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

Fort Knox, Kentucky

Prepared For:
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Preliminary Assessment and Site Inspection of Per- and Polyfluoroalkyl Substances

Fort Knox, Kentucky

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EXECUTIVE SUMMARY

The United States Army (Army) is performing preliminary assessments (PAs) and site inspections (SIs) on the current or potential historical use of 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 Fort Knox (FTKX) PA/SI was completed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), National Oil and Hazardous Substances Pollution Contingency Plan, and Army/Department of Defense (DoD) policy and guidance.

FTKX is located in north-central Kentucky approximately 30 miles south of Louisville. FTKX is the Army's Accessions Platform; home to the US Army's Cadet Command, Recruiting Command, & Human Resources Command. FTKX is also home to V Corps (i.e., formerly known as Fifth Corps) which is America's Forward Deployed Corps in Europe and the 1st Theater Sustainment Command where they are responsible for conducting sustainment operations to ensure warfighters have the supplies and transportation capabilities they need to accomplish their missions within the US Army Central Command. FTKX is comprised of 63 firing ranges, 18 major training areas, 5 base camps, and 29 bivouac sites.

The FTKX PA identified eight AOPIs for investigation during the SI phase. SI sampling results from the eight 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 eight AOPIs; however, only four of the eight AOPIs had PFOS, PFOA, and/or PFBS present at concentrations greater than the risk-based screening levels. The FTKX PA/SI identified the need for further study in a CERCLA remedial investigation. **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 FTKX, and Recommendations

AOPI Name	PFOS, PFOA, and/or PFBS detected greater than OSD Risk Screening Levels?				Recommendation
	GW	SO	SW/SP	SE	
Former Fire Training Area (FTKX-24, 21405.1030)	NS*	No	Yes	No	Future study in a remedial investigation
Former Nozzle Testing Area	NS*	No	Yes	No	Future study in a remedial investigation

AOPI Name	PFOS, PFOA, and/or PFBS detected greater than OSD Risk Screening Levels?				Recommendation
	GW	SO	SW/SP	SE	
Army Reserves Hangar 5222 and Foam Storage Area	NS*	No	NS	NS	No action at this time
Building 5256 Foam Storage Area	NS*	No	NS	NS	No action at this time
Building 5223 Fire Station #3	Yes	No	No	No	Future study in a remedial investigation
Heavy Expanded Mobility Tactical Truck Crash Site	NS*	ND	NS	NS	No action at this time
Active Construction and Demolition Debris Landfill	No	NS	No	ND	No action at this time
Wastewater Treatment Plant Former Sludge Drying Beds (FTKX-11)	NS	Yes	No	NS	Future study in a remedial investigation

Notes:

* FTKX is underlain by karst geology with complex groundwater flow patterns; therefore, groundwater was not sampled at or downgradient of a subset of AOPIs.

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

GW – groundwater

ND – non-detect

NS – not sampled

SE – sediment

SO – soil

SP – spring water (i.e., expressions of groundwater, therefore the data collected at springs are compared to the OSD risk screening levels for tap water)

SW – surface water

1 INTRODUCTION

The United States (U.S.) Army (Army) is performing preliminary assessments (PAs) and site inspections (SIs) on the current or potential historical use of 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 Fort Knox (FTKX), Kentucky 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 FTKX 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 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 or 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

The FTKX PA/SI development generally the process as described in **Sections 1.3.1** through **1.3.5** below. **Section 3** provides a summary of the PA activities completed, and **Section 6** provides a summary of the SI activities completed for FTKX. 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 United States Army Environmental Command (USAEC), United States Army Corps of Engineers (USACE), FTKX, and Arcadis U.S., Inc. (Arcadis). The kickoff call occurred on 26 March 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 FTKX.

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 07 to 09 May 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 FTKX. 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 points 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, was 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 09 May 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 FTKX.

The objectives of the SI kickoff teleconference were to:

- discuss the AOPIs selected for sampling and the proposed sampling plan for each AOPI
- gauge regulatory involvement requirements or preferences
- identify overlapping unexploded ordnance (UXO) or cultural resource areas
- confirm the plan for investigation derived waste (IDW) handling and disposal
- 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 FTKX. Additional discussion topics included:

- discuss logistics for the sampling event
- 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 2019). 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 2019) and the approved installation-specific QAPP Addendum. A Site Safety and Health Plan (SSHP) was also developed as an attachment to the QAPP Addendum 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 FTKX (Arcadis 2020b) 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) 5.3 (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 FTKX, 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. The information contained in this section is excerpted from the sources cited within.

2.1 Site Location

FTKX is located in north-central Kentucky and is approximately 30 miles south of Louisville and 18 miles north of Elizabethtown, Kentucky (Science Applications International Corporation [SAIC] 2007). It is comprised of 109,270 acres, with the main cantonment area of 5,865 acres in the west-central portion of the installation. Portions of the installation are located in Hardin, Meade, and Bullitt counties (SAIC 2011, **Figure 2-1**).

2.2 Mission and Brief Site History

FTKX is the Army's Accessions Platform; home to the US Army's Cadet Command, Recruiting Command, & Human Resources Command. FTKX is also home to V Corps (i.e., formerly known as Fifth Corps), which is America's Forward Deployed Corps in Europe and the 1st Theater Sustainment Command where they are responsible for conducting sustainment operations to ensure warfighters have the supplies and transportation capabilities they need to accomplish their missions within the US Army Central Command

The installation has been in operation since 1918 (FTKX 2016). The current mission at FTKX is soldier career management, and the installation houses the Army Cadet Command, Army Human Resources Command, the 84th Training Command, and the Ireland Army Community Hospital (FPM Remediations, Inc. 2017). The installation directly supports a population of approximately 160,000 active and reserve component service members, retirees, military dependents, DoD civilians and contractors (FTKX 2016). The daytime population of FTKX is approximately 40,000, which includes military personnel, dependents, and civilians. The civilian and military personnel residing on-site comprise approximately two-thirds of the daytime population (Toltest, Inc. 2007). FTKX is home to the Army's single largest training event, U.S. Army Cadet Command's cadet summer training program. Approximately 4,500 instructors and 12,000 cadets converge on FTKX between the months of May and August for cadet summer training. The installation's motto is "Strength Starts Here," as Army accessions missions and the management of soldiers' careers are all headquartered on the military installation. In total, more than 100 commands, units, organizations, and agencies operate on FTKX (FTKX 2016).

2.3 Current and Projected Land Use

FTKX is comprised of 63 firing ranges, 18 major training areas, five base camps, and 29 bivouac sites. Additionally, FTKX has 250 miles of paved roads, 20 miles of railroad, and more than 4,000 buildings (FTKX 2016, **Figure 2-2**). The cantonment area contains most of the installation's permanent residential, military, and commercial structures. Outside the cantonment area, development is sparse.

FTKX supports training missions and programs for the DoD, hosts guard and reserve units, and is the headquarters for Human Resources (USACE, Geo-Environmental Branch 2017). Portions of the installation are used for managed recreational purposes (e.g., managed hunting and fishing). Since FTKX is an active facility, there are no anticipated land use changes for the reasonably anticipated future.

Surrounding land use to the west of the facility is urban with some agriculture (USACE, Geo-Environmental Branch 2017). The areas north, east, west, and south of FTKX are predominantly rural areas used by forestry and agricultural communities (Toltest, Inc. 2007; USACE, Geo-Environmental Branch 2017).

2.4 Climate

FTKX lies within the temperate climate zone typified by warm, humid summers and cool winters. The warmest month is July, with an average high temperature of 87.3 degrees Fahrenheit. The coolest month is January, with an average low temperature of 20.2 degrees Fahrenheit (SAIC 2003).

FTKX experiences a wet and a dry season. The average annual precipitation of FTKX is 49 inches. The wet season occurs from late winter into mid-summer, roughly March through July. The average monthly precipitation at FTKX is approximately 4 inches (SAIC 1999, URS Corporation 2017).

Prevailing winds are from the south and southwest at average speeds of less than 10 miles per hour. The strongest winds are usually associated with thunderstorms from the west or northwest (SAIC 2003).

2.5 Topography

The topography of FTKX is characterized by rolling uplands of low to moderate relief in the central and western parts of the installation, with rounded steep-sided ridges of moderate relief in the eastern portions of the installation (URS Corporation 2017). The elevation varies from 380 feet above mean sea level in the Ohio River flood plain at Hughes Landing near the northwestern corner of the installation to 990 feet above mean sea level at Dawson Knob near the eastern edge of the installation (Advanced Services, Inc. 1992, **Figure 2-3**).

2.6 Geology

The soil at FTKX is composed of highly fertile claypan and silty soils (URS Corporation 2017). The geology of the underlying bedrock is karst limestone and shale of Mississippian age. The bedrock dips toward the west and significantly influences the direction of groundwater flow (FPM Remediations 2017). The depth to bedrock lies between 30 and 40 feet below ground surface (bgs) (SAIC 2007). St. Louis Limestone over 100 feet thick lies under the upland areas of FTKX, and baseline streams cut through Salem Limestone and other Mississippian-age formations (URS Corporation 2017; FPM Remediations 2017). The St. Louis Limestone serves as the region's primary aquifer and contains clean limestone, chert layers, dolomite, and thin shale beds. The St. Louis Limestone is particularly vulnerable to erosion by chemical dissolution which provides caves, sinkholes, and other karst features for the groundwater to move through (SAIC 1999). The Salem Limestone, which is a lower part of the limestone formation, is composed of interbedded limestone, gypsum, and anhydrite (URS Corporation 2017). The major springs and seeps where groundwater reemerges correspond to the area where the St. Louis Limestone meets

Salem Limestone. The cantonment area is located within the Pennyroyal plateau province on the Elizabethtown sinkhole plain (URS Corporation 2017). The sinkhole plain generally has less than 50 feet of relief.

2.7 Hydrogeology

Groundwater generally flows from the upland cantonment area west towards tributaries of Otter Creek, with small portions of the groundwater flowing north towards the Ohio River valley and east to the Mill Creek and Salt River valleys (FPM Remediations 2017). The valleys of the rivers and intermittent streams are filled with loess and fluvial deposits. The thickness of the residuum in the area varies based on the characteristics of the parent limestone. Most of the potable drinking water supply for FTKX comes from groundwater, obtained from a well field in an alluvial aquifer formed by river sediments and ranging in depth from 106 to 148 feet bgs.

Groundwater flow through the mature karst terrain at FTKX develops within fractures in the bedrock and can be difficult to model in comparison to porous media groundwater flow due to the lack of uniformity in flow zone connections. Variables such as climate, tectonics, bedrock structure, base flow elevation, topography and water chemistry create variations within the karst setting that make classification and investigation of groundwater flow using well and aquifer tests alone untenable (URS Corporation 2017). Other methods such as remote sensing, geophysics, structural geology, and dye tracing are necessary to understand the mechanics of the karst aquifer system.

The karst aquifer's groundwater storage is contained in the Epikarst Zone, which is the zone between the organic soils found near the surface and the largely unweathered bedrock found below this region. Shallow groundwater occurs at the base of the soil residuum and in the epikarst where a water table lies at approximately 8 to 37 feet bgs (USACE 2017). The hydraulic properties of this zone vary more than four orders of magnitude in small changes in elevation, and the geologic composition varies from mostly clay to mostly fractured rock. Flow and contaminant concentrations within the karst aquifer system can vary up to five orders of magnitude between wet and dry seasons, making seasonal considerations significant when determining contaminant concentrations over time (URS Corporation 2017). Additionally, changes in precipitation can change the shape of groundwater basins. For example, heavy rains may cause an increase in the potentiometric surface of the groundwater resulting in higher flow passages being used, which may result in groundwater reemerging from different springs than those of typical low flow conditions (SAIC 1999).

Dye tracer tests performed to date indicate that groundwater from multiple sites discharges to the same subset of primary springs for each basin in Otter Creek and Mill Creek. The major discharge points in Otter Creek are Sycamore Spring and the discharge point of the Dry Branch basin. One dye tracer test performed at the former fire fighter training area found that the injected dye resurfaced 1,400 feet southwest of the point of injection in the surface channel of the North Fork of Dry Branch. The dye reached the sinking point of Dry Branch and traveled through the subsurface, reemerging at Fountain Spring and Leaning Cedar Spring near Otter Creek on the West side of the installation (URS Corporation 2017). **Figure 2-4** shows the results of the historical dye tracer studies.

2.8 Surface Water Hydrology

Surface waters at FTKX include rivers, streams/drainages, and impoundments. The Ohio River is the largest surface water feature in the vicinity and is located about 6 miles north of the cantonment area; flow in the Ohio River is to the Southwest. The Ohio River flows into the Mississippi River at the tri-state junction of Illinois, Kentucky, and Missouri (TolTest, Inc. 2009).

FTKX lies within two watersheds of the Ohio River drainage basin: the Salt River in the central and eastern portion of the installation, and Otter Creek in the western portion. Otter Creek, which flows directly to the Ohio River, is located along the western boundary of the FTKX installation and is fed by several springs and Dry Branch. Flow from the springs is highly dependent upon local rainfall. Dry Branch and its tributaries, Gander Branch and North Fork, drain the southern and western interior of the cantonment area. Mill Creek drains the eastern portion of the cantonment area and flows north until joining the Salt River near the center of the installation. Bee Branch and Tioga Creek drain the area along the northwest boundary of the FTKX installation and flow north into the Salt River and Ohio River, respectively, at locations outside of the installation (TolTest, Inc. 2009).

The eastern half of the FTKX installation is drained directly by the Salt River and Rolling Fork, which is a principal tributary of the Salt River. The Salt River enters the installation in the northeast corner and flows west across most of the northern portion of the installation. Rolling Fork enters the FTKX property at the southeast corner and flows northeast until joining the Salt River in the east-central portion of the installation. Cedar Creek, a tributary to Rolling Fork, drains a large portion of the southeast quadrant of the FTKX and enters Rolling Fork in the south-central portion of the installation (TolTest, Inc. 2009).

Surface water impoundments at FTKX include 30 ponds and reservoirs that are used for recreation and the maintenance of wildlife habitats. Many of these surface water bodies are former farm ponds that were typically formed by low earthen dams and shallow excavations (TolTest, Inc. 2009).

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 FTKX.

2.9.1 Stormwater Management System Description

Stormwater collected at FTKX is managed separate from wastewater except for a small amount of stormwater that gets into the sanitary sewer system through inflow and infiltration mostly during rain events. There are 11 permitted storm water outfalls throughout the installation including five associated with sinkholes at the Landfill, two on Mill Creek, and two on Otter Creek.

2.9.2 Sewer System Description

Wastewater collected from the City of Muldraugh and FTKX is sent to the Fort Knox Wastewater Treatment Plant (WWTP) (National Pollutant Discharge Elimination System Permit No. KY0002917). The wastewater primarily consists of municipal sewage as well as wastewater collected in the sewer system from around the installation. Additionally, groundwater collected on-post as IDW during monitoring events

is containerized and disposed of at the WWTP. The treated water from the WWTP is discharged into an unnamed tributary, then to Mill Creek, Salt River, and eventually into the Ohio River.

Sludge drying beds were used from approximately the 1960s until 2009. Seventeen drying beds were utilized in conjunction with the WWTP, occupying approximately 34,000 square feet. The sludge beds have not received sludge since 2009, and the sludge drying beds site is currently under a long-term monitoring program on the installation's Resource Conservation and Recovery Act Corrective Action Permit. Solids from the WWTP have been hauled off-site since the inactivation of the sludge drying beds (SAIC 2011).

2.10 Potable Water Supply and Drinking Water Receptors

Most of the potable drinking water supply for FTKX comes from groundwater, obtained from a well field located approximately 5 miles north of the cantonment area, off post of FTKX, in alluvial sediments near the Ohio River (**Figure 2-2**). These water supply wells are screened in a naturally formed alluvial aquifer bounded by the Ohio River, the Salt River, and the inland hills (FTKX 2016). The water supply wells range in depth from 106 to 148 feet bgs. These wells provide up to 2.5 million gallons of water per day. The average domestic water use is 2,385,000 gallons per day, while the average industrial use is 265,000 gallons per day.

Approximately one quarter of the potable drinking water used at FTKX is supplied by the surface water in Otter Creek (FTKX 2016). McCracken Spring, which emanates from the St. Louis limestone located just west of Otter Creek, provides the remainder of the FTKX water supply. The McCracken Spring reservoir and Otter Creek reservoir (located about 200 feet downstream of the McCracken Spring reservoir) supply up to 1.5 million gallons per day (FTKX 2016).

Groundwater quality varies with location. The water from the limestone aquifers is generally hard; this is attributed to the presence of calcium carbonate. The water from Otter Creek is generally hard and fairly clear, but it discolors during flooding, and bicarbonate, hardness, and pH levels are usually higher than those in the other streams on FTKX.

The Central and Muldraugh Water Treatment Plants, discussed in **Section 2.9**, located in the north central portion of the installation, provide FTKX with treated, potable water (Advanced Services, Inc. 1992). The Central Water Treatment Plant is located within the central cantonment area on Water Street and receives its water source from Otter Creek and McCracken Springs. The Muldraugh Water Treatment plant is 2 miles north of the cantonment area, immediately east of Dixie Highway and receives its water source from a well field located on the Ohio River floodplain southwest of West Point (SAIC 1999, **Figure 2-2**).

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 FTKX, which along with an online query through the Kentucky Geological Survey, identified several off-post public and private wells within 5 miles of the installation boundary (**Figure 2-5**); however, the use status of these wells has not been confirmed and may be unknown. The EDR report providing well search results 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.

Fort Knox is primarily a forest ecosystem interlaced with a narrow stream and broad river riparian ecosystems with numerous palustrine and riverine wetlands surrounding FTKX. Wooded areas at FTKX are comprised largely of pine and hardwood deciduous trees. Common grass species prevalent in these areas include meadow fescue, broom sedge, foxtail grass, panic grass, Johnson grass, barnyard grass, and fall panicum. Streams, ponds, and reservoirs support a variety of aquatic life. In addition, the karst setting has created a system of underground tunnels and caves, many of which also host unique aquatic ecosystems (Engineering Environmental Management, Inc. 2007).

Several federal- and state-listed (i.e., endangered, threatened, or species of special concern) species of animals are present on FTKX, including the grey bat, Indiana bat, bald eagle, Henslow's sparrow, sharp-shinned hawk, northern cavefish, cave crayfish, and gray treefrog. Other federal- or state- listed birds that potentially occur at FTKX include the hooded merganser, yellow-crowned night-heron, and barn owl. Also, three species of reptiles which are federal- or state-listed have potential to be found at FTKX, including the copper belly water snake, Kirtland's snake, and eastern slender glass lizard (Engineering Environmental Management, Inc. 2007).

2.12 Previous PFAS Investigations

Previous (i.e., pre-PA) PFAS investigations relative to FTKX are summarized to provide full context of available PFAS data for FTKX. Only data collected by the Army will be used to make recommendations for further investigation. Several water sources supplying the Central and Muldraugh Water Treatment Plants were sampled in 2013 under the USEPAs PFAS sampling program in response to the Third Unregulated Contaminant Monitoring Rule (UCMR3). The laboratory which analyzed samples under UCMR3 met the USEPA's UCMR3 Laboratory Approval Program application and Proficiency Testing criteria for USEPA Method 537 Version 1.1. PFOS, PFOA, and PFBS were part of the PFAS constituents analyzed in the 2013 sampling. PFOS, PFOA, and PFBS were not detected above the reporting limit in these samples. These data are provided in **Table 2-1** with each analyte's respective reported limit of quantitation. No additional PFAS sampling had been completed at FTKX at the time of the PA/SI.

3 SUMMARY OF PA ACTIVITIES

To document areas where any potential current and/or historical PFAS-containing materials were used, stored, and/or disposed at FTKX, data were collected from three principal sources of information:

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

These sources of data, along with their relative application to this PA, are discussed below. The specific findings of records review, personnel interviews, and site reconnaissance relevant to PFAS-containing materials at FTKX are described in **Section 4**.

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, FTKX fire department documents, FTKX directorate of public works (DPW) documents, and GIS files. Internet searches were also conducted to identify publicly available and other relevant information. Additionally, an EDR report generated for FTKX was reviewed to obtain off-post water supply well information. A list of the specific documents reviewed for FTKX is provided in **Appendix F**.

3.2 Personnel Interviews

Interviews were conducted during the site visit in May 2019. 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 FTKX is presented below (affiliation is with FTKX).

- Fire Chief
- Assistant Fire Chief
- Hazardous Waste/Materials Manager
- Environmental Technician
- Emergency Vehicle Technician
- Range Operations Supervisor
- Range Operations Officer
- Forestry Program Manager
- Chief, Natural Resources Branch
- IRP Manager

- Chief Master Planner
- Master Planning Engineer
- Chief of Operations and Maintenance
- FTKX Systems Director
- Project Engineer, DPW, Operations and Maintenance Division
- Godman Army Airfield Manager
- Historic Preservation Specialist
- Chief of Industrial Hygiene
- Pest Management Personnel

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 FTKX during the records review process, the installation in-brief meeting, and/or during the installation personnel interviews. These areas were classified as an area not retained for further investigation or an AOPI based on a combination of other information collected (e.g., records reviewed, personnel interviews, internet searches) as described in **Sections 5.1** and **5.2**, respectively. 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.

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**), and site reconnaissance logs (**Appendix I**) during the PA process for FTKX 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**.

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

FTKX 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 aqueous film-forming foam (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.

At locations that coincide with an existing IRP site, the site identifier and Headquarters Army Environmental System number are shown as applicable.

4.1 AFFF Use, Storage, and Disposal at FTKX

AFFF was developed in the mid-1960s in response to a need for firefighting foams better suited to extinguish Class B, fuel-based fires. AFFF formulations consist of water, an organic solvent, up to 5 percent (%) hydrocarbon surfactants, and 1 to 3% PFAS (Interstate Technology Regulatory Council 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.

Two areas historically used for fire training activities at FTKX were identified during the PA through document research and personnel interviews. AFFF was reportedly used northwest of the Godman Army Airfield at a Former Fire Training Area (FFTA; IRP identifier FTKX-24 under Resource Conservation and Recovery Act (RCRA)) and at a Former Nozzle Testing Area (FNTA). The FFTA was used from 1965 to 1996 for fire training activities during which jet fuel was ignited and then extinguished using AFFF (URS Corporation 2017). The FFTA was a curbed concrete slab with drainage to an oil water separator (OWS). The number of trainings that occurred and the amount of AFFF used during each training is uncertain. The FNTA was used from 1965 until 2017 and is the only identified location used for nozzle testing at FTKX; fire equipment nozzle testing was conducted yearly by spraying AFFF through nozzles on fire response and crash trucks to ensure optimal flow and release of the AFFF mixture. During these nozzle testing events, an unknown volume of AFFF mixture would be released to soil and/or paved surfaces from the trucks. The FNTA is located upgradient from the FFTA; AFFF mixture expelled at the FNTA also flowed into the same OWS as runoff from the FFTA until the OWS was excavated and removed in 2009 and disposed offsite with the assistance of the FTKX hazardous waste department.

