%

Notes:
% = percent
DQI = data quality indicator
EB = equipment blank
FD = field duplicate
LCS = laboratory control sample
LCSD = laboratory control sample duplicate
LOQ = limit of quantitation
MB = method blank
MPC = measurement performance criteria
MS = matrix spike
MSD = matrix spike duplicate
N/A = not applicable
QC = quality control
RPD = relative percent difference

12.5 Measurement of Performance Criteria – Anions in Groundwater

Matrix: Soil/Water
Analytical Group/Method: Anions by E300.0
Concentration Level: Low

DQI	QC Sample and/or Activity Used to Assess Measurement Performance	MPC
Contamination	EB	No Target Compounds > 1/2 LOQ; or >1/10 the amount measured in any sample or >1/10 the regulatory limit (whichever is greater)
Overall Precision	FD	RPD </= 30
Precision	LCSD[1]	See **Worksheet #28** for additional information
Accuracy	LCS	See **Worksheet #28** for additional information
Precision / Accuracy	MS/MSD	See **Worksheet #28** for additional information
Accuracy	MB	No Target Compounds > 1/2 LOQ; or >1/10 the amount measured in any sample or >1/10 the regulatory limit (whichever is greater)
Completeness	Data completeness check; evaluated during data quality assessment	90%

Notes:
[1] LCSDs are not a method requirement; however, if this information is provided, it will be evaluated.

% = percent
DQI = data quality indicator
EB = equipment blank
FD = field duplicate
GRO = gasoline range organics
LCS = laboratory control sample
LCSD = laboratory control sample duplicate
LOQ = limit of quantitation
MB = method blank
MS = matrix spike
MSD = matrix spike duplicate
QC = quality control
RPD = relative percent difference

12.6 Measurement of Performance Criteria – TOC in Soil and Groundwater

Matrix: Soil/Water
Analytical Group / Method: Total Organic Carbons by 9060A
Concentration Level: Low

DQI	QC Sample and/or Activity Used to Assess Measurement Performance	MPC
Contamination	EB	No Target Compounds >1/2 LOQ; or >1/10 the amount measured in any sample or >1/10 the regulatory limit (whichever is greater)
Overall Precision	FD	RPD </= 30
Precision	LCSD[1]	See **Worksheet #28** for additional information
Accuracy	LCS	See **Worksheet #28** for additional information
Precision / Accuracy	MS/MSD	See **Worksheet #28** for additional information
Accuracy	MB	No Target Compounds > 1/2 LOQ; or >1/10 the amount measured in any sample or >1/10 the regulatory limit (whichever is greater)
Completeness	Data completeness check; evaluated during data quality assessment	90%

Notes:
[1] LCSDs are not a method requirement; however, if this information is provided, it will be evaluated.

% = percent
DQI = data quality indicator
EB = equipment blank
FD = field duplicate
GRO = gasoline range organics
LCS = laboratory control sample
LCSD = laboratory control sample duplicate
LOQ = limit of quantitation
MB = method blank
MS = matrix spike
MSD = matrix spike duplicate
QC = quality control
RPD = relative percent difference

12.7 Measurement of Performance Criteria – Alkalinity in Groundwater

Matrix: Soil/Water
Analytical Group / Method: Alkalinity by SM2320B
Concentration Level: Low

DQI	QC Sample and/or Activity Used to Assess Measurement Performance	MPC
Contamination	EB	No Target Compounds >1/2 LOQ; or >1/10 the amount measured in any sample or >1/10 the regulatory limit (whichever is greater)
Overall Precision	FD	RPD </= 30
Precision	LCSD[1]	See **Worksheet #28** for additional information
Accuracy	LCS	See **Worksheet #28** for additional information
Precision	Sample Duplicate	See **Worksheet #28** for additional information
Accuracy	MB	No Target Compounds >1/2 LOQ; or >1/10 the amount measured in any sample or >1/10 the regulatory limit (whichever is greater)
Completeness	Data completeness check; evaluated during data quality assessment	90%

Notes:

[1] LCSDs are not a method requirement; however, if this information is provided, it will be evaluated.

% = percent
DQI = data quality indicator
EB = equipment blank
FD = field duplicate
GRO = gasoline range organics
LCS = laboratory control sample
LCSD = laboratory control sample duplicate
LOQ = limit of quantitation
MB = method blank
MS = matrix spike
MSD = matrix spike duplicate
QC = quality control
RPD = relative percent difference

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)

This worksheet identifies sources of secondary data not generated for the specific purpose of this project, or data generated under a separate UFP-QAPP, and summarizes their uses for this project. A full list of references reviewed to complete the RI at Fort Gregg-Adams will be provided in the RI Report.

Data Type	Source	Data Uses Relative to Current Project	Factors Affecting the Reliability of Data and Limitations on Data Use
Aerial Imagery	ESRI, ArcGIS Online Aerial Imagery	Provided georeferenced aerial photos for figure backdrops.	There are no known limitations on aerial imagery.
Meteorological	National Weather Service, National Oceanic and Atmospheric Administration	Site conditions which may affect temporal boundaries of the sampling, and which have historically contributed to transport of contaminants.	Various, potentially outdated information and regional (broad) information rather than site-specific.
Topographic	U.S. Geological Survey, Installation GIS Data	Understanding of terrain and how site conditions may have historically contributed to transport of contaminants.	May contain outdated information if development/re-grading or mass wasting has occurred.
Historical site records	Various Historical Reports (Installation Restoration Program Documents, Installation Management Plans, Inventories, Purchase Records)	Background concentrations of various chemicals, historical site operations, physical site settings, and potentially documented fate and transport pathways.	Historical records may be incomplete or inaccurate and may contain old and/or unreliable data. Site usage histories omit records of PFAS-containing materials procurement and use. Additionally, limited PFAS data are available from previous investigations, and it cannot be verified that historical sample collection or laboratory analysis for PFAS constituents was conducted in accordance with best practices (SOPs) for PFAS sampling to obtain technically defensible/usable data (i.e., not affected by sampling methods and procedures).
Installation Personnel Interviews	Various	Provided anecdotal histories of site use, PFAS-containing materials use/storage/disposal, and remedial actions completed.	Several installation personnel who would have worked on site during the peak of PFAS-containing materials use, storage, and/or disposal are retired or out of contact.

QAPP WORKSHEET #14 & #16: PROJECT TASKS & SCHEDULE

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

The project schedule is presented below for sampling activities planned at Fort Gregg-Adams as part of the TCRA.

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Deliverable(s)	Deliverable Due Date
Administrative Kick-off Call	SERES-Arcadis JV	17 July 2024	17 July 2024	Kick-off Meeting Minutes	17 July 2024
Submit Draft Action Memorandum (Army review)	SERES-Arcadis JV	July 2024	August 2024	Draft Action Memorandum	13 August 2024
Submit Draft QAPP Addendum and PRB Work Plan (Army review)	SERES-Arcadis JV	July 2024	August 2024	Draft QAPP Addendum and PRB Work Plan	21 August 2024
Submit Draft Final Action Memorandum (Regulatory review)	SERES-Arcadis JV	September 2024	September 2024	Draft Final Action Memorandum	November 2024
Submit Draft Final QAPP Addendum and PRB Work Plan (Regulatory review)	SERES-Arcadis JV	September 2024	September 2024	Draft Final QAPP Addendum and PRB Work Plan	October 2024
Submit Final Action Memorandum	SERES-Arcadis JV	October 2024	October 2024	Final Action Memorandum	December 2024
Submit Final QAPP Addendum and PRB Work Plan	SERES-Arcadis JV	October 2024	October 2024	Final QAPP Addendum and PRB Work Plan	November 2024
PDI Field Work	SERES-Arcadis JV and subcontractors	November 2024	December 2024	Field Progress Reports	Weekly during field activities
Laboratory Analysis and Data Validation	Pace Analytical and SERES-Arcadis JV	December 2024	February 2025	Laboratory data packages and Data Usability Report	February 2025

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Deliverable(s)	Deliverable Due Date
Remedy Design Refinement	SERES-Arcadis JV	February 2025	February 2025	Memorandum (if necessary)	February 2025
TCRA Field Implementation	SERES-Arcadis JV	March 2025	May 2025	Field Progress Reports	Weekly during field activities
Submit Draft AAR	SERES-Arcadis JV	May 2025	July 2025	Draft AAR	July 2025
Submit Draft Final AAR	SERES-Arcadis JV	August 2025	October 2025	Draft Final AAR	October 2025
Submit Final AAR	SERES-Arcadis JV	December 2025	January 2025	Final AAR	January 2025
Verification Monitoring Event #1	SERES-Arcadis JV	August 2025	August 2025	Field Progress Report	August 2025
Verification Monitoring Event #2	SERES-Arcadis JV	November 2025	November 2025	Field Progress Report	November 2025
Verification Monitoring Event #3	SERES-Arcadis JV	February 2026	February 2026	Field Progress Report	February 2026
Submit Draft Verification Sampling Report (Army review)	SERES-Arcadis JV	April 2026	April 2026	Draft Verification Sampling Report	April 2026
Submit Draft Final Verification Sampling Report (Regulatory review)	SERES-Arcadis JV	May 2026	June 2026	Draft Final Verification Sampling Report	June 2026
Submit Final Verification Sampling Report	SERES-Arcadis JV	August 2026	September 2026	Final Verification Sampling Report	September 2026

Notes:
AAR = After-Action Report
PDI = pre-design investigation
PRB = permeable reactive barrier
QAPP = Quality Assurance Project Plan
TBD = to be determined
TCRA = Time Critical Removal Action

QAPP WORKSHEET #15: REFERENCE LIMITS AND EVALUATION TABLES

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

This worksheet provides the laboratory-specific limits for the PFAS compounds that will be analyzed, including the typical LOQ and LOD. The LOQs and LODs are what the laboratories can achieve and were supplied by the laboratories. The LOQ is the lowest concentration of a substance that produces a quantitative result within specified limits of precision and bias, and the LOD is the lowest concentration for reliable reporting of a non-detect of a specific analyte in a specific medium with a specific method at 99 percent confidence (DoD 2017). Concentrations detected between the LOD and LOQ are estimates, and therefore, will be qualified and indicated as such on laboratory analytical reports. All soil/sediment results are to be reported in dry weight.

Matrix: Groundwater		**Analytical Group: PFAS (Pace) per USEPA Method 1633 compliant with DoD QSM 5.4 Table B-24**			
Analyte	**CAS Number**	**Project Screening Levels[1] (ng/L)**	**Laboratory Specific Limits[2]**		
			LOQ (ng/L)	**LOD (ng/L)**	**DL (ng/L)**
Perfluorobutanoic acid (PFBA)	375-22-4	1,800	4	1.6	0.51
Perfluoropentanoic acid (PFPeA)	2706-90-3	--	2	0.4	0.18
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	--	1	0.75	0.26
Perfluorohexanoic acid (PFHxA)	307-24-4	990	1	0.4	0.14
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	1	0.8	0.21
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	--	1	0.38	0.19
Perfluorooctanoic acid (PFOA)	335-67-1	4.0	1	0.8	0.21
Perfluorononanoic acid (PFNA)	375-95-1	10.0	1	0.4	0.1
Perfluorononanesulfonic acid (PFNS)	68259-12-1	--	1	0.38	0.15
Perfluorodecanoic acid (PFDA)	335-76-2	--	1	0.4	0.14
Perfluorodecanesulfonic acid (PFDS)	335-77-3	--	1	0.39	0.16
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	1	0.8	0.25
Perfluorododecanoic acid (PFDoA)	307-55-1	--	1	0.4	0.11
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	--	1	0.39	0.15
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	1	0.4	0.19
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	--	1	0.8	0.27
Perfluorobutanesulfonic acid (PFBS)	375-73-5	600	1	0.35	0.094
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	10.0	1	0.73	0.18
Perfluorooctane sulfonate (PFOS)	1763-23-1	4.0	1	0.74	0.25

Matrix: Groundwater		**Analytical Group: PFAS (Pace) per USEPA Method 1633 compliant with DoD QSM 5.4 Table B-24**			
Analyte	**CAS Number**	**Project Screening Levels[1] (ng/L)**	**Laboratory Specific Limits[2]**		
			LOQ (ng/L)	**LOD (ng/L)**	**DL (ng/L)**
Perfluorooctanesulfonamide (PFOSA)	754-91-6	--	1	0.4	0.2
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	10.0	4	2.4	0.99
N-ethyl perfluorooctane sulfonamidoacetic acid (NEtFOSAA)	2991-50-6	--	1	0.8	0.29
N-methyl perfluorooctane sulfonamidoacetic acid (NMeFOSAA)	2355-31-9	--	1	0.8	0.29
N-Methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	--	1	0.8	0.22
N-Ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	--	1	0.4	0.13
N-Methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	--	10	2	0.63
N-Ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	--	10	2	0.61
4:2 Fluorotelomer sulfonate (4:2 FTS)	757124-72-4	--	4	1.5	0.4
6:2 Fluorotelomer sulfonate (6:2 FTS)	27619-97-2	--	5	4.6	2
8:2 Fluorotelomer sulfonate (8:2 FTS)	39108-34-4	--	4	1.5	0.61
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	--	4	2.3	0.66
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	--	2	0.6	0.18
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	--	2	1.3	0.39
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	--	2	1.3	0.58
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	--	4	2.2	0.67
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	--	4	2.3	0.87
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	--	2	1.1	0.36
3-Perfluoropropyl propanoic acid (3:3 FTCA)	356-02-5	--	5	2	0.6
2H,2H,3H,3H-Perfluorooctanoic acid (5:3 FTCA)	914637-49-3	--	25	10	4.3
3-Perfluoroheptyl propanoic acid (7:3 FTCA)	812-70-4	--	25	10	4.2

Notes:

[1] Project screening levels are Maximum Contaminant Levels (MCLs) for drinking water as defined in the September 2024 ASD Memorandum, or risk screening levels protective of residential tapwater (based on a target cancer risk of 1×10^{-6} or a noncancer hazard quotient of 0.1) as defined in the August 2023 ASD Memorandum (**Attachment 2**). In anticipation of changes and additions to risk-based screening levels, updates or additions to the list of PFAS to consider for evaluation during investigation will be maintained on the DoD's PFAS website at: https://www.acq.osd.mil/eie/eer/ecc/pfas/tf/policies.html.

[2] These are what Pace can achieve and were supplied by the laboratory.

[3] Based on the CSM developed during the PA and revised based on SI findings, the presence of HFPO-DA is not anticipated at Fort Gregg-Adams because HFPO-DA is generally not a component of military specification AFFF and based on its history including distribution limitations that restricted use of "GenX" or HFPO-DA, it is generally not a component of other products the military used.

-- = no published screening criteria
CAS = Chemical Abstracts Service
DL = detection limit
DoD = Department of Defense
LOD = limit of detection
LOQ = limit of quantitation
ng/L = nanograms per liter
QSM = Quality Systems Manual

USEPA = U.S. Environmental Protection Agency

Matrix: Groundwater		**Analytical Group: VOCs (Pace) per USEPA Method 8260**			
Analyte	**CAS Number**	**Screening Level (µg/L)[1]**	**LOQ (µg/L)**	**LOD (µg/L)**	**DL (µg/L)**
Acetone	67-64-1	N/A	20	10	5
Benzene	71-43-2	N/A	1	0.8	0.4
Bromodichloromethane	75-27-4	N/A	1	0.8	0.4
Bromoform	75-25-2	N/A	1	0.8	0.4
Bromomethane (Methyl bromide)	74-83-9	N/A	2	0.8	0.4
2-Butanone (MEK)	78-93-3	N/A	10	4	2
Carbon disulfide	75-15-0	N/A	1	0.8	0.4
Carbon tetrachloride	56-23-5	N/A	1	0.8	0.4
Chlorobenzene	108-90-7	N/A	1	0.8	0.4
Chloroethane	75-00-3	N/A	2	0.8	0.4
Chloroform	67-66-3	N/A	1	0.8	0.4
Chloromethane (Methyl chloride)	74-87-3	N/A	2	1	0.5
Cyclohexane	110-82-7	N/A	1	0.8	0.4
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	N/A	1	0.8	0.4
Dibromochloromethane	124-48-1	N/A	1	0.8	0.4
1,2-Dibromoethane (EDB)	106-93-4	N/A	1	0.8	0.4
1,2-Dichlorobenzene	95-50-1	N/A	1	0.8	0.4
1,3-Dichlorobenzene	541-73-1	N/A	1	0.8	0.4
1,4-Dichlorobenzene	106-46-7	N/A	1	0.8	0.4
Dichlorodifluoromethane	75-71-8	N/A	2	1.2	0.6
1,1-Dichloroethane	75-34-3	N/A	1	0.8	0.4
1,2-Dichloroethane	107-06-2	N/A	1	0.8	0.4
1,1-Dichloroethene	75-35-4	N/A	1	0.8	0.4
cis-1,2-Dichloroethene	156-59-2	N/A	1	0.8	0.4
trans-1,2-Dichloroethene	156-60-5	N/A	1	0.8	0.4
1,2-Dichloropropane	78-87-5	N/A	1	0.8	0.4
cis-1,3-Dichloropropene	10061-01-5	N/A	1	0.8	0.4
trans-1,3-Dichloropropene	10061-02-6	N/A	1	0.8	0.4
Ethylbenzene	100-41-4	N/A	1	0.8	0.4
2-Hexanone	591-78-6	N/A	10	4	2

Matrix: Groundwater		**Analytical Group: VOCs (Pace) per USEPA Method 8260**			
Analyte	**CAS Number**	**Screening Level (µg/L)[1]**	**LOQ (µg/L)**	**LOD (µg/L)**	**DL (µg/L)**
Isopropylbenzene	98-82-8	N/A	1	0.8	0.4
Methyl acetate	79-20-9	N/A	1	0.8	0.4
Methyl tertiary butyl ether (MTBE)	1634-04-4	N/A	1	0.8	0.4
4-Methyl-2-pentanone	108-10-1	N/A	10	4	2
Methylcyclohexane	108-87-2	N/A	5	0.8	0.4
Methylene chloride	75-09-2	N/A	1	0.8	0.4
Styrene	100-42-5	N/A	1	0.82	0.41
1,1,2,2-Tetrachloroethane	79-34-5	N/A	1	0.8	0.4
Tetrachloroethene	127-18-4	N/A	1	0.8	0.4
Toluene	108-88-3	N/A	1	0.8	0.4
1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1	N/A	1	0.84	0.42
1,2,4-Trichlorobenzene	120-82-1	N/A	1	0.8	0.4
1,1,1-Trichloroethane	71-55-6	N/A	1	0.8	0.4
1,1,2-Trichloroethane	79-00-5	N/A	1	0.8	0.4
Trichloroethene	79-01-6	N/A	1	0.8	0.4
Trichlorofluoromethane	75-69-4	N/A	1	0.8	0.4
Vinyl chloride	75-01-4	N/A	1	0.8	0.4
Xylenes (total)	1330-20-7	N/A	1	0.8	0.4

Notes:

[1] VOCs are not a contaminant of concern for this TCRA and VOC data will be used solely for support of PRB design; therefore, no screening levels are considered.

µg/L = micrograms per liter
CAS = Chemical Abstracts Service
DL = detection limit
LOD = limit of detection
LOQ = limit of quantitation
N/A = not applicable
VOC = volatile organic compound
USEPA = U.S. Environmental Protection Agency

Matrix: Groundwater		**Analytical Group: TPH (Pace) per USEPA Method 8015**			
Analyte	**CAS Number**	**Screening Level (µg/L)**	**LOQ (µg/L)**	**LOD (µg/L)**	**DL (µg/L)**
TPH-DRO	SESI-0003	N/A	200	100	42.68
TPH-GRO	SESI-0004	N/A	100	80	40

Notes:

[1] TPH are not a contaminant of concern for this TCRA and TPH data will be used solely for support of PRB design; therefore, no screening levels are considered.

µg/L = micrograms per liter
CAS = Chemical Abstracts Service
DL = detection limit
DRO = diesel range organics
GRO = gasoline range organics
LOD = limit of detection
LOQ = limit of quantitation
N/A = not applicable
TPH = total petroleum hydrocarbon
USEPA = U.S. Environmental Protection Agency

Matrix: Groundwater		**Analytical Group: Metals (Pace) per USEPA Method 6010**			
Analyte	**CAS Number**	**Screening Level (mg/L)**	**LOQ (mg/L)**	**LOD (mg/L)**	**DL (mg/L)**
Aluminum	7429-90-5	N/A	0.4	0.2	0.1
Antimony	7440-36-0	N/A	0.02	0.015	0.007
Arsenic	7440-38-2	N/A	0.015	0.008	0.0025
Barium	7440-39-3	N/A	0.025	0.0125	0.0031
Beryllium	7440-41-7	N/A	0.005	0.0025	0.0006
Cadmium	7440-43-9	N/A	0.005	0.0025	0.0006
Calcium	7440-70-2	N/A	5	2.5	0.625
Chromium	7440-47-3	N/A	0.01	0.005	0.0013
Cobalt	7440-48-4	N/A	0.025	0.0125	0.0031
Copper	7440-50-8	N/A	0.01	0.005	0.002
Iron	7439-89-6	N/A	0.1	0.08	0.04
Lead	7439-92-1	N/A	0.01	0.009	0.0047
Magnesium	7439-95-4	N/A	5	2.5	0.625
Manganese	7439-96-5	N/A	0.015	0.0075	0.0019
Nickel	7440-02-0	N/A	0.04	0.02	0.005

Matrix: Groundwater		**Analytical Group: Metals (Pace) per USEPA Method 6010**			
Analyte	**CAS Number**	**Screening Level (mg/L)**	**LOQ (mg/L)**	**LOD (mg/L)**	**DL (mg/L)**
Potassium	9/7/7440	N/A	5	2.5	0.625
Selenium	7782-49-2	N/A	0.02	0.017	0.0085
Silver	7440-22-4	N/A	0.01	0.005	0.0021
Sodium	7440-23-5	N/A	5	2.5	0.625
Thallium	7440-28-0	N/A	0.05	0.025	0.0063
Vanadium	7440-62-2	N/A	0.05	0.025	0.0063
Zinc	7440-66-6	N/A	0.02	0.01	0.0025

Notes:

[1] Metals are not a contaminant of concern for this TCRA and metals data will be used solely for support of PRB design; therefore, no screening levels are considered.

CAS = Chemical Abstracts Service
DL = detection limit
LOD = limit of detection
LOQ = limit of quantitation
mg/L = milligrams per liter
N/A = not applicable
USEPA = U.S. Environmental Protection Agency

Matrix: Groundwater		**Analytical Group: Anions (Pace) per USEPA Method 300.0**			
Analyte	**CAS Number**	**Screening Level (mg/L)**	**LOQ (mg/L)**	**LOD (mg/L)**	**DL (mg/L)**
Bromide	SESI-0020	N/A	0.2	0.1	0.05
Chloride	SESI-0021	N/A	1	0.5	0.25
Fluoride	16984-48-8	N/A	0.1	0.05	0.025
Nitrate-N	SESI-0023	N/A	0.02	0.01	0.005
Nitrite-N	SESI-0019	N/A	0.02	0.01	0.005
Sulfate	SESI-0026	N/A	1	0.5	0.25

Notes:

CAS = Chemical Abstracts Service
DL = detection limit
LOD = limit of detection
LOQ = limit of quantitation
mg/L = milligrams per liter
N/A = not applicable
USEPA = U.S. Environmental Protection Agency

Matrix: Groundwater		**Analytical Group: TOC (Pace) per USEPA Method 9060**			
Analyte	**CAS Number**	**Screening Level (mg/L)**	**LOQ (mg/L)**	**LOD (mg/L)**	**DL (mg/L)**
TOC/DOC	N/A	N/A	1	0.9	0.42

Notes:
CAS = Chemical Abstracts Service
DL = detection limit
DOC = dissolved organic carbon
LOD = limit of detection
LOQ = limit of quantitation
mg/L = milligrams per liter
N/A = not applicable
TOC = total organic carbon
USEPA = U.S. Environmental Protection Agency

Matrix: Groundwater		**Analytical Group: Alkalinity (Pace) per SM2320**			
Analyte	**CAS Number**	**Screening Level (mg/L)**	**LOQ (mg/L)**	**LOD (mg/L)**	**DL (mg/L)**
Alkalinity (as $CaCO_3$)	SESI-0034	N/A	20	20	20

Notes:
CAS = Chemical Abstracts Service
DL = detection limit
LOD = limit of detection
LOQ = limit of quantitation
mg/L = milligrams per liter
N/A = not applicable
USEPA = U.S. Environmental Protection Agency

QAPP WORKSHEET #17: SAMPLING DESIGN AND RATIONALE

UFP-QAPP, PFAS Sampling Activities
(UFP-QAPP Manual Section 3.1.1)
(USEPA 2106-G-05 Section 2.3.1)

The goal of this project is to implement a TCRA to reduce the PFAS concentrations in groundwater to levels at or below residential risk screening levels (as described in **Worksheet #11**) after the point of treatment downgradient from the Active and Former FTAs at Fort Gregg-Adams. The selected TCRA technology is in-situ sorption using CAC to reduce concentrations of PFAS in groundwater downgradient of the FTAs. The TCRA involves direct-push injection of CAC in a PRB configuration. The general investigation design for this TCRA was developed to ensure that the amount, type, and quality of data are sufficient to support scalable and targeted application of CAC that relies on a flux-based CSM as the basis for its design. The DQOs for the sampling are described in **Worksheet #11** of this QAPP Addendum #2. The TCRA will be completed concurrently with an RI under a separate contract, which aims to determine the nature and extent of DoD-related PFAS constituents which are equal to or exceed applicable risk screening levels in groundwater, soil, surface water, and sediment installation-wide.

This worksheet provides the detailed rationale and approach for site-specific sampling and TCRA activities at Fort Gregg-Adams, including the following components:

- PDI
- Baseline Sampling
- TCRA Implementation
- Verification Sampling

The final sample locations and number of samples collected as part of the TCRA will be determined by field conditions; deviations from the procedures described in this QAPP Addendum #2 will be documented in non-conformance reports or Field Change Reports, which will be included in the Fort Gregg-Adams TCRA reporting. The subsections below detail the overall sampling approach rationale and the field methods that will be utilized during the TCRA.

The strategy for sampling and TCRA implementation was designed with the understanding that schedule is a key driver to fulfilling the DoD's commitment to mitigating PFAS migration off-post at the Active and Former FTAs. The TCRA strategy uses a scalable, flux-based approach to fill data gaps critical to the design and expedited completion of the selected TCRA approach. The planned project schedule to complete the TCRA for Fort Gregg-Adams is provided in **Worksheet #14 & 16** of this QAPP Addendum #2. The mobilization schedule will be determined upon the finalization of this QAPP Addendum #2. Necessary permits, forms, or other project documentation, subcontracts, or project equipment will be procured before mobilization. Before conducting intrusive activities, the location of underground utilities will be determined. Utility companies and other responsible authorities will be contacted to locate and mark the locations. Any installation-specific requirements and permits for dig clearance will be obtained prior to beginning intrusive work.

Environmental data will be collected as presented within this QAPP Addendum #2 and in accordance with the field SOPs provided in Attachment D of the PQAPP (SERES-Arcadis 2024a) at the locations defined in **Worksheet #18** and on **Figures 4** and **5** of this QAPP Addendum #2, along with the QC sample requirements listed in **Worksheet #20** of this QAPP Addendum #2. Components of some SOPs may require modification or be superseded by the PFAS-specific technical guidance instructions (TGIs; Attachment D of the PQAPP [SERES-Arcadis 2024a]) to accommodate PFAS-specific sampling requirements. The sampling methods described in the SOPs establish equipment requirements; procedures for equipment decontamination before sampling; sampling procedures under various conditions; equipment blank (EB) samples and field duplicate (FD) collection requirements; and requirements for containerizing and storing samples to ensure that sample contamination does not occur during collection and transport.

All field activities will be conducted in accordance with the Accident Prevention Plan and Site Safety and Health Plan, which will be submitted under separate cover. Field notes and field sampling forms will be recorded digitally using Fulcrum App software and synced to cloud storage at least daily. A post-activity inspection will be conducted by the field team lead/SSHO identified in this QAPP Addendum #2 to ensure the location is left clean. The investigation team will demobilize once field activities are complete.

The areas of focus for this TCRA include one active and two inactive FTAs (**Figure 2**) that were identified during the SI to have presence of PFAS. Information from the SI (Arcadis 2022) and ongoing RI including historical documents and data, groundwater flow characteristics, and geologic descriptions were used to develop the CSM provided in **Worksheet #10** of this QAPP Addendum #2.

17.1 Pre-Design Investigation

A PDI will be performed to collect the data needed to confirm the distribution and flux of PFAS along the southern installation boundary, which will inform the final design and location for the TCRA. The scope elements are listed on **Figure 4**. The objectives for the PDI are: 1) Confirm groundwater flow direction in the vicinity of FTAs and southern post boundary; 2) Confirm lateral and vertical distribution of PFAS along southern post boundary with a focus on the high PFAS concentrations emanating from the upgradient Active and Former FTAs; 3) Combine hydrostratigraphy and PFAS distribution data to generate a mass flux based CSM to optimize the PRB location and design; and 4) Evaluate geochemistry and co-contaminants in groundwater to inform CAC dosing in the PRB.

Refinement of Groundwater Flow System Understanding

Three monitoring wells will be installed southeast of the Active and Former FTAs along the southern installation boundary to better define groundwater flow. Monitoring wells will be installed using hollow stem auger drilling and will be completed with 2-inch polyvinyl chloride well materials. The installation of the monitoring wells will include continuous soil logging to identify well screen locations. The monitoring wells will be surveyed, and groundwater levels will be collected from five existing and the three proposed monitoring wells to confirm groundwater gradient direction. The new monitoring wells will also be sampled and analyzed for PFAS using USEPA Method 1633 to obtain an understanding of PFAS distribution at the installation boundary. Analysis will also include additional parameters to evaluate water quality, geochemical conditions, and other contaminants that may affect performance of the PRB (described below). These analyses include anions via USEPA Method 300, carbonate/bicarbonate alkalinity via Method SM2320, TOC/DOC via USEPA Method 9060a, total and dissolved metals via USEPA Method 6010, TPH via USEPA Method 8015, and VOCs via USEPA Method 8260. The total and dissolved values for the organic carbon and metals will be derived from unfiltered and filtered groundwater samples, respectively. Refer to **Section 17.5** for monitoring well installation and groundwater sampling procedures. Additionally, groundwater will be collected from the three new monitoring wells for laboratory treatability testing to confirm the CAC amendment loading required to address the observed PFAS flux.

Stratigraphic Flux Transect via HPT and Vertical Aquifer Profiling

A flux-based CSM (Curry et al. 2020) will be developed to confirm and optimize the design of the TCRA. HPT soundings will identify zones of higher permeability for subsequent vertical aquifer profiling (VAP) sampling. An SOP for conducting HPT soundings is referenced in **Worksheet #21** and included in **Attachment 4**. The relative permeability and PFAS concentrations will be combined into a flux-based CSM to target the zones of highest PFAS flux using appropriate CAC amendment loading. The HPT/VAP points will be advanced along the southern installation boundary (**Figure 4**). HPT/VAP will target the shallow first water bearing zone down to approximately 20 feet bgs. The selection of intervals for groundwater sampling will be based on the HPT data and will target the higher conductivity zones, or potential high PFAS mass flux zones. Four of the 14 (30%) HPT/VAP locations will investigate deeper zones of higher permeability to evaluate if PFAS impacts are present, up to 40 feet bgs. Four of the HPT/VAP locations will be advanced on either side of the transect to confirm PFAS concentrations extending approximately 200 feet west and east. Groundwater samples will be analyzed for PFAS by USEPA Method 1633.

17.2 Monitoring Well Installation and Baseline Sampling

Following confirmation of the PRB design and location based on the PDI results and prior to PRB implementation, baseline conditions will be established via the installation of the performance monitoring network and groundwater sampling. The performance monitoring network will include the three upgradient monitoring wells installed during the PDI along with seven new monitoring wells located upgradient, within, and downgradient of the CAC PRB (**Figure 5**). The new monitoring wells include one additional upgradient well, two wells within the PRB, and four downgradient wells. Monitoring wells will be installed using hollow stem auger and will be completed with 2-inch polyvinyl chloride well materials. The final screen zones of the monitoring wells will be informed based on PDI results but will be screened within the vertical interval targeted for CAC injection. The preliminary design assumes that monitoring wells will be completed with 10-foot slotted screens to a depth of approximately 15 feet bgs, which is consistent with SI findings (Arcadis 2022). Performance monitoring well locations, total depths, and screened intervals may be modified based on the results of the PDI; any changes will be agreed upon by Army via meeting or a teleconference prior to implementation. Prior to installation of the CAC PRB, a baseline sampling event will be conducted at all 10 monitoring wells and groundwater samples will be analyzed for PFAS using USEPA Method 1633. Information regarding groundwater sampling and monitoring well installation procedures can be found in **Section 17.5**.

