FINAL
Site Inspection Report
Barrigada Army Aviation Operations Facility
Barrigada, Guam

Site Inspections for Perfluorooctanoic Acid (PFOA), Perfluorooctanesulfonic Acid (PFOS), Perfluorohexanesulfonic Acid (PFHxS), Perfluorononanoic Acid (PFNA), Hexafluoropropylene oxide dimer Acid (HFPO-DA) and Perfluorobutanesulfonic Acid (PFBS)
ARNG Installations, Nationwide

November 2023

Prepared for:

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

UNCLASSIFIED

This page intentionally left blank

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

°C	Degrees Celsius
°F	Degrees Fahrenheit
%	Percent
µg/kg	Microgram(s) per kilogram
AAOF	Army Aviation Operations Facility
AECOM	AECOM Technical Services, Inc.
AFFF	Aqueous film-forming foam
amsl	Above mean sea level
AOI	Area of interest
ARNG	Army National Guard
ASTM	American Society for Testing and Materials
bgs	Below ground surface
CAFS	Compressed air foam system
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Chain-of-custody
CSM	Conceptual site model
DoD	Department of Defense
DQO	Data quality objective
DUA	Data Usability Assessment
EA	EA Engineering, Science, and Technology, Inc., PBC
EB	Equipment Blank
EDR™	Environmental Data Resources Inc.™
EIS	Extraction internal standard
ELAP	Environmental Laboratory Accreditation Program
EM	Engineer Manual
FD	Field duplicate
FedEx	Federal Express
ft	Foot (feet)
GEPA	Guam Environmental Protection Agency
GUARNG	Guam Army National Guard
HA	Health advisory
HDPE	High-density polyethylene
HFPO-DA	Hexafluoropropylene oxide dimer acid
HSA	Hollow stem auger
IDW	Investigation-derived waste
ITRC	Interstate Technology Regulatory Council

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

LC/MS/MS	Liquid chromatography tandem mass spectrometry
MIL-SPEC	Military Specification
MS	Matrix spike
MSD	Matrix spike duplicate
NA	Not applicable
NAVFAC	Naval Facilities Engineering Command
NCTAMS	Naval Computer and Telecommunications Area Master Station
NELAP	National Environmental Laboratory Accreditation Program
ng/L	Nanogram(s) per liter
No.	Number
OSD	Office of the Secretary of Defense
PA	Preliminary Assessment
PFAS	Per- and polyfluoroalkyl substances
PFBS	Perfluorobutanesulfonic acid
PFHxS	Perfluorohexanesulfonic acid
PFNA	Perfluorononanoic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonic acid
PID	Photoionization detector
ppt	Part(s) per trillion
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
QSM	Quality Systems Manual
RI	Remedial investigation
SB	Soil boring
SI	Site inspection
SL	Screening level
TOC	Total organic carbon
TPP	Technical Project Planning
UFP	Uniform Federal Policy
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency

This page intentionally left blank

EXECUTIVE SUMMARY

The Army National Guard (ARNG) G-9 is performing Preliminary Assessments (PAs) and Site Inspections (SIs) at ARNG facilities nationwide based on the current or potential historical use of per- and polyfluoroalkyl substances (PFAS) with a focus on the six compounds presented in the memorandum from the Office of the Secretary of Defense (OSD) (Assistant Secretary of Defense) dated 6 July 2022. The six compounds listed in the OSD memorandum include perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), perfluorobutanesulfonic acid (PFBS), perfluorononanoic acid (PFNA), perfluorohexanesulfonic acid (PFHxS), and hexafluoropropylene oxide dimer acid (HFPO-DA)[1]. These compounds are collectively referred to as "relevant compounds" throughout the document and the applicable screening levels (SLs) are provided in **Table ES-1**

The PA identified one Area of Interest (AOI) where PFAS-containing materials may have been used, stored, disposed, or released historically (see **Table ES-2** for AOI location). The objective of the SI is to identify whether there has been a release to the environment from the AOI identified in the PA and determine whether further investigation is warranted, a removal action is required to address immediate threats, or no further action is required based on SLs for the relevant compounds. This SI was completed at the Barrigada Army Aviation Operations Facility (AAOF) in Barrigada, Guam and determined no further action is required for AOI 1. Barrigada AAOF will be referred to as the "Facility" throughout this document.

The Facility, operated by Guam ARNG (GUARNG), encompasses approximately 51.3 acres in Barrigada, Guam. The SI focuses on the northeastern portion of the GUARNG property, which includes two buildings (hangar and waste accumulation and storage building), a helipad, and the associated area surrounding the buildings and helipad where AFFF familiarization training may have occurred as early as 2016 (AECOM 2021a).

The PA identified one AOI for investigation during the SI phase. SI sampling results from the AOI were compared to OSD SLs. **Table ES-2** summarizes the SI results for the AOI. Based on the results of this SI, no further evaluation is warranted for the AOI 1 at this time.

[1] Of the six PFAS compounds presented in the 6 July 2022 OSD memorandum, HFPO-DA (commonly referred to as GenX) was not included as an analyte at the time of this SI. Based on the conceptual site model (CSM) developed during the PA and revised based on SI findings, the presence of HFPO-DA is not anticipated at the facility because HFPO-DA is generally not a component of military specification (MIL-SPEC) aqueous film forming foam (AFFF) and based on its history including distribution limitations that restricted use of GenX, it is generally not a component of other products the military used. In addition, it is unlikely that GenX would be an individual chemical of concern in the absence of other PFAS.

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

Analyte[2]	Residential (Soil) (µg/kg)[1] 0 to 2 ft bgs	Industrial/Commercial Composite Worker (Soil) (µg/kg)[1] 2 to 15 ft bgs	Groundwater (ng/L)[1]
PFOA	19	250	6
PFOS	13	160	4
PFBS	1,900	25,000	601
PFHxS	130	1,600	39
PFNA	19	250	6

Notes:
1. Assistant Secretary of Defense. July 2022. Risk Based Screening Levels Calculated for Groundwater and Soil using U.S. Environmental Protection Agency's (USEPA's) Regional Screening Level Calculator. Hazard Quotient (HQ)=0.1. May 2022
2. Of the six PFAS compounds presented in the 6 July 2022 OSD memorandum, HFPO-DA (commonly referred to as GenX) was not included as an analyte at the time of this SI. Based on the CSM developed during the PA and revised based on SI findings, the presence of HFPO-DA is not anticipated at the facility because HFPO-DA is generally not a component of MIL-SPEC AFFF and based on its history including distribution limitations that restricted use of GenX, it is generally not a component of other products the military used. In addition, it is unlikely that GenX would be an individual chemical of concern in the absence of other PFAS.

µg/kg = Microgram(s) per kilogram
ng/L = Nanogram(s) per liter

Table ES-2. Summary of Site Inspection Findings and Recommendations

AOI	Potential Release Area	Soil Source Area	Future Action
1	Fire Extinguisher Maintenance Area		No further action

Legend:
 = Detected; exceedance of screening levels
 = Detected; no exceedance of screening levels
 = Not detected

1. INTRODUCTION

1.1 PROJECT AUTHORIZATION

The Army National Guard (ARNG) G-9 is the lead agency in performing Preliminary Assessments (PAs) and Site Inspections (SIs) at ARNG facilities nationwide based on the current or potential historical use of per- and polyfluoroalkyl substances (PFAS) with a focus on six compounds presented in the memorandum from the Office of the Secretary of Defense (OSD) dated 6 July 2022 (Assistant Secretary of Defense 2022). The six components listed in the OSD memorandum will be referred to as "relevant compounds" throughout this document and include perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), perfluorobutanesulfonic acid (PFBS), perfluorononanoic acid (PFNA), perfluorohexanesulfonic acid (PFHxS), and hexafluoropropylene oxide-dimer acid (HFPO-DA)[2] at ARNG facilities nationwide. The ARNG performed this SI at the Barrigada Army Aviation Operations Facility (AAOF) in Barrigada, Guam. The Barrigada AAOF is also referred to as the "Facility" throughout this document.

The SI project elements were performed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (U.S. 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 the U.S. Department of the Army) requirements and guidance for field investigations.

1.2 SITE INSPECTION PURPOSE

A PA was performed at the Facility (AECOM Technical Services, Inc. [AECOM] 2021a) that identified one Area of Interest (AOI) where PFAS-containing materials were used, stored, and/or disposed, or areas where known or suspected releases to the environment occurred. The objective of the SI is to identify whether there has been a release to the environment from the AOI identified in the PA and determine whether further investigation is warranted, a removal action is required to address immediate threats, or no further action is required based on screening levels (SLs) for the relevant compounds.

[2] Of the six PFAS compounds presented in the 6 July 2022 OSD memorandum, HFPO-DA (commonly referred to as GenX) was not included as an analyte at the time of this SI. Based on the conceptual site model (CSM) developed during the PA and revised based on SI findings, the presence of HFPO-DA is not anticipated at the facility because HFPO-DA is generally not a component of military specification (MIL-SPEC) aqueous film forming foam (AFFF) and based on its history including distribution limitations that restricted use of GenX, it is generally not a component of other products the military used. In addition, it is unlikely that GenX would be an individual chemical of concern in the absence of other PFAS.

This page intentionally left blank

2. FACILITY BACKGROUND

2.1 FACILITY LOCATION AND DESCRIPTION

The Guam ARNG (GUARNG) Barrigada installation is comprised of Readiness Centers, U.S. Property and Fiscal Office and Warehouse, Ready Building, and an AAOF to the northeast, and it is located southeast of the Guam International Airport in Barrigada, Guam (**Figure 2-1**). The Facility provides training and maintenance for the various units that support the GUARNG. The Barrigada installation occupies 78.3 acres of land that was all formerly owned by the U.S. Navy and known as the Naval Computer and Telecommunications Master Station (NCTAMS), Barrigada. Portions of the Facility have been leased to the GUARNG since 1988 and initially managed under a Host Tenant Real Estate Agreement with the Navy. In 2002, 51.3 acres was transferred from the Navy to the Army. The GUARNG was granted a license for use of this area from the Army. The remaining portion of the Facility totaling 27 acres is still under a Host Tenant Real Estate Agreement with the Navy. The U.S. Army Corps of Engineers (USACE) has issued a license to the GUARNG for its use.

This SI focuses on the AAOF occupying the northeastern portion of the GUARNG leased property still under Host Tenant Real Estate Agreement with the Navy, which includes two buildings (hangar and waste accumulation and storage building), a helipad, and the associated area surrounding those features totaling approximately 27.21 acres. The Barrigada AAOF supports a medivac unit and other GUARNG functions. The Barrigada Complex is surrounded by a six-foot high security fence on all sides and is not open to the public.

The remainder of the NCTAMS, which is still operated by the Navy, exists to the north and east of the GUARNG property. Along the northwest side of Barrigada Complex and AAOF is Army Drive (Route 16). The P.C. Lujan Elementary School is located to the south of the Facility, and the residential areas of San Antonio and Ungaguan are to the west (AECOM 2021a).

2.2 FACILITY ENVIRONMENTAL SETTING

The Barrigada AAOF is located approximately 2.5 miles south of Tumon Bay. There is a buffer of undeveloped land immediately surrounding the Barrigada AAOF to the south and east, but further south/southwest there are residential areas and a school. To the north of the AAOF are lands associated with the former NCTAMS. Immediately to the west of the AAOF, sits the ARNG Readiness Center and associated support facilities (located on the former NCTAMS property). The Readiness Center and associated support facilities are abutted by residential areas further to the west (**Figure 2-2**). Throughout the Facility, the natural terrain slopes towards south towards the southern coastline of Guam, ranging from a maximum elevation of approximately 250 to 310 feet (ft) above mean sea level (amsl) (AECOM 2021a).

2.2.1 Geology

Guam has four major physiographic areas: limestone plateau, volcanic uplands, interior basin, and coastal lowlands with alluvial valley floors. The Barrigada AAOF overlies the limestone plateau, which includes the north plateau, Orote Peninsula, and the fringing limestone of the southeast coast. The north plateau is relatively flat and consists of reef associated limestone that

has been uplifted above sea level and tilted to the southwest. Sinkholes range from a few ft to approximately 75 ft deep over most of the limestone plateau (AECOM 2021a).

