FINAL
Site Inspection Report Army Aviation Support Facility, Boone, Iowa

Perfluorooctanesulfonic Acid (PFOS) and
Perfluorooctanoic Acid (PFOA) Impacted Sites
ARNG Installations, Nationwide

August 2021

Prepared for:

Army National Guard Bureau
111 S. George Mason Drive
Arlington, VA 22204

UNCLASSIFIED

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Acronyms and Abbreviations

6:2 FTS	6:2 Fluorotelomer sulfonate
8:2 FTS	8:2 Fluorotelomer sulfonate
µg/Kg	micrograms per kilogram
°C	degrees Celsius
°F	degrees Fahrenheit
%	percent
AASF	Army Aviation Support Facility
AECOM	AECOM Technical Services, Inc.
AFFF	aqueous film forming foam
AOI	Area of Interest
ARNG	Army National Guard
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CoC	chain of custody
CSM	conceptual site model
DA	Department of the Army
DoD	Department of Defense
DPT	direct-push technology
DQI	data quality indicator
DQO	data quality objective
DUA	data usability assessment
DVR	data validation report
EIS	extraction internal standards
ELAP	Environmental Laboratory Accreditation Program
EM	Engineering Manual
FedEx	Federal Express
gpm	gallons per minute
HA	Health Advisory
HDPE	high-density polyethylene
IAARNG	Iowa Army National Guard
IDW	investigation-derived waste
IGS	Iowa Geological Survey
IIS	injection internal standards
ITRC	Interstate Technology Regulatory Council
LC/MS/MS	liquid chromatography with tandem mass spectrometry
LCS	laboratory control spike
LCSD	laboratory control spike duplicate
LOQ	limit of quantitation
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
NELAP	National Environmental Laboratory Accreditation Program
NEtFOSAA	N-ethyl perfluorooctanesulfonamidoacetic acid

ng/L	nanograms per liter
NMeFOSAA	N-methyl perfluorooctanesulfonamidoacetic acid
OSD	Office of the Secretary of Defense
OWS	oil/ water separator
PA	Preliminary Assessment
PFAS	per- and polyfluoroalkyl substances
PFBA	perfluorobutyrate
PFBS	perfluorobutanesulfonic acid
PFDA	perfluorodecanoic acid
PFDoA	perfluorododecanoic acid
PFHpA	perfluoroheptanoic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PFPeA	perfluoropentanoic acid
PFTeDA	perfluorotetradecanoic acid
PFTrDA	perfluorotridecanoic acid
PFUdA	perfluoroundecanoic acid
PID	photoionization detector
PVC	poly-vinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QSM	Quality Systems Manual
RI	Remedial Investigation
RPD	relative percent differences
SI	Site Inspection
SL	screening level
SOP	standard operating procedure
TOC	total organic carbon
TPP	Technical Project Planning
UCMR3	Unregulated Contaminant Monitoring Rule 3
UFP	Uniform Federal Policy
US	United States
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service

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Executive Summary

The Army National Guard (ARNG) is performing Preliminary Assessments (PAs) and Site Inspections (SIs) at per- and polyfluoroalkyl substances (PFAS)-impacted sites at ARNG facilities nationwide. The objective of the SI at each facility is to identify whether there has been a release to the environment from the Areas of Interest (AOIs) identified in the PA and determine the presence or absence of perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), and perfluorobutanesulfonic acid (PFBS) at or above screening levels (SLs). An SI was completed at the Army Aviation Support Facility (AASF) in Boone, Iowa (hereafter referred to as the “facility”).

Boone AASF is located on 28 acres of land owned and leased by the State of Iowa; the AASF facilities occupy 10 acres, and the remaining land is occupied by an ARNG Readiness Center and Field Maintenance Shop. The original 1948 AASF was demolished in 1989 to make space for the current AASF. Construction of the current AASF was completed in 1992. The Boone AASF currently has no aqueous film forming foam (AFFF) fire suppression system. During the PA, one potential PFAS release area, the Wash Rack, was identified as an AOI at the facility (AECOM, 2019). PFAS were released at this site during AFFF fire extinguisher testing every five years from 1992 to the present. This AOI was also used for fire training that used either dish soap or AFFF on multiple occasions. The AOI, as well as upgradient and downgradient areas, were investigated during the SI. SI field activities included soil and groundwater grab sampling from soil borings and temporary monitoring wells installed from 4 to 5 August 2020.

To fulfill the project Data Quality Objectives set forth in the approved SI Quality Assurance Project Plan (QAPP) Addendum (AECOM, 2020b), samples were collected and analyzed for a subset of 18 PFAS by liquid chromatography with tandem mass spectrometry (LC/MS/MS) compliant with Quality Systems Manual (QSM) 5.1 Table B-15. The 18 PFAS analyzed as part of the ARNG SI program are specified in **Section 5.7** of this Report.

The Department of Defense (DoD) has adopted a policy to retain facilities in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process based on risk-based SLs for soil and groundwater, as described in a memorandum from the Office of the Secretary of Defense (OSD) dated 15 October 2019 (Assistant Secretary of Defense, 2019). The ARNG PFAS SIs follow this DoD policy and, when the maximum site concentration for sampled media exceed the SLs, the site will proceed to a Remedial Investigation (RI), the next phase under CERCLA. The SLs apply to three compounds, PFOA, PFOS, and PFBS, for both soil and groundwater, as presented in **Table ES-1**. All other results presented in this report are considered informational in nature and serve as an indication as to whether soil and groundwater contain or do not contain the 18 PFAS analyzed within the boundaries of the Site.

Sample chemical analytical concentrations were compared against the project SLs as described in **Table ES-1**. A summary of the results of the SI data relative to the SLs is as follows:

- PFOS and PFOA in groundwater at AOI 1: Wash Rack exceeded the individual SLs of 40 nanograms per liter (ng/L), with maximum concentrations of 1070 ng/L and 240 ng/L, respectively, at location AOI01-01. Based on the results of the SI, further evaluation of AOI 1 is warranted in the RI.
- PFOS in groundwater at BNE-01: Upgradient Facility Boundary exceeded the SL of 40 ng/L, with a concentration of 265 ng/L at location BNE-01. Based on the results of the SI, further evaluation of the Upgradient Facility Boundary is warranted in the RI.
- PFOS in groundwater at BNE-02: Downgradient Facility Boundary exceeded the SL of 40 ng/L, with a concentration of 44.9 ng/L at location BNE-02. Based on the results of the SI, further evaluation of the Downgradient Facility Boundary is warranted in the RI.

- The detected concentrations of PFOA, PFOS, and PFBS in soil samples from all AOIs were below the SLs.

Table ES-2 summarizes the SI results for soil and groundwater. Based on the conceptual site model developed and revised in light of the SI findings, there is potential for exposure to off-facility residential drinking water receptors caused by DoD activities at or adjacent to the facility.

Table ES-3 summarizes the rationale used to determine if an AOI should be considered for further investigation under CERCLA and undergo an RI. Based on the results of this SI, further evaluation is warranted in the RI for AOI 1: Wash Rack the Upgradient Facility Area, and the Downgradient Facility Area.

Table ES-1: Screening Levels (Soil and Groundwater)

Analyte	Residential (Soil) (μg/Kg)[a] 0 – 2 feet bgs	Industrial/ Commercial Composite Worker (Soil) (μg/Kg)[a] 2 – 15 feet bgs	Tap Water (Groundwater) (ng/L)[a]
PFOA	130	1,600	40
PFOS	130	1,600	40
PFBS	130,000	1,600,000	40,000

Notes:

a.) Assistant Secretary of Defense, 2019. Risk Based Screening Levels Calculated for PFOS, PFOA, PFBS in Groundwater and Soil using United States Environmental Protection Agency's (USEPA's) Regional Screening Level Calculator. Hazard Quotient (HQ)=0.1. 15 October 2019.

bgs = below ground surface
ng/L = nanograms per kilogram
μg/Kg = micrograms per kilogram

Table ES-2: Summary of Site Inspection Findings

AOI	Potential PFAS Release Area	Soil – Source Area	Groundwater – Source Area	Groundwater – Facility Boundary
1	Wash Rack	◐	●	●
Upgradient Facility Area	Unknown	◐	●	●
Downgradient Facility Area	Unknown	◐	●	●

Legend:

● = PFOS, PFOA, and/or PFBS detected; exceedance of the screening levels
◐ = PFOS, PFOA, and/or PFBS detected; no exceedance of the screening levels
○ = PFOS, PFOA, PFBS not detected

Table ES-3: Site Inspection Recommendations

AOI	Description	Rationale	Future Action
1	Wash Rack	Exceedances of SLs in groundwater at source area. No exceedances of SLs in soil.	Proceed to RI
Upgradient Facility Area	Northwest Facility Boundary	Exceedance of SL in groundwater. No exceedances of SLs in soil.	Proceed to RI
Downgradient Facility Area	Northeast Facility Boundary	Exceedance of SL in groundwater. No exceedances of SLs in soil.	Proceed to RI

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1. Introduction

1.1 Project Authorization

The Army National Guard (ARNG) G9 is the lead agency in performing Preliminary Assessments (PAs) and Site Inspections (SIs) for Perfluorooctanesulfonic acid (PFOS) and Perfluorooctanoic acid (PFOA) at Impacted Sites, ARNG Installations, Nationwide. This work is supported by the United States (US) Army Corps of Engineers (USACE) Baltimore District and their contractor, AECOM Technical Services, Inc. (AECOM), under Contract Number W912DR-12-D-0014, Task Order W912DR17F0192, issued 11 August 2017. The ARNG performed this SI at the Army Aviation Support Facility (AASF) in Boone, Iowa. The Boone AASF is referred to as the “facility” throughout this document.

The SI project elements were performed in compliance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; US Environmental Protection Agency [USEPA], 1980), as amended, the National Oil and Hazardous Substances Pollution Contingency Plan (40 Code of Federal Regulations Part 300; USEPA, 1994), and in compliance with US Department of the Army (DA) requirements and guidance for field investigations including specific requirements for sampling for PFOA, PFOS, and perfluorobutanesulfonic acid (PFBS), and the group of related compounds known in the industry as per- and poly-fluoroalkyl substances (PFAS). The term PFAS is used throughout this report to encompass all PFAS chemicals being evaluated, including PFOA, PFOS, and PFBS, which are the key components of the suspected releases being evaluated, and the other 15 related compounds listed in the task order.

1.2 SI Purpose

A PA was performed at Boone AASF (AECOM, 2019) and identified one potential PFAS release area at the facility, which was designated as AOI 1. The objective of the SI is to identify whether there has been a release to the environment from AOI 1 and determine the presence or absence of PFOA, PFOS, and PFBS at or above screening levels (SLs).

As stated in the *Federal Facilities Remedial Site Inspection Summary Guide* (USEPA, 2005), an SI has five goals:

1. Develop information to potentially eliminate a release from further consideration because it is determined that it poses no significant threat to human health or the environment;
2. Determine the potential need for a removal action;
3. Collect or develop data to evaluate potential release;
4. Collect data to better characterize the release for more effective and rapid initiation of a Remedial Investigation (RI), if determined necessary; and
5. Collect data to determine whether the release is more than likely the result of activities associated with the Department of Defense (DoD).

In addition to the USEPA-identified goals of an SI, the ARNG SI also identifies whether there are potential off-facility PFAS sources.

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2. Site Background

2.1 Site Location and Description

The AASF is north of Highway 30 at 700 CPL Snedden Drive, due south of the Boone Municipal Airport in Boone County, Boone, Iowa (**Figure 2-1**).

The current AASF is located on 28 acres of land owned and leased by the State of Iowa. The AASF facilities occupy 10 acres of the site, with the remainder occupied by an ARNG Readiness Center and Field Maintenance Shop. The original 1948 AASF was demolished in 1989 to make space for the current AASF. Construction of the current AASF was completed in 1992. The Boone AASF has no aqueous film forming foam (AFFF) fire suppression system. No information was available as to whether or not the former AASF contained a fire suppression system.

2.2 Facility Environmental Setting

Boone lies within the Des Moines Lobe, a landform region characterized by low-relief glacial terrain. The region has been subjected to repeated periods of Quaternary-age glaciations and erosion, creating morainal ridges and hummocky terrain, and leaving behind pebbly loam glacial till, kettle lakes, and other topographic depressions with poorly developed drainage (Iowa Geological Survey [IGS], 2017c). The elevation of the facility is approximately 1,100 feet above mean sea level. The facility topography is shown on **Figure 2-2**. Groundwater features, including off-facility wells, are displayed on **Figure 2-3**, and groundwater flow contours are shown on **Figure 2-4**. Surface water features are presented on **Figure 2-5**.

2.2.1 Geology

The AASF is situated on Quaternary-aged sand and gravel of the Pilot Knob and Morgan Members of the Dows Formation, which ranges in thickness from 4 to 10 meters. The deposits are characterized as yellowish brown, calcareous, fractured, stratified sand and gravel with interbedded stratified loam diamicton. The sand and gravel deposits overlie calcareous, massive, dense loam diamicton of the Alden Member of the Dows Formation (Geological Survey Bureau, 2001). Pennsylvanian sedimentary bedrock (shale and sandstone) of the Lower Cherokee and Raccoon Creek Groups underlies the Quaternary glacial deposits (Iowa Geological and Water Survey, 2010).

2.2.2 Hydrogeology

The AASF is in the Southern Iowa Groundwater Province and is underlain by a sequence of aquifers, including the surficial aquifer, the Mississippian carbonate, Silurian-Devonian carbonate, and the Cambrian-Ordovician sandstone aquifers (Prior et al., 2003). The surficial aquifer resides with the unconsolidated alluvial, glacial, and channel deposits found in Boone County, which ranges in thickness from 0 to 300 feet. Water yields are variable and range from less than 10 to 500 gallons per minute (gpm) (Thompson, 1982). Alluvial surficial aquifers are valuable in the Southern Groundwater province, especially along the Skunk, Des Moines, and Nishnabotna rivers (Prior et al., 2003).

The surficial aquifer is underlain by the Pennsylvanian-aged bedrock, which acts as an aquiclude. Underlying the Pennsylvanian rocks is the Mississippian aquifer, which is the most heavily used bedrock aquifer in Boone County (Thompson, 1982). Wells tapping the Mississippian aquifer are typically 100 to 300 feet deep and yield 50 to 100 gpm. The Mississippian aquifer water is used to supply private and public water supplies in north-central Iowa, but water quality and yield decreases in central and southeastern Iowa (IGS, 2017a). The Mississippian and Devonian-

Silurian aquifers are separated by the Devonian aquiclude. In Boone County, the Devonian rocks are not significantly used due to the highly mineralized nature of the groundwater and the Silurian rocks have low yields (Thompson, 1982). The Cambrian-Ordovician aquifer is a widespread source of water for high capacity wells, extensively used by municipalities and industries in eastern Iowa. Wells tapping the Cambrian-Ordovician aquifer are typically 300 to 2,000 feet deep (IGS, 2017b).

Surficial groundwater flow at the facility is generally to the east toward the Peas and Big Creek, which both empty to the Des Moines River. However, surficial groundwater flow direction may be seasonally impacted by watering of the Cedar Pointe Golf Course to the west of the facility.

No potable water wells are located within the current AASF; however, private wells exist within 4 miles of the facility. Drinking water for the AASF is supplied by the City of Boone, which utilizes wells northwest of the facility, tapping the Middle Des Moines River sand and gravel alluvial aquifer water as the water source (City of Boone Water Works, 2018). Observed groundwater elevations from the SI sampling event and corresponding groundwater contours are displayed on **Figure 2-4**.

