FINAL PRELIMINARY ASSESSMENT AND SITE INSPECTION OF PER- AND POLYFLUOROALKYL SUBSTANCES

Carlisle Barracks, Pennsylvania

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Preliminary Assessment and Site Inspection of Per- and Polyfluoroalkyl Substances

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EXECUTIVE SUMMARY

The United States (U.S.) Army (Army) is performing preliminary assessments (PAs) and site inspections (SIs) on per- and polyfluoroalkyl substances (PFAS) with a focus on perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and perfluorobutanesulfonic acid (PFBS) at Army installations (installations) nationwide. The PA identifies areas of potential interest (AOPIs) where PFAS-containing materials were used, stored, and/or disposed, or areas where known or suspected releases to the environment occurred. The SI includes multi-media sampling at AOPIs to determine whether or not a release has occurred. The SI may conclude further investigation is warranted, a removal action is required to address immediate threats, or no further action is required. This Carlisle Barracks PA/SI was completed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, National Oil and Hazardous Substances Pollution Contingency Plan, and Army/Department of Defense policy and guidance.

Carlisle Barracks is located in Cumberland County, in the south-central portion of Pennsylvania, east of the town of Carlisle. Carlisle Barracks is surrounded by residential neighborhoods to the north across U.S. Route 11, generally undeveloped farmland to the east, and the Borough of Carlisle to the south and west. Carlisle Barracks consists of 451 acres and includes a main cantonment area, golf course, and the Military History Institute's Academic Research Facility. The developed portions of Carlisle Barracks support a number of diverse functions: family and troop housing, educational facilities (e.g., the U.S. Army War College), and family support activities such as a health clinic, commissary, and the Post Exchange. The area surrounding Carlisle Barracks is predominantly rural (U.S. Army Corps of Engineers 2018).

The Carlisle Barracks PA identified five AOPIs for investigation during the SI phase. SI sampling results from the five AOPIs were compared to risk-based screening levels calculated by the Office of the Secretary of Defense (OSD) for PFOS, PFOA, and PFBS. PFOS, PFOA, and/or PFBS were detected in soil and/or groundwater at all five AOPIs; and two of the five AOPIs had PFOS, PFOA, and/or PFBS present at concentrations greater than the risk-based screening levels. The Carlisle Barracks PA/SI results indicate further study in a remedial investigation is warranted. **Table ES-1** below summarizes the PA/SI sampling results and provides recommendations for further study in a remedial investigation or no action at this time at each AOPI.

Table ES-1 Summary of AOPIs Identified during the PA, PFOS, PFOA, and PFBS Sampling at Carlisle Barracks, and Recommendations

AOPI Name	PFOS, PFOA, and/or PFBS detected greater than OSD Risk Screening Levels? (Yes/No/NA/NS)			Recommendation
	GW	SO	SW	
Current Fire Station (Building 400)	Yes	No	NS	Further study in a remedial investigation
Fire Station Storage Support Facility (Building 400B)	Yes	No	NS	Further study in a remedial investigation
Helipad - AFFF Equipment Testing Area	No	No	NS	No action at this time
AFFF Storage (Building 325)	No	No	NA	No action at this time
Temporary AFFF Storage (Building 301A)	No	No	NS	No action at this time

Notes:
Light gray shading indicates detection greater than the OSD risk screening level
AFFF – aqueous film-forming foam
GW – groundwater
NA - the OSD risk screening levels are not applicable to the surface water sampled
NS – not sampled
SO – soil
SW – surface water

1 INTRODUCTION

The United States (U.S). Army (Army) is performing preliminary assessments (PAs) and site inspections (SIs) on per- and polyfluoroalkyl substances (PFAS) with a focus on perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and perfluorobutanesulfonic acid (PFBS), at Army installations (installations) nationwide. The Army is the lead agency under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Executive Order 12580 and is conducting the PA/SI consistent with its authority under CERCLA, 42 United States Code §§ 9600, et seq. (as amended), and the Defense Environmental Restoration Program, 10 United States Code §§ 2701, et seq. The PFAS PA/SI included two distinct efforts. The PA identified locations that are areas of potential interest (AOPIs) at Carlisle Barracks based on the use, storage and/or disposal of PFAS-containing materials, in accordance with the 2018 Army Guidance for Addressing Releases of Per-and Polyfluoroalkyl Substances (Army 2018). The SI included multi-media sampling at AOPIs to determine whether or not a release has occurred, and the PFOS, PFOA, and PFBS results were compared to the Office of the Secretary of Defense (OSD) PFOS, PFOA, and PFBS risk screening levels to determine whether further investigation is warranted. This report provides the PA/SI for Carlisle Barracks and was completed in accordance with CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan.

1.1 Project Background

PFAS are a class of compounds that have been used in a wide range of industrial applications and commercial products due to their unique surface tension/leveling properties. Due to industry and regulatory concerns about the potential health effects and adverse environmental impacts, there has been a reduction in the manufacture and use of PFAS worldwide. In the United States (U.S.), significant reductions in the production, importation, and use of PFOS and PFOA (two individual compounds in the PFAS class) occurred between 2001 and 2015 (Interstate Technology Regulatory Council 2017). PFBS replaced PFOS in some applications and is currently used and manufactured in the U.S.

In 2016, the United States Environmental Protection Agency (USEPA) established a lifetime health advisory of 70 nanograms per liter (ng/L) in drinking water for PFOS or PFOA and for the sum of PFOS and PFOA when both are present (USEPA 2016). On 15 October 2019, the OSD provided guidance on the investigation of PFOS, PFOA, and PFBS at Department of Defense (DoD) restoration sites (OSD 2019). The DoD guidance provides risk screening levels for PFOS, PFOA, and PFBS in tap water and soil, calculated using the USEPA's Regional Screening Level (RSL) calculator for residential and industrial/commercial worker receptor scenarios. Following the issuance of the 2019 OSD memo, on 08 April 2021, USEPA published an updated toxicity assessment for PFBS (USEPA 2021). Based on the updated toxicity assessment for PFBS, the OSD issued a memorandum on 15 September 2021 to include updated PFBS risk screening levels (OSD 2021). The September 2021 Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program is provided for reference as **Appendix A**. The OSD risk screening levels for tap water (also used to evaluate groundwater or surface water used as drinking water sources) are 40 ng/L for PFOS and PFOA, and 600 ng/L for PFBS. The PFOS and PFOA soil screening levels for the residential and industrial/commercial scenarios are 0.13 milligrams per kilogram (mg/kg) (residential) and 1.6 mg/kg (industrial/commercial).

The soil screening levels for PFBS are 1.9 mg/kg (residential) and 25 mg/kg (industrial/commercial). These screening criteria are discussed further in **Section 6.5**.

1.2 PA/SI Objectives

This PA/SI was conducted consecutively because the results of the PA yielded AOPIs that necessitated continuing onto the SI phase in accordance with CERCLA. Consequently, this report provides the combined objectives of both PA and SI reports.

1.2.1 PA Objectives

During the PA, investigators collect readily available information and conduct site reconnaissance. This PA will evaluate and document areas where PFAS-containing materials were used, stored, and/or disposed, so the Army can distinguish between sites that pose little or no threat to human health and the environment and sites that require further investigation.

1.2.2 SI Objectives

An SI is conducted when the PA determines an AOPI exists based on probable use, storage, and/or disposal of PFAS-containing materials. The SI includes multi-media sampling at AOPIs to determine whether or not a release has occurred. The SI may conclude further investigation is warranted, a removal action is required to address immediate threats, or no further action is required.

Installation-specific data quality objectives (DQOs) and the sampling design and rationale are summarized in **Sections 6.1** and **6.2**.

1.3 PA/SI Process Description

For Carlisle Barracks, PA/SI development followed the process as described below. **Section 3** provides a summary of the PA activities completed, and **Section 6** provides a summary of the SI activities completed for Carlisle Barracks. The PA and SI processes are documented in the PA/SI Quality Control Checklist included as **Appendix B**.

1.3.1 Pre-Site Visit

First, an installation kickoff teleconference was held between applicable points of contact (POCs) from U.S. Army Environmental Command (USAEC), U.S. Army Corps of Engineers (USACE), Carlisle Barracks, and Arcadis U.S., Inc. (Arcadis). The kickoff call occurred on 23 May 2019, 6 weeks before the site visit, to discuss the goals and scope of the PA, project scheduling, installation access, timeline for the site visit, access to installation-specific databases, and to request available records.

Records review was conducted before the site visit to obtain electronically available documents from the installation and external sources for review. The purpose of the records research was to identify any area on the installation that may have been a location where PFAS-containing materials were used, stored,

and/or disposed, as well as to gather information on the physical setting and site history at Carlisle Barracks.

A read-ahead package was prepared and submitted to the appropriate POCs two weeks before the site visit. The read-ahead package contains the following information:

- The Installation Management Command (IMCOM) operation order.
- The Army PA Operations Security requirements package, which includes the antiterrorism/operations security review cover sheet (**Appendix C**).
- The PFAS PA kickoff call minutes.
- An information paper on the PA portion of the Army's PFAS PA/SI.
- Contact information for key POCs.
- A list of the data sources requested and reviewed.
- A list of preliminary locations identified during the kickoff call and pre-site visit records review to be evaluated for use, storage, and/or disposal of PFAS-containing materials, where additional information on those areas will be collected through personnel interviews, additional document review, and site reconnaissance.
- A list of roles for the installation POC to consider when recommending potential interviewees.

1.3.2 Preliminary Assessment Site Visit

The site visit was conducted on 25 June 2019. An in-brief meeting was held to provide installation staff with the objectives of the site visit and team introductions. **Section 3** includes information regarding personnel interviewed.

Personnel interviews were conducted with individuals having significant historical knowledge at Carlisle Barracks. The interviews focused on confirming information discussed in historical documents, collecting information that may have not been in historical documents, and corroborating other interviewees' information.

Site reconnaissance included visual surveys that assessed the areas of potential use, storage, and/or disposal of PFAS-containing materials, as well as potential secondary impacts, and the migration potential from each AOPI (e.g., stormwater drains, building drains and sumps, cracks in the floor/pavement). Physical attributes of the preliminary locations were documented, including local slope and ground and floor conditions (i.e., paved, unpaved, visual staining), surface water bodies and surface flow, potential receptors, and the distance to the installation boundary. Access to existing groundwater monitoring wells, if present, were also noted during the site reconnaissance in case the monitoring wells could be proposed for SI sampling. Photo documentation of the preliminary locations was collected, and access limitations or advantages related to potential future sampling activities were noted.

An exit briefing was offered to installation personnel at the conclusion of the site visit to raise any items identified during the site visit, discuss any follow-up items, and review the schedule for submitting deliverables. The exit briefing was conducted on 25 June 2019 with the installation, USAEC, and USACE to discuss preliminary findings of the PA site visit.

1.3.3 Post-Site Visit

Information collected before, during, and after the site visit was reviewed and corroborated by cross-referencing records and reviewing interview details and observations noted during site visit reconnaissance. A site visit trip report was completed and provided to the installation POC, applicable USAEC POCs, and USACE regional POCs following the site visit. The information collected during the pre-site visit and site visit activities was compiled to develop the installation-specific PA portion of the PA/SI report (**Section 3**). Site data obtained during the PA were used to develop preliminary conceptual site models (CSMs) for each AOPI, which serve as the basis for developing the SI scope of work presented in an installation-specific Quality Assurance Project Plan (QAPP) Addendum.

1.3.4 Site Inspection Planning and Field Work

The SI process was initiated at the installation to evaluate PFOS, PFOA, and PFBS presence or absence at each AOPI and determine whether further investigation is warranted. First, an SI kickoff teleconference was held between the Army PA team and the Carlisle Barracks.

The objectives of the SI kickoff teleconference were to:

- discuss the AOPIs selected for sampling.
- gauge regulatory involvement requirements or preferences.
- identify overlapping historical or cultural resource areas (i.e., as identified in installation asset documents) that require additional planning and avoidance.
- identify specific installation access requirements and potential schedule conflicts.
- discuss general SI deliverable and field work schedule information and logistics.

Following development of the SI sampling technical approach, an SI scoping teleconference was held to obtain concurrence on the SI sampling plan from USAEC, USACE, and the installation. Additional discussion topics included the following:

- discuss the proposed sampling plan for each AOPI.
- confirm the plan for investigation-derived waste (IDW) handling and disposal.
- provide an updated SI deliverable and field work schedule.

A Programmatic Uniform Federal Policy-Quality Assurance Project Plan (PQAPP) was developed and finalized in October 2019 for the USAEC PFAS PA/SI (Arcadis 2019a). The PQAPP details general planning processes for collecting data and describes the implementation of quality assurance (QA) and quality control (QC) activities for the SI portion for Army installations nationwide. Additionally, an installation-specific QAPP Addendum was developed to define the DQOs, present the sampling design and rationale, and provide qualifications for project personnel. The SI field work was completed in accordance with the PQAPP (Arcadis 2019a) and the approved installation-specific QAPP Addendum. A Site Safety and Health Plan (SSHP) was also developed as an attachment to the QAPP Addendum (Arcadis 2020a) to identify specific health and safety hazards that may be encountered at the installation during sampling. The SSHP was designed to supplement the Accident Prevention Plan (Arcadis 2018),

which was developed for Army installations nationwide. The QAPP Addendum and SSHP were submitted to the installation and finalized before commencement of field work.

The DQOs, sampling design and rationale, and field methods employed for the SI are summarized from the QAPP Addendum developed for Carlisle Barracks in **Sections 6.1** through **6.3**.

After finalization of the QAPP Addendum and SSHP, field planning and coordination with the installation and subcontractors was completed. Once the schedule was determined, field teams mobilized to the installation to complete the scope of work defined in the QAPP Addendum.

1.3.5 Data Analysis, Validation, and Reporting

Environmental samples collected during the SI were submitted to a laboratory which is DoD Environmental Laboratory Accreditation Program (ELAP)-accredited for PFOS, PFOA, and PFBS analysis by liquid chromatography with tandem mass spectrometry and compliant with the DoD Quality Systems Manual (QSM) 5.1.1 (DoD 2018) and 5.3 (DoD and Department of Energy 2019). Laboratory analytical results were then validated and verified by a project chemist to assess the usability of the data collected. Validated analytical results were summarized in the context of OSD risk screening levels (defined in **Section 6.5**).

2 INSTALLATION OVERVIEW

The following subsections provide general information about Carlisle Barracks, including the location and layout, the installation mission(s) over time, a brief site history, current and projected land use, climate, topography, geology, hydrogeology, surface water hydrology, potable wells within a 5-mile radius of the installation, and applicable ecological receptors.

2.1 Site Location

Carlisle Barracks is located in Cumberland County, in the south-central portion of Pennsylvania, east of the town of Carlisle (**Figure 2-1**). Carlisle Barracks is located at the juncture of two major transportation routes: Interstate-81 and Interstate-76 (the Pennsylvania Turnpike). Carlisle Barracks is surrounded by residential neighborhoods to the north across U.S. Route 11, generally undeveloped farmland to the east, and the Borough of Carlisle to the south and west (USACE 2011).

Carlisle Barracks consists of 451 acres. The main cantonment consists of 217 developed acres, and another 234 acres house a golf course and the new Military History Institute's Academic Research Facility (**Figure 2-2**). The developed portions of Carlisle Barracks support a number of diverse functions: family housing, troop housing, educational facilities (e.g., the U.S. Army War College [USAWC]), and family support activities such as a health clinic, commissary, and the Post Exchange. The area surrounding Carlisle Barracks is predominantly rural (USACE 2018).

2.2 Mission and Brief Site History

Carlisle Barracks is the oldest continuously occupied military post in the U.S. During the French and Indian War (1756 to 1763), an encampment was established at Carlisle Barracks by British General John Stanwix. During the Revolutionary War (1776 to 1781), Carlisle was used as a strategic supply source. A military post known as 'the Public Works at Carlisle' was established at this time, which served as an armory and supply depot (USACE 2018). After the Revolutionary War, the military facilities at Carlisle were retained and used on a periodic basis for recruitment and training purposes. Over the years, Carlisle Barracks became known as an elite cavalry training post (USACE 2018).

In 1951, USAWC was relocated to Carlisle Barracks from Fort Leavenworth, Kansas. New housing was constructed to provide family housing for the officers attending USAWC. In 2007, Carlisle Barracks permitted the construction of the Army Museum, a complex of buildings that showcase the history of the Army, as well as an area devoted to full-scale military exhibits (USACE 2018).

The current mission of Carlisle Barracks is to plan, direct, and coordinate the operations of installation support services that include: maintenance, repair, and construction of real property facilities; housing and billeting; environmental and safety programs; supply; maintenance; transportation and logistical support planning for installation activities; tenants; military members and their families; and civilians assigned to USAWC, Carlisle Barracks, and other service members from neighboring installations. The mission of USAWC is to prepare graduates for senior leadership positions in the Army, DoD, and related departments and agencies by professional military education in national security affairs (USACE 2011).

2.3 Current and Projected Land Use

For over 200 years, Carlisle Barracks has been a key facility for the DoD and the Army. The Carlisle Barracks primary tenant is USAWC which educates select military, civilian, and international leaders; conducts research; and supports the Army's strategic communication efforts. Carlisle Barracks also contains many historical buildings and features as well as a golf course, athletic field, and military housing (USACE 2011). There are no anticipated land use changes at Carlisle Barracks.

2.4 Climate

Carlisle Barracks has a humid subtropical climate with hot, humid summers and cool winters. The average temperature in Carlisle is 51.3 degrees Fahrenheit (°F) with temperatures exceeding 90°F an average of 11.2 days a year and dropping below 32°F an average of 114.5 days a year. On average, Carlisle Barracks receives 42.3 inches of precipitation annually. Snowfall averages 30.3 inches per year. On average, January is the coolest month, July is the warmest month, and September is the wettest month (USACE 2011).

2.5 Topography

Carlisle Barracks lies in the Cumberland Valley, a section of the Great Appalachian Valley, on the south side of Conodoguinet Creek, a tributary of the Susquehanna River. The Cumberland Valley is characterized predominantly by southwest-trending ridges and valleys. Weathering of the folded and faulted underlying bedrock imparts an overall gently rolling aspect to the local topography. Surface elevations throughout Carlisle Barracks range from approximately 435 to 485 feet above mean sea level (**Figure 2-3**; USACE 2011).

2.6 Geology

The site lies in the Cumberland Valley section of the Valley and Ridge Physiographic Province. Marine carbonate sediments (i.e., limestone), of the Middle Ordovician; St. Paul Group comprise the bedrock in this area. Sedimentary rock of the regional structure is deformed into asymmetric folds and steeply dipping faults that are sub-parallel to the valley trend (Wiley Wilson 2019).

Overburden material thicknesses are highly variable due to the irregular bedrock surface. The soil stratigraphy can generally be described as consisting of fill material (clayey sand and silty clay) overlaying a residual soil layer (silty and sandy clay) on top of bedrock. However, there are places within the installation where either the fill or residual soil layer are nonexistent, and rock outcrops at the surface. The residual soil is derived from the in-place weathering of the parent limestone bedrock. The limestone is characterized as hard, finely crystalline, slightly weathered, thick bedded, and medium to dark gray (Wiley Wilson 2019).

Where present, fill may reach a maximum thickness of about 10 feet. The fill is expected to be the thickest on the north side of the site and thin to the south. The residuum is anticipated to consist of clayey gravel, sandy gravel with silt, and clayey sand with some sand and silty clay. The residual soil may range from 5 to 34 feet in thickness (Wiley Wilson 2019).

2.7 Hydrogeology

The installation lies in the Cumberland Valley, a region where the limestone and dolomite bedrock forms karst. Groundwater flow in karst aquifers occurs in fractures and voids enlarged by dissolution of the rock. The occurrence of solution cavities, clay seams, and fractures will impact the local groundwater levels and flow behavior (Wiley Wilson 2019). Conduits may transport groundwater at much higher rates than in non-karst aquifers, discharging to surface water at springs, such as the spring at Building 830, on the northeastern installation boundary (USACE 2011).

The water table at Carlisle Barracks generally occurs within the bedrock; such that the overburden material is unsaturated. Depth to water at Carlisle Barracks varies from approximately 10 feet to 30 feet below ground surface (bgs), depending on location within the installation. Groundwater flow patterns were not directly evaluated as a component of the PA/SI and have not been evaluated in any prior investigations at the installation. Based on topography, and the locations and elevations of surface water features, groundwater flow at Carlisle Barracks is most likely to trend generally northward across the southern portion of the installation (the golf course), and northeastward across the cantonment area (**Figure 2-2**). Groundwater flow is interpreted to converge and discharge at springs located along the LeTort Spring Run and its tributaries, northeast of the installation. The most significant of the known springs is the post water supply, located at Building 830, on the northeastern installation boundary. Because of the karst geology, actual flow patterns are likely to be complex, following conduit pathways in the rock.

2.8 Surface Water Hydrology

The primary natural surface water feature at Carlisle Barracks is the LeTort Spring Run, a stream that runs along the western boundary of the installation (**Figure 2-2**). The stream is fed by an estimated 21 natural limestone springs. A major groundwater spring on the eastern boundary of the installation feeds a tributary to the LeTort Spring Run. The groundwater spring discharges at Building 830 with an estimated flow rate of 500 million gallons per day and serves as the potable water supply for the installation (500,000 gallons per day permit). The LeTort Spring Run watershed is a sub-watershed of the Conodoguinet Creek watershed and lies within a limestone region, draining approximately 21 square miles. The LeTort Spring Run begins south of the town of Carlisle and flows approximately 9.2 miles through the town of Carlisle and enters the Conodoguinet Creek in Middlesex Township. The stream channel has been lined with a stone wall on Carlisle Barracks since the 19th century (USACE 2011).

2.9 Relevant Utility Infrastructure

The following subsections provide general information regarding the installation's stormwater and wastewater management systems, as well as information on how the utility infrastructures may influence the fate and transport of PFAS constituents at Carlisle Barracks.

2.9.1 Stormwater Management System Description

Carlisle Barracks is located entirely in the LeTort Spring Run watershed. Carlisle Barracks land comprises roughly 3 percent (%) of the LeTort Spring Run watershed, and stormwater from the installation reaches

the stream and/or watershed at 27 outfalls (e.g., discharge pipes and overland flow) (USACE 2011). Following document review, personnel interviews, and site reconnaissance, no known discharges of aqueous film-forming foam (AFFF) to the Carlisle Barracks stormwater system was noted. In other words, none of the AOPIs were in close enough proximity to warrant including surface water/sediments, and specifically, these outfalls.