Additionally, personnel interviews indicated that in 2015, AFFF was used to extinguish a fuel fire after a heavy expanded mobility tactical truck (HEMTT) crashed and rolled over on a road located in the active ranges of FTKX. Approximately 20 to 25 gallons of AFFF concentrate was mixed with water and used on

the fuel fire. Runoff of the AFFF mixture used during the fire response would have flowed downhill into an unnamed tributary.

AFFF has also historically been stored at FTKX. In one 2016 IMCOM AFFF inventory provided by the Army, it was noted that the following were stored on FTKX; 185 gallons of Buckeye Platinum 3% AFFF (BFC-3.1), 175 gallons Chemguard 3% AFFF C-303, 255 gallons Chemguard 3% AFFF C-301MS, and 819 gallons of AFFF in fire department vehicles. A separate 2016 inventory provide by the Army indicated the following volumes of AFFF in storage at FTKX at the time: 30 gallons of 3% AFFF in Engine 1, 30 gallons of 3% AFFF in Engine 3, 202 gallons of 3% AFFF in the Crash 7 Titan, and 30 gallons of 3% AFFF in Engine 12. It was not specified if these reported volumes of AFFF in the fire response vehicles were included in volumes reported in the first described inventory. Additionally, AFFF was housed in hangar suppression systems at the Godman Army Airfield in Building 5222, and 5256 (volume unspecified).

According to personnel interviews, in June 2019, C8 AFFF was removed from crash trucks, fire engines, and trailers stored at Building 5223 Fire Station #3 and disposed with the assistance of the FTKX hazardous waste department. The disposed foam was replaced with another MIL-PRF-24385F approved AFFF.

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

Following document research, personnel interviews, and site reconnaissance at FTKX, underground storage tank (UST) areas, former maintenance areas and shops, the Closed Landfill (FTKX-01), and the WWTP 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**.

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 identify FTKX as an installation having used or stored PFAS-containing pesticides/insecticides. The PA team reviewed available pesticide use inventory documentation provided by the installation and did not identified the PFAS-containing pesticides as an ant bait insecticides. Interviewees stated the ant bait insecticides were used as needed at a single point and not widespread. Exact locations of application are unknown (**Appendix G**).

Additionally, multiple maintenance areas, rinse tanks, and wash racks were identified on post. The Former Pesticide Rinse Tank Area (Building 112) was historically a rinse area for pesticide distribution vehicles and equipment. A 4,000-gallon UST that collected the pesticide rinseate in this area was removed in 1988. Maintenance on all installation vehicles, including fire trucks and crash trucks, has historically been performed at Boatwright Maintenance Area near Building 277 and is still conducted there today. Fire trucks are only at this location during maintenance. Waste from this building is conveyed to an OWS prior to being sent to the WWTP. Other general maintenance sites on post that are still currently in operation perform maintenance on electronics, small arms, furniture, and office equipment and have

generated used oil and oil solvents, asbestos, grease, and paint wastes. After further investigation, all maintenance areas, rinse tanks, and wash racks were not identified as a location of PFAS-containing materials use, storage, or disposal and were not retained for further investigation.

An active landfill that has historically received potential PFAS-containing waste disposal was identified on post. The Active Construction and Demolition Debris (CDD) Landfill received plastic and tape used to seal the hangar during AFFF fire suppression system testing in Building 5222 and 5256. The Active CDD Landfill currently operates under a solid waste permit.

Additionally, a WWTP with historic sludge drying beds that treated potential PFAS-containing wastewater was identified on post. The drains in the Building 5223 Fire Station #3 AOPI lead to the sewer system connected to the WWTP, which historically discharged effluent to the former sludge drying beds. Therefore, PFAS-containing material that may have been used at Building 5223 Fire Station #3 (**Section 5.2.5**) could have reached the former sludge drying beds via the sewer system.

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 FTKX) 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 search and site visit are described below.

There are three fire stations within 5 miles of the installation boundary including the Radcliff City Fire Department, the Elizabethtown Fire Department #3, and the Flaherty Volunteer Fire Department. While minimal information is known regarding specific fire training and/or nozzle testing activities at these stations, it is likely AFFF may have been stored and/or used at these locations due to standard fire station operating procedures.

Several other operations which may use PFAS-containing materials occur in the area surrounding FTKX (i.e., Radcliff, Vine Grove), such as metal fabricating and plating shops, paint shops, automobile maintenance shops, laundering facilities, car washes, and pest management services. Research and data limitations are discussed further in **Section 8**.

5 SUMMARY AND DISCUSSION OF PA RESULTS

The preliminary locations evaluated for potential use, storage and/or disposal of PFAS-containing materials at FTKX 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, eight have been identified as AOPIs. The process used for refining these areas is presented on **Figure 5-1**, below.

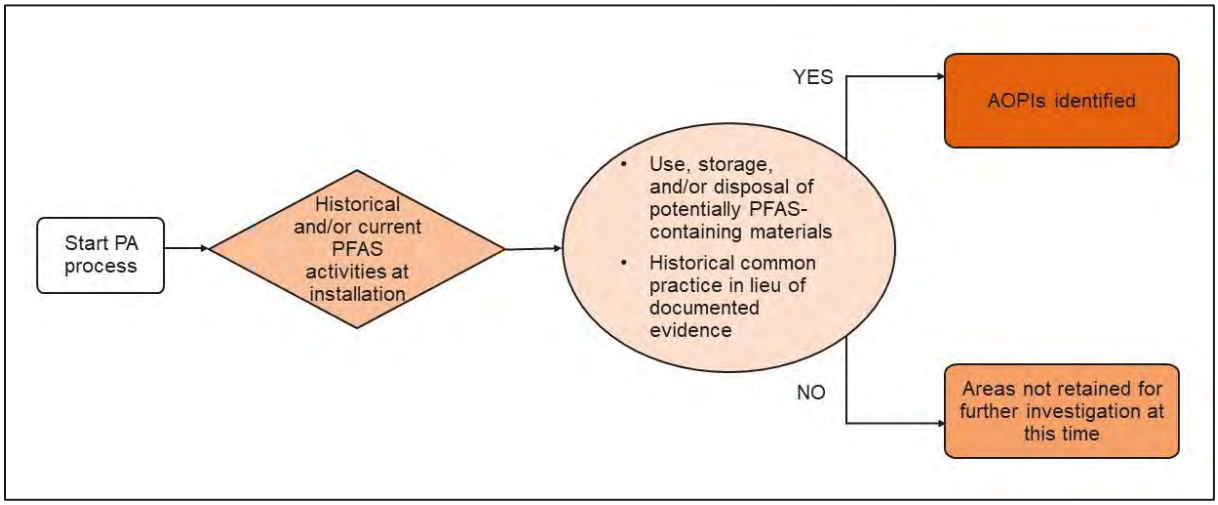

Figure 5-1: AOPI Decision Flowchart

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 FTKX 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	Reason Eliminated
Fire Station #1 – Building 469	1935 to Present	Standard fire station operations. Interviewees indicated no current or historical use or storage of AFFF at this location.	No record of PFAS-containing materials use, storage, or disposal.

Area Description	Dates of Operation	Relevant Site History	Reason Eliminated
Fire Station #2 – Building 160	Unknown to Present	Standard fire station operations. Interviewees indicated no current or historical use or storage of AFFF at this location.	No record of PFAS-containing materials use, storage, or disposal.
UST Areas (FTKX-15D, FTKX-40)	1930s to 1986	FTKX-15D was a one-acre fueling area with two 5,000-gallon USTs for gasoline and diesel that were known to have leaks. Approximately 5,200 cubic yards of soil was excavated in the area to address benzene, toluene, ethylbenzene and xylenes (BTEX) and volatile organic compound (VOC) impacts. FTKX-40 was also a one-acre fueling station with one 10,000-gallon UST and one 2,000-gallon UST, both used for gasoline; the area has known VOCs, trichloroethylene (TCE), vinyl chloride, and BTEX impacts.	No record of PFAS-containing materials use, storage, or disposal.
Former Pesticide Rinse Tank Area (Building 112; FTKX-22)	1970s to 1988	Rinse area for pesticide distribution vehicles and equipment. A 4,000-gallon UST in this area was removed in 1998. The area has known VOCs and pesticide constituent impacts.	No record of PFAS-containing pesticides use, storage, or disposal.
Boatwright Maintenance Area (FTKX-21)	1960s to present	Maintenance on all installation vehicles including fire trucks and crash trucks is conducted here near Building 277. No nozzle or gasket testing of fire trucks is reported at this location. Trucks are only at this location during maintenance events (i.e., short term). The use of the spent solvent area was discontinued in 1987. Waste from this building is conveyed to an OWS prior to being sent to the Current WWTP.	The use of cleaners, lubricants, and preservatives (CLPs) was researched. Following review of safety data sheets (SDSs) for oils and lubricants, there is no record of PFAS-containing materials use, storage, or disposal.
Vehicle Maintenance Areas	Numerous	Nine major vehicle maintenance shops have generated used oil and oil solvents, asbestos, grease, and paint wastes.	The use of CLPs was researched. Following review of SDSs for oils and lubricants, there is no record of PFAS-containing materials use, storage, or disposal.
General Maintenance Shops	Unknown to present	Four general maintenance shop locations at which maintenance for electronics, small arms, furniture, and office equipment is conducted.	No record of PFAS-containing materials use, storage, or disposal.
Closed Landfill (FTKX-01)	1946 to 1950	Constructed over a sinkhole and filled with nonhazardous sanitary waste, wood, paper, metals, incinerator ash, hospital trash, and cinders from coal-fired heating units for soil	No record of PFAS-containing material (including potentially PFAS-containing WWTP sludge) use, storage,

Area Description	Dates of Operation	Relevant Site History	Reason Eliminated
		stabilization. The area has known VOCs and metals impacts.	or disposal at this area. Additionally, landfill ceased operation prior to development of AFFF.
Vehicle Wash Racks and OWSs (FTKX-18)	1983 to present	Two centralized wash racks, each equipped with concrete sediment basins and an OWS. The facilities were used to remove and collect grit, grease, and oil from the wastewater that is generated when tracked vehicles are cleaned.	The use of CLPs was researched. Following review of SDSs for oils and lubricants, there is no record of PFAS-containing materials use, storage, or disposal.
Incinerators	Various to 1990s	Incinerators for burning classified documents (FTKX-04 and -05), hospital waste, and pathological waste (FTKX-06 and -07) and for steam generation (FTKX-03). The facilities were reportedly well-maintained and there were no records of uncontrolled fires requiring fire response according to site interviewees. On-post incinerators are no longer in use.	No record of PFAS-containing materials use, storage, or disposal.
Central Water Treatment Plant	Unknown to present	The Central Water Treatment Plant receives its water source from Otter Creek and McCracken Springs, and provides FTKX with treated, potable water.	No record of PFAS-containing materials use, storage, or disposal.
Muldraugh Water Treatment Plant	Unknown to present	The Muldraugh Water Treatment Plant receives its water source from a well field located on the Ohio River floodplain southwest of West Point and provides FTKX with treated, potable water.	No record of PFAS-containing materials use, storage, or disposal.

5.2 AOPIs

Overviews for each AOPI identified during the PA process are presented in this section. Each AOPI and current site status and discussed with each AOPI subsection presented below. Two AOPI coincides with an existing IRP site; therefore, the site identifier and Headquarters Army Environmental System number are also shown (**Figure 5-2**). At the time of this PA, the one FTKX IRP site has not historically been investigated or is currently being investigated for the possible presence of PFAS constituents.

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 **5-6** and include active monitoring well locations in the vicinity of each AOPI, if present.

5.2.1 Former Fire Training Area (FTKX-24, 21405.1030)

The FFTA (FTKX-24) is identified as an AOPI following records research, personnel interviews, and site reconnaissance due to historical fire training activities. During its use from 1965 to 1996, the FFTA included a curbed concrete slab and other associated fluid collection system components which were

utilized for fire training activities at this location (**Figure 5-3**). During the training exercises, jet fuel was used to ignite fires that were subsequently extinguished using AFFF. Water and foam collected by the berms drained to an OWS, and liquid from the OWS drained to ground surface, which then flowed into a drainage ditch that feeds tributaries of the Ohio River.

The FFTA was identified as an IRP site due to historical fire training activities using jet fuel. Investigations of surface soil were completed under RCRA in 2008 and identified arsenic impacts requiring remedial action (TolTest, Inc. 2009). The FFTA, including the concrete pad, associated OWS, and other fluid collection system components were demolished and removed, and soil generated during excavation of these former structures was utilized as backfill. The soil identified as having arsenic impacts was excavated (an area of approximately 4 feet by 4 feet by 3 feet depth) and disposed of at an offsite location. Soil was also reportedly excavated around the perimeter of the concrete pad to a depth of 2 feet bgs and around the discharge point of the liquid collection system's discharge pipe (TolTest, Inc. 2009).

5.2.2 Former Nozzle Testing Area

The FNTA is identified as an AOPI following records research, personnel interviews, and site reconnaissance due to historical nozzle testing activities. Nozzle testing was conducted yearly from 1965 until 2017 and included testing of AFFF mixtures through the fire equipment nozzles. The nozzle testing area was located upgradient of the FFTA allowing all drainage to flow into the OWS until the system components were excavated and disposed of offsite in 2009 (**Figure 5-3**). From 2009 to 2017, liquid from the nozzle testing would flow downhill into the drainage ditch into the unnamed tributary.

5.2.3 Army Reserves Hangar 5222 and Foam Storage Area

The Army Reserves Hangar 5222 and Foam Storage Area is identified as an AOPI following personnel interviews and site reconnaissance due to historical storage and release of PFAS-containing materials. Two historical fire suppression system releases were identified. During personnel interviews it was stated that a faulty suppression system resulted in two system releases of 330 gallons of Jet-X 2% (a high expansion foam that does not contain PFAS-containing chemicals) in 2017 and 275 gallons of Jet-X 2% in 2018. Interviewees indicated foam released from this area was transported more than 1 mile by wind (**Figure 5-3**). Hangar 5222 is also a storage location of Ansulite 3% AFFF used for under-wing hoses. In an email from an Army Reserves POC, an AFFF SDS and photos of the foam release indicated the use of alcohol-resistant-AFFF. Personnel interviews provided conflicting information on whether under-wing hoses were tested at this area and the type of foam that was released. The plastic and tape used to seal the hangar during fire suppression system testing in Building 5222 was sent to the Active CDD Landfill.

5.2.4 Building 5256 Foam Storage Area

The Building 5256 Foam Storage Area is identified as an AOPI following personnel interviews and site reconnaissance due to Ansulite 3% AFFF storage for under-wing fires and associated hoses. The area has also been used to store tanks of Jet-X 2% (a high expansion foam that does not contain PFAS-containing chemicals) for the hangar fire suppression system (**Figure 5-3**). Personnel interviews provided conflicting information on whether under-wing hoses were tested at this area and the type of foam that was released; however, a high-water mark on the interior walls of the storage area was observed during the PA site visit, which is likely attributable to a release from the storage tank. The plastic and tape used

to seal the hangar during fire suppression system testing in Building 5256 was sent to the Active CDD Landfill. A faulty gasket on the door to the outside was reported during personnel interviews; a release of AFFF to the environment may have therefore occurred at this area although no confirmation was received from the building manager. The location chosen for sampling at this AOPI was based on where there was the highest probability of having presence of PFAS-containing chemicals.

5.2.5 Building 5223 Fire Station #3

The Building 5223 Fire Station #3 is identified as an AOPI following records research, personnel interviews, and site reconnaissance due to historical fire department activities at the station. Fire Station #3 has been active since the 1960s and is the storage location of hundreds of gallons of AFFF; located on a tile and grout floor of a heat-regulated building with no secondary containment (**Figure 5-3**).

A crash truck, historically storing AFFF, is often stored outside the fire station. Additionally, fire trucks were historically filled with AFFF at this location using a pumping system. AFFF was pumped from a drum into a tank on a truck and was stored at the fire station. There is no indication of a release, however it is common for small amounts of AFFF to leak and spill during these activities.

5.2.6 HEMTT Crash Site

The HEMTT Crash Site is identified as an AOPI following personnel interviews due to a fuel spill in 2015. A HEMTT crashed and rolled over resulting in a punctured fuel tank; the crash and fuel leak was responded to with approximately 20 to 25 gallons of AFFF concentrate mixed with water. The crash occurred near the active ranges on the installation at the top of a slight hill (**Figure 5-4**). Sandbags were used to berm the fuel, but it is likely that runoff from the response with the AFFF mixture reached the tributary at the bottom of the hill where the crash took place. Surface water in this tributary eventually flows to the Ohio River.

5.2.7 Active CDD Landfill

The Active CDD Landfill is identified as an AOPI following records research, personnel interviews, and site reconnaissance due to potential PFAS-containing waste disposal at this site. The coinciding municipal landfill (**Figure 5-5**) operated from 1953 to 1992, when it was closed and overlain in the northeast portion by the Active CDD Landfill. The Active CDD Landfill was constructed with engineering controls, including cover and liner elements (Fort Knox 2016). The Active CDD Landfill received plastic and tape used to seal the hangar during AFFF fire suppression system testing in Building 5222 and 5256. The Active CDD Landfill currently operates under a solid waste permit. Historical dye tracer tests indicated that the groundwater from beneath this location discharges to Sycamore Spring (SP-015), which is a tributary of the Ohio River.

5.2.8 WWTP Former Sludge Drying Beds (FTKX-11)

The WWTP Former Sludge Drying Beds (FTKX-11) is identified as an AOPI following records research, personnel interviews, and site reconnaissance due to potential disposal of PFAS-containing materials at this site. The drains in the Building 5223 Fire Station #3 AOPI lead to the sewer system connected to the WWTP (**Figure 5-6**). Wastewater from the City of Muldraugh and FTKX is treated here and primarily

consists of municipal sewage as well as water collected in the sewer system from around the installation. The WWTP effluent was historically discharged to the former sludge drying beds. Therefore, PFAS-containing material that may have been used at Building 5223 Fire Station #3 (**Section 5.2.5**) could have reached the former sludge drying beds via the sewer system. There are no known releases or spills at the plant itself so it is understood that any PFAS-containing water would likely have ended up in the sludge drying beds. Additional information regarding the inclusion of the WWTP Former Sludge Drying Beds is included in **Section 6.3.4**.

The WWTP Sludge Drying Beds (FTKX-11) were identified as an IRP site under RCRA due to soil contamination (FTKX-11). The sludge drying beds were constructed in 1960 and received dried sludge from the WWTP designed to permit percolation in underlying soil. The beds were updated in 1987, with a pump station designed to collect liquid from drain tiles and transfer to the WWTP for further treatment. The sludge beds stopped receiving waste in 1995. During the time of use, overflow was frequently observed. During the Resource Conservation and Recovery Act (RCRA) Phase III Facility Investigation, arsenic hotspots were found south of the sludge beds. As discussed in the 2008 Completion Report for FTKX-10, -11, and -24, the sludge drying beds were regraded to eliminate future use (TolTest, Inc. 2009). The western berm removal allowed for positive drainage of the western lagoon which is heavily wooded. Berms, between and surrounding the 17 sludge beds, were razed and utilized as fill in the beds. Additionally, 17 broken-up influent concrete troughs were also used as fill material in the 17 beds, and there was no borrow material used. The beds were then seeded, mulched, and closed.

6 SUMMARY OF SI ACTIVITIES

Based on the results of the PA at FTKX, an SI for PFOS, PFOA, and PFBS was conducted in accordance with CERCLA. SI sampling was completed at FTKX at all eight of the 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 2020b) was developed to supplement the general information provided in the PQAPP (Arcadis 2019) 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 groundwater, soil, surface water, and/or sediment pathways as potentially complete at the AOPIs, 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 and August 2020 and February and July 2021 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 2020b) and PQAPP (Arcadis 2019). The subsections below summarize the DQOs, sampling design and rationale, sampling activities and methods, and data analysis procedures for the SI phase at FTKX. 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 2020b), 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, surface water, and sediment 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** below.

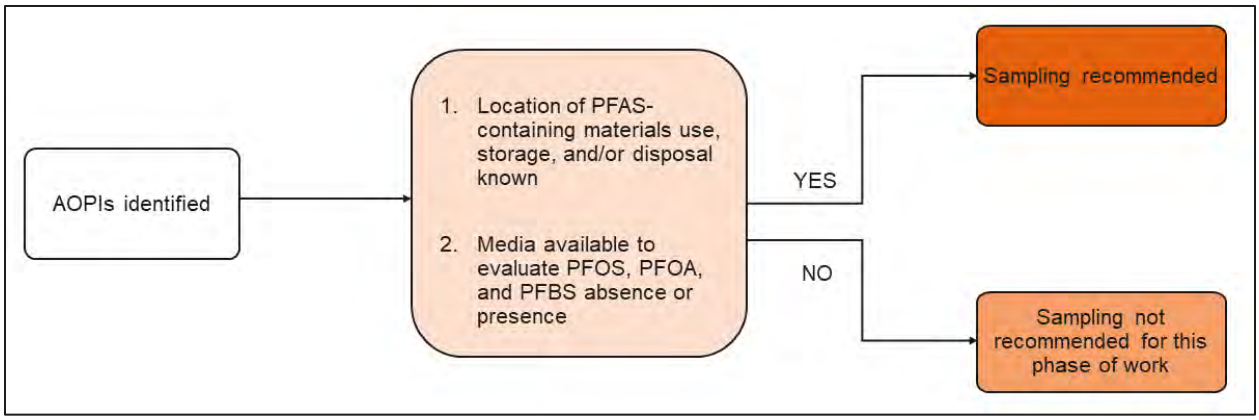

Figure 6-1: AOPI Sampling Decision Tree

The sampling design for SI sampling activities at FTKX is detailed in Worksheet #17 of the QAPP Addendum (Arcadis 2020b) and the Field Change Reports included as **Appendix J** (i.e., for the additional sampling events). Briefly, groundwater, surface water, soil, and/or sediment samples were collected in association with the AOPIs. The sampling summary is as follows: groundwater samples were collected from existing monitoring wells and from temporary boreholes at locations inferred to be downgradient of the AOPIs; soil samples were collected from shallow hand-augered borings from the top two feet of native soil at and downgradient of areas with known or suspected use, storage, and/or disposal of PFAS-containing materials; and surface water and/or sediment samples were collected at locations associated with drainage from AOPIs. At locations where regrading or backfill has been completed soil samples were collected once native soil was encountered.

FTKX is underlain by karst geology with complex groundwater flow patterns; therefore, groundwater was not sampled at or downgradient of all AOPIs. At some AOPIs, springs were sampled to assess PFOS, PFOA, and PFBS in groundwater. The water discharged by springs is an expression of groundwater (that is, springs are points where the groundwater table intersects the land surface). Each spring has a "groundwater basin", analogous to a surface water drainage basin, from which its water is derived. The limits of these basins are typically defined through dye tracing. A sample collected from a spring, therefore, represents a composite sample of the groundwater contained within the spring's basin and provides insight into the quality of the groundwater throughout the basin.