The USEPA's Unregulated Contaminant Monitoring Rule 3 (UCMR3) data indicated that no PFAS were detected in a public water system above the USEPA Health Advisory (HA) within 20 miles of the facility (USEPA, 2017a). The USEPA HA is 70 nanograms per liter (ng/L) for PFOS and PFOA, individually or combined. PFAS analyses performed in 2016 had method detection limits (MDLs) that were higher than currently achievable. Thus, it is possible that low concentrations of PFAS were not detected during the UCMR3 but might be detected if analyzed today.

2.2.3 Hydrology

The AASF is in the Honey Creek-Des Moines River watershed, and tributaries leading to Peas Creek and Big Creek are located less than 0.25 miles southeast of the AASF (**Figure 2-5**). Peas Creek and Big Creek ultimately empty to the Des Moines River. Regional surface water features include the Des Moines River, approximately 4 miles southeast of the Boone AASF, which empties to the Mississippi River.

2.2.4 Climate

The climate at the AASF is humid continental, with warm summers, cold winters, and wet springs. The average temperature is 58 degrees Fahrenheit (°F). Seasonally, temperatures vary from summer highs of 84 °F to winter lows of 9 °F. Average precipitation is 38 inches (National Oceanic and Atmospheric Administration [NOAA], 2020).

2.2.5 Current and Future Land Use

The AASF is a controlled access facility and is adjacent to the Boone Municipal Airport. The Boone Municipal Airport is owned by the City of Boone and operated by Farnham Aviation Services, LLC. The airport provides commercial and general air service to the Boone area. The Boone Municipal Airport has no AFFF fire suppression equipment. Future land use is not anticipated to change.

2.2.6 Critical Habitat and Threatened/ Endangered Species

The following fish, insects, plants, and mammals are federally endangered, threatened, proposed, and/ or are listed as candidate species in Boone County, Iowa (US Fish and Wildlife Service [USFWS], 2020a).

- **Fish**: Topeka shiner, *Notropis topeka* (endangered)
- **Insects:** Rusty patched bumble bee, *Bombus affinis* (endangered)

- **Plants**: Prairie bush-clover, *Lespedeza leptostachya* (threatened); Western prairie fringed Orchid, *Platanthera praeclara* (threatened)
- **Mammals**: Indiana bat, *Myotis sodalis* (endangered); Northern long-eared bat, *Myotis septentrionalis* (threatened)

The AASF is located within the geographic area designated as critical habitat for the endangered Topeka shiner (USFWS, 2020b).

2.3 History of PFAS Use

The AASF facility houses two TriMax^{TM}-3, five TriMax^{TM}-30, and one TriMaxTM-60 fire extinguishers. Approximately every five years from the 1992 to the present day, the TriMax fire extinguishers are turned in for hydrostatic testing. Prior to turn in, the fire extinguishers are emptied at the wash rack at the northern end of the facility by the Iowa ARNG (IAARNG). Additionally, fire extinguisher training was conducted on a barrel fire near the wash rack on multiple occasions with either dish soap or AFFF.

Bulk AFFF (3 percent [%] and 6%) is stored at the facility and used to refill the TriMax^{TM} fire extinguishers upon return from hydrostatic testing. The fire extinguishers are filled in a room with no floor drains or on the ramp by the IAARNG. Spills are cleaned up with rags.

Firefighting services for the AASF are currently provided by the City of Boone; however, the AASF previously had a firetruck at the facility for emergency response. No information was available regarding the firetruck, its use, or when it was removed from the facility. The City of Boone has provided firefighting services for the facility for approximately 20 years.

The potential PFAS release area was designated as an AOI based on proximity to the potential release area and inferred groundwater flow. A description of this AOI is presented in **Section 3**.

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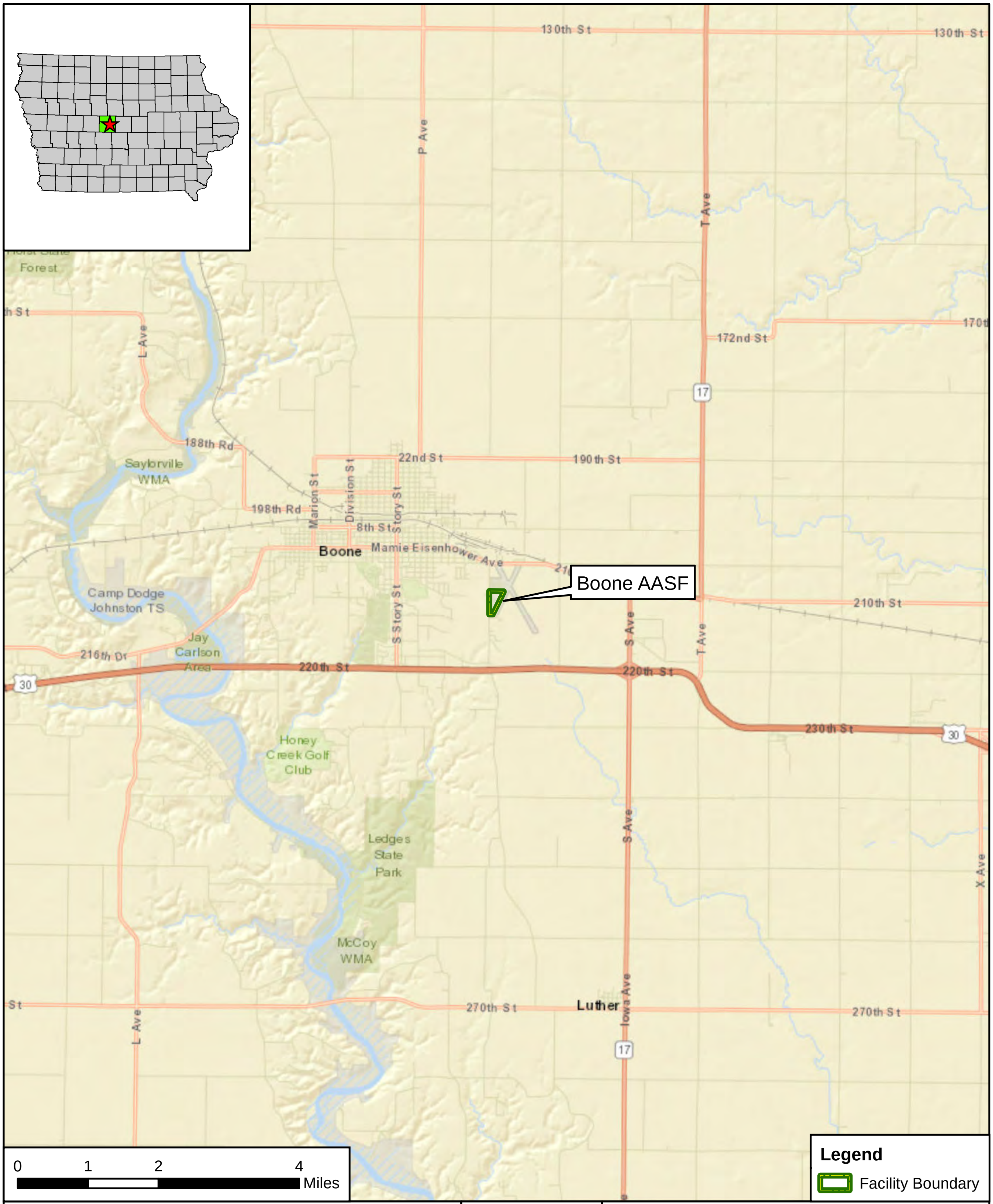

CLIENT	ARNG			
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Base Map: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI,		PM	RG	12/8/2020

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Facility Location

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 2-1

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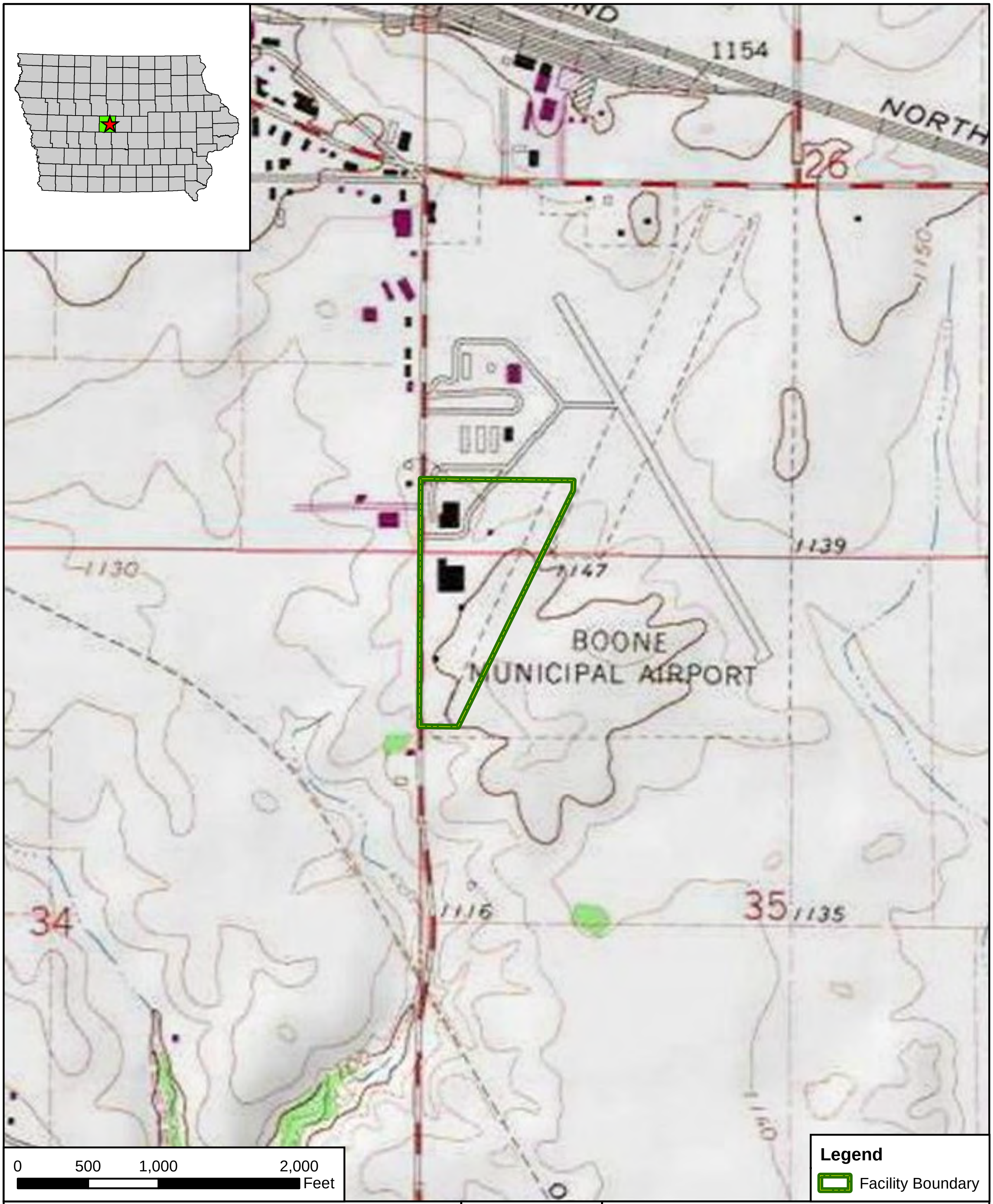

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Base Map: Copyright:© 2013 National Geographic Society, i-cubed		PM	RG	12/8/2020

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Facility Topography

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 2-2

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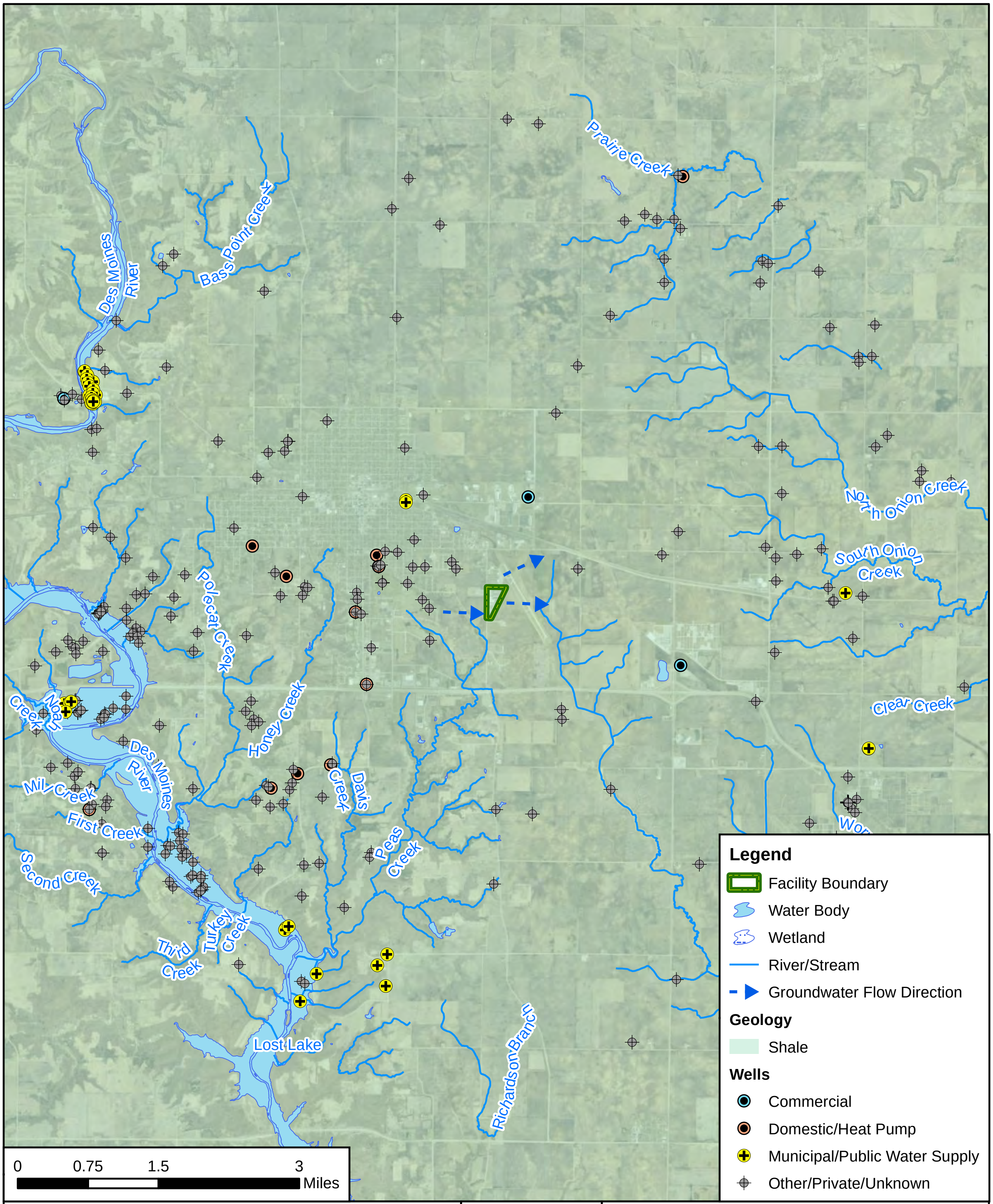