2.9.2 Sewer System Description

Carlisle Barracks has a memorandum of agreement with the Borough of Carlisle to discharge their sanitary wastes, therefore, the installation does not have on-post wastewater treatment. Wastewater from Carlisle Barracks is conveyed to the Carlisle Region Water Pollution Control Facility via sanitary sewer pipe connections. Effluent water from the Carlisle Region Water Pollution Control Facility is discharged into the Conodoguinet Creek, while biosolids are land applied for agricultural utilization (Carlisle Pennsylvania n.d.). Following document review, personnel interviews, and site reconnaissance, no known discharges of AFFF to the Carlisle Barracks sanitary sewer system were noted.

2.10 Potable Water Supply and Drinking Water Receptors

Carlisle Barracks receives drinking water solely from the on-post artesian spring that is fed by groundwater. Unfinished drinking water is then treated at the Building 830 Water Treatment Plant (**Figure 2-2**) by three chemical treatments and one physical treatment prior to distribution. There is no carbon treatment.

According to Carlisle Barracks personnel, residences immediately surrounding Carlisle Barracks are provided water from the Town of Carlisle. The Town of Carlisle obtains drinking water from a surface water intake on the Conodoguinet Creek, located approximately 1 mile north of the northern Carlisle Barracks installation boundary. An Environmental Data Resources, Inc. (EDR) report includes search results from a variety of environmental, state, city, and other publicly available databases for a referenced property. An EDR report was generated for Carlisle Barracks, which along with the Pennsylvania Groundwater Information System database, identified potentially numerous off-post potable wells and/or springs within a 5-mile radius of Carlisle Barracks (**Figure 2-4**). Surface water flows off-post to the east via LeTort Spring Run, which does not have any known potable purposes. The Pennsylvania Groundwater Information System database identified two potable use springs within a 5-mile radius of Carlisle Barracks; Hidden Spring, located approximately 2.5 miles from Carlisle Barracks to the east, and an unnamed spring, located approximately 4.2 miles from Carlisle Barracks to the southeast. Groundwater flow beneath the installation is inferred to trend generally northeast and is expected to discharge to springs located on-post, or a short distance off-post along LeTort Spring Branch. Based on the limited groundwater flow information available, groundwater flow originating at the installation is not expected to reach any known off-post potable well before discharging to surface water. The EDR report well search results are provided as **Appendix E**.

2.11 Ecological Receptors

The PA team collected information regarding ecological receptors that was available in the installation documents. The following information is provided for future reference should the Army decide to evaluate exposure pathways relevant to the ecological receptors.

No recent field surveys or comprehensive inventories or biological resources have been conducted since a 2005 wetland delineation and a 1993 bog turtle survey. Some floral species observed during the 2005 wetland delineation were boxelder (*Acer negundo*), hickory species (*Carya sp*.), rush species (*Juncus spp*.), and English plantain (*Plantago lanceolate*). Some faunal species identified during the 1993 bog turtle survey, or that are likely to occur within Carlisle Barracks, include song sparrow (*Melospiza melodia*), gray squirrel (*Sciurus carolinensis*), eastern box turtle (*Terrapene Carolina*), rainbow trout (*Oncorhynchus mykiss*), and green darter dragonfly (*Anax junius*) (USACE 2011).

2.12 Previous PFAS Investigations

Previous (i.e., pre-PA) PFAS investigations relative to Carlisle Barracks, including both those conducted and not conducted by the Army, are summarized to provide full context of available PFAS data for Carlisle Barracks. However, only data collected by the Army will be used to make recommendations for further investigation. The USEPA conducted the third Unregulated Contaminant Monitoring Rule (UCMR3) related monitoring between 2013 and 2015. UCMR3 is a national program that collects data for contaminants that are suspected to be present in drinking water and do not have health-based standards set under the Safe Drinking Water Act. The UCMR3 utilized the PFAS analytical method USEPA Method 537 Revision 1.1 and included the analysis of PFOS, PFOA, and PFBS in public water systems serving more than 10,000 people between 2013 and 2015. The Town of Carlisle Water Treatment Plant was sampled during the UCMR3, and results indicated that PFOS, PFOA, and PFBS were not detected. The limit of detection (LOD) at the time of UCMR3 sampling was 40 ng/L for PFOS, 20 ng/L for PFOA, and 90 ng/L for PFBS, below or equal to the 2021 OSD tap water screening levels (**Appendix A**; **Table 6-2**). There were two other public water systems sampled during UCMR3 that were within a 5-mile radius of Carlisle Barracks: Pennsylvania American Water Company – West, sampled at the Silver Springs Water Treatment Plant and West Shore Treatment Plant, as well as the South Middleton Township Water Authority, sampled at wells #1, #2, and #3. Neither of the other two public water systems had detections of PFOS, PFOA, or PFBS.

In response to IMCOM Operations Order 16-088 issued in 2016, Carlisle Barracks sampled their drinking water supply for PFAS (including PFOS, PFOA, and PFBS) at the Building 830 Water Treatment Plant (**Figure 2-2**) in December 2016, June 2017, and October 2017. The USEPA Method 537 was the analytical method utilized for each sampling event. PFOS, PFOA, and PFBS were detected in each of the three sampling events, but at levels below the 2021 OSD risk screening levels (**Table 2-1** and **Figure 2-5**). The maximum detection of PFOS, PFOA, and PFBS in drinking water at Carlisle Barracks is summarized below:

- PFOS: 12.5 ng/L (June 2017)
- PFOA: 4.71 ng/L (October 2017)
- PFBS: 4.95 ng/L (December 2016)

3 SUMMARY OF PRELIMINARY ASSESSMENT ACTIVITIES

To document areas where any potential current and/or historical PFAS-containing materials were used, stored and/or disposed at Carlisle Barracks, data were collected from three principal sources of information and are described in the subsections below:

1. Records review
2. Personnel interviews
3. Site reconnaissance

Preliminary locations of potential use, storage, and/or disposal of PFAS-containing materials were then evaluated in the PA (during records review, personnel interviews, and/or site reconnaissance) and were categorized as AOPIs or as areas not retained for further investigation at this time based on a combination of information collected (e.g., records reviewed, personnel interviews, internet searches). A summary of the observations made, and data collected through records reviews (**Appendix F**), installation personnel interviews (**Appendix G**), site reconnaissance photos (**Appendix H**) and site reconnaissance photo logs (**Appendix I**) during the PA process for Carlisle Barracks is presented in **Section 4**. Further discussion regarding rationale for not retaining areas for further investigation is presented in **Section 5.1**, and further discussion regarding categorizing areas as AOPIs is presented in **Section 5.2**.

3.1 Records Review

The records reviewed for this PA included, but were not limited to, various Installation Restoration Program (IRP) administrative record documents, compliance documents, Carlisle Barracks fire department documents, Carlisle Barracks directorate of public works (DPW) documents, and GIS files. Internet searches were also conducted to identify publicly available and other relevant information. A list of the specific documents reviewed for Carlisle Barracks is provided in **Appendix F**.

3.2 Personnel Interviews

Interviews were conducted during the site visit. If a previously identified interviewee was not available during the site visit, attempts were made to complete the interview via telephone before or following the site visit or by contacting an alternate interviewee identified by the installation POC.

The list of roles for the installation personnel interviewed during the PA process for Carlisle Barracks is presented below (affiliation is with Carlisle Barracks unless otherwise noted).

- Environmental Chief / Cultural Resources Manager
- Master Planner / GIS Manager
- Current Chief at Carlisle Barracks Fire Department
- Biological Science Technician

The compiled interview logs are provided in **Appendix G**.

3.3 Site Reconnaissance

Site reconnaissance and visual surveys were conducted at the preliminary locations identified at Carlisle Barracks during the records review process, the installation in-brief meeting, and/or during the installation personnel interviews. A photo log from the site reconnaissance is provided in **Appendix H**; photos were used to assist in verification of qualitative data collected in the field. The site reconnaissance logs are provided in **Appendix I**.

Access to existing groundwater monitoring wells, if present, was also noted during the site reconnaissance in case the monitoring wells could be proposed for SI sampling.

4 POTENTIAL PFAS USE, STORAGE, AND/OR DISPOSAL AREAS

Carlisle Barracks was evaluated for all potential current and historical use, storage, and/or disposal of PFAS-containing materials. There are a variety of PFAS-containing materials used in relation to current and historical Army operations. However, the use, storage, and/or disposal of AFFF is the most prevalent potential source of PFAS chemicals at DoD facilities. As such, this section is organized to summarize the AFFF-related uses first, and all remaining potential PFAS-containing materials in the subsequent section.

4.1 AFFF Use, Storage, and Disposal

AFFF was developed in the mid-1960s in response to a need for firefighting foams better suited to extinguish Class B, fuel-based fires. AFFF formulations consist of water, an organic solvent, up to 5% hydrocarbon surfactants, and 1 to 3% PFAS (Interstate Technology Regulatory Council 2020). AFFF concentrate is designed to be diluted with water to become a 1, 3, or 6% foam. AFFF releases at DoD facilities may have occurred during firefighter training, emergency response actions, equipment testing, or accidental releases. The military still primarily uses AFFF for Class B fires; however, the current formulations of AFFF contain significantly lower amounts of PFOS, PFOA, and their precursors, and significant operational changes have been implemented to restrict uncontrolled releases and non-essential use of PFAS-containing foams. Army installations may still house AFFF, commonly stored in closed containers (e.g., 55-gallon drums, 5-gallon buckets), within designated storage buildings or at firehouses.

At Carlisle Barracks, AFFF has been historically used primarily in relation to the Carlisle Barracks Fire Department equipment testing and training (i.e., no AFFF suppression systems or AFFF fire responses are documented at Carlisle Barracks). During initial documents review, Army records were reviewed which indicated that 250 gallons of 6% AFFF was stored at Carlisle Barracks within storage and possibly within a fire engine.

During the PA site visit, an interview was carried out with the Carlisle Barracks Fire Department Chief, who has been present at Carlisle Barracks since 1998 and is the longest active employee currently at the department. The Fire Chief stated that, currently, the Carlisle Barracks Fire Department has both AR-AFFF and Class A foams. A safety data sheet was collected for the AR-AFFF currently stored at Carlisle Barracks (**Appendix J**). Historically, the Carlisle Barracks Fire Department stored AFFF, however, disposal records show that the AFFF was removed and disposed of off-post in 2017. The Fire Chief stated that AFFF has historically been stored at the Current Fire Station (Building 400), as well as AFFF Storage Area (Building 325), and temporarily at Building 301A. Currently, AR-AFFF is stored at the Current Fire Station (Building 400), the Fire Station Storage Support Facility (Building 400B), and the AFFF Storage Area (Building 325). A description of each storage area is provided below.

Building 400 is the only current and historical fire station at Carlisle Barracks. Fire trucks that carry or have carried AFFF are washed weekly on the ramp outside of Building 400. AFFF-carrying fire trucks were also parked inside and outside at Building 400 prior to 2010, when Building 400B was constructed. Additionally, foam transfers from pails into the truck tanks were reported to have occurred on the ramp in front of Building 400. Historically, AFFF had been stored within one crash fire truck tank at Building 400

prior to 2014 when Carlisle Barracks purchased Class A foam. However, AFFF storage at Carlisle Barracks is unknown prior to 1998. Currently AR-AFFF is stored within 5-gallon pails while Class A foam is stored within fire truck tanks.

Building 400B was constructed in 2010 as an additional fire department support and storage facility (e.g., fire trucks, vehicles, personnel lockers, equipment). The Carlisle Barracks Fire Department currently stores AR-AFFF in 5-gallon pails on fire trucks (not within the tanks in fire trucks) that are parked within this building. There have not been any foam transfers within or outside of Building 400B. Fire trucks have historically been washed on the pavement outside of Building 400B on a less frequent basis than Building 400.

Building 325 is currently and has historically been used by the Carlisle Barracks Fire Department for additional storage of a reserve fire engine, AFFF drums and buckets, AR-AFFF, and other fire department equipment. It is unknown whether the reserve fire truck stored AFFF at some point in time, but it does not store AFFF currently. The Carlisle Barracks Fire Department refilled fire truck tanks with AFFF at Building 325, or on the front ramp at Building 400, and emptied the crash truck tanks holding AFFF into 5-gallon pails for storage at Building 325 prior to retiring the truck from service. Four 55-gallon drums of AFFF had been stored in Building 325 until February 2017, when they were moved to Building 301A to be disposed of off-post. The waste disposal company noted that the AFFF drums were rusty and were then overpacked due to leaking. During site reconnaissance to Building 325, the Fire Chief noted staining on the floor where the AFFF drums had been stored. Currently, there is one 5-gallon bucket of AR-AFFF stored at Building 325.

Building 301A is utilized by Carlisle Barracks as a hazardous waste storage facility. In February 2017, four 55-gallon drums of FC-203CF light water AFFF were brought to Building 301A from Building 325 and stored for approximately one month prior to removal. In March 2017, the four 55-gallon drums of AFFF were removed and disposed of off-post.

During the site visit, the Carlisle Barracks Fire Chief did not note any fire responses involving AFFF; however, it is unknown whether AFFF had been used for fire responses prior to 1998. The Carlisle Barracks Fire Chief also did not note any equipment testing or personnel training using AFFF since 1998; however, the retired Fire Chief stated that AFFF had been used during equipment testing operations prior to 1998. The retired Fire Chief noted that, for emergency preparedness, the Carlisle Barracks Fire Department performed equipment testing (foam induction testing) with AFFF four to five times during the 1980s into the 1990s. Foam induction testing consisted of testing the fire truck equipment to ensure that the AFFF concentrate mixed with water was in the correct fractions and percentages. During this testing, AFFF flowed from the hoses directly out onto the grassy area adjacent to the former Helipad landing area and was then cut off when the AFFF flowed through the end of the hose. Approximately 1 gallon of AFFF concentrate was released per testing event, for a total of 5 gallons overall.

During document research, the PA team identified an off-post fire caused by a gasoline leak in Hampden County, located 11 miles away from Carlisle Barracks. AFFF was reportedly used to extinguish the fire, and the Carlisle Barracks Fire Department was listed as a responder. Site visit interviews with the current Fire Chief confirmed that Carlisle Barracks responded to the fire as the Hazardous Materials team but did not deploy any AFFF. The Fire Chief added that Cumberland County has a designated foam task force to deploy foam and that Carlisle Barracks is not a part of that task force. Therefore, there are no off-post

AFFF releases from the Carlisle Barracks Fire Department. The Fire Chief did not note any additional known AFFF releases proximal to Carlisle Barracks.

4.2 Other PFAS Use, Storage, and/or Disposal Areas

Following document research, personnel interviews, and site reconnaissance at Carlisle Barracks, pesticide areas, printing areas, and maintenance shops were also identified as preliminary locations for use storage, and/or disposal of PFAS-containing materials. A summary of information gathered in the PA for each of these preliminary locations is described below. Specific discussion regarding areas not retained for further investigation is presented in **Section 5.1** and specific discussion regarding areas retained as AOPIs is presented in **Section 5.2**.

Pesticide Areas

During a telephonic interview with the IMCOM Pest Management Consultant, it was noted that products containing Sulfluramid (i.e., associated with insecticides) may have contained PFAS and were phased out in 1996. During the PA records review, the IMCOM Pest Management Consultant provided records of potentially PFAS-containing pesticides and insecticides used at and/or stored at Army installations and did not identify Carlisle Barracks as an installation having used or stored PFAS-containing pesticides/ insecticides. Additionally, the PA team reviewed available pesticide use inventory documentation provided by the installation and did not identify PFAS-containing pesticides use, storage, or disposal.

Printing Areas

The print shop was previously identified by Carlisle Barracks personnel during the PFAS PA kickoff call due to the potential for photo processing operations. Carlisle Barracks personnel followed up on the operations on-post and confirmed that there are no photo processing operations at Carlisle Barracks, and that the operations at the print shop are printing only. No use, storage, and/or disposal of PFAS-containing materials were identified at the print shop.

Maintenance Shops

One maintenance shop and one wash rack were evaluated as preliminary locations for use, storage, and disposal of PFAS-containing materials, specifically, in relation to where AFFF-carrying fire trucks may have been serviced. The Carlisle Barracks fire trucks are inspected at Building 849 once a week. However, fire trucks are not washed at this facility, and only minor repairs (that do not involve flushing or maintenance of the foam components) are performed on an as needed basis only. A vehicle wash rack is located across the road from Building 849. The Carlisle Barracks Fire Chief confirmed Fire Department vehicles and trucks are washed directly at Building 400, not at a separate wash rack.

4.3 Readily Identifiable Off-Post PFAS Sources

An exhaustive search to identify all potential off-post PFAS sources (i.e., not related to operations at Carlisle Barracks) is not part of the PA/SI. However, potential off-post PFAS sources within a 5-mile radius of the installation that were identified during the records research and site visit are described below.

As mentioned in **Section 4.1**, the Carlisle Barracks Fire Department did not identify any off-post AFFF fire responses within a 5-mile radius of the installation. The Carlisle Barracks DPW personnel did note that the Carlisle Fire and Rescue Services is located on the north side of Route 11, approximately 1 mile away from Carlisle Barracks, and the Union Fire Company is located approximately 1.5 miles to the southwest of Carlisle Barracks. The current and historical AFFF use by both off-post fire departments is unknown.

Carlisle Barracks DPW personnel did not identify any known off-post PFAS sources related to major industrial operations. The PA team evaluated available online and database information to identify off-post industrial operations and potential PFAS users. Several potential off-post PFAS sources within a 5-mile radius of Carlisle Barracks were identified:

- Nine fire stations were identified within a 5-mile radius of the installation boundary. These fire stations and associated departments may currently or may have historically used, stored, or disposed of AFFF or other PFAS-containing materials. Additionally, these fire departments may have performed off-post AFFF fire response proximal to Carlisle Barracks. AFFF or other PFAS-containing material use, storage, and disposal at these fire stations or fire departments is unknown at this time.
- Four industrial manufacturers were identified within a 5-mile radius of the installation boundary. These industrial manufacturers may currently or may have historically used, stored, or disposed of PFAS-containing materials. Chemicals currently and historically used and stored at each of these industrial manufacturers are unknown. The following are the manufacturer's name (registered with the USEPA's website), the property, and its current/previous activities:
    - **Carlisle Metal Prep** – 405 North East Street, Carlisle, Pennsylvania 17013: Facility was monitored under the Clean Air Act for minor emissions and has since been closed. The property is currently labeled as the Sheaffer Commons, which includes, but is not limited to, the following businesses: Harvest House Restoration Center, a nondenominational place of worship; Shaffer Machine Shop, an automotive machine shop; Bitner Brothers Construction, a general residential and industrial construction and remodeling service; and LeTort Glass, a glass blowing art studio and retail shop. Other businesses that currently hold addresses here are The Metal Pad, a custom metal furniture outlet, and Coating Concepts, a metal stripping and powder coating facility. Both businesses appear to be co-located. This property is approximately 700 feet west-southwest of AOPI Building 325.
    - **Valpey Fisher Innovation Frequency Manufacturing** – 451 Lincoln Street, Carlisle, Pennsylvania 17013: Facility is currently monitored under the Resource Conservation and Recovery Act (RCRA) as a Very Small Quantity Generator (Less than 100 kilograms of hazardous waste per month) The property is currently labeled as PR Hoffman Machine Products, a manufacturer and distributer of lapping machines and products for polishing a variety of materials. The property is located approximately 1 mile west from installation boundary near AOPI Building 325.
    - **Hoffman Materials, LLC** – 321 Cherry Street, Carlisle, Pennsylvania 17913: Facility is currently monitored under the Clean Water Act as an Unpermitted Facility (not discharging) and the RCRA as a Very Small Quantity Generator (Less than 100 kilograms of hazardous waste per month) The property is currently still labeled as Hoffman Materials, a manufacturer and distributer of optical and piezoelectric crystals, semiconductor and piezoelectric wafers, and piezoelectric

elements. The property is also located approximately 1 mile west from installation boundary near AOPI Building 325.

  - **CTS Reeves Frequency Product Plant Carlisle** – 400 West North Street, Carlisle, Pennsylvania 17013: Facility was monitored under Toxic Release Inventory and RCRA but is now inactive. CTS Reeves Product Plant produced electronic crystals and was in business with Hoffman Materials in the past. Currently, the property is owned by Dickinson College and is their Center for Sustainability Education. The property is also located approximately 1 mile west from installation boundary near AOPI Building 325.

- A small airport is located less than 1 mile from the southern border of the installation. No record of a plane crash resulting in fire has been discovered.
- There are currently 172 RCRA sites within a 5-mile radius of Carlisle Barracks, with 125 of them still reporting to be active.

5 SUMMARY AND DISCUSSION OF PRELIMINARY ASSESSMENT RESULTS

The preliminary locations evaluated for use, storage, and/or disposal of PFAS-containing materials at Carlisle Barracks were further refined during the PA process and identified either as an area not retained for further investigation or as an AOPI. In accordance with the established process for the PA/SI, five areas have been identified as AOPIs. The process used for refining these areas is presented on **Figure 5-1**, below.

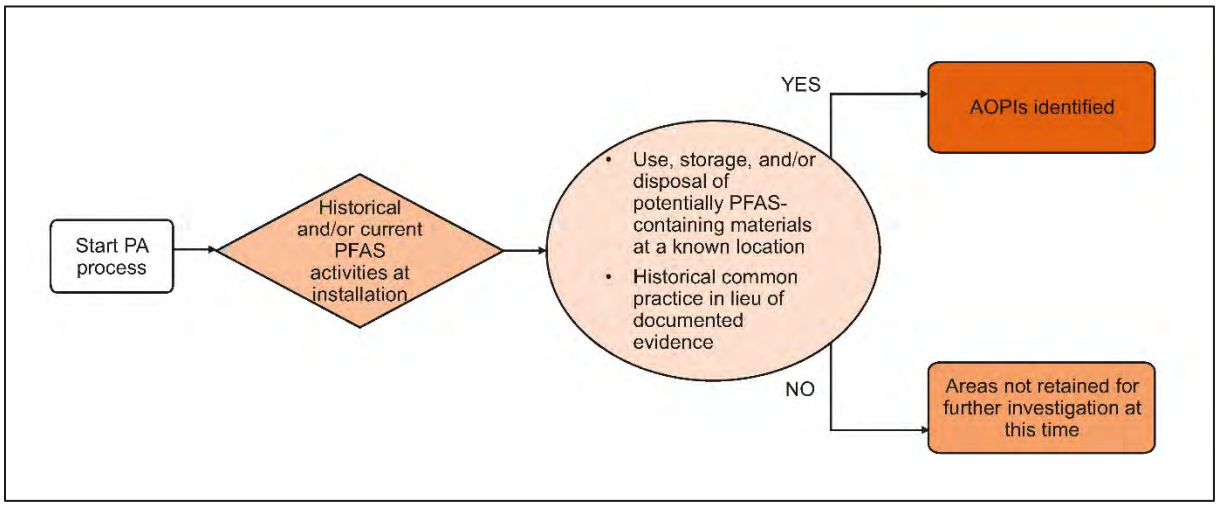

Figure 5-1: AOPI Decision Flowchart

The areas not retained for further investigation are presented in **Section 5.1**. The areas retained as AOPIs are presented in **Section 5.2**.