The Barrigada formation is a white, relatively homogeneous, massive, detrital limestone having a characteristic assemblage of large foraminifera. The Barrigada limestone is the principal rock of northern Guam and underlies most of the northern half of the island; it unconformably overlies Alutom volcanics in some areas and is unconformably overlain by variably thick sequences of Mariana limestone. In many places, the Barrigada limestone is brecciated and ranges from compact and well-lithified to extremely friable. The permeability of the limestone is relatively high and contains fresh basal ground water up to approximately 7 ft amsl (AECOM 2021a).

Soil encountered during SI activities was largely consistent with the above expected lithology, mainly ranging from well graded clayey gravels at 0-2 ft bgs to subsurface (below 2 ft bgs) poorly graded silty sands. Grain size sample analysis confirmed lithology descriptions, as shown in the Grain Size Analysis Table (Appendix F). More than 50 percent of soil was classified as sand, with more than half of that designated as medium sand.

2.2.2 Hydrogeology

The Barrigada AAOF is part of the northern Guam hydrogeologic province and overlays the Northern Guam Lens aquifer situated in the Barrigada limestone. The Barrigada limestone is characterized by high porosity due to the dissolution and cavernous features. The term Northern Guam Lens" refers to the lens that develops from the rainfall percolates through the surface soil to the underlying highly porous limestone and accumulating on and displacing denser water (AECOM 2021a).

The Northern Guam Lens aquifer is the primary drinking water source for Guam and underlies the entire northern half of the island. The aquifer is divided into vertical zones based on chloride concentration. The uppermost zone (i.e., supra-basal) consists of the basal freshwater lens where the chloride concentrations are less than 250 milligrams per liter (mg/L) (EPA secondary Maximum Concentration Level). This zone is the primary zone used for drinking water. The bottom zone (basal) contains saltwater with chloride concentrations at levels nearly of those in seawater. In between is a transition zone (parabasal) with chloride concentrations between those of freshwater and saltwater chloride concentrations. The thickness of the transition zone depends on the extent of mixing between freshwater and saltwater, and is generally several tens of feet thick (AECOM 2021b).

The aquifer is composed of six distinct sub-basins and the Facility is located within the Mangilao sub-basin. Groundwater in this part of the Mangilao sub-basin is unconfined and characterized as parabasal, a term meaning that freshwater lens is of sufficient thickness to be in contact with the underlying poorly permeable volcanic basement rock. The elevation of the local water table is generally within a few feet above sea level. Static depth to groundwater is generally in excess of 300 feet bgs given that the Facility generally rests at elevations above 300 feet msl. Reported groundwater depths for nearby supply wells are known to range between 290 and 331 feet bgs during drilling and well installations. The general direction of groundwater flow is reported to be to the south, southeast toward the Pacific Ocean, although pumping from nearby water supply wells may affect the flow direction locally (AECOM 2021b). Under the provisions of the Safe

Drinking Water Act, the groundwater lens of northern Guam was designated a “principal sole source aquifer” (AECOM 2021a).

An Environmental Data Resources, Inc.™ (EDR™) report conducted a well search for a 1-mile radius surrounding the Facility. Using additional online resources, such as state and local Geographic Information System databases, wells were researched to a 4-mile radius of the Facility. There are no drinking water wells on the Facility, but multiple production wells surround the Facility to the north, northeast, and southwest. Based on the south/southeastern inferred groundwater direction, some of these production wells may be potentially downgradient from the Facility. Groundwater features are presented in **Figure 2-3** (AECOM 2021a).

2.2.3 Hydrology

Despite the large amount of rainfall that occurs on Guam, there are no perennial streams located on or in the vicinity of the Facility because of high infiltration rates into the underlying limestone. All stormwater at the Barrigada Complex is directed toward ponding basins located throughout the facility. All surface water at the AOI is directed to the south into a grass culvert where drainage is directed to the south and eventually to the west where is enters a retention basin (KHLG & Associates Inc., 2023). The entirety of the Facility lies within the Fonte River-Frontal Hagatna Bay Watershed (**Figure 2-4**).

2.2.4 Climate

Guam’s climate is characterized by mild temperatures, easterly trade winds year-round, and humid conditions typical of the tropics. Guam has two seasons: rainy (between July and November) and dry (between January and May). The temperature ranges from mid to high-80s degrees Fahrenheit (°F), with temperatures decreasing at higher elevations. Humidity on Guam ranges from approximately 75 to 100 percent (%). Annual rainfall ranges from 80 inches in the coastal lowland areas to 100 inches in the interior upland of southern Guam (AECOM 2021a).

2.2.5 Current and Future Land Use

Current Barrigada AAOF operations include training and maintenance for the various units that support the GUARNG. In addition, a medivac unit uses the hangar in the northern portion of the property. GUARNG has construction planned and a proposed expansion of the facility's footprint. The GUARNG currently leases the property from the U.S. Navy, which borders the property to the north and east. The town of Barrigada also abuts the AAOF to the south and west. The Facility is fenced, and access is controlled by guarded entry. Reasonably anticipated future land use is not expected to change from the current land use described above (AECOM 2021a).

2.2.6 Sensitive Habitat and Threatened/Endangered Species

A wildlife survey has not occurred at the Facility as part of this investigation, and the Facility does not have any significant areas of habitat. The following Species have not been identified at the facility but may be present in the surrounding area.

The following mammals, birds, reptiles, snails, insects, and plants, are federally endangered, threatened, proposed, and/ or are listed as candidate species in Barrigada, Guam (US Fish and Wildlife Service [USFWS], 2022).

- **Mammals**: Mariana Fruit Bat, *Pteropus mariannus (threatened)*
- **Birds:** Guam Micronesian Kingfisher**,** *Halcyon cinnamomina* (endangered); Guam Rail *Rallus owstoni,* (endangered); Mariana Common Moorhen, *Gallinula chloropus guami,* (endangered)
- **Reptiles**: Slevin's Skink, *Emoia slevini* (endangered)
- **Snails:** Fragile Tree Snail, *Samoana fragilis* (endangered); Guam Tree Snail, *Partula radiolata* (endangered); Humped Tree Snail, *Partula gibba* (endangered)
- **Insects:** Mariana Eight-spot Butterfly, *Hypolimnas octocula marianensis* (endangered); Mariana Wandering Butterfly, *Vagrans egistina* (endangered)
- **Flowering Plants:** Aplokating-palaoan, *Psychotria malaspinae* (endangered); Berenghenas Halomtano, *Solanum guamense* (endangered); Cebello Halumtano, *Bulbophyllum guamense* (threatened); *Dendrobium guamense* (threatened); *Eugenia bryanii* (endangered); *Hayun lagu* (endangered); *Maesa walkeri* (threatened); *Nervilia jacksoniae* (threatened), *Tabernaemontana rotensis* (threatened); *Tinospora homosepala* (endangered); *Tuberolabium guamense* (threatened); Ufa-halomtano, *Heritiera logipetiolata* (endangered)
- **Conifers and Cycads:** Fadang, *Cycas micronesica* (threatened).

2.3 HISTORY OF PFAS USE

One AOI was identified in the PA where aqueous film-forming foam (AFFF) may have been used, stored, disposed, or released historically at the Facility (AECOM 2021a). Interviews and records obtained during the PA indicate that AFFF may have historically been released at the Facility during familiarization training and fire training activities as early as 2016. Additional AFFF releases may also have occurred from incidental spills. A description of the AOI is presented in **Section 3**.

Army National Guard Site Inspections
Site Inspection Report
Barrigada AAOF, Guam

Figure 2-1
Facility Location

Facility Data

Facility Boundary

Data Sources:
ESRI 2021
AECOM 2020

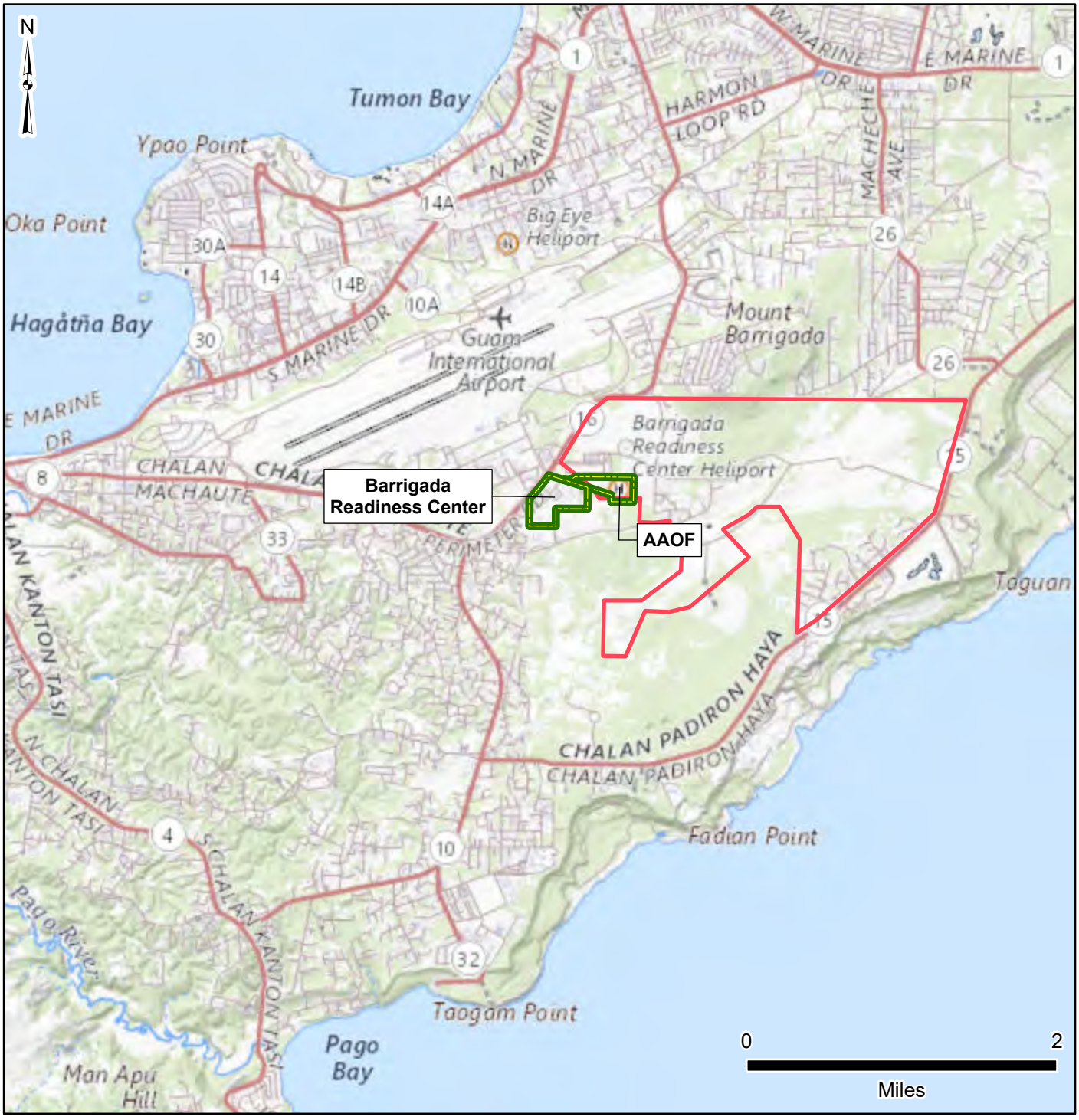
Date:.....May 2023
Prepared By:.....EA
Prepared For:.....USACE
Projection:.....WGS 84 UTM 55N

Path: \\lovetongis\GISdata\Federal\Nationwide\PFAS\MAES_634250383\PROJECTS\SIReport\Barrigada\BarrigadaSI.aprx

This page intentionally left blank

Army National Guard Site Inspections
Site Inspection Report
Barrigada AAOF, Guam

Figure 2-2
Topography



Path: \\lovetongis\GISdata\Federal\Nationwide\PFAS\MAES_63425038\3\PROJECTS\SIReport\Barrigada\Barrigada\BarrigadaSI.aprx