17.3 TCRA Implementation

Based on the current understanding of the CSM and Army objective to mitigate ongoing migration of PFAS-impacted groundwater, the selected TCRA consists of an in-situ PRB approach using injection of CAC for in-situ sorption of PFAS. Implementation of the PRB will include bench-scale treatability testing, a potable water injection test, and CAC injection. Details are presented in the PRB Design and Installation Work Plan, included as **Attachment 1**. Refinement to PRB design parameters, if necessary based on the results of the PDI, will be documented in a memorandum.

An AAR will be developed to document the TCRA actions completed and will include the baseline sampling results, installation specifications for the PRB, including figures documenting the barrier injection and monitoring well locations and injection details including injection rates, injection volumes, and CAC delivered. Draft, Draft Final, and Final AARs will be submitted.

17.4 Verification Sampling

As referenced in **Section 17.2**, a baseline sampling event will be conducted prior to implementing the PRB. Verification and confirmation sampling will be conducted once the PRB installation is complete. Performance of the CAC PRB in reducing PFAS concentrations in groundwater at the point of treatment will be confirmed based on results from downgradient performance monitoring wells. Details regarding performance monitoring may be modified based on the findings of the PDI and PRB implementation; however, the preliminary verification sampling plan is presented in this QAPP Addendum #2 for completeness. The final verification sampling plan will be presented in the forthcoming TCRA Work Plan. Refer to **Section 17.5** for monitoring well installation and groundwater sampling procedures.

Performance monitoring events will be completed at 3 months, 6 months, and 9 months following PRB installation. Each performance monitoring event is expected to include sampling at 10 monitoring wells located upgradient, within, and downgradient of the CAC PRB (**Figure 5**). Groundwater samples will be analyzed for PFAS constituents by Method 1633. Results of the first two sampling events will be communicated to the Army with summary tables and figures upon receipt of validated analytical data. Draft, Draft Final, and Final versions of a Verification Sampling Report documenting all performance monitoring results will be submitted for approval following the last performance monitoring event.

17.5 Field Methods

17.5.1 Monitoring Well Installation and Development

Permanent wells will be installed at select locations to inform the CSM and monitor PRB performance. Concurrence from Army will be obtained on the selected location, total depth, and screened interval of the wells prior to installation via meeting or telephone call. Deviations from the proposed monitoring well locations or construction methods will be documented in a Field Change Report, if necessary.

Monitoring wells will be installed using the appropriate drilling methods with a minimum outer casing size in accordance with state regulations. A direct-push technology rig with auger attachment is anticipated to be used for installation of the new wells; if field conditions necessitate, an alternative drilling method will be used for the new well installation. All equipment and materials used during drilling and for well construction will be composed of non-PFAS-containing materials (i.e., including lubricants used for drill rod threads). Drilling water from a verified source may be introduced to the boreholes if difficult drilling conditions are encountered (which may include hard clays that are not part of a confining unit). However, based on drilling activities completed during previous investigations, the need for use of drilling water is not anticipated. No drilling in bedrock is planned for the TCRA.

Monitoring wells will be constructed with 2-inch polyvinyl chloride screens with polyvinyl chloride risers. Screen slot size and filter pack sand size will be determined based on visual observations of grain size distribution during advancement of soil borings for monitoring well installation. Screen length will be nominally 10 feet, to be finalized based on observed lithology and PFAS concentration distribution. Filter packs will be washed quartz sand, extending from 1 foot below to 2 feet above the well screen unless conditions dictate otherwise. Downhole annular space material will be installed using a tremie pipe. Potential for bridging in the filter pack will be mitigated by performing pre-development before installing bentonite and grout. Pre-development will be performed by gently surging the well to settle the filter pack. Additional filter pack material will then be added if needed due to filter pack settlement during pre-development to achieve the specified filter pack thickness. Following pre-development, 2 feet of hydrated bentonite will be placed above the filter pack. Then the well will be pressure-grouted via a tremie pipe with bentonite cement grout beginning no more than 4 feet above the top of the aquifer or 4 feet above the top of the screen for wells with the top of screen positioned above the aquifer. Water used to make bentonite cement grout will be from a verified source (e.g., the buffalo fill stand at Building 7118, as discussed further in **Section 17.6**) with acceptable concentrations of DoD target PFAS less than or equal to one half the applicable tapwater risk screening levels, and the amount of bentonite will not exceed 2 pounds of bentonite per 94-pound sack of cement. No more than 7 gallons of water will be used per 96 pounds of bentonite-cement mixture. Each well will be completed with a minimum 2-foot by 2-foot and 4-inch-thick concrete pad. Well vaults will be locking and either traffic-rated flush-mount or steel stickup with three protective bollards. The monitoring wells will be constructed in accordance with state well construction standards and the PFAS-Specific Drilling and Monitoring Well Installation TGI (Attachment D of the PQAPP [SERES-Arcadis 2024a]).

Following construction, and after sufficient time has passed to allow for proper curing of the well seal/grout (typically 24 to 48 hours depending on the type of cement used), monitoring wells will be developed in accordance with the TGI for Monitoring Well Development (Attachment D of the PQAPP [SERES-Arcadis 2024a]) using a combination of surging and pumping. Any water introduced to the well during development will be from a verified source (i.e., the buffalo fill stand at Building 7118) with acceptable concentrations of DoD target PFAS not equal to or greater than one half the applicable risk screening levels for tapwater. Well screens will undergo two cycles of surging, for approximately 15 to 30 minutes each time, followed by pumping or bailing to remove accumulated sediments. After the wells have been surged twice, the wells will be pumped at a relatively constant rate until indicator parameters (e.g., pH, specific conductance, and temperature) are stable for three consecutive readings spaced 3 to 5 minutes apart, and the extracted water is clear and free of sediment (i.e., with turbidity less than 50 nephelometric turbidity units [NTUs]). Water levels and depth to bottom will be measured before, during, and after well development. Development water will be temporarily containerized, treated by granular activated carbon, and discharged at an approved location by the installation. Following completion, monitoring wells will be professionally surveyed during the adaptive and/or final delineation/monitoring phases (as described in **Section 17.7**).

Based on estimated groundwater velocity in the surficial aquifer, all wells will be sampled after installation and at least 72 hours after well development, consistent with the methods described in the Verification Sampling section above. During sampling, the field team will complete gauging of monitoring wells from the established measuring point (i.e., typically the top of casing) using an electronic water level meter to within 0.01 foot. Groundwater elevations will be summarized in a groundwater elevation summary table, and a potentiometric surface contour map (or maps, as needed based on potential seasonal influences of groundwater flow direction) will be provided in the TCRA AAR. Surveys for newly installed permanent monitoring wells will be completed shortly after installation. New permanent monitoring wells will be sampled according to the schedule presented in the forthcoming TCRA Work Plan. Anticipated sampling frequency is quarterly for the first year after TCRA implementation.

17.5.2 Groundwater Sampling

Throughout the TCRA phases, groundwater samples will be collected from HPT/VAP borings and newly installed monitoring wells to inform the final TCRA design, update the CSM, and confirm PRB effectiveness.

- Monitoring well sampling: Groundwater samples will be collected from existing monitoring wells from approximately the center of the saturated screened interval using low-flow sampling methods (or bailer methods, if necessary, based on length of the water column or condition of the well, and if acceptable to the state, installation, and Headquarters of the Department of the Army). Groundwater samples will be analyzed for PFAS as defined in **Worksheet #15** of this QAPP Addendum #2, and field parameters (temperature, pH, specific conductivity, DO, turbidity, and ORP) will be measured during purging and allowed to stabilize in accordance with the TGI for PFAS Sampling Procedures and Low-Flow Groundwater Purging for Monitoring Wells (Attachment D of the PQAPP [SERES-Arcadis 2024a]).
    - If the presence of a non-aqueous phase liquid (NAPL) is known or suspected within specific wells or investigation areas, an oil-water interface probe is required for gauging water levels during synoptic gauging events and purging during low-flow groundwater sampling in accordance with the TGI for Manual Water-Level and NAPL Monitoring (Attachment D of the PQAPP [SERES-Arcadis 2024a]). It is uncertain if NAPL will be encountered at the proposed sampling locations; however, it is possible given the historical activities and use of fuels at FTAs.
- HPT/VAP groundwater sampling: As referenced in **Section 17.1**, the selection of intervals for groundwater sampling will be based on the HPT data and will target the higher conductivity zones, or potential high PFAS mass flux zones, away from the source area. The HPT data will be used to identify regions of relatively higher permeability that may represent high PFAS mass flux zones. Based on these data, VAP sampling will occur at up to two regions within the shallow first water bearing zone, estimated to extend down to approximately 20 ft bgs. At four of the 14 (30%) locations, the HPT/VAP program will extend to 40 ft bgs to determine if deeper PFAS impacts are present. At these deeper locations, up to three groundwater samples will be collected per location in regions targeting higher permeability. The deeper HPT VAP/locations will be evenly spaced (occurring every 3rd or 4th location) across the transect. A grab groundwater sample will be collected from target intervals using a drive point screen sampler, or via a temporary well assembled with a slotted screen and polyvinyl chloride riser. Coordinates for each temporary borehole sampling location will be recorded using a handheld global positioning system. Boring and sampling will be completed using top-down, dual-tube methods in accordance with the TGI for VAP (a multi-interval sampling approach) for PFAS Analysis (Attachment D of the PQAPP [SERES-Arcadis 2024a]). Temporary boreholes will be left open at the sample collection intervals to enable accumulation of water for up to 1 hour before an interval is declared “dry,” at which point, the boring will be advanced to the next interval to attempt sample collection. The borehole will be abandoned if the deepest interval is declared dry. All equipment and materials used during drilling and/or for temporary well construction will be composed of non-PFAS-containing materials (i.e., including lubricants used for drill rod threads). Samples will be collected in accordance with the PFAS Field Sampling (all media) Guidance (Attachment D of the PQAPP [SERES-Arcadis 2024a]).

Groundwater samples will be collected following the groundwater sampling protocols (TGI – PFAS Field Sampling [all media]; TGI – PFAS Sampling Procedures and Low-Flow Groundwater Purging for Monitoring Wells; TGI –VAP for PFAS Analysis) detailed in Attachment D of the PQAPP (SERES-Arcadis 2024a).

Groundwater sample collection methods may include the use of non-dedicated portable pumps (i.e., decontaminated bladder pumps, submersible pumps, or peristaltic pumps) or disposable bailers. Any non-dedicated equipment will be decontaminated between sampling locations, and disposable materials (e.g., tubing, bladders, or bailers) will not be used across multiple locations. All groundwater samples will be analyzed for PFAS (**Worksheet #15**). Additionally, field parameters (temperature, pH, conductivity, DO, turbidity, and ORP) will be measured during groundwater purging and prior to sampling to ensure a representative sample of the aquifer is collected and, potentially, to inform the CSMs.

17.6 Decontamination Procedures and Source Water

Given the low DLs and screening levels for PFAS (i.e., on the order of parts per trillion for aqueous samples, rather than parts per billion or parts per million [ppm] for typical contaminants), thorough and proper decontamination is critical for obtaining representative sampling results. Any non-dedicated, reusable sampling equipment that may come into direct contact with sampling media must be decontaminated before first use, between sampling locations/intervals, and before demobilization in accordance with TGI – Groundwater and Soil Sampling Equipment Decontamination (Attachment D of the PQAPP [SERES-Arcadis 2024a]). Types of equipment utilized during the RI on which decontamination procedures must be completed may include but are not limited to stainless steel hand augers, shovels, or trowels; drilling equipment such as cutting shoes and bits, drill stem casing and rods, auger sections, split barrel samplers, screen-point samplers, or tremie pipes; water-level meters; portable bladder pumps or submersible pumps; and stainless-steel bailers. EB (or sometimes referred to as equipment rinsate blank) samples will be collected on non-dedicated equipment at a frequency specified in **Worksheet #20** (typically at a rate of one EB per piece of equipment type per event, but more frequent collection will be conducted for longer field events) following decontamination procedures and using PFAS-free laboratory-supplied deionized water. The JV will request documentation from the laboratory that the PFAS-free deionized water has no detections equal to or greater than half the applicable tapwater risk screening levels. EBs will be analyzed via USEPA Method 1633 (latest version) compliant with QSM 5.4 (or later versions) Table B-24.

Frequent changing of protective nitrile gloves is also vital in assuring cross-contamination is not introduced to the samples. If gloves come in contact with equipment that has not been decontaminated or other material that may introduce cross-contamination, gloves should be changed. This includes before contacting environmental media that will be sampled (i.e., before homogenizing soil samples) and before collection of (containerizing) any environmental or EB samples (i.e., if gloves have come in contact with reusable sampling equipment such as the water quality meters, notebooks, or other materials onsite).

Decontamination should be conducted over an appropriately constructed pad, bucket, or protective lining such that all rinsate can be contained, and such that fully decontaminated equipment can be staged on a clean protective liner or otherwise housed until its next use. The procedure is briefly described below:

1. Knock off loose dirt (if applicable, i.e., for soil sampling equipment); disassemble equipment if possible and don a new pair of nitrile gloves.
2. Initial rinse with deionized water or verified source water.
3. Wash with Alconox® or Liquinox® solution, scrubbing with a clean brush. If the scrub brush shows signs of degradation (i.e., shedding bristles or accumulation of mud that cannot be removed) or has

been used to clean equipment used in an area where contamination concentrations are expected to be high, discard the brush and use a new one.

4. Rinse thoroughly again with deionized water or lab-supplied PFAS-free water.
5. If NAPL is present, a rinse with isopropyl alcohol, acetone, or other solvent spray is recommended. Select the appropriate solvent considering if VOCs are also to be analyzed for the environmental media sampled. Otherwise, this step can be skipped.
6. Finally, rinse thoroughly with lab-supplied PFAS-free water. Discard nitrile gloves and don a new pair.

If submersible pumps must be used, the decontamination procedures 1 through 4 and 6 will be completed by using sectioned polyvinyl chloride pipes with end caps to circulate the respective fluids through the pump apparatus; extra rinses with deionized water should be completed to flush out all detergent and the solvent rinse step should be skipped.

For drilling equipment, a steam-cleaner/pressure washer may instead be used to clean the inside and outside of the tooling using a verified source of potable water that does not contain PFAS at concentrations equal to or greater than one half their respective applicable risk screening levels for tapwater (e.g., ≤ 2.0 ng/L PFOS). Laboratory grade (certified PFAS-free) water must be used for the final rinse. The decontamination water source at Fort Gregg-Adams has been sampled (i.e., from the buffalo fill stand at Building 7118 located at Shop Road and 18th Street) in December 2022 and verified that PFAS concentrations are acceptable to use the water for decontamination processes; PFAS concentrations were non-detect for PFOS, PFOA, PFBS, PFNA, and PFHxS and were 2.4 J ng/L for PFBA and 1.9 J ng/L PFHxA. Therefore, it is not necessary to bring other source water on-post for decontamination procedures or for use as drilling water (e.g., if drilling in bedrock or hard clays), use in well construction (bentonite hydration), or use during well development, and it is not necessary to treat the source water before use.

Equipment such as high-density polyethylene tubing, bailers, and bladders, rope or twine, or other porous or disposable equipment that cannot be properly decontaminated should be discarded in accordance with the IDW management plan below. For groundwater sampling where a water quality meter and flow-through cell are used, the flow-through cell should be rinsed and tubing connections to the apparatus should be changed between sampling locations/intervals. However, the full decontamination procedure does not need to be completed for this setup since no samples should be collected through the flow-through cell.

17.7 Surveying

The horizontal location (i.e., northing and easting), ground surface elevation, and top of casing elevation of each newly installed permanent monitoring well will be surveyed by a licensed surveyor to an accuracy of 0.01 foot. New permanent wells will be surveyed using the coordinate system currently used for other monitoring wells at the installation and will be added to the monitoring well database. Mapping- or survey-grade global positioning system or comparable traditional survey methods will be used to collect geospatial data.

Surveys for permanent monitoring wells newly installed during the RI will be completed during the prescriptive, adaptive, and/or final delineation/monitoring phases depending on how many wells are installed during each phase. Other sampling locations (i.e., temporary groundwater and soil boring locations, surface water/sediment sampling locations) will be recorded with a handheld global positioning system capable of achieving sub-meter accuracy.

17.8 Waste Management Plan

The generation of IDW will be minimized to the extent possible. In general, IDW generated from investigation activities (i.e., soil borings/monitoring well installations; sampling of soil/sediment/groundwater and decontamination of associated equipment; well maintenance; or well abandonment) will be disposed in accordance with Army policy (e.g., installation policy and overarching DoD policy) including the installation's current IDW disposal practices and in accordance with state requirements/regulations. Solid IDW will be temporarily containerized pending analysis of soil samples and disposed off-site. Due to the large volume generated during well development, the development water will be temporarily containerized, treated by granular activated carbon, and discharged at an approved location by the installation. Fort Gregg-Adams permits that purge water IDW can be spread to the ground at the point of collection. Disposable equipment and PPE will be bagged and disposed of at on-post trash receptacles.

17.9 Laboratories

Pace South Carolina will be used for this study. PFAS analysis will be conducted using USEPA Method 1633 (or later versions; USEPA 2024) in accordance with the DoD QSM 5.4 (or later versions; DoD and Department of Energy [DOE] 2021), Table B-24 for the analytes listed in **Worksheet #15** of this QAPP Addendum #2. All PFAS data to be collected will be analyzed via Method 1633. A project chemist will validate the data from the laboratory in accordance with Worksheets #34, #35 of the PQAPP (SERES-Arcadis 2024a) and **Worksheet #36** of this QAPP Addendum #2. A Data Usability Summary Report will review precision, accuracy, completeness, representativeness, comparability, and sensitivity of the analytical methods performed as part of the TCRA. The Data Usability Summary Report will be prepared in accordance with USACE EM 200-1-10 (USACE 2021) and Worksheet #37 of the PQAPP (SERES-Arcadis 2024a). This information will be included in the AAR and Verification Sampling Reports.

QAPP WORKSHEET #18: SAMPLING LOCATIONS AND METHODS

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

Sample identifications will follow the same general format as samples collected during the ongoing PFAS RI for consistency across the program:

- Monitoring well parent groundwater samples: FTGA-TCRA-[Well ID]-([Date])
- Parent HPT/VAP groundwater samples: FTGA-TCRA-[VAP Boring ID]-([Depth Interval])
- FD: FTGA-TCRA-GW-FD-[Duplicate No.]
- Blank QC samples: FTGA-TCRA-[EB/FB/FRB/SB]-[QC sample type number]

The group of PFAS constituents identified for analysis for groundwater samples in the sample summary table below is summarized for all media in **Worksheet #15**. **Worksheet #17** describes the general rationale for the various sampling media; the sampling locations are detailed in **Worksheets #17** and **#18**. Details regarding verification sampling may be modified and documented in a forthcoming TCRA Work Plan. Field activities and sampling procedures will be conducted in accordance with the TGI and SOP documents provided in Attachment D of the PQAPP (SERES-Arcadis 2024a) and in accordance with the sampling plan detailed in **Worksheet #17** of this QAPP Addendum #2. The frequency requirements for QA/QC samples for each medium are noted in **Worksheet #20**. The tentative QA/QC samples are laid out below; however, the final number and identifications of QA/QC samples to be collected may vary based on progression of daily field activities (i.e., total number of samples collected) and field conditions. All PFAS samples will be analyzed via USEPA Method 1633.

Work Phase	Location Type	Matrix	Depth Interval (approximate)	Sample ID	Estimated # Samples [1]	Analytes [2]
PDI (**Figure 4**)	Monitoring Well	Groundwater *(new permanent monitoring well installation)*	Mid-Saturated Screen	FTGA-TCRA-MWxx-(MMDDYY) (xx = monitoring well number from 01 to 03)	3 (N)	PFAS (1633), anions, alkalinity, total and dissolved metals, TOC/DOC, TPH, VOCs, field parameters
		Groundwater *(QA/QC)*	Mid-Saturated Screen	FTGA-TCRA-GW-FD-01	1 (FD)	PFAS (1633), anions, alkalinity, total and dissolved metals, TOC/DOC, TPH, VOCs, field parameters
		Groundwater *(QA/QC)*	Mid-Saturated Screen	Same as parent sample ID	2 (MS/MSD)	PFAS (1633), anions, alkalinity, total and dissolved metals, TOC/DOC, TPH, VOCs, field parameters
	HPT/VAP	Groundwater *(HPT/VAP boring grab sample)*	TBD based on HPT data	FTGA-TCRA-VAP01-(s-ss) (s-ss = TBD depth interval of shallow VAP groundwater sample)	14 (N)	PFAS (1633), field parameters
				FTGA-TCRA-VAP01-(m-mm) (m-mm = TBD depth interval of mid-depth VAP groundwater sample)	14 (N)	
				FTGA-TCRA-VAP01-(d-dd) (d-dd = TBD depth interval of deep VAP groundwater sample)	4 (N)	
		Groundwater *(QA/QC)*	TBD based on HPT data	FTGA-TCRA-GW-FD-02	1 (FD)	
		Groundwater *(QA/QC)*	TBD based on HPT data	Same as parent sample ID	2 (MS/MSD)	
Baseline Sampling (**Figure 5**)	Monitoring Well	Groundwater *(new permanent monitoring well installation)*	Mid-Saturated Screen	FTGA-TCRA-MWxx-(MMDDYY) (xx = monitoring well number from 01 to 10)	10 (N)	PFAS (1633), field parameters
		Groundwater *(QA/QC)*	Mid-Saturated Screen	FTGA-TCRA-GW-FD-01	1 (FD)	
		Groundwater *(QA/QC)*	Mid-Saturated Screen	Same as parent sample ID	2 (MS/MSD)	

Work Phase	Location Type	Matrix	Depth Interval (approximate)	Sample ID	Estimated # Samples [1]	Analytes [2]
Verification Sampling (**Figure 5**)	Monitoring Well	Groundwater *(new permanent monitoring well installation)*	Mid-Saturated Screen	FTGA-TCRA-MWxx-(MMDDYY) (xx = monitoring well number from 01 to 10)	30 (N)	PFAS (1633), field parameters
		Groundwater *(QA/QC)*	Mid-Saturated Screen	FTGA-TCRA-GW-FD-01	3 (FD)	
		Groundwater *(QA/QC)*	Mid-Saturated Screen	Same as parent sample ID	2 (MS/MSD)	
All	EB	QA/QC	N/A	FTGA-TCRA-EB-nn (nn = EB sample number per event)	1 EB per piece of non-dedicated equipment per sample event	PFAS (1633)
	FB			FTGA-TCRA-FB-nn (nn = FB sample number per event)	1 FB per cooler of samples	PFAS (1633)
	SB[3]			FTGA-TCRA-SB-nn (nn = SB sample number per event)	1 SB per source of water used for decontamination	PFAS (1633)

Notes:
1 – Sampling locations and sampling interval depths subject to change based on conditions encountered in field in consultation with stakeholders.
2 – See **Worksheet #15** for individual compounds within the PFAS group. Field parameters include temperature, pH, conductivity, DO, ORP, and turbidity. Field parameters will be collected by field staff upon sample collection, not analyzed in a laboratory.
3 – A source blank (SB) was collected from a buffalo fill stand at Building 7118 (on the corner of 18th Street and Quartermaster Road) during the December 2022 Expanded SI sampling event to evaluate PFAS concentrations in the water prior to its use during decontamination procedures and for drilling activities. The results indicated that the concentrations of the DoD target PFAS were either non-detect or had detectable concentrations less than half the applicable tapwater risk screening levels. Therefore, the water is acceptable for use as decontamination water for the initial rinse and pressure-washing of drill rods, bits, and core barrels. Additional SBs will not be collected unless an alternate source of water is used, which is not anticipated during the TCRA.

DOC = dissolved organic carbon
EB = equipment blank
FB = field blank
FD = field duplicate
HPT = Hydraulic Profiling Tool
MS = matrix spike
MSD = matrix spike duplicate
N = normal (parent)
N/A = not applicable
PDI = pre-design investigation
PFAS = per- and polyfluorinated alkyl substance
QA = quality assurance
QC = quality control
SB = source blank
TBD = to be determined
TOC = total organic carbon
TPH = total petroleum hydrocarbons
VAP = vertical aquifer profiling
VOC = volatile organic compound

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)

Laboratory:
Pace South Carolina (Pace)
106 Vantage Point Drive
West Columbia, SC 29172
Contact: Kathy Smith
Phone: 912.465.7901
Email: Kathy.smith@pacelabs.com
DoD ELAP Expiration Date: November 18, 2025
List any required accreditations/certifications: DoD ELAP and state associated with the site location (NELAP).
Sample Delivery Method: Federal Express Overnight

Analytical Group	Matrix	Method/SOP	Accreditation Expiration Date	Container	Preservation Requirements	Preparation Holding Time	Analytical Holding Time
PFAS	Water	USEPA Method 1633 compliant with DoD QSM 5.4 Table B-24/ ENV-SOP-WCOL-0158	ELAP-11/18/2025	2 - 500mL and 1 – 125 mL wide mouth HDPE with linerless PP cap (3x for designated MS/MSD sample)	Cool, 0 to 6 °C	28 days from collection; 90 days from collection, when stored at ≤ -20ºC and protected from the light	28 days from preparation
VOCs	Water	USEPA Method SW8260D ENV-SOP-WCOL-0107 (ME0012X)	ELAP-11/18/2025	3 – 40 mL VOA vial	Hydrochloric acid (pH<2) Cool, 0 to 6 °C	14 days from collection (7 days from collection if pH>2)	14 days from preparation

Analytical Group	Matrix	Method/SOP	Accreditation Expiration Date	Container	Preservation Requirements	Preparation Holding Time	Analytical Holding Time
TPH-DRO	Water	USEPA Method 8015 ENV-SOP-WCOL-0088 (ME00138)	ELAP-11/18/2025	2 – 250 mL amber glass	Hydrochloric acid (pH<2) Cool, 0 to 6 °C	7 days from collection	40 days from preparation
TPH-GRO	Water	USEPA Method 8015 ENV-SOP-WCOL-0105 (ME00137)	ELAP-11/18/2025	2 – 40 mL VOA vial	Hydrochloric acid (pH<2) Cool, 0 to 6 °C	14 days from collection	14 days from preparation
Total Metals	Water	USEPA Method 6010 ENV-SOP-WCOL-0032 (ME001FJ)	ELAP-11/18/2025	1 – 250-500 mL glass or HDPE	Nitric Acid	6 months from collection	6 months from collection
Dissolved Metals[1]	Water	USEPA Method 6010 ENV-SOP-WCOL-0032 (ME001FJ)	ELAP-11/18/2025	1 – 250-500 mL glass or HDPE	Nitric Acid	6 months from collection	6 months from collection
Anions	Water	USEPA Method 300.0 ENV-SOP-WCOL-0132 (ME001J3)	ELAP-11/18/2025	1 – 250 mL HDPE	Cool, 0 to 6 °C	Nitrate, Nitrite: 48 hours from collection; Bromide, Chloride, Fluoride, Sulfate: 28 days from collection.	Nitrate, Nitrite: 48 hours from collection; Bromide, Chloride, Fluoride, Sulfate: 28 days from collection.
TOC	Water	TOC ENV-SOP-WCOL-0148 (ME0016Q)	ELAP-11/18/2025	250 mL HDPE	Sulfuric Acid Cool, 0 to 6 °C	28 days from sample collection	28 days from sample collection
DOC[1]	Water	TOC ENV-SOP-WCOL-0148 (ME0016Q)	ELAP-11/18/2025	1 – 250 mL HDPE	Sulfuric Acid Cool, 0 to 6 °C	28 days from sample collection	28 days from sample collection
Alkalinity	Water	Method SM2320	ELAP-11/18/2025	1 – 250 mL HDPE	Cool, 0 to 6 °C	14 days from sample collection	14 days from sample collection

Notes:

[1] DOC and dissolved metals are analyzed using a filtered sample.

ºC = degrees Celsius
DOC = dissolved organic carbon
DoD = Department of Defense
DRO = diesel range organics
ELAP = Environmental Laboratory Accreditation Program
GRO = gasoline range organics
HDPE = high density polyethylene
mL = milliliter
MS = matrix spike
MSD = matrix spike duplicate
PFAS = per- and polyfluorinated alkyl substance
PP = polypropylene
QSM = Quality Systems Manual
SOP = standard operating procedure
TOC = total organic carbon
TPH = total petroleum hydrocarbons
USEPA = U.S. Environmental Protection Agency
VOC = volatile organic compound

QAPP WORKSHEET #20: FIELD QC SUMMARY

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

The collection frequency requirements for the FD, MS/MSD, field blank (FB; or field reagent blank), and EB QC samples are listed below, as frequency per number of normal samples. The final number of QC samples collected during each mobilization will depend on field progress. FBs (or field reagent blanks) and EBs will be analyzed for PFAS only. Soil and sediment FD and MS/MSD samples will be analyzed for PFAS and TOC only (i.e., not for pH and/or grain size). FBs will be collected at a frequency of 1 per 20 normal samples, not media specific. EBs will be collected at a frequency of 1 per relevant piece of equipment per week, and collection will be rotated by field samplers if multiple personnel are conducting the decontamination of equipment.

Work Phase	Matrix	Analyte/ Analytical Group	Field Samples	FDs	MS	MSD	FBs	EBs	Total # Analyses
PDI	Groundwater	PFAS (1633)	35	4 (1 per 10)	2 (1 per 20)	2 (1 per 20)	2 (1 per 20)	1 per piece of non-dedicated equipment per week	45
		VOCs	3	1	1	1	1	1 per piece of non-dedicated equipment per week	7
		TPH	3	1	1	1	--	--	6
		Total Metals	3	1	1	1	--	--	6
		Dissolved Metals	3	1	1	1	--	--	6
		TOC	3	1	1	1	--	--	6
		DOC	3	1	1	1	--	--	6
		Anions	3	1	1	1	--	--	6
		Alkalinity	3	1	1	1	--	--	6

Work Phase	**Matrix**	**Analyte/ Analytical Group**	**Field Samples**	**FDs**	**MS**	**MSD**	**FBs**	**EBs**	**Total # Analyses**
Baseline Sampling	Groundwater	PFAS (1633)	10	1	1	1	1	1 per piece of non-dedicated equipment per week	14
Verification Sampling[1]	Groundwater	PFAS (1633)	30	3	3	3	3	1 per piece of non-dedicated equipment per week	42

Notes:

[1] Sample counts presented for verification sampling include three post-PRB implementation monitoring events. Each individual verification sampling event will consist of 10 primary field samples.

DOC = dissolved organic carbon
EB = equipment blank
FB = field blank
FD = field duplicate
MS = matrix spike
MSD = matrix spike duplicate
PDI = pre-design investigation
PFAS = per- and polyfluoroalkyl substances
TPH = total petroleum hydrocarbons
VOC = volatile organic compound

An SB was collected from a buffalo fill stand at Building 7118 (on the corner of 18th Street and Quartermaster Road) during the December 2022 Expanded SI sampling event to evaluate PFAS concentrations in the water prior to its use during decontamination procedures and for drilling activities. The results indicated that the concentrations of the DoD target PFAS were either non-detect or had detectable concentrations less than half the applicable tapwater risk screening levels. Therefore, in accordance with the PQAPP (SERES-Arcadis 2024a), the water is acceptable for use as decontamination water for the initial rinse and pressure-washing of drill rods, bits, and core barrels.

QAPP WORKSHEET #21: FIELD SOPS

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

The field SOPs/TGIs listed below may not apply to all AOIs; however, this comprehensive list is provided to cover the various activities that may occur across the installation during the various RI phases. SOPs/TGIs are included in Attachment D of the PQAPP (SERES-Arcadis 2024a).