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Groundwater Features

AECOM

12420 Milestone Center Drive
Germantown, MD 20876

Figure 2-3

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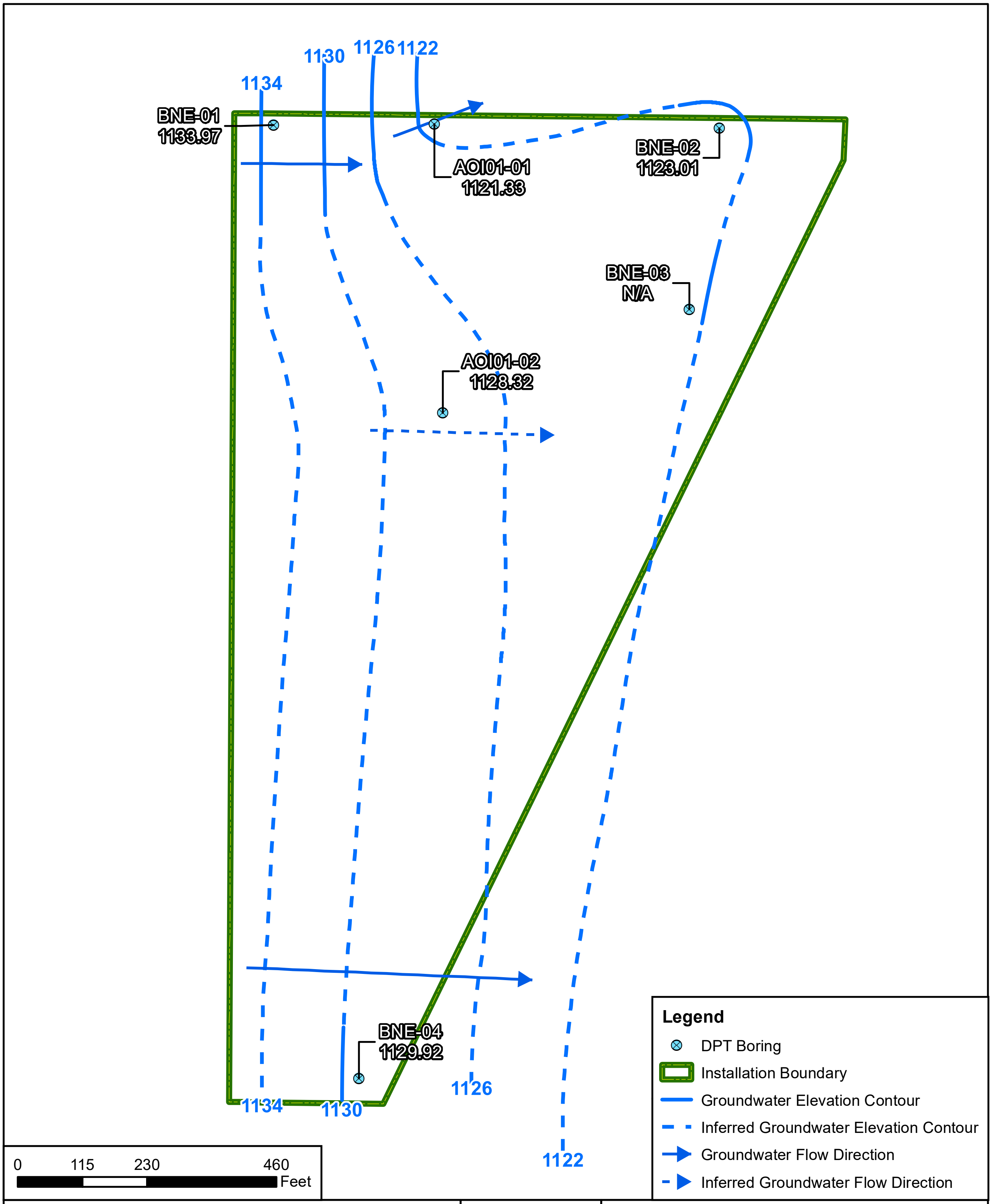

Groundwater Contours

CLIENT	ARNG			
NOTES	Site Inspection for PFAS at Boone AASF, IA			
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[redacted]

12420 Milestone Center Drive
Germantown, MD 20876

Figure 2-4

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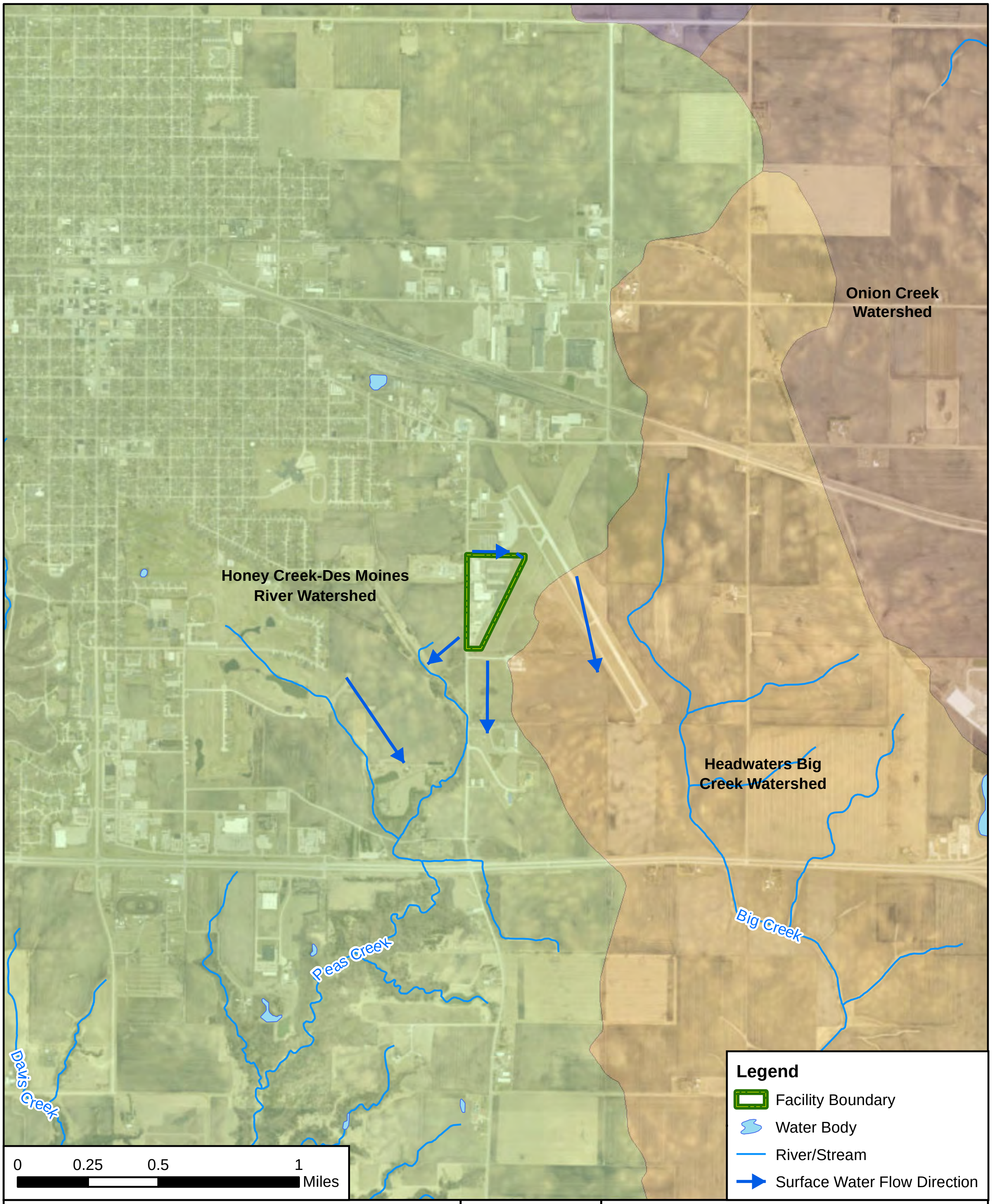

CLIENT	ARNG			
NOTES	Site Inspection for PFAS at Boone AASF, IA			
REVISED	12/8/2020	GIS BY	MS	12/8/2020
SCALE	1:31,680	CHK BY	JW	12/8/2020
Base Map: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,		PM	RG	12/8/2020

Surface Water Features

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 2-5

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3. Summary of Areas of Interest

This section presents a summary of the potential PFAS release areas. One potential PFAS release area was identified as an AOI based on preliminary data and inferred groundwater flow direction (**Figure 3-1**).

3.1 AOI 1

AOI 1 consists of one potential PFAS release area, as described below.

3.1.1 Wash Rack

AOI 1 is the wash rack on the northern edge of the AASF ramp. The concrete surrounding the wash rack is gently sloped, directing surface water flow toward the wash rack drain. The wash rack drain empties to an oil/water separator (OWS) with a diversion valve. When the wash rack is in use, the valve is closed, and discharge water flows to the sanitary sewer; when the wash rack is not in use, the valve is open, and discharge water flows to the ground surface and eventually to the storm water drain (MWH, 2014). Approximately every five years from 1992 to present, TriMax™ fire extinguishers are turned in for hydrostatic testing. Prior to turn in, the fire extinguishers are emptied at the wash rack.

Additionally, fire extinguisher training was conducted on a barrel fire near the wash rack on multiple occasions with either dish soap or AFFF. The dish soap or AFFF were rinsed into the wash rack drain and OWS. IAARNG personnel indicated that the wash rack drains to the sanitary sewer when in use but could not confirm whether the OWS diversion valve were opened or closed during fire training events with AFFF. If the valve were opened during the fire training events, drainage would have been diverted to the storm water drain, off the AASF ramp to the north of the facility, and into an off-facility drainage ditch that flows from west to east along the northern facility boundary, towards the Boone Municipal Airport runway. Stormwater from this off-facility drainage ditch then re-enters Boone AASF and drains into an emergent wetland area located in the northeast corner of the facility.

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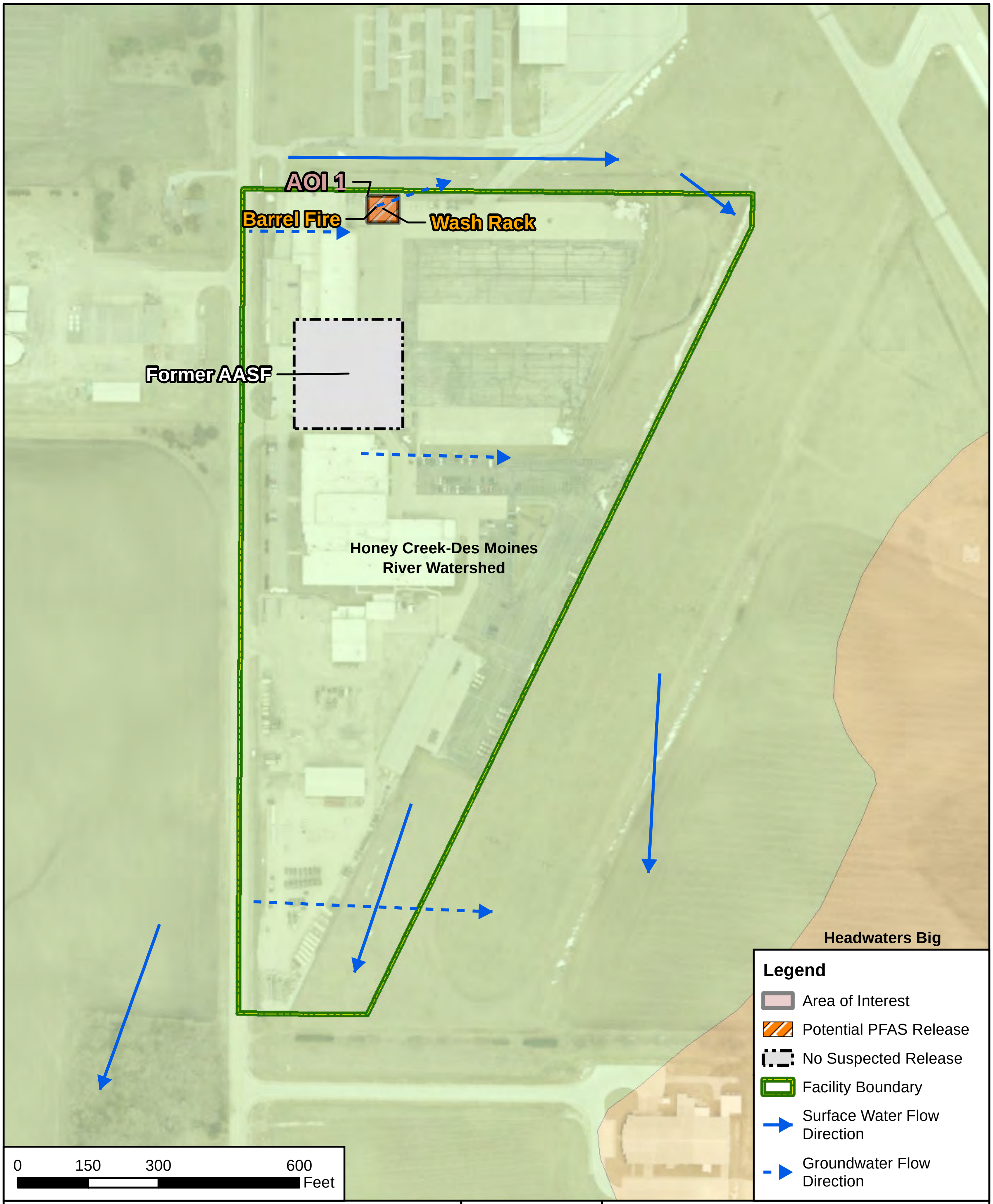

CLIENT	ARNG			
NOTES	Site Inspection for PFAS at Boone AASF, IA			
REVISED	1/22/2021	GIS BY	MS	1/22/2021
SCALE	1:3,600	CHK BY	JW	1/22/2021
Base Map: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,		PM	RG	1/22/2021

N

Area of Interest

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 3-1

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4. Project Data Quality Objectives

Project Data Quality Objectives (DQOs) are qualitative and quantitative statements that specify the quality of data and define the level of certainty required to support project decision-making process. The specific DQOs established for this facility are described below. These DQOs were developed in accordance with the USEPA's seven-step iterative process (USEPA, 2006).

4.1 Problem Statement

The following problem statement was developed during project planning:

The presence of PFAS, which may pose a risk to human health or the environment, in environmental media at the facility is currently unknown. PFAS are classified as emerging environmental contaminants that are garnering increasing regulatory interest due to their potential risks to human health and the environment. The regulatory framework for managing PFAS at both the federal and state level continues to evolve.

The DoD has adopted a policy to retain facilities in the CERCLA process based on risk-based SLs for soil and groundwater, as described in a memorandum from the Office of the Secretary of Defense (OSD) dated 15 October 2019 (Assistant Secretary of Defense, 2019). The ARNG program under which this SI was performed follows this DoD policy. Should the maximum concentration for sampled media exceed the SLs established in the OSD memorandum, the AOI will proceed to the next phase under CERCLA. The SLs established in the OSD memorandum apply to three compounds: PFOS, PFOA, and PFBS. The SLs are presented in **Section 6.1** of this Report.

The following quotes from the DA policy documents form the basis for this project (DA, 2016; DA, 2018):

- "The Army will research and identify locations where PFOS- and/or PFOA-containing products, such as AFFF, are known or suspected to have been used. Installations shall coordinate with installation/facility fire response or training offices to identify AFFF use or storage locations. The Army will consider fire training areas, AFFF storage locations, hangars/buildings with AFFF suppression systems, fire equipment maintenance areas, and areas where emergency response operations required AFFF use as possible source areas. In addition, metal plating operations, which used certain PFOS-containing mist suppressants, shall be considered possible source areas."
- "Based on a review of site records…determine whether a CERCLA PA is appropriate for identifying PFOS/PFOA release sites. If the PA determines a PFOS/PFOA release may have occurred, a CERCLA SI shall be conducted to determine presence/absence of contamination."
- "Identify sites where perfluorinated compounds are known or suspected to have been released, with the priority being those sites within 20 miles of the public systems that tested above USEPA HA levels." (USEPA, 2016a; USEPA, 2016b).

4.2 Goals of the Study

The following goals were established for this SI:

1. Determine the presence or absence of PFOA, PFOS, and PFBS at or above SLs at Boone AASF, Iowa.
2. Develop information to potentially eliminate a release from further consideration because it is determined that it poses no significant threat to human health or the environment.