Data limitations for this PA/SI at Carlisle Barracks are presented in **Section 8**.

5.1 Areas Not Retained for Further Investigation

Through the evaluation of information obtained during records review, personnel interviews, and/or site reconnaissance, the areas described below were categorized as areas not retained for further investigation at this time.

A brief site history and rationale for areas not retained for further investigation are presented in **Table 5-1**, below.

Table 5-1. Installation Areas Not Retained for Further Investigation

Area Description	Dates of Operation	Relevant Site History	Rationale
Building 257	Unknown to present	Identified as a fire support building in the current assets file. During site visit interviews with the Carlisle Barracks Fire Chief, it was confirmed that Building 257 is an old mill that was utilized as a fire department training area, but AFFF is not used or stored here. Fire Chief added that the fire department does not use, store, or dispose of foam or water here as there are no utilities at this location. The Carlisle Barracks Fire Department performs rescue training at Building 257 only.	No AFFF use or storage at this location. No use, storage, or disposal of additional PFAS-containing materials were identified at this location.
Building 849 – Vehicle Maintenance Facility	Unknown to present	The Carlisle Barracks fire trucks are inspected at Building 849 once a week. The fire trucks are not washed at this facility, and only minor repairs (that do not involve flushing or maintenance of the foam components) are performed on an as needed basis only.	No foam component maintenance performed at this location. Therefore, there is no suspected use, storage, or disposal of PFAS-containing materials at this location.
Vehicle Wash Rack	Unknown	During site reconnaissance, a vehicle wash rack was noted located across the road from Building 849 – Vehicle Maintenance Facility. It was confirmed with the Fire Chief that the Carlisle Barracks Fire Department vehicles and trucks are washed directly at Building 400, not at a separate wash rack.	Carlisle Barracks Fire Department vehicles are not washed at this location. Therefore, there is no suspected use, storage, or disposal of PFAS-containing materials at this location.
Print Shop	Unknown to present	The print shop was previously identified by Carlisle Barracks personnel during the PFAS PA kickoff call due to the potential for photo processing operations. Carlisle Barracks personnel followed up on the operations on-post and confirmed that there are no photo processing operations at Carlisle Barracks, and that the operations at the Print Shop are printing only.	There are no photo processing operations at Carlisle Barracks, only printing. Records reviewed and interviews indicated printing operations do not involve the use, storage, or disposal of PFAS-containing materials.

Area Description	Dates of Operation	Relevant Site History	Rationale
Pesticide Application / Storage Areas	Not collected	The 2019 pesticide use list was reviewed and did not contain any PFAS-containing chemicals. Additionally, the PA team spoke with a pest management consultant for IMCOM regarding the use of PFAS-containing pesticides at Carlisle Barracks, who confirmed Carlisle Barracks did not historically use or store PFAS-containing pesticides.	No PFAS-containing pesticides were used, stored, or disposed of at Carlisle Barracks.

5.2 AOPIs

Overviews for each AOPI identified during the PA process are presented in this section. Carlisle Barracks does not currently have an ongoing IRP. Therefore, none of the five AOPIs overlap with Carlisle Barracks IRP sites and/or Headquarters Army Environmental System sites.

The AOPI locations are shown on **Figure 5-2**. Aerial photographs of each AOPI that also show the approximate extent of AFFF use (if applicable) are presented on **Figures 5-3** through **5-7**.

5.2.1 Current Fire Station (Building 400)

The Current Fire Station (Building 400) is identified as an AOPI following records research, personnel interviews, and site reconnaissance due to the potential for use, storage, and/or disposal of PFAS-containing materials, specifically, related to potential releases of AFFF resulting from fire department truck storage and washing. Building 400 currently and historically has served as the main fire station at Carlisle Barracks. Fire trucks that carry or have carried AFFF are washed weekly on the ramp outside of Building 400. AFFF-carrying fire trucks were also parked inside and outside at Building 400 prior to 2010 when Fire Station Support Facility (Building 400B) was constructed. Additionally, foam transfers from pails into the truck tanks were reported to have occurred on the ramp in front of Building 400. The PA team was unable to collect historical knowledge regarding AFFF storage and use at the Current Fire Station (Building 400) prior to 1998, therefore, AFFF could have potentially been stored and released here historically.

The AOPI consists of a brick building used as an active fire station (industrial use). Features of the building include two bays for fire truck and firefighting materials storage as well as office and living space for Carlisle Barracks Fire Department personnel. There is a paved driveway area at the front of the building and grassy areas to the northeast and southwest. Drainage from the front pavement of the Current Fire Station (Building 400) flows to the west and then south towards the grassy area southwest of the active fire station (**Figure 5-3**).

5.2.2 Fire Station Support Storage Facility (Building 400B)

The Fire Station Support Storage Facility (Building 400B) is identified as an AOPI following personnel interviews and site reconnaissance due to the potential for use, storage, and/or disposal of PFAS-containing materials, specifically, related to potential releases of AFFF resulting from fire department truck

storage and washing. Building 400B was constructed in 2010 as an additional fire station support facility. The Carlisle Barracks Fire Department Building 400B has been used as an additional location of fire truck storage. At the time of the PA site visit (June 2019), the Carlisle Barracks Fire Department stored AR-AFFF in 5-gallon pails on trucks (not within the tanks) that are parked within this building. There have not been any foam transfers within or outside of Building 400B. Fire trucks have historically been washed on the pavement outside of Building 400B on a less frequent basis than the Current Fire Station (Building 400). Drainage from the pavement outside of Building 400B flows to the southeast towards a grassy area.

The AOPI is a brick building used as a storage facility (industrial). Features of the building include three bays for fire truck and firefighting materials storage. There is a paved driveway area to the southeast of the building, the Current Fire Station (Building 400) to the west, and additional parking to the east. Drainage from the pavement and garage bay area of the Fire Station Support Storage Facility (Building 400B) flows south towards a storm drain (**Figure 5-4**).

5.2.3 Helipad – AFFF Equipment Testing Area

The Helipad – AFFF Equipment Testing Area is identified as an AOPI following personnel interviews and site reconnaissance due to known uses of AFFF related to fire department truck equipment testing activities. The retired Fire Chief informed the current Fire Chief that this area was used several times for equipment testing (foam induction testing) using AFFF in the 1980s and 1990s. The Carlisle Barracks Fire Department performed equipment testing with AFFF for a total of four to five times at this location. Foam induction testing consisted of testing the fire truck equipment to ensure that the AFFF concentrate mixed with water was in the correct fractions and percentages. During this testing, AFFF flowed from the hoses out onto the grassy area adjacent to the former Helipad landing area and was then cut off when the AFFF flowed through the end of the hose. Approximately 1 gallon of AFFF concentrate was released per testing event, for a total of 5 gallons, overall.

The AOPI is a grassy space at the Carlisle Barracks golf course (recreational use) located approximately 50 feet to the west-southwest of the current helipad (**Figure 5-5**). Golf course parking lots are located to the northwest and southwest.

5.2.4 AFFF Storage Area (Building 325)

The AFFF Storage Area (Building 325) is identified as an AOPI following personnel interviews and site reconnaissance due to known AFFF storage and filling of fire truck tanks. Building 325 is the location of historical and current AFFF storage and reserve fire truck storage for the Carlisle Barracks Fire Department for several decades. The Carlisle Barracks Fire Department performed AFFF transfers from drums/pails into fire truck tanks primarily at Building 325. Additionally, the current Fire Chief confirmed that the AFFF drums stored at Building 325 were rusty and known to be leaking due to the poor condition of the drums. The AFFF drums were removed from this building in 2017.

The AOPI is a brick building with a concrete floor used for storage for various departments, including the Carlisle Barracks Fire Department. Building 325 is surrounded by paved surfaces and storage buildings to the north, east, and south, and the LeTort Spring Run to the west. Drainage from the pavement and garage bay area of Building 325 flows north along the pavement and potentially to the northwest into a grassy area (**Figure 5-6**).

5.2.5 Temporary AFFF Storage (Building 301A)

The Temporary AFFF Storage (Building 301A) is identified as an AOPI following personnel interviews and site reconnaissance due to known former AFFF storage. The Carlisle Barracks Fire Department stated Building 301A, which is the installation's current hazardous waste storage building, was the location of temporary AFFF storage for about one month prior to off-site disposal in March 2017. The stored AFFF drums were noted to have been rusted and in poor condition at the time of transfer. Building 301A is the location of other hazardous materials storage and has secondary containment infrastructure that is cleaned out on an as needed basis (exact frequency not specified).

The AOPI is a small metal building that is used for hazardous waste storage. Stored AFFF drums were placed on a suspended grate flooring. Secondary containment infrastructure (a collection basin) is located underneath the grate. It is not connected to any other infrastructure and is emptied by a waste contractor as needed (**Appendix H**). Temporary AFFF Storage (Building 301A) is surrounded by a concrete wall and fence to the east, gravel surfaces to the north and south, and other industrial use buildings to the west (**Figure 5-7**).

6 SUMMARY OF SI ACTIVITIES

Based on the results of the PA at Carlisle Barracks, an SI for PFOS, PFOA, and PFBS was conducted in accordance with CERCLA. SI sampling was completed at Carlisle Barracks at all five AOPIs to evaluate presence or absence of PFOS, PFOA, and PFBS in comparison with the OSD risk screening levels. As such, an installation-specific QAPP Addendum (Arcadis 2020a) was developed to supplement the general information provided in the PQAPP (Arcadis 2019a) and to detail the site-specific proposed scopes of work for the SI. A preliminary CSM was prepared for each of the installation's AOPIs in accordance with the USACE Engineer Manual on Conceptual Site Models, EM 200-1-12 (USACE 2012). The preliminary CSMs identified potential human receptors and chemical exposure pathways based on current and/or reasonably anticipated future land uses. The preliminary CSMs identified soil, groundwater, surface water, and sediment pathways as potentially complete which guided the SI sampling. The QAPP Addendum details the sampling design and rationale based on each AOPI's preliminary CSM. The SI scope of work was completed in June 2020 and August 2022 through the collection of field data and analytical samples.

The SI field work was completed in accordance with the standard operating procedures (SOPs), technical guidance instructions (TGIs), sampling design, and QA/QC requirements as detailed in the QAPP Addendum (Arcadis 2020a) and PQAPP (Arcadis 2019a). The subsections below summarize the DQOs, sampling design and rationale, sampling activities and methods, and data analyses procedures for the SI at Carlisle Barracks. Non-conformances to the prescribed procedures in the PQAPP and QAPP Addendum are described in **Section 6.3.4** Analytical results obtained through SI field activities are summarized in **Section 7**.

6.1 Data Quality Objectives

As identified during the DQO process and outlined in the site-specific QAPP Addendum (Arcadis 2020a), the objective of the SI is to identify whether there has been a release to the environment at the AOPIs identified in the PA and to determine if further investigation is warranted. This SI evaluated groundwater, soil, and surface water for PFOS, PFOA, and PFBS presence or absence at each of the sampled AOPIs.

6.2 Sampling Design and Rationale

The rationale for sampling at each AOPI is illustrated on **Figure 6-1**.

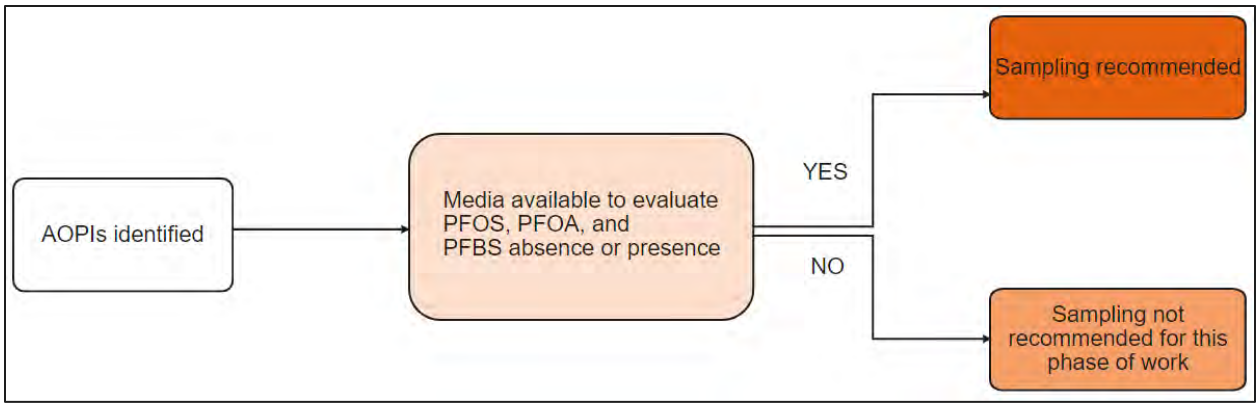

Figure 6-1: AOPI Sampling Decision Tree

The sampling design for SI sampling activities at Carlisle Barracks is detailed in Worksheet #17 of the QAPP Addendum (Arcadis 2020a) and the remobilization field change report (FCR; **Section 6.3.4**). The locations sampled during the SI were selected based on the greatest potential for PFOS, PFOA, and PFBS concentrations (i.e., locations closest to known areas of PFAS-containing materials use, storage, and/or disposal). Groundwater, soil, and surface water were sampled to evaluate PFOS, PFOA, and PFBS presence, type, and concentrations. Additionally, total organic carbon (TOC), pH, and grain size were analyzed in one soil sample per AOPI, in case future fate and transport analysis was needed. The sampling depths and constituents analyzed for each sampling location and medium are included in **Table 6-1**.

During the initial mobilization of the SI (June 2020), soil samples were collected from each AOPI within the area of known AFFF storage, use (i.e., during AFFF equipment testing activities) or within potential AFFF release areas where AFFF may have migrated via surface water runoff on pavement or leaked during AFFF storage periods. Groundwater from the irrigation system at the Carlisle Barracks Golf Course was also collected to evaluate PFOS, PFOA, and PFBS concentrations at the Helipad – AFFF Equipment Testing Area AOPI. The Carlisle Barracks Golf Course irrigation system is made up of three wells; two supply wells and one well used as the irrigation system bypass (i.e., not used as a withdrawal well). Well 1 and Well 2 are used to irrigate the Helipad – AFFF Equipment Testing Area and are located potentially downgradient of, and 0.15 miles northeast of the Helipad – AFFF Equipment Testing Area AOPI. The irrigation Additional information on the Carlisle Barracks Golf Course groundwater sample is provided in **Section 7.3.2**.

A follow-up mobilization was completed in August 2022 to install temporary monitoring wells and collect groundwater samples from each of the AOPIs. Groundwater samples were successfully collected from four of the five AOPIs (i.e., all except the Helipad – AFFF Equipment Testing Area AOPI) following the installation of temporary monitoring wells. At the Helipad – AFFF Equipment Testing Area AOPI, a temporary monitoring well was drilled to 50 ft bgs as scoped in the FCR (**Section 6.3.4**); however, there was no notable production of water within the bedrock. The field team checked the temporary monitoring well the following morning and the borehole was dry. The temporary monitoring well was advanced to 62 ft bgs (as deep as the drill rig was prepared to drill) and left to recharge overnight. The field team checked the temporary monitoring well the following morning and the borehole was dry. Field crews abandoned the temporary monitoring well borehole. A surface water sample was also collected during the follow-up

mobilization from LeTort Spring Run, where the stream enters Carlisle Barracks to determine any potential background surface water and/or groundwater impacts. The surface water sample was collected proximal to the AFFF Storage Area (Building 325) AOPI, and at the first location where the stream enters the installation. The remaining AOPIs were not proximal to surface water bodies and/or the storage of PFAS-containing materials was inside of buildings and not suspected to drain into surface water bodies based on topography.

6.3 Sampling Methods and Procedures

Environmental data were collected and analyzed in accordance with the PQAPP (Arcadis 2019a), the SOPs and TGIs included as **Appendix A** to the PQAPP, the QA/QC requirements identified in Worksheet #20 of the PQAPP, the approved scope and sampling methods outlined in the site-specific QAPP Addendum (Arcadis 2020a), FCRs (**Section 6.3.4**), and the safety procedures specified in the Accident Prevention Plan (Arcadis 2018) and SSHP (Arcadis 2020b). The sampling methods described in the SOPs and TGIs establish equipment requirements, procedures for preparing equipment and containers before sampling, sampling procedures under various conditions, and procedures for storing samples to ensure that sample contamination does not occur during collection and transport. In general, sampling techniques used in the SI were consistent with conventional sampling techniques used in the environmental industry, but special considerations were made regarding PFAS-containing materials and equipment and cross-contamination potential.

The sampling methods employed during the SI are detailed in the PQAPP (Arcadis 2019a) and QAPP Addendum (Arcadis 2020a) and FCRs (**Section 6.3.4**). The subsections below provide a summary of the field methods and procedures utilized to complete the SI scope of work. Field notes and field forms (i.e., soil boring logs, groundwater purging logs, tailgate health and safety forms, and surface water collection logs) documenting the SI sampling activities are included in **Appendices K** and **L**, respectively. Photographs of the sampling activities are included in **Appendix M**.

6.3.1 Field Methods

Field methods employed during the Carlisle Barracks SI field work are described in Worksheet #17 of the Carlisle Barracks QAPP Addendum (Arcadis 2020a).

A total of 13 soil samples were collected at the AOPIs during the initial mobilization via hand auger from discrete points as described in **Table 6-1**. Soil sample boreholes were advanced using a stainless-steel hand auger. With the exception of two samples (further described in **Section 6.3.4**), soil samples were collected between the 0.5 and 2 feet bgs interval and were then homogenized on high-density polyethylene sheeting prior to being placed into sample containers. The stainless-steel hand auger was decontaminated in between each surface soil sample borehole. Soil lithological descriptions were logged and documented on field forms provided in **Appendix L**.

Groundwater samples were collected at all five of the AOPIs during the follow-up mobilization using a combination of temporary monitoring well sampling and modified potable well sampling, as summarized below:

- One groundwater sample was collected from three of five AOPIs (Building 301A: Temporary AFFF Storage, Building 400: Current Fire Station, and Building 400B: Fire Station Support Storage Facility)

following temporary monitoring well installation via hollow stem auger and air rotary drilling. Air rotary drilling was utilized at these AOPIs due to the shallow bedrock present.

- One groundwater samples was collected from one of five AOPIs (Building 325: AFFF Storage Area) following temporary monitoring well installation via air hollow stem auger. Hollow stem augers were able to be used as water was encountered before bedrock.
- One groundwater sample was collected from the Carlisle Barracks irrigation system, which is supplied by Well 1 and Well 2, in accordance with the PFAS Potable Water Sampling Guidance (Arcadis 2019b). The irrigation system was purged for three minutes prior to sample collection at the hose connection. An attempt to install a temporary monitoring well at the Helipad – AFFF Equipment Testing Area was unsuccessful during the follow-up mobilization (See **Section 6.2**)

HSA and air rotary drilling was performed by the same drilling subcontractor in accordance with the TGI for PFAS-Specific Drilling and Monitoring Well Installation (P-12 in Appendix A to the PQAPP [Arcadis 2019a]).

Carlisle Barracks requested that temporary monitoring wells be installed instead of permanent monitoring wells for the SI. After first groundwater was reached, a two-inch well casing consisting of a solid riser, a 5-foot-long schedule 40 well screen, and bottom cap was installed in the borehole. Prior to sampling, the temporary wells were planned to be developed using a bladder pump and high-density polyethylene tubing until field parameters (i.e., temperature, pH, specific conductivity, dissolved oxygen, turbidity, and oxidation-reduction potential) stabilized or for a maximum of 20-minutes, in accordance with the TGI for PFAS-Specific Drilling and Monitoring Well Installation (P-12 in Appendix A to the PQAPP [Arcadis 2019a]). However, all temporary wells went dry before wells could be stabilized. Groundwater samples were collected from approximately the center of the saturated screened interval at the temporary monitoring wells via low-flow methods using a portable bladder pump after the wells sufficiently recharged overnight. Immediately following the groundwater sample collection, the well casing was pulled, and the borehole was abandoned with grout via tremie pipe within 1 foot of ground surface. The remainder of the borehole was completed with material consistent with the surrounding ground surface (e.g., topsoil, gravel).

One grab surface water sample was collected proximal to Building 325 – AFFF Storage Area via direct-fill methods just below the water surface. Field parameters (i.e., temperature, dissolved oxygen, oxidation/ reduction potential, pH, and conductivity) were measured in the water body following sample collection. No other non-dedicated or disposable equipment was used for surface water sample collection.

Coordinates for each sampling location were recorded using a handheld global positioning system.

Decontamination procedures for non-dedicated equipment used during sampling are described in **Section 6.3.5**.

6.3.2 Quality Assurance/Quality Control

Worksheets #20 of the PQAPP and QAPP Addendum provide QA/QC requirements for field duplicates, matrix spike/matrix spike duplicates, equipment blanks (EBs), source blanks for water used in the initial decontamination step for drill tooling, and field blanks for laboratory-supplied water used in the final decontamination step.