Procedure # or Reference[1]	Title, Revision, Date, and URL (if available)	Originating Organization	Procedure Option or Equipment Type (if procedure provides different options)[2]	Modified for Project? Y/N
P-01	Quality Procedure (QP) 3.06 – Field Activities Documentation, Rev. 1, 30 November 2021	SERES-Arcadis JV	Applies to field personnel.	N
P-02	SOP – Sample Chain of Custody, Rev. 3, 28 March 2022	SERES-Arcadis JV	Applies to field personnel with 40-hour HAZWOPER and Department of Transportation HazMat #1 training.	N
P-03	Health and Safety Standard - Utility Location and Clearance, Rev. 16, 17 March 2017	SERES-Arcadis JV	Applies to all subsurface intrusive work.	N
P-04	QP 3.07 – Calibration and Control of measuring and test equipment, Rev. 1, 20 October 2021	SERES-Arcadis JV	Applies to field personnel using equipment that is capable of calibration.	N
P-05	QP 3.08 - Field Sampling, Measurement, and Observation, Rev. 2, 02 December 2022	SERES-Arcadis JV	Applies to field personnel completing field sampling, measurement, and observations.	N
P-06	TGI – Soil Description, Rev. 4, 14 June 2022	SERES-Arcadis JV	Applies to field personnel conducting soil logging.	N
P-07	TGI- Monitoring Well Development, Rev. 1, 12 April 2022	SERES-Arcadis JV	Applies to field personnel developing monitoring wells. See TGI for specific equipment needs.	N
P-08	TGI- Monitoring Well Integrity Survey, Rev. 0, 19 April 2017	SERES-Arcadis JV	See TGI for specific equipment needs.	N

Procedure # or Reference[1]	Title, Revision, Date, and URL (if available)	Originating Organization	Procedure Option or Equipment Type (if procedure provides different options)[2]	Modified for Project? Y/N
P-09	TGI – Groundwater and Soil Sampling Equipment Decontamination, Rev. 3, 30 August 2023	SERES-Arcadis JV	Applies to soil sampling tools; groundwater, sediment, and surface water sampling devices; water testing instruments; downhole instruments; and other activity-specific sampling equipment. The modified procedures are described in **Worksheet #17**.	Y
P-10	TGI - PFAS Field Sampling Guide, Rev. 12, 20 September 2023	SERES-Arcadis JV	Applies to field personnel collecting environmental samples for PFAS analysis. See TGI for specific equipment needs.	N
P-11	TGI – Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells, Rev. 2, 05 April 2022	SERES-Arcadis JV	Applies to field personnel completing low-flow sampling. See TGI for specific equipment needs.	N
P-12	PFAS-Specific Drilling and Monitoring Well Installation TGI, Rev. 4, 06 August 2020	SERES-Arcadis JV	Applies to field personnel installing monitoring wells for PFAS analysis. See TGI for specific equipment needs.	N
P-13	TGI – Equipment and Reagent Blank Sample Collection for PFAS Analysis, Rev. 4, 04 December 2023	SERES-Arcadis JV	Applies to field personnel completing field sampling. See TGI for specific equipment needs.	N
P-14	TGI – Vertical Aquifer Profiling, Rev. 2, 15 June 2022	SERES-Arcadis JV	Applies to field personnel using VAP to collect soil and groundwater samples. See TGI for specific equipment needs.	N
P-16	TGI – Investigation-Derived Waste Handling and Storage, Rev. 1, 15 May 2020	SERES-Arcadis JV	See TGI for specific equipment needs.	N
P-18	TGI – Manual Water-Level and NAPL Monitoring, Rev. 2, 05 April 2023	SERES-Arcadis JV	Applies to field personnel collecting groundwater samples at monitoring wells where the presence of NAPL is known or suspected within specific wells or investigation areas.	N

Procedure # or Reference[1]	**Title, Revision, Date, and URL (if available)**	**Originating Organization**	**Procedure Option or Equipment Type (if procedure provides different options)[2]**	**Modified for Project? Y/N**
P-19	TGI – Standard Groundwater Sampling for Monitoring Wells, Rev. 1, 12 April 2022	SERES-Arcadis JV	Applies to field personnel completing standard groundwater sampling. See TGI for specific equipment needs.	N
P-20	TGI – Bailer-Grab Groundwater Sampling, Rev. 1, 11 April 2022	SERES-Arcadis JV	Applies to field personnel completing bailer grab groundwater sampling. See TGI for specific equipment needs.	N
P-22	TGI – General Slug Testing, Rev. 5, 28 April 2022	SERES-Arcadis JV	Applies to field personnel completing slug testing. See TGI for specific equipment needs.	N
P-23	TGI – Geoprobe® Hydraulic Profiling Tool (HPT)	SERES-Arcadis JV	Applies to field personnel using HPT for obtaining relative soil permeability data. See TGI for specific equipment needs.	N

Notes:

[1] Copies of the field SOPs are included in Attachment D of the PQAPP (SERES-Arcadis 2024a), except P-23 which is included as **Attachment 4** of this QAPP Addendum #2. Some SOPs may be applicable for only certain field events.

[2] For all TGIs pertaining to the collection of samples for PFAS analysis, there is concern that sampling for PFAS using sampling equipment manufactured from fluoropolymers could result in sample cross-contamination. The materials of construction of all downhole and surface sampling and monitoring equipment — including pumps, packers, transducers, tubing, liners, valves, and wiring — should be free from polytetrafluorethylene or ethylene tetrafluoroethylene to the maximum extent practicable. In addition, well drilling procedures and completion materials should avoid the use of fluorocarbon-based lubricants, O-rings and pipe thread pastes, tapes, and sealants. If possible, a confirmation letter with analytical testing results should be obtained from a manufacturer or service provider certifying that the equipment (or supplies) is free of any PFAS.

QAPP WORKSHEET #22: FIELD EQUIPMENT CALIBRATION, MAINTENANCE, TESTING, AND INSPECTION

(UFP-QAPP Section 3.1.2.4)
(USEPA 2016-G-05 Section 2.3.6)

The equipment listed below may not apply to all AOIs; however, the list below is provided to account for the various activities and site conditions that may necessitate the need for such equipment.

Instrument or Equipment	Description	Field Calibration Procedure	Performance Criteria	Responsible Personnel
Water Quality Meter – YSI 6-Series Multi-Parameter Instrument or Equivalent	Multi-parameter tool designed for field use with battery operation. **Ranges:** 0 – 14 pH; -999 to +999 millivolt ORP -5 to 50 °C temperature 0 to 50 micrograms per liter DO 0 to 100 milliSiemens per centimeter conductivity 0 to 1,000 NTU turbidity	The unit is factory calibrated. Unit responsiveness will be checked before use each day with appropriate standards provided by the supplier.	± 10% of included standard solutions with meter	Sample Collection Personnel
		Unit responsiveness is checked against the solution standards provided by each manufacturer.		
Turbidimeter – Hach 2100P or Equivalent	Designed for field use with battery operation. Range: 0 to 1,000 NTU	Each day before use, the turbidimeter is calibrated against the standard solutions provided by each manufacturer.	±10% of included standard solutions with turbidimeter	Sample Collection Personnel

Instrument or Equipment	Description	Field Calibration Procedure	Performance Criteria	Responsible Personnel
4-Gas Meter – MultiRAE or Equivalent	Designed for field use with battery operation. **Ranges:** 0 to 100% lower explosive limit 0 to 100 ppm hydrogen sulfide 0 to 30% (by volume) oxygen 0 to 2,000 ppm carbon monoxide 0.1 to 5,000 ppm VOCs	Each day before use, the 4-Gas Meter is calibrated against clean (ambient) air and supplier-provided standard (mixed gas cannister).	± 10% of included standard gas value	Sample Collection Personnel
Water Level Indicator	Instrument designed for field use to detect water levels (i.e., groundwater level within monitoring wells or boreholes).	The unit is factory calibrated. Unit responsiveness will be checked before use each day with appropriate standards provided an aqueous solution and decontaminated between each use location.	Water indicator sensor alerts when in contact with water	Sample Collection Personnel

Notes:
% = percent
ºC = degrees Celsius
DO = dissolved oxygen
NTU = nephelometric turbidity unit
ORP = oxidation-reduction potential
ppm = parts per million
VOC = volatile organic compound

QAPP WORKSHEET #23: ANALYTICAL SOPS

(UFP-QAPP Section 3.2.1)
(USEPA 2016-G-05 Section 2.3.4)

SOP Reference Number[1]	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix/Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
ENV-SOP-WCOL-0158	PFAS by Method 1633, Rev 04, Date: 4/19/24	Definitive	Groundwater/PFAS	LC/MS/MS	Pace	N
ENV-SOP-WCOL-0107 (ME0012X)	VOCs by Method 8260	Definitive	Groundwater/VOCs	GC/MS	Pace	N
ENV-SOP-WCOL-0088 (ME00138)	GC/FID Diesel Range Organics (DRO) Analysis by 8015C and Prepared by USEPA 3520C, 3546, 3550C and 3580A	Definitive	Groundwater/TPH-DRO	GC/FID	Pace	N
ENV-SOP-WCOL-0105 (ME00137)	Gasoline Range Organics (GRO) by GC/FID Analysis Method 8015C / USEPA 5030B and 3585	Definitive	Groundwater/TPH-GRO	GC	Pace	N
ENV-SOP-WCOL-0032 (ME001FJ)	Inductively Coupled Plasma - Atomic Emission Spectroscopy Method 6010D	Definitive	Groundwater/Total and Dissolved Metals	ICP/AES	Pace	N
ENV-SOP-WCOL-0132 (ME001J3)	Inorganic Anions by Ion Chromatography – Method 300.0	Definitive	Groundwater / Anions	IC	Pace	N
ENV-SOP-WCOL-0148 (ME0016Q)	Total Organic Carbon by Method 9060	Definitive	Groundwater / TOC and DOC	TOC Analyzer	Pace	N

SOP Reference Number[1]	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix/Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
ENV-SOP-WCOL-0114 (ME0013Z)	Alkalinity by Titration, Carbon Dioxide and Alkalinity by Calculation SM2320B	Definitive	Groundwater / Alkalinity	Autotitrator	Pace	N

Notes:

Copies of the Analytical Laboratory QA Plans and SOPs are included in Attachment E of the PQAPP (SERES-Arcadis JV 2024a).

AES = atomic emission spectroscopy
DOC = dissolved organic carbon
DRO = diesel range organics
FID = flame ionization detector
GC = gas chromatography
GC/FID = gas chromatography/flame ionization detector
GC/MS = gas chromatography/mass spectrometry
GRO = gasoline range organics
IC = ion chromatography
ICP = inductively coupled plasma
LC/MS/MS = liquid chromatography/tandem mass spectrometry
Pace = Pace Analytical
PFAS = per- and polyfluorinated alkyl substance
TOC = total organic carbon
TPH = total petroleum hydrocarbons
VOC = volatile organic compound

QAPP WORKSHEET #24: ANALYTICAL INSTRUMENT CALIBRATION

(UFP-QAPP Section 3.2.2)
(USEPA 2016-G-05 Section 2.3.6)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
LC/MS/MS for PFAS in soil, sediment, groundwater, and surface water	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/zs by the instrument. Mass calibration must be performed using the calibration compounds and procedures prescribed by the manufacturer. Mass calibration range must bracket the ion masses of interest. The most recent mass calibration must be used for every acquisition in an analytical run. Peak drift from the expected masses must not exceed 0.2 atomic mass units.	Retune instrument and peak check tune. Maintenance may be required.	Analyst, Department Manager	WI48593 WI46412 ENV-SOP-WCOL-0158
	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		
	Mass Spectral Acquisition Rate	Each analyte, EIS analyte.	A minimum of 10 spectra scans are acquired across each chromatographic peak.	N/A		
LC/MS/MS for PFAS	Ion Transitions (Parent→Product)	Prior to initial calibration.	In order to avoid biasing results high due to known interferences	N/A	Analyst, Department	WI48593 WI46412

Instrument	**Calibration Procedure**	**Frequency of Calibration**	**Acceptance Criteria**	**Corrective Action**	**Person Responsible for Corrective Action**	**SOP Reference**^{1}
(continued)		See more details in DoD QSM 5.4 or later version, Table B-24.	for some transitions, the transitions listed in Table 2 of USEPA Method 1633 must be used for the quantification.		Manager	ENV-SOP-WCOL-0158
	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”.		
LC/MS/MS for PFAS (continued)	ICAL Standards containing both branched and linear isomers must be used	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	Verify standard solutions still valid, perform instrument maintenance as needed, then repeat	Analyst, Department Manager	WI48593 WI46412 ENV-SOP-WCOL-

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
	when commercially available. Isotope Dilution or IS Calibration is required. Minimum five-point ICAL for linear, or six-point calibration for quadratic.		for linear and non-linear regressions. Signal to Noise Ratio: ≥ 3:1 for all ions used for quantification. Linearity Option 1 Average RF: RSD of the RFs for each analyte ≤ 20%. Option 2: Calculate 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.	the ICAL.		0158
	RT 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 istopically labeled compound.	Correct problem and reanalyze samples.		
LC/MS/MS for PFAS (continued)	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.	Analyst, Department Manager	WI48593 WI46412 ENV-SOP-WCOL-0158

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference^1
	NIS	Every field sample, standard, blank, and QC sample.	EIS and NIS are used to establish the ICAL 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		
	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.		
	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.		
LC/MS/MS for PFAS (continued)	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.	Analyst, Department Manager	WI48593 WI46412 ENV-SOP-WCOL-0158

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
LC/MS/MS for PFAS (continued)	Instrument Blanks	Immediately following highest standard analyzed and daily prior to sample analysis.	Concentration of each analyte must be ≤ 1/2 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.	Analyst, Department Manager	WI48593 WI46412 ENV-SOP-WCOL-0158
	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.		
GC/MS	Tune Check	Prior to ICAL and prior to each 12-hour period of sample analysis.	Specific ion abundance criteria of BFB from SOP ENV-SOP-WCOL-0107 (ME0012X).	Retune instrument and verify.	Analyst/ Supervisor	ENV-SOP-WCOL-0107 (ME0012X)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
GC/MS	ICAL (ICAL) for all analytes (including surrogates)	Initially and as needed after ICV and/or CCV failure.	Each analyte must meet one of the three options below: Option 1: RSD for each analyte ≤ 15%. Option 2: linear least squares regression for each analyte: $r^2 \geq 0.99$. Option 3: non-linear least squares regression (quadratic) for each analyte: $r^2 \geq 0.99$.	Correct problem then repeat ICAL.	Analyst/ Supervisor	ENV-SOP-WCOL-0107 (ME0012X)
GC/MS	ICV	Once after each ICAL, analysis of a second source standard prior to sample analysis.	All reported analytes within ± 20% of true value.	Correct problem. Rerun ICV. If that fails, repeat ICAL.	Analyst/ Supervisor	ENV-SOP-WCOL-0107 (ME0012X)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
GC/MS	CCV Note - If the specific version of a method requires additional evaluation (e.g., average RFs), these additional requirements must also be met.	Daily before sample analysis; after every 12 hours of analysis time; and at the end of the analytical batch run.	Beginning: All reported analytes and surrogates within ± 20% of true value. Ending: All reported analytes and surrogates within ± 50% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails or if two consecutive CCVs cannot be run, perform corrective action(s) and repeat CCV and all associated samples since last successful CCV. Alternately, recalibrate if necessary; then reanalyze all associated samples since the last acceptable CCV.	Analyst/ Supervisor	ENV-SOP-WCOL-0107 (ME0012X)
GC/MS	RT Window position establishment	Once per ICAL and at the beginning of the analytical sequence.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	N/A	Analyst/ Supervisor	ENV-SOP-WCOL-0107 (ME0012X)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
GC/FID	ICAL for all analytes (including surrogates) Minimum 5 levels for linear and 6 levels for quadratic. Results may not be quantitated using a single point. No samples shall be analyzed until ICAL has passed.	At instrument set-up and after ICV or CCV failure, prior to sample analysis.	ICAL must meet one of the three options below: Option 1: RSD for each analyte ≤ 20%. Option 2: linear least squares regression for each analyte: r2 ≥ 0.99. Option 3: non-linear least squares regression (quadratic) for each analyte: r2 ≥ 0.99.	Correct problem then repeat ICAL.	Analyst/ Supervisor	ENV-SOP-WCOL-0088 (ME00138)
GC/FID	ICV No samples shall be analyzed until calibration has been verified with a second source.	Once after each ICAL, analysis of a second source standard prior to sample analysis.	All reported analytes within established RT windows. All reported analytes within ± 20% of true value.	Correct problem, rerun ICV. If that fails, repeat ICAL.	Analyst/ Supervisor	ENV-SOP-WCOL-0088 (ME00138)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
GC/FID	CCV Results may not be reported without a valid CCV. Flagging is only appropriate in cases where the samples cannot be reanalyzed.	Before sample analysis, after every 10 field samples, and at the end of the analysis sequence with the exception of CCVs	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ± 20% of true value.	Recalibrate, and reanalyze all affected samples since the last acceptable CCV. or Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst/ Supervisor	ENV-SOP-WCOL-0088 (ME00138)
GC/FID	RT window width Calculated for each analyte and surrogate.	At method set-up and after major maintenance (e.g., column change).	RT width is ± 3 times standard deviation for each analyte RT from the 72-hour study.	N/A	Analyst/ Supervisor	ENV-SOP-WCOL-0088 (ME00138)
GC/FID	RT window position establishment - Calculated for each analyte and surrogate.	Once per ICAL and at the beginning of the analytical sequence.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	N/A	Analyst/ Supervisor	ENV-SOP-WCOL-0088 (ME00138)
GC	ICAL	Initially and as needed after ICV and CCV failure.	<20% RSD; R2 > 0.99	As needed and re-analyze.	Analyst/ Supervisor	ENV-SOP-WCOL-0105 (ME00137)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
GC	RT window position establishment	Once per ICAL and at the beginning of the analytical sequence.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	N/A	Analyst/ Supervisor	ENV-SOP-WCOL-0105 (ME00137)
GC	RT window width	At method set-up and after major maintenance (e.g., column change).	RT width is ± 3 times standard deviation for each analyte RT from the 72- hour study or 0.03 minutes, whichever is greater.	N/A	Analyst/ Supervisor	ENV-SOP-WCOL-0105 (ME00137)
GC	ICV	Once after each ICAL, second source standard prior to sample analysis.	All reported analytes within RT windows. +/- 20% of true value.	Correct problem, rerun. If rerun fails, rerun ICAL.	Analyst/ Supervisor	ENV-SOP-WCOL-0105 (ME00137)
GC	CCV	Before sample analysis, after every 10 field samples, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ± 20% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported Without reanalysis. If either fails, or if two consecutive CCVs cannot be run, perform corrective action(s) and repeat CCV and all associated samples since last successful CCV. Alternately, recalibrate if necessary; then reanalyze all associated samples since the last acceptable CCV.	Analyst/ Supervisor	ENV-SOP-WCOL-0105 (ME00137)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
ICP/AES	ICAL for all analytes Minimum of a blank and one standard	Daily calibration prior to sample analysis.	If more than one calibration standard is used, $R^2 \geq 0.99$.	Terminate analysis; Correct the problem; Recalibrate.	Analyst/ Supervisor	ENV-SOP-WCOL-0032 (ME001FJ)
ICP/AES	ICV	Once after each ICAL, analysis of a second source standard prior to sample analysis.	All reported analytes within ± 10% of true value.	Correct problem. Rerun ICV. If that fails, repeat ICAL.	Analyst/ Supervisor	ENV-SOP-WCOL-0032 (ME001FJ)
ICP/AES	LLCCV	Daily. LLCCV should be less than or equal to the LOQ.	All reported analytes within ± 20% of true value. No samples shall be analyzed without a valid LLCCV.	Correct problem and repeat ICAL.	Analyst/ Supervisor	ENV-SOP-WCOL-0032 (ME001FJ)
ICP/AES	CCV	After every 10 field samples and at the end of the analysis sequence.	All reported analytes within ± 10% of the true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails or if two consecutive CCVs cannot be run, perform corrective action(s) and repeat CCV and all associated samples since last successful CCV. Alternately, recalibrate if necessary; then reanalyze all associated samples since the last acceptable CCV.	Analyst/ Supervisor	ENV-SOP-WCOL-0032 (ME001FJ)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
ICP/AES	ICB/CCB	Immediately after the ICV and immediately after every CCV. (Results may not be reported without valid calibration blanks)	The absolute values of all analytes must be < 1/2 LOQ or < 1/10th the amount measured in any sample. Non-detects associated with positive blank infractions may be reported. Sample results >10X the LOQ associated with negative blanks may be reported.	ICB: Correct problem and repeat ICV/ICB analysis. If that fails, rerun ICAL. All samples following the last acceptable Calibration Blank must be reanalyzed. CCBs may not be re-analyzed without re-analysis of the associated samples and CCV(s). For CCB, failures due to carryover may not require an ICAL.	Analyst/ Supervisor	ENV-SOP-WCOL-0032 (ME001FJ)
ICP/AES	ICS (also called Spectral Interference Checks)	After ICAL and prior to sample analysis. All analytes must be within the LDR. ICS-AB is not needed if instrument can read negative responses.	ICSA: Absolute value of concentration for all non-spiked project analytes <1/2 LOQ (unless they are a verified trace impurity from one of the spiked analytes); ICS-AB: Within ± 20% of true value.	Terminate analysis; locate and correct problem; reanalyze ICSA (and ICS-AB if applicable), reanalyze all samples. If corrective action fails, apply Q-flag to all results for specific analyte(s) in all samples associated with the failed ICS.	Analyst/ Supervisor	ENV-SOP-WCOL-0032 (ME001FJ)
IC	ICAL for all analytes	ICAL prior to sample analysis.	$R^2 \geq 0.99$.	Correct problem, then repeat ICAL.	Analyst/ Supervisor	ENV-SOP-WCOL-0132 (ME001J3)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
IC	RT window position establishment	Once per multipoint calibration.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	N/A	Analyst/ Supervisor	ENV-SOP-WCOL-0132 (ME001J3)
IC	RT window width	At method set-up and after major maintenance (e.g., column change).	RT width is ± 3 times standard deviation for each analyte RT over a 24-hour period.	N/A	Analyst/ Supervisor	ENV-SOP-WCOL-0132 (ME001J3)
IC	ICV	Once after each ICAL, analysis of a second source standard prior to sample analysis.	All reported analytes within established RT windows. All reported analytes within ± 10% of true value.	Correct problem. Rerun ICV. If that fails, repeat ICAL.	Analyst/ Supervisor	ENV-SOP-WCOL-0132 (ME001J3)
IC	CCV	Before sample analysis; after every 10 field samples; and at the end of the analysis sequence.	All reported analytes within established RT windows. All reported analytes within ± 10% of true value.	Two consecutive CCVs must be analyzed and show results within ± 10% before continuing. Otherwise, a new calibration curve is required.	Analyst/ Supervisor	ENV-SOP-WCOL-0132 (ME001J3)
TOC Analyzer	ICAL	ICAL is verified with a CCV and CCB and only re-run if these fail.	R^2=0.995	As needed; Linearity must be reestablished.	Analyst/ Supervisor	ENV-SOP-WCOL-0148 (ME0016Q)
TOC Analyzer	ICV	After ICAL.	± 10% of true value	Reanalyze once; if the second ICV passes, the run may continue. If the second ICV fails, recalibrate.	Analyst/ Supervisor	ENV-SOP-WCOL-0148 (ME0016Q)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
TOC Analyzer	ICB	Immediately following the ICV. CCBs after every CCV.	<1/2 PQL	Reanalyze samples associated with the ICB.	Analyst/ Supervisor	ENV-SOP-WCOL-0148 (ME0016Q)
TOC Analyzer	CCV	After every 10 injections and at the end of the analytical day.	± 10% of true value	Reanalyze; if the second CCV is in range, the analysis can continue, however all samples associated with the preceding CCV must be reanalyzed. If the second CCV fails, 2 consecutive CCVs must pass in order to continue.	Analyst/ Supervisor	ENV-SOP-WCOL-0148 (ME0016Q)
TOC Analyzer	CCB	After every CCB.	<1/2 PQL	If the CCB does not meet the criteria listed, all samples analyzed since the last passing CCB must be reanalyzed.	Analyst/ Supervisor	ENV-SOP-WCOL-0148 (ME0016Q)
Autotitrator	ICV	Daily.	± 10% of true value	Two consecutive ICVs must be analyzed and show results within ± 10% before continuing. Otherwise, a new calibration curve is required.	Analyst/ Supervisor	ENV-SOP-WCOL-0114 (ME0013Z)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
Autotitrator	ICB	Daily.	< 1/2 PQL	Two consecutive ICBs must be analyzed and show results that are <1/2 PQL before continuing. Otherwise a new calibration curve is required.	Analyst/ Supervisor	ENV-SOP-WCOL-0114 (ME0013Z)
Autotitrator	CCV	At the end of every 10 samples and at the end of the analytical sequence.	± 10% of true value	Two consecutive CCVs must pass before analysis can continue. The preceding samples must be reanalyzed.	Analyst/ Supervisor	ENV-SOP-WCOL-0114 (ME0013Z)
Autotitrator	CCB	After every 10 injections and at the end of the analytical sequence.	< 1/2 PQL	Reanalyze preceding samples.	Analyst/ Supervisor	ENV-SOP-WCOL-0114 (ME0013Z)

Notes:

[1] SOP reference numbers correspond to Laboratory SOPs in **Worksheet #23**

% = percent
CAS = Chemical Abstracts Service
CCB = continuing calibration blank
CCV = continuing calibration verification
DoD = Department of Defense
EIS = extracted internal standard
GC = gas chromatography
GC/FID = gas chromatography/flame ionization detector
GC/MS = gas chromatography/mass spectrometry
IC = ion chromatography
ICAL = initial calibration
ICB = initial calibration blank
ICS = interference check solution
ICV = initial calibration verification
ICP/AES = inductively coupled plasma/atomic emission spectroscopy
IS = internal standard
ISC = instrument sensitivity check
LC/MS/MS = liquid chromatography/tandem mass spectrometry
LLCCV = low-level calibration check standard
LOD = limit of detection
LOQ = limit of quantitation
N/A = not applicable
NIS = non-extracted internal standard
PFAS = per- and polyfluorinated alkyl substance
PQL = practical quantitation limit
QC = quality control
QSM = Quality Systems Manual
RF = response factor
RSD = relative standard deviation
RSE = relative standard error
RT = retention time
SOP = standard operating procedure
TOC = total organic carbon
USEPA = U.S. Environmental Protection Agency

QAPP WORKSHEET #25: ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE, TESTING, AND INSPECTION

(UFP-QAPP Section 3.2.3)
(USEPA 2016-G-05 Section 2.3.6)

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[1]
LC/MS/MS	See Laboratory QA Manual and/or SOP	PFAS	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	Analyst, Department Manager	See Laboratory QA Manual and/or SOP
GC/MS	See Laboratory QA Manual and/or SOP	VOCs	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	Analyst, Department Manager	See Laboratory QA Manual and/or SOP
GC/FID	See Laboratory QA Manual and/or SOP	VOCs	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	Analyst, Department Manager	See Laboratory QA Manual and/or SOP
ICP/AES	See Laboratory QA Manual and/or SOP	Total and dissolved metals	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	Analyst, Department Manager	See Laboratory QA Manual and/or SOP
IC	See Laboratory QA Manual and/or SOP	Anions	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	Analyst, Department Manager	See Laboratory QA Manual and/or SOP

Instrument/ Equipment	**Maintenance Activity**	**Testing Activity**	**Inspection Activity**	**Frequency**	**Acceptance Criteria**	**Corrective Action**	**Responsible Person**	**SOP Reference[1]**
TOC Analyzer	See Laboratory QA Manual and/or SOP	TOC	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	Analyst, Department Manager	See Laboratory QA Manual and/or SOP
Autotitrator	See Laboratory QA Manual and/or SOP	Alkalinity	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	See Laboratory QA Manual and/or SOP	Analyst, Department Manager	See Laboratory QA Manual and/or SOP

Notes:
GC/FID = gas chromatography/flame ionization detector
GC/MS = gas chromatography/mass spectrometry
IC = ion chromatography
ICP/AES = inductively coupled plasma/atomic emission spectroscopy
LC/MS/MS = liquid chromatography/tandem mass spectrometry
PFAS = per- and polyfluorinated alkyl substance
QA = quality assurance
SOP = standard operating procedure
TOC = total organic carbon
VOC = volatile organic compound

QAPP WORKSHEET #28: ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION

(UFP-QAPP Section 3.4 and Tables 4, 5, and 6)
(USEPA 2016-G-05 Section 2.3.5)

The purpose of this worksheet is to ensure that the selected analytical methods are capable of meeting project-specific MPC, which are based on project quality objectives/DQOs).

Matrix	Groundwater
Analytical Group	PFAS
Analytical Method/SOP Reference	PFAS per USEPA Method 1633, or later versions, compliant with DoD QSM 5.4 or later versions Table B-24/ WI46412, and ENV-SOP-WCOL-0158

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
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	MPC
EIS	Added to every field sample, standard, blank, and QC sample.	Added to aqueous samples, into the original container, before extraction. Added to 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 USEPA 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%.
NIS	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 ICAL 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 ICAL 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	MPC
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.
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 contamination 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.
FB	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
EB	One 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

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
LCS (OPR in Method 1633)	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%.
LLLCS (Low-level OPR in Method 1633)	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%.

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
MS	One pair per preparatory batch. Sample spiked with all analytes at 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%.
MSD or MD	For MSD: One per preparatory batch. Sample spiked at same concentration as MS. For MD: Each aqueous sample prepared by serial dilution instead of SPE.	%R same as MS. RPD ≤ 30% (between MS and MSD or sample and MD). 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%
FD	One per 10 field samples	RPD ≤ 30%	Qualify data as appropriate	Data Validator	Overall precision	RPD ≤ 30%

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
Aqueous Sample Preparation	Each sample and associated batch QC samples.	SPE must be used unless samples are known to contain high PFAS concentrations (e.g., AFFF formulations). Inline SPE is acceptable. Entire sample plus bottle rinsate must be extracted using SPE. Known high PFAS concentration samples require serial dilution be performed in duplicate. Samples with > 1% solids may require centrifugation prior to SPE extraction. Pre-screening of separate aliquots of aqueous samples is recommended.	N/A	Analyst, Supervisor, QA Manager	Accuracy	SPE must be used unless samples are known to contain high PFAS concentrations. Entire sample plus bottle rinsate must be extracted using SPE. Known high PFAS concentration samples require serial dilution be performed in duplicate.

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
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.

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
Bile Salt Standards	Daily, prior to analysis of all matrix types (aqueous, solid, tissue, and AFFF).	Evaluation of the relationship of the RT of the bile salt peak(s) to the RT window of PFOS must be met for all matrix types. The RT window of PFOS applies to the RT of all isomers of PFOS. The RT of the bile salt(s) peak must fall out of the RT window of PFOS by at least one minute.	N/A	Analyst, Supervisor, QA Manager	Accuracy	Same as QC Acceptance Limits.