Facility Data

- Facility Boundary
- NCTAMS Boundary

Note: Map by USGS, 2006

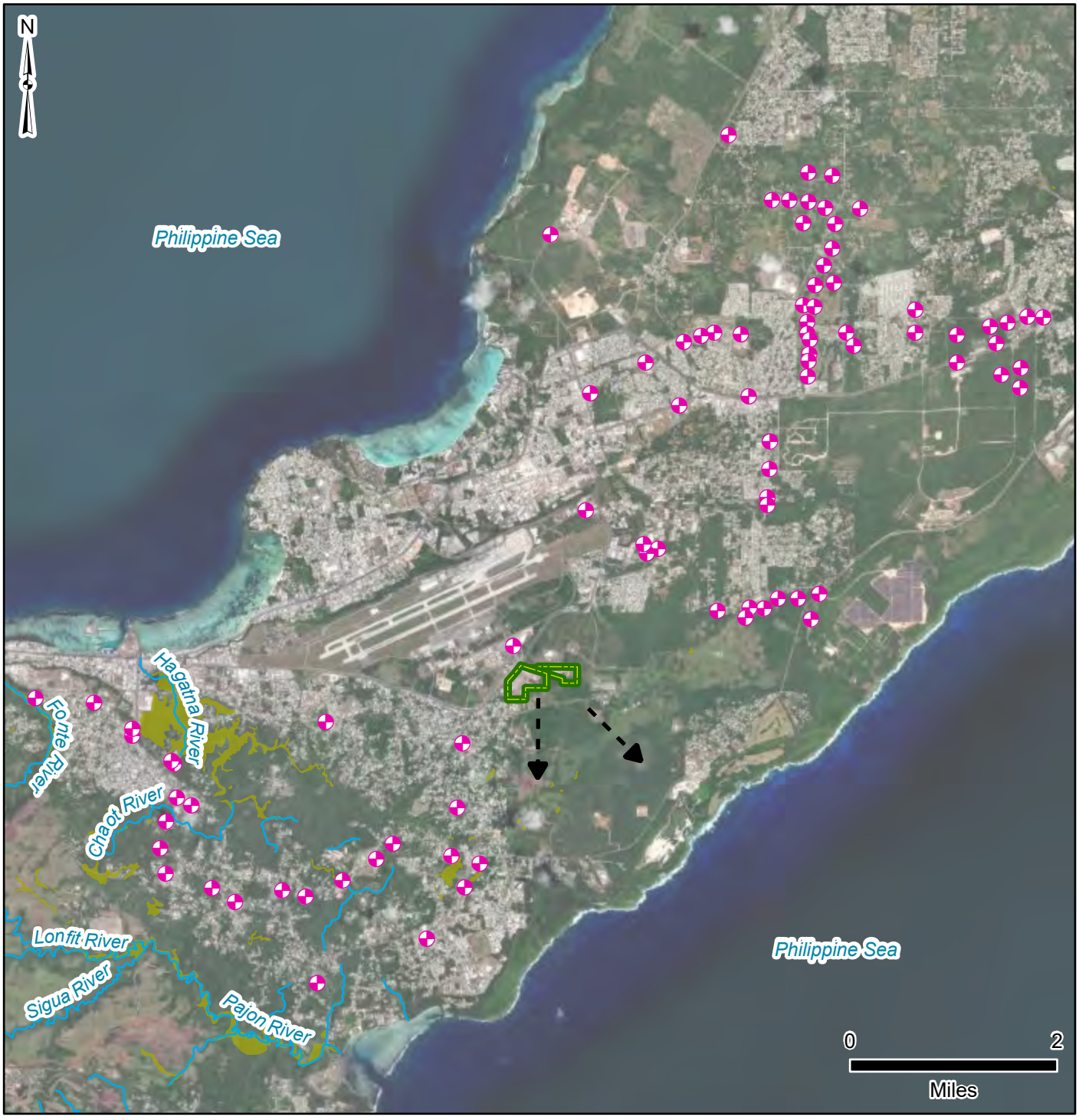
Data Sources:
ESRI 2021
AECOM 2020

Date:.....May 2023
Prepared By:.....EA
Prepared For:.....USACE
Projection:.....WGS 84 UTM 55N

This page intentionally left blank

Army National Guard Site Inspections
Site Inspection Report
Barrigada AAOF, Guam

Figure 2-3
Groundwater Features



Facility Data
- Facility Boundary

Well Type
- Production Well

Hydrology/Hydrogeology
- Inferred Groundwater Flow Direction
- River/Stream
- Wetlands

Data Sources:
ESRI 2021
AECOM 2020

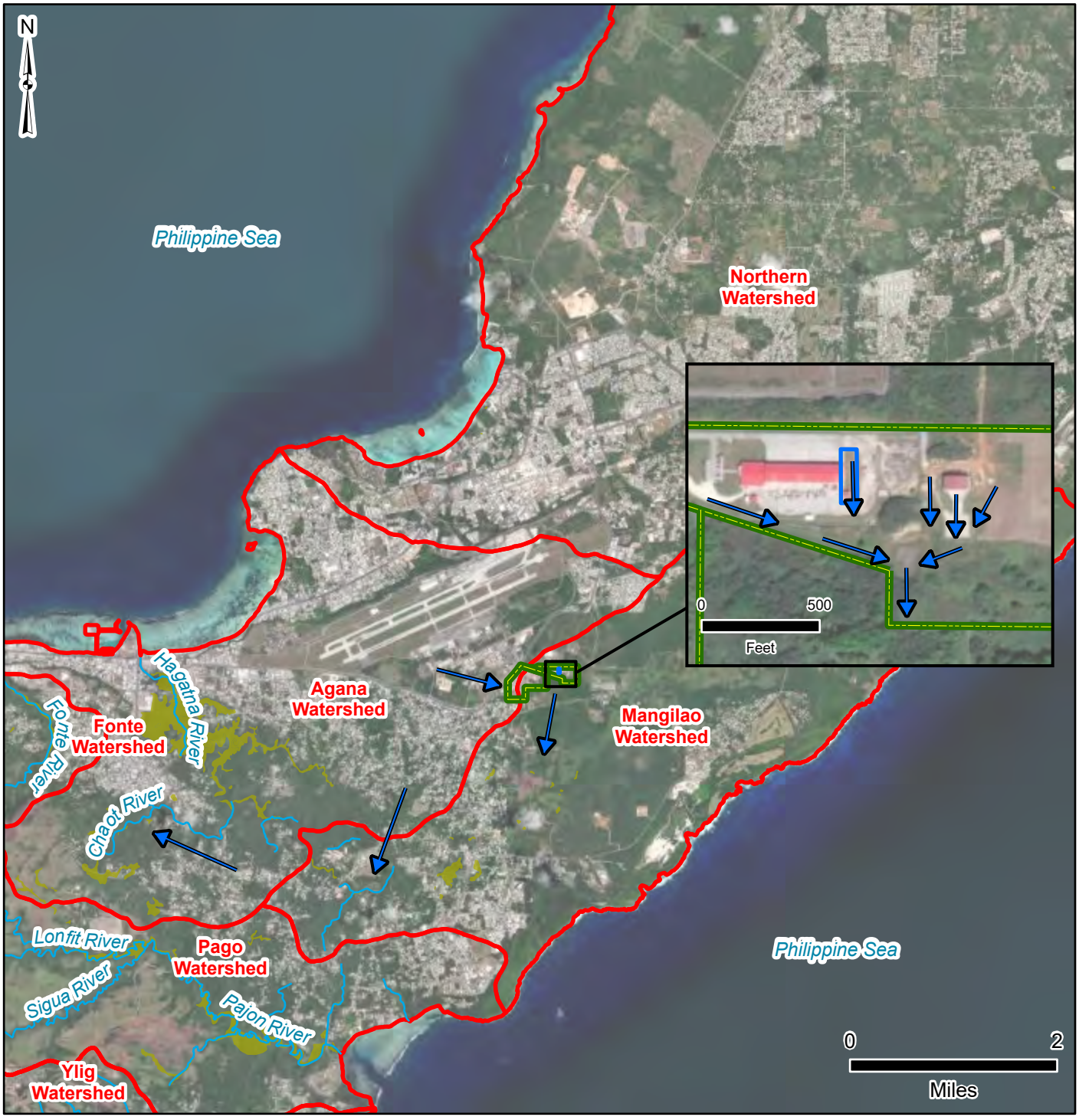
Date:.....May 2023
Prepared By:.....EA
Prepared For:.....USACE
Projection:.....WGS 84 UTM 55N

Path: \\lovetongis\GISdata\Federal\Nationwide\PFAS\MAES_634250383\PROJECTS\SIReport\Barrigada\BarrigadaSI.aprx

This page intentionally left blank

Army National Guard Site Inspections
Site Inspection Report
Barrigada AAOF, Guam

Figure 2-4
Surface Water Features



Path: \\lovetongis\GISdata\Federal\Nationwide\PFAS\MAES_634250383\PROJECTS\SIReport\Barrigada\BarrigadaSI.aprx

Facility Data
- Facility Boundary
- Area of Interest

Hydrology
- Surface Water Flow Direction
- River/Stream
- Wetlands
- Watershed Boundary

Data Sources:
ESRI 2021
AECOM 2020

Date:.....May 2023
Prepared By:.....EA
Prepared For:.....USACE
Projection:.....WGS 84 UTM 55N

This page intentionally left blank

3. SUMMARY OF AREAS OF INTEREST

The PA evaluated areas where PFAS-containing materials may have been used, stored, disposed, or released historically. Based on the PA findings, one potential PFAS release area was identified at the Barrigada AAOF (AECOM 2021a). The potential release area is shown on **Figure 3-1**.

3.1 AOI 1 – FIRE EXTINGUISHER MAINTENANCE AREA

In 2016, new Tri-Max™ compressed air foam systems (CAFSs) were issued to the GUARNG, and personnel received training on the new systems. Training was conducted in the northern grassy area of the hangar. As part of the training, personnel were instructed on how to load the Tri Max™ and were shown the various parts of the extinguisher. In addition, hands-on demonstrations were conducted on how to properly use the Tri-Max™. Based on interviews, there was a large amount of foam released during the hands-on demonstrations. One of the interviewees maintained that the Tri-Max™ CAFSs were filled with soap and not AFFF during the demonstrations because the AFFF material had not yet arrived (AECOM 2021a).

In early 2019, the Tri-Max™ CAFSs were emptied of AFFF and the AFFF was moved to containers for storage (a 55-gallon drum plus a 5.5-gallon drum). To empty the Tri-Max™, the personnel interviewed stated that they siphoned the AFFF and then used a shop vac once the siphoning was no longer productive. Absorbent pads were placed around the CAFSs and drums during the siphoning process to catch any AFFF spills. The shop vac was cleaned with the spigot located on the north end of the hangar, and the rinse water was allowed to drain naturally. After being cleaned, the shop vac was disposed of in regular municipal waste. The used absorbent pads were placed in a single 55-gallon drum and stored with the AFFF drums inside a storage shed, located also in the grassy area of the hangar next to where training and maintenance activities were conducted (AECOM 2021a).

3.2 POTENTIAL ADJACENT SOURCES

3.2.1 NBG Barrigada

In 2020 a PA and subsequent SI were performed by Naval Facilities Engineering Command (NAVFAC) Pacific of sites at NBG typically associated with PFAS storage or use, or that are particularly sensitive to a potential PFAS release, including NBG Barrigada. The PA identified seven potential PFAS-affected sites at NBG Barrigada, of which three were identified as potential sites for PFAS releases warranting further evaluation (Figure 3-2), including:

- Building 55 – A former Fire Station located approximately 0.5 miles east-southeast from AOI 1. The PA was unable to determine definitive use of the facility for AFFF storage, however based on interviews with personnel at other fire stations within NBG, it is possible that AFFF was stored and potentially released at this site since AFFF was stored at and used by the NBG Fire Department starting in 1976.
- The Nimitz Golf Course, located approximately 0.6 miles from AOI 1 in the southwestern portion of the NBG Barrigada boundary, encompasses an approximate 275-acre area that constitutes a lateral extension southward from the rest of NBG Barrigada. The PA determined there was potential that irrigation water used to maintain the golf

course was reclaimed from the wastewater treatment plant and may have contained PFAS.

- Two NBG Barrigada potable water supply wells, located approximately 0.6 miles to the east, and 0.8 miles to the southeast from AOI 1, are known to exist within the NBG Barrigada boundary. The PA determined the potential for PFAS in groundwater at NBG (AECOM 2021b).