QA/QC samples were collected at the frequencies specified in the QAPP Addendum (Arcadis 2020a), typically at a rate of 1 per 20 parent samples. Field duplicates and matrix spike/matrix spike duplicate samples were collected for media sampled for PFOS, PFOA, and PFBS, and TOC only. EBs were collected for media sampled for PFOS, PFOA, and PFBS, at a frequency of one per piece of relevant equipment (i.e., decontaminated reusable equipment) for each sampling event, as specified in the QAPP Addendum (Arcadis 2020a). One EB was collected on the stainless-steel hand auger during the initial mobilization, and two EBs were taken from drilling and sampling tooling during the follow-up mobilization. Source blanks were collected from the laboratory- and driller-supplied water used during the last step of decontamination. Analytical results for blank samples are discussed in **Section 7.8**

6.3.3 Dedicated Equipment Background

Since the exact construction of the irrigation well system and components (e.g., pumps, gaskets) were unknown, a dedicated equipment background (DEB) sample was collected from the system in order to evaluate potential background PFOS, PFOA, and/or PFBS concentrations observed in the irrigation well sample that may be resulting from well system materials/components (i.e., that may contain PFOS, PFOA, and PFBS) instead of the aquifer.

One DEB was collected in association with the Helipad – AFFF Equipment Testing Area AOPI groundwater irrigation well sampling. The DEB was collected from the hose connection immediately following system start up and purging to represent first water produced through the irrigation system components. Following DEB collection, the irrigation system was purged for three minutes prior to the parent sample collection. The DEB sample was analyzed similarly to the rest of the QA/QC samples as described in **Section 6.4.1**. Results from the DEB are compared to the irrigation system groundwater in **Section 7.6**.

6.3.4 Field Change Reports

No instances of major scope modifications (i.e., those that may have had a significant impact on the project scope and/or data usability/quality, or required stop-work, and warranted discussion with USACE) were encountered during the Carlisle Barracks SI work. However, as described below, a follow-up groundwater sampling event was agreed upon based on the results from the initial SI mobilization.

In some cases, clarifications to the established scope of work were needed but do not necessarily constitute a non-conformance from the sampling plans described in the QAPP Addendum. Minor modifications from and clarifications for the procedures and scope of work detailed in the QAPP Addendum and PQAPP that did not affect DQOs are documented in FCRs included as **Appendix N** and are summarized below:

- CBKS-FCR-01: One Equipment blank (CBKS-EB-1-062930) was collected on the stainless-steel hand auger as part of the Carlisle Barracks SI instead of two equipment blanks as outlined in the QAPP Addendum (i.e., both equipment blanks in the QAPP Addendum were planned to be collected on the stainless-steel augers). The field teams used the same stainless-steel hand auger and decontamination procedures for all soil sample collection, therefore, only one equipment blank was required. No other reusable equipment was used during sample collection.

- CBKS-FCR-02: The soil sample CBKS-B325-1-SO-(0.5-2)-062920 collection interval and associated sample ID changed from planned interval 0.5-2 feet bgs to 4-5.5 feet bgs. The Carlisle Barracks QAPP Addendum stated the soil sampling interval will be from 0.5-2 feet bgs, or when native soil is encountered. Field staff noted soils within the originally proposed boring interval of 0.5-2 feet bgs were fill materials and, therefore, non-native soils for the area.
- CBKS-FCR-03: The soil sample CBKS-B325-2-SO-(0.5-2)-062920 was moved approximately 3 feet east of the originally scoped position toward Building 325 and closer to the potential source area. The originally proposed boring location was obstructed by a fence and was not accessible. The new soil boring was relocated to a more accessible area.
- CBKS-FCR-04: Soil samples CBKS-B301A-1-SO-(0.5-2)-062920, CBKS-B301A-1-SO-(0.5-2)-063020, and CBKS-B301A-2-SO-(0.5-2)-062920 sampling interval and associated sample IDs changed from the originally proposed 0.5-2 feet bgs to 0-0.5 feet bgs. The field staff hit refusal following multiple attempts at 0.5 foot bgs and could not continue the boring to the originally planned interval of 0.5-2 feet bgs. Therefore, the available soils within the 0-0.5 foot bgs interval were collected to evaluate the AOPI. Samples CBKS-B301A-1-SO-(0-0.5)-062920 (analyzed for PFOS, PFOA, and PFBS) and CBKS-B301A-1-SO-(0-0.5)-063020 (analyzed for TOC, pH, and grain size) were collected from the same borehole, but on two separate days after confirming TOC, pH, and grain size soil sample analyses were needed.
- CBKS-FCR-05: An additional SI sampling event was conducted at Carlisle Barracks to determine the presence or absence of PFOS, PFOA, and PFBS in groundwater at existing AOPIs Current Fire Station (Building 400), Fire Station Support Storage Facility (Building 400B) Helipad - AFFF Equipment Testing Area, AFFF Storage Building (Building 325), and Temporary AFFF Storage (Building 301A) where groundwater data was not collected during the initial mobilization of SI sampling. The sampling scope was agreed upon by USAEC, USACE, and Carlisle Barracks during a scoping teleconference conducted on 07 July 2022. The final field details (e.g., sample location, sampling techniques) are recorded in **Section 6.2** and **Section 6.3.1**.

6.3.5 Decontamination

The only non-dedicated reusable sampling equipment that came into direct contact with soil sampling media during the initial SI field work was the stainless-steel hand auger used for surface soil sampling. Drill tooling, interface probe, and a bladder pump were in direct contact with the groundwater samples during the follow-up mobilization. All tooling and equipment was decontaminated before first use, between sampling locations/intervals, and before demobilization in accordance with P-09, TGI - Groundwater and Soil Sampling Equipment Decontamination provided in the PQAPP (Arcadis 2019a, Appendix A).

6.3.6 Investigation-Derived Waste

IDW generated during the initial mobilization of the Carlisle Barracks SI (i.e., decontamination fluid) was collected and placed in a 5-gallon bucket prior to treatment via a portable carbon adsorption media and discharge to the ground surface. Excess soils from drilling activities was placed back in the originating boreholes.

IDW during the follow-up mobilization of the SI (i.e., decontamination fluid and purge water) were collected and placed in a 55-gallon steel drum to be picked up and disposed of by a certified waste disposal facility. Low soil recovery was observed during the temporary well installation. Soils that were recovered were placed back in the originating boreholes to bring location to surface after the borehole was grouted. Equipment IDW was collected in bags and disposed in municipal waste receptacles on-post. Equipment IDW includes personal protective equipment and other disposable materials (e.g., gloves, plastic sheeting) that may come in contact with sampling media. Analytical results for IDW samples collected during the SI are discussed in **Section 7.7**.

6.4 Data Analysis

The subsections below summarize the laboratory analytical methods and the methodology used to evaluate data collected during the SI through data verification and usability assessments (as completed by a project chemist, independent of the project team).

6.4.1 Laboratory Analytical Methods

Analytical samples collected during the SI were submitted to Eurofins Lancaster Laboratories Environmental, an ELAP-accredited laboratory for PFAS analysis, including PFOS, PFOA, and PFBS, by liquid chromatography with tandem mass spectrometry. Laboratory analyses associated with the SI were completed in accordance with Worksheets #12.1 through #12.5 in the PQAPP (Arcadis 2019a). Eighteen PFAS-related compounds, including PFOS, PFOA, and PFBS, were analyzed were analyzed for in groundwater, soil and surface water samples using an analytical method that is ELAP-accredited and compliant with QSM 5.1.1 (DoD 2018) and QSM 5.3 (DoD and Department of Energy 2019) Table B-15.

Additionally, the following general chemistry and physical characteristic analyses were completed for select soil samples in accordance with Worksheet #18 of the QAPP Addendum (Arcadis 2020a) by the analytical method noted:

- TOC by Solid Waste Test Method 846 9060A
- Grain size analysis by American Society for Testing and Materials D422-63
- pH by Solid Waste Test Method 846 9045D

These data are collected as they may be useful in future fate and transport studies.

The laboratory LOD is defined as “the lowest concentration for reliable reporting of a non-detect of a specific analyte in a specific matrix with a specific method at 99% confidence” (DoD 2017). The lowest concentration of a substance that produces a quantitative result within specified limits of precision and bias is known as the limit of quantitation ([LOQ]; DoD 2017). Concentrations detected between the LOD and LOQ, therefore, are considered estimates and are qualified as such on laboratory analytical reports. Instrument-specific detection limits (e.g., the smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration with 99% confidence; DoD 2017), as provided for each analyte by the laboratory, are reported along with the LODs and LOQs in the laboratory analytical reports included in the Data Usability Summary Report (DUSR) (**Appendix O**).

6.4.2 Data Validation

All analytical data generated during the SI, except grain size, were verified and validated in accordance with the data verification procedures described in Worksheets #34 through #36 of the PQAPP (Arcadis 2019a). Each laboratory data package/sample delivery group underwent Stage 3 data validation in accordance with DoD QSM 5.1.1 (DoD 2018) and 5.3 (DoD and Department of Energy 2019). Additionally, 10% of the data underwent Stage 4 data validation. Copies of the data validation reports for each sample delivery group are included as attachments to the DUSR in **Appendix O**. The Level IV analytical reports are included within **Appendix O** in the final electronic deliverable only.

6.4.3 Data Usability Assessment and Summary

A data usability assessment was completed for all analytical data associated with SI sampling at Carlisle Barracks. Documentation generated during the data usability assessments, which were compiled into a DUSR (**Appendix O**), was prepared in accordance with the USACE Engineer Manual 200-1-10 (USACE 2005), the Final DoD General Data Validation Guidelines (DoD 2019) and the Final DoD Data Validation Guidelines Module 3: Data Validation Procedure for Per-and Polyfluoroalkyl Substances Analysis by QSM Table B-15 (DoD 2020), that reviewed precision, accuracy, completeness, representativeness, comparability, and sensitivity. A statement of overall data usability is included in the DUSR.

Based on the final data usability assessment, the environmental data collected at Carlisle Barracks during the SI were found to be acceptable and usable for this SI evaluation with the qualifications documented in the DUSR and its associated data validation reports (**Appendix O**), and as indicated in the full analytical tables (**Appendix P**) provided for the SI results. These data are of sufficient quality to meet the objectives and requirements of the PQAPP (Arcadis 2019a) and Carlisle Barracks QAPP Addendum (Arcadis 2020a). Data qualifiers applied to laboratory analytical results for samples collected during the Carlisle Barracks SI are provided in the data tables, data validation reports, and the Data Usability Summary Table located at the end of DUSR. Qualifiers for data shown on figures are defined in the notes of figures.

6.5 Office of the Secretary of Defense Risk Screening Levels

The OSD risk screening levels for PFOS, PFOA, and PFBS in groundwater (tap water) and soil were calculated using the USEPA's RSL calculator for residential and industrial/commercial worker receptor scenarios and current toxicity values. These risk screening levels are shown in **Table 6-2**.

Table 6-2. OSD Risk Screening Levels Calculated for PFOS, PFOA, and PFBS in Tap Water and Soil Using USEPA's Regional Screening Level Calculator

Chemical	Residential Scenario Risk Screening Levels Calculated Using USEPA RSL Calculator		Industrial/Commercial Scenario Risk Screening Levels Calculated Using USEPA RSL Calculator
	Tap Water (ng/L or ppt) [1]	Soil (mg/kg or ppm) [1,2]	Soil (mg/kg or ppm) [1,2]
PFOS	40	0.13	1.6
PFOA	40	0.13	1.6
PFBS	600	1.9	25

Notes:
1. Risk screening levels for tap water and soil provided by the OSD 2021. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. September 15. (**Appendix A**).
2. All soil data will be screened against both the Residential Scenario and Industrial/Commercial risk screening levels (if collected from less than 2 feet bgs), regardless of the current and projected land use of the AOPI. Soil samples collected from greater than 2 feet, but less than 15 feet bgs will be compared to the Industrial/Commercial risk screening levels only.
mg/kg = milligram per kilogram
ng/L = nanograms per liter
ppm = parts per million
ppt = parts per trillion

The OSD residential tap water risk screening levels will be used to compare all groundwater data for this Army PFAS PA/SI. While the current and most likely future land uses of the AOPIs at Carlisle Barracks are industrial/commercial, both residential and industrial/commercial soil risk screening levels for PFOS, PFOA, and PFBS will be used to evaluate detected soil concentrations. The data from the SI sampling event are compared to the OSD risk screening levels in **Section 7**. If concentrations of PFOS, PFOA, or PFBS were detected greater than the applicable OSD risk screening levels, further study in a remedial investigation would be recommended in **Section 8**.

7 SUMMARY AND DISCUSSION OF SITE INSPECTION RESULTS

This section summarizes the analytical results obtained from samples collected during the SI at Carlisle Barracks (field duplicate results are provided in the associated tables). Sampled media and QA/QC samples were analyzed for the constituents prescribed per Worksheet #18 of the QAPP Addendum (Arcadis 2020a) and as noted in **Table 6-1**. The sample results discussion below focuses on the PFOS, PFOA, and PFBS analytical results because they have OSD risk screening levels. The Army will make subsequent investigation decisions based on these constituents' concentrations relative to the OSD risk screening levels.

Table 7-1, **Table 7-2**, and **Table 7-3** provide a summary of the soil, groundwater, and surface water analytical results for PFOS, PFOA, and PFBS. **Table 7-4** summarizes AOPIs and whether their SI results exceed the OSD risk screening levels. **Appendix P** includes the full suite of analytical results for these media, as well as for the QA/QC samples. **Figures 7-2** through **7-6** show the PFOS, PFOA, and PFBS analytical results in groundwater, soil, and surface water, as applicable, for each AOPI. Non-detected results are reported as less than the LOQ. Final qualifiers applied to the data by the laboratory and the project chemist (as defined in **Section 6.4.3**) are defined and presented on the analytical tables. Groundwater and surface water data collected during the SI are reported in ng/L, or parts per trillion, and soil data are reported in mg/kg, or parts per million.

Field parameters measured for groundwater during low-flow purging and sample collection and for surface water during sample collection are provided on the field forms in **Appendix K**. Soil descriptions are provided on the field forms in **Appendix K**. The results of the SI are grouped by AOPI and discussed for each medium as applicable.

Table 7-4 AOPIs and OSD Risk Screening Level Exceedances

AOPI Name	OSD Exceedances (Yes/No)
Current Fire Station (Building 400)	Yes
Fire Station Storage Support Facility (Building 400B)	Yes
Helipad- AFFF Equipment Testing Area	No
AFFF Storage (Building 325)	No
Temporary AFFF Storage (Building 301A)	No

7.1 Current Fire Station (Building 400)

The subsection below summarizes the soil PFOS, PFOA, and PFBS analytical results associated with the Current Fire Station (Building 400).

7.1.1 Soil

Soil sampling at the Current Fire Station (Building 400) occurred on 30 June 2020. Three surface soil samples (CBKS-B400-1-SO, CBKS-B400-2-SO, and CBKS-B400-3-SO) were collected from the 0.5-2 feet bgs interval using a hand auger and were located within the low-lying drainage area where AFFF potentially migrated following fire truck washing activities (**Figure 7-2**).

PFOS and PFOA were detected in each of the three surface soil samples collected, all at concentrations lower than the residential and industrial/commercial OSD risk screening levels (**Table 7-1**). The maximum concentration of PFOS was observed in surface soil sample CBKS-B400-1-SO (0.0097 mg/kg). The maximum concentration of PFOA was observed in surface soil sample CBKS-B400-3-SO (0.00065 mg/kg). PFBS was not detected in any of the soil samples at the Current Fire Station (Building 400).

7.1.2 Groundwater

Groundwater sampling at the Current Fire Station (Building 400) occurred on 25 August 2022. One groundwater sample, CBKS-B400-1-GW, was collected following the installation of a temporary well. The groundwater sample/temporary well boring was located within the grassy area on the southwest side of the Current Fire Station (Building 400), where runoff from AFFF use, storage, and/or disposal on the driveway possibly drained (**Figure 7-2**).

PFOS (52 J ng/L, duplicate) was detected in groundwater sample CBKS-B400-1-GW at a concentration above the OSD risk screening level (40 ng/L). PFOA (15 ng/L, duplicate) and PFBS (7.4 ng/L, duplicate) were both detected in groundwater sample CBKS-B400-1-GW at concentrations below the applicable OSD risk screening levels (40 ng/L for PFOA and 600 ng/L for PFBS) (**Table 7-2**).

7.2 Fire Station Support Storage Facility (Building 400B)

The subsection below summarizes the soil PFOS, PFOA, and PFBS analytical results associated with the Fire Station Support Storage Facility (Building 400B).

7.2.1 Soil

Soil sampling at the Fire Station Support Storage Facility (Building 400B) occurred on 30 June 2020. Two surface soil samples (CBKS-B400B-1-SO and CBKS-B400B-2-SO) were collected from the 0.5-2 feet bgs interval using a hand auger and were located within the low-lying drainage area where AFFF potentially migrated following fire truck washing activities (**Figure 7-3**).

PFOS was detected in both surface soil samples collected, and PFOA was detected in one of the two surface soil samples collected, each at concentrations lower than the residential and industrial / commercial OSD risk screening levels (**Table 7-1**). The maximum concentration of PFOS was observed in surface soil sample CBKS-B400B-1-SO (0.0012 J mg/kg [0.0047 J mg/kg, duplicate]). The maximum concentration of PFOA was observed in surface soil sample CBKS-B400B-2-SO (0.001 mg/kg). PFBS was not detected in any of the soil samples collected at the Fire Station Support Storage Facility (Building 400B).

7.2.2 Groundwater

Groundwater sampling at the Fire Station Support Storage Facility (Building 400B) occurred on 26 August 2022. One groundwater sample, CBKS-B400B-GW-01, was collected following the installation of a temporary well. The groundwater sample/temporary well boring was located within a grassy area on the assumed downgradient edge of the paved driveway. The boring was located on the southeast side of the Fire Station Support Storage Facility (Building 400B), where runoff from AFFF use, storage, and/or disposal on the driveway possibly drained (**Figure 7-3**).

PFOS (68 ng/L) was detected in groundwater sample CBKS-B400B-GW-01 at a concentration above the OSD risk screening level (40 ng/L). PFOA (39 ng/L) and PFBS (12 ng/L) were both detected in groundwater sample CBKS-B400B-GW-01 at concentrations below the applicable OSD risk screening levels (40 ng/L for PFOA and 600 ng/L for PFBS) (**Table 7-2**).

7.3 Helipad – AFFF Equipment Testing Area

The subsections below summarize the soil and groundwater PFOS, PFOA, and PFBS analytical results associated with Helipad – AFFF Equipment Testing Area. See **Section 6.2** for information regarding the attempted temporary well borehole at the Helipad – AFFF Equipment Testing Area AOPI.

7.3.1 Soil

Soil sampling at Helipad – AFFF Equipment Testing Area occurred on 29 June 2020. Four surface soil samples (CBKS-HELIPAD-1-SO, CBKS-HELIPAD-2-SO, CBKS-HELIPAD-3-SO, and CBKS-HELIPAD-4-SO) were collected from the 0.5-2 feet bgs interval using a hand auger from locations within the area of suspected AFFF release. One additional surface soil sample was collected outside of the suspected AFFF release area to evaluate background PFOS, PFOA, and PFBS concentrations related to the irrigation system, which services the golf course at Carlisle Barracks (**Figure 7-4**).

Out of the three surface soil samples collected within the suspected AFFF release area, PFOS and PFOA were detected in only one of the samples (CBKS-HELIPAD-2-SO). The PFOS and PFOA detections (0.0017 mg/kg and 0.0014 mg/kg, respectively) were at concentrations lower than the residential and industrial/commercial OSD risk screening levels (**Table 7-1**). PFBS was not detected in any of the surface soil samples from the AOPI.

In the surface soil sample collected outside of the AOPI, but within the irrigated portion of the Carlisle Barracks Golf Course (**Figure 7-4**), PFOS (0.00085 mg/kg) was detected at concentrations lower than the residential and industrial/commercial OSD risk screening levels (**Table 7-1**). PFOA and PFBS were not detected. PFOS, PFOA and PFBS analytical results observed in the surface soil sample outside of the AOPI are similar to those collected within the AOPI (**Figure 7-4**).

7.3.2 Groundwater

One groundwater sample (CBKS-WELL#1/WELL#2-1-GW) was collected on 29 June 2020 from the Carlisle Barracks Golf Course irrigation system (supplied by Well 1 and Well 2), which is used to irrigate the Helipad – AFFF Equipment Testing Area (**Figure 7-4**). Well construction details cannot be confirmed; however, the supply wells are reported to be 8 inches in diameter, have 50 to 60 feet of steel casing, and

depths of 180 feet and 297 feet bgs. The irrigation water is not treated prior to being distributed to the golf course. Because the exact material construction of the irrigation well system and components (e.g., pumps, gaskets) were unknown, a DEB sample was also collected from the system. Groundwater samples from a combination of the two supply wells were collected from a hose connection to the system (i.e., after groundwater from the two supply wells combine). PFOS (10 ng/L), PFOA (2.8 ng/L), and PFBS (2.5 ng/L) were detected at concentrations less than the OSD risk screening levels for tap water in the groundwater irrigation system parent sample (CBKS-WELL#1/WELL#2-1-GW) (**Table 7-2**). Results of the DEB collected in association with groundwater sample CBKS-WELL#1/WELL#2-1-GW are described in **Section 7.6**.

7.4 AFFF Storage Area (Building 325)

The subsection below summarizes the soil PFOS, PFOA, and PFBS analytical results associated with AFFF Storage Area (Building 325).

7.4.1 Soil

Soil sampling at AFFF Storage Area (Building 325) occurred on 29 June 2020. One surface soil sample (CBKS-B325-1-SO) was collected from the 4.5-5 feet bgs interval (i.e., where native soil was encountered) behind Building 325 to account for any potential releases from the compromised AFFF drums that were stored at the back of Building 325. One surface soil sample was collected from the 0.5-2 feet bgs interval (CBKS-B325-2-SO) immediately downslope of the drainage path from the pavement outside of the Building 325 bay door to account for potential historical AFFF spills during AFFF transport (**Figure 7-5**). Both soil samples were collected using a hand auger.

PFOS and PFOA were detected in only one of the two surface soil samples collected (CBKS-B325-2-SO), each at concentrations lower than the residential and industrial/commercial OSD risk screening levels (**Table 7-1**). PFOS was detected at 0.0014 mg/kg and PFOA was detected at 0.00089 mg/kg in CBKS-B325-2-SO. PFBS was not detected in either sample.

7.4.2 Groundwater

Groundwater sampling at the AFFF Storage Area (Building 325) occurred on 29 August 2022. One groundwater sample, CBKS-B325-GW-01, was collected following the installation of a temporary well. The groundwater sample/temporary well boring was located within the grassy area immediately outside of Building 325 (**Figure 7-5**).