Soil samples were analyzed for PFOS, PFOA, and PFBS, and one soil sample from each AOPI was also analyzed for total organic carbon (TOC), pH, and grain size. The sampling depths at existing monitoring wells were at approximately the center of the saturated screened interval. **Table 6-1** includes the monitoring well construction details for the existing and temporary wells sampled during the SI (as available).

6.3 Sampling Methods and Procedures

Environmental data were collected and analyzed in accordance with the PQAPP (Arcadis 2019), 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 2020b), and the safety procedures specified in the Accident Prevention Plan (Arcadis

2018) and SSHP (Arcadis 2020a). 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 2019) and QAPP Addendum (Arcadis 2020b). 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, equipment calibration forms, tailgate health and safety forms, and sample collection logs) documenting the SI sampling activities are included in **Appendices K** and **L**, respectively. Photographs of the sampling activities are included in **Appendix L** with the SI field forms.

6.3.1 Field Methods

Groundwater samples were collected using low-flow purging methods (using a decontaminated, portable bladder pump and purged through high-density polyethylene [HDPE] tubing) from approximately the center of the saturated screened interval at existing monitoring wells (**Table 6-1**). At temporary boreholes for grab groundwater collection, a sonic drill rig was used to advance the casing to approximately 5 feet below first-encountered groundwater. A temporary casing was installed with a new, pre-packed screen, and low-flow purge methods were used to collect the sample from approximately the center of the saturated screened interval (**Table 6-1**). The temporary casing and screen were removed following sample collection, and the boreholes were grouted from the bottom of the borehole up to the ground surface in accordance with state regulations. The surface water samples were collected just below the water surface prior to sediment sample collection to reduce siltation. All groundwater and surface water samples were analyzed for PFOS, PFOA, and PFBS, and field parameters (temperature, pH, conductivity, dissolved oxygen, turbidity, and oxidation-reduction potential) were measured during sampling to potentially inform the interpretation of analytical data.

Shallow soil samples (collected to maximum depth of 4 feet bgs) were collected via hand auger, in accordance with the TGI P-12 in Appendix A to the PQAPP (Arcadis 2019). The boreholes were backfilled with the augured cuttings and sand (as needed) upon completion of sampling, after extracting sample volumes (Arcadis 2020b).

Sediment sampling locations were co-located with surface water sampling locations and surface water samples were collected first to reduce siltation. Sediment samples were collected from the upper 10 centimeters using new, PFAS-free bailers as Lexan™ tubing was not available for the event, and the sediment was decanted before bottling for laboratory analysis. 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), 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 2020b), typically at a rate of 1 per 20 parent samples per media. Field duplicates and matrix spike/matrix spike duplicate samples were collected for media sampled for PFOS, PFOA, PFBS, and total organic carbon (TOC) only. EBs were collected for media sampled for PFOS, PFOA, and PFBS at a frequency of one per piece of relevant equipment for each sampling event, as specified in the QAPP Addendum (Arcadis 2020b). The decontaminated reusable equipment from which EBs were collected include bladder pumps, hand augers, water-level meters, bailers used for sediment sampling, stainless-steel trowels, and drill bit and casing, as applicable to the sampled media. Analytical results for blank samples are discussed in **Section 7.12**.

6.3.3 Dedicated Equipment Background

One dedicated equipment background (DEB) sample was collected at the Active CDD Landfill (DEBs were prescribed to be collected at a rate of one per AOPI where sampling was conducted at existing monitoring wells that contained dedicated, down-hole equipment). The DEB sample was collected from the first water produced through the pump and tubing and was used to evaluate whether the dedicated equipment may be impacting the PFOS, PFOA, and/or PFBS results (i.e., in the groundwater sample collected following the proper purging procedures at the well), as it is unknown if the dedicated equipment contained PFAS-containing components: PFOS, PFOA and/or PFBS. The parent sample was collected at the well following purging and parameter stabilization.

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 FTKX SI work.

In some cases, clarifications and additions to the established scope of work were needed but did 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 and that did not affect DQOs are documented in Field Change Reports included as **Appendix J** and are summarized below:

- The surface water sample (FTKX-SP19-SW) planned to be collected from the tributary downgradient from the FFTA (FTKX-24) and FNTA was not collected. It was determined that the surface water location SP-19 was downgradient from SP-17 (another spring sampling location) and would have provided duplicate data.
- The DEB sample planned to be collected in association with existing monitoring well MW-7S was collected with existing monitoring well MW-1S at the Active CDD Landfill AOPI instead.

- PFOS was detected in one soil sample collected in June 2020 at a concentration approaching the OSD risk screening level at the Building 5223 Fire Station #3 AOPI. Additional soil sampling was completed at the AOPI in August 2020 to further evaluate PFOS, PFOA, and PFBS presence/absence due to this PFOS detection, the fact that PFOS and PFOA were detected in all the June samples, and the inability to collect groundwater samples at this location (i.e., no existing monitoring wells in the area). Four additional soil samples at the AOPI and one collocated surface water sample and sediment sample downgradient of the AOPI were proposed. The work was completed in August 2020 as proposed, except the surface water sample planned to be collected from the tributary downgradient from the AOPI was unable to be collected as the location was dry.
- Results of the supplemental soil and sediment sampling completed at the Building 5223 Fire Station #3 AOPI were still inconclusive to make a recommendation for whether the site should be included in a future study during the remedial investigation phase. Therefore, two temporary boreholes were advanced at the AOPI in February 2021 to collect groundwater samples at first-encountered groundwater to further evaluate PFOS, PFOA, and PFBS presence/absence at the AOPI and their concentrations relative to the OSD risk screening levels.
- The WWTP Former Sludge Drying Beds (FTKX-11) were identified as an AOPI following the subsequent sampling at the Building 5223 Fire Station #3 AOPI. The drains in the Building 5223 Fire Station #3 AOPI led to the sewer system connected to the WWTP during the time of AFFF use at the fire station. WWTP effluent was historically discharged to the former sludge drying beds. Therefore, PFAS-containing material that may have been used at Building 5223 Fire Station #3 potentially reached the former sludge drying beds via the sewer system. As such, soil and surface water representative of groundwater (i.e., a spring) were sampled at the WWTP Former Sludge Drying Beds (FTKX-11) to evaluate PFOS, PFOA, and PFBS presence/absence at this AOPI.

6.3.5 Decontamination

Non-dedicated reusable sampling equipment (e.g., stainless-steel trowels, hand augers, water-level meters, bladder pumps, drill bit and casing) that came into direct contact with sampling media was decontaminated before first use, between sampling locations/intervals, and before demobilization in accordance with P-09, TGI - Groundwater and Soil Sampling Equipment Decontamination (Arcadis 2019, Appendix A).

6.3.6 Investigation-Derived Waste

Purge water from the sampling at the Active CDD Landfill was combined with the purge water from the quarterly monitoring event at the landfill and was disposed of accordingly. IDW, including only decontamination fluids from the June 2020 and July 2021 events, were collected in a 5-gallon bucket with a lid in the DPW shed at the waste storage yard and labeled as non-hazardous.

IDW from drilling in February 2021, including soil cuttings and purge water, decontamination fluids, and disposable equipment were collected and placed in DOT-approved 55-gallon drums, labeled as non-hazardous, segregated by medium: waters, soil/sediment, and equipment, and transported to a staging area in a DPW shed at the waste storage yard to be stored, pending analysis. IDW was analyzed for PFAS, flashpoint reactives, toxicity characteristic leaching procedure, and toxicity characteristic leaching

procedure VOCs. Soil cuttings generated at shallow soil borings using a hand auger were returned to the ground at the point of collection at the direction of the installation. Equipment IDW (including personal protective equipment and other disposable materials such as gloves, plastic sheeting, HDPE bailers, and HDPE and silicon tubing) that may have come in contact with sampling media was collected in bags and disposed in on-post waste receptacles.

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 Pace South Carolina (formerly Shealy Environmental Services, Inc.), a DoD 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 2019). Eighteen PFAS-related compounds, including PFOS, PFOA, and PFBS, were analyzed for in groundwater, soil, surface water, and sediment samples using an analytical method that is ELAP-accredited and compliant with QSM 5.3, Table B-15. Copies of laboratory analytical reports generated during the SI are included as attachments to the Data Usability Summary Report (DUSR) in **Appendix M**.

Additionally, the following general chemistry and physical characteristic analyses were completed for select soil and sediment samples in accordance with Worksheet #18 of the QAPP Addendum (Arcadis 2020b) 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 limit of detection (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 percent 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 percent 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 DUSR (**Appendix M**).

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 2019). Each laboratory data package/sample delivery group underwent Stage 3 data validation in accordance with DoD QSM 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 M**. The Level IV analytical reports are included within **Appendix M** 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 FTKX. Documentation generated during the data usability assessments, which were compiled into a DUSR (**Appendix M**), 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 FTKX 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 M**), and as indicated in the full analytical tables (**Appendix N**) provided for the SI results. These data are of sufficient quality to meet the objectives and requirements of the PQAPP (Arcadis 2019) and FTKX QAPP Addendum (Arcadis 2020b). Data qualifiers applied to laboratory analytical results for samples collected during the SI at FTKX 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, 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 and sediment 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, and soil samples collected from greater than fifteen feet below ground surface will not be compared to either risk screening level.

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 and/or surface water data (if the surface water is an expression of groundwater [i.e., springs/seeps]) for this Army PFAS PA/SI. While the current and most likely future land uses of the AOPIs at FTKX 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 are detected greater than the applicable OSD risk screening levels, further study in a remedial investigation is recommended in **Section 8**.

7 SUMMARY AND DISCUSSION OF SI RESULTS

This section summarizes the analytical results obtained from samples collected during the SI at FTKX (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 2020b). 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.

Tables 7-1 through **7-4** summarize the groundwater, soil, surface water, and sediment analytical results for PFOS, PFOA, and PFBS. **Table 7-5** summarizes AOPIs and whether their SI results exceed the OSD risk screening levels. There is currently no OSD risk screening level available for surface water. If surface water was not an expression of groundwater, it was not compared to any screening level because there are no surface water screening levels available at this time. **Appendix N** includes the full suite of analytical results for these media, as well as for the QA/QC samples. An overview of AOPIs at FTKX with OSD risk screening level exceedances is depicted on **Figure 7-1**. **Figures 7-2** through **7-7** show the PFOS, PFOA, and PFBS analytical results in groundwater, soil, surface water, and sediment for each AOPI. Non-detected results are reported at the LOQ. Detections of PFOS, PFOA, and/or PFBS greater than the applicable OSD risk screening levels are highlighted in summary tables and on figures. Final qualifiers applied to the data by the laboratory and the project chemist (as defined in **Section 6.4.3**) are 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 and sediment 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 L**. Soil and sediment descriptions are provided on the field forms in **Appendix L**. The results of the SI are grouped by AOPI and discussed for each medium as applicable.

Table 7-5 AOPIs and OSD Risk Screening Level Exceedances

AOPI Name	OSD Exceedances?
Former Fire Training Area (FTKX-24, 21405.1030)	Yes
Former Nozzle Testing Area	Yes
Army Reserves Hangar 5222 and Foam Storage Area	No
Building 5256 Foam Storage Area	No
Building 5223 Fire Station #3	Yes
HEMTT crash site	No
Active CDD Landfill	No
WWTP Former Sludge Drying Beds (FTKX-11)	Yes

7.1 Former Fire Training Area (FTKX-24, 21405.1030) and Former Nozzle Testing Area

The subsections below summarize the PFOS, PFOA, and PFBS analytical results in surface water, sediment, and soil samples associated with the FFTA (FTKX-24, 21405.1030) and FNTA AOPIs. Groundwater was not sampled at this AOPI due to the heavily karstified geology and low detection in soil samples.

7.1.1 Surface Water

Surface water sampling was conducted downgradient of the FFTA (FTKX-24) and FNTA at one stream location (ST-216). **Figure 7-2, 7-3,** and **Table 7-3** show the surface water analytical results for these two AOPIs.

At ST-216, PFOS, PFOA, and PFBS were detected at concentrations of 84 ng/L,18 ng/L, and 3.4 ng/L, respectively. This PFOS concentration at ST-216 was greater than the OSD risk screening level. The highest concentration of PFOS, PFOA, and PFBS in surface water was observed at ST-216, the closest downgradient surface water/sediment sampling location to the two AOPIs. Sampling station ST-216 has been shown by dye tracing to receive groundwater from this AOPI (**Figure 7-2**; URS 2017).

7.1.2 Sediment

One collocated sediment sample was collected at the SP-216 location where a surface water sample was also collected as noted above. **Figure 7-2, 7-3,** and **Table 7-4** show the analytical results for the sediment sample collected in association with these two AOPIs.

PFOS was detected in sediment collected at ST-216 (0.0017 mg/kg). PFOA and PFBS were not detected in this sediment sample. The highest concentration of PFOS, PFOA, and PFBS in sediment was observed at ST-216, the closest downgradient surface water/sediment sampling location to the two AOPIs that is understood to be a discharge point of groundwater from beneath the AOPIs based on historical dye tracer studies.

7.1.3 Soil

Eight soil samples were collected between these two AOPIs: five composite samples from the 2 to 3 foot or 3-to-4-foot intervals at the FFTA (FTKX-FFTA-1-SO through FTKX-FFTA-5-SO), and three composite samples from the 0-to-2-foot intervals at the FNTA (FTKX-FNT-1-SO through FTKX-FNT-3-SO). **Figure 7-3** and **Table 7-2** show the soil analytical results for these two AOPIs.

PFOS was detected in all eight soil samples at concentrations less than the OSD risk screening levels; concentrations ranged from 0.00076 mg/kg at FTKX-FNT-2-SO to 0.057 mg/kg at FTKX-FFTA-2-SO. PFOA was detected in seven of the eight soil samples (i.e., excluding FTKX-FNT-2-SO) at concentrations less than the OSD risk screening levels; detected concentrations ranged from 0.00055 J mg/kg at FTKX-FNT-3-SO to 0.0040 mg/kg at FTKX-FFTA-3-SO.

PFBS was detected in two of the eight soil samples (FTKX-FFTA-2-SO and FTKX-FFTA-4-SO) at concentrations less than the OSD risk screening levels; the PFBS concentration at both locations listed was 0.0011 mg/kg.

7.2 Army Reserves Hangar 5222 and Foam Storage Area

The subsection below summarizes the PFOS, PFOA, and PFBS analytical results in soil samples associated with the Army Reserves Hangar 5222 and Foam Storage Area AOPIs. Groundwater was not sampled at this AOPI due to the heavily karstified geology and low detection in soil samples.

7.2.1 Soil

Five composite soil samples were collected from the 0-to-2-foot interval at the Army Reserves Hangar 5222 and Foam Storage Area AOPI (FTKX-5222-1-SO through FTKX-5222-5-SO). **Figure 7-4** and **Table 7-2** show the soil analytical results for this AOPI.

PFOS was detected in soil at all five sampling locations at concentrations less than the OSD risk screening levels, ranging from 0.00083 J mg/kg at FTKX-5222-1-SO to 0.0028 mg/kg at FTKX-5222-5-SO. PFBS and PFOA were not detected in soil at any of the five sampling locations.

The fact that PFBS and PFOA were not detected in soil and that PFOS was only detected at low concentrations in soil at this AOPI (i.e., below the OSD screening level), it is likely the only foam released during the 2017 and 2018 releases was Jet-X 2%.

7.3 Building 5256 Foam Storage Area

The subsection below summarizes the PFOS, PFOA, and PFBS analytical results in soil samples associated with the Building 5256 Foam Storage Area AOPI. Groundwater was not sampled at this AOPI due to the heavily karstified geology and low PFAS concentrations in soil samples.

7.3.1 Soil

One soil sample was collected from the 0 to 2 feet interval (FTKX-5256-1-SO) outside of Building 5256 Foam Storage Area (**Figure 7-4** and **Table 7-2**). PFOS was detected at a concentration less than the OSD risk screening level at this location (0.00063 J mg/kg). PFBS and PFOA were not detected in the sample.

7.4 Building 5223 Fire Station #3

The subsections below summarize the PFOS, PFOA, and PFBS analytical results in sediment, surface water, soil, and groundwater samples associated with Building 5223 Fire Station #3 AOPI. Initially, two soil samples were collected from outside of Building 5223 Fire Station #3 in June 2020. As discussed in **Section 6.3.4**, additional sampling was needed at the AOPI to further evaluate presence/absence of PFOS, PFOA, and PFBS. Four additional soil samples (FTKX-5223-3-SO, FTKX-5223-4-SO, FTKX-5223-5-SO, FTKX-5223-6-SO), one sediment sample (FTKX-5223-1-SE), one surface water sample (FTKX-5223-1-SW) and two groundwater samples (FTKX-5223-1-GW and FTKX-5223-2-GW) were collected

during additional sampling at this AOPI to evaluate if future study in a remedial investigation is warranted. All soil samples at this AOPI were collected from the 0 to 2 feet interval bgs.

7.4.1 Sediment

One sediment sample was collected downgradient of the AOPI (FTKX-5223-1-SE), where a proposed collocated surface water sample could not be collected as the location was dry during the 2020 sampling event (**Section 6.3.4**). However, a surface water sample was collected from the same location during the February 2021 sampling event. Sediment results for this sampling location are shown on **Figure 7-4** and **Table 7-4**. At FTKX-5223-1-SE, PFOS was detected at a concentration of 0.00071 J- [0.00074 J] mg/kg; PFOA and PFBS were not detected in the sample.

7.4.2 Surface Water

One surface water sample (FTKX-5223-1) was collected downgradient of the AOPI. **Figure 7-4** and **Table 7-3** show the analytical results for this AOPI.

PFOS, PFOA, and PFBS were detected in both the parent sample and the duplicate samples at this location (60 BJ+ [62 BJ+] ng/L, 5.5 [4.8] ng/L, and 3.3 J [3.3 J] ng/L, respectively).

7.4.3 Soil

A total of six composite soil samples were collected from the 0-to-2-foot interval at the Building 5223 Fire Station #3 (FTKX-5223-1-SO through FTKX-5223-6-SO). **Figure 7-4** and **Table 7-2** show the analytical results for this AOPI.

PFOS was detected at all six locations, at concentrations less than the OSD risk screening levels, ranging from 0.0064 mg/kg at FTKX-5223-6-SO to 0.096 mg/kg at FTKX-5223-1-SO. PFOA was detected in five of the six soil samples, at concentrations less than the OSD risk screening levels, ranging from 0.00051 mg/kg in the duplicate sample collected at FTKX-5223-6-SO (the PFOA concentration in the parent sample collected at this location was 0.0012 mg/kg) to 0.0029 mg/kg at FTKX-5223-1-SO. PFBS was not detected in any of the soil samples.

7.4.4 Groundwater

Two grab groundwater samples were collected at temporary boreholes completed at the AOPI. The samples were collected at first encountered groundwater (**Appendix L**). **Figure 7-4** and **Table 7-1** show the groundwater and analytical results for this AOPI. At FTKX-5223-1, PFOS, PFOA, and PFBS were detected at concentrations of 4800 DJ [4700 DJ+] ng/L, 350 [340] ng/L, and 340 [350 DJ] ng/L, respectively. PFOS and PFOA were greater than the OSD risk screening level, but PFBS was below. At FTKX-5223-2, PFOS, PFOA, and PFBS were detected at concentrations of 5800 DJ ng/L, 600 ng/L, and 340 DJ ng/L, respectively. PFOS and PFOA were greater than the OSD risk screening level, but PFBS was below.

The greatest concentration of PFOS, PFOA, and PFBS observed in groundwater during the SI were observed at this AOPI.

7.5 HEMTT Crash Site

The subsection below summarizes the PFOS, PFOA, and PFBS analytical results in soil samples associated with the HEMTT Crash Site AOPI. Groundwater was not sampled at this AOPI due to the heavily karstified geology and no detections of PFOS, PFOA, and/or PFBS in soil samples.

7.5.1 Soil

Three composite soil samples were collected from the 0-to-2-foot interval at the HEMTT Crash Site AOPI (FTKX-HEMTT-1-SO through FTKX-HEMTT-3-SO). **Figure 7-5** and **Table 7-2** show the analytical results for this AOPI. PFOS, PFOA, and PFBS were not detected in any of the three soil samples collected at this AOPI.

7.6 Active CDD Landfill

The subsections below summarize the PFOS, PFOA, and PFBS analytical results in groundwater, surface water, and sediment collected in association with the Active CDD Landfill AOPI. Because the landfill is capped, shallow soil was not sampled as it would not be representative of any potential PFAS containing material.

7.6.1 Groundwater

Groundwater samples were collected at two existing monitoring wells (MW-7S and MW-1S) at the south side of the Active CDD Landfill. **Figure 7-6** and **Table 7-1** show the groundwater analytical results for this AOPI. PFOS, PFOA, and PFBS were not detected in groundwater at FTKX-MW-1S, nor were they detected in the DEB sample collected at this well. At FTKX-MW-7S, PFOS, PFOA, and PFBS were detected at concentrations less than the OSD risk screening level including 5.0 ng/L PFOS, 3.5 ng/L PFOA, and 2.5 J ng/L PFBS.

7.6.2 Surface Water

One surface water sample (FTKX-SP15; Sycamore Spring) was collected at a location identified as a discharge point for groundwater originating from beneath the Active CDD Landfill during historical dye tracer tests. **Figure 7-2** and **Table 7-3** show the analytical results for this AOPI.

PFOS, PFOA, and PFBS were detected in surface water at concentrations less than the OSD risk screening level (11 ng/L, 4.1 ng/L, and 1.9 J ng/L, respectively).

7.6.3 Sediment

One collocated sediment sample was collected at the SP15 location where a surface water sample was also collected as noted above. **Figure 7-2** and **Table 7-4** show the analytical results for this AOPI.

PFOS, PFOA, and PFBS were not detected in the FTKX-SP-15-SE sediment sample.

7.7 WWTP Former Sludge Drying Beds (FTKX-11)

The subsections below summarize the PFOS, PFOA, and PFBS analytical results in soil and surface water collected in association with the WWTP Former Sludge Drying Beds (FTKX-11) AOPI. Groundwater was not sampled at this AOPI due to the heavily karstified geology, drill rig access to appropriate sample locations, and soil concentrations above the OSD risk screening level.

7.7.1 Soil

Three composite soil samples from the 0-to-2-foot interval, one composite soil sample from the 1.5-to-2-foot interval, one composite soil sample from the 2-to-3-foot interval, and one composite soil sample from the 3-to-3.5-foot interval were collected at the WWTP Former Sludge Drying Beds (FTKX-11) AOPI (FTKX-FSDB-1-SO through FTKX-FSDB-6-SO) for a total of six composite soil samples. **Figure 7-7** and **Table 7-2** show the analytical results for this AOPI.