Notes:
% = percent
AFFF = aqueous film-forming foam
CCV = continuing calibration verification
DQI = data quality indicator
EB = equipment blank
EIS = extracted internal standard
FB = field blank
FD = field duplicate
IAR = ion abundance ratio
LCS = laboratory control sample
LLLCS = low-level laboratory control sample
LOQ = limit of quantitation
MB = method blank
MD = matrix duplicate
MPC = measurement performance criteria
MS = matrix spike
MSD = matrix spike duplicate
N/A = not applicable
NIS = non-extracted internal standard
OPR = ongoing precision and recovery
PFOS = perfluorooctane sulfonate
QA = quality assurance
QC = quality control
RPD = relative percent difference
RT = retention time
SOP = standard operating procedure
SPE = solid phase extraction
USEPA = U.S. Environmental Protection Agency

Matrix	Groundwater
Analytical Group	VOCs
Analytical Method/SOP Reference	VOCs per Method 8260 D and ENV-SOP-WCOL-0107 (ME0012X)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
IS	Every field sample, standard and QC sample.	RT within ± 10 seconds from RT of the midpoint standard in the ICAL; EICP area within - 50% to +100% of ICAL midpoint standard. On days when ICAL is not performed, the daily initial CCV can be used.	Inspect mass spectrometer and GC for malfunctions and correct problem. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
MB	One per preparatory batch.	No analytes detected > 1/2 LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater. Common contaminants must not be detected > LOQ.	Correct problem. If required, re-prepare and reanalyze MB and all samples processed with the contaminated blank.	Analyst, Supervisor, QA Manager	Bias/ Contamination	N/A

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
LCS	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified.	Correct problem, then re-prepare and reanalyze LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.	Analyst, Supervisor, QA Manager	Bias/ Contamination	N/A
MS	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified.	Examine the project- specific requirements. Contact the client as to additional measures to be taken.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
MSD or MD	One per preparatory batch.	A laboratory must use the DoD/DOE QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified. MSD or MD: RPD of all analytes ≤ 20% (between MS and MSD or sample and MD).	Examine the project- specific requirements. Contact the client as to additional measures to be taken.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
Surrogate Spike	All field and QC samples.	QC acceptance criteria specified by the project, if available; otherwise use DoD/DOE QSM Appendix C limits or in-house LCS limits if analyte(s) are not listed.	Correct problem, then re-prepare and reanalyze all failed samples for all surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
Evaluation of RRT	With each sample.	RRT of each reported analyte within ± 0.06 RRT units.	Correct problem, then rerun ICAL.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A

Notes:

% = percent
CCV = continuing calibration verification
DoD = Department of Defense
DOE = Department of Energy
DQI = data quality indicator
ICAL = initial calibration
IS = internal standard
LCS = laboratory control sample
LOQ = limit of quantitation
MB = method blank
MD = matrix duplicate
MPC = measurement performance criteria
MS = matrix spike
MSD = matrix spike duplicate
N/A = not applicable
QA = quality assurance
QC = quality control
QSM = Quality Systems Manual
RRT = relative retention time
RT = retention time
SOP = standard operating procedure

Matrix	Groundwater
Analytical Group	TPH-DRO
Analytical Method/SOP Reference	TPH-DRO per USEPA Method 8015 and ENV-SOP-WCOL-0088 (ME00138)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
MB	One per preparatory batch.	No analytes detected > 1/2 LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater.	Correct problem. If required, reprepare and reanalyze MB and all samples processed with the contaminated blank.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
LCS	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified.	Correct problem, then reprepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
MS	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified.	Examine the project- specific requirements. Contact the client as to additional measures to be taken.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
MSD or MD	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified. RPD ≤ 30% (between MS and MSD or sample and MD).	Examine the project- specific requirements. Contact the client as to additional measures to be taken.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
Surrogate Spike	All field and QC samples.	QC acceptance criteria specified by the project, if available; otherwise use QSM Appendix C limits or in-house LCS limits if analyte(s) are not listed.	Correct problem, then reprepare and reanalyze all failed samples for all surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst, Supervisor, QA Manager	Accuracy	N/A

Notes:

% = percent
DQI = data quality indicator
LCS = laboratory control sample
LOQ = limit of quantitation
MB = method blank
MD = matrix duplicate
MPC = measurement performance criteria
MS = matrix spike
MSD = matrix spike duplicate
N/A = not applicable
QA = quality assurance
QC = quality control
QSM = Quality Systems Manual
RPD = relative percent difference
SOP = standard operating procedure

Matrix	Groundwater
Analytical Group	TPH-GRO
Analytical Method/SOP Reference	TPH-GRO per USEPA Method 8015, and ENV-SOP-WCOL-0105 (ME00137)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
ICAL for all analytes (including surrogates)	Initially and as needed after ICV and CCV failure.	<20% RSD; $R^2 > 0.99$	As needed and re-analyze	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
RT window position establishment	Once per ICAL and at the beginning of the analytical sequence	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	N/A	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
RT window width	At method set-up and after major maintenance (e.g., column change).	RT width is ± 3 times standard deviation for each analyte RT from the 72-hour study or 0.03 minutes, whichever is greater.	N/A	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
ICV	Once after each ICAL, second source standard prior to sample analysis	All reported analytes within RT windows. +/20% of true value	Correct problem, rerun. If rerun fails, rerun ICAL.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
CCV	Before sample analysis, after every 10 field samples, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ± 20% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, or if two consecutive CCVs cannot be run, perform corrective action(s) and repeat CCV and all associated samples since last successful CCV. Alternately, recalibrate if necessary; then reanalyze all associated samples since the last acceptable CCV.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
IS	If employed, every field sample, standard, and QC sample.	RT within ± 0.06 RRT units from RT of the midpoint standard in the ICAL; IS signal (area or height) within -50% to +100% of ICAL midpoint standard. On days when ICAL is not performed, the daily initial CCV can be used.	Inspect GC for malfunctions and correct problem. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst, Supervisor, QA Manager	Accuracy/ Bias	N/A
MB	One per preparatory batch	No analytes detected > 1/2 LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater.	Correct problem. If required, reprepare and reanalyze MB and all QC samples and field samples processed with the contaminated blank.	Analyst, Supervisor, QA Manager	Bias/ Contamination	N/A

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
LCS	One per preparatory batch.	A laboratory must use the DoD/DOE QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified.	Correct problem, then reprepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes if sufficient sample material is available.	Analyst, Supervisor, QA Manager	Accuracy/ Bias	N/A
MS	One per preparatory batch.	A laboratory must use the DoD/DOE QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified.	Examine the project-specific requirements. Contact the client as to additional measures to be taken.	Analyst, Supervisor, QA Manager	Accuracy/ Bias	N/A
MSD or MD	One per preparatory batch.	A laboratory must use the DoD/DOE QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified. RPD ≤ 30% (between MS and MSD or sample and MD).	Examine the project-specific requirements. Contact the client as to additional measures to be taken.	Analyst, Supervisor, QA Manager	Accuracy/ Bias	N/A

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
Surrogate Spike	All field and QC samples.	QC acceptance criteria specified by the project if available; otherwise use DoD/DOE QSM Appendix C limits or in-house LCS limits if analyte(s) are not listed.	Correct problem, then reprepare and reanalyze all failed samples for all surrogates in the associated preparatory batch if sufficient sample material is available. If obvious chromatographic interference is present, reanalysis may not be necessary, but the client must be notified prior to reporting data, and the failures must be discussed in the Case Narrative.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A

Notes:

% = percent
CCV = continuing calibration verification
DoD = Department of Defense
DOE = Department of Energy
DQI = data quality indicator
GC = gas chromatography
ICAL = initial calibration
IS = internal standard
LCS = laboratory control sample
LOQ = limit of quantitation
MB = method blank
MD = matrix duplicate
MPC = measurement performance criteria
MS = matrix spike
MSD = matrix spike duplicate
N/A = not applicable
QA = quality assurance
QC = quality control
QSM = Quality Systems Manual
RPD = relative percent difference
RRT = relative retention time
RSD = relative standard deviation
RT = retention time
SOP = standard operating procedure

Matrix	Groundwater
Analytical Group	Metals
Analytical Method/SOP Reference	Metals per USEPA Method 6010, and ENV-SOP-WCOL-0032 (ME001FJ)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
MB	One per preparatory batch.	The absolute values of all analytes must be < 1/2 LOQ or < 1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater.	Correct problem. If required, reprepare and reanalyze MB and all samples processed with the contaminated blank.	Analyst, Supervisor, QA Manager	Bias/ Contamination	N/A
LCS	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified.	Correct problem, then reprepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
MS	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified.	Examine the project-Specific requirements. Contact the client as to additional measures to be taken.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
MSD or MD	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified. MSD or MD: RPD of all analytes ≤ 20% (between MS and MSD or sample and MD).	Examine the project-specific requirements. Contact the client as to additional measures to be taken.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
Dilution Test	One per preparatory batch if MS or MSD fails.	Five-fold dilution must agree within ± 10% of the original measurement.	No specific corrective action, unless required by the project.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
PDS Addition (ICP only)	Perform if MS/MSD fails. One per preparatory batch (using the same sample as used for the MS/MSD if possible).	Recovery within 80-120%.	No specific corrective action, unless required by the project.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
MSA	When dilution test or post digestion spike fails and if required by project.	N/A	N/A	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A

Notes:
% = percent
DQI = data quality indicator
ICP = inductively coupled plasma
LCS = laboratory control sample
LOQ = limit of quantitation
MB = method blank
MD = matrix duplicate
MPC = measurement performance criteria
MS = matrix spike
MSA = Method of Standard Additions
MSD = matrix spike duplicate
N/A = not applicable
PDS = post-digestion spike
QA = quality assurance
QC = quality control
QSM = Quality Systems Manual
RPD = relative percent difference
SOP = standard operating procedure

Matrix	Groundwater
Analytical Group	Anions (nitrate, nitrite, bromide, chloride, fluoride, sulfate)
Analytical Method/SOP Reference	Anions per USEPA Method 300.0, and ENV-SOP-WCOL-0132 (ME001J3)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
MB	One per preparatory batch.	No analytes detected > 1/2 LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater.	Correct problem. If required, reprepare and reanalyze MB and all samples processed with the contaminated blank.	Analyst, Supervisor, QA Manager	Bias/ Contamination	N/A
LCS	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified.	Correct problem, then re- prep and reanalyze the LCS and all samples in the associated preparatory batch for all reported analytes, if sufficient sample material is available.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
MS	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified.	Follow project specific requirements. Contact the client as to additional measures to be taken.	Analyst, Supervisor, QA Manager	Accuracy/ Bias	N/A

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
MSD or MD	One per preparatory batch.	A laboratory must use the QSM Appendix C Limits for batch control if project limits are not specified. If the analyte(s) are not listed, use in-house LCS limits if project limits are not specified. MSD or MD: RPD of all analytes 15% (between MS and MSD or sample and MD).	Follow project specific requirements. Contact the client as to additional measures to be taken.	Analyst, Supervisor, QA Manager	Accuracy/ Bias	N/A

Notes:
% = percent
DQI = data quality indicator
LCS = laboratory control sample
LOQ = limit of quantitation
MB = method blank
MD = matrix duplicate
MPC = measurement performance criteria
MS = matrix spike
MSD = matrix spike duplicate
N/A = not applicable
QA = quality assurance
QC = quality control
QSM = Quality Systems Manual
RPD = relative percent difference
SOP = standard operating procedure

Matrix	Groundwater
Analytical Group	TOC and DOC
Analytical Method/SOP Reference	TOC per USEPA Method 9060, and ENV-SOP-WCOL-0148 (ME0016Q)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
MB	1/20 samples	<1/2 LOQ	Reanalyze, recalibrate if second MB fails. All samples associated with failing MB must be reanalyzed as well.	Analyst, Supervisor, QA Manager	Bias/ Contamination	N/A
LCS/LCSD	One LCS/LCSD pair with each preparation batch	Limits- 90-110% recovery and RPD<20	Reanalyze, recalibrate if second LCS fails. All samples associated with failing LCS must be reanalyzed as well.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
MS/MSD	One MS/MSD pair for each set of 10 samples or fraction thereof	Limits- 70-130% recovery and RPD < 20	If LCS/LCSD results are within limits, report results.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A

Notes:
% = percent
DQI = data quality indicator
LCS = laboratory control sample
LCSD = laboratory control sample duplicate
LOQ = limit of quantitation
MB = method blank
MPC = measurement performance criteria
MS = matrix spike
MSD = matrix spike duplicate
N/A = not applicable
QA = quality assurance
QC = quality control
RPD = relative percent difference
SOP = standard operating procedure

Matrix	Groundwater
Analytical Group	Alkalinity
Analytical Method/SOP Reference	Alkalinity per SM2320, and ENV-SOP-WCOL-0114 (ME0013Z)

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
MB/ICB	One per batch	< 1/2 PQL	Rerun once. Analysis can continue if it passes. If second MB/ICB fails, recalibrate	Analyst, Supervisor, QA Manager	Bias/ Contamination	N/A
LCS/LCSD	One per batch	+/- 10%	20 samples in batch must be reanalyzed. If reanalysis is not possible, the data must be qualified and NCM'd.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
MS/MSD	One MS/MSD pair for each set of 10 samples or fraction thereof	Limits- 70-130% recovery and RPD < 20	NCM if matrix interference has been identified by checking calculations and LCS/LCSD recoveries. Reanalysis is not needed if a dilution of 5 times or greater was performed. NCM. If sample analyte is greater than 4 times the spike amount, reanalysis is not required.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
ICV	After ICAL	+/- 10%	Reanalyze once. If 2nd ICV passes, the run can continue. If it fails, recalibrate	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
CCV	After every 10 samples and end of analytical day	+/- 10%	2 consecutive CCVs must be analyzed to show results within 10%. 10 preceding samples must be reanalyzed.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
CCB	After every 10 titrations and at the end of the analytical day.	<1/2 PQL	Rerun once. Analysis can continue if it passes. 10 samples preceding CCB must be reanalyzed.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A
ICAL	Beginning of procedure	Three point pH meter calibration.	Refer to F-IN-016 for specific calibration procedures.	Analyst, Supervisor, QA Manager	Accuracy/Bias	N/A

Notes:
% = percent
CCB = continuing calibration blank
CCV = continuing calibration verification
DQI = data quality indicator
ICAL = initial calibration
ICB = initial calibration blank
ICV = initial calibration verification
LCS = laboratory control sample
LCSD = laboratory control sample duplicate
MB = method blank
MPC = measurement performance criteria
MS = matrix spike
MSD = matrix spike duplicate
N/A = not applicable
PQL = practical quantitation limit
QA = quality assurance
QC = quality control
RPD = relative percent difference
SOP = standard operating procedure

QAPP WORKSHEET #36: DATA VALIDATION PROCEDURES

(UFP-QAPP Section 5.2.2)
(USEPA 2016-G-05 Section 2.5.1)

Data Validator: Contractor Project Chemist, or designee

Analytical Group/Method:	PFAS, VOCs, TPH, TOC, Alkalinity, Anions, Total and Dissolved Metals
Data deliverable requirements:	Stage 4 Data Package (pdf) EQuIS 4-File EDD and SEDD 2a
Analytical specifications:	PFAS per USEPA Method 1633, or later versions, compliant with DoD QSM 5.4 Table B-24 VOCs by USEPA Method 8260 TPH by USEPA Method 8015 TOC by SW-846 9060A Alkalinity by Method SM2320 Anions by USEPA Method 300 Total and Dissolved Metals by USEPA Method 6010
Measurement performance criteria:	USEPA Method 1633, or later versions, compliant with DoD QSM 5.4 or later versions; **Worksheets #12** and **#28**
Percent of data packages to be validated:	100% Stage 2B manual for PFAS. 100% Stage 2B manual for non-PFAS parameters.
Percent of raw data reviewed:	10% of field samples Stage 4 (only PFAS)
Percent of results to be recalculated:	10% of field samples as part of Stage 4 (DoD target PFAS detections) Of the data which will be reviewed at Stage 3/4 level, representative subset of recalculations will be documented. This will include laboratory reported results verified versus the laboratory report. These results include calibration factors, surrogate, EIS, LCS/LCSD, MS/MSD, and sample quantitated results. This will verify the potential systematic errors within the laboratory quantitation software. If there is a mismatch in results a high number of results will be documented through verification process and the root cause of the error investigated by the project chemist. In addition to verification all manually integrated peaks for proper integration and justification for the manually integrated peak will be reviewed

Validation procedure:	• DoD General Data Validation Guidelines. November 2019. • DoD Module 6 Data Validation Guidelines for 1633 -Data Validation Procedure for Per and Polyfluoroalkyl Substances Analysis by QSM Table B-24 November 2022 • Where not addressed in project or the above documents general guidance provided in National Functional Guidelines for Organic Method will be used where applicable. • This UFP-QAPP, USEPA Method 1633, or later versions, compliant with DoD QSM 5.4 or later versions • Data validation reports are produced for each sample delivery group incorporating all sample analyses.
Validation code:	PFAS: 100% S2BVM; 10% S4VM VOCs, TPH, Alkalinity, Anions, Total and Dissolved Metals: 100% S2BVM

Notes:
100% of the data will be reviewed and verified.

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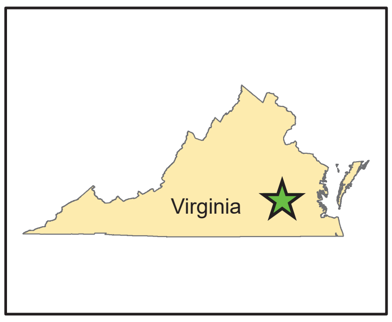
Figures

Quality Assurance Project Plan Addendum #2
PFAS Time Critical Removal Action
Fort Gregg-Adams, VA

SERES Engineering & Services, LLC
ARCADIS
a joint venture

Figure 1
Fort Gregg-Adams Installation Layout and AOI Locations



Installation Boundary
▲ AOI Location
River/Stream (Perennial)
Stream (Intermittent)
Water Body
Inferred Groundwater Flow Direction
Surface Water Flow Direction
Drinking Water Intake

AOI = area of interest

Data Sources:
Fort Gregg-Adams, GIS Data, 2019
USGS, NHD, Water Bodies, 2019
EDR, Well Data, 2019
ESRI, ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 18 North

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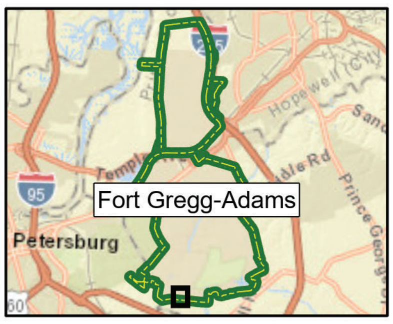
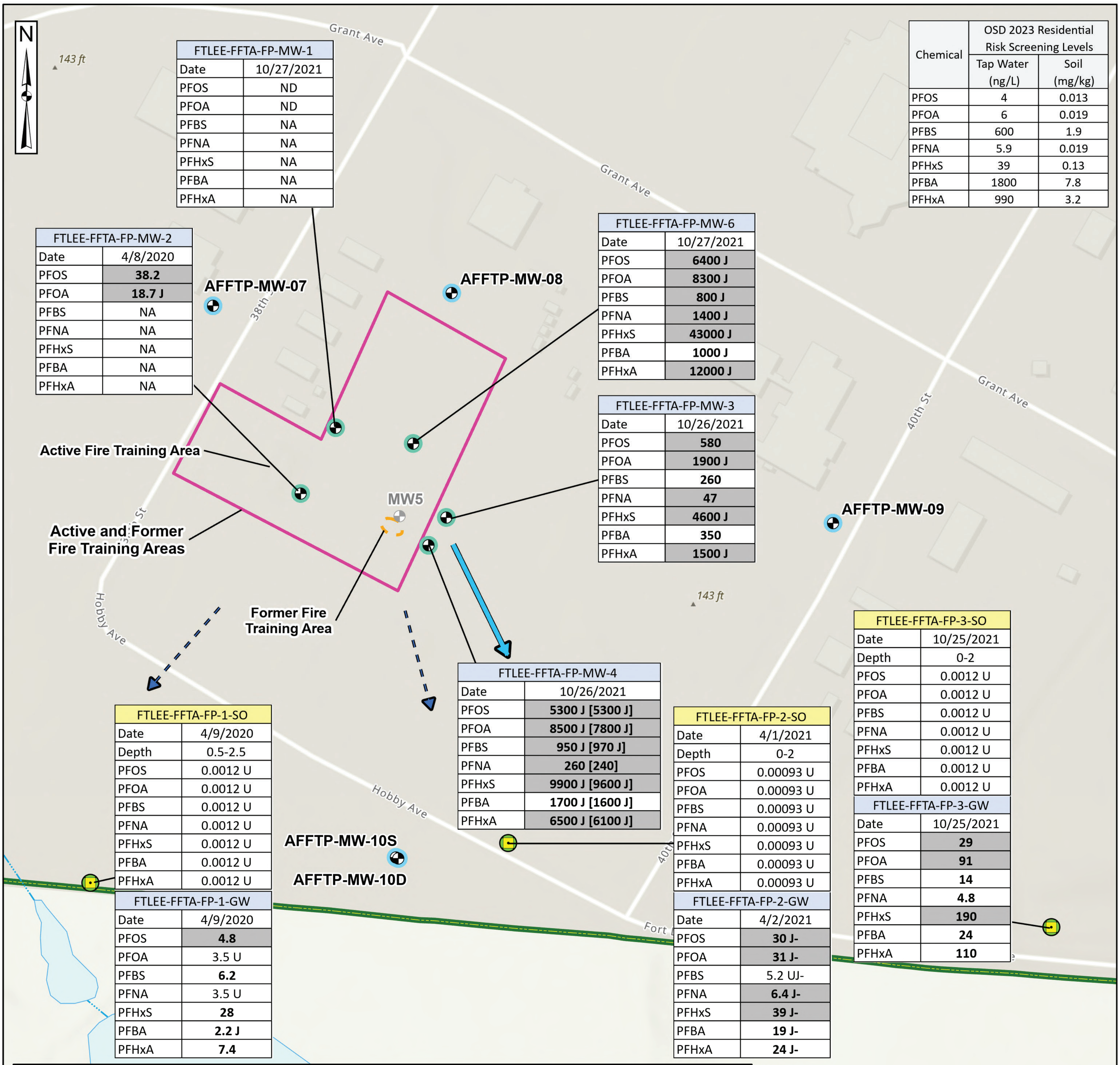
PFAS Time Critical Removal Action
Fort Gregg-Adams, VA

Figure 2
Active and Former Fire Training Areas FTLE-7, FTLE 30, and FTLE-31 AOI: Historical Sampling Results





Chemical	OSD 2023 Residential Risk Screening Levels	
	Tap Water (ng/L)	Soil (mg/kg)
PFOS	4	0.013
PFOA	6	0.019
PFBS	600	1.9
PFNA	5.9	0.019
PFHxS	39	0.13
PFBA	1800	7.8
PFHxA	990	3.2

FTLEE-FFTA-FP-MW-1	
Date	10/27/2021
PFOS	ND
PFOA	ND
PFBS	NA
PFNA	NA
PFHxS	NA
PFBA	NA
PFHxA	NA

FTLEE-FFTA-FP-MW-2	
Date	4/8/2020
PFOS	**38.2**
PFOA	**18.7 J**
PFBS	NA
PFNA	NA
PFHxS	NA
PFBA	NA
PFHxA	NA

FTLEE-FFTA-FP-MW-6	
Date	10/27/2021
PFOS	**6400 J**
PFOA	**8300 J**
PFBS	**800 J**
PFNA	**1400 J**
PFHxS	**43000 J**
PFBA	**1000 J**
PFHxA	**12000 J**

FTLEE-FFTA-FP-MW-3	
Date	10/26/2021
PFOS	**580**
PFOA	**1900 J**
PFBS	**260**
PFNA	**47**
PFHxS	**4600 J**
PFBA	**350**
PFHxA	**1500 J**

FTLEE-FFTA-FP-3-SO	
Date	10/25/2021
Depth	0-2
PFOS	0.0012 U
PFOA	0.0012 U
PFBS	0.0012 U
PFNA	0.0012 U
PFHxS	0.0012 U
PFBA	0.0012 U
PFHxA	0.0012 U

FTLEE-FFTA-FP-3-GW	
Date	10/25/2021
PFOS	**29**
PFOA	**91**
PFBS	**14**
PFNA	**4.8**
PFHxS	**190**
PFBA	**24**
PFHxA	**110**

FTLEE-FFTA-FP-MW-4	
Date	10/26/2021
PFOS	**5300 J [5300 J]**
PFOA	**8500 J [7800 J]**
PFBS	**950 J [970 J]**
PFNA	**260 [240]**
PFHxS	**9900 J [9600 J]**
PFBA	**1700 J [1600 J]**
PFHxA	**6500 J [6100 J]**

FTLEE-FFTA-FP-1-SO	
Date	4/9/2020
Depth	0.5-2.5
PFOS	0.0012 U
PFOA	0.0012 U
PFBS	0.0012 U
PFNA	0.0012 U
PFHxS	0.0012 U
PFBA	0.0012 U
PFHxA	0.0012 U

FTLEE-FFTA-FP-1-GW	
Date	4/9/2020
PFOS	**4.8**
PFOA	3.5 U
PFBS	**6.2**
PFNA	3.5 U
PFHxS	**28**
PFBA	**2.2 J**
PFHxA	**7.4**

FTLEE-FFTA-FP-2-SO	
Date	4/1/2021
Depth	0-2
PFOS	0.00093 U
PFOA	0.00093 U
PFBS	0.00093 U
PFNA	0.00093 U
PFHxS	0.00093 U
PFBA	0.00093 U
PFHxA	0.00093 U

FTLEE-FFTA-FP-2-GW	
Date	4/2/2021
PFOS	**30 J-**
PFOA	**31 J-**
PFBS	5.2 UJ-
PFNA	**6.4 J-**
PFHxS	**39 J-**
PFBA	**19 J-**
PFHxA	**24 J-**

Notes:
1. Groundwater results are reported in nanograms per liter (ng/L).
2. Soil results are reported in milligrams per kilogram (mg/kg).
3. Depths are in feet below ground surface (ft bgs).
4. Bolded values indicate detections.
5. Duplicate sample results are shown in brackets.
6. 2014 samples were collected by Method 537 Modified. Results are from 7/30/2014 ECC Report and are not validated.
7. Human health risk-based screening levels were used to evaluate detected concentrations. Groundwater results were compared to residential tap water screening levels and soil results were compared to residential soil screening levels. Exceedances are shaded gray.

Qualifiers:
J = The analyte was positively identified; however, the associated numerical value is an estimated concentration only.
J- = The analyte was positively identified; however the associated numerical value is an estimated concentration only; the result may be biased low.
U = The analyte was analyzed for, but was not detected above the limit of quantitation.
UJ- = The analyte was analyzed for but was not detected. The reported limit of quantitation is approximate and may be biased low.

0 100 200
Feet

▭	Installation Boundary
▭	AOI
◌	Former Fire Training Area Location
➔	Inferred Surface Runoff Flow Direction
◐	Monitoring Well
◐	Monitoring Well Destroyed

Sampling Locations

▪	Shallow Soil
⊗	Groundwater Boring
●	Groundwater (Existing Well)
●	Groundwater (To Be Sampled During RI)

OSD = Office of the Secretary of Defense
PFBA = perfluorobutanoic acid
PFBS = perfluorobutanesulfonic acid
PFHxA = perfluorohexanoic acid
PFHxS = perfluorohexane sulfonate
PFNA = perfluorononanoic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate

Data Sources:
Fort Gregg-Adams, GIS Data, 2019
USGS, NHD, Water Bodies, 2019
ESRI, ArcGIS Online, Topo Map

Coordinate System:
WGS 1984, UTM Zone 18 North

Quality Assurance Project Plan Addendum #2
PFAS Time Critical Removal Action
Fort Gregg-Adams, VA

SERES Engineering & Services, LLC
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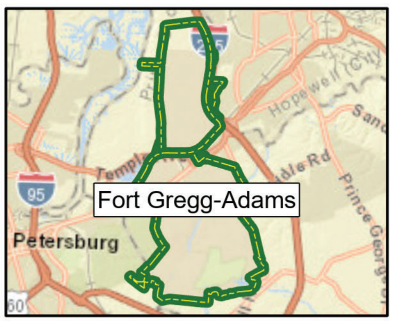
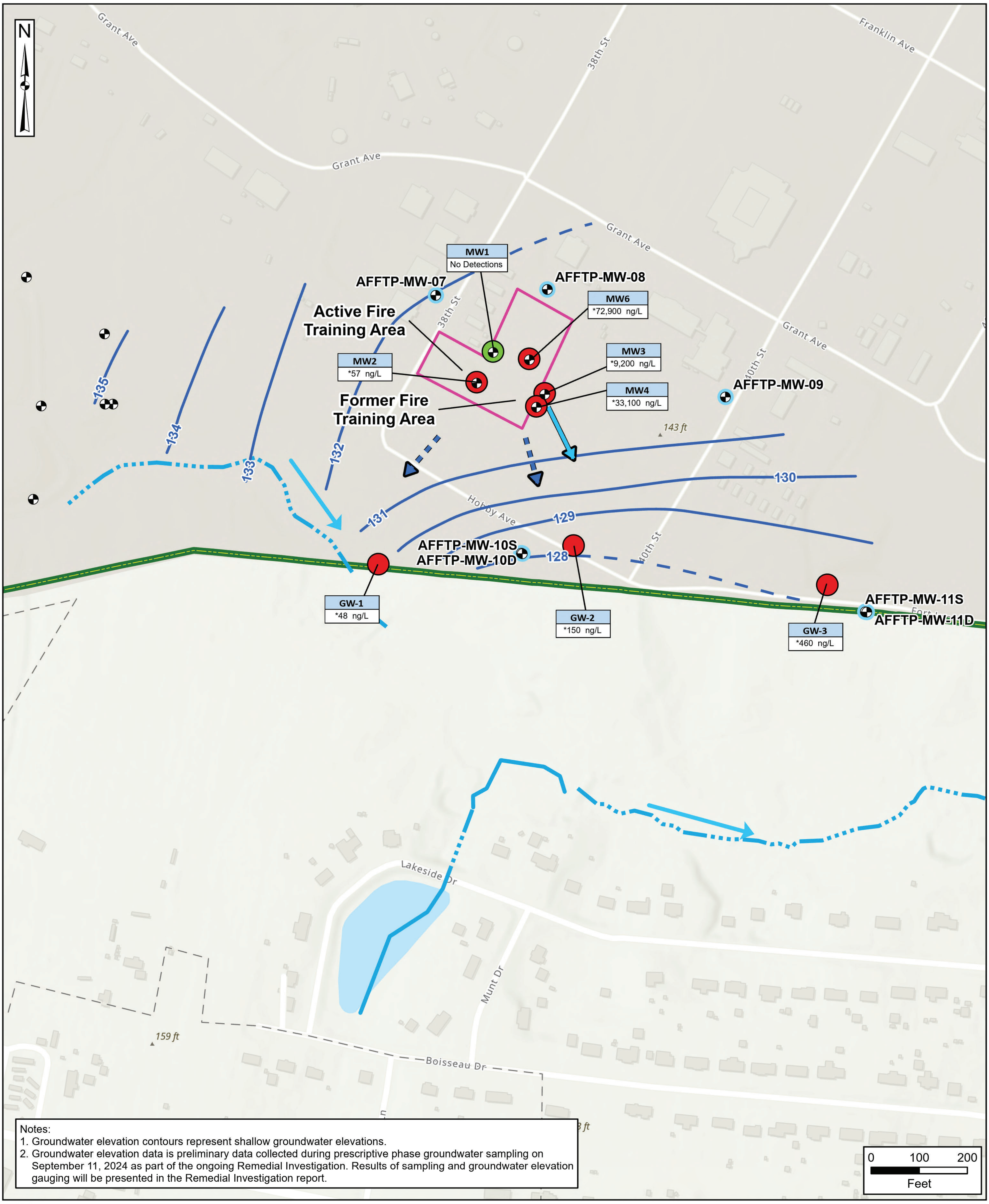


Figure 3
Active and Former Fire Training Areas CSM - PFAS Distribution in Groundwater



Notes:
1. Groundwater elevation contours represent shallow groundwater elevations.
2. Groundwater elevation data is preliminary data collected during prescriptive phase groundwater sampling on September 11, 2024 as part of the ongoing Remedial Investigation. Results of sampling and groundwater elevation gauging will be presented in the Remedial Investigation report.