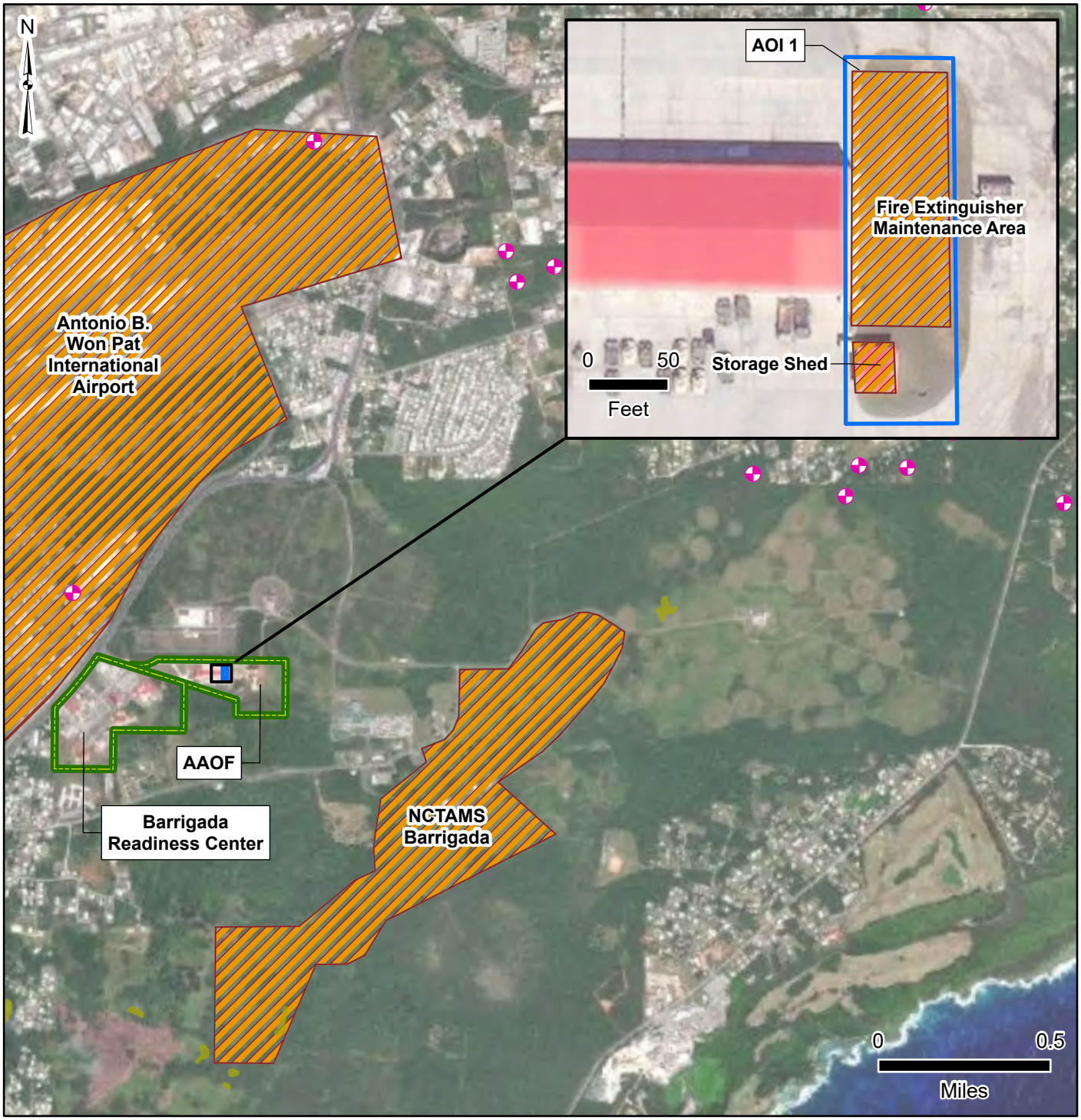
During the subsequent SI, soil, sediment, surface water, and potable water samples were collected, as appropriate, to further assess the potential for PFAS contamination in the three identified areas of concern. PFAS were detected in all surface soil and sediment samples collected from NBG Barrigada. Concentrations were generally similar (within an order of magnitude) for all samples, and all were below applicable project SLs. PFAS were not detected in the surface water located at the former Nimitz Golf Course site indicating PFAS are not present in surface water at NBG Barrigada. One potable water sample was collected from a supply well which contained concentrations of PFAS at concentrations below the EPA's drinking water lifetime health advisory. The SI recommended additional evaluation of PFAS detections in soil and potable water sources at NBG Barrigada (AECOM 2021b).

3.2.2 Guam Antonio B. Won Pat International Airport

The Guam international airport is located to the northwest of the Barrigada Facility and based on the south/southeastern inferred groundwater direction, the site is likely upgradient from the Facility. Airports generally use AFFF and, while the was no observed AFFF use or release at the airport, it is conservatively assumed AFFF is present to respond to airport emergencies. The airport is shown on Figure 3-1.

Army National Guard Site Inspections
Site Inspection Report
Barrigada AAOF, Guam

Figure 3-1
Area of Interest



Path: \\lovetongis\GISdata\Federal\Nationwide\PFAS\MAES_634250383\PROJECTS\SIReport\Barrigada\BarrigadaSI.aprx

Facility Data
- Facility Boundary
- Area of Interest
- Potential PFAS Release

Well Type
- Production Well

Hydrology
- Wetlands

Data Sources:
ESRI 2021
AECOM 2020

Date:.....May 2023
Prepared By:.....EA
Prepared For:.....USACE
Projection:.....WGS 84 UTM 55N

This page intentionally left blank

4. PROJECT DATA QUALITY OBJECTIVES

As identified during the data quality objective (DQO) process and outlined in the SI Uniform Federal Policy (UFP)–Quality Assurance Project Plan (QAPP) Addendum (EA Engineering, Science, and Technology, Inc., PBC [EA] 2022), the objective of the SI is to identify whether there has been a release to the environment at the AOIs identified in the PA. For each AOI, ARNG determines if further investigation is warranted, a removal action is required to address immediate threats, or whether no further action is warranted. This SI evaluated soil for presence or absence of relative compounds at each of the sampled AOIs.

4.1 PROBLEM STATEMENT

ARNG will recommend an AOI for Remedial Investigation (RI) if related soil and groundwater samples have concentrations of the relevant compounds above the OSD risk-based SLs. The SLs are presented in **Section 6.1** of this report.

4.2 INFORMATION INPUTS

Primary information inputs for the SI include the following:

- The PA Report for Barrigada AAOF (AECOM 2021a)
- The Final Preliminary Assessment and Focused Site Inspection of Per- and Polyfluoroalkyl Substances, Naval Base Guam, Guam NAVACT Base-wide (AECOM 2021b)
- Analytical data from soil samples collected as part of this SI in accordance with the site-specific UFP-QAPP Addendum (EA 2022).

4.3 STUDY BOUNDARIES

The scope of the SI was bounded horizontally by the property limits of the Barrigada AAOF (**Figure 2-2**). Off-Facility sampling was not included in the scope of this SI. If future off-Facility sampling is required, the proper stakeholders will be notified, and necessary rights of entry will be obtained by GUARNG with property owner(s). Given the anticipated depth to groundwater of several hundred ft, the scope of the SI was vertically bounded as follows: soil from hand augers (up to 2 ft below ground surface [bgs]) and soil from hollow stem auger (HSA) borings (2 to 30 ft bgs). Temporal boundaries were limited to the earliest available time field resources were available to complete the study.

4.4 ANALYTICAL APPROACH

Samples were analyzed by Eurofins Environment Testing, USA, accredited under the Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP); Accreditation Number [No.] L2468) and the National Environmental Laboratory Accreditation Program (NELAP); Certificate No. 4040). PFAS data underwent 100% Stage 2B validation in accordance with the DoD General Data Validation Guidelines (2019a) and DoD Data Validation

Guidelines Module 3: Data Validation Procedure of Per- and Polyfluoroalkyl Substances Analysis by Quality Systems Manual (QSM) Table B-15 (2020). Data were compared to applicable SLs and decision rules as defined in the UFP-QAPP Addendum (EA 2022).

4.5 DATA USABILITY ASSESSMENT

The Data Usability Assessment (DUA), which is provided in **Appendix A**, 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 2019a, 2019b; USEPA 2017).

Based on the DUA, the environmental data collected during the SI were found to be acceptable and usable for this SI evaluation with the qualifications documented in the DUA and its associated data validation reports. These data are of sufficient quality to meet the objectives and requirements of the UFP-QAPP Addendum (EA 2022).

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 was implemented in accordance with the following approved documents:

- *Final Preliminary Assessment Report, Barrigada Readiness Center, Guam*, dated August 2020 (AECOM 2021a)
- *Final Programmatic Uniform Federal Policy-Quality Assurance Project Plan, Site Inspections for Per- and Polyfluoroalkyl Substances Impacted Sites, ARNG Installations, Nationwide*, dated December 2020 (EA 2020a)
- *Final Site Inspection Uniform Federal Policy-Quality Assurance Project Plan Addendum, Barrigada Army Aviation Operations Facility, Guam*, dated February 2022 (EA 2022)
- *Final Programmatic Accident Prevention Plan, Revision 1*, dated November 2020 (EA 2020b)
- *Final Site Safety and Health Plan, Barrigada Army Aviation Operations Facility, Guam*, dated November 2021 (EA 2021).

The SI field activities were conducted on 13 January 2022 and 28 June 2022. Field activities consisted of source water sampling and soil sample collection from borings and hand augering locations. Field activities were conducted in accordance with the UFP-QAPP Addendum (EA 2022), except as noted in **Section 5.6**.

The following samples were collected during the SI and analyzed for a subset of 24 compounds via liquid chromatography/tandem mass spectrometry (LC/MS/MS) compliant with QSM Version 5.3 Table B-15 to fulfill the project DQOs:

- Twelve (12) soil samples from 9 soil borings/hand auger locations
- Five (5) quality assurance (QA)/quality control (QC) samples

Figure 5-1 provides the sample locations for all media across the Facility. **Table 5-1** presents the list of samples collected for each medium. 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**. Sampling forms are provided in **Appendix B2** and land survey data is 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 of these activities are presented below.

5.1.1 Technical Project Planning

The U.S. Army Corps of Engineers (USACE) TPP Process, Engineer Manual (EM) 200-1-2 (Department of the Army 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 DQOs, and formulating a sampling approach to address the AOIs identified in the PA.

A combined TPP Meeting 1 and 2 was held on 23 November 2021, prior to SI field activities with stakeholders. The combined TPP Meeting 1 and 2 was conducted in general accordance with EM 200-1-2. The stakeholders for this SI include ARNG, GUARNG, USACE, and the Guam Environmental Protection Agency (GEPA) representatives familiar with the Facility, 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 UFP-QAPP Addendum (EA 2022).

A TPP Meeting 3 was held on 28 September 2023 to discuss the results of the SI. Meeting minutes for TPP 3 are included in Appendix D of this report. Future TPP meetings will provide an opportunity to discuss the results and findings, and future actions, where warranted.

5.1.2 Utility Clearance

EA contacted the GUARNG to notify them of intrusive work at the Facility. Utility clearance was performed at each of the proposed boring and hand auger locations on 7 June 2022 with input from the GUARNG and the EA field team. Utility maps and access points were used to complete the utility clearance. Additionally, for most locations (except AOI01-03) the first 2 ft of each boring were pre-cleared by EA's drilling subcontractor, using a hand auger to verify utility clearance in shallow subsurface where utilities would typically be encountered (refer to Section 5.6 which discusses deviations).

5.1.3 Source Water and PFAS Sampling Equipment Acceptability

A sample from a potable water source at the northeast corner of the GUARNG hangar, Building 800, was collected on 13 January 2022, prior to mobilization, and analyzed for PFAS by LC/MS/MS compliant with QSM 5.3 Table B-15.The potable water source used for decontamination of drilling equipment was confirmed to be acceptable for use in this investigation, and therefore used throughout the field activities.

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 appendix to the Programmatic UFP-QAPP Addendum (EA 2022).