PFOS was detected at all six locations ranging from 0.0048 mg/kg at FTKX-FSDB-6-SO to 0.13 mg/kg at FTKX-FSDB-3-SO. One of the six PFOS detections was at a concentration greater than the OSD risk screening level (FTKX-FSDB-3-SO). PFOA was detected in four of the six soil samples, at concentrations less than the OSD risk screening level, ranging from 0.00075 mg/kg at FTKX-FSDB-1-SO to 0.0022 mg/kg at FTKX-FSDB-2-SO. PFBS was not detected in any of the six soil samples.

The greatest concentration of PFOS observed in soil during the SI is observed at this AOPI.

7.7.2 Surface Water

One surface water sample (FTKX-SP-38) was collected at a location identified as a discharge point for groundwater originating from beneath the WWTP Former Sludge Drying Beds (FTKX-11) during historical dye tracer tests. **Figure 7-7** and **Table 7-3** show the analytical results for this AOPI.

PFOS, PFOA, and PFBS were detected in surface water at concentrations less than the OSD risk screening level in both the parent sample and the duplicate sample (10 [16] ng/L, 20 J- [20] ng/L, and 13 [14] ng/L, respectively).

7.8 Other Sampling Locations

Two additional surface water and sediment samples were collected at location SP12 (Leaning Cedar Spring), and SP-17 (McCracken Spring). Springs are points at which groundwater discharges at the surface and the results, therefore, are indicative of the quality of groundwater drained by the springs. **Figure 7-2** and **Table 7-3** show the analytical results for these samples. Low concentrations of PFOS were observed in spring water (2.8 J [3.4] ng/L) and sediment (0.00082 J mg/kg) at SP12. PFOA was not detected in the spring water sample, though PFBS was detected in the duplicate sample at 1.8 J J ng/L. PFOA and PFBS were not detected in the sediment sample at SP12. PFOS, PFOA, and PFBS were not detected in spring water and sediment at SP-17.

7.9 Dedicated Equipment Background Samples

One DEB pair was collected at monitoring well FTKX-MW-1S. No equipment influences on PFOS, PFOA, or PFBS concentrations was observable as there was no detectable PFOS, PFOA, or PFBS in either the parent or its companion DEB sample (**Table 7-6**).

7.10 Investigation Derived Waste

In February 2021, a composite sample of the soil IDW (i.e., soil cuttings from drilling activities) was collected from the 55-gallon drum currently in storage at the DPW Hazardous Waste Storage shed. The results state PFOS was detected at a concentration of 0.0033 mg/kg. PFOA and PFBS were not detected in the soil IDW sample (**Appendix N**).

In June 2020, a composite sample of the decontamination fluid IDW was collected from the 5-gallon bucket currently in storage at the DPW Hazardous Waste Storage shed. The results state PFOS was detected at a concentration of 1,000 ng/L. PFOA and PFBS were not detected in the June 2020 decontamination fluid IDW sample (**Appendix N**).

In February 2021, a composite sample of the decontamination fluid and purge water mix was collected from the 55-gallon drum currently in storage at the DPW Hazardous Waste Storage shed. The results state PFOS was detected at a concentration of 3,300 ng/L, PFOA was detected at a concentration of 150 ng/L, and PFBS was detected at a concentration of 120 B ng/L (**Appendix N**).

The full analytical results of the soil and groundwater IDW are included in **Appendix N**.

7.11 TOC, pH, and Grain Size

In addition to sampling soil for PFOS, PFOA, and PFBS, one soil sample per AOPI (except at the Active CDD Landfill, which was not sampled for soil) was analyzed for TOC, pH, moisture content, and grain size as these data may be useful in future fate and transport studies. The TOC in the soil samples ranged from 2,560 mg/kg at the FFTA (FTKX-FFTA-2-SO) to 41,200 mg/kg at the Army Reserves Hangar 5222 and Foam Storage Area (FTKX-5222-1-SO). The TOC at this installation was generally in range of that typically observed in topsoil (5,000 to 30,000 mg/kg). The combined percentage of fines in soils at FTKX ranged from 13.3% at the Army Reserves Hangar 5222 and Foam Storage Area to 81.7% at the FNTA with an average of 63.7%. In general, PFAS constituents tend to be more mobile in soils with less than 20% fines (silt and clay) and lower TOC. The percent moisture of the soil (6.2% to 20.7%, with an average of 16.4%) was typical for clay-rich soils (typical range of 0 to 20%). The pH of the soil was acidic (5.1 standard units) at the FNTA but was generally neutral to slightly alkaline (7.5 to 8.0 standard units) across the other AOPIs. Based on the geochemical data obtained during the SI at FTKX, the mobility of PFAS constituents may be relatively hindered given the high percentage of fines and greater TOC.

7.12 Blank Samples

The full analytical results for blank samples collected during the SI are included in **Appendix N**. PFOS was detected in a field blank from the February 2021 sampling event at a concentration of 5.4 BJ+ ng/L. The qualifiers indicate the blank contamination may be biased high. The detection is not believed to

impact any analytical results from that sampling event. PFOA, and PFBS were not detected in any of the blank samples collected during the SI work.

7.13 Conceptual Site Models

The preliminary CSMs presented in the QAPP Addendum (Arcadis 2020b) were re-evaluated and updated, if necessary, based on the SI sampling results. The CSMs presented on **Figures 7-8** through **7-10** and in this section therefore 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, 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 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, discharge/recharge between groundwater and 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., commercial/industrial 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 are 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 have been developed for each individual AOPI and are 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 except for the HEMTT Crash Site AOPI:

- FTKX obtains potable water from drinking water wells located approximately 5 miles north of the cantonment area, off post of FTKX, in alluvial sediments near the Ohio River. The AOPIs are generally upgradient of and may be within the capture zone of these off-post drinking water wells. PFOS, PFOA, and/or PFBS were detected in groundwater samples collected at Building 5223 Fire Station #3 and the Active CDD Landfill AOPI. As discussed in **Section 6.2**, surface water samples were collected at multiple points near springs and/or streams at FTKX to evaluate the potential presence of PFOS, PFOA, and/or PFBS in groundwater. PFOS, PFOA, and/or PFBS were detected in these surface water samples, which are considered expressions of the groundwater. Although not all AOPIs are directly associated with a groundwater or surface water sample that was collected for the SI, the groundwater exposure pathways (via drinking water ingestion and dermal contact) for on-installation site workers and residents are potentially complete, due to the uncertainty in groundwater flow directions given karst geology and to account for potential future use of the downgradient on-post groundwater.
- Recreational users are not likely to contact groundwater during outdoor recreational activities. Therefore, the groundwater exposure pathway for on-installation recreational users is incomplete.
- Generally, groundwater originating at the AOPIs flows off post through the installation's western and northern boundaries toward numerous tributaries, creeks, streams, and the Ohio River. Therefore, the groundwater exposure pathway for off-installation receptors is potentially complete due to a lack of land use controls in the area.
- The AOPIs are wholly located on-post and are not used for residential or recreational purposes. Therefore, the soil exposure pathways for on-installation residents and recreational users and for off-installation receptors are incomplete.

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

Figure 7-8 shows the CSM for the FNTA, FFTA (FTKX-24), Building 5223 Fire Station #3, Army Reserves Hangar 5222 and Foam Storage Area, Building 5256 Foam Storage Area, and the WWTP Former Sludge Drying Bed (FTKX-11) AOPIs. AFFF was historically released to soil and paved surfaces during fire training, nozzle testing, and other fire department activities. Potential PFAS-containing materials were disposed of at the WWTP Former Sludge Drying Bed (FTKX-11) AOPIs.

- PFOS, PFOA, and/or PFBS were detected in soil at these AOPIs. Site workers (i.e., installation personnel) 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.
- Groundwater from these AOPIs could potentially discharge to (and surface runoff could flow to) on-post unnamed tributaries that flow to on-post McCracken Spring and Otter Creek, which are used for drinking water and recreation. PFOS, PFOA, and/or PFBS were detected in the surface water samples collected in association with the FNTA, FFTA (FTKX-24), Building 5223 Fire Station #3, and the WWTP Former Sludge Drying Bed (FTKX-11) AOPIs. Surface water samples were not collected in association with the Army Reserves Hangar 5222 and Foam Storage Area and Building 5256 Foam Storage Area AOPIs. However, the surface water exposure pathways are potentially complete at all the AOPIs on **Figure 7-8** due to either the documented presence of PFOS, PFOA, and/or PFBS in surface water or the uncertainty given karst geology. The surface water pathways are potentially complete for on-installation site workers and residents (via

drinking water ingestion and dermal contact) and for on-installation recreational users (via incidental ingestion and dermal contact).

- PFOS, PFOA, and/or PFBS were detected in sediment samples collected in association with the FNTA, FFTA (FTKX-24), and Building 5223 Fire Station #3 AOPIs. Sediment samples were not collected in association with the remaining AOPIs. However, due to the documented presence of PFOS, PFOA, and/or PFBS in surface water or the uncertainty given karst geology, the sediment exposure pathways are potentially complete at all the AOPIs on **Figure 7-8**. The sediment exposure pathways are potentially complete for on-installation site workers and recreational users who could contact constituents in sediment via incidental ingestion and dermal contact downgradient of these AOPIs. Exposure to sediment is not generally evaluated for residential receptors; therefore, the sediment exposure pathway for on-installation residents is incomplete.
- Surface water bodies downgradient of the AOPIs flow off post through McCracken Spring and Otter Creek and into the Ohio River, which is used for drinking water and recreation. Therefore, the surface water exposure pathway (via drinking water ingestion, incidental ingestion, and dermal contact) and sediment exposure pathway (via incidental ingestion and dermal contact) for off-installation receptors are potentially complete.

Figure 7-9 shows the CSM for the HEMTT crash site. Potential PFAS-containing materials were released to soil and paved surfaces during a single emergency response event during which AFFF was used.

- PFOS, PFOA, and/or PFBS were not detected in soil at this AOPI. Based on the SI sample results, the soil exposure pathway for on-installation site workers is incomplete.
- Groundwater or surface water samples were not collected in association with this AOPI. The surface water body in the vicinity of the AOPI (Mill Creek, a tributary of the Salt River) is not used for drinking water and was dry at the time of the sampling event. Due to the absence of PFOS, PFOA, and/or PFBS in soil and the fact that the release was a one-time event, the groundwater, surface water, and sediment exposure pathways are considered to be incomplete.

Figure 7-10 shows the CSM for the Active CDD Landfill which historically received potential PFAS-containing waste (which would be buried in subsurface soil).

- Soil samples were not collected at the Active CDD Landfill AOPI. However, site workers (i.e., installation personnel) are not likely to contact constituents in the subsurface soil. Therefore, the soil exposure pathway for on-installation site workers is incomplete.
- Considering the potential constituent source at this landfill AOPI is in the subsurface, surface runoff is not an applicable migration pathway. However, constituents could desorb from subsurface soil, dissolve in or be transported with groundwater that ultimately discharges to surface water. Additionally, PFOS, PFOA, and PFBS were detected in surface water at a spring (i.e., groundwater expression) located downstream from this AOPI, which ultimately leads to Otter Creek. Therefore, the surface water exposure pathways are potentially complete for on-installation site workers and residents (via drinking water ingestion and dermal contact) and for on-installation recreational users (via incidental ingestion and dermal contact).
- PFOS, PFOA, and/or PFBS were not detected in the co-located sediment sample. However, due to the presence of these constituents in surface water, the sediment exposure pathways are potentially complete for on-installation site workers and recreational users (via incidental ingestion

and dermal contact). Exposure to sediment is not generally evaluated for residential receptors; therefore, the sediment exposure pathway for on-installation residents is incomplete.

- Surface water bodies flow off post through McCracken Spring and Otter Creek, into the Ohio River, which is used for drinking water off-installation. Therefore, the surface water exposure pathway (via drinking water ingestion, incidental ingestion, and dermal contact) and sediment exposure pathway (via incidental ingestion and dermal contact) for off-installation receptors are potentially complete.

Following the SI sampling, seven out of the eight 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 FTKX 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 FTKX. Following the evaluation, eight AOPIs were identified.

FTKX's potable water utility system includes numerous Army-owned groundwater supply wells located north of the main cantonment area near the Ohio River. Water from these supply wells is treated at the Central and Muldraugh Water Treatment Plants. The 2013 data collected at these treatment plants by the USEPA in response to third Unregulated Contaminant Monitoring Rule indicated PFOS, PFOA, and PFBS were not detected in the finished water at the treatment plants.

All AOPIs were sampled during the SI at FTKX 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 2019) and the FTKX QAPP Addendum (Arcadis 2020b), along with field change reports which detailed the scope of the additional sampling at the Building 5223 Fire Station #3 and WWTP Former Sludge Drying Beds (FTKX-11).

Seven of the eight AOPIs had detections of PFOS, PFOA, and PFBS in groundwater, soil, and/or surface water, and four AOPIS exceeded OSD risk screening levels.

The maximum concentrations of PFOS, PFOA, and PFBS detected in groundwater, soil, surface water, and sediment from FTKX were:

Groundwater

- PFOS was detected at 5,800 DJ ng/L, above the OSD risk screening level (40 ng/L), in sample FTKX-5223-2-GW-020221 at the Building 5223 Fire Station #3 AOPI
- PFOA was detected at 600 ng/L, above the OSD risk screening level (40 ng/L), in sample FTKX-5223-2-GW-020221 at the Building 5223 Fire Station #3 AOPI
- PFBS was detected at 350 ng/L, below the OSD risk screening level (600 ng/L), in the duplicate sample at FTKX-5223-1-GW-020221 at the Building 5223 Fire Station #3 AOPI. PFBS was detected at 340 ng/L in the parent sample at FTKX-5223-1-GW-020221

Soil

- PFOS was detected at 0.13 mg/kg, equivalent to the OSD risk screening level for soil (0.13 mg/kg), in sample FTKX-FSDB-3-SO-(0-2)-072721 at the WWTP Former Sludge Drying Beds (FTKX-11)

- PFOA was detected at 0.0040 mg/kg, below the OSD risk screening level for soil (0.13 mg/kg), in sample FTKX-FFTA-3-SO-(3-4)-060820 at the Former Fire Training Area (FTKX-24)
- PFBS was detected at 0.0011 mg/kg, below the OSD risk screening level for soil (1.9 mg/kg), in samples FTKX-FFTA-2-SO-(2-3)-061020 and FTKX-FFTA-4-SO-(2-3)-061020 at the Former Fire Training Area (FTKX-24)

Surface Water

- PFOS was detected at 84 ng/L, above the OSD risk screening level (40 ng/L), in sample FTKX-ST-216-SW-060820 at the Former Fire Training Area (FTKX-24)
- PFOA was detected at 20 ng/L, below the OSD risk screening level (40 ng/L), in sample FTKX-SP-38-072721 at the WWTP Former Sludge Drying Beds (FTKX-11)
- PFBS was detected at 14 ng/L, below the OSD risk screening level (600 ng/L), in sample FTKX-SP-38-072721 at the WWTP Former Sludge Drying Beds (FTKX-11)

Sediment

- PFOS was detected at 0.0017 mg/kg in sample FTKX-ST-216-SE-060820 at the Former Fire Training Area (FTKX-24)
- PFOA was not detected in any of the sediment samples at FTKX
- PFBS was not detected in any of the sediment samples at FTKX

Following the SI sampling, seven out of the eight AOPIs (i.e., all except the HEMTT Crash Site AOPI) were considered to have complete or potentially complete exposure pathways.

Complete exposure pathways consist of:

- Soil exposure pathways for site workers at five of the eight AOPIs.

Potentially complete exposure pathways consist of:

- Groundwater exposure pathways for site workers and residents at six of the eight AOPIs (excluding the HEMTT Crash site) and for off-installation receptors at all eight AOPIs.
- Surface water and sediment exposure pathways for site workers and on-installation recreational users at all eight AOPIs (excluding the HEMTT Crash site).
- Surface water exposure pathways for residents at six of the eight AOPIs (excluding the HEMTT Crash site).
- Surface water exposure pathways for off-installation receptors at six of the eight AOPIs (excluding the HEMTT Crash site).

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 analytical results for PFOS, PFOA, and PFBS to the OSD risk screening levels (**Table 6-2**). **Table 8-1** below summarizes the AOPIs identified during the PA, PFOS, PFOA, and PFBS sampling at FTKX, and recommendations for future study in a remedial investigation or no action at this time at

each AOPI; further investigation is warranted at FTKX. In accordance with CERCLA, site-specific risk will be assessed during a future phase to evaluate whether remedial actions are required.

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

AOPI Name	PFOS, PFOA, and/or PFBS detected greater than OSD Risk Screening Levels? (Yes/No/NS)				Recommendation
	GW	SO	SW/SP	SE	
Former Fire Training Area (FTKX-24, 21405.1030)	NS*	No	Yes	No	Future study in a remedial investigation
Former Nozzle Testing Area	NS*	No	Yes	No	Future study in a remedial investigation
Army Reserves Hangar 5222 and Foam Storage Area	NS*	No	NS	NS	No action at this time
Building 5256 Foam Storage Area	NS*	No	NS	NS	No action at this time
Building 5223 Fire Station #3	Yes	No	No	No	Future study in a remedial investigation
HEMTT crash site	NS*	ND	NS	NS	No action at this time
Active CDD Landfill	No	NS	No	ND	No action at this time
WWTP Former Sludge Drying Beds (FTKX-11)	NS	Yes	No	NS	Future study in a remedial investigation

Notes:
* FTKX is underlain by karst geology with complex groundwater flow patterns; therefore, groundwater was not sampled at or downgradient of a subset of AOPIs.
Light gray shading – detection greater than the OSD risk screening level
GW – groundwater
ND – non-detect
NS – not sampled
SE – sediment
SO – soil
SP – spring water (i.e., expressions of groundwater, therefore the data collected at springs are compared to the OSD risk screening levels for tap water)
SW – surface water

Data collected during the PA (**Section 3**, **Section 4**, **Section 5**) and the SI (**Section 6 a**nd **Section 7**) were sufficient to draw the conclusions summarized in this section. The data limitations relevant to the development of this PA/SI for PFOS, PFOA, and PFBS at FTKX 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. The exact locations, volumes, types, and frequency of use of AFFF at FTKX may not be known.

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 those historically collected in response to the third Unregulated Contaminant Monitoring Rule (**Table 2-1**) and those collected on post from groundwater, soil, surface water, and sediment during the SI events. Available data, including PFOS, PFOA, and PFBS, are listed in **Appendix N**, which were analyzed per the selected analytical method. The complex groundwater flow regimes in the karst underlying FTKX introduce uncertainty regarding the source(s) of PFAS detected in groundwater samples. For example, PFAS detected in bedrock groundwater beneath one AOPI may actually be derived, in whole or in part, from sources located in other AOPIs.

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

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ACRONYMS

%	percent
AFFF	aqueous film-forming foam
AOPI	area of potential interest
Arcadis	Arcadis U.S., Inc.
Army	United States Army
bgs	below ground surface
CDD	construction and demolition debris
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CLP	cleaners, lubricants, and preservatives
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
FFTA	Former Fire Training Area (FTKX-24)
FNTA	Former Nozzle Testing Area
FTKX	Fort Knox, Kentucky
GIS	geographic information system
GW	groundwater
HDPE	high-density polyethylene
HEMTT	heavy expanded mobility tactical truck
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
mg/kg	milligrams per kilogram (parts per million)
NA	not available
ng/L	nanograms per liter (parts per trillion)
NS	not sampled
OSD	Office of the Secretary of Defense
OWS	oil water separator
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
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
SAIC	Science Applications International Corporation
SDS	safety data sheet
SE	sediment
SI	site inspection
SO	soil
SOP	standard operating procedure
SP	spring water
SSHP	Site Safety and Health Plan
SW	surface water

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
USEPA	United States Environmental Protection Agency
UST	underground storage tank
UXO	unexploded ordnance
VOC	volatile organic compound
WWTP	wastewater treatment plant

TABLES

Table 2-1 - Historical PFAS Analytical Data
USAEC PFAS Preliminary Assessment/Site Inspection
Fort Knox, Kentucky

Sample Location	Public Water System ID	Source Water Type	Sample Date	PFOS	PFOA	PFBS	PFHpA	PFHxS	PFNA
				µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Muldraugh Water Treatment Plant, Building 3009	KY0470990	Groundwater	February 2013	< 0.04	< 0.02	< 0.09	< 0.01	< 0.03	< 0.02
			August 2013	< 0.04	< 0.02	< 0.09	< 0.01	< 0.03	< 0.02
Central Water Treatment Plant, Building 1205	KY0470990	Surface Water	February 2013	< 0.04	< 0.02	< 0.09	< 0.01	< 0.03	< 0.02
			May 2013	< 0.04	< 0.02	< 0.09	< 0.01	< 0.03	< 0.02
			August 2013	< 0.04	< 0.02	< 0.09	< 0.01	< 0.03	< 0.02
			November 2013	< 0.04	< 0.02	< 0.09	< 0.01	< 0.03	< 0.02

Table 2-1 - Historical PFAS Analytical Data
USAEC PFAS Preliminary Assessment/Site Inspection
Fort Knox, Kentucky

Acronyms:

< = Concentration not detected greater than the laboratory reporting limit. Non-detect concentrations are shown as less than (<) the reporting limit provided.
µg/L = micrograms per liter (parts per billion)
ID = identification
OSD = Office of the Secretary of Defense
PFBS = perfluorobutanesulfonic acid
PFHpA = perfluoroheptanoic acid
PFHxS = perfluorohexanesulfonic acid
PFNA = perfluorononanoic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate

Notes:
1. OSD guidance has only been provided for PFOS, PFOA, and PFBS, therefore only these three consituents will be discussed in the report. However, other PFAS constituents are included for informational purposes.

Sources:

1. USEPA. 2017. Occurrence Data for the Unregulated Contaminant Monitoring Rule: UCMR3 (2013-2015) Occurrence Data. January. Available online at: https://www.epa.gov/dwucmr/occurrence-data-unregulated-contaminant-monitoring-rule, downloaded July 2019. While the zip code in which the utilities' water supply intake is indicated for the Madison County Utilities District, the exact location of the intake is not known and may be located greater than 5 miles from the installation boundary.

2. Tetrahedron, Inc. 2018. Updated Drinking Water Quality Assessment Related to Perfluirinated Compounds at U.S. Army Materiel Command Installations. January.