- 🟩 Installation Boundary
- 🟥 AOI
- ▶ Inferred Surface Runoff Flow Direction
- ➡ Shallow Groundwater Flow Direction
- ➡ Surface Water Flow Direction
- River/Stream (Perennial)
- Stream (Intermittent)
- Groundwater Elevation Contour**

- ◉ Monitoring Well
- 🔴 Historical Groundwater Sampling Location with Risk Screening Level Exceedance
- 🟢 Historical Groundwater Sampling Location with no Risk Screening Level Exceedances

Sampling Locations

- ● Groundwater (To Be Sampled During RI)

* = Sum of PFOA, PFOS, PFHxS, PFNA, PFBS, PFBA and PFHxA, as ng/L.
** Dashed where inferred

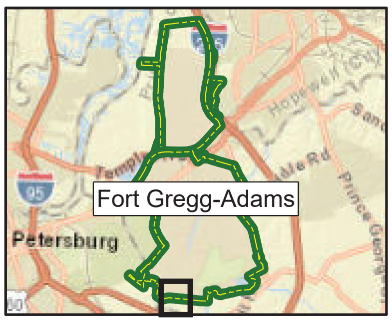
Data Sources:
Fort Gregg-Adams, GIS Data, 2019
USGS, NHD, Water Bodies, 2019
ESRI, ArcGIS Online, Topo Map

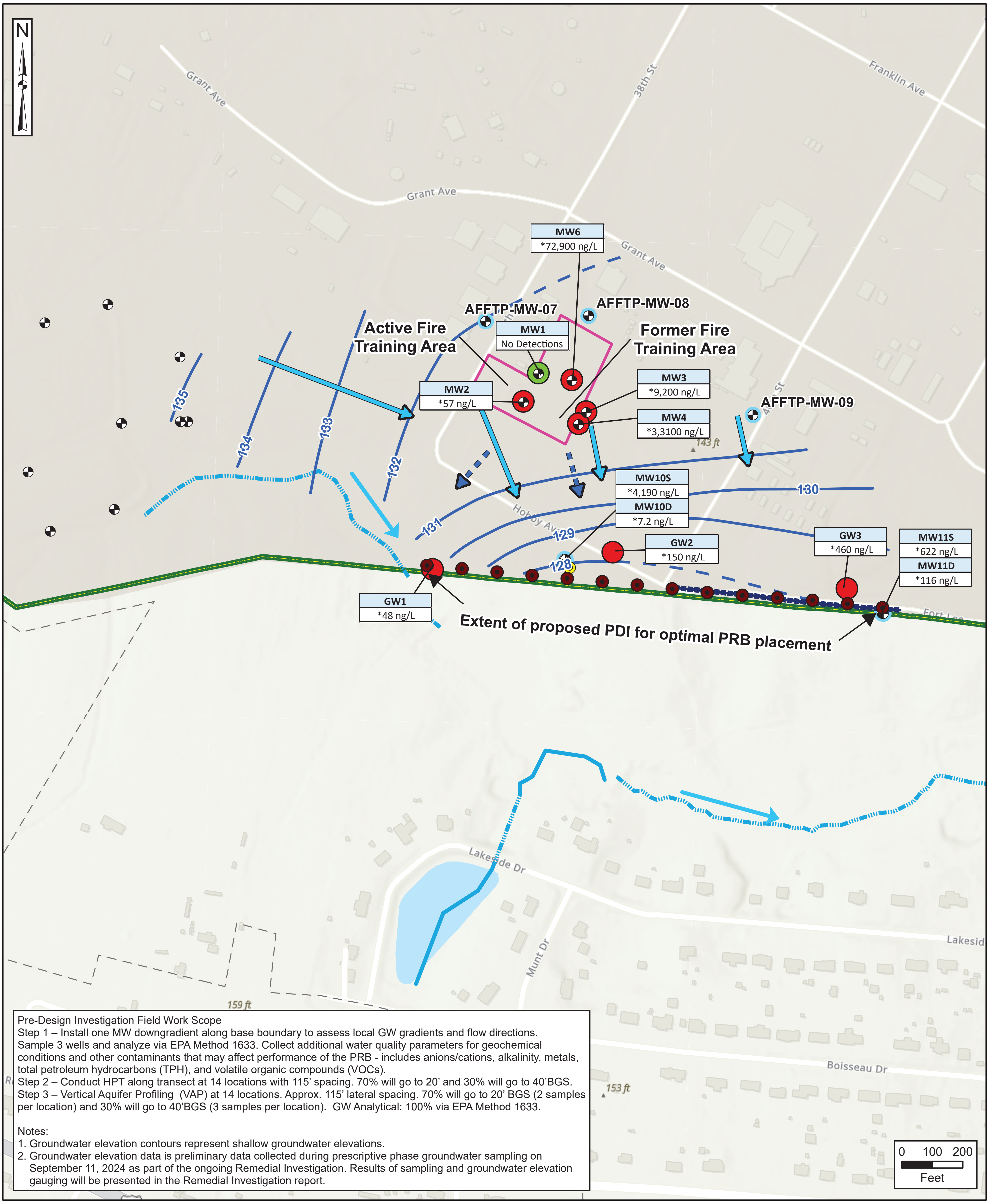
Coordinate System:
WGS 1984, UTM Zone 18 North

SERES Engineering & Services, LLC
ARCADIS
a joint venture

Quality Assurance Project Plan Addendum #2
PFAS Time Critical Removal Action
Fort Gregg-Adams, VA

Figure 4
Active and Former Fire Training Areas
Pre-Design Investigation





Pre-Design Investigation Field Work Scope
Step 1 – Install one MW downgradient along base boundary to assess local GW gradients and flow directions. Sample 3 wells and analyze via EPA Method 1633. Collect additional water quality parameters for geochemical conditions and other contaminants that may affect performance of the PRB - includes anions/cations, alkalinity, metals, total petroleum hydrocarbons (TPH), and volatile organic compounds (VOCs).
Step 2 – Conduct HPT along transect at 14 locations with 115' spacing. 70% will go to 20' and 30% will go to 40'BGS.
Step 3 – Vertical Aquifer Profiling (VAP) at 14 locations. Approx. 115' lateral spacing. 70% will go to 20' BGS (2 samples per location) and 30% will go to 40'BGS (3 samples per location). GW Analytical: 100% via EPA Method 1633.

Notes:
1. Groundwater elevation contours represent shallow groundwater elevations.
2. Groundwater elevation data is preliminary data collected during prescriptive phase groundwater sampling on September 11, 2024 as part of the ongoing Remedial Investigation. Results of sampling and groundwater elevation gauging will be presented in the Remedial Investigation report.

🟩 Installation Boundary
▭ AOI
➡ Shallow Groundwater Flow Direction
➡ Inferred Surface Runoff Flow Direction
➡ Surface Water Flow Direction
River/Stream (Perennial)
Stream (Intermittent)
Drainage Channel (Approximate)

Groundwater Elevation Contour**
◐ Monitoring Well
🔴 Historical Groundwater Sampling Location with Risk Screening Level Exceedance
🟢 Historical Groundwater Sampling Location with no Risk Screening Level Exceedances

* = Sum of PFOA, PFOS, PFHxS, PFNA, PFBS, PFBA and PFHxA, as ng/L.
** Dashed where inferred

Sampling Locations
● Groundwater (To Be Sampled During RI)

Proposed Sampling Locations
● HPT/VAP
◉ PRB Performance Well installed during Pre-Design Investigation (1 total)

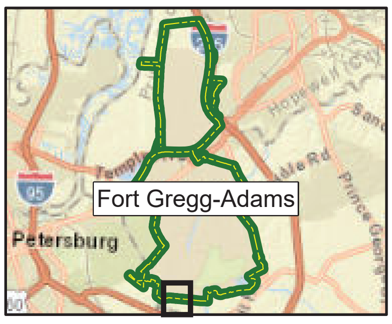
Data Sources:
Fort Gregg-Adams, GIS Data, 2019
USGS, NHD, Water Bodies, 2019
ESRI, ArcGIS Online, Topo Map

Coordinate System:
WGS 1984, UTM Zone 18 North

SERES Engineering & Services, LLC
ARCADIS
a joint venture

Quality Assurance Project Plan Addendum #2
PFAS Time Critical Removal Action
Fort Gregg-Adams, VA

Figure 5
Active and Former Fire Training Areas
Permeable Reactive Barrier and Performance Monitoring



Performance Monitoring Scope
- Install 7 performance MWs (total of 10 MWs) approx. 5-15' BGS.
- Conduct baseline GW sampling event at 10 PRB monitoring MWs prior to PRB installation.
- Performance monitoring at 10 PRB monitoring wells at 3, 6, and 9 months after PRB installation.
- Analytical: 100% via EPA Method 1633

Locations shown may be adjusted based on PDI results. Assumed width of treatment area is approximately 1,000 ft wide.

Notes:
1. Groundwater elevation contours represent shallow groundwater elevations.
2. Groundwater elevation data is preliminary data collected during prescriptive phase groundwater sampling on September 11, 2024 as part of the ongoing Remedial Investigation. Results of sampling and groundwater elevation gauging will be presented in the Remedial Investigation report.

🟩 Installation Boundary
▭ AOI
➔ Shallow Groundwater Flow Direction
▶ Inferred Surface Runoff Flow Direction
➔ Surface Water Flow Direction
River/Stream (Perennial)
Stream (Intermittent)
— Groundwater Elevation Contour**

◐ Monitoring Well
● Historical Groundwater Sampling Location with Risk Screening Level Exceedance
● Historical Groundwater Sampling Location with no Risk Screening Level Exceedances
🟥 Proposed Permeable Reactive Barrier

* = Sum of PFOA, PFOS, PFHxS, PFNA, PFBS, PFBA and PFHxA, as ng/L.
** Dashed where inferred

Sampling Locations
● Groundwater (To Be Sampled During RI)

Proposed Sample Locations
◎ PRB Performance Well installed prior to baseline sampling (7 total)
◎ PRB Performance Well installed during Pre-Design Investigation (3 total)

Data Sources:
Fort Gregg-Adams, GIS Data, 2019
USGS, NHD, Water Bodies, 2019
ESRI, ArcGIS Online, Topo Map

Coordinate System:
WGS 1984, UTM Zone 18 North

Attachment 1

PRB Design and Installation Work Plan

Contract Number: W912DR-19-D-0009

Delivery Order: W912DR24F0232

SERES
Engineering & Services, LLC
ARCADIS
a joint venture

U.S. Army Corps of Engineers, Baltimore District

Final Preliminary PRB Design and Installation Work Plan

Fort Gregg-Adams, Virginia

March 2025

Contract: W912DR-19-D-0009
Delivery Order: W912DR24F0232

Prepared For:

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Final PRB Design and Installation Work Plan

Fort Gregg-Adams, Virginia

March 2025

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Contents

Figures

Attachments

Acronyms and Abbreviations

CAC	colloidal activated carbon
Cascade	Cascade Remediation Services, LLC
DoD	Department of Defense
DPT	direct push technology
FTA	fire training area
PDI	pre-design investigation
PFAS	per- and polyfluoroalkyl substances
PQAPP	Programmatic Uniform Federal Policy-Quality Assurance Project Plan
PRB	permeable reactive barrier
QAPP	Quality Assurance Project Plan
TCRA	Time-Critical Removal Action
TGI	technical guidance instructions
USEPA	United States Environmental Protection Agency

1 Introduction

Fort Gregg-Adams is approximately 5,907 acres and lies within the Virginia Coastal Plain within Prince George County, Virginia, west/southwest of the City of Hopewell and northeast of Petersburg (Figure 1 of Quality Assurance Project Plan [QAPP] Addendum #2). Per- and polyfluoroalkyl substances (PFAS) are present in groundwater within the vicinity of the Active and Former Fire Training Areas (FTAs; FTLE-7, FTLE 30, and FTLE-31) and there is evidence that groundwater impacts that extend to the southern boundary of the installation (Figure 2 of QAPP Addendum #2). PFAS-impacted groundwater has the potential to migrate off-post, which may pose a risk to off-post receptors. To mitigate off-post migration of PFAS, a time-critical removal action (TCRA) will be executed. The TCRA is a permeable reactive barrier (PRB) composed of colloidal activated carbon (CAC) along the southern installation boundary to reduce PFAS in groundwater to levels that are at or below residential risk screening levels at the point of treatment. This Work Plan describes the details of the CAC PRB design, implementation, and monitoring.

2 TCRA Implementation

In-situ containment of PFAS via sorption to injectable CAC will be used to address migration of PFAS in groundwater. This approach is based on the well-established use of activated carbon for ex-situ water treatment and utilizes low-micron size activated carbon particles that can be delivered to the subsurface via liquid injection. The low-micron size of the particles allows for delivery as a liquid suspension using traditional injection methods including injection wells and direct push technology (DPT). Once distributed within the pore space of the aquifer, target contaminants are sequestered within the activated carbon pores upon contact, thus mitigating ongoing migration of PFAS via groundwater. The selected remediation product for this application consists of CAC (ColloidalChem + Anchor™, commercially available from Cascade Remediation Services, LLC [Cascade]). The following sections describe the activities to be performed as part of this TCRA, including bench scale testing, potable water injection testing, well installation, CAC injection, and verification sampling.

2.1 Summary of Pre-Design Investigation

To properly design the CAC PRB, PFAS distribution and related hydrogeological and mass flux data are needed along the region of the southern boundary where groundwater PFAS impacts are present. The pre-design investigation (PDI) will be conducted along the southern installation boundary (Figure 2 of QAPP Addendum #2) and will consist of a targeted investigation to finalize the design and location of the PRB. The objectives of the PDI are as follows:

1. Confirm groundwater flow direction in the vicinity of FTAs and southern installation boundary.
2. Confirm lateral and vertical distribution of PFAS along southern installation boundary with a focus on the high PFAS concentrations migrating from the upgradient Active and Former FTAs.
3. Combine hydrostratigraphy and PFAS distribution data to generate a mass flux based conceptual site model to optimize the PRB location and design.
4. Evaluate geochemistry and co-contaminants (e.g., volatile organic compounds) in groundwater to confirm CAC loading during PRB design.

PDI activities will include installation and sampling of groundwater monitoring wells, and implementation and sampling of Hydraulic Profiling Tool/vertical aquifer profiling points. This work is described in further detail in QAPP Addendum #2.

2.2 Bench Scale Test

A bench scale test will be completed prior to injection of the activated carbon. Laboratory testing will be performed by Cascade. The bench test will identify potential interferences to sorption of PFAS and confirm the required loading of CAC (ColloidalChem + Anchor™) within the PRB to remove PFAS constituents from groundwater. Groundwater for the bench testing will be obtained during the PDI and will be sent to Cascade for testing.

CAC dosing will be determined through evaluation of target groundwater constituents, treatment goals, and related groundwater parameters that might affect treatment performance. The goal of these tests is to establish CAC dosing for PRB design. Laboratory testing does not attempt to mimic the full set of variables encountered in a field site and should be used as one of many inputs for dosing modeling.

Bench testing will involve batch testing using CAC and site groundwater. There will be two loadings of CAC during the first round, along with a blank sample and spiked controls (e.g. 100 parts per trillion control). Additional rounds of testing will be designed and performed depending on results of the first round. Samples will be centrifuged and filtered to remove treatment product, and water phase will be analyzed for PFAS by liquid chromatography/tandem mass spectrometry by a laboratory selected by Cascade. These data are not for regulatory purposes and are for remedy optimization only. In most cases, a few iterations of this type of batch testing are needed to address unexpected cross-contamination, analytical quality control issues, matrix interferences, and other challenges associated with non-routine parts per trillion-level analyses.

Results of the bench testing will be obtained prior to field application and if adjustments need to be made to the field plan for dosing, this will be communicated in a Field Change Report.

2.3 Potable Water Injection Test

An injection pilot test will be performed during the PDI fieldwork to validate the injection method used to deliver the injectable CAC product to the subsurface treatment area. The injection test will consist of up to four injection borings using DPT implemented over a one-day period. Injection borings will be spaced approximately 6 feet apart. Injection boring locations may be adjusted in the field as needed. The target vertical zone for injection is approximately 5 to 15 feet below ground surface and may be adjusted based on the results of the PDI. The vertical injection interval within each boring is approximately 5 feet, and there will be two injection intervals per boring.

Pilot test injections will be performed using DPT methods for injection of liquid remediation substrates. The top 5 feet of each boring will be hand cleared. Injection will be implemented using a “top down” approach in which DPT is used to advance injection tooling to the shallowest target interval. Once the injection tooling is at the shallowest injection interval, injection of potable water is performed. Injection pressure limits of 25 to 35 pounds per square inch will be utilized to avoid fracturing of the formation during injection. Pressure and flow rate will be monitored for each injection point throughout the injection. If the maximum pressure is reached and injection has not occurred, the pump will be shut down and the lines cleared. If a second attempt to inject at that interval is also unsuccessful, the tooling will be advanced to the next injection interval. Once the target volume has been injected at the first depth, direct push is used to lower the tooling down to the next injection interval. This process is repeated for each injection interval.

The expected injection volume is approximately 211 gallons per 5-foot injection interval for a total of approximately 422 gallons per injection boring. It is anticipated that potable water will be provided by the buffalo fill stand at Building 7118 (on the corner of 18th Street and Quartermaster Road) located near the injection area. A source blank was previously collected from this fire hydrant and analyzed for PFAS via United States Environmental Protection Agency (USEPA) Method 1633; results indicated that the concentrations of the Department of Defense (DoD) target PFAS were either non-detect or had detectable concentrations less than half the applicable tapwater risk screening levels (Arcadis 2022). Further information regarding source blank collection is provided in Section 17.6 of the QAPP Addendum #2.

The potable water will be transferred to a piping manifold equipped with flow control valves, flow meters, and pressure gauges to monitor and control the flow rate and pressure to each injection location. The potable water will be delivered to each injection location using temporary above grade transfer hoses.

Once injection procedures are complete, location abandonment will be completed by removing injection tooling and installing a 1-inch tremie pipe to the bottom of the borehole. Portland Type 1 cement or a bentonite slurry will be added to the borehole via pressure injection from the base of the location to ground surface. The area around the boring will be restored to match the ground surface immediately adjacent to the boring.

2.4 Installation and Development of Performance Monitoring Wells

To supplement three monitoring wells installed during the PDI (FTGA-TCRA-MW01 through FTGA-TCRA-MW03), seven monitoring wells will be installed prior to injection of the CAC PRB (FTGA-TCRA-MW04 through FTGA-TCRA-MW10), as shown on **Figure 1**. One well (FTGA-TCRA-MW04) will be installed approximately 25 feet upgradient of the CAC PRB, two wells (FTGA-TCRA-MW05 and FTGA-TCRA-MW06) will be installed within the anticipated ROI of the CAC PRB, and four wells (FTGA-TCRA-MW07 through FTGA-TCRA-MW10) will be installed approximately 10 to 20 feet downgradient of the CAC PRB.

Well installation will be completed using the appropriate drilling methods with a minimum outer casing size in accordance with state regulations. A DPT rig with auger attachment is anticipated to be used for installation of the new wells; if field conditions necessitate, an alternative drilling method will be used for the new well installation. All equipment and materials used during drilling and for well construction will be composed of non-PFAS-containing materials (e.g., including lubricants used for drill rod threads). Drilling water from a verified source may be introduced to the boreholes if difficult drilling conditions are encountered (which may include hard clays that are not part of a confining unit). However, based on drilling activities completed during previous investigations, the need for use of drilling water is not anticipated. No drilling in bedrock is planned.

Monitoring wells will be constructed using 2-inch polyvinyl chloride screens and polyvinyl chloride risers. Screen slot size and filter pack sand size will be determined based on the well installation completed during the PDI. Screen length will be nominally 10 feet, to be finalized based on observed lithology and PFAS concentration distribution. Filter packs will be washed quartz sand, extending from 1 foot below to 2 feet above the well screen unless conditions indicate otherwise. Downhole annular space material will be installed using a tremie pipe. Potential for bridging in the filter pack will be mitigated by performing pre-development before installing bentonite and grout. Pre-development will be performed by gently surging the well to settle the filter pack. Additional filter pack material will then be added if needed due to filter pack settlement during pre-development to achieve the specified filter pack thickness. Following pre-development, approximately 2 feet of hydrated bentonite will be placed above the filter pack. The well will then be pressure-grouted via a tremie pipe with bentonite cement grout beginning no more than 4 feet above the top of the aquifer or 4 feet above the top of the screen for wells with the top of screen positioned above the aquifer. Water used to make bentonite cement grout will be from a verified source (e.g., the buffalo fill stand at Building 7118, as discussed further in Section 17.6 of the QAPP Addendum #2) with acceptable concentrations of DoD target PFAS less than or equal to one half the applicable tapwater risk screening levels, and the amount of bentonite will not exceed 2 pounds of bentonite per 94-pound sack of cement. No more than 7 gallons of water will be used per 96 pounds of bentonite-cement mixture.. Each well will be completed with a minimum 2-foot by 2-foot and 4-inch-thick concrete pad. Well vaults will be locking and either traffic-rated flush-mount or steel stickup with three protective bollards. The monitoring wells will be constructed in accordance with state well construction standards and the PFAS-Specific Drilling and Monitoring Well Installation Technical Guidance Instructions (TGI; Attachment D of the Programmatic Uniform Federal Policy-Quality Assurance Project Plan [PQAPP; SERES-Arcadis 2024]).

Following construction, and after sufficient time has passed to allow for proper curing of the well seal/grout (typically 24 to 48 hours depending on the type of cement used), monitoring wells will be developed in accordance with the TGI for Monitoring Well Development (Attachment D of the PQAPP [SERES-Arcadis JV 2024]) using a combination of surging and pumping. Any water introduced to the well during development will be from a verified source (e.g., the buffalo fill stand at Building 7118) with acceptable concentrations of DoD target PFAS not equal to or greater than one half the applicable risk screening levels for tapwater. Well screens will undergo two cycles of surging, for approximately 15 to 30 minutes each time, followed by pumping or bailing to remove accumulated sediments. After the wells have been surged twice, the wells will be pumped at a relatively constant rate until indicator parameters (e.g., pH, specific conductance, and temperature) are stable for three consecutive readings spaced 3 to 5 minutes apart, and the extracted water is clear and free of sediment (i.e., with turbidity less than 50 nephelometric turbidity units). Water levels and depth to bottom will be measured before, during, and after well development. Development water will be temporarily containerized, treated by granular activated carbon, and discharged at an approved location by the installation.

Following completion, monitoring wells will be professionally surveyed.

2.5 Baseline Groundwater Sampling

Monitoring wells FTGA-TCRA-MW01 through FTGA-TCRA-MW10 will be sampled consistent with the methods described in Section 17.5.2 of QAPP Addendum #2. For the newly installed wells (FTGA-TCRA-MW04 through FTGA-TCRA-MW10), sampling will occur a minimum of 72 hours after well development. During sampling, the field team will complete gauging of monitoring wells from the established measuring point (i.e., typically the top of casing) using an electronic water level meter to within 0.01 foot.

Groundwater samples will be collected from approximately the center of the saturated screened interval using low-flow sampling methods (or bailer methods, if necessary, based on length of the water column or condition of the well, and if acceptable to the state, installation, and Headquarters of the Department of the Army). Groundwater samples will be analyzed for PFAS using USEPA Method 1633 as defined in Worksheet #15 of QAPP Addendum #2, and field parameters (temperature, pH, specific conductivity, DO, turbidity, and ORP) will be measured during purging and allowed to stabilize in accordance with the TGI for PFAS Sampling Procedures and Low-Flow Groundwater Purging for Monitoring Wells (Attachment D of the PQAPP [SERES-Arcadis 2024]).

2.6 Colloidal Activated Carbon Barrier Injection

CAC will be injected across an approximately 1,000-foot long transect of injection borings near the property boundary (**Figure 1**). Injection will be performed using DPT and the final design will be based on the results of the PDI, bench scale test, and potable water injection test. The CAC substrate will be ColloidalChem™, which is commercially available from Cascade. Following CAC injections, up to four DPT borings will be advanced to confirm injection radius and CAC distribution in the subsurface.

Target injection volumes are calculated using the target radius of influence, length of target injection interval, and estimated mobile fraction of the aquifer using the following equation for the volume of a conceptualized cylinder:

$$V = (ROI)^2 \times \pi \times h \times \theta_m \times 7.48$$

Where:

V = injection volume (gallons)

ROI = radius of influence (feet)

h = vertical target interval (feet)

θ_m = mobile fraction (unitless)

Current design assumptions for the CAC PRB include:

- Up to 637 injection points oriented in three parallel lines along the property boundary.
- Injection points will be spaced approximately 6 feet apart, targeting approximately a 3-foot ROI during injection.
- Barrier thickness is assumed to be 18 feet.
- Target injection zone is anticipated to be between 5 and 15 feet below ground surface with two 5-foot injection intervals per boring. PDI results will be evaluated to confirm the target depth before injections begin.
- Mobile fraction is assumed to be approximately 10 percent.
- Injection volume will be approximately 211 gallons per injection point. This includes approximately 72 pounds of ColloidalChem, and 29 pounds of Anchor™ material per injection point. Final CAC loading will be informed by the results of the PDI and bench scale testing.

Refinement to PRB design parameters, if necessary based on the results of the PDI, will be documented in a memorandum.

2.7 Verification Sampling

A verification sampling program will be performed to document changes in PFAS concentrations as a result of PFAS treatment at the CAC PRB.

Verification sampling at the CAC PRB will be focused on monitoring groundwater upgradient, within, and downgradient of the treatment area, including three existing monitoring wells installed during the PDI (FTGA-TCRA-MW01 through FTGA-TCRA-MW03) and seven new monitoring wells (FTGA-TCRA-MW03 through FTGA-TCRA-MW10) (**Figure 1**). Performance monitoring events will be completed at 3 months, 6 months, and 9 months following PRB installation at these ten monitoring well locations.

Analytes will include the following:

- PFAS by USEPA Method 1633
- Field parameters: pH, dissolved oxygen, temperature, oxidation-reduction potential, and specific conductance.

Groundwater samples will be collected as described in Section 2.5, above.

3 Reporting

PDI results will be presented in a letter report. These data will be used to review and verify design assumptions presented in this document. An After-Action Report will be developed to document the TCRA actions completed and will include the installation specifications for the PRB, including figures documenting the barrier injection and monitoring well locations and injection details (including injection rates, injection volumes, and CAC delivered). Draft, Draft Final, and Final After-Action Reports will be submitted.

Additionally, Verification Sampling Reports will be submitted to document PFAS concentrations following PRB installation. Verification Sampling Reports will include laboratory analytical data summary tables, figures, and validated laboratory analytical packages. Draft, Draft Final, and Final Verification Sampling Reports will be submitted for approval.

4 Permitting

An underground injection control permit application will be prepared and submitted to the USEPA Underground Injection Control Program. The permit will cover injection activities for the injection test and injection remedy. Considerations for an erosion and sediment control plan exemption and rationale for why a plan is not necessary for the PRB installation is documented in **Attachment 1**. It is anticipated that no additional permits will be required to perform the injection activities.

5 Decontamination and Investigation-Derived Waste Management

All non-dedicated sampling equipment used during the investigation will be decontaminated according to the procedures specified in Section 17.6 of QAPP Addendum #2 and TGI – Groundwater and Soil Sampling Equipment Decontamination (Attachment D of the PQAPP [SERES-Arcadis 2024]). Investigation-derived waste generated during PRB implementation (decontamination water) will be managed as described in Section 17.8 of QAPP Addendum #2.

6 References

Arcadis. 2022. Final Preliminary Assessment and Site Inspection of Per- and Polyfluoroalkyl Substances, Fort Lee, Virginia. June 23.

SERES-Arcadis. 2024. Final Programmatic UFP-QAPP, USAEC PFAS Remedial Investigations, Northeast Army Installations, USA. May.

Figures

Preliminary PRB Design and Installation Work Plan
PFAS Time Critical Removal Action
Fort Gregg-Adams, VA

SERES Engineering & Services, LLC
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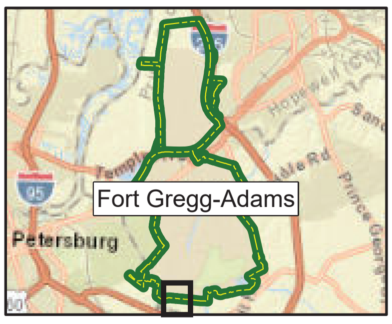
Figure 1
Active and Former Fire Training Areas
Permeable Reactive Barrier and Performance Monitoring



Performance Monitoring Scope
- Install 7 performance MWs (total of 10 MWs) approx. 5-15' BGS.
- Conduct baseline GW sampling event at 10 PRB monitoring MWs prior to PRB installation.
- Performance monitoring at 10 PRB monitoring wells at 3, 6, and 9 months after PRB installation.
- Analytical: 100% via EPA Method 1633

Locations shown may be adjusted based on PDI results. Assumed width of treatment area is approximately 1,000 ft wide.

Notes:
1. Groundwater elevation contours represent shallow groundwater elevations.
2. Groundwater elevation data is preliminary data collected during prescriptive phase groundwater sampling on September 11, 2024 as part of the ongoing Remedial Investigation. Results of sampling and groundwater elevation gauging will be presented in the Remedial Investigation report.

🟩 Installation Boundary
▭ AOI
➡ Shallow Groundwater Flow Direction
▶ Inferred Surface Runoff Flow Direction
➡ Surface Water Flow Direction
River/Stream (Perennial)
Stream (Intermittent)
Groundwater Elevation Contour**

⊕ Monitoring Well
● Historical Groundwater Sampling Location with Risk Screening Level Exceedance
● Historical Groundwater Sampling Location with no Risk Screening Level Exceedances
🟧 Proposed Permeable Reactive Barrier

* = Sum of PFOA, PFOS, PFHxS, PFNA, PFBS, PFBA and PFHxA, as ng/L.
** Dashed where inferred

Sampling Locations
● Groundwater (To Be Sampled During RI)

Proposed Sample Locations
◎ PRB Performance Well installed prior to baseline sampling (7 total)
◎ PRB Performance Well installed during Pre-Design Investigation (3 total)

Data Sources:
Fort Gregg-Adams, GIS Data, 2019
USGS, NHD, Water Bodies, 2019
ESRI, ArcGIS Online, Topo Map

Coordinate System:
WGS 1984, UTM Zone 18 North

Attachment 1

Erosion and Sediment Control Plan Exemption Rationale

Attachment 1

Erosion and Sediment Control Exemption Rationale

The objective of this scope of work is to install a 1,000-foot permeable reactive barrier composed of colloidal activated carbon to reduce PFAS in groundwater to levels that are at or below residential risk screening levels at the point of treatment (**Work Plan - Figure 1**). To facilitate this objective, up to 637 injection borings will be installed along the 1,000-foot transect using direct push technology, and ten monitoring will be installed via hollow-stem auger to aid in the implementation design. Assuming a standard boring diameter of 5 inches, the area of total land disturbed is estimated to be 88 square feet. Therefore, an Erosion and Sedimentation Control Plan (E&SCP) is not required for this removal action because the area of total land disturbed is less than 2,500 square feet.

According to the conservation standards contained in the Virginia Erosion and Sediment Control Handbook (9VAC25-875), adopted by Prince George County, where the Site is located, land disturbing activities are nonregulated where the total disturbed land area is less than 2,500 square feet (specifically, within the James River watershed). Additionally, according to Prince George County Erosion and Sediment Control Ordinance, land disturbing activities that are confined wholly by federal lands are exempt from the provisions of the ordinance (Ord. No. O-01-003, § 10-94, 8-22-2001).

If the scope of work to be performed under this contract should change such that an exemption no longer applies, the JV will prepare an E&SCP using the sample outline provided below (**Exhibit 1**).

Exhibit 1 – Sample E&SC Plan Outline:

1 Project Description
2 Existing Site Conditions
3 Adjacent Property
4 Offsite Areas
5 Soils
6 Critical Erosion Areas
7 Erosion and Sediment Control Measures
8 Structural Practices
9 Vegetative Practices
10 Management Strategies
    10.1 Permanent Stabilization
    10.2 Stormwater Management
    10.3 Maintenance

Attachment 2

Office of the Secretary of Defense. 2023. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. August.

ASSISTANT SECRETARY OF DEFENSE
3400 DEFENSE PENTAGON
WASHINGTON, DC 20301-3400

ENERGY, INSTALLATIONS,
AND ENVIRONMENT

August 24, 2023

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY (INSTALLATIONS, ENERGY AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE NAVY (ENERGY, INSTALLATIONS AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE AIR FORCE (INSTALLATIONS, ENVIRONMENT AND ENERGY)
DIRECTOR, NATIONAL GUARD BUREAU (JOINT STAFF, J3/4/7)
DIRECTOR, DEFENSE LOGISTICS AGENCY (INSTALLATION MANAGEMENT)

SUBJECT: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program

The Department of Defense (DoD) conducts cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Defense Environmental Restoration Program (DERP). Our goal is protection of human health and the environment in a risk-based, fiscally-sound manner. This memorandum provides clarifying technical guidance on the investigation of eight per- and polyfluoroalkyl substances (PFAS): perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), perfluorobutanoic acid (PFBA), perfluorobutanesulfonic acid (PFBS), perfluorononanoic acid (PFNA), perfluorohexanoic acid (PFHxA), perfluorohexanesulfonic acid (PFHxS), and hexafluoropropylene oxide dimer acid (HFPO-DA, or GenX) based on recent U.S. Environmental Protection Agency (EPA) information. This guidance is applicable to investigating these chemicals at Environmental Restoration Account-funded, Base Realignment and Closure Account-funded, and federal Air and Army Guard Operation and Maintenance account-funded sites.