5.2 SOIL BORINGS AND SOIL SAMPLING

Surface soil samples from 0 to 2 ft bgs were collected from eight of nine locations using a hand auger (except AOI01-03 where the HSA drilling rig was used to collect the 0-2 ft sample). The reader is referred to Section 5.6 for a discussions of deviations from the UFP-QAPP. All soil sample locations are shown on **Figure 5-1**. The hand auger location was selected based on the AOI information provided in the PA (AECOM 2021a) and as agreed upon by stakeholders during the TPP and review of the UFP-QAPP Addendum (EA 2022). Samples were collected in grass areas where applicable, to avoid disturbing concrete or asphalt surfaces. Non-dedicated sampling equipment (i.e., hand auger) was decontaminated between sampling locations.

At two locations, subsurface soil samples were collected via HSA drilling methods in accordance with UFP-QAPP Addendum (EA 2022) and details of analysis are listed in **Table 5-1**. A Model B-61 sampling system was used to collect continuous soil cores to the target depth. Three discrete soil samples were collected for chemical analysis from each soil boring: one sample at the surface (0 to 2 ft bgs) and two subsurface soil samples. One subsurface soil sample was collected at approximately 15 ft bgs, and one deep subsurface soil sample collected at 30 ft bgs. Total boring completion depth was 30 ft bgs at both subsurface boring locations.

Subsurface soil samples were collected in accordance with the plan, with the exception of AOI01-07 which was offset as described in **Section 5.6.** Borings were installed in grass areas where applicable, to avoid disturbing concrete or asphalt surfaces. All soil sample locations are shown on **Figure 5-1**, and boring sample depths are provided in **Table 5-2**.

During the sampling, the soil cores were continuously logged for lithological descriptions by the field lead using the Unified Soil Classification System. A photoionization detector (PID) was used to screen the breathing zone during boring activities as a 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, Munsell color, and Unified Soil Classification System texture were recorded. The boring logs are provided in **Appendix E**.

Soil borings completed during the SI were found to contain predominantly fine to coarse grained sands with varying levels of fines as the dominant subsurface lithology of the unconsolidated sediments at the Facility. Surface soils (0-2 ft bgs) were mainly composed of well graded clayey gravels. The borings were completed at depths between 2 and 30 ft bgs. These observations are consistent with the understood depositional environment of the region.

Each sample was collected into a laboratory-supplied PFAS-free high-density polyethylene (HDPE) bottle 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 Version 5.3 Table B-15) in accordance with the UFP-QAPP Addendum. QC samples and analysis were performed as described in the UFP-QAPP Addendum (EA 2022).

Field duplicate samples were collected at a rate of 10% and analyzed for the same parameters as the accompanying samples. Matrix spike (MS)/matrix spike duplicates (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 and the HSA for deep soil samples, one equipment blank (EB) was collected per day 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.

After removal of the drill, boreholes were abandoned using the excess soil cuttings from borehole drilling activities.

5.3 SURVEYING

The location of each sampling point was surveyed using a Trimble Geo 7X global positioning system. Positions were collected in the applicable Universal Transverse Mercator zone 55N projection with World Geodetic System 1984 datum (horizontal) and North American Vertical Datum 1988 (vertical). The vertical and horizontal accuracy of the points is +/- 1 meters. Position data were collected on 28 June 2022 and are provided in **Appendix B3**.

5.4 INVESTIGATION-DERIVED WASTE

As of the date of this report, the disposal of PFAS investigation-derived waste (IDW) is not regulated federally. IDW generated during the SI is considered non-hazardous waste and was managed in accordance with the UFP-QAPP Addendum (EA 2022).

Soil IDW (i.e., soil cuttings) and liquid IDW (i.e., purge water, development water, and decontamination fluids) generated during the SI activities were placed within the boring and discharged directed to the ground surface slightly downgradient from the source of generation, respectively (see Appendix B-4 for disposal locations).

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.

5.5 LABORATORY ANALYTICAL METHODS

Samples were analyzed for PFAS by LC/MS/MS compliant with QSM Version 5.3 Table B-15 at Eurofins Environment Testing, USA, in Sacramento, California, a DoD ELAP- and NELAP-certified laboratory.

Soil samples were also analyzed for Total organic carbon (TOC) using USEPA Method 9060A, pH by USEPA Method 9045D, and grain size by American Society for Testing and Materials (ASTM) method D-442.

5.6 DEVIATIONS FROM SITE INVESTIGATION UFP-QAPP ADDENDUM

Deviations from the UFP-QAPP Addendum occurred based on conditions encountered during the field investigation activities. These deviations were discussed between EA, GUARNG, and USACE. Four deviations from the UFP-QAPP Addendum are noted below:

- The field team deviated from the UFP-QAPP by collecting the surface soil sample from 0-2 ft bgs from location AOI01-03 using the HSA drilling rig (instead of hand auger).
- The subsurface soil samples from location AOI01-07 were collected laterally approximately 5 ft east of the surface soil sample AOI01-07H due to access issues (the drill rig could not set up on the steep slope).
- Material from multiple locations was composited for the TOC and grain size analysis due to similar geologic composition and lack of recovery from borings, which is a deviation from the UFP-QAPP.
- Sample AOI01-03-SB-15 had poor recovery at 15 ft bgs. Due to the poor recovery additional material beyond 15 was used to supplement the sample volume. It was also noted that the sample is being compared to SLs but this is considered a deviation from the UFP-QAPP.

Table 5-1. Site Inspection Samples by Medium
Barrigada AAOF, Guam
Site Inspection Report

Sample Identification	Sample Collection Date	Sample Depth (ft bgs)	PFAS (USEPA Method 537 Modified)	TOC (USEPA Method 9060A)	pH (USEPA Method 9045D)	Grain Size (ASTM D-422)	Comments
Soil Samples							
AOI01-01-SB-2	6/28/2022	0-2	x		x		
AOI01-02-SB-2	6/28/2022	0-2	x				
AOI01-03-SB-2	6/28/2022	0-2	x				
AOI01-03-SB-15	6/28/2022	15-18[4]	x				MS/MSD
AOI01-03-SB-30	6/28/2022	29-30	x				
AOI01-04-SB-2	6/28/2022	0-2	x				
AOI01-05-SB-2	6/28/2022	0-2	x				
AOI01-06-SB-2	6/28/2022	0-2	x				
AOI01-07-SB-2[1]	6/28/2022	0-2	x				
AOI01-07-SB-15	6/28/2022	14-15	x				
AOI01-07-SB-30	6/28/2022	29-30	x				
AOI01-08-SB-2	6/28/2022	0-2	x				
AOI01-09-SB-2[2]	6/28/2022	0-2	x				FD
AOI01-10-SB-2[2]	6/28/2022	0-2	x				FD
BRC-TOC-01[3]	6/28/2022	0-2		x			Composite
BRC-GS-01[3]	6/28/2022	0-2				x	Composite
Blank Samples							

Sample Identification	Sample Collection Date	Sample Depth (ft bgs)	PFAS (USEPA Method 537 Modified)	TOC (USEPA Method 9060A)	pH (USEPA Method 9045D)	Grain Size (ASTM D-422)	Comments
Soil Samples							
ARNG-Tap-01	1/13/2022	NA	x				Source Water
BRC-EB-01	6/28/2022	NA	x				EB

Notes:
[1] AOI01-SB-2 correlated to location AOI01-07H where the hand auger sample was collected. Subsurface soil samples at AOI01-07 were collected laterally approximately 5 ft east of the hand auger location as discussed in Section 5.6.
[2] These samples are duplicate samples from the original 8 borings, not separate sampling locations as the names may imply.
[3] Material was similar in every location so material was composited due to lack of recovery. See deviation from UFP-QAPP addendum listed in Section 5.6.
[4] due to poor recovery additional material beyond 15 was used to augment sample volume.
ASTM = American Society for Testing and Materials
FD = field duplicate
GS = grain size
SB = soil boring
EB = equipment blank

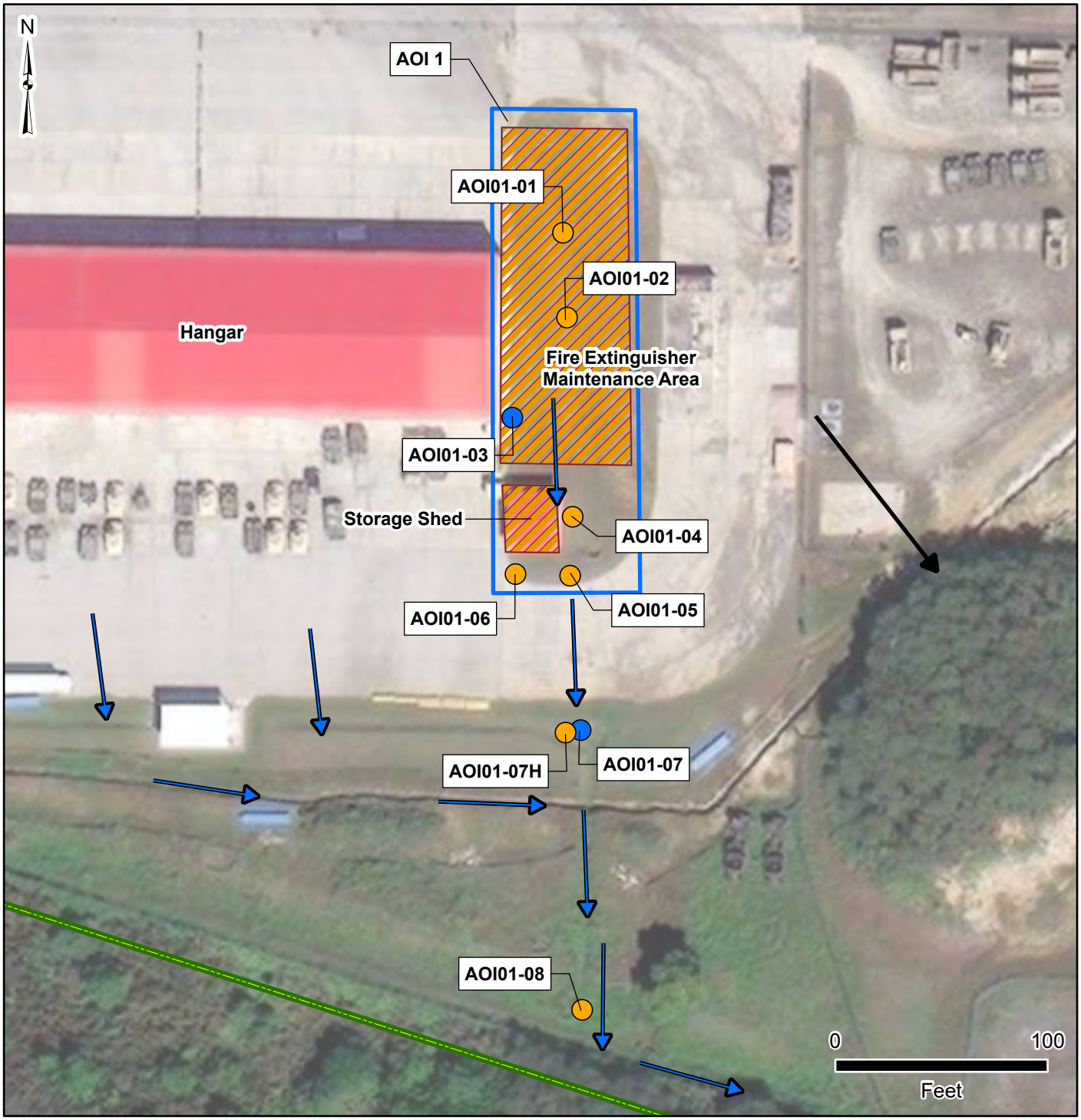
Table 5-2. Soil Boring Depths
Barrigada AAOF, Guam
Site Inspection Report

Area of Interest	Boring ID	Soil Boring Depth (ft bgs)
1	AOI01-01	2
	AOI01-02	2
	AOI01-03	30
	AOI01-04	2
	AOI01-05	2
	AOI01-06	2
	AOI01-07H	2
	AOI01-07	30
	AOI01-08	2

Notes:
NA = not applicable

Army National Guard Site Inspections
Site Inspection Report
Barrigada AAOF, Guam

Figure 5-1
Site Inspection Sample Locations



Path: \\lovetongis\GISdata\Federal\Nationwide\PFAS\MAES_634250383\PROJECTS\SIReport\Barrigada\BarrigadaSI.aprx

Facility Data
- Facility Boundary
- Area of Interest
- Potential PFAS Release

Sample Locations
- Hand Auger 0-2 Feet
- Hollow Stem Auger to 30 feet

Hydrology/Hydrogeology
- Surface Water Flow Direction
- Groundwater Flow Direction

Data Sources:
ESRI 2021
AECOM 2020

Date:.....May 2023
Prepared By:.....EA
Prepared For:.....USACE
Projection:.....WGS 84 UTM 55N

This page intentionally left blank

6. SITE INSPECTION RESULTS

This section presents the analytical results of the SI. The SLs used in this evaluation are presented in **Section 6.1**. A discussion of the results for the AOI is provided in **Section 6.2**. **Tables 6-2 through 6-4** present results for soil for the relevant compounds. Tables that contain all results are provided in **Appendix F**, and the laboratory reports are provided in **Appendix G**.