PFOS (14 ng/L), PFOA (6.3 ng/L) and PFBS (1.6 J ng/L) were detected in groundwater sample CBKS-B325-GW-01 at concentrations below the applicable OSD risk screening levels (40 ng/L for PFOS and PFOA, 600 ng/L for PFBS) (**Table 7-2**).

7.4.3 Surface Water

Surface water sampling at the AFFF Storage Area (Building 325) occurred on 30 August 2022. One surface water sample, CBKS-B325-SW-01, was collected from LeTort Spring Run, where the stream first enters the installation (**Figure 7-5**).

PFOS (1.0 J ng/L), PFOA (1.1 J ng/L) and PFBS (1.3 J ng/L) were detected in surface water sample CBKS-B325-SW-01 (**Table 7-3**).

7.5 Temporary AFFF Storage (Building 301A)

The subsection below summarizes the soil PFOS, PFOA, and PFBS analytical results associated with Temporary AFFF Storage (Building 301A).

7.5.1 Soil

Soil sampling at Temporary AFFF Storage (Building 301A) occurred on 29 June 2020. Two surface soil samples (CBKS-B301A-1-SO and CBKS-B301A-2-SO) were collected from the 0-0.5 foot bgs interval (as described in **Section 6.3.4**) immediately in front of the doors to Building 301A, where AFFF spills may have occurred while transporting the drums in and out of the building (**Figure 7-6**). Both soil samples were collected using a hand auger.

PFOS was detected in both surface soil samples collected at concentrations lower than the residential and industrial/commercial OSD risk screening levels (**Table 7-1**). The maximum concentration of PFOS (0.0012 mg/kg) was observed in surface soil sample CBKS-B301A-2-SO. PFOA and PFBS were not detected in either of the soil samples at Temporary AFFF Storage (Building 301A).

7.5.2 Groundwater

Groundwater sampling at the Temporary AFFF Storage (Building 301A) occurred on 29 August 2022. One groundwater sample, CBKS-B301A-GW-01, was collected following the installation of a temporary well. The groundwater sample/temporary well boring was located immediately outside of Building 301A (**Figure 7-6**).

PFOS (1.1 J ng/L), PFOA (3.5 ng/L) and PFBS (2.1 ng/L) were detected in groundwater sample CBKS-B301A-GW-01 at concentrations below the applicable OSD risk screening levels (40 ng/L for PFOS and PFOA, 600 ng/L for PFBS) (**Table 7-2**).

7.6 Dedicated Equipment Background Samples

One DEB was collected. Both the parent sample and DEB pair had detections for PFOS, PFOA, and/or PFBS constituents (**Table 7-2**). The DEB, CBKS-DEB-1-GW, was collected from the hose connection immediately upon system start up. The system was purged for three minutes prior to collecting the irrigation system parent sample, CBKS-WELL#1/WELL#2-1-GW. PFOS (10 ng/L), PFOA (2.9 ng/L), and PFBS (2.6 ng/L) were detected at concentrations less than the OSD risk screening levels for tap water in the DEB sample. PFOS, PFOA, and/or PFBS results between the paired DEB and parent sample were similar (i.e., PFOS results were the same and values for PFOA and PFBS were within 4% or less of one another between the DEB and parent sample). Despite the potential presence of equipment-related PFOS, PFOA, and/or PFBS, comparison of PFOS, PFOA, and PFBS concentrations observed in the DEB and the groundwater irrigation system parent sample indicate the well system components did not influence PFOS, PFOA, and PFBS detections observed in the irrigation well samples and the detections are representative of the aquifer (**Figure 7-4**).

7.7 Investigation Derived Waste

A composite sample of the decontamination wastewater was collected from the 5-gallon sealed bucket (which contained approximately 2.5 gallons of liquid) stored at the Hazardous Waste Storage Building 301A. PFOS (25 ng/L) was detected in the decontamination wastewater. PFOA and PFBS were not detected in the IDW sample collected (**Appendix P**). The IDW wastewater was run through a carbon filtration system and disposed of on-site, as agreed upon by the installation after above results were reported. The full analytical results for IDW samples collected during the SI are included in **Appendix P**.

A grab sample of the decontamination wastewater/small amounts of purge water was collected from one 55-gallon drum during the follow-up mobilization. PFOS (13 ng/L) and PFOA (5.1 ng/L) were detected in the decontamination wastewater (**Appendix P**). PFBS was not detected in the decontamination wastewater sample (**Appendix P**).

7.8 TOC, pH, and Grain Size

In addition to sampling soil for PFOS, PFOA, and PFBS, one soil sample per AOPI was analyzed for TOC, pH, moisture content, and grain size data as they may be useful in future fate and transport studies. The TOC in the soil samples ranged from 6,350 to 43,500 mg/kg. The TOC at this installation was within or somewhat above the range of typically organic content in soil (topsoil: 5,000 to 30,000 mg/kg). The combined percentage of fines (silt and clay) in soils at Carlisle Barracks ranged from 14.5% to 88.8% with an average of 57.66%. PFAS constituents tend to be more mobile in soils with less than 20% fines and lower TOC. The percent moisture of the soil ranged from 3-29.5% which is typical for sand, silts, and clay. The pH of the soil was neutral (approximately 7). Based on the geochemical data obtained during the SI at Carlisle Barracks, PFAS constituents may be relatively less mobile than in soils with less fines and lower TOC content.

7.9 Blank Samples

The full analytical results for blank samples collected during the SI are included in **Appendix P**. Detections of PFOS, PFOA, and PFBS constituents are summarized below for blank samples. Other than those noted below, concentrations of PFOS, PFOA, and PFBS in all other blank samples were not detected.

- PFOA (1.0 J ng/L) was detected in source blank sample CBKS-SB-3-082922 during the second SI mobilization. The source blank was collected from water used as the initial rinse in the decontamination process. However, all equipment blank samples collected during the follow-up mobilization were collected from equipment after the full decontamination process and PFOS, PFOA, and PFBS were not detected.

7.10 Conceptual Site Models

The preliminary CSMs presented in the QAPP Addendum (Arcadis 2020a) were re-evaluated and updated, if necessary, based on the SI sampling results. The CSMs presented on **Figures 7-7**, **7-8**, and **7-9**, and in this section, represent the current understanding of the potential for human exposure. For some AOPIs, the CSM is the same and thus shown on the same figure.

Many of the PFAS constituents found in AFFF are surfactants (which do not volatilize) and are found in a charged or ionic state at environmentally-relevant pH (i.e., pH 5 to 9 standard units). PFOS, PFOA, and PFBS are each negatively charged at environmentally-relevant pH. The media potentially affected by PFOS, PFOA, and PFBS releases at Army installations are soil, groundwater, surface water, and sediment. Once released to the environment, a primary factor that inhibits the movement of PFAS constituents is the presence of organic matter and organic co-constituents in soils and sediments. Generally, PFAS constituents are mobile in the potentially affected media, and they are not known to be fully broken down by natural processes.

Based on the use, storage, and/or disposal of PFAS-containing materials (i.e., AFFF) at the AOPIs, affected media are likely to consist of soil, groundwater, surface water, and sediment. Release and transport mechanisms include dissolution/desorption from soil to groundwater, transport via sediment carried in and dissolution to stormwater and surface water, groundwater discharge to surface water, and adsorption/desorption between surface water and sediment. Generic categories of potential human receptors and their associated exposure scenarios that are typically evaluated in a CERCLA human health risk assessment were considered and include on-installation site workers (e.g., industrial/ commercial workers, utility workers, or future construction workers who could be exposed to chemicals in soil at an AOPI or to chemicals in tap water in an industrial/commercial building), on-installation residents (e.g., adults and children who could be exposed to chemicals in tap water in a residence), and on-installation recreational users (e.g., hikers or hunters who could be exposed to chemicals in waterways at an installation). Off-installation receptor types could include drinking water receptors (i.e., industrial/commercial workers or residents) and recreational users.

Human exposure pathways are shown as “complete”, “potentially complete”, or “incomplete” on the CSM figures. A complete exposure pathway consists of a constituent source and release mechanism, a transport or retention medium, an exposure point where human contact with the contaminated medium could occur, and an exposure route at the exposure point. If any of these elements is missing, the exposure pathway is incomplete. Pathways are “potentially complete” where data are insufficient to conclude the pathway is either “complete” or “incomplete”. Additionally, the CSMs do not include ecological receptors and exposure pathways. The potential for ecological exposures to PFOS, PFOA, and PFBS may be evaluated at a future date if those pathways warrant further consideration.

CSMs were developed for each individual AOPI and were combined where source media, potential migration pathways and exposure media, and human exposure pathway determinations are congruent. The following exposure pathway determinations apply to all CSMs:

- PFOS, PFOA, and PFBS were detected in groundwater samples collected from all five AOPIs. All five AOPIs are potentially upgradient of and/or proximal to the current potable groundwater spring adjacent to Building 830. Therefore, the groundwater exposure pathways (via drinking water ingestion and dermal contact) for on-installation site workers and residents are potentially complete.
- Recreational users are not likely to contact groundwater during outdoor recreational activities; therefore, the groundwater exposure pathway for on-installation recreational users is incomplete.
- Groundwater originating at the AOPIs may also flow off-post. Due to the absence of land use controls preventing potable use of groundwater in the off-post area, the groundwater exposure pathway (via drinking water ingestion and dermal contact) for off-installation receptors is potentially complete.

- Sediment samples were not collected in association with these AOPIs during the SI. On-installation site workers and residents are not likely to have regular contact with sediment (i.e., LeTort Spring Run); therefore, these exposure pathways are incomplete. However, recreational users could routinely contact constituents in LeTort Spring Run via incidental ingestion and dermal contact; therefore, the sediment exposure pathways for on-installation recreational users are potentially complete.
- Surface water bodies at Carlisle Barracks flow off-post through the installation's eastern boundary and into Conodoguinet Creek, which is used as a potable water source within 5 miles of the installation's boundary. Groundwater at Carlisle Barracks could also discharge to surface water bodies off post. Therefore, the surface water exposure pathway (via drinking water ingestion and dermal contact) for off-installation drinking water receptors is potentially complete. Additionally, off-installation recreational users could routinely contact constituents in surface water and sediment via incidental ingestion and dermal contact; therefore, the surface water and sediment exposure pathways for off-installation recreational receptors are potentially complete.

Additional exposure pathway descriptions for each CSM are listed below by figure.

Figure 7-7 shows the CSM for AOPIs Current Fire Station (Building 400), Fire Station Support Storage Facility (Building 400B), and Temporary AFFF Storage (Building 301A). Releases of AFFF from Carlisle Barracks Fire Department activities (e.g., AFFF equipment/nozzle testing, AFFF-carrying fire truck washing, AFFF filling in truck tanks, AFFF storage) to soil and/or paved surfaces could migrate to groundwater via desorption and/or dissolution. Groundwater from these AOPIs could potentially migrate to springs such as the Building 830 spring or others on the LeTort Spring Run.

- PFOS and/or PFOA were detected in at least one soil sample at each AOPI, and site workers could contact constituents in soil via incidental ingestion, dermal contact, and inhalation of dust. Therefore, the soil exposure pathway for on-installation site workers is complete. The AOPIs are not likely to be regularly accessed by on-installation residents and recreational users, or by off-installation receptors. Therefore, the soil exposure pathways for these receptors are incomplete.
- Surface water samples were not collected in association with these AOPIs during the SI. On-installation site workers and residents are not likely to have regular contact with surface water (i.e., LeTort Spring Run); therefore, these exposure pathways are incomplete. However, recreational users could routinely contact constituents in LeTort Spring Run via incidental ingestion and dermal contact; therefore, the surface water exposure pathways for on-installation recreational users are potentially complete.

Figure 7-8 shows the CSM for the AFFF Storage Area (Building 325) AOPI. Releases of AFFF from AFFF storage to soil and/or paved surfaces could migrate to groundwater via desorption and/or dissolution. Groundwater from this AOPI could potentially migrate to springs such as the Building 830 spring or others on the LeTort Spring Run.

- PFOS and PFOA were detected in a soil sample collected at the AOPI, and site workers could contact constituents in soil via incidental ingestion, dermal contact, and inhalation of dust. Therefore, the soil exposure pathway for on-installation site workers is complete. The AOPI is not likely to be regularly accessed by on-installation residents and recreational users, or by off-installation receptors. Therefore, the soil exposure pathways for these receptors are incomplete.

- PFOS, PFOA, and PFBS were detected in surface water collected from LeTort Spring Run, which is not used for drinking water. The LeTort Spring Run surface water sample location is downstream of AFFF Storage Area (Building 325). On-installation site workers and residents are not likely to otherwise contact surface water in the LeTort Spring Run. Therefore, these exposure pathways are incomplete. Recreational users could contact constituents in LeTort Spring Run through incidental ingestion and dermal contact. Therefore, the surface water exposure pathway for on-installation recreational users is conservatively considered to be complete.

Figure 7-9 shows the CSM for the Helipad – AFFF Equipment Testing Area AOPI. Releases of AFFF from Carlisle Barracks Fire Department activities (i.e., AFFF use in equipment/nozzle testing) to soil could migrate to groundwater via desorption and/or dissolution. Groundwater from this AOPI could potentially migrate to springs such as the Building 830 spring or others on the LeTort Spring Run.

- PFOS and/or PFOA were detected in soil at the Helipad – AFFF Equipment Testing Area AOPI. Site workers (i.e., installation personnel) and recreational users (i.e., golfers) could contact constituents in soil via incidental ingestion, dermal contact, and inhalation of dust. Therefore, the soil exposure pathways for on-installation site workers and recreational users are complete. The AOPI is not likely to be regularly accessed by on-installation residents or by off-installation receptors. Therefore, the soil exposure pathways for these receptors are incomplete.
- Surface water was not collected in association with the Helipad – AFFF Equipment Testing Area AOPI during the SI. On-installation site workers and residents are not likely to have regular contact with surface water (i.e., LeTort Spring Run); therefore, these exposure pathways are incomplete. However, recreational users could routinely contact constituents in LeTort Spring Run via incidental ingestion and dermal contact; therefore, the surface water exposure pathways for on-installation recreational users are potentially complete.

Following the SI sampling, all the AOPIs were considered to have complete or potentially complete exposure pathways. Although the CSMs indicate complete or potentially complete exposure pathways may exist, the recommendation for remedial investigation is based on the comparison of analytical results for PFOS, PFOA, and PFBS to the OSD risk screening levels (**Table 6-2**).

8 CONCLUSIONS AND RECOMMENDATIONS

The PFAS PA/SI included two distinct efforts. The PA identified AOPIs at Carlisle Barracks based on the use, storage, and/or disposal of PFAS-containing materials, in accordance with the 2018 Army Guidance for Addressing Releases of Per-and Polyfluoroalkyl Substances (Army 2018). The SI included multi-media sampling at AOPIs to determine whether or not a release of PFOS, PFOA, and PFBS to the environment occurred.

OSD provided residential risk screening levels based on the USEPA oral reference dose for PFOS, PFOA, and PFBS in soil and groundwater (tap water) and industrial/commercial risk screening levels for PFOS, PFOA, and PFBS in soil (**Appendix A**). A combination of document review, internet searches, interviews with installation personnel, and an installation site visit were used to identify specific areas of suspected PFOS, PFOA, and PFBS use, storage, and/or disposal at Carlisle Barracks. Following the evaluation, five AOPIs were identified.

Carlisle Barracks receives drinking water solely from the on-post artesian spring that is fed by groundwater, and unfinished drinking water is then treated at the Building 830 Water Treatment Plant. In response to IMCOM Operations Order 16-088 issued in 2016, Carlisle Barracks sampled their drinking water supply for PFOS, PFOA, and PFBS at the Building 830 Water Treatment Plant in December 2016, June 2017, and October 2017. The USEPA Method 537 was the analytical method utilized for each sampling event. PFOS, PFOA, and PFBS were detected during each of the three sampling events at levels below the OSD risk screening levels. The maximum detection of PFOS, PFOA, and PFBS in drinking water at Carlisle Barracks is 12.5 ng/L, 4.71 ng/L, and 4.95 ng/L, respectively.

All AOPIs were sampled during the SI at Carlisle Barracks to identify presence or absence of PFOS, PFOA, and PFBS at each AOPI. The SI scope of work was completed in accordance with the Final PQAPP (Arcadis 2019a), the Carlisle Barracks QAPP Addendum (Arcadis 2020a), and the remobilization FCR (**Section 6.3.4**).

PFOS, PFOA, and/or PFBS were detected in at least one soil sample collected from each AOPI. However, none of the soil samples collected during the SI were greater than the OSD risk screening levels. The maximum concentration of PFOS in soil (0.0097 mg/kg) was observed at Current Fire Station (Building 400). The maximum concentration of PFOA in soil (0.0014 mg/kg) was observed at the Helipad – AFFF Equipment Testing Area. PFBS was not detected in soil collected during the SI.

PFOS, PFOA, and/or PFBS were detected in each groundwater sample collected during the SI. However, only two of the groundwater samples had detections of PFOS, PFOA, and/or PFBS above the OSD risk screening levels. The maximum concentrations of PFOS (68 ng/L), PFOA (39 ng/L), and PFBS (12 ng/L) were observed at the Fire Station Support Storage Facility (Building 400B).

PFOS, PFOA, and PFBS were detected in the surface water sample collected from LeTort Spring Run during the SI.

Following the SI sampling, all five AOPIs with confirmed PFOS, PFOA, and/or PFBS presence were considered to have complete or potentially complete exposure pathways.

- PFOS and/or PFOA were detected in at least one soil sample collected from each AOPI and human contact with constituents in soil could occur. Therefore, soil exposure pathways are complete for on-

installation site workers at all five AOPIs and for on-installation recreational users at one AOPI, the Helipad-AFFF Equipment Testing Area.

- PFOS, PFOA, and PFBS were detected in all groundwater samples collected from the AOPIs, which are potentially upgradient of and/or proximal to the current potable groundwater spring at Building 830. Therefore, the groundwater exposure pathways (via drinking water ingestion and dermal contact) for on-installation site workers, on-installation residents, and off-installation receptors are potentially complete for all five AOPIs.
- Groundwater from the AOPIs could potentially migrate to springs such as the Building 830 spring or others on the LeTort Spring Run. PFOS, PFOA, and PFBS were detected in a surface water sample collected from LeTort Spring Run, downstream of the AFFF Storage Area (Building 325) AOPI. On-installation recreational users could contact constituents in LeTort Spring Run through incidental ingestion and dermal contact. Therefore, the surface water exposure pathway for recreational users is conservatively considered to be complete for the AFFF Storage Area (Building 325) and potentially complete for the other four AOPIs. The sediment exposure pathway for on-installation recreational users is potentially complete for all AOPIs.
- Surface water bodies at Carlisle Barracks flow off-post and into Conodoguinet Creek, which could be used for recreation and is a potable water source within 5 miles of the installation's boundary. Therefore, the surface water exposure pathway for off-installation drinking water receptors is potentially complete. Additionally, the surface water and sediment exposure pathways (via incidental ingestion and dermal contact) for off-installation recreational users are potentially complete.

Although the CSMs indicate complete or potentially complete exposure pathways may exist, the recommendation for future study in a remedial investigation or no action at this time is based on the comparison of the SI analytical results for PFOS, PFOA, and PFBS to the OSD risk screening levels (**Table 6-2**). **Table 8-1** below summarizes the AOPIs identified at Carlisle Barracks, PFOS, PFOA, and PFBS sampling and recommendations for each AOPI.

Table 8-1 Summary of AOPIs Identified during the PA, PFOS, PFOA, and PFBS Sampling at Carlisle Barracks, and Recommendations

AOPI Name	PFOS, PFOA, and/or PFBS detected greater than OSD Risk Screening Levels? (Yes/No/NA/NS)			Recommendation
	GW	SO	SW	
Current Fire Station (Building 400)	Yes	No	NS	Further study in a remedial investigation
Fire Station Storage Support Facility (Building 400B)	Yes	No	NS	Further study in a remedial investigation
Helipad - AFFF Equipment Testing Area	No	No	NS	No action at this time
AFFF Storage (Building 325)	No	No	NA	No action at this time
Temporary AFFF Storage (Building 301A)	No	No	NS	No action at this time

Notes:
Light gray shading – detection greater than the OSD risk screening level

AFFF – aqueous film-forming foam
GW – groundwater
NA - the OSD risk screening levels are not applicable to the surface water sampled
NS – not sampled
SO – soil
SW – surface water

Data collected during the PA (**Sections 3** through **5**) and SI (**Sections 6** through **8**) were sufficient to draw conclusions and recommendations summarized above. The data limitations relevant to the development of this PA/SI for PFOS, PFOA, and PFBS at Carlisle Barracks are discussed below.

Records gathered for the use, storage and/or disposal of PFAS-containing materials were reviewed during the PA process. Documentation specific to AFFF may have been limited (e.g., each AFFF use; procurement records, documentation of AFFF used during crash responses or fire training activities) due to lack of recordkeeping requirements for the full timeline of common AFFF practices. Anecdotal accounts of AFFF use (and therefore likely PFOS, PFOA, and PFBS use) were limited to available installation personnel, whose knowledge of AFFF use may have been restricted by their time spent at the installation or previous roles held that limited their relevant knowledge of potential AFFF (or other PFAS-containing material) use.

A comprehensive well survey was not completed as part of this PA; therefore, the information reviewed regarding off-post wells is limited to what is contained in the off post well search results (**Appendix E**).

The searches for ecological receptors and off-post PFOS, PFOA, and PFBS sources were not exhaustive and were limited to easily identifiable and readily available information evaluated during the relevant documents research, installation personnel interviews, and site reconnaissance.

Finally, the available PFOS, PFOA, and PFBS analytical data are limited to on post media only, including soil and groundwater collected from each AOPI during the SI, one surface water sample collected during the SI, and historical groundwater data. Available data, including PFOS, PFOA, and PFBS, are listed in **Appendix P**, which were analyzed per the selected analytical method.

Results from this PA/SI indicate further study in a remedial investigation is warranted at Carlisle Barracks in accordance with the guidance provided by the OSD.