This revised memorandum accounts for the May 2023 EPA regional screening levels (RSLs) for PFBA and PFHxA in addition to the RSLs for the other six PFAS. The RSLs for PFOS, PFOA, PFBS, PFNA, PFHxS, and HFPO-DA remain unchanged since EPA's May 2022 update. EPA has provided screening levels for these PFAS compounds using updated, final, peer-reviewed information from the Agency for Toxic Substances and Disease Registry[1], the

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[1] Agency for Toxic Substances and Disease Registry (ATSDR), May 2021. *Toxicological Profile for Perfluoroalkyls*.

EPA Office of Research and Development,[2] the EPA Office of Water,[3] and the Integrated Risk Information System (IRIS).[4]

PFAS shall be addressed in the same manner as other contaminants of concern within the DERP. 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. As with all chemicals, the conceptual site model should be used to determine the necessity for addressing HFPO-DA.

CERCLA RSLs for these chemicals are shown in the EPA RSL Tables[5] and are provided in the attachment. When multiple PFAS are encountered at a site, RSLs set at a hazard quotient of 0.1 are used for screening purposes. Consistent with the CERCLA process, DoD Components will incorporate these screening values into ongoing and future preliminary assessment/site inspections (PA/SI) and should be used to determine if further investigation in the remedial investigation (RI) phase is warranted or if no further action is required. Completed PA/SIs with determinations of "no further action" will be re-assessed based on the updated RSLs.

During the RI phase, the non-carcinogenic reference doses (RfDs) for PFOS, PFOA, PFBA, PFBS, PFNA, PFHxA, PFHxS, and HFPO-DA and the oral cancer slope factor (SFO) for PFOA of 0.07 $(\mathrm{mg/kg\text{-}day})^{-1}$ will be used to conduct site specific risk assessments in accordance with Risk Assessment Guidance for Superfund Volume I, Part A (EPA/540/1-89/002, December 1989).[7] Site-specific risk assessment results will depend on the levels of PFAS found at each site, and will be used to determine if any necessary remedial actions are required in accordance with CERCLA, DERP, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

This memorandum is effective immediately and supersedes and cancels the Assistant Secretary of Defense for Sustainment memorandum, "Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program," July 6, 2022. In anticipation of changes and additions to RSLs, DoD will maintain future updates or additions to existing PFAS-related RSLs on its PFAS website at:
https://www.acq.osd.mil/eie/eer/ecc/pfas/tf/policies.html instead of updating this memo.

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[2] U.S. Environmental Protection Agency (EPA), April 2021. *Provisional Peer-Reviewed Toxicity Values for Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3).*

[3] EPA, October 2021. *Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CASRN 13252-13-6 and CASRN 62037-80-3), Also Known as "GenX Chemicals"*. EPA, May 2016. *Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA*

[4] EPA, *IRIS Toxicological Review of Perfluorobutanoic Acid (PFBA) and Related Salts* (Final Report, 2022, EPA/635/R-22/277F). EPA, *IRIS Toxicological Review of Perfluorohexanoic Acid (PFHxA) and Related Salts* (Final Report, 2023 EPA/635/R-23/027F)

[5] The EPA RSL Tables are located at: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables.

[7] Currently there are eight PFAS – PFOS, PFOA, PFBA, PFBS, PFNA, PFHxA. PFHxS, HFPO-DA (GenX) – with established toxicity values that DoD can use to perform a baseline risk assessment to determine whether remedial action is needed under CERCLA.

The point of contact for this matter is Ms. Cristina Harvey at 703-571-9067 or marcia.c.harvey2.civ@mail.mil.

Brendan M. Owens

Attachment:
As stated

Attachment: Risk Screening Levels for PFOS, PFOA, PFBA, PFBS, PFNA, PFHxA, PFHxS, and HFPO-DA in Groundwater and Soil Based on EPA's RSL Tables Dated May 2023

Chemical	Carcinogenic Slope Factor - Oral (SFO) (mg/kg-day)-1	Non-Carcinogenic Reference Dose (RfD) (mg/kg-day)	Residential Scenario Screening Levels Based on EPA RSL Tables Dated May 2023								Industrial/Commercial Composite Worker Screening Levels Based on EPA RSL Tables Dated May 2023			
			Tap Water (ng/L or ppt)				Soil (mg/kg or ppm)				Soil (mg/kg or ppm)			
			THQ = 0.1	THQ = 1.0	TR = 1E-06	TR = 1E-04	THQ = 0.1	THQ = 1.0	TR = 1E-06	TR = 1E-04	THQ = 0.1	THQ = 1.0	TR = 1E-06	TR = 1E-04
PFOS	NA	2.00E-06	4.0	40	NA	NA	0.013	0.13	NA	NA	0.16	1.6	NA	NA
PFOA	7.00E-02	3.00E-06	6.0	60	1,100	111,000	0.019	0.19	7.8	780	0.25	2.5	33	3,300
PFBA	NA	1.00E-03	1,800	18,000	NA	NA	7.8	78	NA	NA	120	1,200	NA	NA
PFBS	NA	3.00E-04	600	6,000	NA	NA	1.9	19	NA	NA	25	250	NA	NA
PFNA	NA	3.00E-06	5.9	59	NA	NA	0.019	0.19	NA	NA	0.25	2.5	NA	NA
PFHxA	NA	5.00E-04	990	9,900	NA	NA	3.2	32	NA	NA	41	410	NA	NA
PFHxS	NA	2.00E-05	39	390	NA	NA	0.13	1.3	NA	NA	1.6	16	NA	NA
HFPO-DA	NA	3.00E-06	6	60	NA	NA	0.023	0.23	NA	NA	0.35	3.5	NA	NA

THQ=Target Hazard Quotient
TR=Target Risk
NA=Not available/applicable

NOTES:

- Default exposure assumptions for each receptor scenario shown above are from EPA's RSL Calculator on May 2023. The RSLs may be found in EPA's RSL table or by using EPA's RSL calculator
- Final peer reviewed toxicity values considered valid for a CERCLA risk assessment and the screening levels may be found in EPA's RSL table or EPA's RSL calculator. (The 2022 interim health advisories for PFOS and PFOA are based on draft toxicity values and are not used in CERCLA risk assessments.)
- Other potential receptor scenarios (e.g., recreational user, site trespasser, construction worker) are not included in the above table, but could be relevant receptors at a site potentially containing PFAS. These receptors, and their associated exposure scenarios, should be further considered in the scoping phase and completion of the Baseline Human Health Risk Assessment typically completed during an RI.
- The shaded values represent conservative screening levels in groundwater or soil that when exceeded should be considered a contaminant of potential concern in the Remedial Investigation's risk assessment process.

Attachment 3

Project Planning Session Summary

RECORD OF MEETING

MEETING TITLE

Environmental Services for PFAS Impacted Areas (TCRA)– Fort Gregg-Adams Kick-off Meeting
Contract: W912DR19D0009

DATE

09 September 2024

ORGANIZER

Nicole Walworth, USACE Project Manager

OUR REF

30234159

LOCATION

Teleconference

COPIES TO

All

PARTICIPANTS

Nicole Walworth (USACE)
Erica Steiner (USACE)
Hap Gonser (USAEC)
Ruby Crysler (USAEC)
Hector Anchondo (USAEC)
Craig Norris (Fort Gregg-Adams)
Katie Watson (Fort Gregg-Adams)*

Rhonda Stone (Arcadis)
Catherine Coffey (Arcadis)
Jen Mayers (Arcadis)
Eric Killenbeck (Arcadis)
Joe Quinnan (Arcadis)
Aubrey Thomas (Arcadis)
Jessica Travis (SERES)

*Not in attendance

MEETING SUMMARY

MEETING AGENDA

- Introductions
- Roles and Responsibilities
- Lines of Communication
- Finalizing the PMP
- Developing Interim Payment Milestones
- Finalizing the QASP
- Quality Monitoring
- Invoicing
- Review PWS and technical approach
- Schedule
- Open Discussion

DISCUSSION POINTS AND MEETING DECISIONS

Introductions and Roles and Responsibilities

- Ms. Nicole Walworth is managing the project and is the contract officer representative (COR).
- Ms. Erica Stiner is the contract specialist and will be available for contracting terms or changes.
- Ms. Stiner is to be included on all items.
- Mr. Hap Gonser is the Division Chief for the Northeast (NE) Division.
- Ms. Ruby Crysler is the team lead for the NE Division and the PFAS coordinator for NE Division.
- Mr. Hector Anchondo is the ESM for Fort Gregg-Adams (FGA).
- Mr. Craig Norris is the Environmental Compliance Manager at FGA.
- Mr. Alan Mills is the Chief of Environmental Management Division. Mr. Mill was not in attendance.
- Ms. Katie Watson is contractor support to the FGA Environmental Management Division. Ms. Watson was not in attendance.
- Ms. Rhonda Stone is the Project Manager (PM).
- Ms. Catherine Coffey is the Deputy PM and the point of contact for the joint venture (JV) on this task order (TO).
- Mr. Joe Quinnan is the Senior Scientist.
- Ms. Jen Mayers is the Program Manager for the TO. She is also a part of the overall MAES contract as support on contract needs and resource allocation.
- Ms. Jess Travis is the Quality Control Task Manager for the TO.
- Mr. Eric Killenbeck is technical support.
- Ms. Aubrey Thomas is project support and helping with deliverables and coordination.
- Additional resources will be included on the larger kick-off call.
  - Not in attendance:
    - Norfolk District USACE, of which FGA is a part of, will be involved with documentation and awareness perspective.
    - Cliff Opdyke, Kiera Hearn, Genna Roehler, Scott Forbes from Baltimore District USACE
    - EMCX will also ben involved and will be reviewing technical documents.
    - LarryLamar Courtney is the Contracting Officer (KO) and has the overall responsibility for overseeing the contract.

Communication and PMP

- Meeting slides will be distributed to the team via Ms. Walworth.
- There is going to be continuity between the PFAS RI team and the TCRA team.
- Ms. Jennifer Martin (Arcadis) and Ms. Kim Heinz (Arcadis) will be subject matter experts on the specific technical design.
- The draft of the Project Management Plan (PMP) is scheduled to be submitted on 24 July 2024.

- Interim milestone payments will be included in the PMP.
- Ms. Crysler requested the overall project schedule to be included in the PMP.

PWS Review and Technical Approach Overview

- There are two CLINS to be completed within a 36 month period of performance:
    - Project Planning (PMP, monthly meetings/monthly status reports)
    - Time-Critical Removal Action (TCRA)
- CLIN 0001:
    - Contract Kickoff (17 July 2024)
    - Monthly Calls – requested to conduct these concurrently with current RI calls. Ms. Coffey will check schedules to coordinate with the RI team.
    - Draft PMP in progress (Draft scheduled to be submitted 24 July 2024)
    - MSRs will have monthly schedule updates
    - The dates in the proposal have shifted since the contract was awarded earlier than anticipated due to award date of 05 July 2024 as opposed to the assumed start date of 31 July 2024. The period of performance is 09 July 2024 to 08 July 2027.
- CLIN 0002:
    - The workplan/Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) includes details for the PDI and pre-PRB baseline monitoring, PRB installation, post PRB installation verification sampling, monitoring well installation, lab sheets, points of contacts, erosion and sediment control plan, waste management plan, Accident Prevention Plan and Site Safety and Health Plan with the traffic control plan.
    - The workplan will have EMCX review and regulatory reviews. Regulatory review only includes Mr. Kyle Newman from VDEQ.
    - The Action Memorandum and the QAPP are to be completed concurrently per the schedule.
    - Other reports include the Community Relations Plan, the Monitoring and Inspection Report, and the After-Action Report.
    - After Action Report will include as-builts and all details regarding the PDI.
    - That the design document will be included in the Quality Assurance Project Plan. The PRB installation cannot be refined until after we have completed the PDI. The PRB design info will be included as an addendum to the QAPP after the PDI data is received.
    - Action memo anticipated finish December 2024.
    - PDI anticipated start December 2024 and will be finished April 2024.
    - PRB installation anticipated in May 2024; target end date June 2024.
    - Then verification monitoring (3 events, 3 months apart).
    - All verification info will be documented in an After-Action Report.

Overview of Technical Approach (Mr. Quinnan)

  - Mr. Joe Quinnan provided technical overview of the proposed PDI and PRB. A technical call will be scheduled for a later date.

Additional questions/comments from USAEC

- ASD committed to interim remedial actions (IRA) to address PFAS migrating off-post. Quarterly reporting on IRAs will be completed by USAEC; however, USAEC may require project information from Arcadis to complete this reporting.
- Consider public affairs outreach and needs, if any, (i.e. local leader engagement, public meeting, press release). A public meeting will be required once the TCRA memo is finalized.
- The TCRA document will be reviewed at Headquarters Department of the Army.
- What happens with the PRB at the end of 3 years when this contract is over? Ms. Walworth and team to start thinking about beyond the PoP regarding the PRB.

ACTION ITEMS RECORDED

- JV to submit draft PMP.
- Ms. Coffey to verify existing meeting schedule(s) to schedule a recurring team call.
- Ms. Walworth – Will solicit a time for a technical kickoff.

SERES
Engineering & Services, LLC
ARCADIS
a joint venture

Environmental Services for PFAS Impacted Areas (TCRA)

Fort Gregg-Adams

July 17, 2024

Agenda

- Introductions
- Roles and Responsibilities
- Lines of Communication
- Finalizing the PMP
- Developing Interim Payment Milestones
- Finalizing the QASP
- Quality Monitoring
- Invoicing
- Review PWS and Technical Approach
- Schedule
- Open Discussion

Contract Overview & Roles and Responsibilities

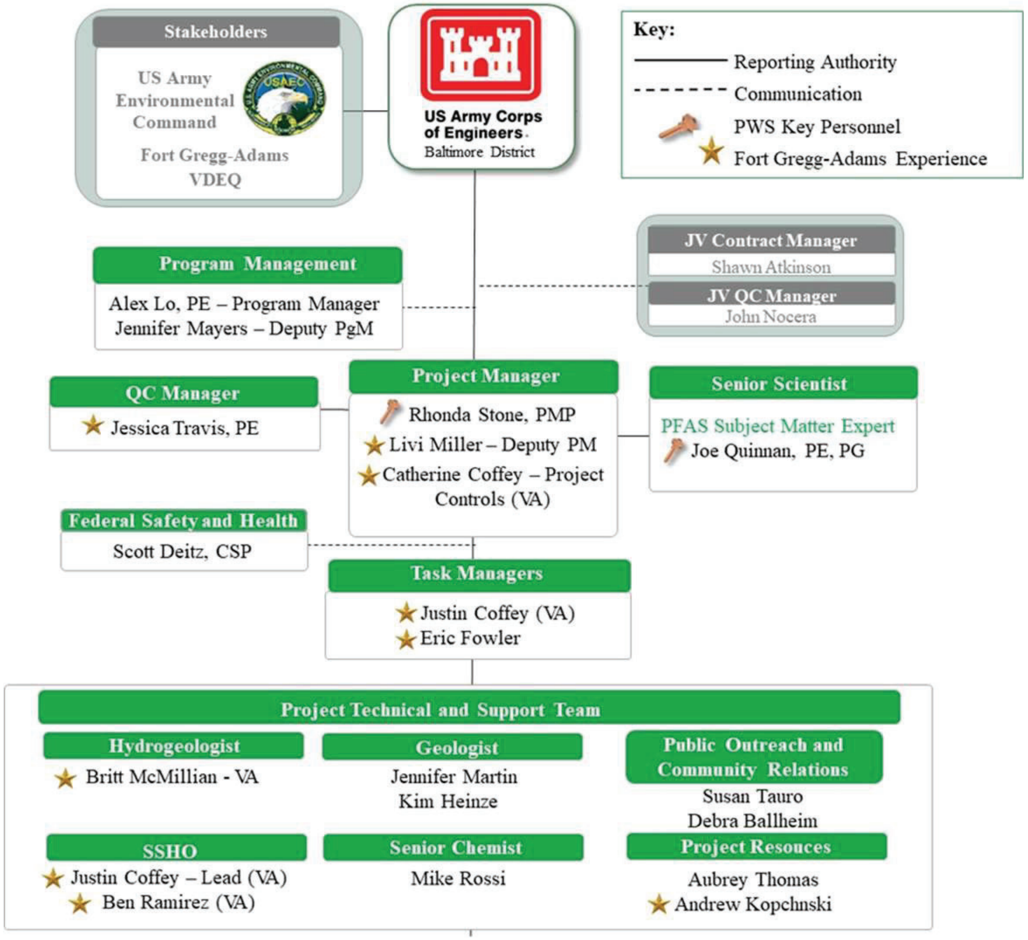
Contract/Delivery Order No:	W912DR190009 / W912DR24F0232
Contractor:	SERES-Arcadis SB JV, LLC
Subcontractors:	Cascade Remediation Services
Contract Type:	Firm-Fixed Price
Period of Performance:	09 July 2024 through 08 July 2027
USACE Contracting Officer:	LarryLamar Courtney
USACE COR:	Nicole Walworth
USACE Technical POCs:	Cliff Opdyke, Kiera Hearn, Scott Forbes
USAEC:	Hap Gonser, Ruby Crysler
Fort Gregg-Adams:	Craig Norris

Project Description:

1. Programmatic Project Planning and Management
2. Time-Critical Removal Action

Lines of Communication

USACE	**Nicole Walworth – Baltimore**
	Meg Gillespie – Norfolk
	Matthew McKeehan - Norfolk
USAEC	**Hap Gonser**
	Ruby Crysler
	Hector Anchondo
Fort Gregg-Adams	**Craig Norris - DPW**
	Allan Mills - DPW
	Katie Watson – IPR Manager



Project Team Organization

Position	Responsibility
Program Manager: ***Rhonda Stone, PMP***	- Meet contractual obligations - Implement procedures to eliminate conflicts, errors, and omissions and ensure the accuracy of all output - Maintain communication and coordination with USACE and the integrated team - Incorporate lessons learned from previous projects
Deputy Project Manager: ***Livi Miller, PG***	- Serves as liaison between the RI execution and TCRA execution - Develops, updates, and maintains compliance with project work breakdown structure and schedule - Reviews all invoices and cost details - Maintains communication and coordination with USACE and integrated team - Attends all meetings
Project Controls: ***Catherine Coffey***	- Main Point of Contact - Develops, updates, and maintains compliance with project WBS and schedule - Prepares/submits daily/monthly/weekly progress and cost reporting and PWS-required periodic reports - Reviews all invoices and cost details - Maintains communication and coordination with USACE and integrated team - Attends all meeting

Project Team Organization

Position	Responsibility
Technical Expert: ***Joe Quinnan, PE, PG***	• Technical lead for all engineering efforts to work with broader technical team and promote program consistency • Primary POC for technical coordination of project requirements, project technical QC, and planning and execution (including field and laboratory sampling and reporting) • Works with QA/QC team for quality reviews and audit scheduling / assignments • Provides technical input on development of plans, specifications, and reports • Participates in project meetings as needed, including with regulatory agencies
SME/Quality: PFAS Programmatic QC: ***Jessica Travis, PE***	• Lead QC for document control and reviews • Leads development of CQCP and supports development of QAPP and QASP • Assigns staff for appropriate quality reviews including technical editing • Reviews all documents for QC elements and consistency in documents across the Army
Geologists: ***Eric Killenbeck*** ***Jennifer Martin*** ***Kim Heinze***	• POC for technical coordination of project requirements, project technical QC, and planning and execution (including field and laboratory sampling and reporting) • Lead PDI technical team and data evaluation • Technical liaison for RI team and TCRA team • Technical support for TCRA and PRB in collaboration with technical team • Technical input on development of plans, specifications, and reports • Works with QA/QC team for quality reviews and audit scheduling / assignments • Participates in project meetings as needed, including regulatory agencies

Project Team Organization

Position	Responsibility
Installation Support Staff ***Aubrey Thomas*** ***Ariel Lampell***	• Support the project team with Army programmatic consistency • Support communication and coordination with USACE and integrated team • Support meetings as needed
Site Safety and Health Officers: ***Justin Coffey*** ***Eric Fowler***	• Enforce all provisions of the approved APP/SSHP & coordinates SSHP changes • Present daily safety meetings and Project specific training • Perform safety audits • Determine and responsible for PPE level required and PPE • Enforce/implement corrective action plans

Contract Funding Summary

Title	Contract Line Item Number (CLIN) Description	Period of Performance
Project Planning	**CLIN 0001** • Draft and Final Project Management Plan (PMP) • Monthly meetings and meeting minutes, status reports, and invoices	*09 July 2024 - 08 July 2027 (36 months)*
Active and Former Fire Training Area Groundwater Time-Critical Removal Action (TCRA)	**CLIN 0002** • Draft, Draft-Final, Final Plan/QAPP • Draft, Draft-Final, Final Action Memorandum • Draft, Draft-Final, Final TCRA Work Plan and Implementation • Field Progress Reports • Complete IDW Laboratory Data Packages (electronic) and Excel flat files of sample analytical data • Draft, Draft-Final, Final Waste Management Work Plan • Draft, Draft-Final, Final Technical Memorandum documenting waste management • Geospatial Database • Draft, Draft-Final, and Final After Action Report (AAR) • Public Outreach and Community Relations Plan (CRP) • Verification Sampling Reports	*09 July 2024 - 08 July 2027 (36 months)*

CLIN 0001: Project Planning

- Contract K**ick-Off Meeting**
    - Discuss overall project objectives, overview of technical approach and schedule, and team members' roles and responsibilities.
- Attendance of monthly status calls with USAEC and USACE (coordinated with RI contract calls) and preparation of meeting minutes
- **Draft PMP** for the overall contract (Draft 7/24/24)
    - Includes communication approach, overview of project, and a suggested payment schedule
    - Contractor Quality Control Plan included
    - Draft QASP will be submitted with the PMP for review by USACE and USAEC
    - **Final PMP** will address any comments received on the Draft PMP
- Preparation of **monthly status reports (MSRs)** with invoices and status trackers
    - Updated project schedule

CLIN 0002: Active and Former Fire Training Area Groundwater TCRA

- Work Plan / UFP-QAPP (QAPP) will be prepared including the following:
  - Details for the PDI and pre-PRB baseline monitoring, PRB installation, and post-PRB verification monitoring sampling
  - Monitoring well installation
  - Laboratory sheets
  - Points of contact
  - Includes E&S Plan and Waste Management Plan
  - Accident Prevention Plan (APP) and Site Safety and Health Plan (SSHP) with Traffic Control Plan included

- **Draft Work Plan / QAPP** submitted for USACE and USAEC for review
  - CX review
  - Regulatory review

- **Final Work Plan / QAPP** submitted following comment resolution

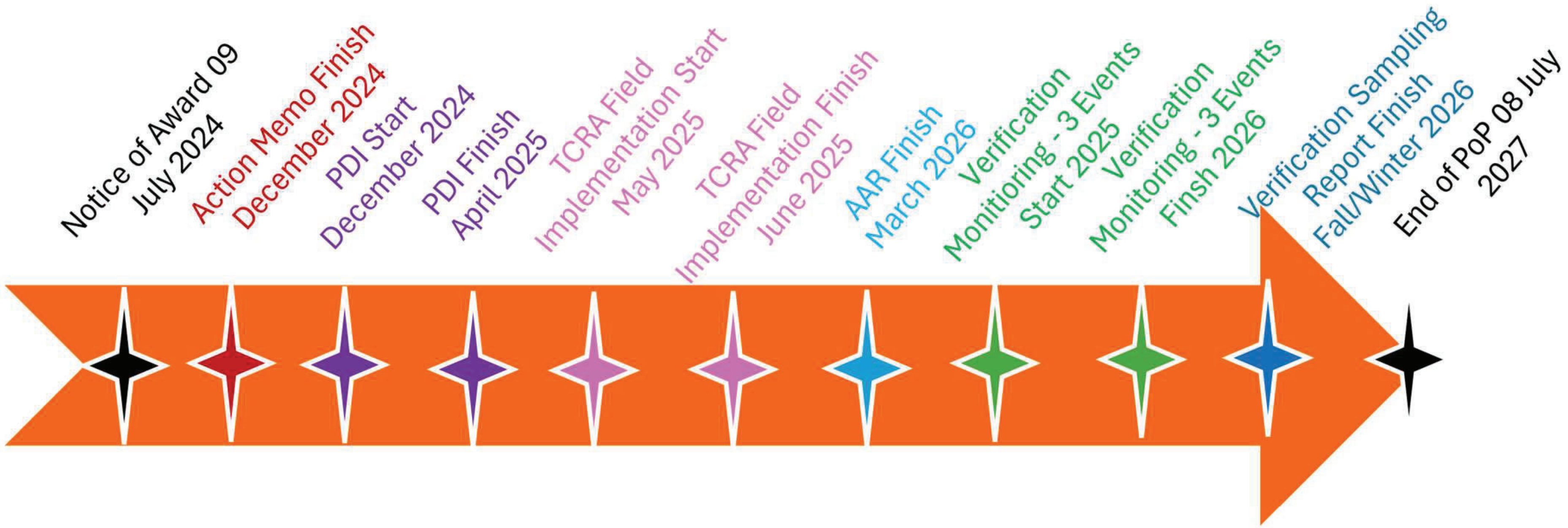
CLIN 0002: Active and Former Fire Training Area Groundwater TCRA

- Field work to include:
  - Monitoring well installation of a total of 10 new wells
    - 3 for PDI and 7 for CAC Injection
  - VAP to delineate PFAS plume
    - 10 shallow wells
    - 4 deep wells
  - Groundwater Sampling
    - Baseline (Pre-VAP)
    - Baseline (Pre-PRB)
  - PRB Installation (DPT Injection)
  - Verification Monitoring
    - Post PRB Installation

- Deliverables submitted for USACE review*:
  - Draft, Draft-Final and Final Action Memorandum
  - Draft, Draft-Final, Final Community Relations Plan
  - Draft, Draft-Final, Final Monitoring and Inspection Report
  - Draft, Draft-Final and Final After-Action Report

**Final Reports submitted following comment resolution*

Schedule



Notice of Award 09 July 2024

Action Memo Finish December 2024

PDI Start December 2024

PDI Finish April 2025

TCRA Field Implementation Start May 2025

TCRA Field Implementation Finish June 2025

AAR Finish March 2026

Verification Monitioring - 3 Events Start 2025

Verification Monitoring - 3 Events Finsh 2026

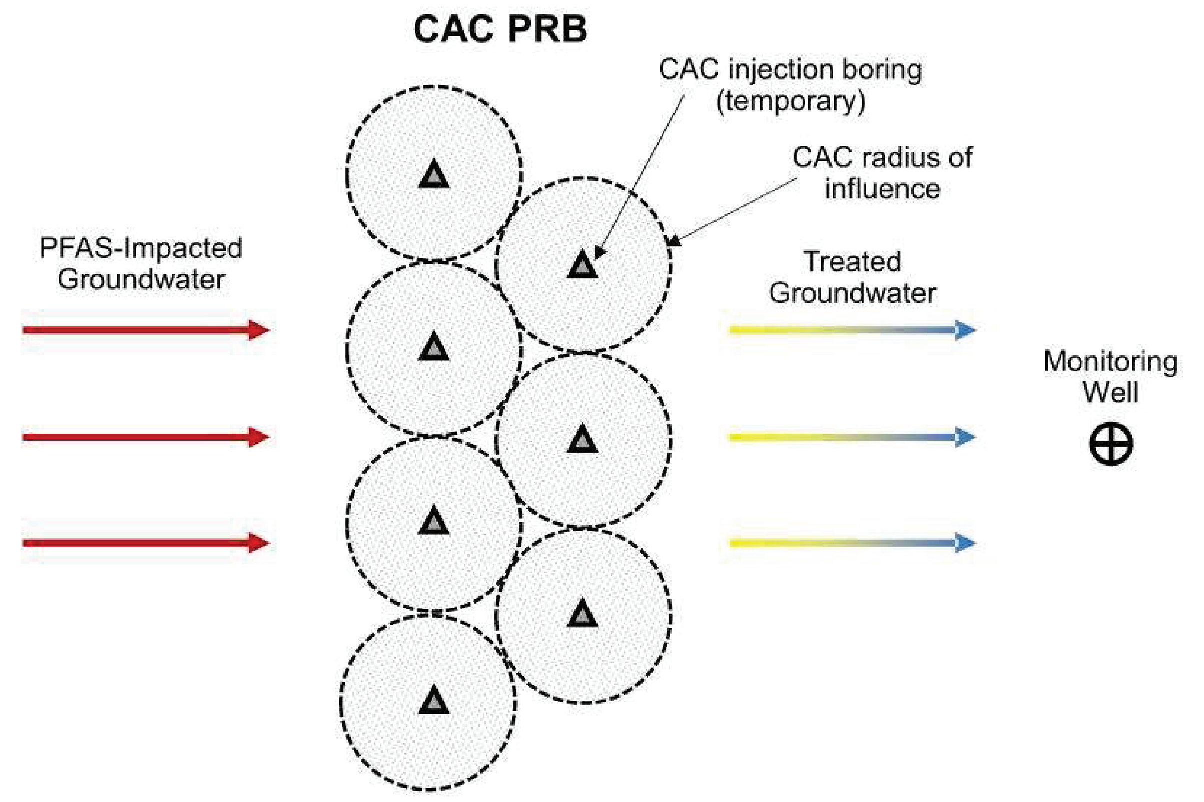
Verification Sampling Report Finish Fall/Winter 2026

End of PoP 08 July 2027

Dates are based on current schedule and will be updated accordingly monthly.

Overview of Technical Approach

- Pre-Design Investigation
- Permeable Reactive Barrier (PRB) – ColliodalChem Barrier (CAC)
- Verification Monitoring



CAC PRB

CAC injection boring (temporary)

CAC radius of influence

PFAS-Impacted Groundwater

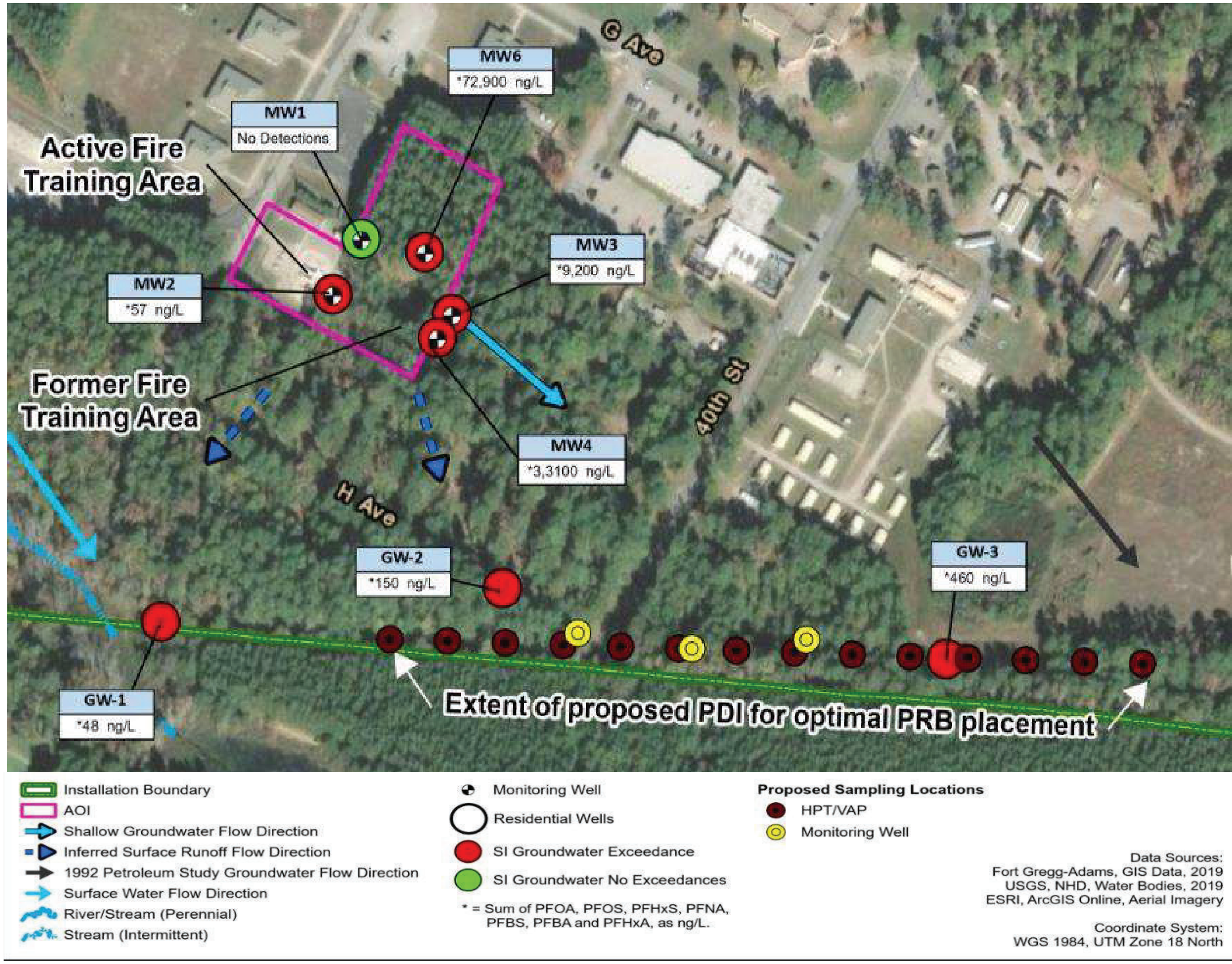
Treated Groundwater

Monitoring Well

- ➢ CAC PRB intercepts PFAS-impacted groundwater
- ➢ Groundwater is treated as it migrates through the PRB
- ➢ PFAS concentrations at downgradient monitoring wells take time to decline as treated water from the PRB mixes with impacted groundwater between the PRB and the monitoring well

Pre-Design Investigation

- Confirm groundwater flow direction near FTA and at post boundary
- Confirm lateral and vertical distribution of PFAS along southern post boundary to focus on highest concentrations of PFAS
- Combine hydro-stratigraphy and PFAS distribution data to generate a mass flux based CSM to determine PRB location and design
- Evaluate geochemistry and co-contaminants in groundwater to better understand the longevity and performance of PRB.