3. Determine the potential need for a time critical removal action (applies to drinking water only). The primary actions that will be considered include provision of alternative water supplies or wellhead treatment.

4. Collect data to better characterize the release areas for more effective and rapid initiation of an RI (if determined necessary).

5. Identify within 4 miles of the installation other potential PFAS sources (fire stations, major manufacturers, other DoD facilities) and receptors, including both groundwater and surface water receptors, to determine whether the ARNG is the likely source of PFAS, or whether there is an off-facility source of PFAS responsible for installation detections of PFAS (USEPA, 2005).

6. Determine whether a potentially complete pathway exists between the source and potential receptors and whether ARNG is the likely source of the contamination.

4.3 Information Inputs:

Primary information inputs included:

- The PA for Boone AASF, Iowa (AECOM, 2019);
- Analytical data from groundwater and soil samples collected as part of this SI in accordance with the site-specific Uniform Federal Policy (UFP)-Quality Assurance Project Plan (QAPP) Addendum (AECOM, 2020b); and
- Field data collected during the SI, including groundwater elevation and water quality parameters measured at the time of sampling.

4.4 Study Boundaries

The scope of the SI was horizontally bounded by the property limits of Boone AASF. Off-facility sampling is not included in the scope of this SI; however, if future off-facility sampling is required, the proper stakeholders will be notified, and necessary rights of entry will be obtained by ARNG with the property owner(s).

4.5 Analytical Approach

Samples were analyzed by Pace Analytical Gulf Coast (formerly Gulf Coast Analytical Laboratory, LLC.), accredited under the DoD Environmental Laboratory Accreditation Program (DoD ELAP; Accreditation Number 74960) and the National Environmental Laboratory Accreditation Program (NELAP; Certificate Number 01955). Data were compared to applicable SLs and decision rules as defined in the SI QAPP Addendum (AECOM, 2020b). These rules governed response actions based on the results of the SI sampling effort.

The decision rules described in the **Worksheet #11** of the SI QAPP Addendum (AECOM, 2020b) identify actions based on the following:

Groundwater:

- Is there a human receptor within 4 miles of the site?
- What is the concentration of PFOA, PFOS, and PFBS at the potential release areas?
- What is the concentration of PFOA, PFOS, and PFBS at the facility boundary upgradient and downgradient of the potential release areas?

- What does the conceptual site model (CSM) suggest in terms of source, pathway and receptor?

Soil:

- What is the concentration of PFOA, PFOS, and PFBS in shallow surface soil (0 to 2 feet below ground surface [bgs])?
- What is the concentration of PFOA, PFOS, and PFBS in deep soil (i.e., capillary fringe)?
- What does the CSM suggest in terms of source, pathway, and receptor?

Soil and groundwater samples were collected from each of the potential release areas. Groundwater was encountered at approximately 8 to 19 feet bgs. The Mississippian Aquifer and Cambrian-Ordovician sandstone aquifers are significantly deeper, at 100 to 300 feet bgs and 300 to 2,000 feet bgs, respectively, and were not subject to drilling during this investigation.

4.6 Data Usability Assessment

The Data Usability Assessment (DUA) is an evaluation at the conclusion of data collection activities that uses the results of both data verification and validation in the context of the overall project decisions or objectives. Using both quantitative and qualitative methods, the assessment determines whether project execution and the resulting data have met installation-specific DQOs. Both sampling and analytical activities are considered to assess whether the collected data are of the right type, quality, and quantity to support the decision-making (DoD, 2018a; DoD, 2018b; USEPA, 2017b).

Data Quality Indicators (DQIs) (Precision, Accuracy, Representativeness, Comparability, Completeness and Sensitivity) are important components in assessing data usability. These DQIs were evaluated in the subsequent sections and demonstrate that the data presented in this SI report are of high quality. Although the SI data are considered reliable, some degree of uncertainty can be associated with the data collected. Specific factors that may contribute to the uncertainty of the data evaluation are described below. The Data Validation Report (DVR) (**Appendix A**) presents explanations for all qualified data in greater detail.

4.6.1 Precision

Precision is the degree of agreement among repeated measurements of the same characteristic on the same sample or on separate samples collected as close as possible in time and place. Field sampling precision is measured with the field duplicate relative percent differences (RPD); laboratory precision is measured with calibration verification, internal standard recoveries, laboratory control spike (LCS) and matrix spike (MS) duplicate RPD.

Extraction internal standards (EIS) were added by the laboratory during sample extraction to measure relative responses of target analytes and used to correct for bias associated with matrix interferences and sample preparation efficiencies, injection volume variances, mass spectrometry ionization efficiencies, and other associated preparation and analytical anomalies. The field sample results associated with EIS area counts less than the lower quality control (QC) limit were non-detect and were qualified “UJ”. The qualified field sample results should be considered usable as estimated values with a negative bias. The positive field sample results associated with EIS area counts greater than the upper QC limit were qualified “J-”. The qualified field sample results were considered usable as estimated values with a positive bias.

Injection internal standards (IIS) were added by the laboratory after sample extraction and prior to analysis as a requirement of DoD QSM 5.1 to measure relative responses of target analytes. Several field samples displayed IIS recoveries greater than the QC limit of 50 % for surrogate perfluoro-n-(1,2-13C2) decanoic acid in the re-extraction analysis. PFAS analytes are not quantitated based on IIS recoveries in non-drinking water matrices; therefore, no data quality impact is anticipated.

LCS/LCS duplicate (LCSD) pairs were prepared by addition of known concentrations of each analyte in a matrix-free media known to be free of target analytes. LCS/LCSD pairs were analyzed for every analytical batch to demonstrate the ability of the laboratory to detect similar concentrations of a known quantity in matrix-free media. One LCS/LCSD performed displayed a RPD greater than the QC limit of 30% for perfluorotetradecanoic acid (PFTeDA) at 40%. The associated field sample results were non-detect; therefore, no data qualifying action was required, and the associated parent sample results should be considered usable as reported.

MS/MS duplicate (MSD) samples were prepared, analyzed, and reported for all preparation batches. MS/MSD samples demonstrated that the analytical system was in control for the matrix being tested with limited exceptions. MS/MSD samples were submitted to the laboratory for analysis at a rate of 5%. One MS/MSD displayed a RPD greater than the QC limit of 30% for perfluoroheptanoic acid (PFHpA) and PFOS at 31% and 34%, respectively. One MS/MSD displayed a RPD greater than the QC limit of 30% for N--methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA) at 31%. The parent sample results associated with the MS/MSD imprecision were non-detect; therefore, no data qualifying action was required, and no impact on data quality is anticipated.

Field duplicate samples were collected at a rate of 10% to assess the overall sampling and measurement precision for this sampling effort. The field duplicate samples were analyzed for PFAS and general chemistry parameters. The field duplicate samples were within the project established precision limits presented in the QAPP Addendum (AECOM, 2020b).

4.6.2 Accuracy

Accuracy is a measure of confidence in a measurement. The smaller the difference between the measurement of a parameter and its "true" or expected value, the more accurate the measurement. The more precise or reproducible the result, the more reliable or accurate the result. Accuracy is measured through percent recoveries in the LCS/LCSD, MS/MSD, and surrogates.

LCS/LCSD samples were prepared by addition of known concentrations of each analyte in a matrix free media known to be free of target analytes. LCS/LCSD samples were analyzed for every analytical batch and demonstrated that the analytical system was in control during sample preparation and analysis. The LCS/LCSD samples were within the project established accuracy limits presented in the QAPP Addendum (AECOM, 2020b).

MS/MSD samples were prepared, analyzed, and reported at a rate of 5%. MS/MSD samples demonstrated that the analytical system was in control for the matrix being tested, with one exception. One MSD displayed a percent recovery less than the lower QC limit of 70% for PFOS at 67%. The positive field sample result associated with the negative bias was qualified “J-“ and should be considered usable as an estimated value with a negative bias.

Calibration verifications were performed routinely to ensure that instrument responses for all calibrated analytes were within established QC criteria. The calibration verifications performed during the laboratory analyses were within the project established precision limits presented in the QAPP Addendum (AECOM, 2020b), with one exception. One instrument calibration sensitivity standard associated recovered below the QC limits for NMeFOSAA at 65%. The re-extraction analysis displayed similar results to the initial analysis and the initial result is recommended for data use since this was re-extracted after the holding time had expired.

4.6.3 Representativeness

Representativeness qualitatively expresses the degree to which data accurately reflect site conditions. Factors that affect the representativeness of analytical data include appropriate sample population definitions, proper sample collection and preservation techniques, analytical holding times, use of standard analytical methods, and determination of matrix or analyte interferences.

Relating to the use of standard analytical methods, the laboratory followed the method as established in PFAS by liquid chromatography with tandem mass spectrometry (LC/MS/MS) Compliant with Quality Systems Manual (QSM) 5.1 Table B-15, including the specific preparation requirements (i.e. ENVI-Carb or equivalent used), mass calibration, spectra, all the ion transitions identified in Table B-15 were monitored, standards that contained both branch and linear isomers when available were used, and isotopically labeled standards were used for quantitation.

Field QC samples were collected to assess the representativeness of the data collected. Field duplicates were collected at a rate of 10% for all field samples, while MS/MSD samples were collected at a rate of 5%. All preservation techniques were followed by the field staff, and all technical and analytical holding times were met by the laboratory. The laboratory used approved standard methods in accordance with the QAPP Addendum (AECOM, 2020b) for all analyses.

Instrument blanks and method blanks were prepared by the laboratory in each batch as a negative control. All associated instrument blanks and method blanks were non-detect for all target analytes.

Equipment blanks and field blanks were also collected for groundwater and soil samples. All equipment blanks and field blanks were non-detect for all target analytes.

A sample of the water used for decontamination of the drill rig was collected in advance of the field effort. The drill rig decontamination sample displayed a concentration above the detection limit of 1.78 ng/L for PFBA at 10.8 ng/L. The associated field sample results were treated as true positives by the project team.

Field samples were extracted and analyzed within the appropriate holding time in order to qualitatively express the degree to which data accurately reflect site conditions with limited exceptions. When field samples were analyzed out of the technical holding time for PFAS, it was due to a QC failure in the initial analysis and displayed similar results. In all instances, the initial results were recommended for use and should be considered usable as an estimated value. The holding time for pH analysis is “immediate”, all field samples analyzed for pH were qualified “J” and should be considered usable as estimated values.

Overall, the data are usable for evaluating the presence or absence of PFAS at the facility. Sufficient usable data were obtained to meet the objectives of the SI.

4.6.4 Comparability

Comparability is the extent to which data from one study can be compared directly to either past data from the current project or data from another study. Using standardized sampling and analytical methods, units of reporting, and site selection procedures help ensure comparability. Standard field sampling and typical laboratory protocols were used during the SI and are considered comparable to ongoing investigations.

4.6.5 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount of data expected under normal conditions. The laboratory provided data meeting system QC acceptance criteria for all samples tested. Project completeness was determined by evaluating the planned versus actual quantities of data. Percent completeness per parameter is as follows and reflects the exclusion of ‘X” flagged data, if applicable:

- PFAS in groundwater by LC/MS/MS compliant with QSM 5.1 Table B-15 at 100%
- PFAS in soil by LC/MS/MS compliant with QSM 5.1 Table B-15 at 100%
- pH in soil by USEPA Method 9045D at 100%
- Total organic carbon (TOC) by USEPA Method 9060 at 100%

4.6.6 Sensitivity

Sensitivity is the capability of a test method or instrument to discriminate between measurement responses representing different levels (e.g., concentrations) of a variable of interest. Examples of QC measures for determining sensitivity include laboratory fortified blanks, an MDL study, and calibration standards at the limit of quantitation (LOQ). In order to meet the needs of the data users, project data must meet the measurement performance criteria for sensitivity and project LOQs specified in the QAPP Addendum (AECOM, 2020b). The laboratory provided the requested MDL studies and provided applicable calibration standards at the LOQ. In order to achieve the DQOs for sensitivity outlined in the QAPP Addendum (AECOM, 2020b), the laboratory reported all field sample results at the lowest possible dilution. Additionally, any analytes detected below the LOQ and above the MDL were reported and qualified “J” as estimated values by the laboratory.

5. Site Inspection Activities

This section describes the environmental investigation and sampling activities that occurred as part of the SI. The SI sampling approach was based on the findings of the PA and implemented in accordance with the following approved documents:

- *Final Site Inspection Programmatic Uniform Federal Policy-Quality Assurance Project Plan dated March 2018* (AECOM, 2018a);
- *Final Programmatic Accident Prevention Plan dated July 2018* (AECOM, 2018b); and
- *Final Preliminary Assessment Report, Army Aviation Support Facility, Boone, Iowa dated June 2019* (AECOM, 2019);
- *Final Site Safety and Health Plan, Army Aviation Support Facility, Boone, Iowa dated July 2020* (AECOM, 2020a);
- *Final Site Inspection Uniform Federal Policy-Quality Assurance Project Plan Addendum, Army Aviation Support Facility, Boone, Iowa dated July 2020* (AECOM, 2020b).

SI field activities included soil and groundwater grab sampling from 4 August to 5 August 2020. Field activities were conducted in accordance with the QAPP Addendum (AECOM, 2020b).

The following samples were collected during the SI and analyzed for a subset of 18 PFAS by LC/MS/MS compliant with QSM 5.1 Table B-15 to fulfill the project DQOs:

- Eighteen (18) soil grab samples from six boring locations;
- Six groundwater grab samples from six temporary well locations; and
- Fourteen Quality Assurance (QA) samples collected.

Figure 5-1 provides the sample locations for all media across the facility. **Table 5-1** presents the list of samples collected for each media. Field documentation is provided in **Appendix B**. A Log of Daily Notice of Field Activity was completed throughout the SI field activities, which is provided in **Appendix B1**. Groundwater sampling forms are provided in **Appendix B2**. Survey data containing latitude, longitude, and elevations of sampling locations are provided in **Appendix B3**. Additionally, a photographic log of field activities is provided in **Appendix C**.

5.1 Pre-Investigation Activities

In preparation for the SI field activities, project team members participated in Technical Project Planning (TPP) meetings, performed utility clearance, and sampled decontamination source water. Details for each of these activities are presented below.

5.1.1 Technical Project Planning

The USACE TPP Process, Engineering Manual (EM) 200-1-2 (USACE, 2016) defines four phases to project planning: 1.) defining the project phase; 2.) determining data needs; 3.) developing data collection strategies; and 4.) finalizing the data collection plan. The process encourages stakeholder involvement in the SI, beginning with defining overall project objectives, including quantitative and qualitative DQOs, and formulating a sampling approach to address the AOIs identified in the PA.

A combined TPP Meeting 1 and 2 was held remotely via teleconference on 28 April 2020, prior to SI field activities. Meeting minutes are provided in **Appendix D**. TPP meetings 1 and 2 were conducted in general accordance with EM 200-1-2.

The stakeholders for this SI include the ARNG, IAARNG, USACE, Iowa Department of Natural Resources, and representatives familiar with the Site, the regulations, and the community. Stakeholders were provided the opportunity to make comments on the technical sampling approach and methods at the combined TPP Meeting 1 and 2. The outcome of the combined TPP Meeting 1 and 2 was memorialized in the SI QAPP Addendum (AECOM, 2020b). Future TPP meetings will provide an opportunity to discuss the results and findings, and future actions, where warranted.

5.1.2 Utility Clearance

Utility clearance was conducted by the AECOM field team with assistance from local utilities and IAARNG personnel. AECOM's drilling subcontractor, Cascade Technical Services, LLC, contacted "Iowa 811," the one-call utility clearance contractor to notify them of intrusive work. Additionally, the first 5 feet of each boring were advanced using hand augering methods to verify utility clearance in shallow subsurface where utilities would typically be encountered.