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 6 July 2022 (Assistant Secretary of Defense 2022). 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 the five compounds presented on **Table 6-1**.

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

Analyte[2]	Residential (Soil) (µg/kg)[1] 0 to 2 ft bgs	Industrial/Commercial Composite Worker (Soil) (µg/kg)[1] 2 to 15 ft bgs	Groundwater (ng/L)[1]
PFOA	19	250	6
PFOS	13	160	4
PFBS	1,900	25,000	601
PFHxS	130	1,600	39
PFNA	19	250	6

Notes:
1. Assistant Secretary of Defense. July 2022. Risk-Based Screening Levels in Groundwater and Soil using EPA's Regional Screening Level Calculator. Hazard Quotient (HQ)=0.1. May 2022.
2. Of the six PFAS compounds presented in the 6 July 2022 OSD memorandum, HFPO-DA (commonly referred to as GenX) was not included as an analyte at the time of this SI. Based on the CSM developed during the PA and revised based on SI findings, the presence of HFPO-DA is not anticipated at the facility because HFPO-DA is generally not a component of MIL-SPEC AFFF and based on its history including distribution limitations that restricted use of GenX, it is generally not a component of other products the military used. In addition, it is unlikely that GenX would be an individual chemical of concern in the absence of other PFAS.

µg/kg = Microgram(s) per kilogram
ng/L = Nanogram(s) per liter

The data in the subsequent sections are compared against the SLs presented in **Table 6-1**. The SLs for soil are based on incidental ingestion and are applied to the depth intervals reasonably anticipated to be encountered by the receptors identified at the Facility: the residential scenario is applied to surface soil results (0 to 2 ft bgs) and the industrial/commercial worker scenario is applied to shallow subsurface soil results (2 to 15 ft bgs). The SLs are not applied to deep subsurface soil results (>15 ft bgs) because 15 ft is the anticipated limit of construction activities.

6.2 SOIL PHYSICOCHEMICAL ANALYSES

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

The data collected in this investigation will be used in subsequent investigations, where appropriate, to assess fate and transport. 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 (K_{oc} 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).

Soil pH was measured as 8.4 in samples collected from AOI 1. TOC was 8.6 g/kg in the sample collected from AOI 1.

Grain size was analyzed from a single composite sample (as the material was observed to be homogeneous) and compared with United Soil Classification grain size ranges. The combined silt and clay content was over 41.5%. The content of sand was 56.5% and grain size ranged from 16% to 13.2. Only 2.2% gravel was noted in the sample.

6.3 AOI 1

This section presents the analytical results for soil in comparison to SLs for AOI 1 - Fire Extinguisher Maintenance Area. The soil results are summarized on **Table 6-2** through **Table 6-4**. Soil results are presented on **Figure 6-1** through **Figure 6-5**.

6.3.1 AOI 1 – Soil Analytical Results

Figures 6-1 through 6-5 present the ranges of detections in soil. **Tables 6-2 through 6-4** summarize the soil results.

Soil was sampled from surface soil (0 to 2 ft bgs) from eight locations (AOI01-01 through AOI01-08). Soil was also sampled from shallow subsurface soil (15 ft bgs) and deep subsurface soil (30 ft bgs) from two boring locations (AOI01-03 and AOI01-07)[3].

PFOA was detected in surface soil at location AOI01-08 at an estimated concentration of 1.3 J+ Microgram(s) per kilogram (µg/kg) below the SL of 19 µg/kg, but not was not detected at any

[3] As noted in Section 5.6, sample AOI01-03-SB-15 had poor recovery at 15 ft bgs. Due to the poor recovery additional material beyond 15 ft bgs (down to 18 ft bgs) was used to supplement the sample volume. This sample is being compared to SLs, but this is considered a deviation from the UFP-QAPP.

other surface soil locations. PFNA was detected at surface soil location AOI01-08 at an estimated concentration of 0.57 J+ µg/kg, below the SL of 19 µg/kg, but it was not detected at any other surface soil locations. There were no detections of PFOS, PFBS, or PFHxS in any surface soil samples associated with AOI 1.

PFOS was detected within the shallow subsurface soil interval of boring locations AOI01-03 and AOI01-07 at estimated concentrations of 2.9 J+ µg/kg and 0.81 J+ µg/kg, respectively. These results were below the SL of 160 µg/kg There were no detections of PFOA, PFBS, PFHxS, and PFNA in any shallow subsurface soil samples associated with the AOI.

PFHxS was detected within the deep subsurface soil interval of boring location AOI01-03 at an estimated concentration of 0.26 J+ µg/kg. PFOS was also detected at an estimated concentration of 5.4 J+ µg/kg within the deep subsurface interval of boring location AOI01-03. PFBS, PFNA, and PFOA were not detected in deep subsurface soil at AOI01-03. PFBS, PFHxS, PFNA, PFOS, and PFOA were not detected in deep subsurface soil interval from boring location AOI01-07.

6.3.2 AOI 1 - Conclusions

Based on the results of the SI, all five relevant compounds (PFOA, PFOS, PFHxS, and PFNA) were detected in soil below their respective SLs. Therefore, further evaluation at AOI 1 is not warranted.

This page intentionally left blank

Table 6-2. PFOA, PFOS, PFBS, PFNA, and PFHxS Results in Surface Soil, Site Inspection Report, Barrigada AAOF

		Location ID	AOI01-01		AOI01-02		AOI01-03		AOI01-04		AOI01-05		AOI01-05		AOI01-06		AOI01-07		AOI01-08	
		Sample Name	AOI01-01-SB-2		AOI01-02-SB-2		AOI01-03-SB-2		AOI01-04-SB-2		AOI01-05-SB-2		AOI01-10-SB-2		AOI01-06-SB-2		AOI01-07-SB-2		AOI01-08-SB-2	
		Parent Sample ID											AOI01-05-SB-2							
		Sample Date	6/28/2022		6/28/2022		6/28/2022		6/28/2022		6/28/2022		6/28/2022		6/28/2022		6/28/2022		6/28/2022	
		Depth (ft bgs)	0-2		0-2		0-2		0-2		0-2		0-2		0-2		0-2		0-2	
Analyte	**Screening Level[1,2]**	**Unit**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**
PFAS by LC/MS/MS compliant with QSM Version 5.3 Table B-15 (µg/kg)																				
Perfluorobutanesulfonic acid (PFBS)	1900	µg/kg	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ
Perfluorohexanesulfonic acid (PFHxS)	130	µg/kg	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ
Perfluorononanoic acid (PFNA)	19	µg/kg	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	0.57	J+
Perfluorooctanesulfonic acid (PFOS)	13	µg/kg	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ
Perfluorooctanoic acid (PFOA)	19	µg/kg	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	ND	UJ	1.3	J+

Notes:
J+ = Estimated concentration, biased high.
UJ = The analyte was not detected at a level greater than or equal to the adjusted Limit of Detection (LOD). Associated numerical value is approximate.
µg/kg = Microgram(s) per kilogram.
1. Assistant Secretary of Defense. July 2022. Risk-Based Screening Levels in Groundwater and Soil using EPA's Regional Screening Level Calculator. Hazard Quotient (HQ)=0.1. May 2022.
2. The Screening Levels for soil are based on a residential scenario for direct ingestion of contaminated soil.
ft bgs = Feet below ground surface.
Qual = Qualifier.
ND = Analyte not detected above the LOD (LOD values are presented in Appendix F).

This page intentionally left blank

Table 6-3. PFOA, PFOS, PFBS, PFNA, and PFHxS Results in Shallow Subsurface Soil, Site Inspection Report, Barrigada AAOF

		Location ID	AOI01-03		AOI01-03		AOI01-07	
		Sample Name	AOI01-03-SB-15		AOI01-09-SB-2		AOI01-07-SB-15	
		Parent Sample ID			AOI01-03-SB-15			
		Sample Date	6/28/2022		6/28/2022		6/28/2022	
		Depth (ft bgs)	15-18		15-18		14-15	
Analyte	**Screening Level[1,2]**	**Unit**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**
PFAS by LC/MS/MS compliant with QSM Version 5.3 Table B-15 (µg/kg)								
Perfluorobutanesulfonic acid (PFBS)	25000	µg/kg	ND	UJ	ND	UJ	ND	UJ
Perfluorohexanesulfonic acid (PFHxS)	1600	µg/kg	ND	UJ	ND	UJ	ND	UJ
Perfluorononanoic acid (PFNA)	250	µg/kg	ND	UJ	ND	UJ	ND	UJ
Perfluorooctanesulfonic acid (PFOS)	160	µg/kg	2.9	J+	0.68	J+	0.81	J+
Perfluorooctanoic acid (PFOA)	250	µg/kg	ND	UJ	ND	UJ	ND	UJ

Notes:
J+ = Estimated concentration, biased high.
UJ = The analyte was not detected at a level greater than or equal to the adjusted Limit of Detection (LOD). Associated numerical value is approximate.
µg/kg = Microgram(s) per kilogram.
1. Assistant Secretary of Defense. July 2022. Risk-Based Screening Levels in Groundwater and Soil using EPA's Regional Screening Level Calculator. Hazard Quotient (HQ)=0.1. May 2022.
2. The Screening Levels for soil are based on incidental ingestion of soil in a industrial/commercial worker scenario.
ft bgs = Feet below ground surface.
Qual = Qualifier.
ND = Analyte not detected above the LOD (LOD values are presented in Appendix F).

This page intentionally left blank

Table 6-4. PFOA, PFOS, PFBS, PFNA, and PFHxS Results in Deep Subsurface Soil, Site Inspection Report, Barrigada AAOF