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10 ACRONYMS

°F	degrees Fahrenheit
%	percent
AFFF	aqueous film-forming foam
AOPI	area of potential interest
AR-AFFF	alcohol-resistant aqueous film-forming foam
Arcadis	Arcadis U.S., Inc.
Army	United States Army
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CSM	conceptual site model
DEB	dedicated equipment background
DoD	Department of Defense
DPW	Directorate of Public Works
DQO	data quality objective
DUSR	Data Usability Summary Report
EB	equipment blank
EDR	Environmental Data Resources, Inc.
ELAP	Environmental Laboratory Accreditation Program
FCR	Field Change Report
GIS	geographic information system
GW	groundwater
IDW	investigation-derived waste
IMCOM	Installation Management Command
installation	United States Army or Reserve installation
IRP	Installation Restoration Program
LOD	limit of detection
LOQ	limit of quantitation
M	manually integrated compound
mg/kg	milligrams per kilogram (parts per million)

N	no
ng/L	nanograms per liter (parts per trillion)
NS	not sampled
OSD	Office of the Secretary of Defense
PA	preliminary assessment
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutanesulfonic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
POC	point of contact
ppm	parts per million
ppt	parts per trillion
PQAPP	Programmatic Uniform Federal Policy-Quality Assurance Project Plan
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QSM	Quality Systems Manual
RCRA	Resource Conservation and Recovery Act
RSL	Regional Screening Level
SI	site inspection
SO	soil
SOP	standard operating procedure
SSHP	Site Safety and Health Plan
TGI	technical guidance instruction
TOC	total organic carbon
UCMR3	third Unregulated Contaminant Monitoring Rule
U.S.	United States
USACE	United States Army Corps of Engineers
USAEC	United States Army Environmental Command
USAWC	United States Army War College
USEPA	United States Environmental Protection Agency

TABLES

Table 2-1 -Historical PFOS, PFOA, and PFBS Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Carlisle Barracks, PA

	Location	Carlisle Barracks Water Supply System	Carlisle Barracks Water Supply System	Carlisle Barracks Water Supply System
	Sample ID	B830 EP1	EP1	EP1
	Sample Date	12/22/2016	6/9/2017	10/24/2017
Units	OSD risk screening level for tap water	ng/L	ng/L	ng/L
Perfluorooctanoic acid (PFOA)	40	4.6	4.23	4.71
Perfluorobutanesulfonic acid (PFBS)	600	4.95	3.85	4.72
Perfluorooctane sulfonate (PFOS)	40	12.4	12.5	12.3

Notes and Acronyms:
ng/L - nanograms per liter
OSD - Office of the Secretary of Defense

Data sources:
Analytical laboratory reports provided by Carlisle Barracks

Table 6-1 - Site Inspection Sampling Location Details
USAEC PFAS Preliminary Assessment/Site Inspection
Carlisle Barracks, PA

ARCADIS

AOPI	Matrix	Sample ID	Depth Interval	Sample Method	Analytes
Building 400-Current Fire Station	SO	CBKS-B400-1-SO-(0.5-2)-063020	0.5-2	Hand Auger	PFAS
	SO	CBKS-B400-2-SO-(0.5-2)-063020	0.5-2	Hand Auger	PFAS, TOC, pH, grain size
	SO	CBKS-B400-3-SO-(0.5-2)-063020	0.5-2	Hand Auger	PFAS
	GW	CBKS-B400-1-GW-082522	30-35	Bladder Pump	PFAS
Building 400B-Fire Station Storage Support Facility	SO	CBKS-B400B-1-SO-(0.5-2)-063020	0.5-2	Hand Auger	PFAS
	SO	CBKS-B400B-2-SO-(0.5-2)-063020	0.5-2	Hand Auger	PFAS, TOC, pH, grain size
	GW	CBKS-B400B-GW-01-082622	35-40	Bladder Pump	PFAS
Helipad- AFFF Equipment Testing Area	SO	CBKS-HELIPAD-1-SO-(0.5-2)-062920	0.5-2	Hand Auger	PFAS, TOC, pH, grain size
	SO	CBKS-HELIPAD-2-SO-(0.5-2)-062920	0.5-2	Hand Auger	PFAS
	SO	CBKS-HELIPAD-3-SO-(0.5-2)-062920	0.5-2	Hand Auger	PFAS
	SO	CBKS-HELIPAD-4-SO-(0.5-2)-062920	0.5-2	Hand Auger	PFAS
	GW	CBKS-WELL#1/WELL#2-1-GW-062920	NA	Grab	PFAS
Building 325-AFFF Storage	SO	CBKS-B325-1-SO-(4-5.5)-062920	4-5.5	Hand Auger	PFAS
	SO	CBKS-B325-2-SO-(0.5-2)-062920	0.5-2	Hand Auger	PFAS, TOC, pH, grain size
	GW	CBKS-B325-GW-01-082922	10-15	Bladder Pump	PFAS
	SW	CBKS-B325-SW-01-083022	NA	Grab	PFAS
Building 301A-Temporary AFFF Storage	SO	CBKS-B301A-1-SO-(0-0.5)-062920	0-0.5	Hand Auger	PFAS
	SO	CBKS-B301A-1-SO-(0-0.5)-063029	0-0.5	Hand Auger	TOC, pH, grain size
	SO	CBKS-B301A-2-SO-(0-0.5)-062920	0-0.5	Hand Auger	PFAS
	GW	CBKS-B301A-GW-01-082922	20-25	Bladder Pump	PFAS

Notes:
1. Depth units are reported in ft bgs unless otherwise noted.
2. The PFAS analyte group includes PFOS, PFOA, PFBS and 15 other PFAS constituents.
3. Groundwater sample from Helipad - AFFF Equipment Testing Area is a combined sample of two irrigation wells. Sample was collected from spigot attached to well house post-combination.

AFFF = aqueous film forming foam
AOPI = Area of Potential Interest
ft bgs = feet below ground surface
GW = groundwater
ID = identification
N/A = not available or not applicable
PFAS = per- and polyfluoroalkyl substances
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate
SO = Soil
TOC = total organic carbon

Table 7-1 - Soil PFOS, PFOA, and PFBS Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Carlisle Barracks, Pennsylvania

AOPI	Sample/Parent ID	Sample Date	Analyte	PFOS (mg/kg)		PFOA (mg/kg)		PFBS (mg/kg)	
			OSD Industrial/Commercial Risk Screening Levels	1.6		1.6		25	
			OSD Residential Risk Screening Levels	0.13		0.13		1.9	
			Sample Type	Result	Qual	Result	Qual	Result	Qual
Helipad- AFFF Equipment Testing Area	CBKS-HELIPAD-1-SO-(0.5-2)-062920	6/29/2020	N	0.00069	U	0.00069	U	0.0023	U
	CBKS-HELIPAD-2-SO-(0.5-2)-062920	6/29/2020	N	**0.0017**		**0.0014**		0.0022	U
	CBKS-HELIPAD-3-SO-(0.5-2)-062920	6/29/2020	N	0.00068	U	0.00068	U	0.0023	U
	CBKS-HELIPAD-4-SO-(0.5-2)-062920	6/29/2020	N	**0.00085**		0.00066	U	0.0022	U
Current Fire Station (Building 400)	CBKS-B400-1-SO-(0.5-2)-063020	6/30/2020	N	**0.0097**		**0.00061**	J	0.0022	U
	CBKS-B400-2-SO-(0.5-2)-063020	6/30/2020	N	**0.0059**		**0.00051**	J	0.0023	U
	CBKS-B400-3-SO-(0.5-2)-063020	6/30/2020	N	**0.0015**		**0.00065**		0.0022	U
Fire Station Support Storage Facility (Building 400B)	CBKS-B400B-1-SO-(0.5-2)-063020	6/30/2020	N	**0.0012**	J	0.00071	U	0.0024	U
	CBKS-B400B-2-SO-(0.5-2)-063020	6/30/2020	N	**0.001**		**0.001**		0.0022	U
	CBKS-FD-1-SO-063020/ CBKS-B400B-1-SO-(0.5-2)-063020	6/30/2020	FD	**0.0047**	J	0.00074	U	0.0025	U
AFFF Storage Area (Building 325)	CBKS-B325-1-SO-(4-5.5)-062920	6/29/2020	N	0.00083	U	0.00083	U	0.0028	U
	CBKS-B325-2-SO-(0.5-2)-062920	6/29/2020	N	**0.0014**		**0.00089**		0.0023	U
Temporary AFFF Storage (Building 301A)	CBKS-B301A-1-SO-(0-0.5)-062920	6/29/2020	N	**0.00063**		0.00057	U	0.0019	U
	CBKS-B301A-2-SO-(0-0.5)-062920	6/30/2020	N	**0.0012**		0.00058	U	0.0019	U

Notes:
1. **Bolded** values indicate the result was detected greater than the limit of detection
2. Data are compared to the Office of the Secretary of Defense (OSD) risk screening levels for both the residential as well as the industrial/commercial scenarios (OSD. 2021. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. September.). No concentrations of PFBS, PFOS, or PFOA exceeded the OSD risk screening levels.

Acronyms/Abbreviations:
-- = not applicable/not analyzed
AFFF = aqueous film forming foam
AOPI = Area of Potential Interest
CBKS = Carlisle Barracks
FD = field duplicate sample
ID = identification
mg/kg = milligrams per kilogram (parts per million)
N = primary sample
PFBS = perfluorobutane sulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonic acid
Qual = qualifier
SO = soil

Qualifiers
J = The analyte was positively identified; however the associated numerical value is an estimated concentration only
U = The analyte was analyzed for but the result was not detected above the limit of quantitation (LOQ).

Table 7-2 - Groundwater PFOS, PFOA, and PFBS Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Carlisle Barracks, Pennsylvania

AOPI	Sample/ Parent ID	Sample Date	Analyte	PFOS (ng/L)		PFOA (ng/L)		PFBS (ng/L)	
			OSD Tapwater Risk Screening Levels	40		40		600	
			Sample Type	Result	Qual	Result	Qual	Result	Qual
Helipad- AFFF Equipment Testing Area	CBKS-WELL#1/WELL#2-1-GW-062920	6/29/2020	N	**10**		**2.8**		**2.5**	
	CBKS-FD-1-GW-062920/ CBKS-WELL#1/WELL#2-1-GW-062920	6/29/2020	FD	**9.7**		**2.9**		**2.6**	
	CBKS-DEB-1-GW-062920	6/29/2020	N	**10**		**2.9**		**2.6**	
Temporary AFFF Storage (Building 301A)	CBKS-B301A-GW-01-082922	08/29/2022	N	**1.1**	J	**3.5**		**2.1**	
AFFF Storage Area (Building 325)	CBKS-B325-GW-01-082922	08/29/2022	N	**14**		**6.3**		**1.6**	J
Current Fire Station (Building 400)	CBKS-B400-1-GW-082522	08/25/2022	N	**32**	J+	**12**		**5.4**	
	CBKS-DUP-1-GW-082522 / CBKS-B400-1-GW-082522	08/25/2022	FD	**52**	J	**15**		**7.4**	
Fire Station Support Storage Facility (Building 400B)	CBKS-B400B-GW-01-082622	08/26/2022	N	**68**		**39**		**12**	

Notes:

1. **Bolded** values indicate the result was detected greater than the limit of detection
2. Grey shaded values indicate the result was detected greater than the 2021 Office of the Secretary of Defense (OSD) risk screening levels, (OSD. 2021. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. September.).

Acronyms/Abbreviations:

-- = not applicable
% = percent
AFFF = aqueous film forming foam
AOPI = Area of Potential Interest
CBKS = Carlisle Barracks
FD = field duplicate sample
GW = groundwater
ID = identification
N = primary sample
ng/L = nanograms per liter (parts per trillion)
PFBS = perfluorobutane sulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonic acid
Qual = qualifier

Qualifiers

J = The analyte was positively identified; however the associated numerical value is an estimated concentration only

Table 7-3 - Surface Water PFOS, PFOA, and PFBS Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Carlisle Barracks, Pennsylvania

AOPI	Sample/ Parent ID	Sample Date	Analyte	PFOS (ng/L)		PFOA (ng/L)		PFBS (ng/L)	
			Sample Type	Result	Qual	Result	Qual	Result	Qual
AFFF Storage Area (Building 325)	CBKS-B325-SW-01-083022	8/30/2022	N	**1.0**	J	**1.1**	J	**1.3**	J

Notes:
1. **Bolded** values indicate the result was detected greater than the limit of detection

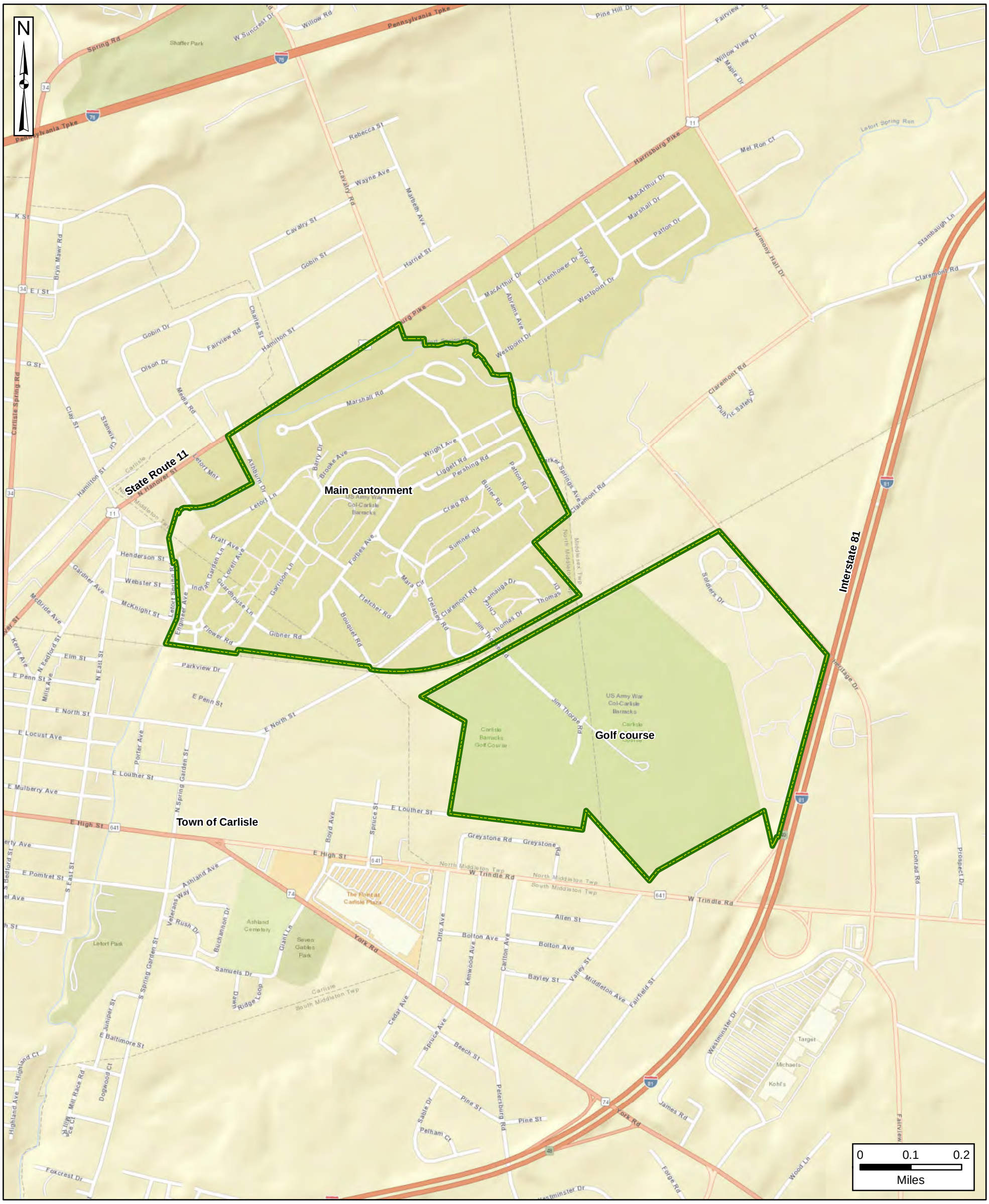
Acronyms/Abbreviations:
-- = not applicable
AFFF = aqueous film forming foam
AOPI = Area of Potential Interest
CBKS = Carlisle Barracks
FD = field duplicate sample
GW = groundwater
ID = identification
N = primary sample
ng/L = nanograms per liter (parts per trillion)
PFBS = perfluorobutane sulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonic acid
Qual = qualifier

Qualifiers
J = The analyte was positively identified; however the associated numerical value is an estimated concentration only

FIGURES

USAEC PFAS Preliminary Assessment / Site Inspection
Carlisle Barracks, PA

Figure 2-1
Site Location



Installation Boundary

Data Sources:
ESRI ArcGIS Online, StreetMap Data

Coordinate System:
WGS 1984, UTM Zone 18 North

USAEC PFAS Preliminary Assessment / Site Inspection
Carlisle Barracks, PA

Figure 2-2
Site Layout

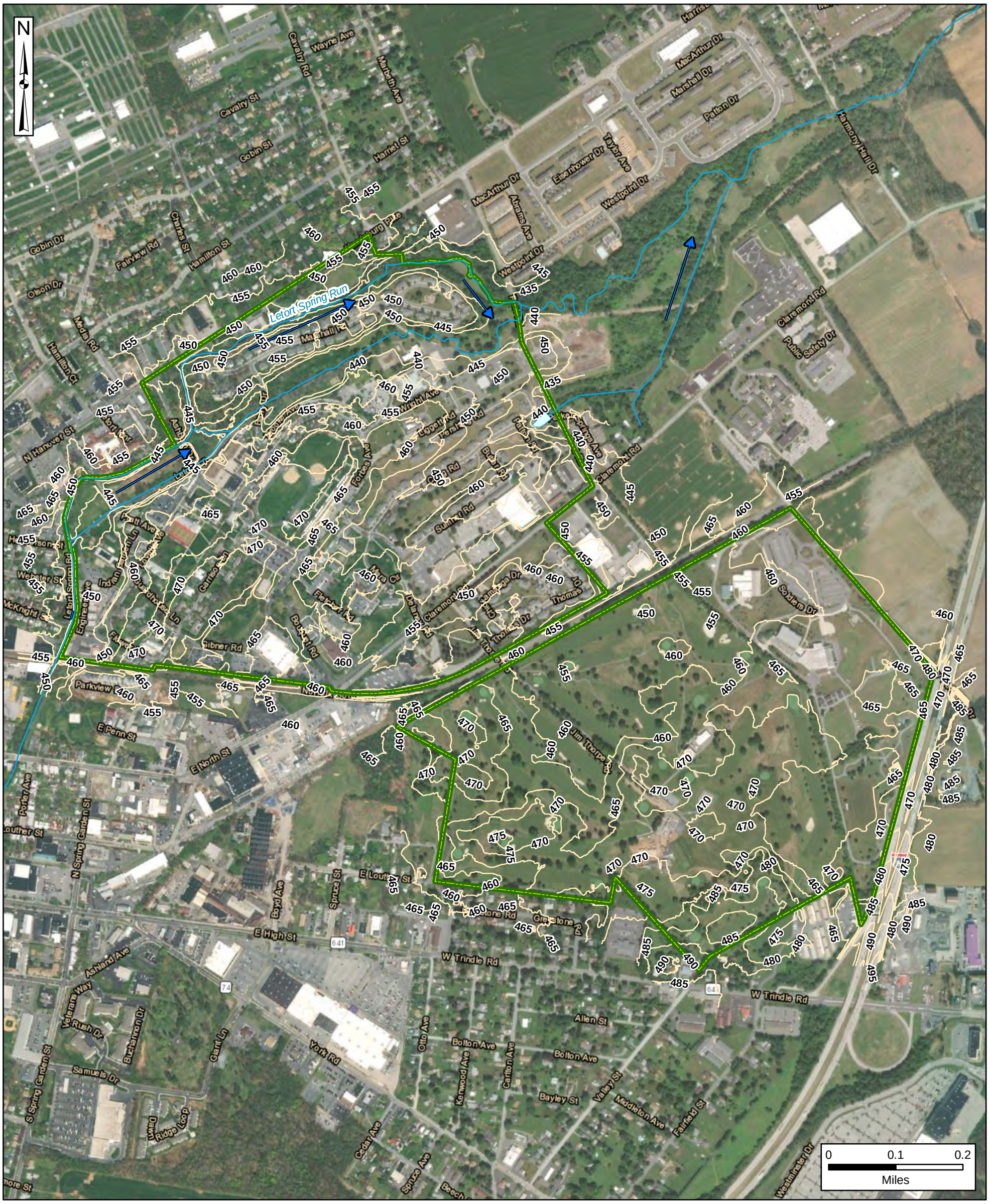
Installation Boundary
River/Stream (Perennial)
Stream (Intermittent)
Water Body
General Surface Water Flow Direction
General Groundwater Flow Direction
Building 830 Spring
Water Well in PaGWIS Database (location not verified)

Data Sources:
Pennsylvania Groundwater Information System (PaGWIS), 2019
USGS, NHD Data, 2019
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 18 North

USAEC PFAS Preliminary Assessment / Site Inspection
Carlisle Barracks, PA

Figure 2-3
Topographic Map



Installation Boundary

River/Stream (Perennial)

Stream (Intermittent)