Table 6-1 - Monitoring Well Construction Details
USAEC PFAS Preliminary Assessment/Site Inspection
Fort Knox, Kentucky

Area of Potential Interest	Sampling Location ID	Date of Measurement	Measuring Point	Measured Depth to Water (ft bmp)	Total Measured Well Depth (ft bmp)	TOC Elevation (ft amsl)	Groundwater Elevation (ft amsl)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Screen Diameter (inches)	Dedicated Pump (Y/N)
Active CDD Landfill (FTKX-02)	MW-1S	6/10/2020	TOC	104.18	113.5	788.27	684.09	101	111	2	Y
	MW-7S	6/11/2020	TOC	34.52	39.95	712.02	677.5	27.7	37.7	4	Y
Building 5223 Fire Station #3 [1]	5223-1-GW	2/2/2021	GS	32.1	41	NS	NC	33.0	38.0	2	N
	5223-2-GW	2/2/2021	GS	29.5	38.5	NS	NC	31.5	36.5	2	N

Notes:

1. Permanent wells were not installed at the Building 5223 Fire Station #3 AOPI; the total depths listed indicate the total depth of the temporary borehole from the measuring point (top of temporary casing, which had approximately 2.5 to 3.0 feet of stick-up). The screened interval listed for the temporary sampling points indicate the depth that the pre-packed screen was set for grab sample collection at first-encountered groundwater.

amsl - above mean sea level
AOPI - area of potential interest
bgs - below ground surface
bmp - below measurement point
btoc - below top of casing
CDD - construction and demolition debris
ft - feet
FTKX - Fort Knox
GS - ground surface
ID - identification
N - no
NC - not calculated
NS - not surveyed
TBD - to be determined at time of sampling
TOC - top of casing
Y - yes

Table 7-1 - Groundwater PFOS, PFOA, and PFBS Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Fort Knox, Kentucky

				Analyte	PFOS (ng/L)		PFOA (ng/L)		PFBS (ng/L)	
				OSD Risk Screening Level - Tap Water	40		40		600	
Associated AOPI	Location	Sample/Parent ID	Sample Date	Sample Type	Result	Qual	Result	Qual	Result	Qual
Active CDD Landfill	FTKX-MW-1S	FTKX-MW-1S-061020	06/10/2020	N	3.4	U	3.4	U	3.4	U
		FTKX-FD-1-GW-061020	06/10/2020	FD	3.3	U	3.3	U	3.3	U
	FTKX-MW-7S	FTKX-MW-7S-061120	06/11/2020	N	**5.0**		**3.5**		**2.5**	J
Building 5223 Fire Station #3	FTKX-5223-1	FTKX-5223-1-GW-020221	2/2/2021	N	**4,800**	J	**350**		**340**	
		FTKX-FD-1-GW-020221	2/2/2021	FD	**4,700**	J+	**340**		**350**	J
	FTKX-5223-2	FTKX-5223-2-GW-020221	2/2/2021	N	**5,800**	J	**600**		**340**	J

Table 7-1 - Groundwater PFOS, PFOA, and PFBS Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Fort Knox, Kentucky

Notes:
1. **Bolded** values indicate the result was detected greater than the limit of detection.
2. Gray 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:
AOPI = area of potential interest
CAS = Chemical Abstracts Service number
CDD = Construction and Demolition Debris
DEB = dedicated equipment background sample
FD = field duplicate sample
FTKX = Fort Knox
GW = groundwater
ID = identification
N = primary sample
ng/L = nanograms per liter (parts per trillion)
OSD = Office of the Secretary of Defense
PFAS = per- and polyfluoroalkyl substances
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate
Qual = Qualifier

Qualifier	Description
J+	The result was an estimated quantity, but the result may be biased high.
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 detection (LOD) and the limit of quantitation (LOQ). The non-detect value reported is the LOQ.

Table 7-2 - Soil PFOS, PFOA, and PFBS Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Fort Knox, Kentucky

Analyte					PFOS (mg/kg)		PFOA (mg/kg)		PFBS (mg/kg)	
OSD Risk Screening Level - Industrial/Commercial					1.6		1.6		25	
OSD Risk Screening Level - Residential					0.13		0.13		1.9	
Associated AOPI	**Location**	**Sample ID**	**Sample Date**	**Sample Type**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**
Army Reserves Hangar 5222 and Foam Storage Area	FTKX-5222-1	FTKX-5222-1-SO-(0-2)-060820	06/08/2020	N	**0.00083**		0.00099		0.00099	
	FTKX-5222-2	FTKX-5222-2-SO-(0-2)-060820	06/08/2020	N	**0.0021**		0.0010		0.0010	
	FTKX-5222-3	FTKX-5222-3-SO-(0-2)-060820	06/08/2020	N	**0.0014**		0.0011		0.0011	
	FTKX-5222-4	FTKX-5222-4-SO-(0-2)-060820	06/08/2020	N	**0.00097**		0.0012		0.0012	
	FTKX-5222-5	FTKX-5222-5-SO-(0-2)-060820	06/08/2020	N	**0.0028**		0.0012		0.0012	
Building 5223 - Fire Station #3	FTKX-5223-1	FTKX-5223-1-SO-(0-2)-060820	06/08/2020	N	**0.096**		**0.0029**		0.0012	
	FTKX-5223-2	FTKX-5223-2-SO-(0-2)-060820	06/08/2020	N	**0.0088**		**0.00093**		0.0011	
	FTKX-5223-3	FTKX-5223-3-SO-082020	08/20/2020	N	**0.0075**		0.0011	U	0.0011	U
	FTKX-5223-4	FTKX-5223-4-SO-082020	08/20/2020	N	**0.0074**	J-	**0.00068**	J	0.0012	U
	FTKX-5223-4	FTKX-FD-1-SO-082020	08/20/2020	FD	**0.0064**		**0.00051**	J	0.0010	U
	FTKX-5223-5	FTKX-5223-5-SO-082020	08/20/2020	N	**0.024**		**0.0021**		0.0012	U
	FTKX-5223-6	FTKX-5223-6-SO-082020	08/20/2020	N	**0.045**		**0.0012**		0.0011	U
Building 5226 Foam Storage	FTKX-5226-1	FTKX-5226-1-SO-(0-2)-060820	06/08/2020	N	**0.00063**	J	0.0011	U	0.0011	U
	FTKX-5226-1	FTKX-FD-1-SO-060820	06/08/2020	FD	**0.00062**	J	0.0010	U	0.0010	U
Former Fire Training Area (FTKX-24)	FTKX-FFTA-1	FTKX-FFTA-1-SO-(3-4)-060820	06/08/2020	N	**0.028**		**0.00061**	J	0.0011	U
	FTKX-FFTA-2	FTKX-FFTA-2-SO-(2-3)-061020	06/10/2020	N	**0.057**		**0.0036**		**0.0011**	
	FTKX-FFTA-3	FTKX-FFTA-3-SO-(3-4)-060820	06/08/2020	N	**0.051**		**0.0040**		0.0011	U
	FTKX-FFTA-4	FTKX-FFTA-4-SO-(2-3)-061020	06/10/2020	N	**0.037**		**0.0018**		**0.0011**	
	FTKX-FFTA-5	FTKX-FFTA-5-SO-(2-3)-061020	06/10/2020	N	**0.016**		**0.0023**		0.0012	U
Former Nozzle Testing Area	FTKX-FNT-1	FTKX-FNT-1-SO-(0-2)-060820	06/08/2020	N	**0.0058**		**0.0017**		0.0012	U
	FTKX-FNT-2	FTKX-FNT-2-SO-(0-2)-060820	06/08/2020	N	**0.00076**	J	0.0011	U	0.0011	U
	FTKX-FNT-3	FTKX-FNT-3-SO-(0-2)-060820	06/08/2020	N	**0.0027**		**0.00055**	J	0.0010	U
HEMTT Crash Site	FTKX-HEMTT-1	FTKX-HEMTT-1-SO-(0-2)-060920	06/09/2020	N	0.0012	U	0.0012	U	0.0012	U
	FTKX-HEMTT-2	FTKX-HEMTT-2-SO-(0-2)-060920	06/09/2020	N	0.0010	U	0.0010	U	0.0010	U
	FTKX-HEMTT-3	FTKX-HEMTT-3-SO-(0-2)-060920	06/09/2020	N	0.0010	U	0.0010	U	0.0010	U
WWTP Former Sludge Drying Beds (FTKX-11)	FTKX-FSDB-1	FTKX-FSDB-1-SO-(0-2)-072721	07/27/2021	N	**0.018**		**0.0012**		0.00060	U
		FTKX-FD-1-SO-072721	07/27/2021	FD	**0.012**		**0.00075**	J	0.00050	U
	FTKX-FSDB-2	FTKX-FSDB-2-SO-(0-2)-072721	07/27/2021	N	**0.031**		**0.0022**		0.00055	U
	FTKX-FSDB-3	FTKX-FSDB-3-SO-(0-2)-072721	07/27/2021	N	**0.13**		**0.0017**		0.00060	U
	FTKX-FSDB-4	FTKX-FSDB-4-SO-(1.5-2)-072721	07/27/2021	N	**0.0096**		0.00050	U	0.00050	U
	FTKX-FSDB-5	FTKX-FSDB-5-SO-(2-3)-072721	07/27/2021	N	**0.11**		**0.00084**	J	0.00050	U
	FTKX-FSDB-6	FTKX-FSDB-6-SO-(3-3.5)-072721	07/27/2021	N	**0.0048**		0.00060	U	0.00060	U

Table 7-2 - Soil PFOS, PFOA, and PFBS Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Fort Knox, Kentucky

Notes:
1. **Bolded** values indicate the result was detected greater than the limit of detection
2. All laboratory reported results in nanograms per gram (ng/g) were converted to milligrams per kilogram (mg/kg).
3. Gray shaded values indicate the result was detected greater than the 2021 Office of the Secretary of Defense (OSD) risk screening levels for the residential and industrial/commercial scenario (if collected from less than 2 feet below ground surface) (OSD. 2021. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. September.). Soil samples collected from greater than two feet but less than 15 feet below ground surface are compared to the industrial/commercial risk screening levels only.

Acronyms/Abbreviations:
AOPI = area of potential interest
CAS = Chemical Abstracts Service number
FD = field duplicate sample
FTKX = Fort Knox
HEMTT = heavy expanded mobility tactical truck
ID = identification
mg/kg = milligrams per kilogram (parts per million)
N = primary sample
PFAS = per- and polyfluoroalkyl substances
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate
WWTP = wastewater treatment plant

Qualifier	Description
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 low.
U	The analyte was analyzed for but the result was not detected above the limit of quantitation (LOQ).

Table 7-3 - Surface Water PFOS, PFOA, and PFBS Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Fort Knox, Kentucky

Analyte						PFOS (ng/L)		PFOA (ng/L)		PFBS (ng/L)	
OSD Tapwater RiskScreening Level						40		40		600	
Associated AOPI	Location Type	Location	Sample ID	Sample Date	Sample Type	Result	Qual	Result	Qual	Result	Qual
Active CDD Landfill	Surface Water/Seep	FTKX-SP-15	FTKX-SP-15-SW-060920	06/09/2020	N	**11**		**4.1**		**1.9**	J
Former Fire Training Area (FTKX-24) and Former Nozzle Testing Area	Surface Water/Seep	FTKX-ST-216	FTKX-ST-216-SW-060820	06/08/2020	N	**84**		**18**		**3.4**	J
Building 5223 - Fire Station #3	Surface Water/Seep	FTKX-5223-1	FTKX-5223-1-SW-020121	02/01/2021	N	**60**	BJ+	**5.5**		**3.3**	J
			FTKX-FD-1-SW-020121 / FTKX-5223-1-SW-020121	02/01/2021	FD	**62**	BJ+	**4.8**		**3.3**	J
WWTP Former Sludge Drying Beds (FTKX-11)	Surface Water/Seep	FTKX-SP-38	FTKX-SP-38-072721	07/27/2021	N	**10**		**20**	J-	**13**	
			FTKX-FD-1-SW-072721	07/27/2021	FD	**16**		**20**		**14**	
Other Sampling Location	Surface Water/Seep	FTKX-SP12	FTKX-SP12-SW-060920	06/09/2020	N	**2.8**	J	3.7	U	3.7	U
			FTKX-FD-1-SW-060920	06/09/2020	FD	**3.4**		3.4	U	**1.8**	J
	Surface Water/Seep	FTKX-SP-17	FTKX-SP-17-SW-060920	06/09/2020	N	3.5	U	3.5	U	3.5	U

Table 7-3 - Surface Water PFOS, PFOA, and PFBS Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Fort Knox, Kentucky

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:
AOPI = area of potential interest
CAS = Chemical Abstracts Service number
CDD = construction and demolition debris
FD = field duplicate sample
FTKX = Fort Knox
ID = identification
N = primary sample
ng/L = nanograms per liter (parts per trillion)
OSD = Office of the Secretary of Defense
PFAS = per- and polyfluoroalkyl substances
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate
Qual = qualifier
SW = surface water
WWTP = wastewater treatment plant

Qualifier	Description
BJ+	The result may be biased high due to blank contamination
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 low.
U	The analyte was analyzed for but the result was not detected above the limit of detection (LOD) and the limit of quantitation (LOQ). The non-detect value reported is the LOQ.

Table 7-4 - Sediment PFOS, PFOA, and PFBS Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Fort Knox, Kentucky

Analyte					PFOS (mg/kg)		PFOA (mg/kg)		PFBS (mg/kg)	
OSD Risk Screening Level - Industrial/Commercial					1.6		1.6		25	
OSD Risk Screening Level - Residential					0.13		0.13		1.9	
Associated AOPI	**Location**	**Sample ID**	**Sample Date**	**Sample Type**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**
Building 5223 - Fire Station #3	FTKX-5223-1	FTKX-5223-1-SE-082020	08/20/2020	N	**0.00071**	J-	0.0011	U	0.0011	U
	FTKX-5223-1	FTKX-FD-1-SE-082020	08/20/2020	FD	**0.00074**	J	0.0010	U	0.0010	U
Active CDD Landfill	FTKX-SP-15	FTKX-SP-15-SE-060920	06/09/2020	N	0.0012	U	0.0012	U	0.0012	U
Former Fire Training Area (FTKX-24) Former Nozzle Testing Area	FTKX-ST-216	FTKX-ST-216-SE-060820	06/08/2020	N	**0.0017**		0.0013	U	0.0013	U
Other Sampling Location	FTKX-SP12	FTKX-SP12-SE-060920	06/09/2020	N	**0.00082**	J	0.0012	U	0.0012	U
	FTKX-SP-17	FTKX-SP-17-SE-060920	06/09/2020	N	0.0012	U	0.0012	U	0.0012	U

Table 7-4 - Sediment PFOS, PFOA, and PFBS Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Fort Knox, Kentucky

Notes:

1. **Bolded** values indicate the result was detected greater than the limit of detection
2. All laboratory reported results in nanograms per gram (ng/g) were converted to milligrams per kilogram (mg/kg).
3. Data are compared to the Office of the Secretary of Defense (OSD) risk screening levels for the residential industrial/commercial scenario (if collected from less than 2 feet below ground surface) (OSD. 2021. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. September.). Soil samples collected from greater than two feet but less than 15 feet below ground surface are compared to the industrial/commercial risk screening levels only.

Acronyms/Abbreviations:
AOPI = Area of Potential Interest
CAS = Chemical Abstracts Service number
CDD = Construction and Demolition Debris
FD = field duplicate sample
FTKX = Fort Knox
ID = identification
mg/kg = milligrams per kilogram (parts per million)
N = primary sample
PFAS = per- and polyfluoroalkyl substances

Qualifier	Description
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 low.
U	The analyte was analyzed for but the result was not detected above the limit of quantitation (LOQ).

Table 7-6 - Dedicated Equipment Background Sample Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Fort Knox, Kentucky

		Sample/Parent ID	FTKX-MW-1S-061020		FTKX-MW-1S-DEB-061020	
		Locations	FTKX-MW-1S		FTKX-MW-1S	
		Sample Date	06/10/2020		06/10/2020	
		Sample Type	Original Sample		Dedicated Equipment Blank	
Analyte	CAS	Units	Result	Qual	Result	Qual
6:2 Fluorotelomer sulfonic acid (6:2 FTSA)	27619-97-2	ng/L	6.9	U	6.8	U
8:2 Fluorotelomer sulfonic acid (8:2 FTSA)	39108-34-4	ng/L	6.9	U	6.8	U
N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	2991-50-6	ng/L	6.9	U	6.8	U
N-Methylperfluoroocatane sulfonamidoacetic acid (MeFOSAA)	2355-31-9	ng/L	6.9	U	6.8	U
Perfluorobutane sulfonic acid (PFBS)	375-73-5	ng/L	3.4	U	3.4	U
Perfluorobutanoic acid (PFBA)	375-22-4	ng/L	3.4	U	**48**	
Perfluorodecanoic acid (PFDA)	335-76-2	ng/L	3.4	U	3.4	U
Perfluorododecanoic acid (PFDoA)	307-55-1	ng/L	3.4	U	3.4	U
Perfluoroheptanoic acid (PFHpA)	375-85-9	ng/L	3.4	U	3.4	U
Perfluorohexane sulfonic acid (PFHxS)	355-46-4	ng/L	3.4	U	3.4	U
Perfluorohexanoic acid (PFHxA)	307-24-4	ng/L	3.4	U	**3.2**	J
Perfluorononanoic acid (PFNA)	375-95-1	ng/L	3.4	U	3.4	U
Perfluorooctane sulfonic acid (PFOS)	1763-23-1	ng/L	3.4	U	3.4	U
Perfluorooctanoic acid (PFOA)	335-67-1	ng/L	3.4	U	3.4	U
Perfluoropentanoic acid (PFPeA)	2706-90-3	ng/L	3.4	U	**11**	
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	ng/L	6.9	U	6.8	U
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	ng/L	3.4	U	3.4	U
Perfluoroundecanoic acid (PFUdA)	2058-94-8	ng/L	3.4	U	3.4	U

Table 7-6 - Dedicated Equipment Background Sample Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Fort Knox, Kentucky

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

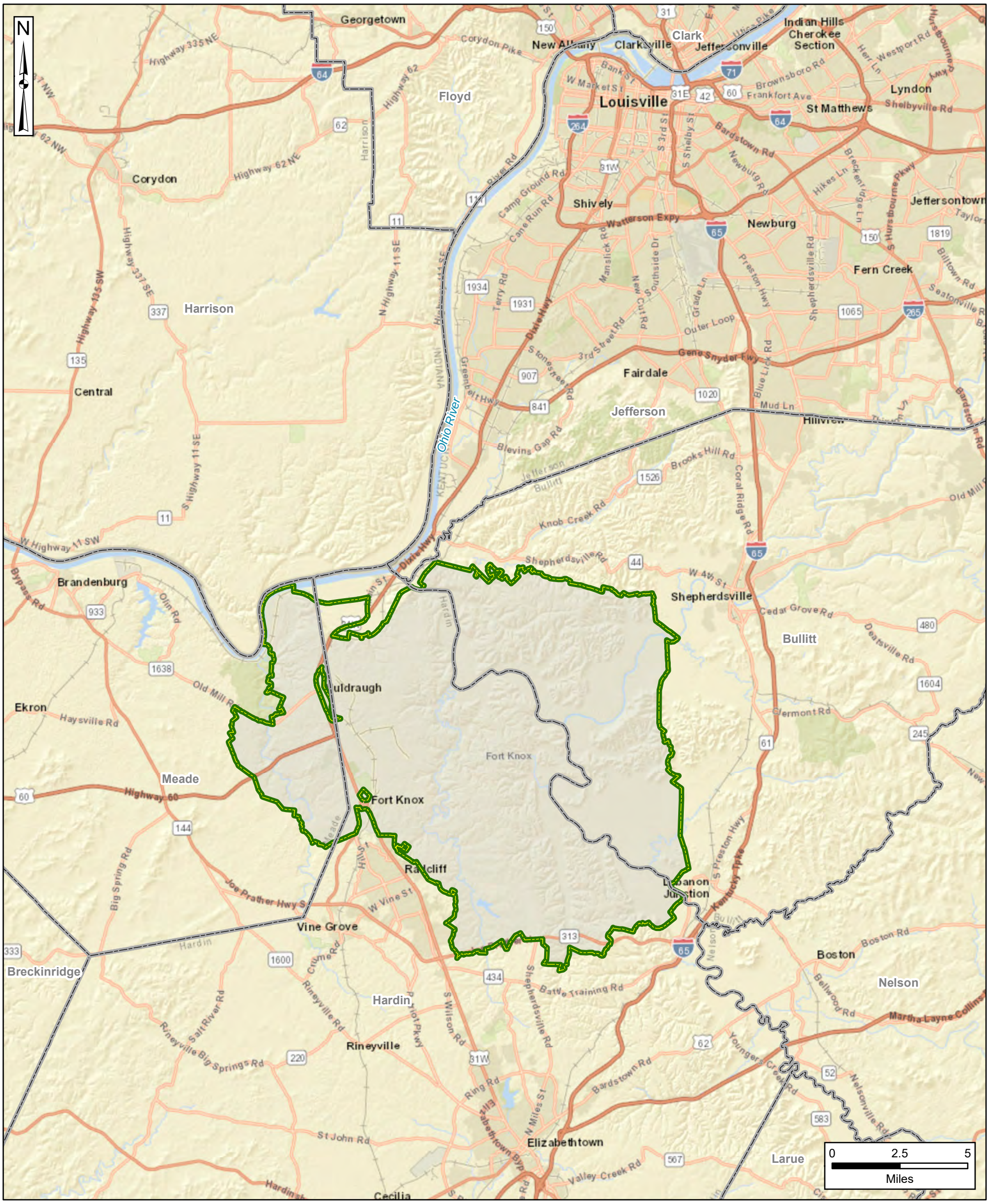
Acronyms/Abbreviations:
-- = not applicable
CAS = Chemical Abstracts Service number
DEB = dedicated equipment background sample
ID = identification
ng/L = nanograms per liter (parts per trillion)
PFAS = per- and polyfluoroalkyl substances

Qualifier	Description
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 method detection limit.