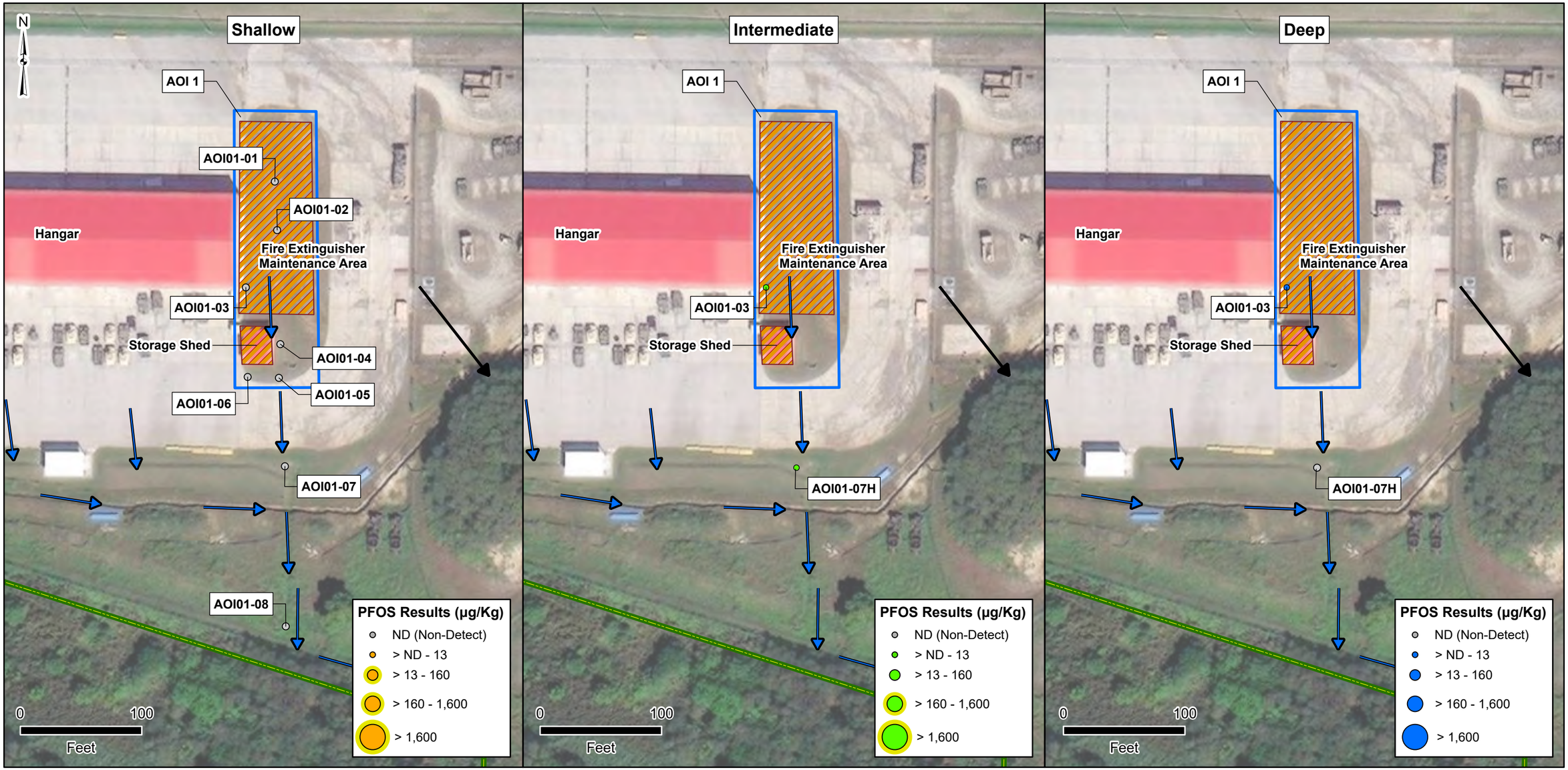
	Location ID	AOI01-03		AOI01-07	
	Sample Name	AOI01-03-SB-30		AOI01-07-SB-30	
	Parent Sample ID				
	Sample Date	6/28/2022		6/28/2022	
	Depth (ft bgs)	29-30		29-30	
Analyte	**Unit**	**Result**	**Qual**	**Result**	**Qual**
PFAS by LC/MS/MS compliant with QSM Version 5.3 Table B-15 (µg/kg)					
Perfluorobutanesulfonic acid (PFBS)	µg/kg	ND	UJ	ND	UJ
Perfluorohexanesulfonic acid (PFHxS)	µg/kg	0.26	J+	ND	UJ
Perfluorononanoic acid (PFNA)	µg/kg	ND	UJ	ND	UJ
Perfluorooctanesulfonic acid (PFOS)	µg/kg	5.4	J+	ND	UJ
Perfluorooctanoic acid (PFOA)	µg/kg	ND	UJ	ND	UJ

Notes:
J+ = Estimated concentration, biased high.
UJ = The analyte was not detected at a level greater than or equal to the adjusted Limit of Detection (LOD). Associated numerical value is approximate.
µg/kg = Microgram(s) per kilogram.
ft bgs = Feet below ground surface.
Qual = Qualifier.
ND = Analyte not detected above the LOD (LOD values are presented in Appendix F).

This page intentionally left blank

Army National Guard Site Inspections
Site Inspection Report
Barrigada AAOF, Guam

Figure 6-1
PFOS Detections in Soil (AOI 1)



Facility Data
- Facility Boundary
- Area of Interest
- Potential PFAS Release

Hydrology/Hydrogeology
- Surface Water Flow Direction
- Groundwater Flow Direction

Notes:
PFOS = Perfluorooctanesulfonic acid
Exceedances of the OSD SL are depicted with a yellow halo. Depth intervals shown represent respective sampling position within a given soil boring location.

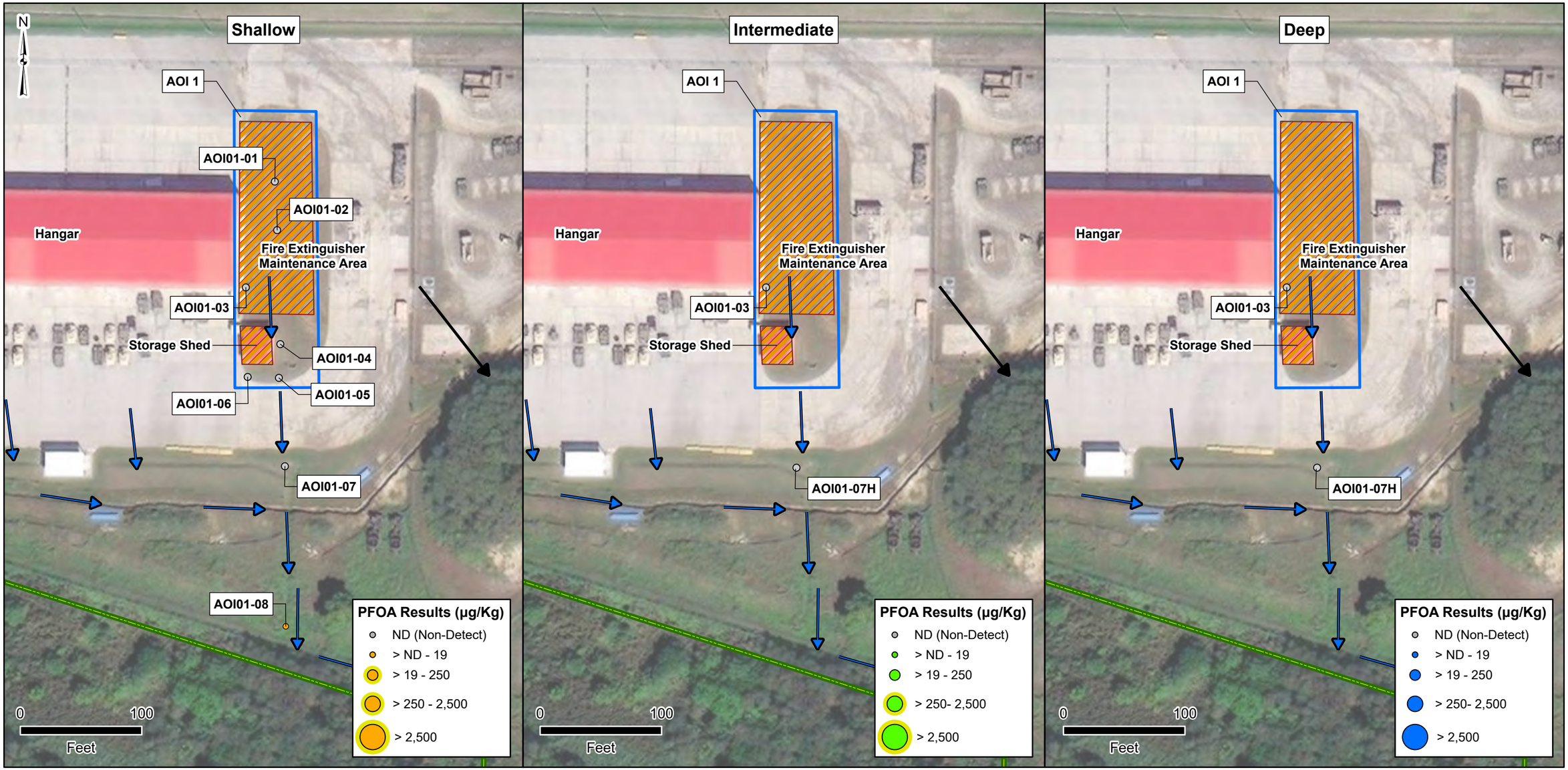
Data Sources:
ESRI 2020
AECOM 2020

Date:.....May 2023
Prepared By:.....EA
Prepared For:.....USACE
Projection:.....WGS 84 UTM 55N

This page intentionally left blank

Army National Guard Site Inspections
Site Inspection Report
Barrigada AAOF, Guam

Figure 6-2
PFOA Detections in Soil (AOI 1)



Facility Data
- Facility Boundary
- Area of Interest
- Potential PFAS Release

Hydrology/Hydrogeology
- Surface Water Flow Direction
- Groundwater Flow Direction

Notes:
PFOA = Perfluorooctanoic acid
Exceedances of the OSD SL are depicted with a yellow halo. Depth intervals shown represent respective sampling position within a given soil boring location.

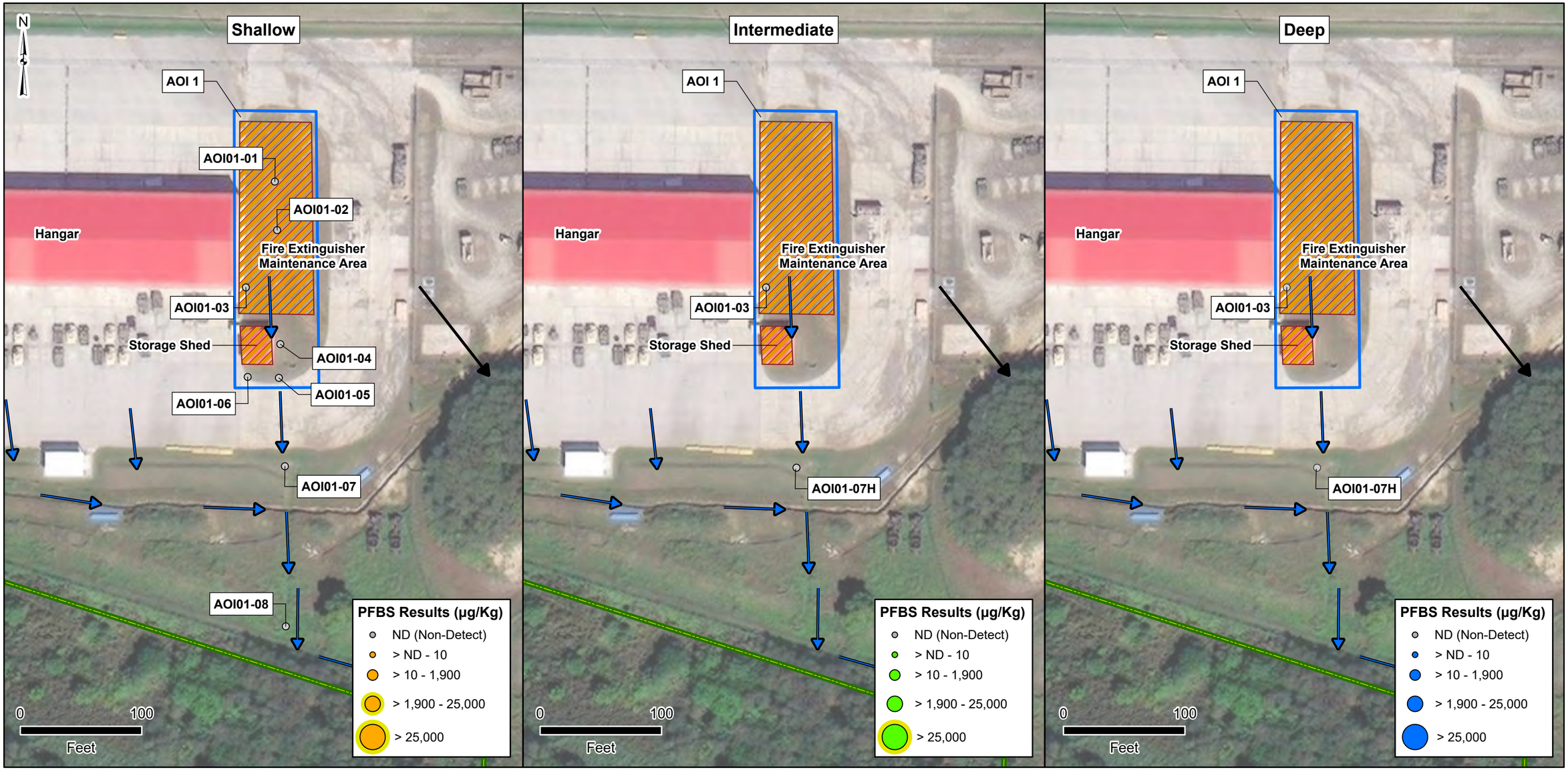
Data Sources:
ESRI 2020
AECOM 2020

Date:.....May 2023
Prepared By:.....EA
Prepared For:.....USACE
Projection:.....WGS 84 UTM 55N

This page intentionally left blank

Army National Guard Site Inspections
Site Inspection Report
Barrigada AAOF, Guam

Figure 6-3
PFBS Detections in Soil (AOI 1)



Facility Data
- Facility Boundary
- Area of Interest
- Potential PFAS Release

Hydrology/Hydrogeology
- Surface Water Flow Direction
- Groundwater Flow Direction

Notes:
PFBS = Perfluorobutanesulfonic acid
Exceedances of the OSD SL are depicted with a yellow halo. Depth intervals shown represent respective sampling position within a given soil boring location.