Water Body

General Surface Water Flow Direction

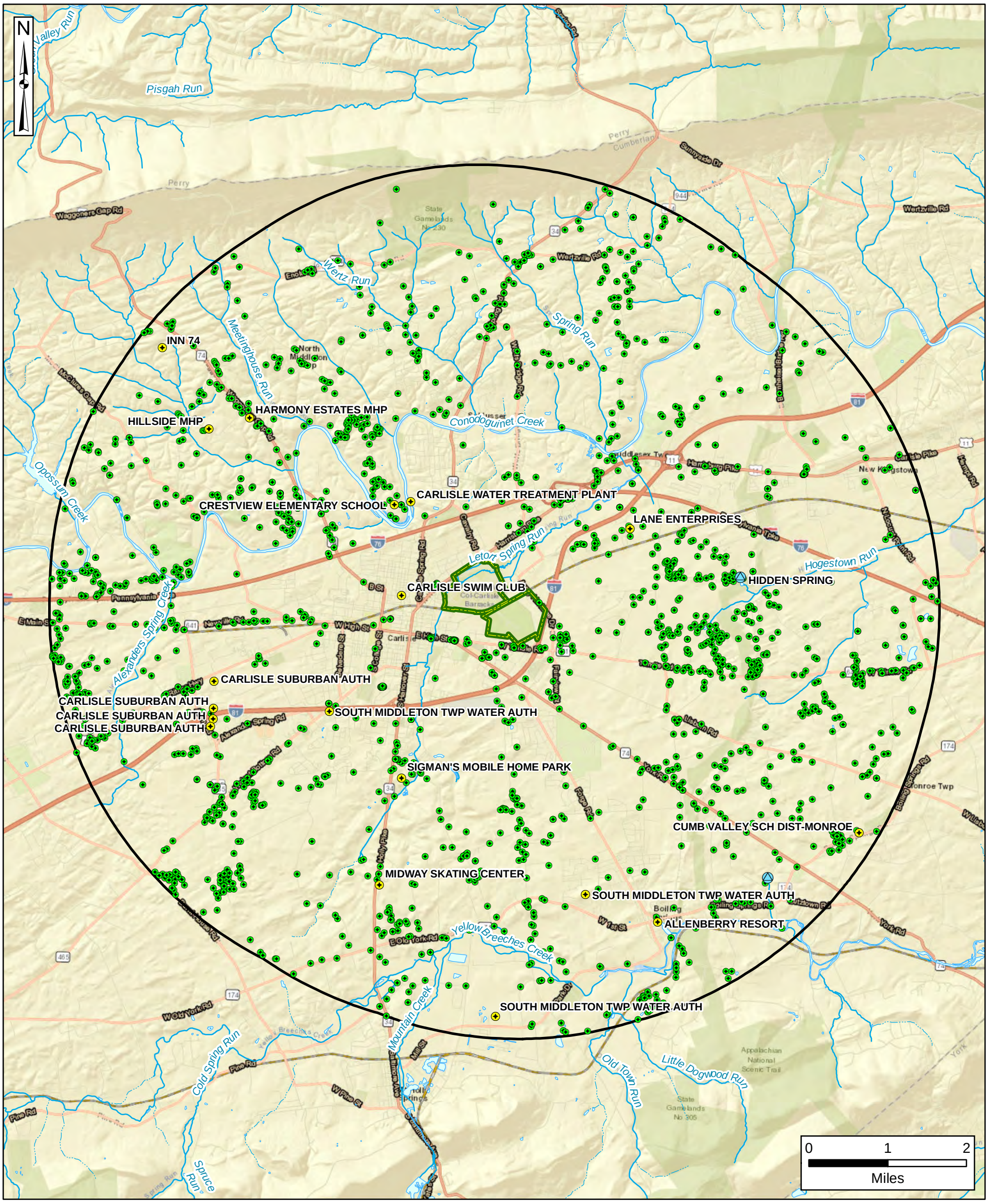
Elevation Contour (feet)

Data Sources:
USGS, NHD Data, 2019
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 18 North

USAEC PFAS Preliminary Assessment / Site Inspection
Carlisle Barracks, PA

Figure 2-4
Off-Post Potable Wells



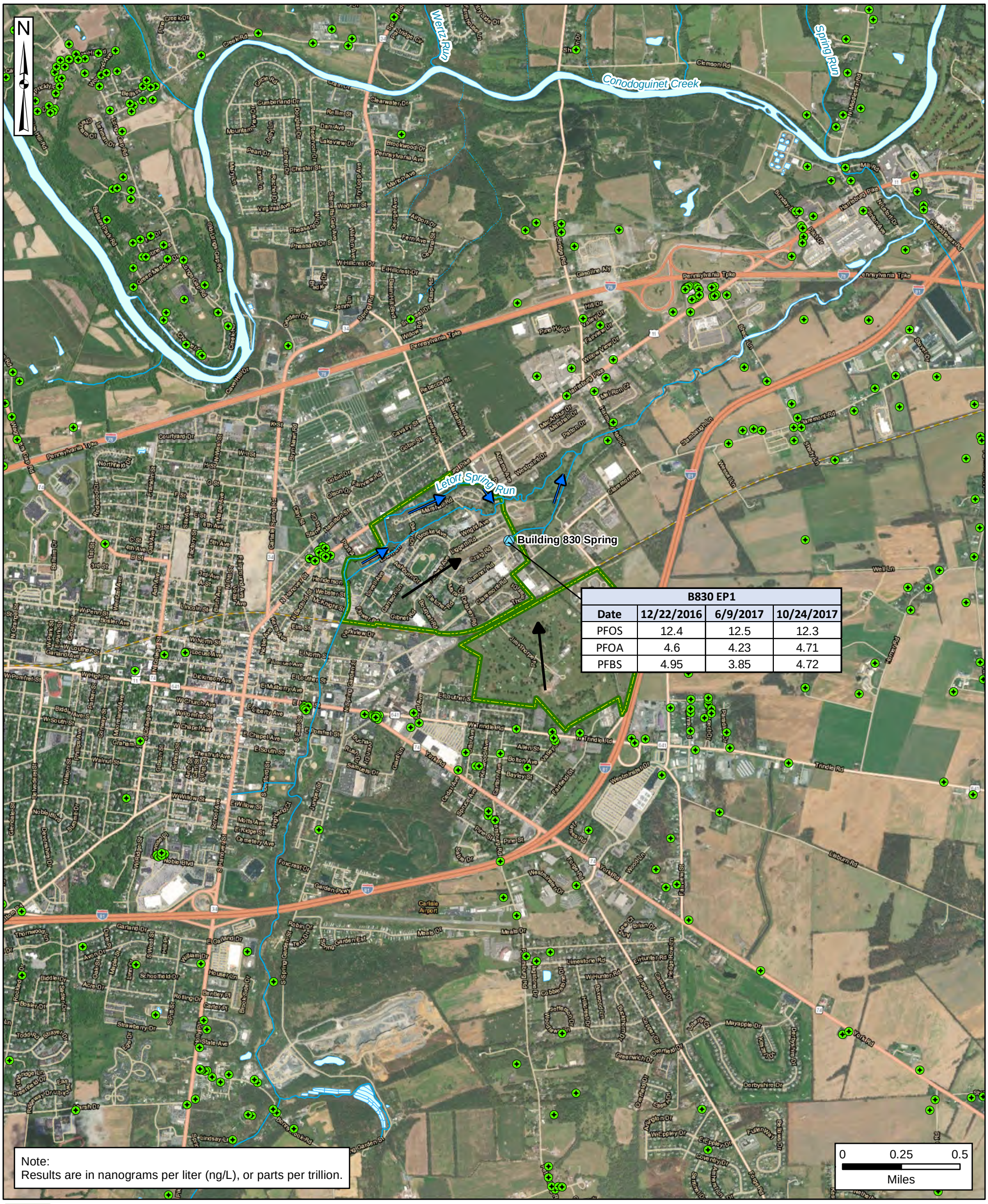
- Installation Boundary
- 5-Mile Radius
- River/Stream (Perennial)
- Stream (Intermittent)
- Water Body
- Public Water Supply System Well
- Water Well in PaGWIS Database (location not verified)
- Potable Water Use Spring

Data Sources:
Pennsylvania Groundwater Information System (PaGWIS), 2019
EDR, Well Data, 2018
USGS, NHD Data, 2019
ESRI ArcGIS Online, StreetMap Data

Coordinate System:
WGS 1984, UTM Zone 18 North

USAEC PFAS Preliminary Assessment / Site Inspection
Carlisle Barracks, PA

Figure 2-5
Historical PFOS, PFOA, and PFBS Data



B830 EP1			
Date	12/22/2016	6/9/2017	10/24/2017
PFOS	12.4	12.5	12.3
PFOA	4.6	4.23	4.71
PFBS	4.95	3.85	4.72

Installation Boundary
River/Stream (Perennial)
Stream (Intermittent)
Water Body
General Surface Water Flow Direction
General Groundwater Flow Direction
Building 830 Spring
Water Well in PaGWIS Database (location not verified)

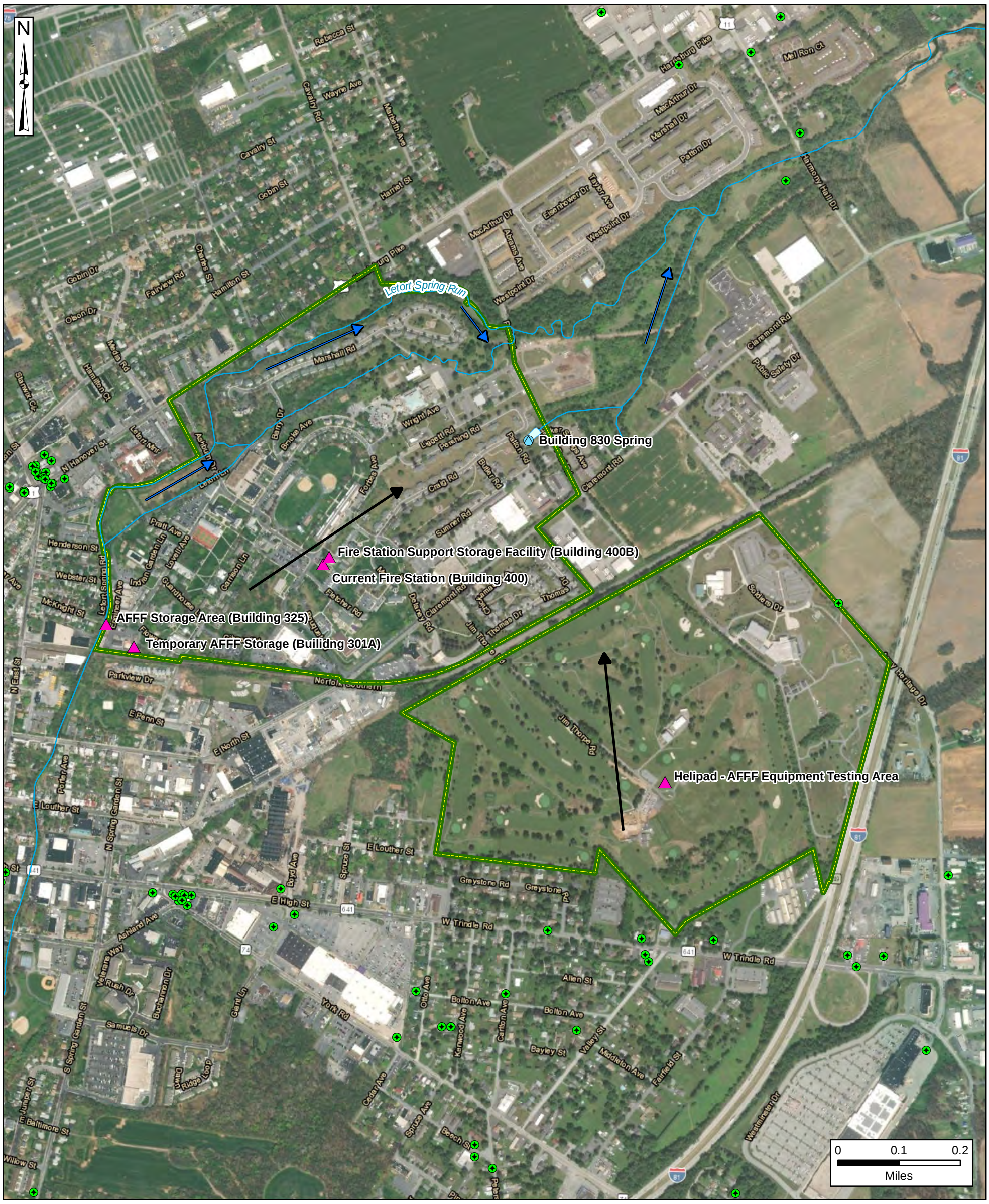
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate

Data Sources:
Pennsylvania Groundwater Information System (PaGWIS), 2019
USGS, NHD Data, 2019
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 18 North

USAEC PFAS Preliminary Assessment / Site Inspection
Carlisle Barracks, PA

Figure 5-2
AOPI Locations



Installation Boundary
AOPI
River/Stream (Perennial)
Stream (Intermittent)
Water Body
General Surface Water Flow Direction
Inferrred Groundwater Flow Direction
Water Well in PaGWIS Database (location not verified)
Building 830 Spring

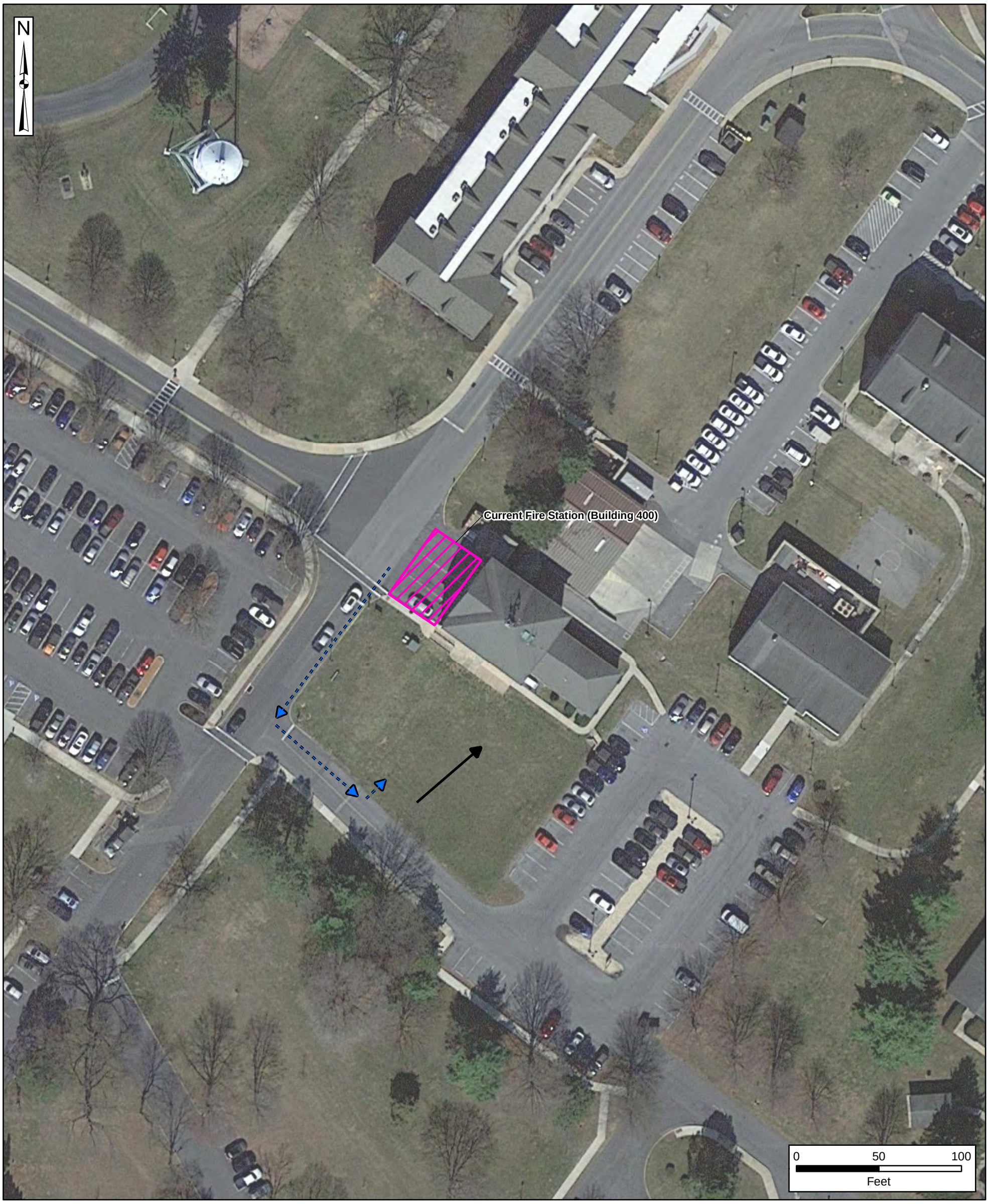
AFFF = Aqueous Film-Forming Foam
AOPI = Area of Potential Interest

Data Sources:
Pennsylvania Groundwater Information System (PaGWIS), 2019
EDR, Well Data, 2018
USGS, NHD Data, 2019
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 18 North

USAEC PFAS Preliminary Assessment / Site Inspection
Carlisle Barracks, PA

Figure 5-3
Aerial Photo of
Current Fire Station (Building 400)



AOPI

Truck Washing/AFFF Transfer Area

Surface Water Runoff Flow Direction

Inferred Groundwater Flow Direction

AFFF = Aqueous Film-Forming Foam
AOPI = Area of Potential Interest

Data Sources:
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 18 North

USAEC PFAS Preliminary Assessment / Site Inspection
Carlisle Barracks, PA

Figure 5-4
Aerial Photo of
Fire Station Support Storage Facility (Building 400B)

AOPI
Truck Washing/AFFF Transfer Area
Surface Water Runoff Flow Direction
Inferred Groundwater Flow Direction

AFFF = Aqueous Film-Forming Foam
AOPI = Area of Potential Interest

Data Sources:
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 18 North

USAEC PFAS Preliminary Assessment / Site Inspection
Carlisle Barracks, PA

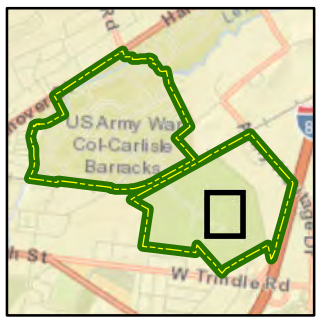
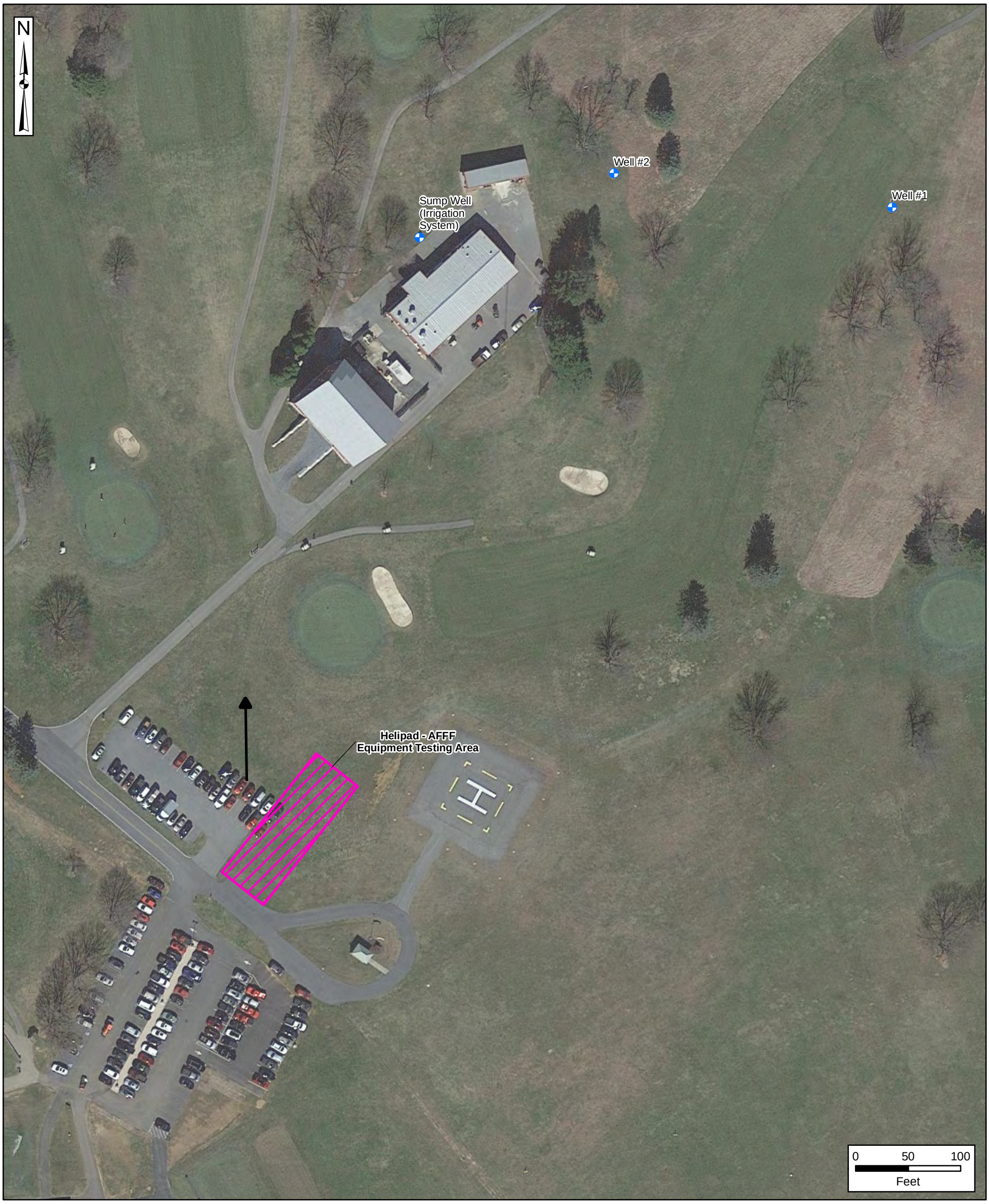


Figure 5-5
Aerial Photo of
Helipad - AFFF Equipment Testing Area



AOPI
AFFF Spray Area
Inferred Groundwater Flow Direction
Irrigation System

AFFF = Aqueous Film-Forming Foam
AOPI = Area of Potential Interest

Data Sources:
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 18 North

USAEC PFAS Preliminary Assessment / Site Inspection
Carlisle Barracks, PA

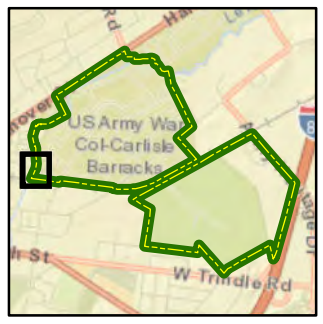


Figure 5-6
Aerial Photo of
AFFF Storage Area (Building 325)

Installation Boundary
AOPI
River/Stream (Perennial)
Surface Water Flow Direction
Inferred Groundwater Flow Direction

AFFF = Aqueous Film-Forming Foam
AOPI = Area of Potential Interest

Data Sources:
USGS, NHD Data, 2019
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 18 North

USAEC PFAS Preliminary Assessment / Site Inspection
Carlisle Barracks, PA

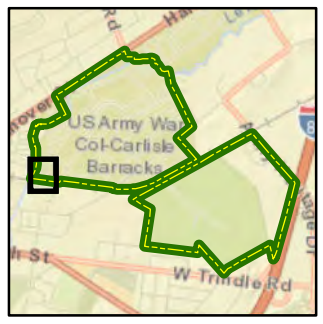


Figure 5-7
Aerial Photo of
Temporary AFFF Storage (Building 301A)