FIGURES

USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, KY

Figure 2-1
Site Location



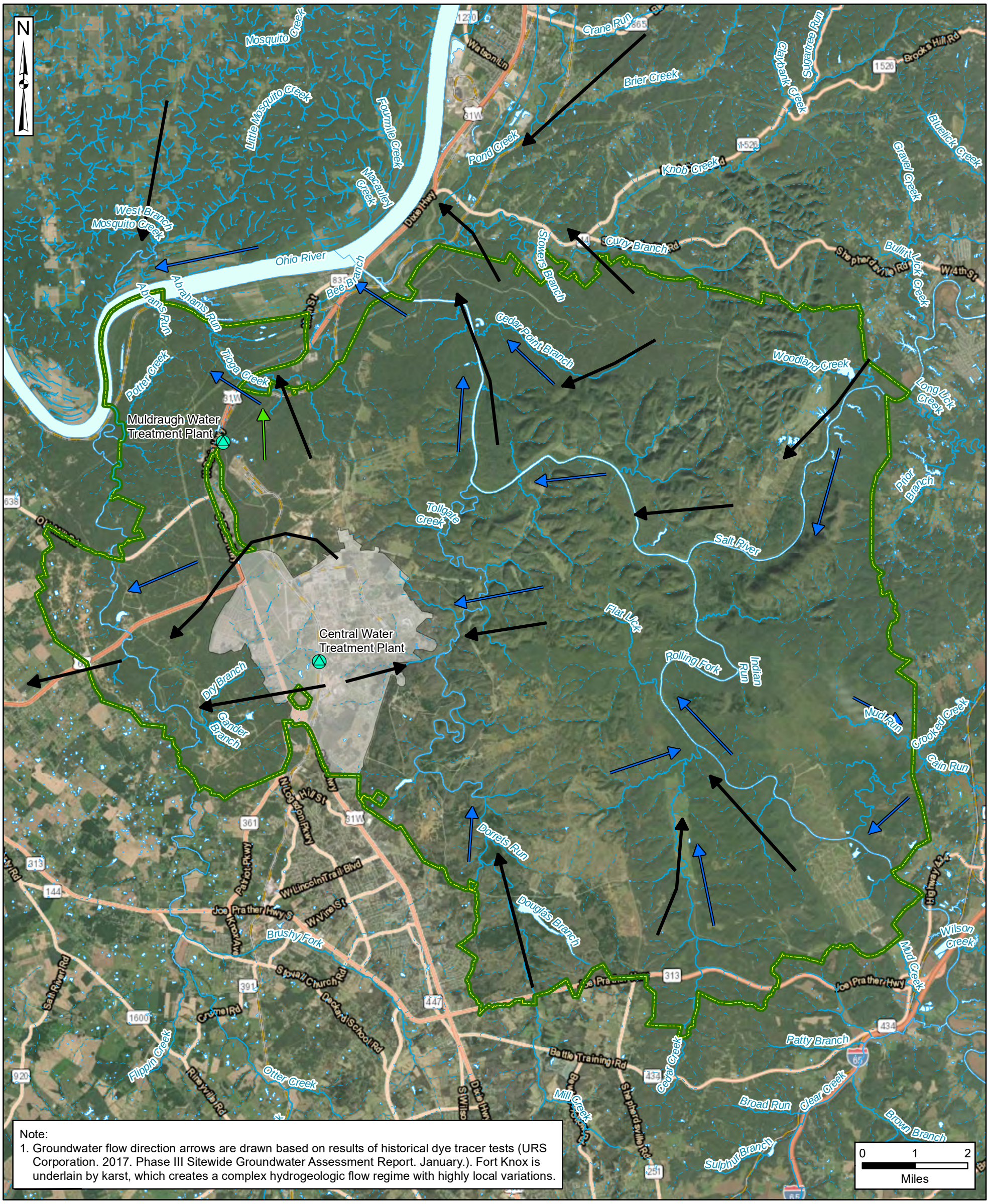
Installation Boundary
County Boundary

Data Sources:
ESRI ArcGIS Online, StreetMap

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, KY

Figure 2-2
Site Layout



Note:
1. Groundwater flow direction arrows are drawn based on results of historical dye tracer tests (URS Corporation. 2017. Phase III Sitewide Groundwater Assessment Report. January.). Fort Knox is underlain by karst, which creates a complex hydrogeologic flow regime with highly local variations.

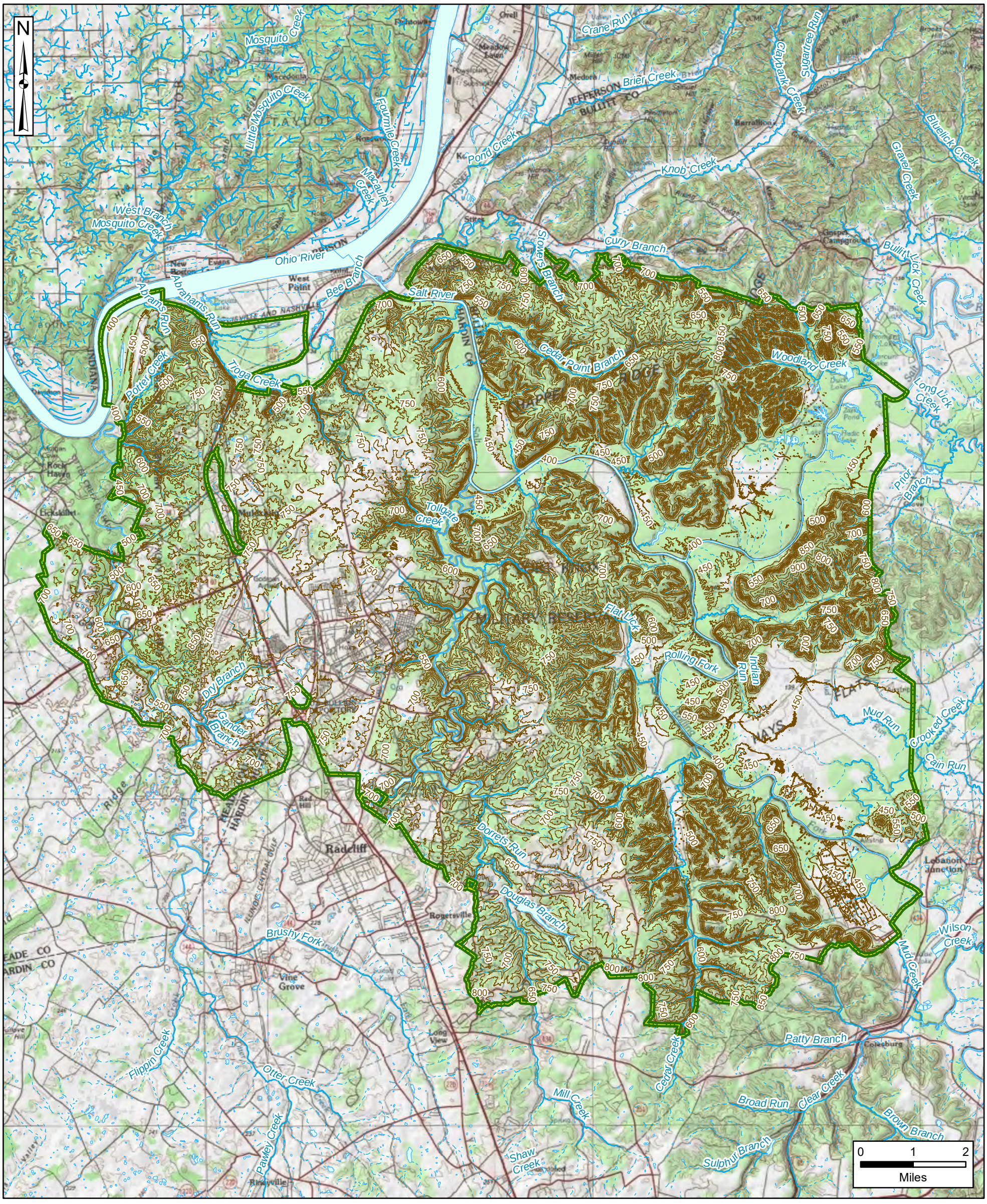
- Installation Boundary
- Cantonment Area
- River/Stream (Perennial)
- Stream (Intermittent)
- Water Body
- Surface Water Flow Direction
- Groundwater Flow Direction
- Direction of Downgradient Supply Well
- Water Treatment Plant

Data Sources:
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, KY

Figure 2-3
Topographic Map



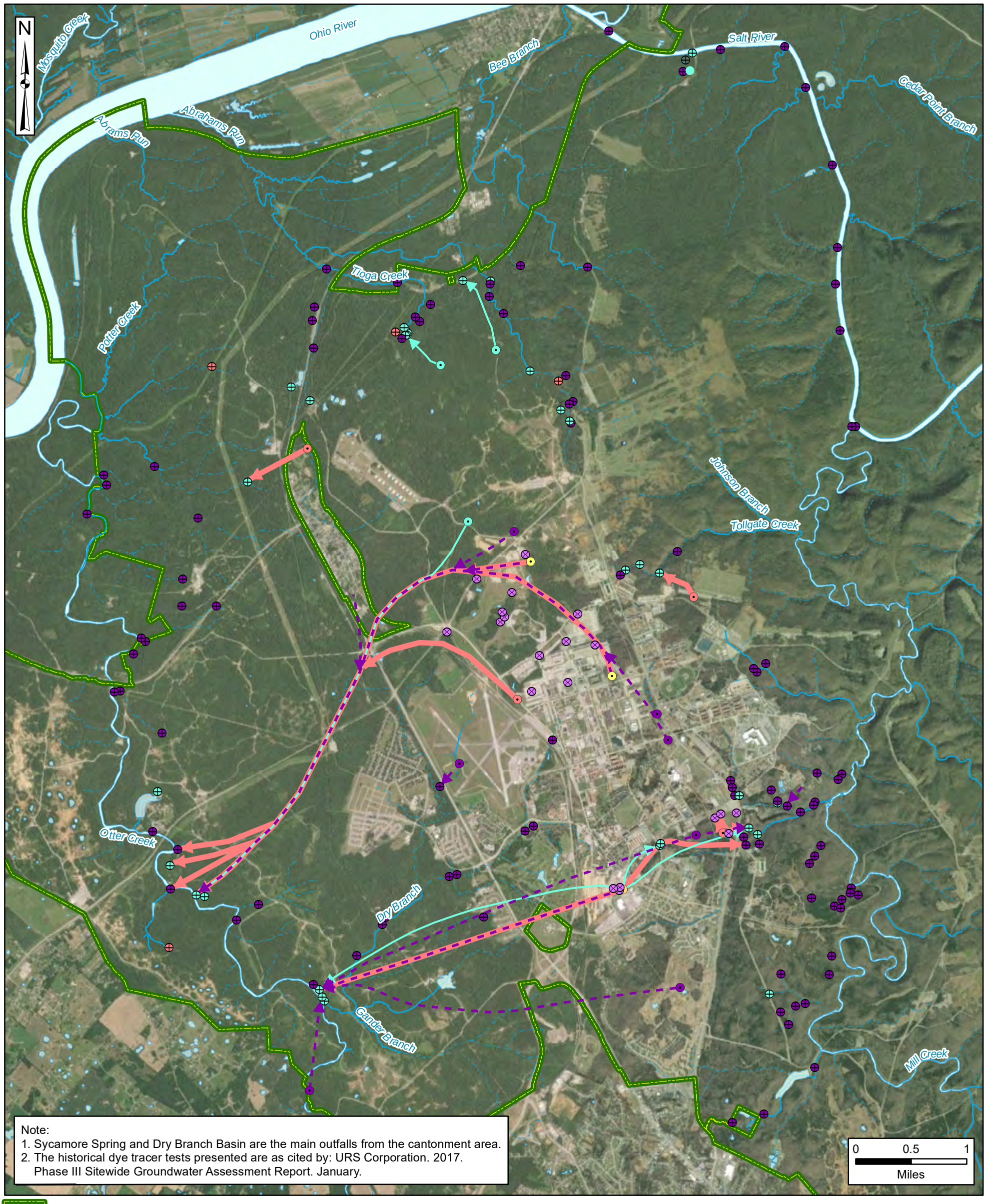
Installation Boundary
Water Body
River/Stream (Perennial)
Stream (Intermittent)
Elevation Contour (50-feet)

Data Sources:
ESRI ArcGIS Online, USGS Topo Map

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, KY

Figure 2-4
Historical Dye Tracer Tests



Note:
1. Sycamore Spring and Dry Branch Basin are the main outfalls from the cantonment area.
2. The historical dye tracer tests presented are as cited by: URS Corporation. 2017. Phase III Sitewide Groundwater Assessment Report. January.

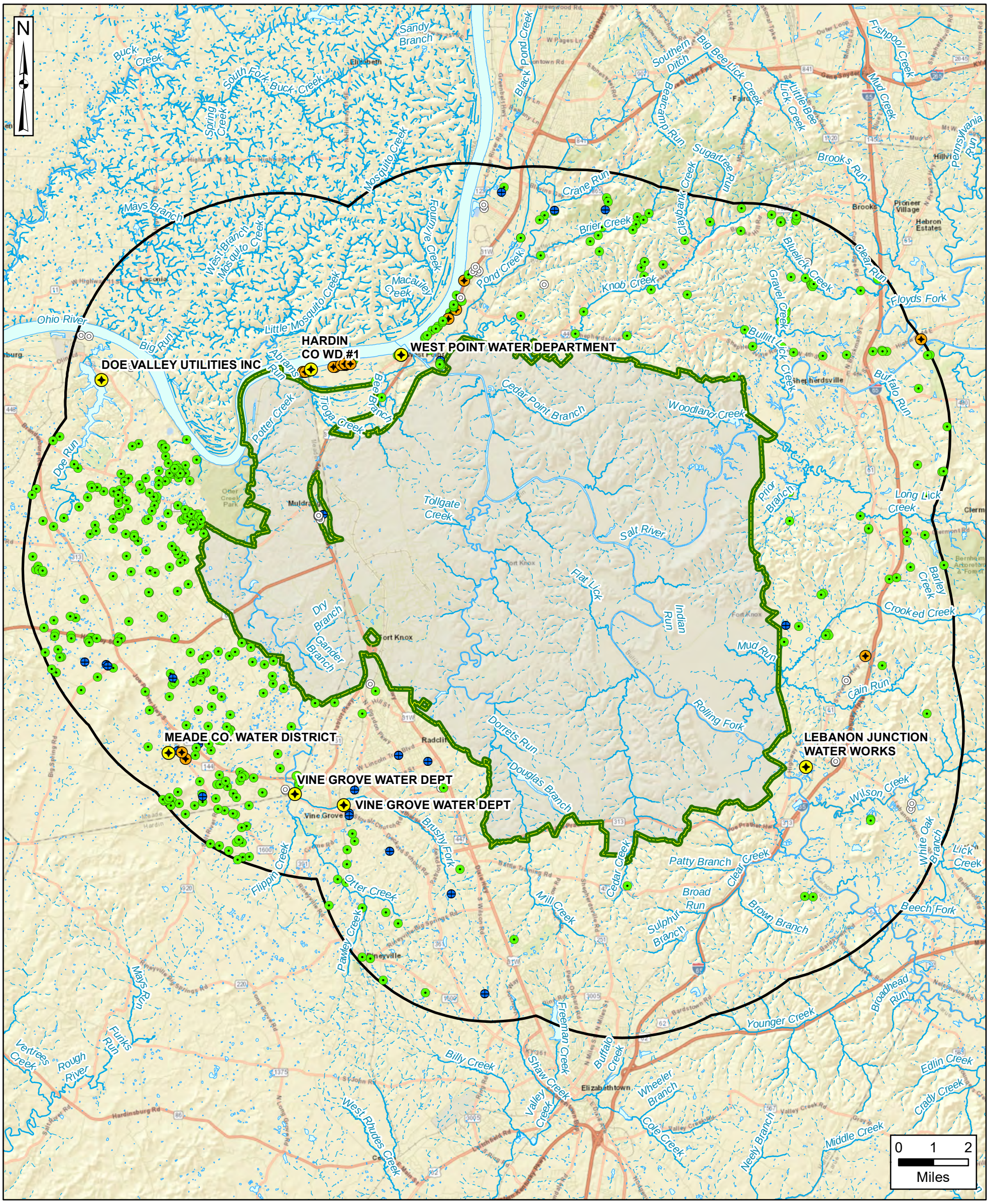
- Installation Boundary
- Dye Injection Well (AECOM 2016)
- Dye Injection Well (URS 2001)
- Dye Injection Well (SAIC 1999, URS 2001, and AECOM 2016)
- Dye Injection Well (SAIC 1999 and URS 2001)
- Dye Injection Well (SAIC 1999)
- Monitoring Location (AECOM 2016)
- Monitoring Location (URS 2001)
- Monitoring Location (DM 1996)
- Monitoring Well (DM 1996)
- Dye Tracer Route (AECOM 2016)
- Dye Tracer Route (URS 2001)
- Dye Tracer Route (SAIC 1999)

Data Sources:
URS. 2017. Phase III Sitewide Groundwater Assessment. January.
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, KY

Figure 2-5
Off-Post Potable Supply Wells



Installation Boundary
5-Mile Radius
River/Stream (Perennial)
Stream (Intermittent)
Water Body

Public Water Supply System Well (EDR)
Public Supply Well (KGS)
Domestic Well (KGS)
Agricultural/Irrigation Well (KGS)
Industrial/Remedial Well (KGS)

EDR = Environmental Data Resources, Inc.
KGS = Kentucky Geological Survey

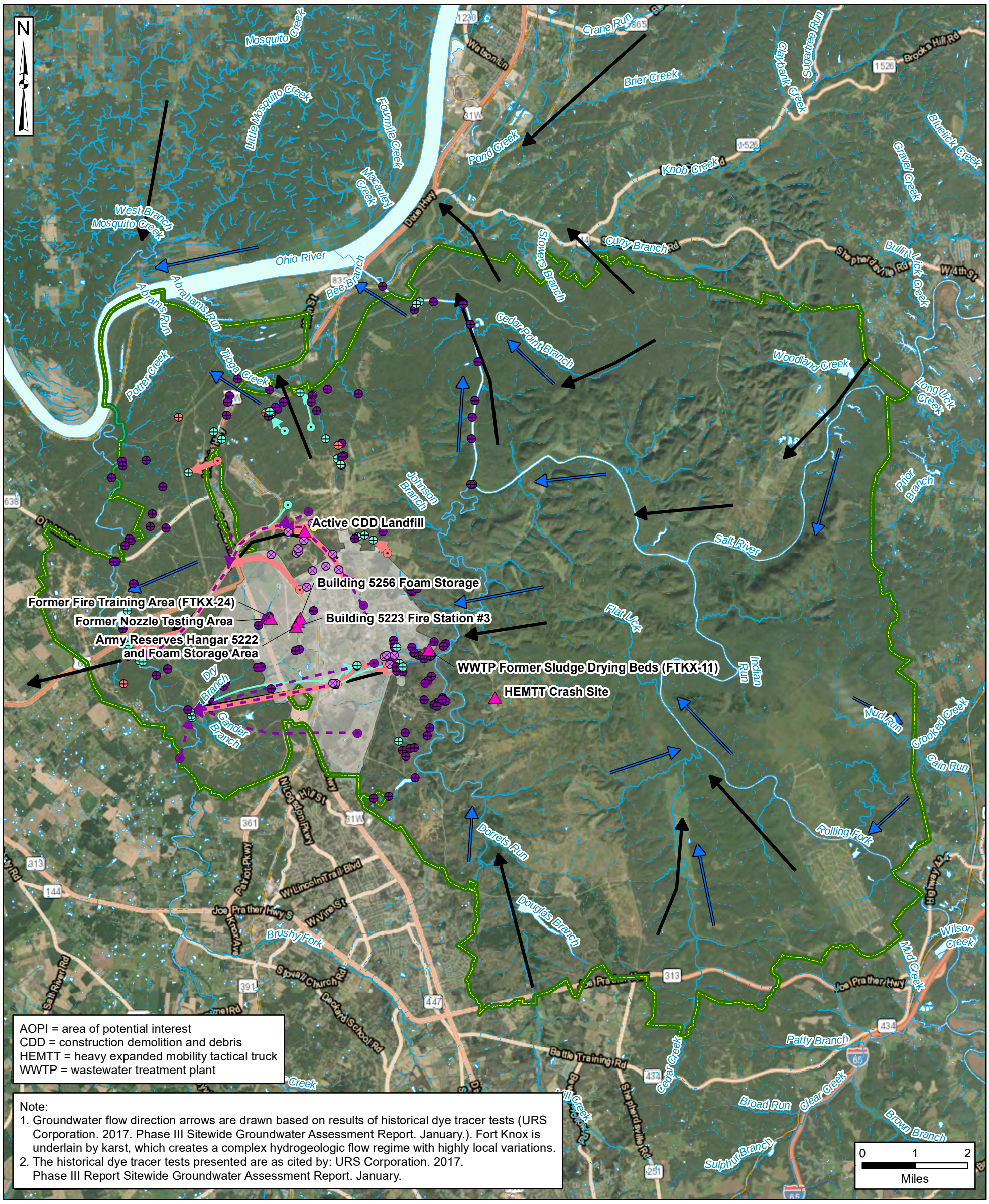
Note: Well owner labels are as provided in the Environmental Data Resources (EDR) Report. See Appendix E for further information.

Data Sources:
EDR Well Data, 2018
KGS Well Data, 2019
ESRI ArcGIS Online, StreetMap

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, KY

Figure 5-2
AOPI Locations



AOPI = area of potential interest
CDD = construction demolition and debris
HEMTT = heavy expanded mobility tactical truck
WWTP = wastewater treatment plant

Note:
1. Groundwater flow direction arrows are drawn based on results of historical dye tracer tests (URS Corporation. 2017. Phase III Sitewide Groundwater Assessment Report. January.). Fort Knox is underlain by karst, which creates a complex hydrogeologic flow regime with highly local variations.
2. The historical dye tracer tests presented are as cited by: URS Corporation. 2017. Phase III Report Sitewide Groundwater Assessment Report. January.