5.1.3 Source Water and PFAS Sampling Equipment Acceptability

The potable water source used for decontamination of drilling equipment was confirmed to be PFAS-free prior to the start of field activities. A sample from the Camp Dodge potable water supply was collected from a water hose at Camp Dodge on 18 September 2019, prior to mobilization, and analyzed for PFAS by LC/MS/MS compliant with QSM 5.1 Table B-15. The results of the Camp Dodge potable well sample are provided in **Appendix G**. A discussion of the results is presented in **Section 4.6.3**.

Materials that were used within the sampling zone were confirmed as acceptable for use in the PFAS sampling environment. The checklist of acceptable materials for use in the PFAS sampling environment was provided in the Standard Operating Procedures (SOPs) appendix to the QAPP Addendum (AECOM, 2020b). Prior to the start of field work each day, a PFAS Sampling Checklist was completed as an additional layer of control. The checklist served as a daily reminder to each field team member regarding the allowable materials within the sampling environment.

5.2 Soil Borings and Soil Sampling

Soil samples were collected via direct-push technology (DPT) in accordance with the QAPP Addendum (AECOM, 2020b). A GeoProbe® 7822DT dual-tube sampling system was used to collect continuous soil cores to the target depth.

Three discrete soil samples were collected from the vadose zone for chemical analysis from each soil boring. One subsurface soil sample approximately 1 foot above the groundwater table, one subsurface soil sample at the mid-point between the ground surface and the groundwater table, and one surface soil sample at the 0 to 1 foot bgs depth interval were collected at each boring using DPT.

The soil boring locations are shown on **Figure 5-1,** and sample depths are provided **Table 5-1**. The soil boring locations were selected based on the AOI information as agreed on through TPP and QAPP Addendum review.

The soil cores were continuously logged for lithological descriptions by a field geologist using the Unified Soil Classification System (USCS). A photoionization detector (PID) was used to screen the breathing zone during boring activities as part of personal safety requirements. Observations and measurements were recorded on sampling forms (**Appendix B2**) and in a non-treated field logbook. Depth interval, recovery thickness, PID concentrations, moisture, relative density, color (using a Munsell soil color chart), and texture (using the USCS) were recorded. The boring logs are provided in **Appendix E**.

Each soil sample was collected into laboratory-supplied PFAS-free high-density polyethylene (HDPE) bottles and labeled using a PFAS-free marker or pen. Samples were packaged on ice and transported via Federal Express (FedEx) under standard chain of custody (CoC) procedures to the laboratory and analyzed for PFAS (LC/MS/MS compliant with QSM 5.1 Table B-15), TOC (USEPA Method 9060A) and pH (USEPA Method 9045D) in accordance with the QAPP Addendum (AECOM, 2020b).

Field duplicate samples were collected at a rate of 10% and analyzed for the same parameters as the accompanying samples. MS/MSDs were collected at a rate of 5% and analyzed for the same parameters as the accompanying samples. In instances when non-dedicated sampling equipment was used, such as a hand auger for the shallow soil samples, an equipment rinsate blank was collected at a rate of 5% and analyzed for the same parameters as the soil samples. A temperature blank was placed in each cooler to ensure that samples were preserved at or below 6 degrees Celsius (°C) during shipment.

DPT borings were converted to temporary wells, which were subsequently abandoned in accordance with the QAPP Addendum (AECOM, 2020b) using wetted bentonite chips at completion of sampling activities. Borings were installed in grassy areas to avoid disturbing concrete or asphalt surfaces.

5.3 Temporary Well Installation and Groundwater Grab Sampling

Temporary wells were installed using a GeoProbe® 7822DT dual-tube sampling system. Once the borehole was advanced to the desired depth, wherever conditions allowed, a temporary well was constructed of a 5-foot section of 1-inch Schedule 40 poly-vinyl chloride (PVC) screen with sufficient casing to reach ground surface. New PVC pipe and screen were used to avoid cross contamination between locations. The screen intervals for the temporary wells are provided in **Table 5-2**.

At temporary well locations at AOI01-01 and BNE-03, refusal was encountered prior to ground water. One off-set attempt was made at each location; both of which were successful.

The temporary wells were purged for five to ten minutes after installation before collection of groundwater samples. After the recharge period, groundwater samples were collected using a peristaltic pump with PFAS-free HDPE tubing. Each sample was collected into laboratory-supplied PFAS-free HDPE bottles and labeled using a PFAS-free marker or pen. The temporary wells were purged at a rate determined in the field to reduce turbidity and draw down prior to sampling. Water quality parameters (e.g., temperature, specific conductance, pH, dissolved oxygen, and oxidation-reduction potential) were measured using a water quality meter and recorded on the field sampling form (**Appendix B2**) after each grab sample was collected. Additionally, a subsample of each groundwater sample was collected in a separate container and a shaker test was completed to identify if there was any foaming. No foaming was noted in any of the groundwater samples.

Each sample was collected into laboratory-supplied PFAS-free HDPE bottles and labeled using a PFAS-free marker or pen. Samples were packaged on ice and transported via FedEx under standard CoC procedures to the laboratory and analyzed for PFAS by LC/MS/MS Compliant with QSM 5.1 Table B-15 in accordance with the QAPP Addendum (AECOM, 2020b).

Field duplicate samples were collected at a rate of 10% and analyzed for the same parameters as the accompanying samples. MS/MSDs were collected at a rate of 5% and analyzed for the same parameters as the accompanying samples. One field reagent blank was collected in accordance with the Programmatic UFP-QAPP (AECOM, 2018a). A temperature blank was placed in each cooler to ensure that samples were preserved at or below 6°C during shipment.

Temporary wells were abandoned in accordance with the QAPP Addendum (AECOM, 2020b) by removing the PVC and backfilling the hole with wetted bentonite chips. Temporary wells were installed in grassy areas to avoid disturbing concrete or asphalt.

5.4 Synoptic Water Level Measurements

A synoptic groundwater gauging event was performed on 4 to 5 August 2019. Groundwater elevation measurements were collected from the six temporary monitoring wells installed during the SI. Water level measurements were taken from the northern side of the well casing. A groundwater flow contour map is provided in **Figure 2-4**. Groundwater elevation data are provided in **Table 5-3**.

5.5 Surveying

The northern side of each well casing was surveyed by an Iowa-Licensed land surveyor following guidelines provided in the SOPs provided in the SI QAPP Addendum (AECOM, 2020b). Survey data from the newly installed wells on the facility were collected on 5 August 2020 in the Universal Transverse Mercator Zone 15 North projection with World Geodetic System 84 datum. The surveyed well data are provided in **Appendix B3**.

5.6 Investigation-Derived Waste

As of the date of this report, the disposal of PFAS investigation-derived waste (IDW) is not regulated federally. PFAS IDW generated during the SI is considered non-hazardous waste and was managed in accordance with the QAPP Addendum (AECOM, 2020b) and with the Army Guidance for Addressing Releases of PFAS, Q18 (DA, 2018).

Soil IDW (i.e., soil cuttings) generated during the SI activities were left in place at the point of the source. The soil cuttings were distributed on the ground surface on the downgradient side of the boring. Soil IDW was not sampled and assumes the PFAS characteristics of the associated soil samples collected from that source location.

Liquid IDW generated during SI activities (i.e. purge water, development water, and decontamination fluids) were discharged directly to the ground surface slightly downgradient of the source. The liquid IDW was not sampled and assumes the PFAS characteristics of the associated groundwater samples collected from that source location.

Geographic coordinates were collected using a Global positioning system around each location where IDW was placed (i.e., an IDW polygon). The IDW polygons are displayed on the figure in **Appendix F**.

Other solids such as spent personal protective equipment, plastic sheeting, tubing, rope, unused monitoring well construction materials, and other environmental media generated during the field activities were disposed of at a licensed solid waste landfill.

5.7 Laboratory Analytical Methods

Samples were analyzed for a subset of 18 PFAS by LC/MS/MS compliant with QSM 5.1 Table B-15 at Pace Analytical Gulf Coast in Baton Rouge, Louisiana, a DoD ELAP and NELAP certified laboratory. The 18 PFAS analyzed as part of the ARNG SI program include the following:

- 6:2 fluorotelomer sulfonate (6:2 FTS)
- 8:2 fluorotelomer sulfonate (8:2 FTS)
- Perfluorohexanoic acid (PFHxA)
- Perfluorohexanesulfonic acid (PFHxS)

- N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)
- N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)
- Perfluorobutyrate (PFBA)
- Perfluorobutanesulfonic acid (PFBS)
- Perfluorodecanoic acid (PFDA)
- Perfluorododecanoic acid (PFDoA)
- Perfluoroheptanoic acid (PFHpA)
- Perfluorononanoic acid (PFNA)
- Perfluorooctanoic acid (PFOA)
- Perfluorooctanesulfonic acid (PFOS)
- Perfluoropentanoic acid (PFPeA)
- Perfluorotetradecanoic acid (PFTeDA)
- Perfluorotridecanoic acid (PFTrDA)
- Perfluoroundecanoic acid (PFUdA)

Soil samples were also analyzed for TOC using USEPA Method 9060A, pH by USEPA Method 9045D, and grain size by ASTM D-422.

5.8 Deviations from QAPP Addendum

No deviations from the QAPP Addendum (AECOM, 2020b) were identified following completion of the SI field sampling event.

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Table 5-1
Site Inspection Samples by Medium
Site Inspection Report, Boone AASF, Iowa

Sample Identification	Sample Collection Date	Sample Depth (feet bgs)	PFAS (LC/MS/MS compliant with QSM 5.1 Table B-15)	TOC (USEPA Method 9060A)	pH (USEPA Method 9045D)	Grain Size (ASTM D-422)	Comments
Soil Samples							
BNE-AOI01-01-SB-0-2	8/5/2020	0 - 2	x	x	x		
BNE-AOI01-01-SB-0-2-FD	8/5/2020	0 - 2		x	x		Field Duplicate
BNE-AOI01-01-SB-7-9	8/5/2020	7 - 9	x				
BNE-AOI01-01-SB-7-9-MS	8/5/2020	7 - 9	x				MS/MSD
BNE-AOI01-01-SB-7-9-MSD	8/5/2020	7 - 9	x				MS/MSD
BNE-AOI01-01-SB-13-15	8/5/2020	13 - 15	x				
BNE-AOI01-02-SB-0-2	8/4/2020	0 - 2	x				
BNE-AOI01-02-SB-10-12	8/4/2020	10 - 12	x				
BNE-AOI01-02-SB-10-12-FD	8/4/2020	10 - 12	x				Field Duplicate
BNE-AOI01-02-SB-20-22	8/4/2020	20 - 22	x				
BNE-01-SB-0-2	8/4/2020	0 - 2	x				
BNE-01-SB-3-5	8/4/2020	3 - 5	x			x	
BNE-01-SB-5-7	8/4/2020	5 - 7	x				
BNE-02-SB-0-2	8/4/2020	0 - 2	x				
BNE-02-SB-8-10	8/4/2020	8 - 10	x				
BNE-02-SB-15-17	8/4/2020	15 - 17	x				
BNE-03-SB-0-2	8/4/2020	0 - 2	x				
BNE-03-SB-6-8	8/4/2020	6 - 8	x				
BNE-03-SB-14-16	8/4/2020	14 - 16	x				
BNE-03-SB-14-16-FD	8/4/2020	14 - 16	x				Field Duplicate
BNE-04-SB-0-2	8/4/2020	0 - 2	x	x	x		
BNE-04-SB-0-2-MS	8/4/2020	0 - 2		x	x		MS/MSD
BNE-04-SB-0-2-MSD	8/4/2020	0 - 2		x	x		MS/MSD
BNE-04-SB-8-10	8/4/2020	8 - 10	x			x	
BNE-04-SB-14-16	8/4/2020	14 - 16	x				
Groundwater Samples							
BNE-AOI01-01-GW	8/5/2020	20 - 25	x				
BNE-AOI01-01-GW-FD	8/5/2020	20 - 25	x				Field Duplicate
BNE-AOI01-02-GW	8/4/2020	20 - 25	x				
BNE-01-GW	8/4/2020	10 - 15	x				
BNE-02-GW	8/4/2020	15 - 20	x				
BNE-02-GW-MS	8/4/2020	15 - 20	x				MS/MSD
BNE-02-GW-MSD	8/4/2020	15 - 20	x				MS/MSD
BNE-03-GW	8/5/2020	10 - 15	x				
BNE-04-GW	8/4/2020	15 - 20	x				
Blank Samples							
CAMP DODGE DECON	9/18/2019	NA	x				Decontamination Water Blank
FRB-072919	9/18/2019	NA	x				Field Reagent Blank
BNE-ERB-01	8/4/2020	NA	x				Equipment Rinsate Blank
BNE-FRB-01	8/4/2020	NA	x				Field Reagent Blank

Notes:

AASF = Army Aviation Support Facility
AOI = Area of Interest
ASTM = American Society for Testing Materials
bgs = below ground surface
BNE = Boone
ERB = equipment rinsate blank
FD = field duplicate
FRB = field reagent blank
GW = groundwater
LC/MS/MS = liquid chromatography with tandem mass spectrometry
MS/MSD = matrix spike/ matrix spike duplicate

Table 5-1
Site Inspection Samples by Medium
Site Inspection Report, Boone AASF, Iowa

Sample Identification	Sample Collection Date	Sample Depth (feet bgs)	PFAS (LC/MS/MS compliant with QSM 5.1 Table B-15)	TOC (USEPA Method 9060A)	pH (USEPA Method 9045D)	Grain Size (ASTM D-422)	Comments

NA = not applicable

PFAS = per- and polyfluoroalkyl substances

pH = potential for hydrogen

QSM = Quality Systems Manual

SB = Soil Boring

TOC = total organic carbon

USEPA = United States Environmental Protection Agency

Table 5-2
Soil Boring Depths and Temporary Well Screen Intervals
Site Inspection Report, Boone AASF, Iowa

Area of Interest	Soil Boring ID	Soil Boring Depth (feet bgs)	Temporary Well Screen Interval (feet bgs)
AOI 1	AOI01-01-SB	20	15 - 20
	AOI01-02-SB	25	20 - 25
Upgradient Facility Boundary	BNE-01-SB	15	10 - 15
Downgradient Facility Boundary	BNE-02-SB	20	15 - 20
	BNE-03-SB	20	15 - 20
	BNE-04-SB	20	15 - 20

Notes:

AASF = Army Aviation Support Facility
AOI = area of interest
bgs = below ground surface
BNE = Boone
ID = Identification
SB = soil boring

Table 5-3
Groundwater Elevations at Temporary Groundwater Monitoring Wells
Site Inspection Report, Boone AASF, Iowa

Temporary Groundwater Monitoring Well ID	Ground Surface Elevation (feet amsl)	Depth to Water (feet bgs)	Groundwater Elevation (feet amsl)
AOI01-01	1140.03	18.7	1121.33
AOI01-02	1144.62	16.3	1128.32
BNE-01	1141.87	7.9	1133.97
BNE-02	1137.76	14.8	1123.01
BNE-03	1141.32	11.0	1130.32
BNE-04	1143.72	13.8	1129.92

Notes:

AASF = Army Aviation Support Facility

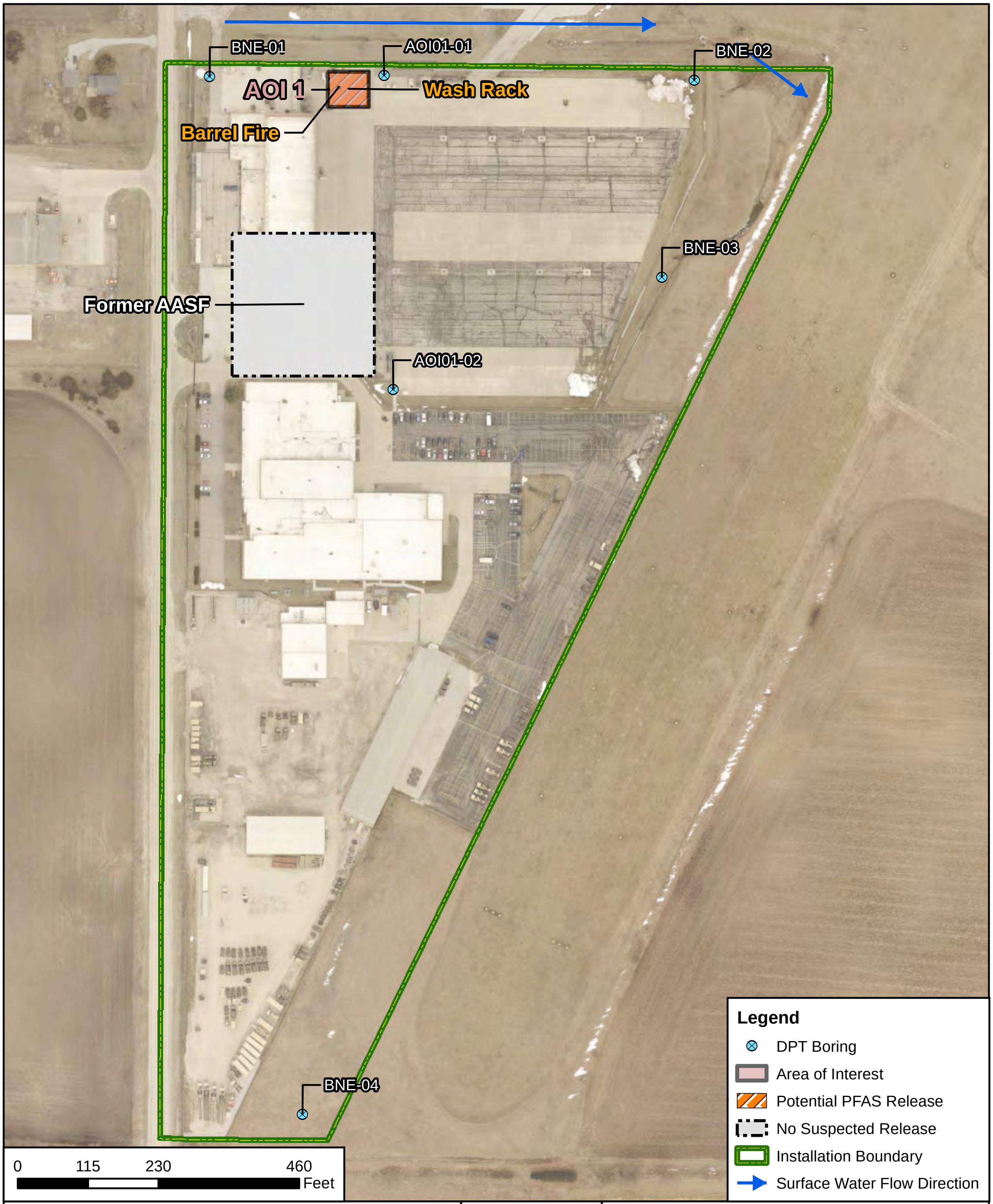
amsl = above mean sea level

AOI = Area of Interest

bgs = below ground surface

BNE = Boone

ID = Identifier



CLIENT	ARNG			
NOTES	Site Inspection for PFAS at Boone AASF, IA			
REVISED	12/8/2020	GIS BY	MS	12/8/2020
SCALE	1:2,760	CHK BY	JW	12/8/2020
Base Map: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,		PM	RG	12/8/2020

N

Site Inspection Sample Locations

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 5-1

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6. Site Inspection Results

This section presents the analytical results of the SI for each AOI. The SLs used in this evaluation are presented in **Section 6.1**. A discussion of the results for each AOI is provided in **Section 6.3** through **Section 6.5**. **Table 6-2** through **Table 6-4** present PFAS results for samples with detections in soil or groundwater; only constituents detected in one or more samples are included. Tables that contain all results are provided in **Appendix G**, and the laboratory reports are provided in **Appendix H**.

6.1 Screening Levels

The DoD has adopted a policy to retain facilities in the CERCLA process based on risk-based SLs for soil and groundwater, as described in a memorandum from the OSD dated 15 October 2019 (Assistant Secretary of Defense, 2019). The ARNG program under which this SI was performed follows this DoD policy. Should the maximum concentration for sampled media exceed the SLs established in the OSD memorandum, the AOI will proceed to an RI, the next phase under CERCLA. The SLs apply to three compounds, PFOA, PFOS, and PFBS, for both soil and groundwater, as presented in **Table 6-1**.

All other results presented in this report are considered informational in nature and serve as an indication as to whether soil and groundwater contain or do not contain PFAS within the boundaries of the facility.

Table 6-1: Screening Levels (Soil and Groundwater)

Analyte	Residential (Soil) (µg/Kg)[a] 0-2 feet bgs	Industrial/ Commercial Composite Worker (Soil) (µg/Kg)[a] 2-15 feet bgs	Tap Water (Groundwater) (ng/L)[a]
PFOA	130	1,600	40
PFOS	130	1,600	40
PFBS	130,000	1,600,000	40,000

Notes:

a.) Assistant Secretary of Defense, 2019. Risk Based Screening Levels Calculated for PFOS, PFOA, PFBS in Groundwater and Soil using United States Environmental Protection Agency's (USEPA's) Regional Screening Level Calculator. Hazard Quotient (HQ)=0.1. 15 October 2019.

bgs = below ground surface
ng/L = nanograms per liter
µg/Kg = micrograms per kilogram

6.2 Soil Physicochemical Analyses

To provide basic soil parameter information, soil samples were analyzed for TOC and pH, which are important for evaluating transport through the soil medium. **Appendix G** contains the results of the TOC and pH sampling.

The data collected in this investigation will be used in subsequent investigations, where appropriate, to assess fate and transport of PFAS contaminants. According to the Interstate Technology Regulatory Council (ITRC), several important PFAS partitioning mechanisms include hydrophobic and lipophobic effects, electrostatic interactions, and interfacial behaviors. At relevant environmental pH values, certain PFAS are present as organic anions and are therefore relatively mobile in groundwater (Xiao et al., 2015), but tend to associate with the organic carbon fraction that may be present in soil or sediment (Higgins and Luthy 2006; Guelfo and Higgins, 2013). When sufficient organic carbon is present, organic carbon normalized distribution coefficients (Koc values) can help in evaluating transport potential, though other geochemical factors (for example, pH and presence of polyvalent cations) may also affect PFAS sorption to solid phases (ITRC, 2018).

6.3 AOI 1

This section presents the analytical results for soil and groundwater in comparison to SLs for AOI 1, which includes one potential PFAS release area: Wash Rack. The detected compounds in soil and groundwater are summarized on **Table 6-2** through **Table 6-4**. The detections of PFOS and PFOA in soil and groundwater are presented on **Figure 6-1** through **Figure 6-3**.

6.3.1 AOI 1 Soil Analytical Results

Soil was sampled at AOI 1 from three depth intervals at boring locations AOI01-01 and AOI01-02 during the SI: shallow (0 to 2 feet bgs), intermediate (7 to 15 feet bgs), and deep (20 to 22 feet bgs). PFOA was detected in the shallow soil interval at a concentration of 0.178 J micrograms per kilogram (µg/Kg) but was not detected in the intermediate or deep soil intervals. PFOS was detected in the shallow and intermediate soil intervals at concentrations ranging from 0.224 J µg/Kg to 3.08 µg/Kg but was not detected in the deep interval. PFBS was not detected in soil at AOI 1.

6.3.2 AOI 1 Groundwater Analytical Results

Groundwater samples were collected from two temporary monitoring well locations at AOI 1 during the SI (BNE-AOI01-01-GW, BNE-AOI01-02-GW). The SL of 40 ng/L for PFOS in groundwater was exceeded at BNE-AOI01-01-GW, with a concentration of 1,070 ng/L. The SL of 40 ng/L for PFOA in groundwater was exceeded at BNE-AOI01-01-GW, with a concentration of 240 ng/L. PFBS was detected below the SL of 40,000 ng/L in both temporary well locations, with concentrations ranging from 1.70 J ng/L to 165 ng/L.

6.3.3 AOI 1 Conclusions

Based on the results of the SI, PFOA, PFOS, and PFBS were detected in soil and groundwater at AOI 1. The detected concentrations of PFOA, PFOS, and PFBS in soil were at least an order of magnitude lower than the individual soil SLs. PFOA and PFOS were detected in groundwater at concentrations exceeding the individual SLs of 40 ng/L for each compound. Based on the exceedances of the SLs for PFOA and PFOS in groundwater, further evaluation at AOI 1 is warranted.

6.4 Upgradient Facility Boundary

This section presents the analytical results for soil and groundwater in comparison to SLs for the Upgradient Facility Boundary, which was sampled to examine potential off-facility sources of PFAS located upgradient of Boone AASF. The detected compounds in soil and groundwater are summarized on **Table 6-2** through **Table 6-4**. The detections of PFOS and PFOA in soil and groundwater are presented on **Figure 6-1** through **Figure 6-3**.

6.4.1 Upgradient Facility Boundary Soil Analytical Results

Soil was sampled at the Upgradient Facility Boundary from three intervals at boring location BNE-01: shallow (0 to 2 feet bgs), intermediate (3 to 5 feet bgs), and deep (5 to 7 feet bgs). PFOS was detected in soil at BNE-01 in each interval at concentrations ranging from 0.258 J µg/Kg to 0.515 J µg/Kg. PFOA and PFBS were not detected in soil at BNE-01.

6.4.2 Upgradient Facility Boundary Groundwater Analytical Results

Groundwater was collected from a temporary monitoring well installed at BNE-01 during the SI (BNE-01-GW). The SL of 40 ng/L for PFOS in groundwater was exceeded at BNE-01-GW with a concentration of 265 ng/L. PFOA was detected below the SL of 40 ng/L at a concentration of 4.85 J ng/L. PFBS was detected below the SL of 40,000 ng/L at a concentration of 167 ng/L.

6.4.3 Upgradient Facility Boundary Conclusions

Based on the results of the SI, PFOA, PFOS, and PFBS were detected in soil and groundwater at the Upgradient Facility Boundary. The detected concentrations of PFOS in soil were at least two orders of magnitude lower than the individual soil SL, and PFOA and PFBS were non-detect in soil. PFOS was detected in groundwater at a concentration exceeding the individual SL of 40 ng/L. The detected concentrations of PFOA and PFBS in groundwater were below their respective SLs. Based on the exceedance of the SL for PFOS in groundwater, further evaluation at the Upgradient Facility Boundary is warranted.

6.5 Downgradient Facility Boundary

This section presents the analytical results for soil and groundwater in comparison to SLs for the Downgradient Facility Boundary. The detected compounds in soil and groundwater are summarized on **Table 6-2** through **Table 6-4**. The detections of PFOS and PFOA in soil and groundwater are presented on **Figure 6-1** through **Figure 6-3**.

6.5.1 Downgradient Facility Boundary Soil Analytical Results

Soil was sampled at the Downgradient Facility Boundary from three intervals at boring locations BNE-02, BNE-03, and BNE-04: shallow (0 to 2 feet bgs), intermediate (6 to 14 feet bgs), and deep (15 to 17 feet bgs). PFOS was detected in soil at BNE-03 in the shallow interval at a concentration of 2.02 µg/Kg but was not detected in the intermediate or deep intervals. PFOA and PFBS were not detected in soil at BNE-02, BNE-03, and BNE-04.

6.5.2 Downgradient Facility Boundary Groundwater Analytical Results

Groundwater was collected from temporary monitoring wells installed at BNE-02, BNE-03, and BNE-04 during the SI (BNE-02-GW, BNE-03-GW, and BNE-04-GW). The SL of 40 ng/L for PFOS was exceeded at BNE-02-GW, with a concentration of 44.9 ng/L. PFOS was also detected at concentrations below the SL at BNE-03-GW and BNE-04-GW, with concentrations ranging from 1.90 J ng/L to 2.07 J ng/L. PFOA was detected below the SL of 40 ng/L at BNE-02-GW at a concentration of 6.93 J ng/L, but it was not detected in groundwater at BNE-03-GW and BNE-04-GW. PFBS was detected below the SL of 40,000 ng/L at BNE-02-GW and BNE-03-GW, with concentrations ranging from 2.62 J ng/L to 2.94 J ng/L. PFBS was not detected in groundwater at BNE-04-GW.

6.5.3 Downgradient Facility Boundary Conclusions

Based on the results of the SI, PFOA, PFOS, and PFBS were detected in soil and groundwater at the Downgradient Facility Boundary. The detected concentration of PFOS in soil was an order of magnitude lower than the individual soil SL, and PFOA and PFBS were non-detect. PFOS was detected in groundwater at a concentration exceeding the individual SL of 40 ng/L. The detected concentrations of PFOA and PFBS in groundwater were below their respective SLs. Based on the exceedance of the SL for PFOS in groundwater, further evaluation at the Downgradient Facility Boundary is warranted.

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Table 6-2
PFAS Detections in Surface Soil
Site Inspection Report, Boone AASF, Iowa

Area of Interest		AOI 1				Upgradient Facility Boundary		Downgradient Facility Boundary					
Sample ID		BNE-AOI01-01-SB-0-2		BNE-AOI01-02-SB-0-2		BNE-01-SB-0-2		BNE-02-SB-0-2		BNE-03-SB-0-2		BNE-04-SB-0-2	
Sample Date		08/05/2020		08/04/2020		08/04/2020		08/04/2020		08/04/2020		08/04/2020	
Depth		0 - 2 ft		0 - 2 ft		0 - 2 ft		0 - 2 ft		0 - 2 ft		0 - 2 ft	
Analyte	**OSD Screening Level [a]**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**
Soil, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15 (µg/kg)													
PFBA	-	0.966	J	0.197	J	0.140	J	0.229	J	ND		0.315	J
PFHpA	-	1.15		ND		ND		0.164	J	ND		ND	
PFHxA	-	2.41		ND		ND		0.297	J	ND		ND	
PFHxS	-	1.20		ND		0.196	J	ND		ND		ND	
PFOA	130	0.178	J	ND		ND		ND		ND		ND	
PFOS	130	3.08		0.287	J	0.515	J	ND		2.02		ND	
PFPeA	-	3.08		ND		ND		0.355	J	ND		ND	

Grey Fill	Detected concentration exceeded OSD Screening Levels

References

a. Assistant Secretary of Defense, 2019. Risk Based Screening Levels Calculated for PFOS, PFOA, PFBS in Groundwater or Soil using USEPA's Regional Screening Level Calculator. HQ=0.1. 15 October 2019. Soil screening levels based on residential scenario for direct ingestion of contaminated soil.