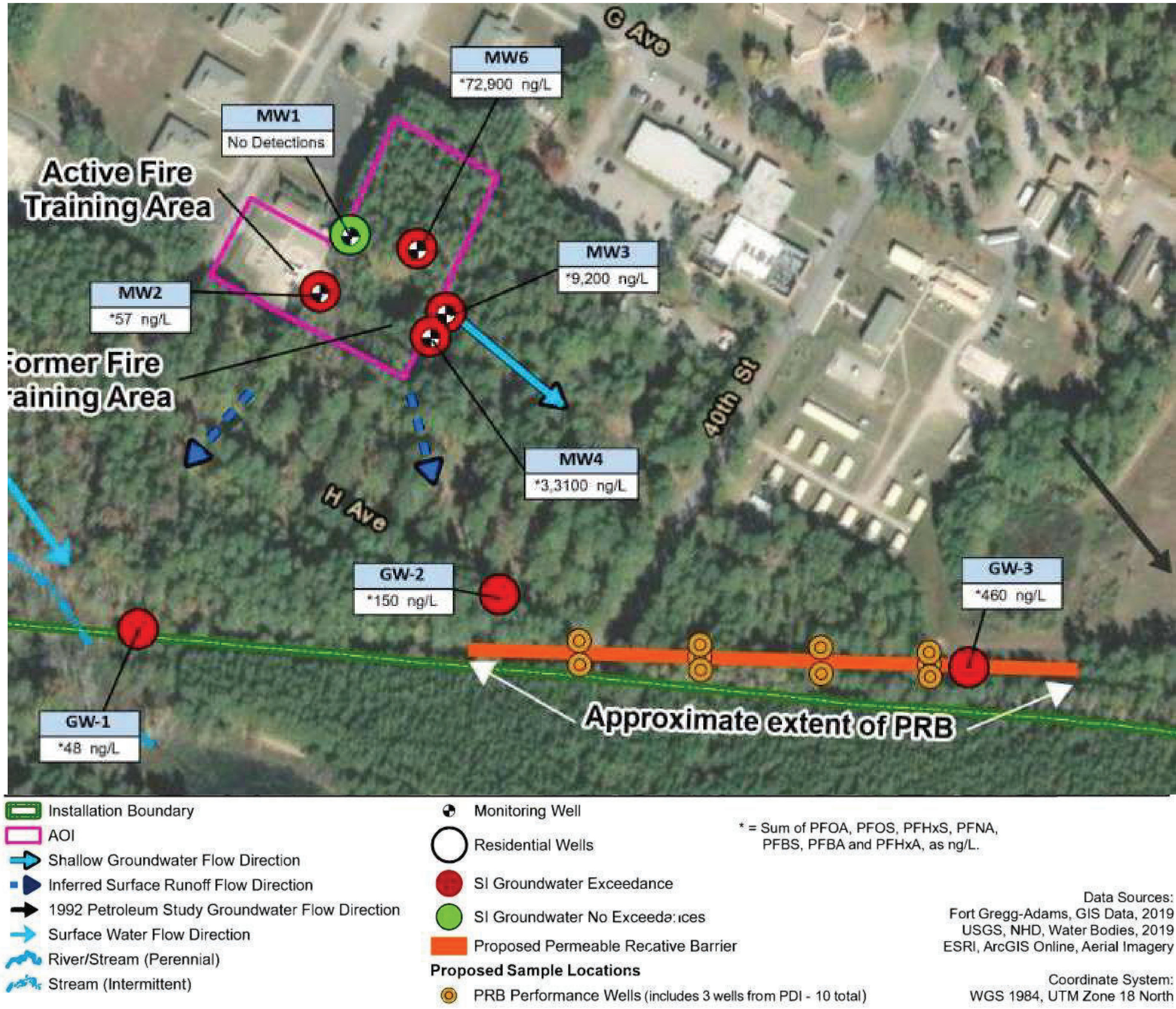
PRB – CAC Barrier

PRB Injection:

- 637 DPT locations
- Injection of ColloidalChem batch mixed with water.

Performance Monitoring Scope:

- Installation of 7 performance MW (10 total) approximately 5-15 ft bgs
- Conduct baseline GW monitoring at 10 MW prior to PRB installation
- Analysis by EPA Method 1633



Attachment 4

Technical Guidance Instruction – Geoprobe® Hydraulic Profiling Tool (HPT)

TGI - Geoprobe® Hydraulic Profiling Tool (HPT)

Rev: 4

Rev Date: June 20, 2024

Version Control

Issue	Revision No.	Date Issued	Page No.	Description	Reviewed By
	0	February 2013	8	Procedures for Use of the Geoprobe® Hydraulic Profiling Tool (HPT)	Joe Quinnan
	1	October 9, 2018	8	TGI – Geoprobe® Hydraulic Profiling Tool (HPT)	Nick Welty
	2	February 10, 2022		TGI – Geoprobe® Hydraulic Profiling Tool (HPT)	Patrick Curry
	3	February 6, 2023	All	Annual update approved by Patrick Curry. Revision # and revision date updated to reflect annual review approval.	Patrick Curry
	4	June 20, 2024	All	Annual review completed/approved by Patrick Curry	Patrick Curry

Approval Signatures

Prepared by:

6/20/2024

Ian Drost

Date

Reviewed by:

6/20/2024

Patrick Curry

Date

1 Introduction

This document provides a technical guidance instruction (TGI) for collecting and analyzing data with the Geoprobe® Hydraulic Profiling Tool (HPT). The general principles of the tool operation are described, as are the field procedures, post processing of the HPT data and general principles of data interpretation.

2 Intended Use and Responsibilities

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.

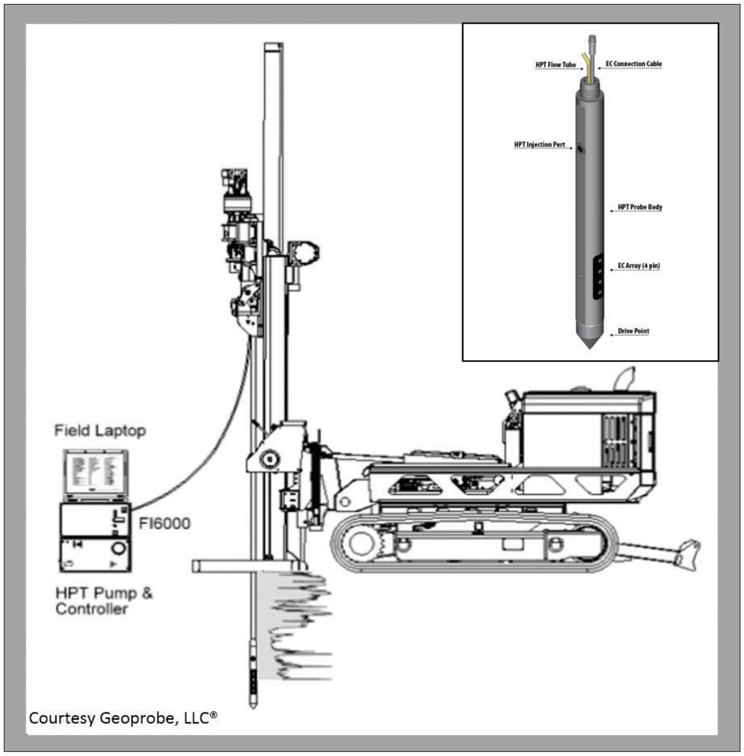
In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are 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.

3 Scope and Application

The HPT provides a continuous profile of relative soil permeability at the centimeter scale. The resulting profile can be used to correlate hydrogeologic units across a site and guide vertical aquifer profile (VAP) groundwater sampling. With knowledge of depositional setting, the HPT profiles can be used to infer hydrofacies and add geologic interpretation to guide interpolation between the soundings. The HPT is advanced through an unconsolidated aquifer using a standard direct push drilling rig. The HPT tool is attached to the end of a drill string and enables a continuous metered injection of small volumes of water (typically between 200 to 300 milliliters per minute) during advancement of the probe. At the same time, the fluid backpressure due to injection into the formation, as well as the flow rate, are measured and logged at a high frequency. After correcting for atmospheric and hydrostatic pressure effects, the flow and pressure data are plotted as relative hydraulic conductivity by recognizing that hydraulic conductivity (K) is proportional to flow divided by pressure (Q/P). An example HPT log is provided as **Attachment 1**.

The HPT also includes a dipole that logs the electrical conductivity of the soil to assist with correlating stratigraphy between HPT borings. Increasing clay content may correspond to increasing electrical conductivity. Other useful documents are provided on the Geoprobe website (http://geoprobe.com/hpt-technical-documents).

The ability of the HPT to resolve relative permeability of soils and achieve both the depth and sampling goals for a project, is governed by the geologic setting.



Courtesy Geoprobe, LLC®

Figure 1. Typical drilling setup for hydraulic profiling rig. The HPT or APS probe is advanced into the subsurface using a direct push drilling rig.

With the introduction of the 8040 series Geoprobe, the depth capabilities of direct push drilling have been extended to 100 feet or more in some geologic settings. However, for sites that require characterization deeper than 100 feet it is recommended that the tooling be tested at the site and confirmed to achieve the target depth. The HPT is very effective when utilized in aquifers with units of contrasting permeability. Sites dominated by very low-K soils (clay) or very high-K soils (well sorted sands and gravels) will provide only a maximum or minimum undifferentiated pressure and flow response and are not well-suited for the application of HPT. The typical range of K that provides a distinctive HPT response is 10^{-4} to 10^{-2} centimeters per second (cm/sec).

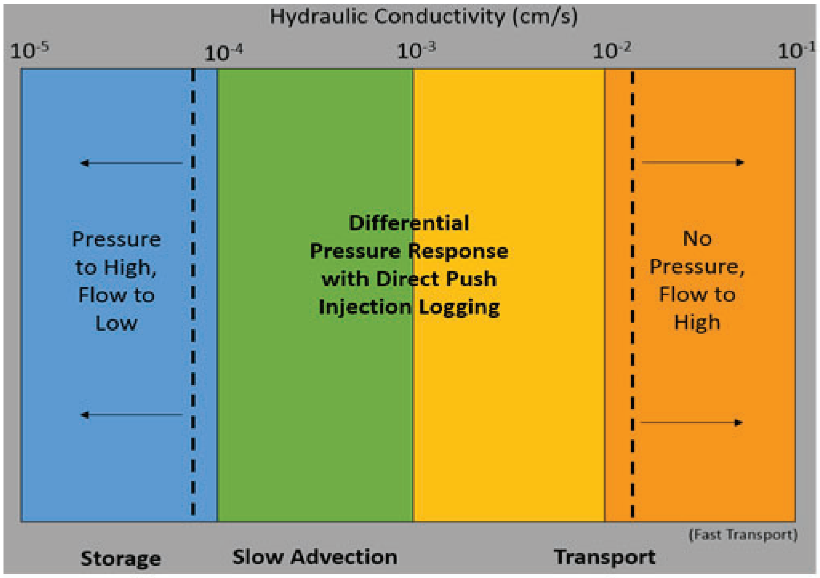


Figure 2. Range of hydraulic conductivity (permeability) that provides a unique response at standard injection rates.

4 Personnel Qualifications

Oversight of HPT drilling should be provided by an experienced geologist that is familiar with the general principals of hydrogeology. The Geoprobe® software package Direct Image® Viewer (DI Viewer) can be used to evaluate HPT data, provide final logs, and produce data in spreadsheet format for manipulation in Microsoft® Excel or other 3D modeling programs. Review of final HPT logs should be completed by a senior level geologist with familiarity with HPT design and function.

5 Equipment List

The advantage of drilling with HPT is the ability to communicate the boring results to the project team in near real-time. The project team can then collaborate on the decisions (such as what intervals to groundwater sample) and modify the work plan as needed to best accomplish the goals of the investigation. Therefore, unlike traditional drilling methods, the only equipment required of the field personnel is that which facilitates preparation and transmittal of the HPT data, including:

- Field Book or Tablet
- Cell Phone
- If real-time evaluation and data compilation is required - laptop computer and Satellite Internet hotspot capability for transmitting HPT data via email
    - Requires Geoprobe DI Viewer software package

- USB thumb drive

Cell Phone – when real-time entry is not required - can be used to photograph logs in the field and transmit to the project team via text or email.

6 Cautions

Prior to beginning field work, the ARCADIS utility clearance policy must be review and implemented. The ARCADIS utility clearance policy is outlined on the Health and Safety Team Site. (https://arcadiso365.sharepoint.com/sites/Intranet-ANA-Health-Safety/Shared%20Documents/Utility%20and%20Structures%20Checklist_Rev%2017_13%20May%202020.pdf)

The amount of water added to a given aquifer by the HPT is very small (typically 200-300 ml/min at an average drilling of 2 centimeters per second); however, if desired or required, fluorescein dye can be added to HPT injection water and monitored for during follow-up groundwater sampling. The general use of tracers to track drilling fluids is summarized in the Vertical Aquifer Profiling TGI available on the Arcadis Source website: (https://arcadiso365.sharepoint.com/teams/QMS/SitePages/QMS-Training-Dashboard.aspx)

Grouting of HPT boreholes requires removing the HPT tooling, re-drilling the hole to final depth with drilling rods and drive-point and injecting grout during the removal of the rods. Specifications of materials used for grouting will be selected to meet state and/or federal requirements, if any, as well as project quality objectives. For aquifers without significant confining units, natural collapse may be sufficient to abandon the borehole.

HPT should not be used within source zones where dense non-aqueous phase liquid (DNAPL) is suspected or possible. Typically, the best approach for evaluating a DNAPL source zone uses methods such as dye-laser induced florescence (Dye-LIF), continuous whole-core soil sampling with NAPL dye testing, or a combination of both.

7 Health and Safety Considerations

Field activities associated with HPT drilling will be performed in accordance with a site-specific Health and Safety Plan (HASP), a copy of which will be present on site during all drilling activities.

8 Procedure

Pre-Field Activities

Before completing an HPT investigation, the project team should review existing boring logs and have a general understanding of what to expect for HPT response. Whenever possible, the first HPT boring should be completed in the vicinity of a continuously sampled and logged soil boring where there is reasonable confidence in the logged lithology. If beginning an investigation near an existing boring is impractical, or if there are no pre-existing borings, a calibration boring should be completed adjacent to the first HPT boring to provide a lithologic correlation to the HPT response curve. It is critical to account for the calibration process whenever planning to use HPT. Calibration soundings allow accurate interpretation of the HPT data, so they must be accounted for in project schedules and budgets. Soil description for the calibration boring should adhere to the Soil Description

TGI located in The Source SOP catalog (https://arcadiso365.sharepoint.com/teams/QMS/SitePages/QMS-Training-Dashboard.aspx).

In general, the completion of HPT borings on a transect (or transects) at regularly spaced intervals provides the best results for aquifer characterization. Transects should be completed either perpendicular or parallel to groundwater flow within the groundwater plume or area of interest. This approach provides a high-resolution cross-section of hydrostratigraphic units controlling groundwater flow. The spacing and depth of the borings and the length of the transect should be selected based on considerations such as the size of the plume, the goals of the investigation, and budget.

If HPT is to be used in combination with VAP sampling a provision should be made to complete measurements of absolute hydraulic conductivity for comparison to the HPT data. Hydraulic conductivity measurements could be based on sieve analysis, slug testing of VAP intervals, or specific capacity testing completed during VAP interval pumping.

Communication

A clear line of communication between the geologist providing oversight and the HPT operator should be established prior to drilling. The monitor that provides the HPT readout should be positioned so as to be viewable by both the Arcadis geologist and the drilling personnel. Following completion of the HPT drilling, the HPT data should be copied to a secured website provided by the subcontractor, or to a thumb drive and transferred to the Arcadis geologist’s laptop for analysis. The log can then be emailed to the project team for discussion or photographed and transmitted via cell phone.

General HPT Drilling Methodology

The HPT is attached to a standard direct push drill string. The trunk line, supplying injection water and relaying information to and from the tool, is threaded through the drilling rods. Older versions of the HPT system use the “Direct Viewer” monitor that has a small LCD readout showing the HPT response. Newer versions are connected directly to a laptop and the real-time information is displayed through the laptop monitor. Setup of the HPT will be handled by the drilling subcontractor.

Before an HPT boring begins, pre-test calibration is performed to ensure the HPT pressure and EC responses are consistent with expected values. Arcadis field staff should ensure this process is completed and documented in the field notes. The HPT is then advanced into the subsurface with the direct push rig at an average rate of 2 centimeters per second (cm/sec). The typical injection rate is 200-300 milliliters per minute (ml/min).

Once below the water table a “dissipation test” should be completed to verify the elevation of the water table. During a dissipation test the drilling is paused and the HPT flow is turned off. The pressure response is then recorded as it returns to a stable baseline reading consistent with ambient hydrostatic pressure. The dissipation test results are used post drilling to correct the HPT pressure curve for hydrostatic pressure effects. The test is also required for the Geoprobe DI Viewer® software to determine the estimated hydraulic conductivity profile curve (Est K). It is recommended that dissipation tests be completed in a low-pressure response region of the aquifer (corresponding to higher K soils) to expedite the return to static conditions. At least two dissipation tests should be completed per borehole; one within a relatively shallow portion of the aquifer and second test within a deeper interval of the aquifer near to the total depth of the boring. Note that the dissipation tests should be performed above and below apparent confining units. This data can be used post investigation to evaluate vertical gradient at the site and is helpful for understanding connectivity between permeable zones.

Following completion of the HPT boring, post-test calibration will be performed to verify HPT performance and quantify sensor "drift", if any, during borehole advancement. Arcadis field staff should ensure this process is completed and documented in the field notes.

Grouting of HPT boreholes requires removing the HPT tooling, re-drilling the hole to final depth with the drilling rods and a drive-point and then injecting grout while pulling the rods out of the borehole. Specifications of materials used for grouting will be selected to meet state and/or federal requirements, if any, as well as project quality objectives. For aquifers without significant confining units, natural collapse may be sufficient to abandon the borehole.

Post Processing of HPT Data

Interpretation of the HPT data should be completed by a geologist familiar with the principles of hydrostratigraphy and hydrogeologic interpretation. Correlation of HPT response to geologic units should consider existing soil descriptions and nearby boring logs, as well as absolute K measurements completed during the HPT field activities.

Post-processing of the HPT response data can be completed using the DI Viewer software. A copy of the raw HPT files is required to manipulate the data using DI Viewer. The DI Viewer software can be used to produce a variety of logs for the final project deliverable. Once the dissipation test data is manipulated and the pressured data corrected for hydrostatic effects, the Est K profile can be generated for display alongside the HPT pressure, flow and EC curves. As mentioned above, a dissipation test is required for the DI Viewer software to determine an Est K curve for the boring. The Est K is a product of the Q/P curve corrected by an empirical relationship developed by Geoprobe using the relationship of Q/P and correlated absolute K measurements collected within the central US.

Any or all of the datasets can be exported from DI Viewer to a text based or Excel format for further manipulation, or used to import the curves into logging programs (e.g., gINT) or 3D modeling platforms such as Earth Volumetric Studio (EVS). Project teams should contact the Smart Characterization Community of Practice team members for help or advice on how best to manipulate HPT data.

The DI Viewer Est K profile is a good approximation of hydraulic conductivity within the appropriate window (~10^{-4} to 10^{-2} cm/sec), but should not be relied upon as an absolute value of hydraulic conductivity. When possible, hydraulic testing should be combined with an HPT investigation to verify hydraulic conductivity and help calibrate the HPT Est K results. Post processing of the data can include a comparison of the Q/P curve to absolute hydraulic conductivity measurements collected from the site such as slug tests or sieve analysis.

Vertical Aquifer Groundwater Sampling

The HPT Est K or pressure curves are typically used to target zones for VAP sampling. In most cases, the most efficient way to complete an HPT/VAP investigation is to complete the HPT profile first and then drill an adjacent borehole with standard Geoprobe screen-point tooling to collect the VAP samples. The screen-point should be advanced to a higher permeability (low pressure or higher Est K) zone of interest and opened to collect a groundwater sample. VAP sampling strategies are beyond the scope of this TGI, however, there are two ways to collect a series of VAP samples: top-down sampling or bottom-up sampling. Sampling top-down requires pulling the tooling after each sample interval followed by decontaminating the tooling, resetting the sampler, and then advancing the tooling to the next planned interval. Bottom-up sampling consists of driving the sampling device to the bottom of the target aquifer, opening the sampler, and then stopping at the additional prescribed sample intervals during retrieval of the sampler. 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. There are several general rules that guide the decision to complete top-down or bottom-up sampling. These rules require answering the following questions:

1) Are the impacts at the top or bottom of the aquifer, or unknown?
2) Are confining layers present in the aquifer that could affect mass distribution?
3) Is there potential for DNAPL to be present in the aquifer?

If the dissolved phase mass is situated at the top of the aquifer, and zone of interest is free of confining units and there is no potential for DNAPL, then bottom-up sampling is a reasonable approach with limited potential for cross-contamination.

9 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, or groundwater collected during VAP sampling will be collected and contained on-site 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.

10 Data Recording and Management

Digital data collection is the Arcadis standard using available FieldNow® applications that enable real-time, paperless data collection, entry, and automated reporting. Paper forms should only be used as backup to FieldNow® digital data collection and/or as necessary to collect data not captured by available FieldNow® applications. The Field Now® digital form applications follow a standardized approach, correlate to most TGIs and are available to all projects accessible with a PC or capable mobile device. Once the digital forms are saved within FieldNow®, the data is instantly available for review on a web interface. This facilitates review by project management team members and SMEs enabling error or anomalous data detection for correction while the staff are still in the field. Continual improvements of FieldNow® applications are ongoing, and revisions are made as necessary in response to feedback from users and subject matter experts.

Following completion of the HPT drilling, the HPT data should be posted to a secured website provided by the subcontractor or copied to a disc or thumb drive and transferred to the Arcadis geologist’s laptop for analysis and then emailed to the project team for discussion, or photographed an emailed or tested to the team via cell phone.

11 Quality Assurance

Following the processing of the HPT data, a senior review should be completed by a geologist familiar with the operation and application of the HPT, and should include a thorough review of the HPT dissipation tests, calibration data, and a review of the final deliverable.

12 References

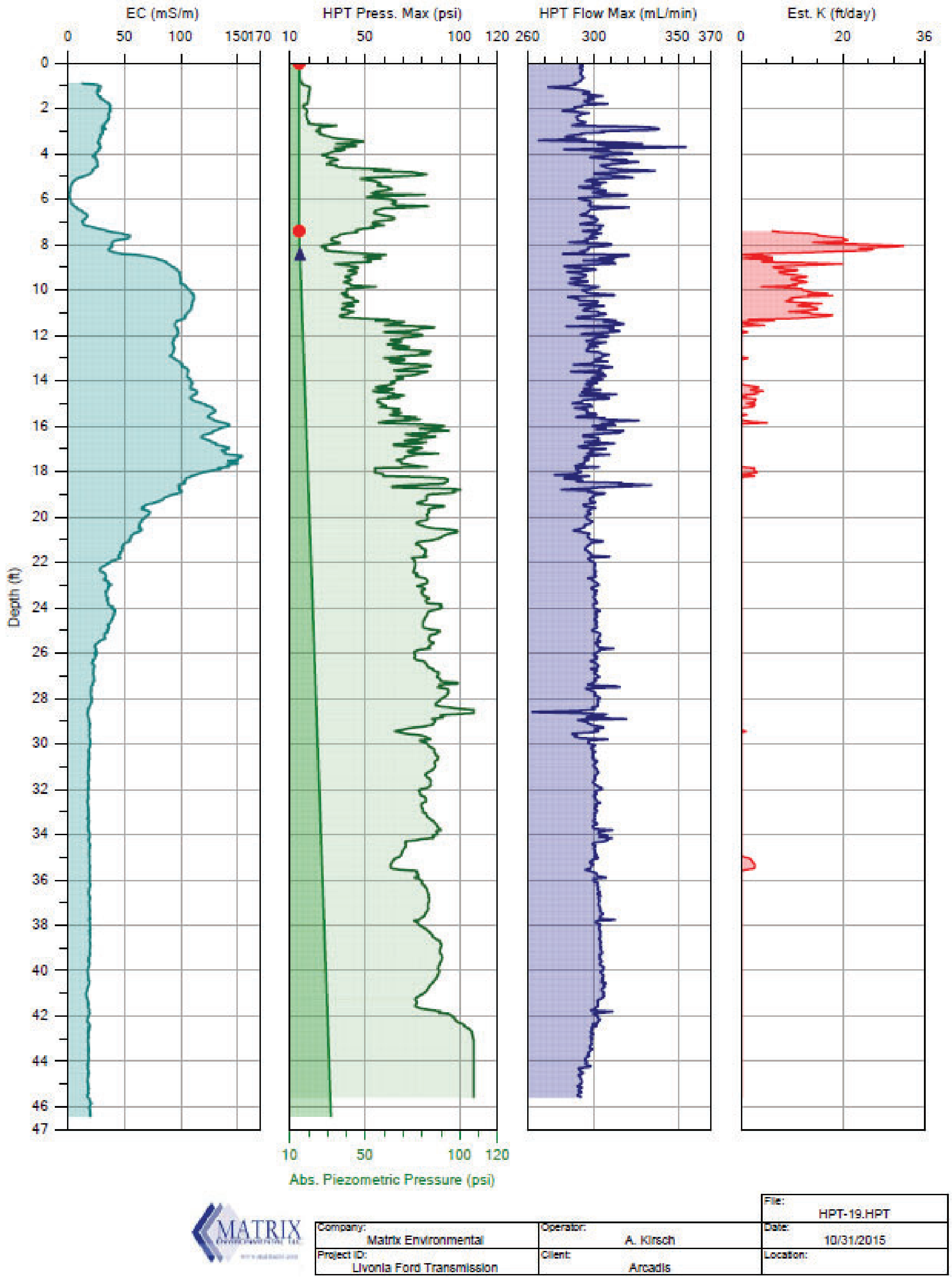
Not Applicable.

13 Attachments

Attachment 1 - Geoprobe Hydraulic Profiling Tool - HPT Attachment 1 Example Log

Attachment 1

Geoprobe Hydraulic Profiling Tool - HPT Attachment 1 Example Log



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Company: Matrix Environmental
Operator: A. Kirsch
Date: 10/31/2015
Project ID: Livonia Ford Transmission
Client: Arcadis
Location:

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U.S. ARMY CORPS OF ENGINEERS
ACTION MEMORANDUM FOR TIME-CRITICAL REMOVAL ACTION GROUNDWATER TREATMENT IN THE FIRE TRAINING AREA FOR PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)

FOR

FORT GREGG-ADAMS, VIRGINIA
WEBCASS-E CDRL ID: 51315.1044

MARCH 2025

I. PURPOSE

This Action Memorandum documents the approval and decision by the United States (U.S.) Army (Army) to conduct a time-critical removal action (TCRA) in response to the release of per- and polyfluoroalkyl substances (PFAS) associated with past operations at the Fire Training Area (FTA) located near Hobby Avenue and 38th Street that could potentially impact off-post drinking water near Fort Gregg-Adams, Virginia (**Figure 1**).

The Army completed a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, 42 U.S. Code [U.S.C.] §9601 et. seq.) Preliminary Assessment (PA) and Site Inspection (SI) in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP, 40 C.F.R. §300.420), to address actual and potential exposure to PFAS to nearby human populations from hazardous substances or pollutants or contaminants [40 Code of Federal Regulations [CFR] §300.415(b)(2)(i)], and actual or potential contamination of drinking water supplies [40 CFR §300.415(b)(2)(ii)] at Fort Gregg-Adams (**Figure 2**) (Arcadis 2022). Perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) have been listed as hazardous substances under CERCLA (Environmental Protection Agency [EPA] 2024) effective April 10, 2024. Historical sampling of PFAS at the Fort Gregg-Adams FTA detected PFOS as high as 8,330 parts per trillion (ppt), PFOA as high as 8,500 ppt , perfluorononanoic acid (PFNA) as high as 1,400 ppt, and perfluorohexane sulfonic acid (PFHxS) as high as 43,000 ppt in groundwater wells. These detections exceed the PFAS EPA Maximum Contaminant Levels (MCLs) promulgated on April 10, 2024 of 4 ppt for PFOS and PFOA and 10 ppt for PFNA and PFHxS by several orders of magnitude. At the FTA, groundwater flows to the south/southeast direction off-post. PFOS concentrations along the southern boundary of Fort Gregg-Adams downgradient of the FTA have been detected at concentrations of 29 ppt, and PFOA has been detected as high as 91 ppt. Residences are located approximately 0.5 mile downgradient of the installation boundary.

This Action Memorandum documents the Army's decision to mitigate human exposure to PFAS in drinking water, where the Army is the potential source of exposure above the EPA MCLs. Based on historical reports and the final PA/SI report, the PFAS compounds could be attributed to historical operations of the FTA at Fort Gregg-Adams. Therefore, the Army will perform an expedited installation of a permeable reactive barrier (PRB) with colloidal activated carbon (CAC) injections along the southern installation boundary (**Figure 3**) to address exposure to PFAS in drinking water supplies or sensitive ecosystems from the FTA at Fort Gregg-Adams. This PRB will be placed between the highest concentrations at the FTA and the drinking water receptors (i.e. residences) to intercept PFAS groundwater with the objective of reducing the PFAS concentrations in groundwater after the point of treatment to at or below MCLs, thus mitigating PFAS migration in groundwater to off-post receptors. All necessary documentation will be prepared to conduct this effort as a CERCLA TCRA (40 CFR §300.415(b)) in accordance with the Superfund Removal Guidance for Preparing Action Memoranda (EPA 2009). The FTA is concurrently an Area of Interest in a Remedial Investigation (RI) (40 CFR §300.430) for PFAS to further delineate the nature and extent of the PFAS release and evaluate the risks posed to human health.

This Action Memorandum is issued in accordance with and satisfies the requirements of CERCLA, Title 42 U.S.C. 9601 et seq., and the NCP, Title 40 CFR Part 300. The Defense Environmental Restoration Program, 10 U.S.C. § 2700 et seq., is the environmental restoration program the military services follow to conduct CERCLA response actions and satisfy CERCLA lead agency responsibilities as delegated by Executive Order (EO) 12580 (EO 12580 1987).

II. SITE CONDITIONS AND BACKGROUND

A. Site Description

1. Physical Location and Description

Fort Gregg-Adams is approximately 5,900 acres and is located in Price George County, Virginia, west/southwest of the City of Hopewell and northeast of Petersburg. The installation is bounded to the north by the Appomattox River and to the west, east, and south by residential and light commercial development and Petersburg National Battlefield Park. The installation acreage includes a 1,600-acre Range Complex, a 400-acre Ordnance Campus, and a nearly 3,800-acre Cantonment area separated by state highways. According to the U.S. Census Bureau, approximately 5,763 residents lived at Fort Gregg-Adams in 2022. Each year, approximately 70,000 troops pass through the Fort Gregg-Adams classrooms.