- Installation Boundary
- Cantonment Area
- River/Stream (Perennial)
- Stream (Intermittent)
- Water Body
- AOPI
- Surface Water Flow Direction
- Groundwater Flow Direction
- Dye Injection Well (AECOM 2016)
- Dye Injection Well (URS 2001)
- Dye Injection Well (SAIC 1999, URS 2001, and AECOM 2016)
- Dye Injection Well (SAIC 1999 and URS 2001)
- Dye Injection Well (SAIC 1999)
- Monitoring Location (AECOM 2016)
- Monitoring Location (URS 2001)
- Monitoring Location (DM 1996)
- Monitoring Well (DM 1996)
- Dye Tracer Route (AECOM 2016)
- Dye Tracer Route (URS 2001)
- Dye Tracer Route (SAIC 1999)

Data Sources:
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, KY

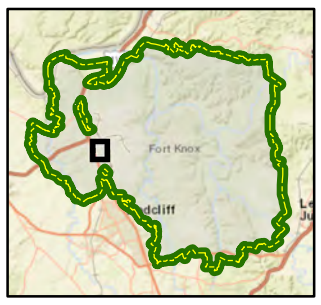
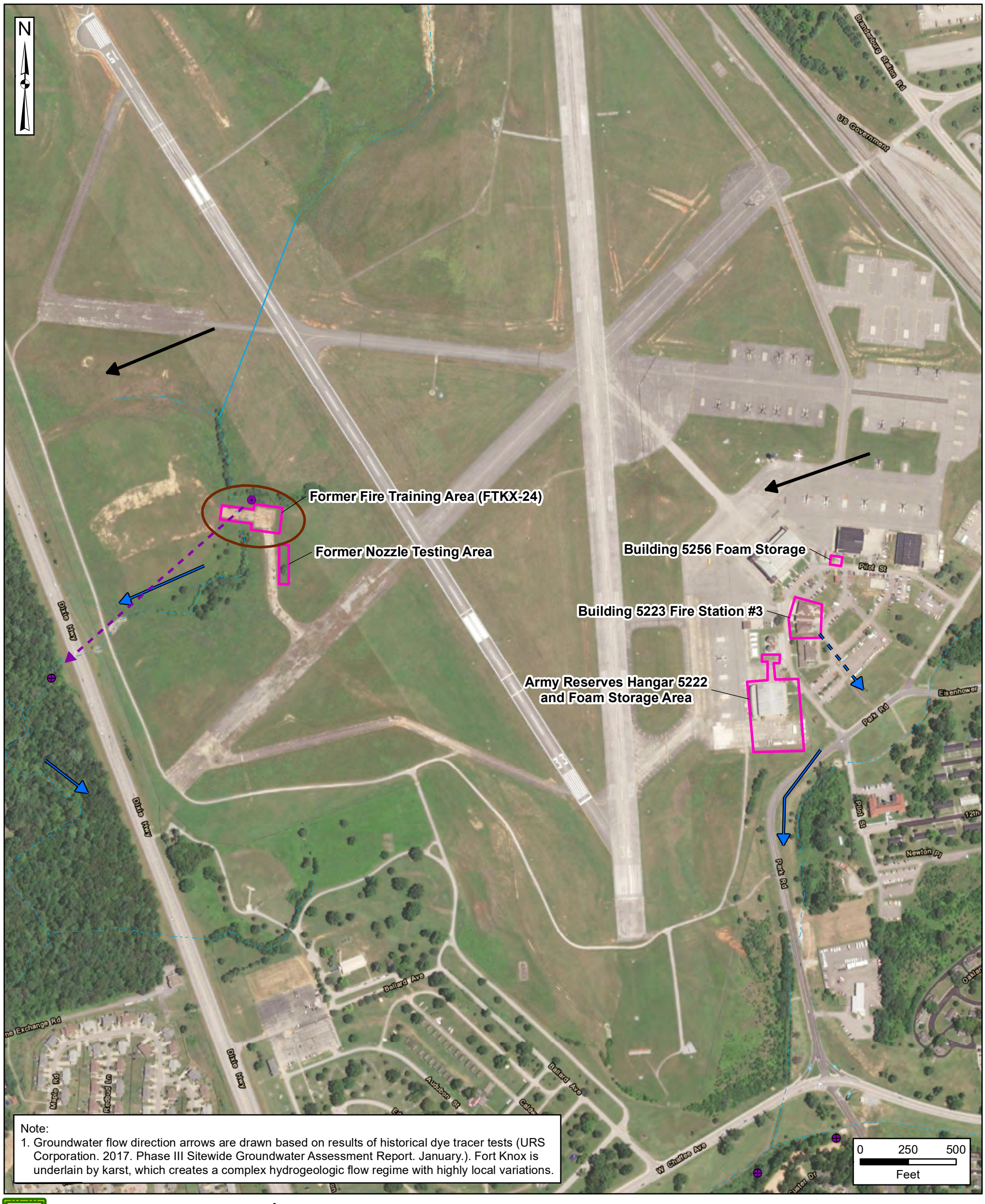


Figure 5-3
Aerial Photo of
Godman Army Airfield AOPI



Note:
1. Groundwater flow direction arrows are drawn based on results of historical dye tracer tests (URS Corporation. 2017. Phase III Sitewide Groundwater Assessment Report. January.). Fort Knox is underlain by karst, which creates a complex hydrogeologic flow regime with highly local variations.

- Installation Boundary
- AOPI
- IRP Site (FTKX-24)
- River/Stream (Perennial)
- Stream (Intermittent)
- Surface Runoff Flow Direction
- Surface Water Flow Direction
- Groundwater Flow Direction
- Dye Injection Well (SAIC 1999)
- Monitoring Location (DM 1996)
- Dye Tracer Route (SAIC 1999)

AOPI = area of potential interest
IRP = Installation Restoration Program

Data Sources:
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, KY

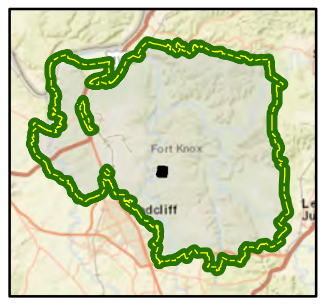


Figure 5-4
Aerial Photo of
HEMTT Crash Site AOPI

Installation Boundary
AOPI
Firing Range
Stream (Intermittent)
Surface Water Flow Direction
Surface Runoff Flow Direction
Groundwater Flow Direction

AOPI = area of potential interest
HEMTT = heavy expanded mobility tactical truck

Data Sources:
Fort Knox, GIS Data, 2019
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, KY

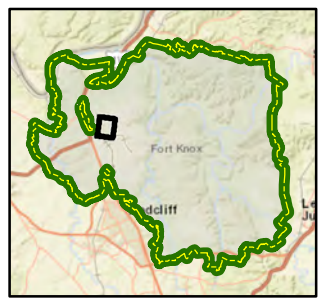


Figure 5-5
Aerial Photo of
Active CDD Landfill AOPI

Note:
1. Groundwater flow direction arrows are drawn based on Environmental Chemical Corporation and Leidos. 2020. Final Analytical Summary – First Quarter 2020 Groundwater Analytical Data and Statistical Report: Residential and CDD Landfills (Site FTKX-02), Fort Knox Military Reservation – Hardin, Meade, and Bullitt Counties, Kentucky. April.

Installation Boundary
AOPI
IRP Site Boundary (FTKX-02)
Surface Runoff Flow Direction
Groundwater Flow Direction
Monitoring Well (Non-Potable)

AOPI = area of potential interest
CDD = construction demolition and debris
IRP = Installation Restoration Program

Data Sources:
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, KY

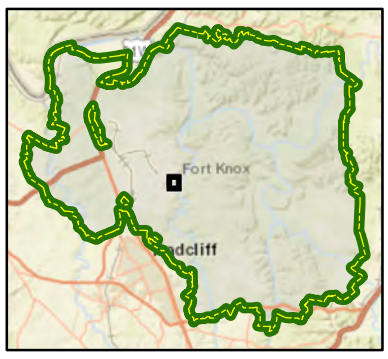


Figure 5-6
Aerial Photo of
WWTP Former Sludge Drying Beds (FTKX-11) AOPI

Installation Boundary
AOPI
River/Stream (Perennial)
Stream (Intermittent)
Surface Runoff Flow Direction
Surface Water Flow Direction
Groundwater Flow Direction
Dye Tracer Route (SAIC 1999)

Fill and Cap Area
FTKX-10
FTKX-11

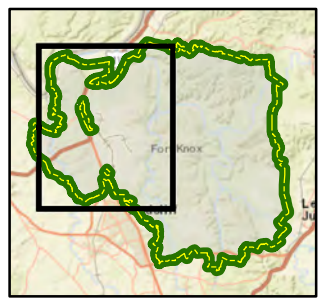
AOPI = area of potential interest
WWTP = wastewater treatment plant

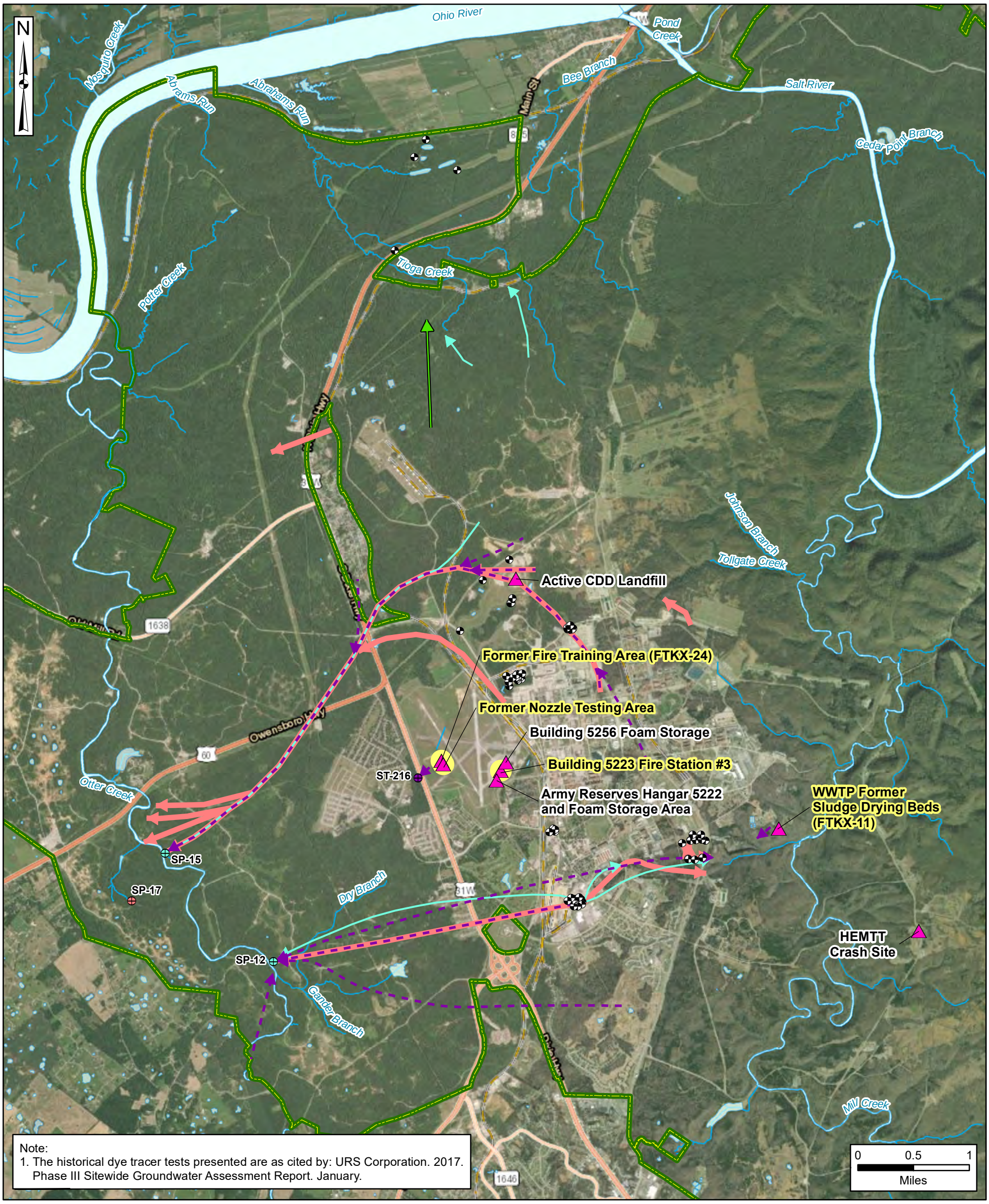
Data Sources:
URS, Phase III Sitewide Groundwater Assessment Report, 2017;
SAIC / Dames & Moore, Sitewide Karst Groundwater Assessment Report,
Phase 1 Activities at US Army Armor Center and Fort Knox, 1999;
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, KY

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





Note:
1. The historical dye tracer tests presented are as cited by: URS Corporation. 2017. Phase III Sitewide Groundwater Assessment Report. January.

- Installation Boundary
- River/Stream (Perennial)
- Stream (Intermittent)
- Water Body
- Monitoring Location (AECOM 2016)
- Monitoring Location (URS 2001)
- Monitoring Location (DM 1996)
- Dye Tracer Route (AECOM 2016)
- Dye Tracer Route (URS 2001)
- Dye Tracer Route (SAIC 1999)
- Direction of Downgradient Supply Well
- Monitoring Well
- AOPI
- AOPI with OSD Risk Screening Level Exceedance

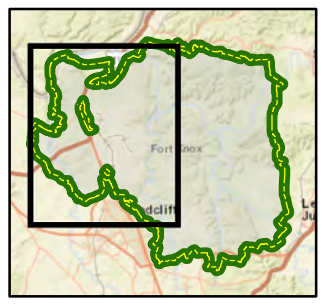
AOPI = area of potential interest
CDD = construction demolition and debris
HEMTT = heavy expanded mobility tactical truck
OSD = Office of the Secretary of Defense
WWTP = wastewater treatment plant

Data Sources:
URS. 2017. Phase III Sitewide Groundwater Assessment. January.
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, KY

Figure 7-2
Surface Water and Sediment
PFOS, PFOA, and PFBS Analytical Results



FTKX-SP-17-SW	
Date	6/9/2020
PFOS	3.5 U
PFOA	3.5 U
PFBS	3.5 U

FTKX-SP-17-SE	
Date	6/9/2020
Depth	0-1
PFOS	0.0012 U
PFOA	0.0012 U
PFBS	0.0012 U

FTKX-SP-15-SW	
Date	6/9/2020
PFOS	**11**
PFOA	**4.1**
PFBS	**1.9 J**

FTKX-SP-15-SE	
Date	6/9/2020
Depth	0-1
PFOS	0.0012 U
PFOA	0.0012 U
PFBS	0.0012 U

FTKX-ST-216-SW	
Date	6/8/2020
PFOS	**84**
PFOA	**18**
PFBS	**3.4 J**

FTKX-ST-216-SE	
Date	6/8/2020
Depth	0-1
PFOS	**0.0017**
PFOA	0.0013 U
PFBS	0.0013 U

FTKX-5223-1-SW	
Date	2/1/2021
PFOS	**60 BJ+ [62 BJ+]**
PFOA	**5.5 [4.8]**
PFBS	**3.3 J [3.3 J]**

FTKX-5223-1-SE	
Date	8/20/2020
Depth	0-1 ft
PFOS	**0.00071 J- [0.00074 J]**
PFOA	0.0011 U [0.0010 U]
PFBS	0.0011 U [0.0010 U]

FTKX-SP-12-SW	
Date	6/9/2020
PFOS	**2.8 J [3.4]**
PFOA	3.7 U [3.4 U]
PFBS	3.7 U [**1.8 J**]

FTKX-SP-12-SE	
Date	6/9/2020
Depth	0-1
PFOS	**0.00082 J**
PFOA	0.0012 U
PFBS	0.0012 U

FTKX-SP-38-SW	
Date	7/27/2021
PFOS	**10 [16]**
PFOA	**20 J- [20]**
PFBS	**13 [14]**

Notes:
1. Surface water results (blue boxes) are reported in nanograms/liter (ng/L), or parts per trillion.
2. Sediment results (tan boxes) are reported in milligrams per kilogram (mg/kg), or parts per million.
3. All depths are in feet below ground surface (ft bgs).
4. Duplicate sample results are shown in brackets.
5. Bolded values indicate detections.
6. Concentrations of PFOS and PFOA 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.
7. FTKX-5223-1-SW was not compared to the OSD risk screening levels for tap water because the aqueous sample is not a direct expression of groundwater at the related AOPI and is not a drinking water source.
8. The historical dye tracer tests presented are as cited by: URS Corporation. 2017. Phase III Sitewide Groundwater Assessment Report. January.

Qualifiers:
BJ+ = The result may be biased high due to blank contamination.
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 low.
U = The analyte was analyzed for, but was not detected above the limit of quantitation (LOQ).

Installation Boundary
AOPI
River/Stream (Perennial)
Stream (Intermittent)
Water Body
Monitoring Location (AECOM 2016)
Monitoring Location (URS 2001)
Monitoring Location (DM 1996)
Dye Tracer Route (AECOM 2016)
Dye Tracer Route (URS 2001)
Dye Tracer Route (SAIC 1999)
Direction of Downgradient Supply Well
Monitoring Well
Surface Water and Sediment Sampling Location
Surface Water Sampling Location

AOPI = area of potential interest
CDD = construction demolition and debris
HEMTT = heavy expanded mobility tactical truck
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate
WWTP = wastewater treatment plant

Data Sources:
URS. 2017. Phase III Sitewide Groundwater Assessment. January.
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, KY

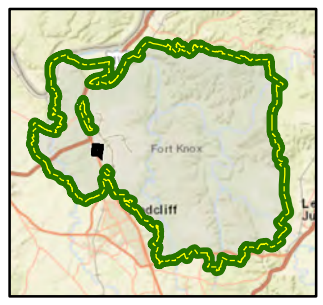


Figure 7-3
Godman Army Airfield (west)
PFOS, PFOA, and PFBS Analytical Results

FTKX-FFTA-4-SO	
Date	6/10/2020
Depth	2-3
PFOS	**0.037**
PFOA	**0.0018**
PFBS	**0.0011**

FTKX-FFTA-3-SO	
Date	6/8/2020
Depth	3-4
PFOS	**0.051**
PFOA	**0.004**
PFBS	0.0011 U

FTKX-FFTA-1-SO	
Date	6/8/2020
Depth	3-4
PFOS	**0.028**
PFOA	**0.00061 J**
PFBS	0.0011 U

FTKX-FFTA-5-SO	
Date	6/10/2020
Depth	2-3
PFOS	**0.016**
PFOA	**0.0023**
PFBS	0.0012 U

FTKX-FFTA-2-SO	
Date	6/10/2020
Depth	2-3
PFOS	**0.057**
PFOA	**0.0036**
PFBS	**0.0011**

Former Fire Training Area (FTKX-24)

Former Nozzle Testing Area

FTKX-FNT-1-SO	
Date	6/8/2020
Depth	0-2
PFOS	**0.0058**
PFOA	**0.0017**
PFBS	0.0012 U

FTKX-FNT-3-SO	
Date	6/8/2020
Depth	0-2
PFOS	**0.0027**
PFOA	**0.00055 J**
PFBS	0.0010 U

FTKX-FNT-2-SO	
Date	6/8/2020
Depth	0-2
PFOS	**0.00076 J [0.00062 J]**
PFOA	0.0011 U [0.0010 U]
PFBS	0.0011 U [0.0010 U]

FTKX-ST-216-SW	
Date	6/8/2020
PFOS	**84**
PFOA	**18**
PFBS	**3.4 J**

FTKX-ST-216-SE	
Date	6/8/2020
Depth	0-1
PFOS	**0.0017**
PFOA	0.0013 U
PFBS	0.0013 U

Notes:
1. Surface water results (blue boxes) are reported in nanograms/liter (ng/L), or parts per trillion.
2. Soil results (green boxes) and sediment results (tan boxes) are reported in milligrams per kilogram (mg/kg), or parts per million.
3. All depths are in feet below ground surface (ft bgs).
4. Duplicate sample results are shown in brackets.
5. Bolded values indicate detections.
6. Concentrations of PFOS and PFOA 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.
7. Groundwater flow direction arrows are drawn based on results of historical dye tracer tests (URS Corporation. 2017. Phase III Sitewide Groundwater Assessment Report. January.). Fort Knox is underlain by karst, which creates a complex hydrogeologic flow regime with highly local variations.
8. The historical dye tracer tests presented are as cited by: URS Corporation. 2017. Phase III Report Sitewide Groundwater Assessment Report. January.

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).

0 100 200
Feet

- Installation Boundary
- AOPI
- IRP Site (FTKX-24)
- River/Stream (Perennial)
- Stream (Intermittent)
- Surface Water Flow Direction
- Groundwater Flow Direction
- Dye Injection Well (SAIC 1999)
- Monitoring Location (DM 1996)
- Dye Tracer Route (SAIC 1999)
- Soil Sampling Location
- Surface Water and Sediment Sampling Location

AOPI = area of potential interest
IRP = Installation Restoration Program
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate

Data Sources:
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, KY

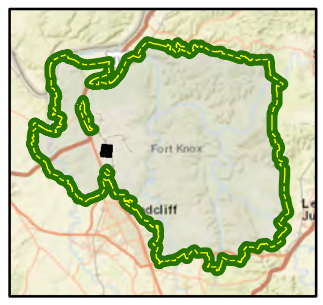


Figure 7-4
Godman Army Airfield (east)
PFOS, PFOA, and PFBS Analytical Results

FTKX-5223-2-SO	
Date	6/8/2020
Depth	0-2 ft
PFOS	**0.0088**
PFOA	**0.00093 J**
PFBS	0.0011 U

FTKX-5223-1-SO	
Date	6/8/2020
Depth	0-2 ft
PFOS	**0.096**
PFOA	**0.0029**
PFBS	0.0012 U

FTKX-5223-6-SO	
Date	8/20/2020
Depth	0-2 ft
PFOS	**0.045**
PFOA	**0.0012**
PFBS	0.0011 U

FTKX-5222-4-SO	
Date	6/8/2020
Depth	0-2 ft
PFOS	**0.00097 J**
PFOA	0.0012 U
PFBS	0.0012 U

FTKX-5222-5-SO	
Date	6/8/2020
Depth	0-2 ft
PFOS	**0.0028**
PFOA	0.0012 U
PFBS	0.0012 U

FTKX-5222-2-SO	
Date	6/8/2020
Depth	0-2 ft
PFOS	**0.0021**
PFOA	0.0010 U
PFBS	0.0010 U

FTKX-5222-3-SO	
Date	6/8/2020
Depth	0-2 ft
PFOS	**0.0014**
PFOA	0.0011 U
PFBS	0.0011 U

FTKX-5223-3-SO	
Date	8/20/2020
Depth	0-2 ft
PFOS	**0.0075**
PFOA	0.0011 U
PFBS	0.0011 U

FTKX-5256-1-SO	
Date	6/8/2020
Depth	0-2
PFOS	0.0011 U
PFOA	0.0011 U
PFBS	**0.00063 J**

Building 5256
Foam Storage

FTKX-5223-1-GW	
Date	2/2/2021
PFOS	**4,800 J [4,700 J+]**
PFOA	**350 [340]**
PFBS	**340 [350 J]**

Building 5223
Fire Station #3

FTKX-5223-4-SO	
Date	8/20/2020
Depth	0-2 ft
PFOS	**0.0074 J- [0.0064]**
PFOA	**0.00068 J [0.00051 J]**
PFBS	0.0012 U [0.0010 U]

FTKX-5223-5-SO	
Date	8/20/2020
Depth	0-2 ft
PFOS	**0.024**
PFOA	**0.0021**
PFBS	0.0012 U

FTKX-5223-2-GW	
Date	2/2/2021
PFOS	**340 J**
PFOA	**600**
PFBS	**5,800 J**

FTKX-5222-1-SO	
Date	6/8/2020
Depth	0-2 ft
PFOS	**0.00083 J**
PFOA	0.00099 U
PFBS	0.00099 U

FTKX-5223-1-SW	
Date	2/1/2021
PFOS	**60 BJ+ [62 BJ+]**
PFOA	**5.5 [4.8]**
PFBS	**3.3 J [3.3 J]**

FTKX-5223-1-SE	
Date	8/20/2020
Depth	0-1 ft
PFOS	**0.00071 J- [0.00074 J]**
PFOA	0.0011 U [0.0010 U]
PFBS	0.0011 U [0.0010 U]

Army Reserves Hangar 5222
and Foam Storage Area

Notes:
1. Groundwater (light blue boxes) and surface water (dark blue boxes) results are reported in nanograms/liter (ng/L), or parts per trillion.
2. Soil (green boxes) and sediment (tan boxes) results are reported in milligrams per kilogram (mg/kg), or parts per million.
3. All depths are in feet below ground surface (ft bgs).
4. Duplicate sample results are shown in brackets.
5. Bolded values indicate detections.
6. Concentrations of PFOS and PFOA 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.
7. FTKX-5223-1-SW was not compared to the OSD risk screening levels for tap water because the aqueous sample is not a direct expression of groundwater at the related AOPI and is not a drinking water source
8. Groundwater flow direction arrows are drawn based on results of historical dye tracer tests (URS Corporation. 2017. Phase III Sitewide Groundwater Assessment Report. January.). Fort Knox is underlain by karst, which creates a complex hydrogeologic flow regime with highly local variations.