Interpreted Qualifiers

J = Estimated concentration

Chemical Abbreviations

PFAS	per- and polyfluoroalkyl substances
PFBA	perfluorobutanoic acid
PFHpA	perfluoroheptanoic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexanesulfonic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PFPeA	perfluoropentanoic acid

Acronyms and Abbreviations

AASF	Army Aviation Support Facility
AOI	Area of Interest
BNE	Boone
ft	feet
HQ	Hazard quotient
ID	Identifier
LCMSMS	Liquid Chromatography Mass Spectrometry
ND	Analyte not detected above the limit of detection
OSD	Office of the Secretary of Defense
QSM	Quality Systems Manual
Qual	Interpreted Qualifier
SB	Soil boring
USEPA	United States Environmental Protection Agency
µg/Kg	micrograms per kilogram
-	Not applicable

Table 6-3
PFAS Detections in Subsurface Soil
Site Inspection Report, Boone AASF, Iowa

Area of Interest		AOI 1								Upgradient Facility Boundary				Downgradient Facility Boundary							
Sample ID		BNE-AOI01-01-SB-7-9		BNE-AOI01-01-SB-13-15		BNE-AOI01-02-SB-10-12		BNE-AOI01-02-SB-10-12-FD		BNE-01-SB-3-5		BNE-01-SB-5-7		BNE-02-SB-8-10		BNE-03-SB-6-8		BNE-03-SB-14-16		BNE-03-SB-14-16-FD	
Sample Date		08/05/2020		08/05/2020		08/04/2020		08/04/2020		08/04/2020		08/04/2020		08/04/2020		08/04/2020		08/04/2020		08/04/2020	
Depth		7 - 9 ft		13 - 15 ft		10 - 12 ft		10 - 12 ft		3 - 5 ft		5 - 7 ft		8 - 10 ft		6 - 8 ft		14 - 16 ft		14 - 16 ft	
Analyte	**OSD Screening Level [a]**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**
Soil, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15 (µg/kg)																					
6:2 FTS	-	0.778	J	0.861	J	ND		ND		ND		ND		ND		ND		ND		ND	
8:2 FTS	-	0.410	J	ND		ND		ND		ND		ND		ND		ND		ND		ND	
PFBA	-	ND		ND		ND		ND		0.178	J	0.241	J	ND		ND		ND		0.184	J
PFHxA	-	0.174	J	ND		ND		ND		ND		ND		ND		ND		ND		ND	
PFHxS	-	ND		0.468	J	ND		ND		ND		ND		ND		ND		ND		ND	
PFOS	1600	0.658	J-	0.224	J	ND		ND		0.264	J	0.258	J	ND		ND		ND		ND	

▨ Grey Fill Detected concentration exceeded OSD Screening Levels

References

a. Assistant Secretary of Defense, 2019. Risk Based Screening Levels Calculated for PFOS, PFOA, PFBS in Groundwater or Soil using USEPA's Regional Screening Level Calculator. HQ=0.1. 15 October 2019. Soil screening levels based on industrial/commercial composite worker scenario for incidental ingestion of contaminated soil.

Interpreted Qualifiers

J = Estimated concentration

J- = Estimated concentration, biased low

Chemical Abbreviations

6:2 FTS	6:2 fluorotelomer sulfonate
8:2 FTS	8:2 fluorotelomer sulfonate
PFAS	per- and polyfluoroalkyl substances
PFBA	perfluorobutanoic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexanesulfonic acid
PFOS	perfluorooctanesulfonic acid

Acronyms and Abbreviations

AASF	Army Aviation Support Facility
AOI	Area of Interest
BNE	Boone
FD	Duplicate
ft	feet
HQ	Hazard quotient
ID	Identifier
LCMSMS	Liquid Chromatography Mass Spectrometry
ND	Analyte not detected above the limit of detection
OSD	Office of the Secretary of Defense
QSM	Quality Systems Manual
Qual	Interpreted Qualifier
SB	Soil boring
USEPA	United States Environmental Protection Agency
µg/kg	micrograms per kilogram
-	Not applicable

Table 6-3
PFAS Detections in Subsurface Soil
Site Inspection Report, Boone AASF, Iowa

	Area of Interest	Downgradient Facility Boundary			
	Sample ID	BNE-04-SB-8-10		BNE-04-SB-14-16	
	Sample Date	08/04/2020		08/04/2020	
	Depth	8 - 10 ft		14 - 16 ft	
Analyte	**OSD Screening Level [a]**	**Result**	**Qual**	**Result**	**Qual**
Soil, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15 (µg/kg)					
6:2 FTS	-	ND		ND	
8:2 FTS	-	ND		ND	
PFBA	-	0.193	J	0.295	J
PFHxA	-	ND		ND	
PFHxS	-	ND		ND	
PFOS	1600	ND		ND	

Grey Fill	Detected concentration exceeded OSD Screening Levels

References

a. Assistant Secretary of Defense, 2019. Risk Based Screening Levels Calculated for PFOS, PFOA, PFBS in Groundwater or Soil using USEPA's Regional Screening Level Calculator. HQ=0.1. 15 October 2019. Soil screening levels based on industrial/commercial composite worker scenario for incidental ingestion of contaminated soil.

Interpreted Qualifiers

J = Estimated concentration

J- = Estimated concentration, biased low

Chemical Abbreviations

6:2 FTS	6:2 fluorotelomer sulfonate
8:2 FTS	8:2 fluorotelomer sulfonate
PFAS	per- and polyfluoroalkyl substances
PFBA	perfluorobutanoic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexanesulfonic acid
PFOS	perfluorooctanesulfonic acid

Acronyms and Abbreviations

AASF	Army Aviation Support Facility
AOI	Area of Interest
BNE	Boone
FD	Duplicate
ft	feet
HQ	Hazard quotient
ID	Identifier
LCMSMS	Liquid Chromatography Mass Spectrometry
ND	Analyte not detected above the limit of detection
OSD	Office of the Secretary of Defense
QSM	Quality Systems Manual
Qual	Interpreted Qualifier
SB	Soil boring
USEPA	United States Environmental Protection Agency
µg/kg	micrograms per kilogram
-	Not applicable

Table 6-4
PFAS Detections in Groundwater
Site Inspection Report, Boone AASF, Iowa

	Area of Interest	AOI 1						Upgradient Facility Boundary		Downgradient Facility Boundary					
	Sample ID	BNE-AOI01-01-GW		BNE-AOI01-01-GW-FD		BNE-AOI01-02-GW		BNE-01-GW		BNE-02-GW		BNE-03-GW		BNE-04-GW	
	Sample Date	08/05/2020		08/05/2020		08/04/2020		08/04/2020		08/04/2020		08/05/2020		08/04/2020	
Analyte	**OSD Screening Level [a]**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**
Water, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15 (ng/L)															
6:2 FTS	-	3410		2950	J-	ND		ND		ND		ND		ND	
8:2 FTS	-	88.7		100		ND		ND		ND		ND		ND	
PFBA	-	279		285		6.40	J	12.5		28.5		7.58	J	3.31	J
PFBS	40000	164		165		1.70	J	167		2.94	J	2.62	J	ND	
PFDA	-	4.34	J	5.41	J	ND		ND		ND		ND		ND	
PFHpA	-	359		345		2.54	J	2.70	J	15.1		ND		ND	
PFHxA	-	1310		1290		2.95	J	5.75	J	65.5		3.18	J	ND	
PFHxS	-	953		978		14.9		25.1		12.3		5.72	J	ND	
PFNA	-	18.2		22.2		ND		ND		ND		ND		ND	
PFOA	40	232		240		2.68	J	4.85	J	6.93	J	ND		ND	
PFOS	40	899		1070		4.96	J	265		44.9		2.07	J	1.90	J
PFPeA	-	1130		1220		2.73	J	3.31	J	84.7		3.47	J	ND	

Grey Fill	Detected concentration exceeded OSD Screening Levels

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a. Assistant Secretary of Defense, 2019. Risk Based Screening Levels Calculated for PFOS, PFOA, PFBS in Groundwater or Soil using USEPA's Regional Screening Level Calculator. HQ=0.1. 15 October 2019. Groundwater screening levels based on residential scenario for direct ingestion of groundwater.

Interpreted Qualifiers

J = Estimated concentration

J- = Estimated concentration, biased low

Chemical Abbreviations

6:2 FTS	6:2 fluorotelomer sulfonate
8:2 FTS	8:2 fluorotelomer sulfonate
PFAS	Per- and polyfluoroalkyl substances
PFBA	perfluorobutanoic acid
PFBS	perfluorobutanesulfonic acid
PFDA	perfluorodecanoic acid
PFHpA	perfluoroheptanoic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PFPeA	perfluoropentanoic acid

Acronyms and Abbreviations

AASF	Army Aviation Support Facility
AOI	Area of Interest
BNE	Boone
FD	Duplicate
GW	Groundwater
HQ	Hazard quotient
ID	Identifier
LCMSMS	Liquid Chromatography Mass Spectrometry
ND	Analyte not detected above the limit of detection
OSD	Office of the Secretary of Defense
QSM	Quality Systems Manual
Qual	Interpreted Qualifier
USEPA	United States Environmental Protection Agency
ng/L	nanogram per liter
-	Not applicable

CLIENT	ARNG			
PROJECT	Site Inspection for PFAS at Boone AASF, IA			
REVISED	1/22/2021	GIS BY	MS	1/22/2021
SCALE	1:3,000	CHK BY	JW	1/22/2021
Base Map: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community		PM	RG	1/22/2021

Legend

🟩 Facility Boundary

0 125 250 500 Feet

N

PFOS Detections in Soil

AECOM

12420 Milestone Center Drive
Germantown, MD 20876

Figure 6-1

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CLIENT	ARNG			
PROJECT	Site Inspection for PFAS at Boone AASF, IA			
REVISED	1/22/2021	GIS BY	MS	1/22/2021
SCALE	1:3,000	CHK BY	JW	1/22/2021
Base Map: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community		PM	RG	1/22/2021

Legend

🟩 Facility Boundary

0 125 250 500
Feet

N

PFOA Detections in Soil

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 6-2

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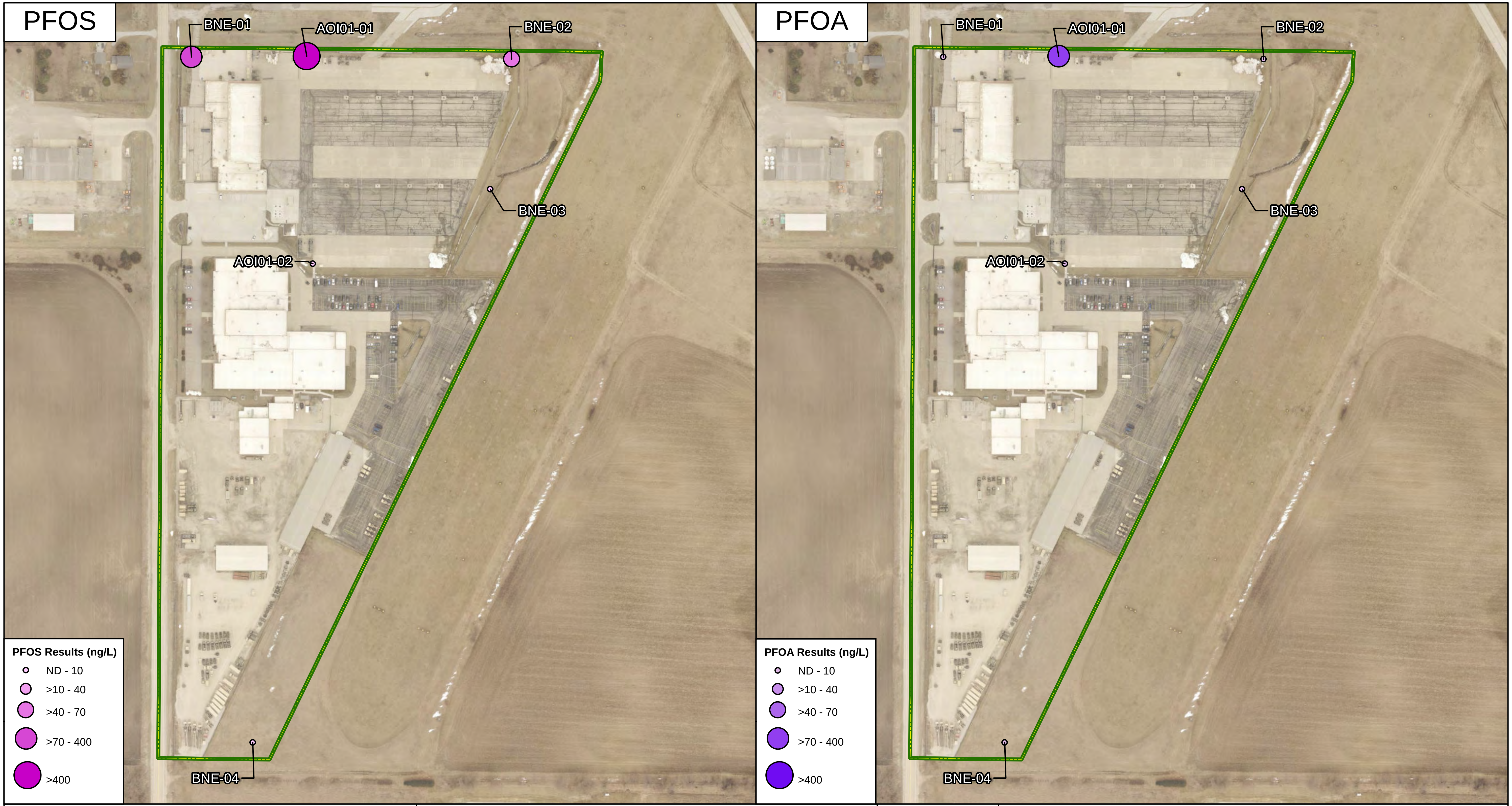

PFOS and PFOA Detections in Groundwater

CLIENT	ARNG			
PROJECT	Site Inspection for PFAS at Boone AASF, IA			
REVISED	12/8/2020	GIS BY	MS	12/8/2020
SCALE	1:2,880	CHK BY	JW	12/8/2020
Base Map: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community		PM	RG	12/8/2020

Legend

🟩 Facility Boundary

0 120 240 480 Feet

N

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 6-3

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7. Exposure Pathways

The CSM for the AOI, revised based on the SI findings, is presented on **Figure 7-1**. A CSM presents the current understanding of the site conditions with respect to known and suspected sources, potential transport mechanisms and migration pathways, and potentially exposed human receptors. A human exposure pathway is considered potentially complete when the following conditions are present:

1. Contaminant source;
2. Environmental fate and transport;
3. Exposure point;
4. Exposure route; and
5. Potentially exposed populations.

If any of these elements are missing, the pathway is incomplete. The CSM figure uses an empty circle symbol to represent an incomplete exposure pathway. Areas with an incomplete pathway generally warrant no further action. However, the pathway is considered potentially complete if PFOA, PFOS, or PFBS are detected, in which case the CSM figure uses a half-filled circle symbol to represent a potentially complete exposure pathway. Additionally, a completely filled circle symbol is used to indicate when a potentially complete exposure pathway has detections of PFOA, PFOS, or PFBS above the SLs. Areas with an identified potentially complete pathway may warrant further investigation.

In general, the potential routes of exposure to PFAS are ingestion and inhalation. Human exposure via the dermal contact pathway may occur, and current risk practice suggests it is an insignificant pathway compared to ingestion; however, exposure data for dermal pathways are sparse and continue to be the subject of PFAS toxicological study. The receptors evaluated are consistent with those listed in USEPA guidance for risk screening (USEPA, 2001). Receptors at the facility include site workers (e.g., facility staff and visiting soldiers), construction workers, trespassers (though unlikely due to restricted access), residents outside the facility boundary, and recreational users outside of the facility boundary. The CSM for AOI 1, revised based on the SI findings, is presented on **Figure 7-1**.

7.1 Soil Exposure Pathway

The SI results for PFOA, PFOS, and PFBS in soil were used to determine whether a potentially complete pathway exists between the source and potential receptors at each AOI based on the aforementioned criteria.

7.1.1 AOI 1

PFAS were released to the wash rack drain at AOI 1 by the IAARNG approximately every 5 years, from 1992 to the present, when the contents of AFFF fire extinguishers were emptied at the wash rack prior to hydrostatic testing. Additionally, fire extinguisher training was conducted on a barrel fire near the wash rack on multiple occasions with either dish soap or AFFF. The dish soap or AFFF were rinsed into the wash rack drain and OWS. IAARNG personnel indicated that the wash rack drains to the sanitary sewer when in use but could not confirm whether the OWS diversion valve were opened or closed during fire training events with AFFF. If the valve were opened during the fire training events, drainage would have been diverted to the storm water drain and off the AASF ramp to the north of the facility, and into an off-facility drainage ditch that flows from west to east along the northern facility boundary, towards the Boone Municipal Airport runway.