2. Site Operations History

The installation, originally known as Camp Lee, was built in 1917 and was in use until 1924, coinciding with the end of World War I. Operations resumed in 1941, with the start of the Quartermaster Replacement Training Center, and the installation has been continuous operation since. Camp Lee obtained permanent status in 1950 and was designated as Fort Lee. In 2005, as part of Base Realignment and Closure mandates, Fort Lee was designated as the Army Sustainment Center of Excellence and became a focused training base for military supply, subsistence maintenance, munitions, and transportation. This change resulted in the construction of multiple new facilities and the modernization and revitalization of existing infrastructure. In 2023, Fort Lee was redesignated as Fort Gregg-Adams.

A former FTAs was reportedly operational from the 1960s through the early 1980s. An unknown volume of aqueous film-forming foam was reportedly used at the former FTAs (unlined pits) during that time. For the oldest former FTA, no historical documents are available, and the location of the pit is estimated based on historical aerial imagery in the northern portion of the Area of Interest boundary (north of MW-03).

An active FTA is currently in use in the area and consists of three propane-fed and concrete-lined pits that are used for fire simulations during training activities. Prior to the concrete pit construction, the area was an earthen dike with a metal pan (burn pad) on the bottom where diesel fuel was ignited for training exercises. A metal pipe with a valve was also installed through the dike for drainage. The concrete area was constructed on top of the old FTA according to installation personnel. Drainage from the active pit is to the southeast (ECC 2008). Sodium bicarbonate (baking soda) and water are currently used for fire training activities in this training area. Purple K has previously been used at the active FTA on a tactical fire training trailer until the 1990s. Purple K is a potassium bicarbonate-based fire suppressant and does not contain PFAS. The trailer was reportedly not equipped to use aqueous film-forming foam and used nitrogen cylinders, according to the installation Compliance Chief.

3. Current and Projected Land Use

Fort Gregg-Adams is an operating installation. The perimeter of the Post is fenced with guarded gates allowing public access to active portions of the installation. Approximately half of the installation is developed, while the other half remains a mix of forest and residential on-post housing (Fort Lee Command Team 2019). In accordance with Base Realignment and Closure legislation passed in 2005, Fort Gregg-Adams has undergone significant development and revitalization; construction was completed in 2011. The site is expected to continue to remain a military training installation and provide on-post residential housing for active service members and their families (Fort Lee Command Team 2019).

The historical land use of the FTA was as an FTA between the 1960’s through the early 1980’s, during which time AFFF was used. The FTA is located in the southern portion of the installation and the installation boundary is less than 0.25 mile from the FTA. The FTA currently consists of three propane fed and concrete lined pits that are used for fire training activities using sodium bicarbonate and future projected land use is anticipated to remain unchanged.

4. Site Evaluation

In 2014, Fort Gregg-Adams had groundwater samples collected for PFOS and PFOA from existing monitoring wells at the FTA site and analyzed by United States Environmental Protection Agency (USEPA) Modified Method 537. The results of this sampling indicated presence of PFOS and PFOA at maximum concentrations of 8,330 nanograms per liter (ng/L) and 6,840 ng/L, respectively (i.e., at MW-06) in the area of release, also known as the source area. As part of a nationwide effort to complete PAs and SIs on Army installations on the use, storage or disposal of PFAS-containing materials, a PA and SI were completed at Fort Gregg-Adams to identify and investigate sites that were determined to have had a release of PFAS-containing materials.

During the SI, a groundwater sample was collected on April 9, 2020 via direct push technology (DPT) at first encountered groundwater at the installation boundary southwest of the FTA. PFOS was detected FTLEE-FFTAFP-1-GW at a concentration of 4.8 ng/L. PFOA was below the limit of quantitation.

An additional groundwater sample was collected on April 2, 2021 via DPT at first-encountered groundwater downgradient and southeast of the site based on groundwater flow direction. PFOS and PFOA were detected at concentrations at FTLEE-FFTAFP-GW-02 of 30 ng/L and 31 ng/L, respectively.

On October 25, 2021, a groundwater sample was collected from a third location (FTLEE-FFTAFP-GW-3) located further southeast than FTLEE-FFTAFP-GW-02 of the FTA via DPT at first encountered groundwater. PFOS was detected at 29 ng/L, and PFOA was detected at 91 ng/L.

Based on the results of the SI, it was concluded that further investigation in a RI and a removal action is required to address immediate threats to human health and the environment (Arcadis 2022).

Existing groundwater sampling data was re-screened and compared to the promulgated EPA MCLs, where concentrations of PFOS are as high as 6,400 ppt, PFOA are as high as 8,300 ppt, and mixtures of PFBS, PFNA, PFHxS, and PFHxA are as high as 57,200 ppt (sum of PFBS, PFNA, PFHxS, and PFHxA) in groundwater in MW-06, which is located within the source area.

The water table is generally within 15 to 30 feet of the ground surface throughout the installation, the water table at the FTA is approximately 2 feet below ground surface. At the FTA, the groundwater generally flows south and southeast. Residential drinking water wells in the area south of Fort Gregg-Adams are generally in the Yorktown-Eastover aquifer that is separated from the shallow water table, however the Yorktown-Eastover aquifer may crop out at the surface (Arcadis 2022).

5. Release or Threatened Release into the Environment of a Hazardous Substance, Pollutant, or Contaminant

The historical operations information obtained during the PA and the sampling data obtained during the SI at Fort Gregg-Adams was used to identify areas where release(s) of PFAS may contribute to impacts in groundwater. The PA/SI results indicate that PFAS is present in groundwater at levels above human health risk levels. Although delineation of PFAS in groundwater has not been completed, testing results indicate that PFAS in groundwater at the FTAs could impact downgradient residences with drinking water wells within 0.5 miles from the site. SI results indicate that concentrations of PFAS increase as groundwater flows southeast away from the FTA. Therefore, the Army will take appropriate action under CERCLA to protect human health by performing this TCRA to install a PRB with CAC injections.

The Army will continue its CERCLA response actions, to include a RI, to determine the nature and extent of PFAS released from the on-post source areas and to evaluate potential risks to human health on- and off-post. This TCRA will mitigate PFAS exposure to off-post residents and the environment at concentrations greater than the MCLs in groundwater.

B. Other Actions to Date

1. Previous Actions

Previous actions related to PFAS include the CERCLA PA/SI and the CERCLA RI that is currently underway as described in Section I.

2. Current Actions

The Army is conducting a TCRA to address PFAS exceedances of the drinking water MCLs in groundwater at and downgradient of the FTAs. The Army will perform an expedited design and construction of a PRB. The objective of the treatment system is to reduce PFAS in groundwater with a goal of achieving groundwater PFAS concentrations at or below MCLs. The treatment system will involve a CAC PRB and will be supported by a Pre-Design Investigation (PDI) to refine the placement of the PRB, the installation of the PRB performance monitoring network and baseline sampling. The costs associated with these actions are $1,375,064.60 . The remedy was selected due to the proven effectiveness of CAC in the treatment of PFAS in groundwater, the flexibility to adapt the PRB as information becomes available as the RI progresses, and the minimal ongoing operations and maintenance costs for maintaining PRBs. CAC is more sorptive than granular activated carbon and groundwater is treated as it flows through the PRB, and the CAC creates a treatment barrier between the FTA and the installation boundary. Activated carbon is the most widely accepted and effective method to treat PFAS in water and CAC is designed to remain in-place at the selected point of treatment and eliminates the need to repeat injections. The PRB CAC will serve to mitigate the imminent threat by treating the area of the known highest concentrations of PFAS in groundwater along the southern installation boundary. All necessary documentation will be prepared to conduct this effort as a CERCLA TCRA.

The Army is also conducting a concurrent CERCLA RI to further delineate the nature and extent of the PFAS release and evaluate the risks posed to human health and the environment from the release. The purpose of the RI is to collect media samples from groundwater, soil, surface water, and sediment to characterize site conditions and determine the nature and extent of PFAS at the FTA. The RI process will use the results of the data collected to assess the risk to human health and the environment. The Army collected samples from off-post residences with drinking water wells, and analytical results indicated concentrations of PFOS and/or PFOA as high as 7.1 ppt each. PFAS concentrations in groundwater on-post at the installation boundary have shown concentrations of PFAS are increasing as they migrate towards the installation boundary. As groundwater flows through the PRB the CAC will intercept additional migration of PFAS off-post towards sensitive receptors.

3. Planned Actions

Planned activities to be completed as part of this TCRA include a work plan detailing the design criteria for the PRB including the objectives and details of a PDI. A PDI will be conducted to identify where the highest PFAS concentrations are occurring along the southern installation boundary near the FTA and refine the PRB design. Results of the PDI and final design for the PRB will be detailed in an After-Action Report. Verification monitoring of groundwater will be conducted upon completion of the installation of the PRB and results will be documented in a monitoring report. The Army will also continue to conduct CERCLA response actions including the RI and an evaluation of possible remedial actions, as appropriate, following the RI. This interim action will provide temporary protection while the final remedy is being developed and may be incorporated into the final remedy as a long-term solution. The Army is also evaluating the need to provide an alternate water source to impacted residences where concentrations of PFAS now exceed the MCLs.

C. Federal, State and Local Roles

1. Federal Agencies

The Army is the lead agency under CERCLA and EO 12580, and is conducting the RI as the lead agency, consistent with its authority under CERCLA, 42 U.S.C. §9600, et seq. (as amended), and the Defense Environmental Restoration Program, 10 U.S.C. §2701, et seq. This TCRA is consistent with 40 CFR §300.415(e)(9).

2. State Agencies

The Army is in coordination with the Virginia Department of Environmental Quality (VDEQ) of all results and progress through emails and phone conversations. The Army has partnered with VDEQ and future developments will be shared with VDEQ through continued briefings and meetings at key project milestones. Planning, schedule, and work plan documents will be shared to maintain communication and concurrence throughout the lifecycle of the project.

3. Local Authorities

The communities surrounding Fort Gregg-Adams have been notified of the results of PFAS investigations through mailings and through public notices. Most residents are connected to the public drinking water supply except for select residences that had previously elected not to connect to the public drinking water supply.

III. THREATS TO PUBLIC HEALTH, WELFARE, OR THE ENVIRONMENT

Section 300.415(b)(2) of the NCP lists the criteria to assess whether a removal action is appropriate. The factors most applicable to current site conditions related to Fort Gregg-Adams are discussed in the following subsections.

A. Threats to Human Health

Based on information gathered during the PA/SI, the Army identified a potential threat to human health and the environment due to the presence of PFAS in groundwater at Fort Gregg-Adams. Detections above the risk screening levels of 4 ppt (PFOS) and 6 ppt (PFOA) in groundwater have been confirmed in monitoring wells at the FTA. Significant exceedances of risk screening levels and MCLs for PFOS and/or PFOA have been confirmed in groundwater near the installation boundary downgradient of the FTA at Fort Gregg-Adams. Residences with private drinking water wells are located immediately downgradient of the installation boundary. Should contamination at the installation boundary migrate off-post, the cost to implement remedial alternatives off-post would take longer to implement and be less cost efficient, and cause disruption to the environment and community. Additionally, wetlands are located south of the installation boundary which could be a potential receptor and could potentially facilitate migration through a groundwater/surface water interface. Based on the site-specific circumstances, a TCRA is warranted to address potential exposure to PFAS in groundwater and drinking water above the MCLs for PFOS and PFOA from the FTA, and to immediately abate of migration of hazardous substance contamination. The following factors warrant this TCRA:

i. “Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants.”

ii. “Actual or potential contamination of drinking water supplies or sensitive ecosystems.”

B. Statutory and Regulatory Authorities

PFOA and PFOS are identified as hazardous substances as determined by CERCLA. PFAS detected in groundwater above the MCLs poses a potential threat to human health. The TCRA presented in this action memorandum is in accordance with 40 CFR §300.415 and serves to meet the requirements of the ASD memorandum "Memorandum for Taking Interim Actions to Address Per- and Polyfluoroalkyl Substances Migration from DoD Installations and National Guard Facilities” dated July 11, 2023 (ASD 2023). Data collected during the PA/SI and from the on-going RI support that an interim action can be taken to mitigate further PFAS plume migration or ongoing impacts to groundwater from the PFAS source area located on-post at Fort Gregg-Adams. The Army therefore is implementing a TCRA to urgently address removal of PFAS from groundwater by way of a CAC PRB.

IV. PROPOSED ACTIONS AND ESTIMATED COSTS

A. Proposed Action Description

The Removal Action Objective protects human health by implementing a treatment system to sorb PFAS from the groundwater. Prior to installing the PRB, a PDI will be completed to refine the PRB design. The PDI includes sample collection and analysis of soil and groundwater samples to evaluate site geochemical conditions and evaluate for co-contaminants that may refine the volume of CAC. Vertical aquifer profiling and a hydraulic profiling tool will be used to identify zones of higher permeability and conductivity. Groundwater samples will be collected to refine the understanding of PFAS in groundwater at the proposed location of the PRB. The treatment system's preliminary design consists of a performance monitoring well network, three parallel rows of CAC injection borings, and approximately 46,400 pounds of injected CAC. Performance monitoring wells will be installed upgradient, within, and downgradient of the PRB. Data from the PDI will be used to refine the location of the PRB and the mass of CAC needed. Additional features and quantities will be confirmed during the engineering and design phase, as needed.

B. Contribution to Remedial Performance

This removal action will reduce human exposure to groundwater containing PFAS above MCLs by installing a PRB that will adsorb these substances in place. The PRB will be installed by injecting CAC into the ground to a depth that intercepts PFAS-impacted groundwater. PFAS will be adsorbed onto the CAC as groundwater passes through the treatment barrier and PFAS concentrations in groundwater will be reduced. The Army is conducting appropriate CERCLA response actions, consistent with the NCP, to address potential releases of PFAS from past activities and determine the nature, extent, and source of PFAS contamination present at Fort Gregg-Adams. In accordance with the NCP, the selected removal action will control PFAS from migrating off-post and adsorb contaminants in place and supports a long-term remedial action with respect to the release or threatened release from the FTA by being a scalable solution by which can be amended or extended as additional data is gathered during the RI (40 CFR §300.415[d]).

C. Project Schedule

Installation activities are anticipated to begin in 2025, pending completion and acceptance of the remedial design and procurement of materials. A PDI remedy design refinement is anticipated to be completed in April 2025, with PRB installation to follow in May 2025. Samples will be collected prior to, and after, the PRB installation for a baseline monitoring event and three quarterly verification monitoring events, respectively, and analyzed for PFAS using USEPA Method 1633. The performance metric is the reduction of PFAS concentrations in groundwater at the point of treatment and will be based on the results of from downgradient performance monitoring wells.

D. Project Costs

This TCRA only applies to the implementation of the CAC PRB. Cost associated with this is estimated at $1,375,064.60 based on current contract costs.

E. Public Participation

A public comment period of no less than 30 calendar days will be held for this TCRA in accordance with 40 CFR §300.820(b)(2). The Army will inform the community of actions taken, respond to inquiries, and provide information regarding the removal action if responses are received. This Action Memorandum and the supporting Administrative Record will also be made available for public view.

As part of public outreach activities, a Community Relations Plan will be developed and will detail the approach to engage the community, stakeholder and local leadership to encourage community involvement in the cleanup process.

V. EXPECTED CHANGE IN THE SITUATION SHOULD ACTION BE DELAYED OR NOT TAKEN

A delay in action or no action regarding this TCRA FTA would result in potential human exposure to PFAS compounds through the migration of the hazardous substance.

VI. OUTSTANDING POLICY ISSUES

No outstanding policy issues are currently identified.

VII. ENFORCEMENT

There is no enforcement order for the removal action described in this Action Memorandum.

VIII. RECOMMENDATION

As the CERCLA lead agency, the Army documents the decision for a TCRA to mitigate human exposure to PFAS in groundwater and the environment in Prince George County and Petersburg, Virginia. This Action Memorandum was developed in accordance with CERCLA, as amended, and with the NCP. The NCP establishes the framework for responding to releases of hazardous substances and guides how the government and responsible party(ies) respond to cleanup actions. The TCRA is consistent with the Army's PFAS policy (Army 2018) and ASD policy (ASD 2024).

This Action Memorandum will be incorporated into the Administrative Record for Fort Gregg-Adams. Conditions meet the Section 300.415(b) criteria for a removal action. This memorandum, documenting the action, is approved by the undersigned.

Signatures

The signature documents the decision made to conduct the TCRA. The decision may be reviewed and modified in the future if new information becomes available that indicates the presence of pollutants, contaminants, hazardous substances or exposures that may cause unacceptable risk to human health or the environment.

RICHARD J. BENDELELWSKI
COL, MI
Commanding

____
Date

IX. REFERENCES

Arcadis. 2022. Final Preliminary Assessment and Site Inspection of Per- and Polyfluoroalkyl Substances, Fort Lee, Virginia. June.

Army. 2018. Final Army Guidance for Addressing Releases of Per- and Polyfluoroalkyl Substances. May. Available online at: https://www.fedcenter.gov/admin/itemattachment.cfm?attachmentid=1150.

ASD. 2023. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. August.

ASD. 2023. Memorandum: Memorandum for Taking Interim Actions to Address Per- and Polyfluoroalkyl Substances Migration from DoD Installations and National Guard Facilities. July 11.

ASD. 2024. Memorandum: Prioritization of Department of Defense Cleanup Actions to Implement the Federal Drinking Water Standards for Per- and Polyfluoroalkyl Substances Under the Defense Environmental Restoration Program. September 3.

CERCLA. 40 CFR §300.415(b)

CERCLA. 42 U.S.C. §9601 et. seq.

ECC. 2008. Draft Final Interim Removal Action Work Plan: Fire Training Pit, Installation Restoration Program, Fort Lee, Virginia. August.

EPA, “Designation of Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) as CERCLA Hazardous Substances,” Federal Register 89, no. 90 (May 8, 2024): 39124, https://www.govinfo.gov/content/pkg/FR-2024-05-08/pdf/2024-08547.pdf.

EO 12580. 1987. Superfund Implementation. Washington: Federal Register. January.

Fort Lee Command Team. 2019. About US Army Garrison Fort Lee. October. https://home.army.mil/lee/index.php/about

NCP. 40 CFR Part 300.

Figures

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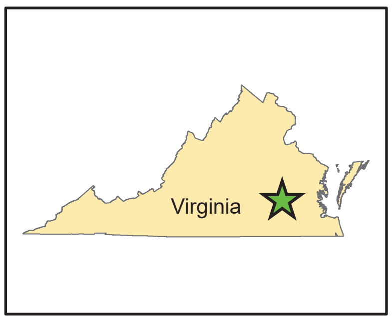
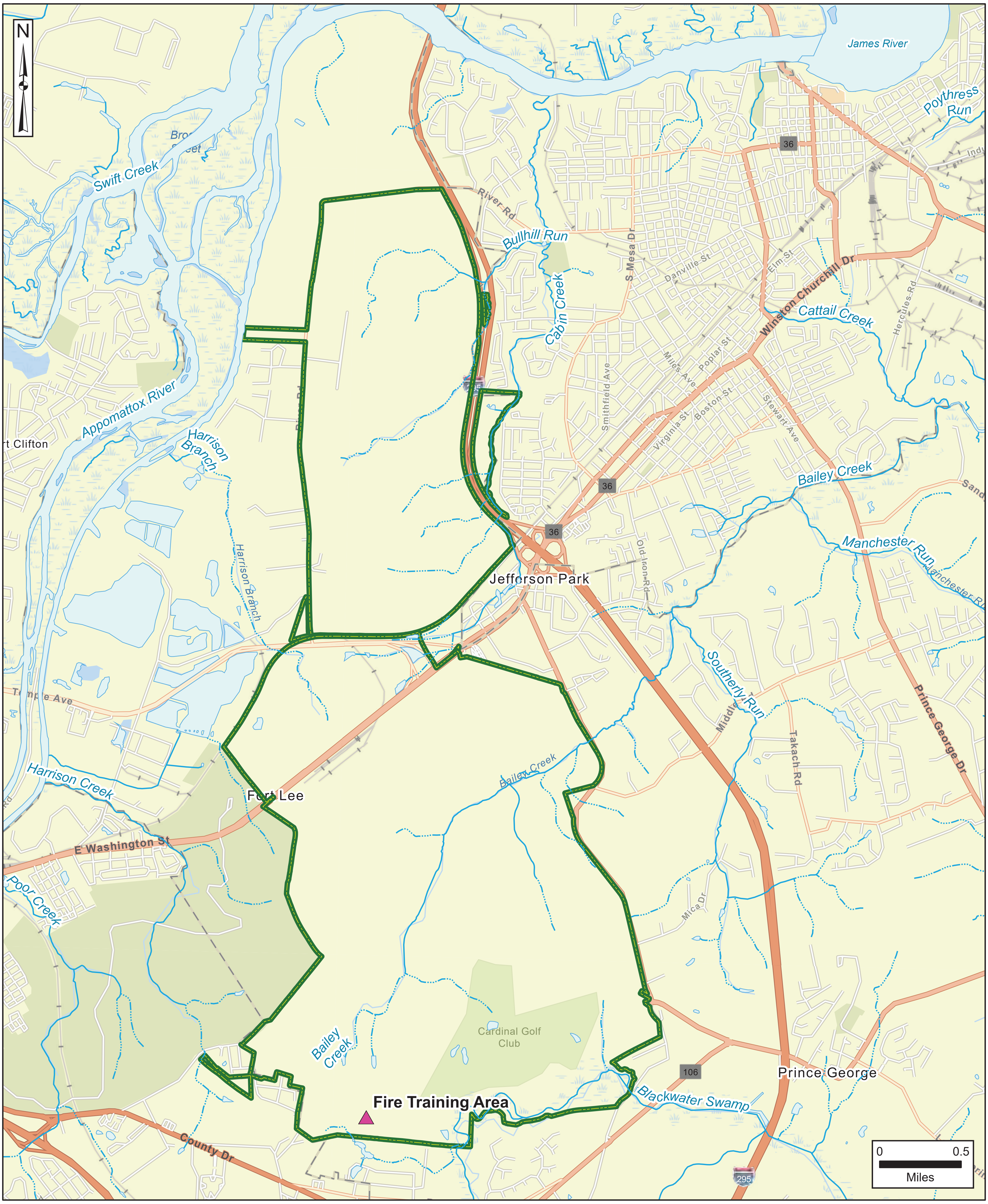
Action Memorandum for Time Critical Removal Action
Fort Gregg-Adams, Virginia

Figure 1
Fire Training Area Location





- 🟩 Installation Boundary
- ▲ AOI Location
- River/Stream (Perennial)
- Stream (Intermittent)
- Water Body

AOI = area of interest

Data Sources:
Fort Gregg-Adams, GIS Data, 2019
USGS, NHD, Water Bodies, 2019
EDR, Well Data, 2019
ESRI, ArcGIS Online, StreetMap Data

Coordinate System:
WGS 1984, UTM Zone 18 North

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Action Memorandum for Time Critical Removal Action
Fort Gregg-Adams, Virginia

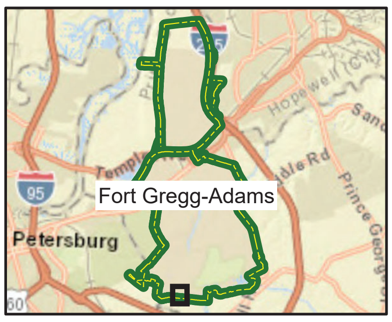
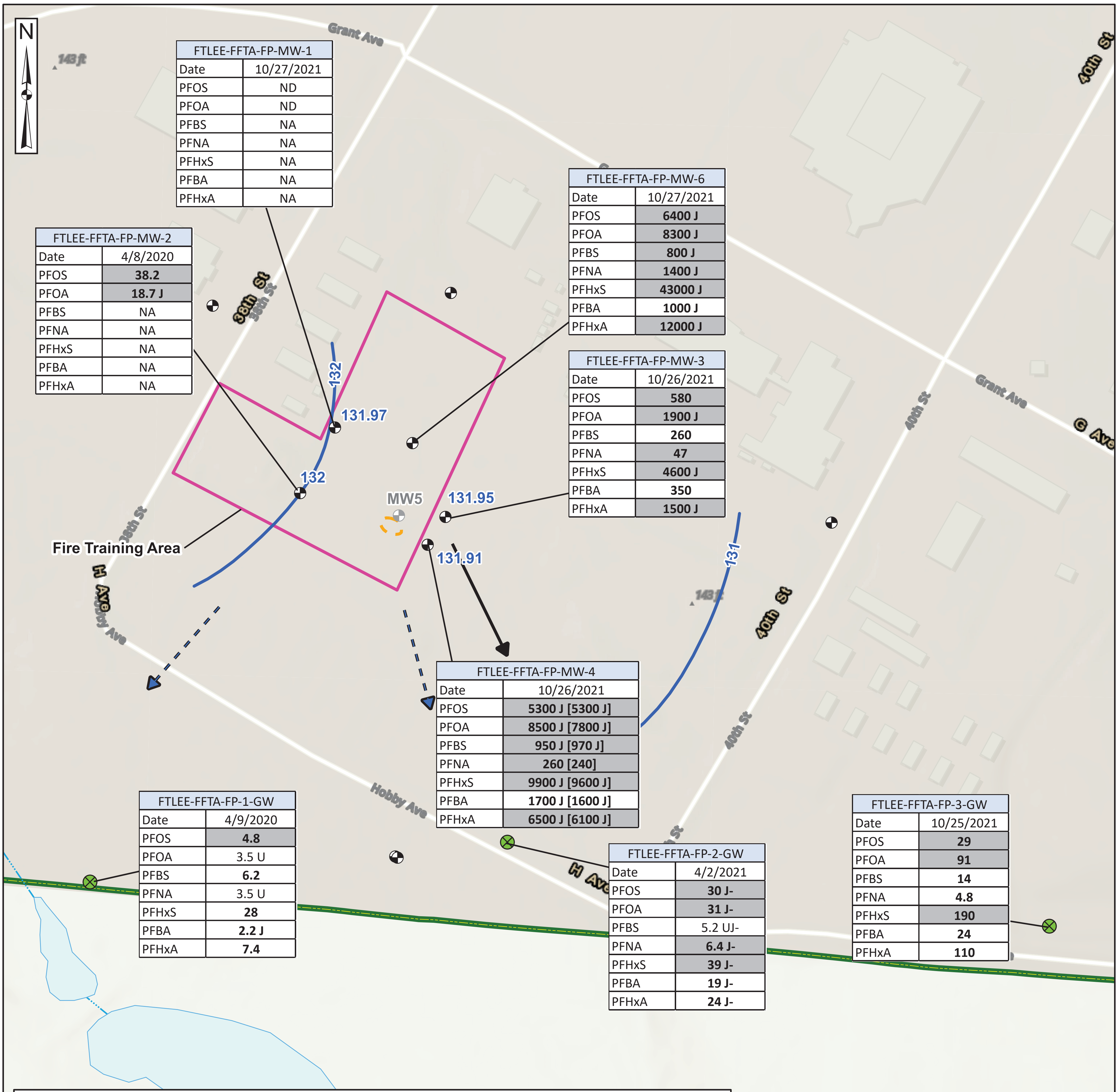


Figure 2
Fire Training Area
Site Inspection Analytical Results



FTLEE-FFTA-FP-MW-1	
Date	10/27/2021
PFOS	ND
PFOA	ND
PFBS	NA
PFNA	NA
PFHxS	NA
PFBA	NA
PFHxA	NA

FTLEE-FFTA-FP-MW-2	
Date	4/8/2020
PFOS	**38.2**
PFOA	**18.7 J**
PFBS	NA
PFNA	NA
PFHxS	NA
PFBA	NA
PFHxA	NA

FTLEE-FFTA-FP-MW-6	
Date	10/27/2021
PFOS	**6400 J**
PFOA	**8300 J**
PFBS	**800 J**
PFNA	**1400 J**
PFHxS	**43000 J**
PFBA	**1000 J**
PFHxA	**12000 J**

FTLEE-FFTA-FP-MW-3	
Date	10/26/2021
PFOS	**580**
PFOA	**1900 J**
PFBS	**260**
PFNA	**47**
PFHxS	**4600 J**
PFBA	**350**
PFHxA	**1500 J**

FTLEE-FFTA-FP-MW-4	
Date	10/26/2021
PFOS	**5300 J [5300 J]**
PFOA	**8500 J [7800 J]**
PFBS	**950 J [970 J]**
PFNA	**260 [240]**
PFHxS	**9900 J [9600 J]**
PFBA	**1700 J [1600 J]**
PFHxA	**6500 J [6100 J]**

FTLEE-FFTA-FP-1-GW	
Date	4/9/2020
PFOS	**4.8**
PFOA	3.5 U
PFBS	**6.2**
PFNA	3.5 U
PFHxS	**28**
PFBA	**2.2 J**
PFHxA	**7.4**

FTLEE-FFTA-FP-2-GW	
Date	4/2/2021
PFOS	**30 J-**
PFOA	**31 J-**
PFBS	5.2 UJ-
PFNA	**6.4 J-**
PFHxS	**39 J-**
PFBA	**19 J-**
PFHxA	**24 J-**

FTLEE-FFTA-FP-3-GW	
Date	10/25/2021
PFOS	**29**
PFOA	**91**
PFBS	**14**
PFNA	**4.8**
PFHxS	**190**
PFBA	**24**
PFHxA	**110**

Notes:
1. Groundwater results are reported in nanograms per liter (ng/L), which is equivalent to parts per trillion; the limit of detection for PFOA/PFOS/PFBS in groundwater and surface water = 2 ng/L.
2. Bolded values indicate detections.
3. Duplicate sample results are shown in brackets.
4. Concentrations of PFOS and PFOA that exceed the Office of the Secretary of Defense (OSD) risk screening level of 40 ng/L are highlighted gray.
5. MW-06 was not used to create contours because casing elevation data is not available.

Qualifiers:
J = The analyte was positively identified; however, the associated numerical value is an estimated concentration only.
J- = The analyte was positively identified; however the associated numerical value is an estimated concentration only; the result may be biased low.
U = The analyte was analyzed for, but was not detected above the limit of quantitation.
UJ- = The analyte was analyzed for but was not detected. The reported limit of quantitation is approximate and may be biased low.

0 100
Feet

- 🟩 Installation Boundary
- 🟪 AOI
- ◌ Former Fire Training Area Location
- ➔ Surface Runoff Flow Direction
- ➔ Groundwater Flow Direction
- — Groundwater Elevation Contour
- 132 Groundwater Elevation
- ● Monitoring Well
- ○ Monitoring Well Destroyed
- ⊗ Groundwater Sampling Location

AOI = area of interest
NA = not analyzed
OSD = Office of the Secretary of Defense
PFBA = perfluorobutanoic acid
PFBS = perfluorobutanesulfonic acid
PFHxA = perfluorohexanoic acid
PFHxS = perfluorohexane sulfonate
PFNA = perfluorononanoic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate

Data Sources:
Fort Lee, GIS Data, 2019
USGS, NHD, Water Bodies, 2019
ESRI, ArcGIS Online, Topo Map

Coordinate System:
WGS 1984, UTM Zone 18 North

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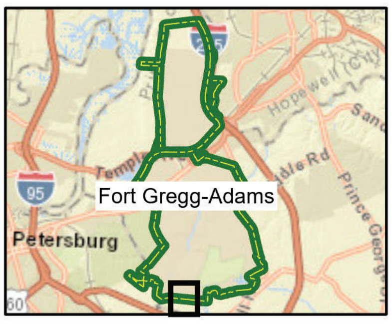
Action Memorandum for Time Critical Removal Action
Fort Gregg-Adams, Virginia

Figure 3
Fire Training Area Removal Action



- 🟩 Installation Boundary
- 🟪 AOI
- ➔ Shallow Groundwater Flow Direction
- ➔ Inferred Surface Runoff Flow Direction
- ➔ 1992 Petroleum Study Groundwater Flow Direction
- ➔ Surface Water Flow Direction
- River/Stream (Perennial)
- Stream (Intermittent)
- ◐ Monitoring Well
- 🟧 Proposed Permeable Reactive Barrier
- 🔴 SI Groundwater Exceedance
- 🟢 SI Groundwater No Exceedances

Data Sources:
Fort Gregg-Adams, GIS Data, 2019
USGS, NHD, Water Bodies, 2019
ESRI, ArcGIS Online, Topo Map

Coordinate System:
WGS 1984, UTM Zone 18 North