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

0 100 200
Feet

Installation Boundary
AOPI
Stream (Intermittent)
Surface Water Flow Direction
Surface Runoff Flow Direction
Groundwater Flow Direction
Soil Sampling Location
Surface Water/Sediment Sampling Location
Temporary Well Groundwater Sampling Location

AOPI = area of potential interest
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate

Data Sources:
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, KY

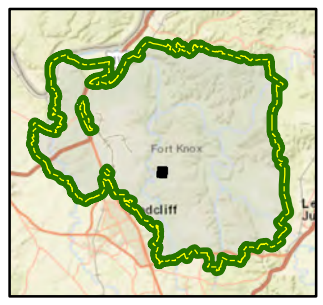


Figure 7-5
HEMTT Crash Site
PFOS, PFOA, and PFBS Analytical Results

N

Donnelly Range

FTKX-HEMTT-1-SO	
Date	6/9/2020
Depth	0-2
PFOS	0.0012 U
PFOA	0.0012 U
PFBS	0.0012 U

FTKX-HEMTT-2-SO	
Date	6/9/2020
Depth	0-2
PFOS	0.0010 U
PFOA	0.0010 U
PFBS	0.0010 U

HEMTT Crash Site

FTKX-HEMTT-3-SO	
Date	6/9/2020
Depth	0-2
PFOS	0.0010 U
PFOA	0.0010 U
PFBS	0.0010 U

Boydston Range

Notes:
1. Soil results are reported in milligrams per kilogram (mg/kg), or parts per million.
2. All depths are in feet below ground surface (ft bgs).
3. Groundwater flow direction arrows are drawn based on results of historical dye tracer tests (URS Corporation. 2017. Phase III Sitewide Groundwater Assessment Report. January.). Fort Knox is underlain by karst, which creates a complex hydrogeologic flow regime with highly local variations.

Qualifiers:
U = The analyte was analyzed for, but was not detected above the limit of quantitation (LOQ).

0 100 200
Feet

Installation Boundary
AOPI
Firing Range
Stream (Intermittent)
Surface Water Flow Direction
Surface Runoff Flow Direction
Groundwater Flow Direction
Soil Sampling Location

AOPI = area of potential interest
HEMTT = heavy expanded mobility tactical truck
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate

Data Sources:
Fort Knox, GIS Data, 2019
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, KY

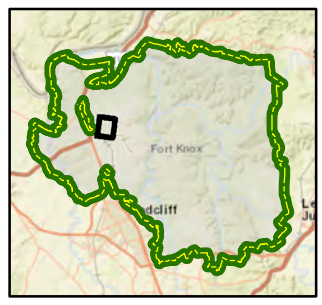
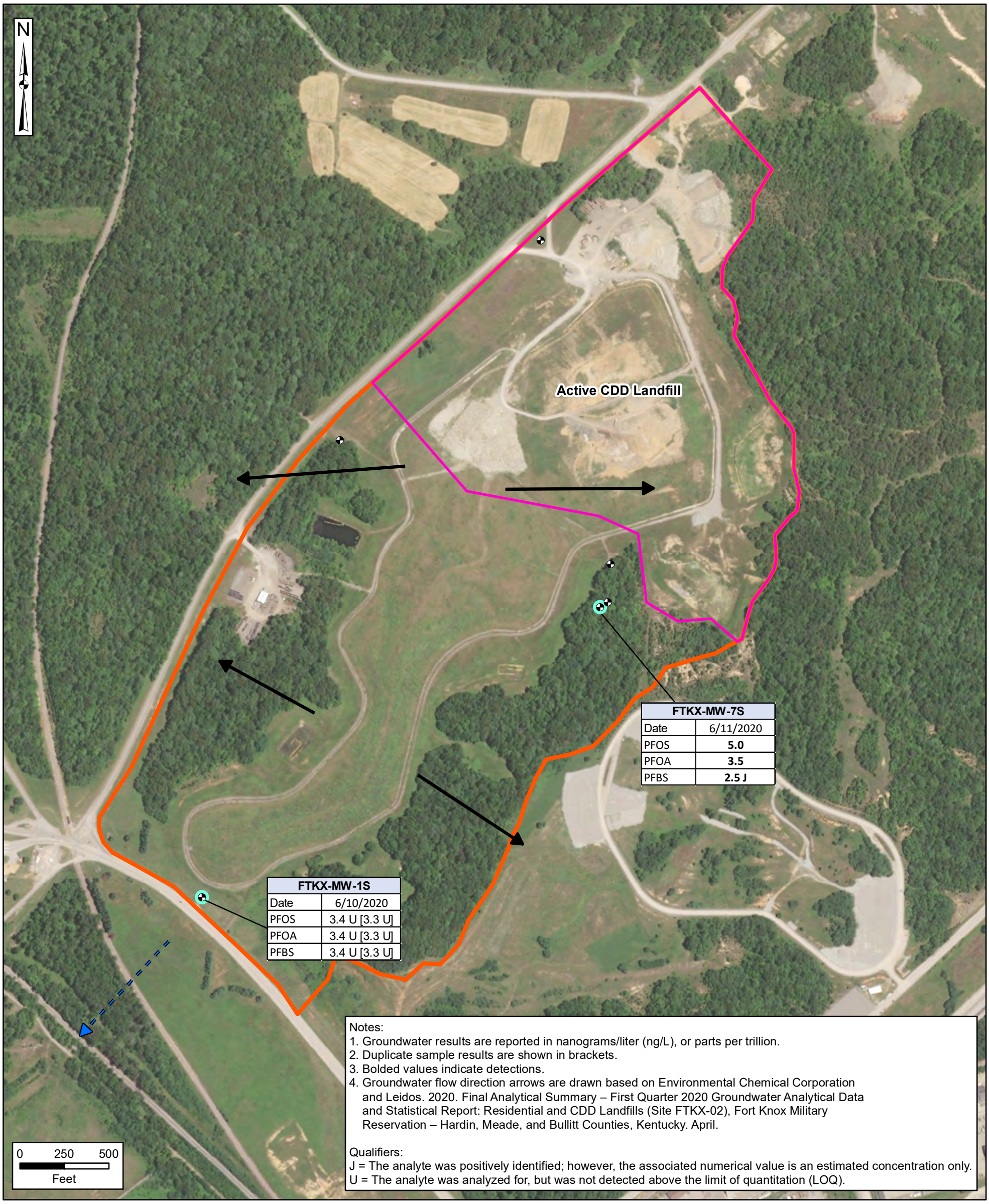


Figure 7-6
Active CDD Landfill
PFOS, PFOA, and PFBS Analytical Results



Notes:
1. Groundwater results are reported in nanograms/liter (ng/L), or parts per trillion.
2. Duplicate sample results are shown in brackets.
3. Bolded values indicate detections.
4. Groundwater flow direction arrows are drawn based on Environmental Chemical Corporation and Leidos. 2020. Final Analytical Summary – First Quarter 2020 Groundwater Analytical Data and Statistical Report: Residential and CDD Landfills (Site FTKX-02), Fort Knox Military Reservation – Hardin, Meade, and Bullitt Counties, Kentucky. April.

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
- IRP Site Boundary (FTKX-02)
- Surface Runoff Flow Direction
- Groundwater Flow Direction
- Monitoring Well (Non-Potable)
- Groundwater Sampling Location - Exisiting Well

AOPI = area of potential interest
CDD = construction demolition and debris
IRP = Installation Restoration Program
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate

Data Sources:
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

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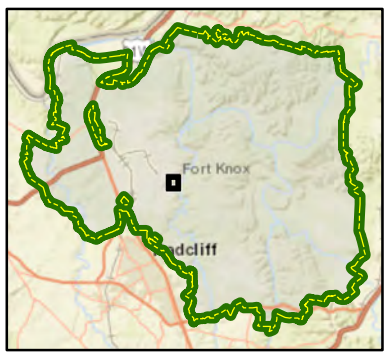
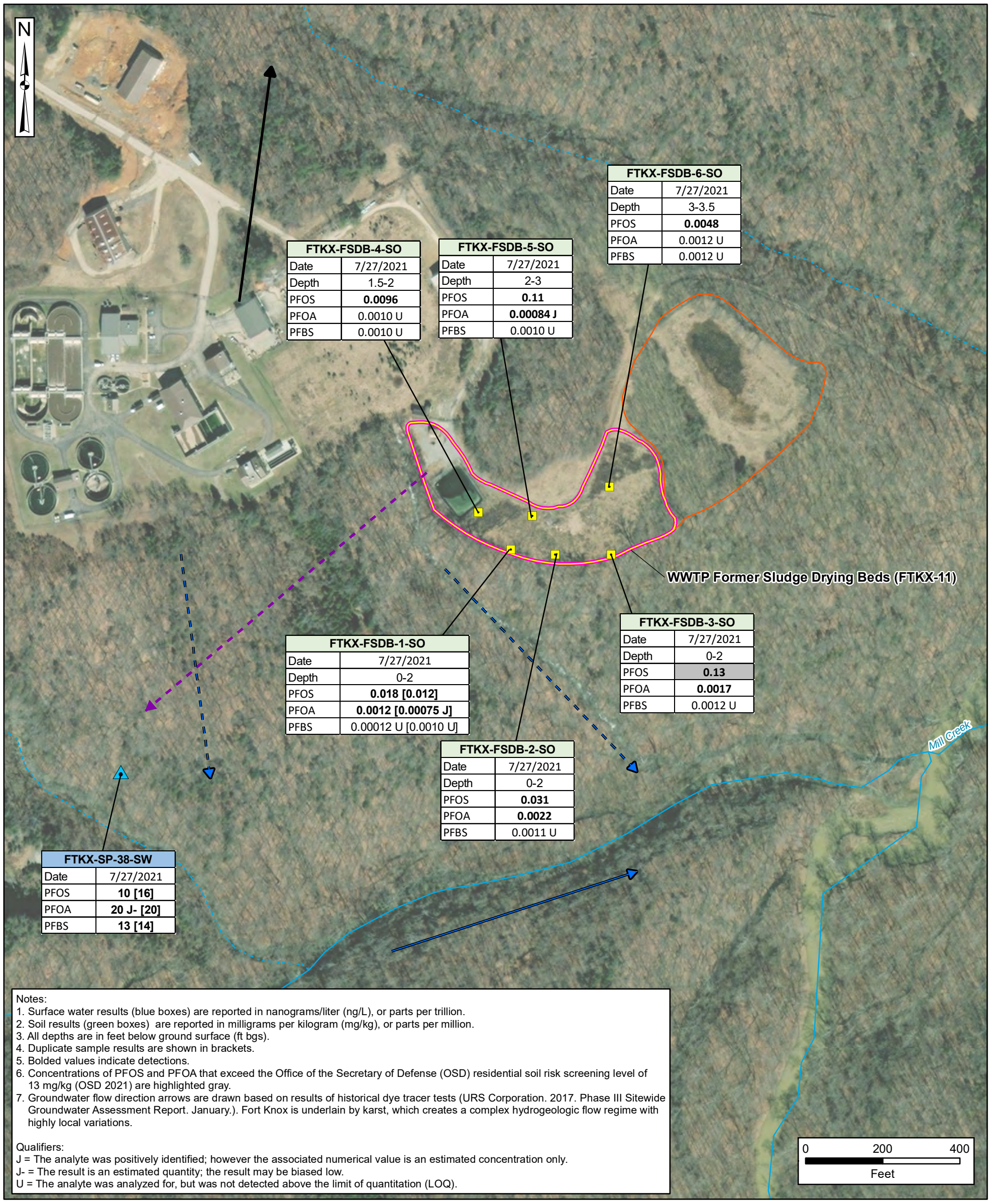
Fort Knox, KY

Figure 7-7
WWTP Former Sludge Drying Beds (FTKX-11)
PFOS, PFOA, and PFBS Analytical Results





Notes:
1. Surface water results (blue boxes) are reported in nanograms/liter (ng/L), or parts per trillion.
2. Soil results (green boxes) are reported in milligrams per kilogram (mg/kg), or parts per million.
3. All depths are in feet below ground surface (ft bgs).
4. Duplicate sample results are shown in brackets.
5. Bolded values indicate detections.
6. Concentrations of PFOS and PFOA that exceed the Office of the Secretary of Defense (OSD) residential soil risk screening level of 13 mg/kg (OSD 2021) are highlighted gray.
7. Groundwater flow direction arrows are drawn based on results of historical dye tracer tests (URS Corporation. 2017. Phase III Sitewide Groundwater Assessment Report. January.). Fort Knox is underlain by karst, which creates a complex hydrogeologic flow regime with highly local variations.

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 low.
U = The analyte was analyzed for, but was not detected above the limit of quantitation (LOQ).

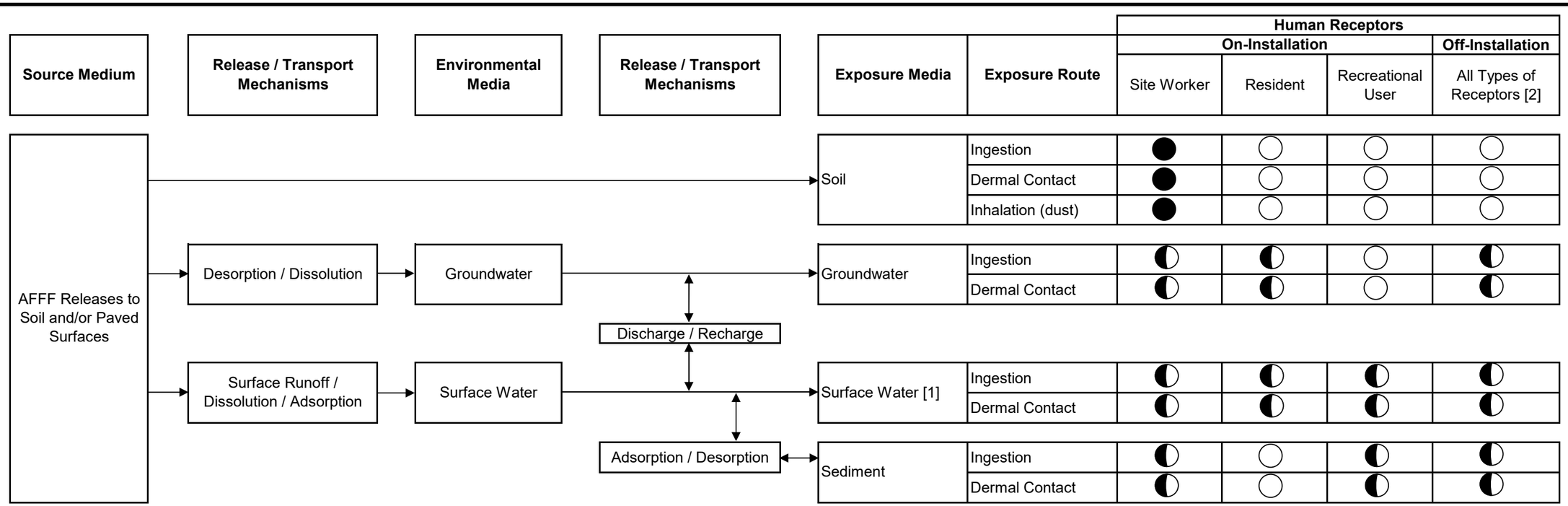
- Installation Boundary
- AOPI
- River/Stream (Perennial)
- Stream (Intermittent)
- Surface Runoff Flow Direction
- Surface Water Flow Direction
- Groundwater Flow Direction
- Dye Tracer Route (SAIC 1999)
- Soil Sampling Location
- Surface Water Sampling Location

Fill and Cap Area
- FTKX-10
- FTKX-11

AOPI = area of potential interest
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate
WWTP = wastewater treatment plant

Data Sources:
URS, Phase III Sitewide Groundwater Assessment, 2017;
SAIC / Dames & Moore, Sitewide Karst Groundwater Assessment Report, Phase 1 Activities at US Army Armor Center and Fort Knox, 1999;
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 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 outdoor recreational activities.
[2] All types of off-installation human receptors include drinking water receptors and recreational users.

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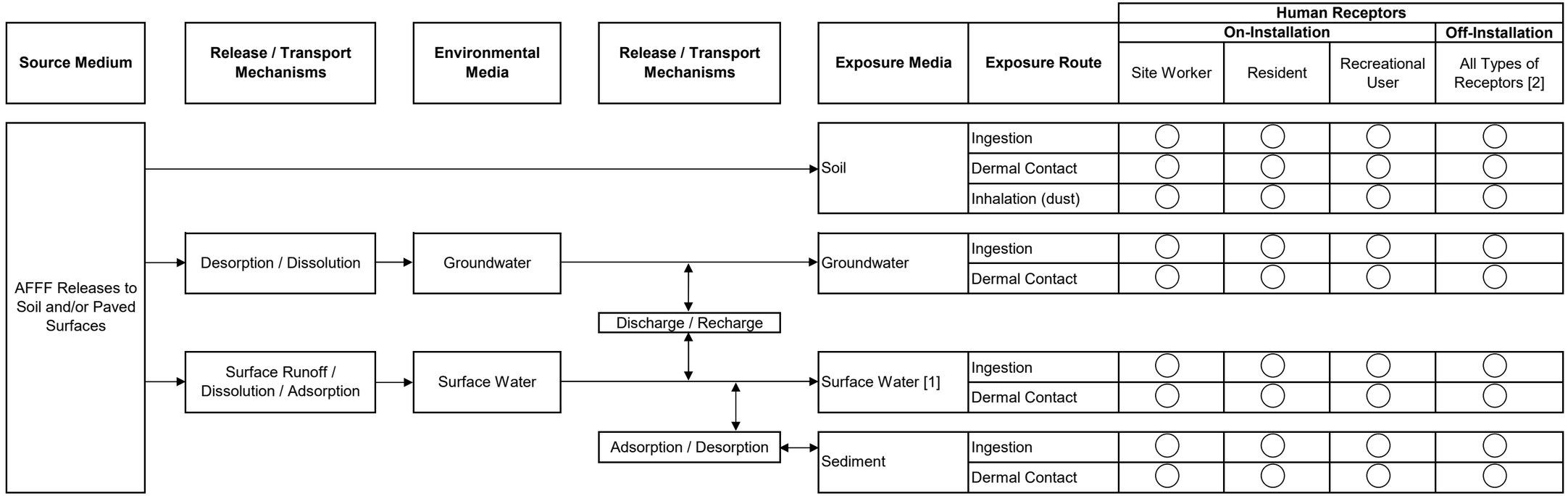
Conceptual Site Model - Former Nozzle Testing Area, Former Fire Training Area (FTKX-24), Building 5223 Fire Station #3, Army Reserves Hangar 5222 and Foam Storage Area, Building 5256 Foam Storage Area, and WWTP Former Sludge Drying Bed AOPIs
USAEC PFAS Preliminary Assessment / Site Inspection
Fort Knox, Kentucky

Figure 7-8



Legend:

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

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Conceptual Site Model - HEMTT Crash Site AOPI
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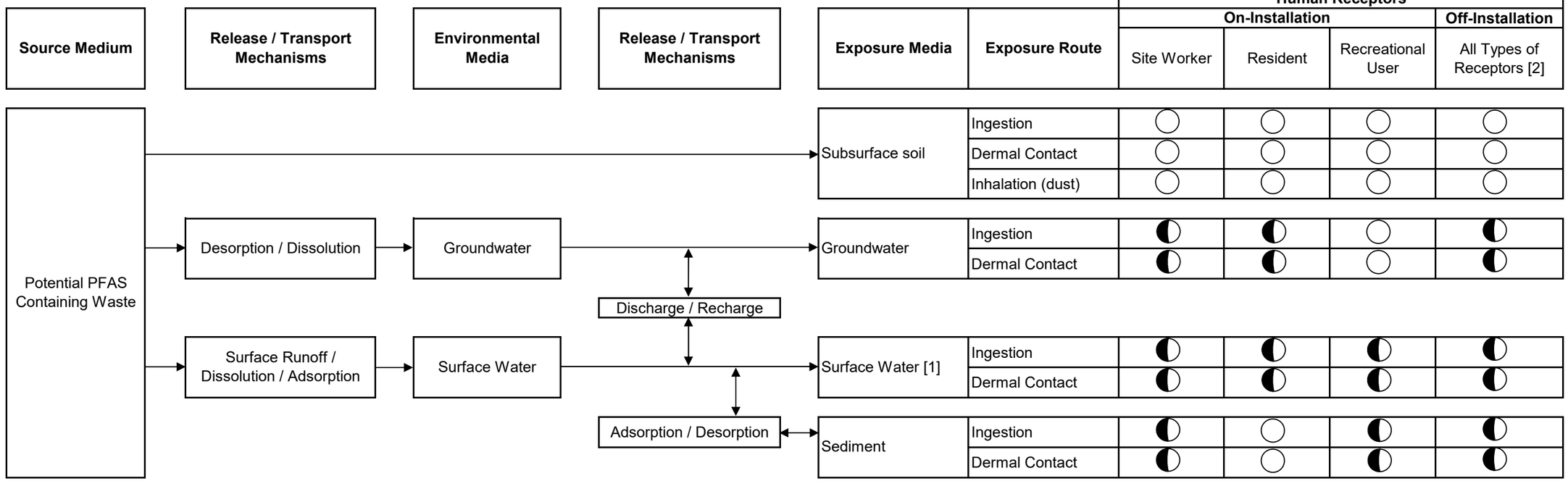
Fort Knox, Kentucky

Figure 7-9



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

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Conceptual Site Model - Active CDD Landfill AOPI
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Fort Knox, Kentucky

Figure 7-11

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APPENDIX A

Office of the Secretary of Defense. 2021. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. September 15.

APPENDIX B

Preliminary Assessment/Site Inspection Quality Control Checklist

APPENDIX C

Antiterrorism/Operations Security Review Cover Sheet

APPENDIX E

Installation EDR Survey Reports

APPENDIX F

Research Log

APPENDIX G

Compiled Interview Logs

APPENDIX H

Site Reconnaissance Photo Log

APPENDIX I

Compiled Site Reconnaissance Logs

APPENDIX J

Field Change Reports

APPENDIX K

Site Inspection Field Notes

APPENDIX L

Site Inspection Field Forms

APPENDIX M

Data Usability Summary Reports (Level IV analytical reports included in final electronic deliverable only)

APPENDIX N

Site Inspection Laboratory Analytical Results

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