Installation Boundary
AOPI
River/Stream (Perennial)
Surface Water Flow Direction
Inferred Groundwater Flow Direction

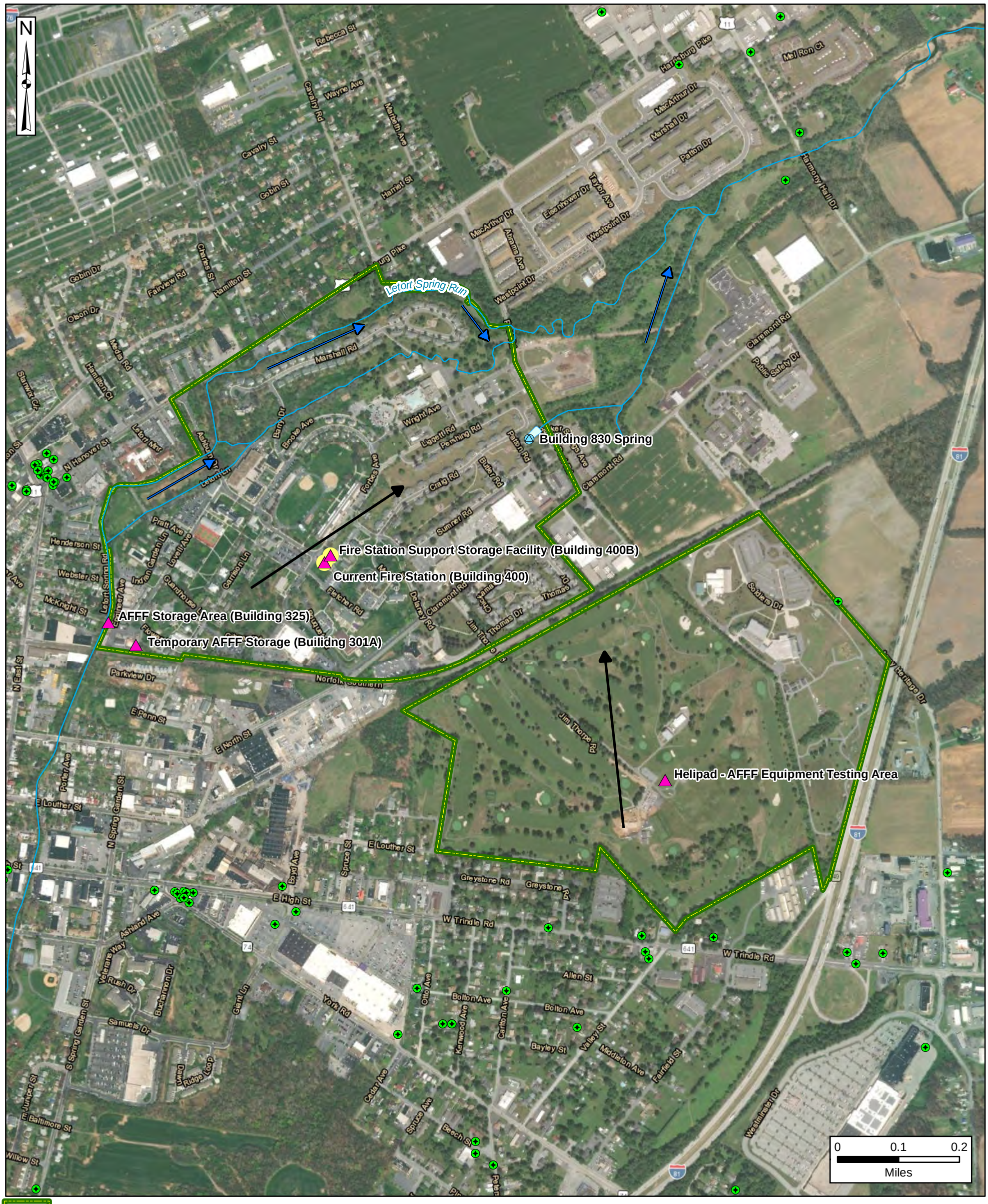
AFFF = Aqueous Film-Forming Foam
AOPI = Area of Potential Interest

Data Sources:
USGS, NHD Data, 2019
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 18 North

USAEC PFAS Preliminary Assessment / Site Inspection
Carlisle Barracks, PA

Figure 7-1
AOPI Locations and
OSD Risk Screening Level Exceedances



Installation Boundary
AOPI
AOPI with OSD Risk Screening Level Exceedance
River/Stream (Perennial)
Stream (Intermittent)
Water Body
General Surface Water Flow Direction
Inferrred Groundwater Flow Direction
Water Well in PaGWIS Database (location not verified)
Building 830 Spring

AFFF = aqueous film-forming foam
AOPI = area of potential interest
OSD = Office of the Secretary of Defense

Data Sources:
Pennsylvania Groundwater Information System (PaGWIS), 2019
EDR, Well Data, 2018
USGS, NHD Data, 2019
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 18 North

USAEC PFAS Preliminary Assessment / Site Insepction
Carlisle Barracks, PA

Figure 7-2
Current Fire Station (Building 400)
PFOS, PFOA, and PFBS Analytical Results

Current Fire Station (Building 400)

CBKS-B400-1-GW	
Date	8/25/2022
PFOS	**32 J+ [52 J]**
PFOA	**12 [15]**
PFBS	**5.4 [7.4]**

CBKS-B400-3-SO	
Date	6/30/2020
Depth	0.5-2 ft
PFOS	**0.0015**
PFOA	**0.00065**
PFBS	0.0022 U

CBKS-B400-1-SO	
Date	6/30/2020
Depth	0.5-2 ft
PFOS	**0.0097**
PFOA	**0.00061 J**
PFBS	0.0022 U

CBKS-B400-2-SO	
Date	6/30/2020
Depth	0.5-2 ft
PFOS	**0.0059**
PFOA	**0.00051 J**
PFBS	0.0023 U

Notes:
1. Groundwater results are in nanograms per liter (ng/L), or parts per trillion.
2. Soil results are in milligrams per kilogram (mg/kg), or parts per million.
3. Duplicate sample results are shown in brackets.
4. Bolded values indicate detections.
5. Concentrations of PFOS that exceed the Office of the Secretary of Defense (OSD) residential tap water risk screening level of 40 ng/L (OSD 2021) are highlighted gray.

Qualifiers:
J = The analyte was positively identified; however, the associated numerical value is an estimated concentration only.
J+ = The result is an estimated quantity; the result may be biased high.
U = The analyte was analyzed for but was not detected above the limit of quantitation (LOQ).

0 50 100
Feet

AOPI
Truck Washing/AFFF Transfer Area
Surface Water Runoff Flow Direction
Inferred Groundwater Flow Direction
Surface Soil Sample Location
Groundwater Sample Location

AFFF = aqueous film-forming foam
AOPI = area of potential interest
ft = feet
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate

Data Sources:
Google Earth, Aerial Imagery, Accessed 2019

Coordinate System:
WGS 1984, UTM Zone 18 North

USAEC PFAS Preliminary Assessment / Site Insepction
Carlisle Barracks, PA

Figure 7-3
Fire Station Support Storage Facility (Building 400B)
PFOS, PFOA, and PFBS Analytical Results

CBKS-B400B-GW-01	
Date	8/26/2022
PFOS	**68**
PFOA	**39**
PFBS	**12**

Fire Station Support Storage Facility (Building 400B)

CBKS-B400B-1-SO	
Date	6/30/2020
Depth	0.5-2 ft
PFOS	**0.0012 J [0.0047 J]**
PFOA	0.00071 U [0.00074 U]
PFBS	0.0024 U [0.0025 U]

CBKS-B400B-2-SO	
Date	6/30/2020
Depth	0.5-2 ft
PFOS	**0.0010**
PFOA	**0.0010**
PFBS	0.0022 U

Notes:
1. Groundwater results are in nanograms per liter (ng/L), or parts per trillion.
2. Soil results are in milligrams per kilogram (mg/kg), or parts per million.
3. Duplicate sample results are shown in brackets.
4. Bolded values indicate detections.
5. Concentrations of PFOS that exceed the Office of the Secretary of Defense (OSD) residential tap water risk screening level of 40 ng/L (OSD 2021) are highlighted gray.

Qualifiers:
J = The analyte was positively identified; however, the associated numerical value is an estimated concentration only.
U = The analyte was analyzed for but was not detected above the limit of quantitation (LOQ).

0 50 100
Feet

AOPI
Truck Washing/AFFF Transfer Area
Surface Water Runoff Flow Direction
Inferred Groundwater Flow Direction
Surface Soil Sample Location
Groundwater Sample Location

AFFF = aqueous film-forming foam
AOPI = area of potential interest
ft = feet
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate

Data Sources:
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 18 North

USAEC PFAS Preliminary Assessment / Site Insepction
Carlisle Barracks, PA

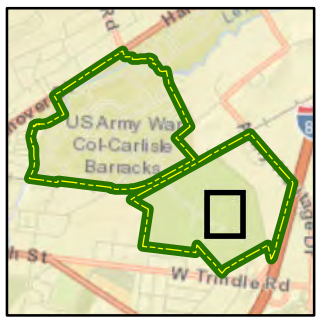


Figure 7-4
Helipad - AFFF Equipment Testing Area
PFOS, PFOA, and PFBS Analytical Results

CBKS-WELL_1_2-GW	
Date	6/29/2020
PFOS	**10 [9.7]**
PFOA	**2.8 [2.9]**
PFBS	**2.5 [2.6]**

CBKS-DEB-1-GW	
PFOS	**10**
PFOA	**2.9**
PFBS	**2.6**

CBKS-HELIPAD-4-SO	
Date	6/29/2020
Depth	0.5-2 ft
PFOS	**0.00085**
PFOA	0.00066 U
PFBS	0.0022 U

CBKS-HELIPAD-1-SO	
Date	6/29/2020
Depth	0.5-2 ft
PFOS	0.00069 U
PFOA	0.00069 U
PFBS	0.0023 U

CBKS-HELIPAD-2-SO	
Date	6/29/2020
Depth	0.5-2 ft
PFOS	**0.0017**
PFOA	**0.0014**
PFBS	0.0022 U

CBKS-HELIPAD-3-SO	
Date	6/29/2020
Depth	0.5-2 ft
PFOS	0.00068 U
PFOA	0.00068 U
PFBS	0.0023 U

Notes:
1. Groundwater results are in nanograms per liter (ng/L), or parts per trillion. Soil results are in milligrams per kilogram (mg/kg), or parts per million.
2. Duplicate sample results are shown in brackets.
3. Bolded values indicate detections.
4. The groundwater samples are composite samples collected from a spigot.
5. Sample CBKS-DEB-1-GW is a dedicated equipment blank collected from CBKS-WELL_1_2-GW prior to purge to evaluate background PFAS concentrations in the irrigation system.

Qualifiers:
J = The analyte was positively identified; however, the associated numerical value is an estimated concentration only.
U = The analyte was analyzed for but was not detected above the limit of quantitation (LOQ).

AOPI
AFFF Spray Area
Inferred Groundwater Flow Direction
Irrigation System
Groundwater Sample Location[8]
Surface Soil Sample Location

AFFF = aqueous film-forming foam
AOPI = area of potential interest
ft = feet
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate

Data Sources:
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 18 North

USAEC PFAS Preliminary Assessment / Site Insepction
Carlisle Barracks, PA

Figure 7-5
AFFF Storage Area (Building 325)
PFOS, PFOA, and PFBS Analytical Results

CBKS-B325-SW-01	
Date	8/30/2022
PFOS	**1.0 J**
PFOA	**1.1 J**
PFBS	**1.3 J**

CBKS-B325-2-SO	
Date	6/29/2020
Depth	0.5-2 ft
PFOS	**0.0014**
PFOA	**0.00089**
PFBS	0.0023 U

CBKS-B325-1-SO	
Date	6/29/2020
Depth	4-5.5 ft
PFOS	0.00083 U
PFOA	0.00083 U
PFBS	0.0028 U

CBKS-B325-GW-01	
Date	8/29/2022
PFOS	**14**
PFOA	**6.3**
PFBS	**1.6 J**

AFFF Storage Area (Building 325)

Letort Spring Run

0 100 Feet

0 50 100 Feet

Notes:
1. Groundwater and surface water results are in nanograms per liter (ng/L), or parts per trillion.
2. Soil results are in milligrams per kilogram (mg/kg), or parts per million.
3. Bolded values indicate detections.

Qualifiers:
J = The analyte was positively identified; however, the associated numerical value is an estimated concentration only.
U = The analyte was analyzed for but was not detected above the limit of quantitation (LOQ).

Installation Boundary
AOPI
River/Stream (Perennial)
Surface Water Flow Direction
Inferred Groundwater Flow Direction
Surface Soil Sample Location
Groundwater Sample Location
Surface Water Sample Location

AFFF = aqueous film-forming foam
AOPI = area of potential interest
ft = feet
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate

Data Sources:
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 18 North

USAEC PFAS Preliminary Assessment / Site Inspection
Carlisle Barracks, PA

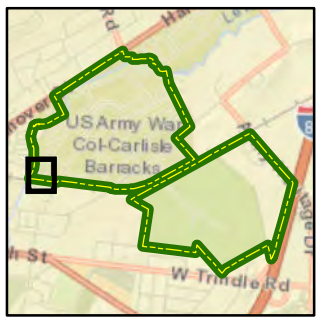


Figure 7-6
Temporary AFFF Storage (Building 301A)
PFOS, PFOA, and PFBS Analytical Results

N

Letort Spring Run

CBKS-B301A-1-SO	
Date	6/29/2020
Depth	0-0.5 ft
PFOS	**0.00063**
PFOA	0.00057 U
PFBS	0.0019 U

CBKS-B301A-2-SO	
Date	6/29/2020
Depth	0-0.5 ft
PFOS	**0.0012**
PFOA	0.00058 U
PFBS	0.0019 U

CBKS-B301A-GW-01	
Date	8/29/2022
PFOS	**1.1 J**
PFOA	**3.5**
PFBS	**2.1**

Temporary AFFF Storage (Buildng 301A)

Notes:
1. Groundwater results are in nanograms per liter (ng/L), or parts per trillion.
2. Soil results are in milligrams per kilogram (mg/kg), or parts per million.
3. Bolded values indicate detections.

Qualifiers:
J = The analyte was positively identified; however, the associated numerical value is an estimated concentration only.
U = The analyte was analyzed for but was not detected above the limit of quantitation (LOQ).

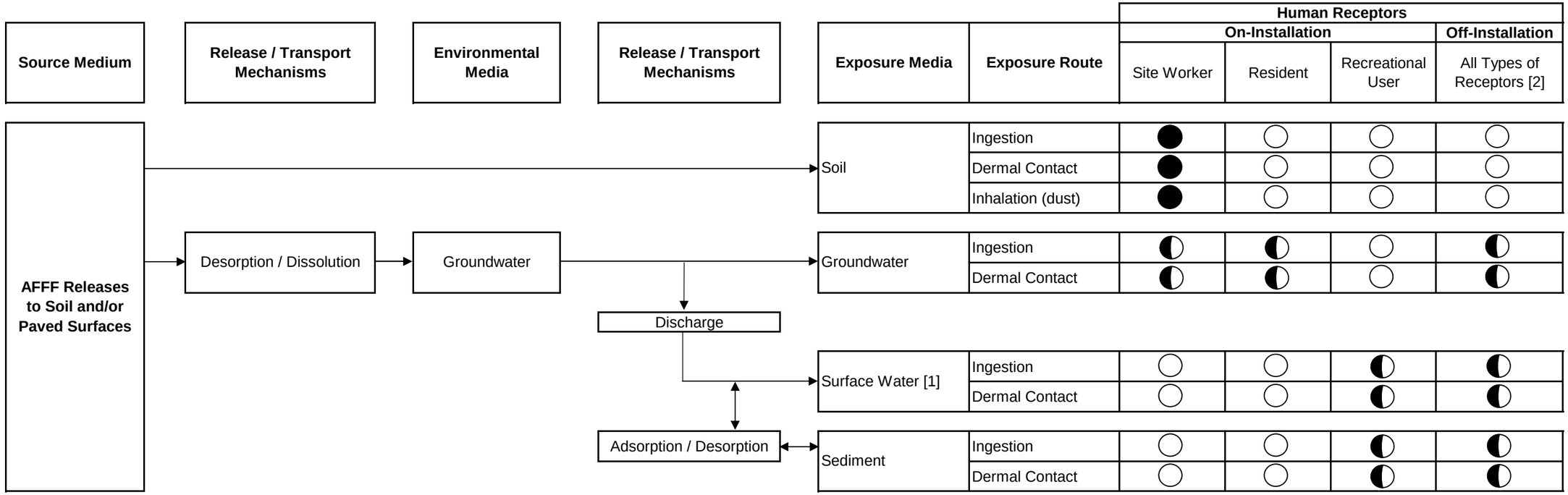
0 50 100
Feet

Installation Boundary
AOPI
River/Stream (Perennial)
Surface Water Flow Direction
Inferred Groundwater Flow Direction
Surface Soil Sample Location
Groundwater Sample Location

AFFF = aqueous film-forming foam
AOPI = area of potential interest
ft = feet
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate

Data Sources:
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 18 North



Legend:

- = Complete Exposure Pathway
- = Potentially Complete Exposure Pathway
- = Incomplete Exposure Pathway

Notes:
[1] Surface water exposure pathway for Site Workers and Residents describes a drinking water scenario, and for Recreational Users describes incidental ingestion and dermal contact during an outdoor recreational scenario.
[2] All types of off-installation human receptors include drinking water receptors and recreational users.

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Conceptual Site Model for the Current Fire Station (Building 400), Fire Station Support Storage Facility (Building 400B), and Temporary AFFF Storage (Building 301A) AOPIs
USAEC PFAS Preliminary Assessment / Site Inspection
Carlisle Barracks, Pennsylvania

Figure 7-7

Source Medium	Release / Transport Mechanisms	Environmental Media	Release / Transport Mechanisms	Exposure Media	Exposure Route	Human Receptors: On-Installation: Site Worker	On-Installation: Resident	On-Installation: Recreational User	Off-Installation: All Types of Receptors [2]
AFFF Releases to Soil and/or Paved Surfaces				Soil	Ingestion	●	○	○	○
					Dermal Contact	●	○	○	○
					Inhalation (dust)	●	○	○	○
	Desorption / Dissolution	Groundwater		Groundwater	Ingestion	◐	◐	○	◐
					Dermal Contact	◐	◐	○	◐
			Discharge						
				Surface Water [1]	Ingestion	○	○	●	◐
					Dermal Contact	○	○	●	◐
			Adsorption / Desorption	Sediment	Ingestion	○	○	◐	◐
					Dermal Contact	○	○	◐	◐

Legend:

● = Complete Exposure Pathway

◐ = Potentially Complete Exposure Pathway

○ = Incomplete Exposure Pathway

Notes:

[1] Surface water exposure pathway for Site Workers and Residents describes a drinking water scenario, and for Recreational Users describes incidental ingestion and dermal contact during an outdoor recreational scenario.

[2] All types of off-installation human receptors include drinking water receptors and recreational users.

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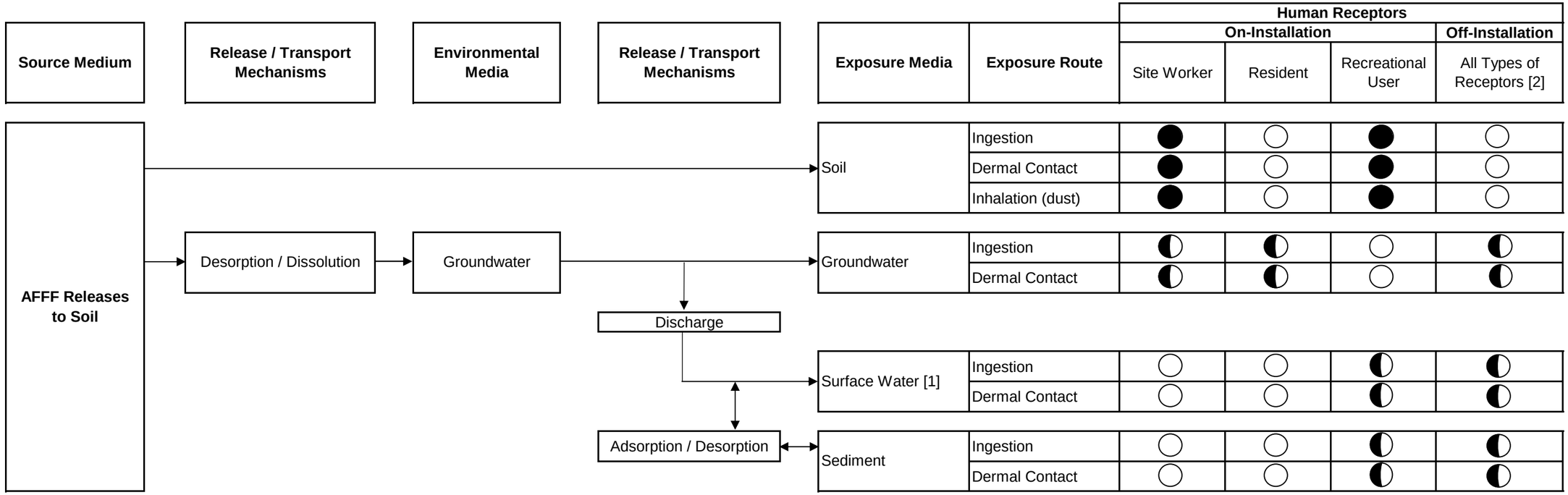
Conceptual Site Model for the AFFF Storage Area (Building 325) AOPI
USAEC PFAS Preliminary Assessment / Site Inspection
Carlisle Barracks, Pennsylvania

Figure 7-8



Legend:

- = Complete Exposure Pathway
- = Potentially Complete Exposure Pathway
- = Incomplete Exposure Pathway

Notes:
[1] Surface water exposure pathway for Site Workers and Residents describes a drinking water scenario, and for Recreational Users describes incidental ingestion and dermal contact during an outdoor recreational scenario.
[2] All types of off-installation human receptors include drinking water receptors and recreational users.

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Conceptual Site Model for the Helipad- AFFF Equipment Testing Area AOPI
USAEC PFAS Preliminary Assessment / Site Inspection
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Figure 7-9

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