Stormwater from this off-facility drainage ditch then re-enters Boone AASF and drains into an emergent wetland area located in the northeast corner of the facility.

PFOS and PFOA were detected in soil at AOI 1 and confirm the release of PFAS to soil in AOI 1. Based on the results of the SI in AOI 1, ground-disturbing activities could potentially result in site worker, future construction worker, and trespasser exposure to PFOS and PFOA via inhalation of dust or incidental ingestion of surface soil. Ground-disturbing activities could potentially result in future construction worker exposure to subsurface soil during trenching activities. No current construction is occurring at AOI 1. The CSM is presented on **Figure 7-1**.

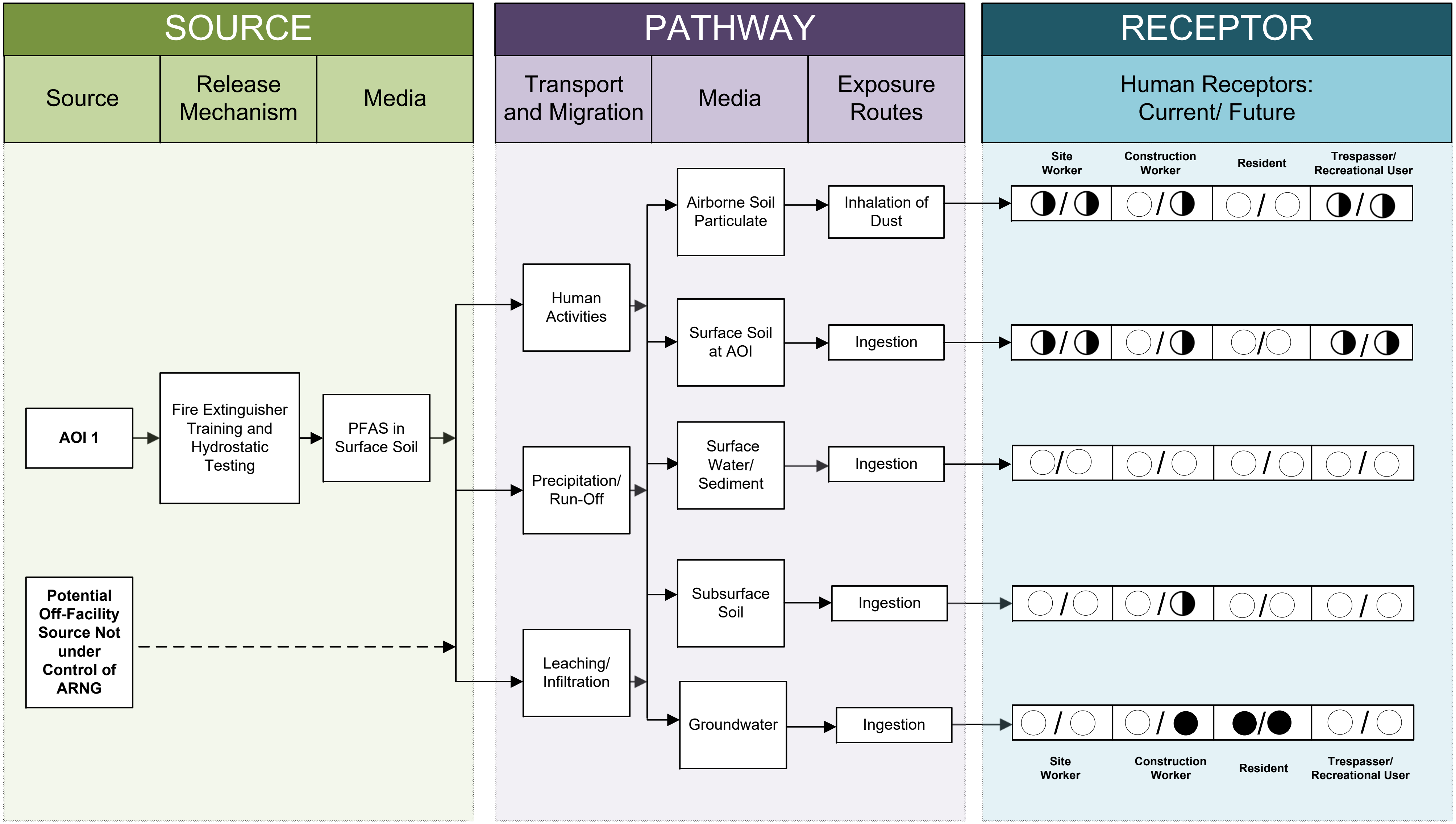
7.2 Groundwater Exposure Pathway

No potable water wells are located within the current AASF; however, private wells exist within 4 miles of the facility. Drinking water for the AASF is supplied by the City of Boone, which utilizes wells northwest of the facility tapping the Middle Des Moines River sand and gravel alluvial aquifer water as the water source (City of Boone Water Works, 2018).

The SI results for PFOA, PFOS, and PFBS in groundwater were used to determine whether a potentially complete exposure pathway exists between the source and future construction workers at AOI 1, as well as off-facility residents, based on the aforementioned criteria.

7.2.1 AOI 1

PFOA, PFOS, and PFBS were detected in groundwater from temporary monitoring wells at AOI 1, confirming the migration of PFAS from soil to groundwater. PFOS and PFOA exceeded the individual SLs for both compounds. The incidental groundwater exposure pathway is potentially complete for construction workers during trenching activities deep enough to encounter shallow groundwater. The exposure pathway is considered potentially complete for off-facility residential drinking water receptors, since it is unknown if the presence of an aquiclude beneath the surficial aquifer prevents PFAS in the surficial aquifer from migrating to the deeper Mississippian aquifer. The CSM is presented on **Figure 7-1**.



SOURCE: Source | Release Mechanism | Media

PATHWAY: Transport and Migration | Media | Exposure Routes

RECEPTOR: Human Receptors: Current/ Future

AOI 1 → Fire Extinguisher Training and Hydrostatic Testing → PFAS in Surface Soil → Human Activities; Precipitation/ Run-Off; Leaching/ Infiltration

Potential Off-Facility Source Not under Control of ARNG - - →

Human Activities; Precipitation/ Run-Off; Leaching/ Infiltration → Airborne Soil Particulate; Surface Soil at AOI; Surface Water/ Sediment; Subsurface Soil; Groundwater

Media	Exposure Routes	Site Worker	Construction Worker	Resident	Trespasser/ Recreational User
Airborne Soil Particulate	Inhalation of Dust	◐/◐	○/◐	○/○	◐/◐
Surface Soil at AOI	Ingestion	◐/◐	○/◐	○/○	◐/◐
Surface Water/ Sediment	Ingestion	○/○	○/○	○/○	○/○
Subsurface Soil	Ingestion	○/○	○/◐	○/○	○/○
Groundwater	Ingestion	○/○	○/●	●/●	○/○

LEGEND

Flow-Chart Stops

Flow-Chart Continues

Partial / Possible Flow

○ Incomplete Pathway

◐ Potentially Complete Pathway

● Potentially Complete Pathway with Exceedance of SL

Notes:
1. The resident and recreational user receptors refer to off-facility receptors.
2. Dermal contact exposure pathway is incomplete for PFAS.

Figure 7-1
Conceptual Site Model
AOI 1 Wash Rack, Boone AASF, Iowa

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8. Summary and Outcome

This section summarizes SI activities and findings. The most significant findings are summarized in this section and are reproduced directly or abstracted from information contained in this report. The outcome provides general and comparative interpretations of the findings relative to the SLs.

8.1 SI Activities

SI field activities included soil and groundwater grab sampling from 4 August to 5 August 2020. Field activities were conducted in accordance with the QAPP Addendum (AECOM, 2020b).

To fulfill the project DQOs set forth in the approved SI QAPP Addendum (AECOM, 2020b), samples were collected and analyzed for a subset of PFAS by LC/MS/MS compliant with QSM Table B-15 as follows. The 18 PFAS analyzed as part of the ARNG SI program are specified in **Section 5.8** of this Report.

- Eighteen (18) soil grab samples from six boring locations;
- Six groundwater grab samples from Six temporary well locations; and
- Fourteen (14) QA samples collected.

The information gathered during this investigation was used to determine if PFOA, PFOS, and/or PFBS were present at or above SLs. Additionally, the CSMs were refined to assess whether a potentially complete pathway exists between the source and potential receptors for potential exposure to PFOA, PFOS, and PFBS at the AOI, which is described in **Section 7**.

8.2 SI Goals Evaluation

As described in **Section 4.2**, the SI activities were designed to achieve six main goals or DQOs. This section describes the SI goals and the conclusions that can be made for each based on the data collected during this investigation.

1. *Determine the presence or absence of PFOA, PFOS, and PFBS at or above SLs.*

   PFOA, PFOS, and PFBS were detected at the facility in soil and groundwater. PFOA, PFOS, and PFBS were detected both at the source area, as well as at the upgradient and downgradient facility boundaries. Detected concentrations of PFOA and PFOS in groundwater at AOI 1 exceeded the individual SLs of 40 ng/L for both compounds. Detected concentrations of PFOS in groundwater at both the Upgradient and Downgradient Facility Boundary exceeded the individual SL of 40 ng/L. The detected concentrations of PFOA, PFOS, and PFBS in all soil samples were below the SLs or non-detect.

2. *Develop information to potentially eliminate a release from further consideration because it is determined that it poses no significant threat to human health or the environment.*

   AOI 1 was the only potential PFAS release area identified during the PA and examined during the SI. PFOS and PFOA were detected in groundwater above the SLs at AOI 1; therefore, this area may pose a threat to human health and the environment.

3. *Determine the potential need for a removal action.*

   Based on the data collected during this SI, there is not a complete pathway between source and on-facility or off-facility drinking water receptors. Drinking water for the AASF is supplied by the City of Boone, which utilizes wells northwest of the facility tapping the

Middle Des Moines River sand and gravel alluvial aquifer water as the water source (City of Boone Water Works, 2018). Additionally, the surficial aquifer that was subject to investigation during this SI is underlain by Pennsylvanian-aged bedrock, which acts as an aquiclude. The presence of this confining layer likely prevents PFAS in the surficial aquifer from migrating to the deeper Mississippian aquifer. Based on the CSM developed and revised in light of the SI findings, there is no potential for exposure to downgradient drinking water receptors caused by DoD activities at or adjacent to the facility.

4. *Collect data to better characterize the release areas for more effective and rapid initiation of an RI.*

The geological data collected as part of the SI indicate a low to moderately permeable and conductive environment. Shallow soils (0 to 6 feet bgs) are dominated by silt with or without a minor sand component. The silt dominated soils are underlain by either clay- or sand-rich soils. In the northwestern portion of the facility, clayey sands are frequently observed beneath the silt, whereas in other portions of the facility, clay or clay with sand predominate.

The most permeable layers (i.e., sand-dominated soils, such as clayey sands and poorly graded sand) are shallowest in the northwestern part of the facility and are encountered around 6 feet bgs. Across the rest of the facility, permeable soils are encountered anywhere from 11 to 23.5 feet bgs. However, in many cases, such as at borehole BNE-03 and BNE-04, the sand-dominated layers are thin (1 to 2 feet thick) and the overall lithology observed is relatively impermeable. Poorly graded sands were encountered at depths ranging from 15 to 23.5 feet bgs, which displays that the most permeable and conductive soils are relatively deep in the subsurface beneath the silt- and clay-rich soils. The exceedances of PFOA and PFOS in groundwater were observed in the northern portion of the facility in wells that were screened within the lean clay (with or without sand) and clayey sands.

Depth to water at the facility ranges from approximately 8 to 19 feet bgs. Groundwater flow direction is generally to the east. These geologic and hydrogeologic observations inform development of technical approach for the RI.

5. *Identify within 4 miles of the installation other potential PFAS sources (fire stations, major manufacturers, other DoD facilities) and receptors, including both groundwater and surface water receptors, to determine whether the ARNG is the likely source of PFAS, or whether there is an off-facility source of PFAS responsible for installation detections of PFAS (USEPA, 2005).*

Based upon the evaluation of groundwater and soil results in comparison to SLs, in combination with the groundwater flow direction analysis, the results of the SI indicate that the source of detected concentrations of PFOA, PFOS, and PFBS at the facility is likely attributable to ARNG activities.

6. *Determine whether a complete pathway exists between the source and potential receptors and whether ARNG is the likely source of the contamination.*

Detections of PFOA and PFOS in soil at the source area, as well as detections of PFOS at the upgradient and downgradient facility boundary, indicate there is a potentially complete exposure pathway between source and site workers, future construction workers, and trespassers. The PFOA and PFOS SL exceedances in surficial groundwater indicate there is a potentially complete exposure pathway between source, future construction workers, and off-facility residential drinking water receptors.

8.3 Outcome

Based on the CSM developed and revised in light of the SI findings, there is potential for exposure to off-facility residential drinking water receptors caused by DoD activities at or adjacent to the facility. Sample chemical analytical concentrations collected during the SI were compared against the project SLs for PFOA, PFOS, and PFBS in soil and groundwater, as described in **Table 6-1**. The following bullets summarize the SI results:

- PFOS and PFOA in groundwater at AOI 1: Wash Rack exceeded the individual SLs of 40 ng/L, with maximum concentrations of 1,070 ng/L and 240 ng/L, respectively, at location AOI01-01. Based on the results of the SI, further evaluation of AOI 1 is warranted in the RI.
- PFOS in groundwater at BNE-01: Upgradient Facility Boundary exceeded the SL of 40 ng/L, with a concentration of 265 ng/L at location BNE-01. Based on the results of the SI, further evaluation of the Upgradient Facility Boundary is warranted in the RI.
- PFOS in groundwater at BNE-02: Downgradient Facility Boundary exceeded the SL of 40 ng/L, with a concentration of 44.9 ng/L at location BNE-02. Based on the results of the SI, further evaluation of the Downgradient Facility Boundary is warranted in the RI.
- The detected concentrations of PFOA, PFOS, and PFBS in soil samples from all AOIs were below the SLs.

Table 8-1 summarizes the SI results for soil and groundwater. Based on the CSMs developed and revised in light of the SI findings, there is potential for exposure to off-facility residential drinking water receptors caused by DoD activities at or adjacent to the facility.

Table 8-2 summarizes the rationale used to determine if an AOI should be considered for further investigation under CERCLA and undergo an RI. Based on the results of this SI, further evaluation is warranted in the RI for AOI 1: Wash Rack, the Upgradient Facility Area, and the Downgradient Facility Area.

Table 8-1: Summary of Site Inspection Findings

AOI	Potential PFAS Release Area	Soil – Source Area	Groundwater – Source Area	Groundwater – Facility Boundary
1	Wash Rack	◐	●	●
Upgradient Facility Area	Unknown	◐	●	●
Downgradient Facility Area	Unknown	◐	●	●

Legend:

● = PFOS, PFOA, and/or PFBS detected; exceedance of the screening levels
◐ = PFOS, PFOA, and/or PFBS detected; no exceedance of the screening levels
○ = PFOS, PFOA, and PFBS not detected

Table 8-2: Site Inspection Recommendations

AOI	Description	Rationale	Future Action
1	Wash Rack	Exceedances of SLs in groundwater at source area. No exceedances of SLs in soil.	Proceed to RI
Upgradient Facility Area	Northwest Facility Boundary	Exceedance of SL in groundwater. No exceedances of SLs in soil.	Proceed to RI
Downgradient Facility Area	Northeast Facility Boundary	Exceedance of SL in groundwater. No exceedances of SLs in soil.	Proceed to RI

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