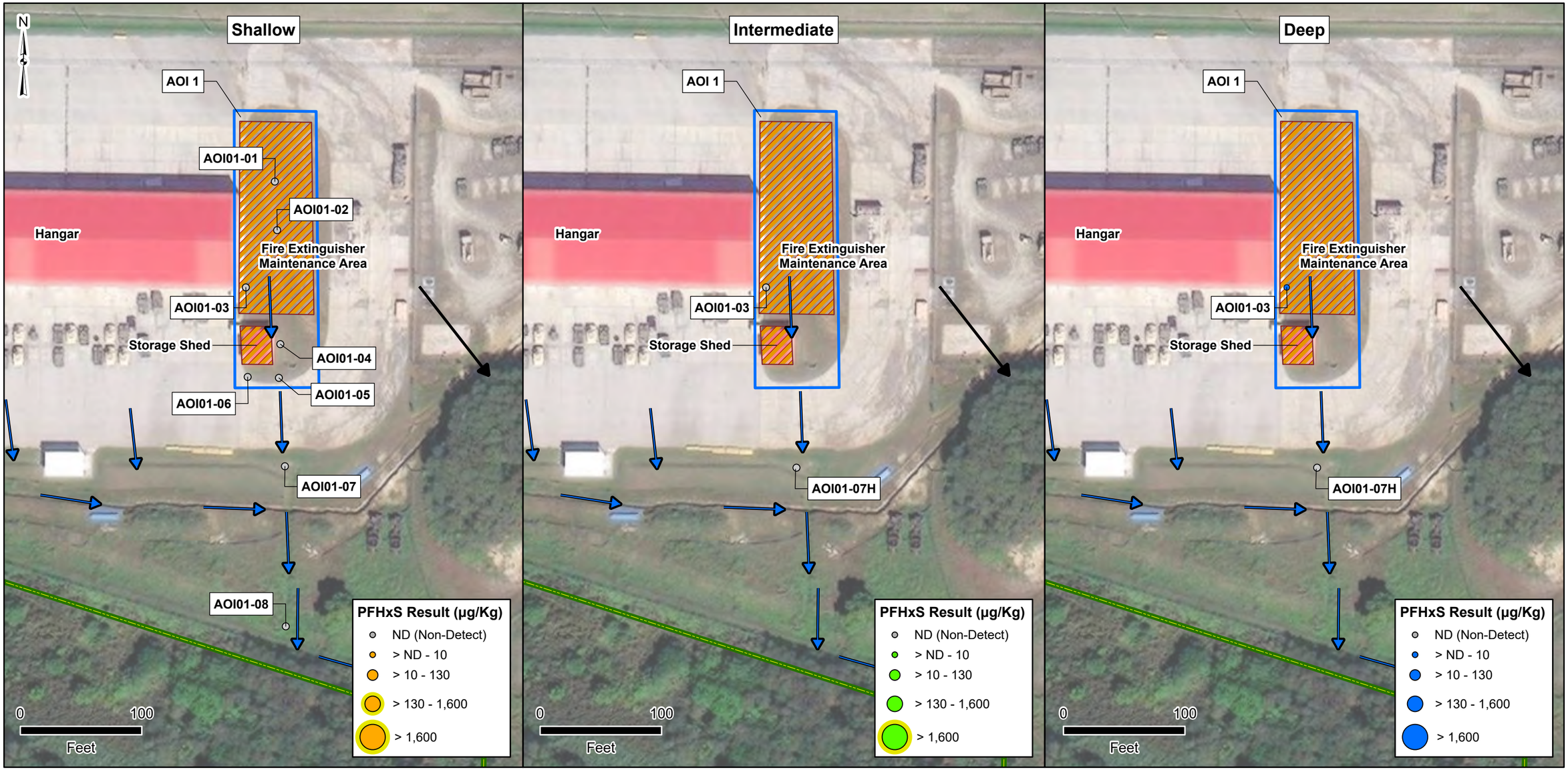
Data Sources:
ESRI 2020
AECOM 2020

Date:.....May 2023
Prepared By:.....EA
Prepared For:.....USACE
Projection:.....WGS 84 UTM 55N

This page intentionally left blank

Army National Guard Site Inspections
Site Inspection Report
Barrigada AAOF, Guam

Figure 6-4
PFHxS Detections in Soil (AOI 1)



Facility Data
- Facility Boundary
- Area of Interest
- Potential PFAS Release

Hydrology/Hydrogeology
- Surface Water Flow Direction
- Groundwater Flow Direction

Notes:
PFHxS = Perfluorohexanesulfonic acid
Exceedances of the OSD SL are depicted with a yellow halo. Depth intervals shown represent respective sampling position within a given soil boring location.

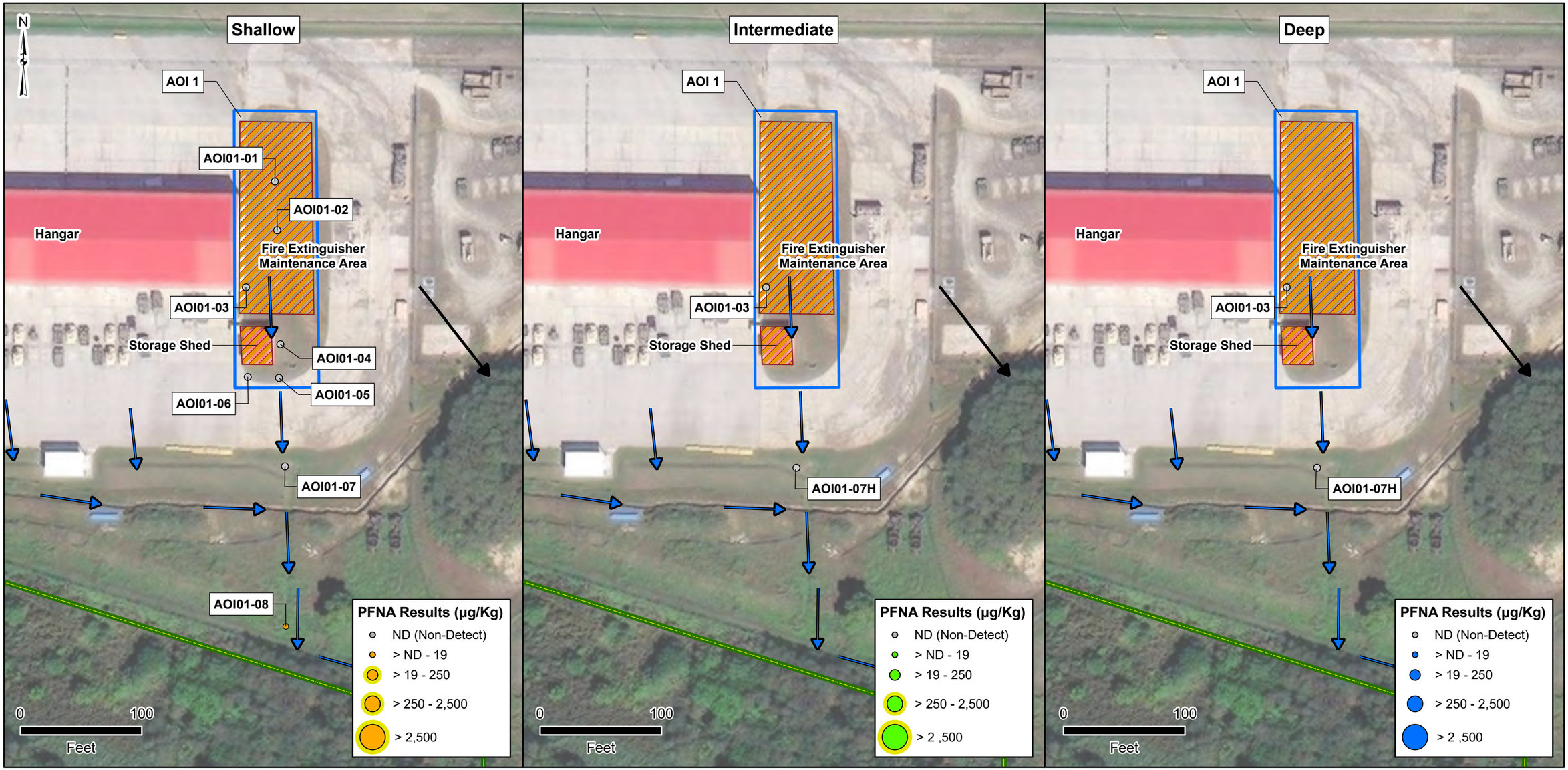
Data Sources:
ESRI 2020
AECOM 2020

Date:.....May 2023
Prepared By:.....EA
Prepared For:.....USACE
Projection:.....WGS 84 UTM 55N

This page intentionally left blank

Army National Guard Site Inspections
Site Inspection Report
Barrigada AAOF, Guam

Figure 6-5
PFNA Detections in Soil (AOI 1)



Facility Data
- Facility Boundary
- Area of Interest
- Potential PFAS Release

Hydrology/Hydrogeology
- Surface Water Flow Direction
- Groundwater Flow Direction

Notes:
PFNA = Perfluorononanoic acid
Exceedances of the OSD SL are depicted with a yellow halo. Depth intervals shown represent respective sampling position within a given soil boring location.

Data Sources:
ESRI 2020
AECOM 2020

Date:.....May 2023
Prepared By:.....EA
Prepared For:.....USACE
Projection:.....WGS 84 UTM 55N

This page intentionally left blank

7. EXPOSURE PATHWAYS

The conceptual site model (CSM) for AOI 1, revised based on the SI findings, is presented on **Figure 7-1**. Please note that while the CSM discussion assists in determining if a receptor may be impacted, the decision to move from SI to RI or interim action is determined based upon exceedances of the SLs for the relevant compounds and whether the release is more than likely attributable to the DoD. A CSM presents the current understanding of the Facility 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
5. Potentially exposed populations

If any of these elements are missing, the pathway is incomplete. The CSM figures use an empty circle symbol to represent an incomplete exposure pathway. Areas with no identified complete pathway generally warrant no further action. However, the pathway is considered potentially complete if the relevant compounds 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 relevant compounds above the SLs. Areas with an identified potentially complete pathway that have detections of the relevant compounds above the SLs may warrant further investigation. Although the CSMs indicate whether potentially complete exposure pathways may exist, the recommendation for future study in an RI or no action at this time is based on the comparison of the SI analytical results for the relevant compounds to the SLs.

In general, the potential routes of exposure to the relevant compounds 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 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 (although unlikely due to restricted access/fencing), residents outside the Facility boundary, and recreational users outside of the Facility boundary.

7.1 SOIL EXPOSURE PATHWAY

The SI results for soil were used to determine whether a potentially complete pathway exists between the source and potential receptors at AOI 1 based on the aforementioned criteria.

7.1.1 AOI 1

AOI 1 is associated with a fire extinguisher maintenance area where controlled AFFF releases through familiarization training may have occurred potentially as early as 2016. PFOA and

PFNA were detected below SLs in surface soil at AOI 1. Site workers and construction workers could contact constituents in surface soil via incidental ingestion and inhalation of dust. PFOS and PFHxS were detected below SLs in shallow subsurface soil. Construction workers could also contact constituents in soil via incidental ingestion and inhalation of dust. GUARNG has construction planned and a proposed expansion of the facility's footprint. Therefore, the soil exposure pathway for site workers and construction workers are considered potentially complete.

The site is fenced and secured and there are no residents onsite or adjacent to the Facility; therefore, the incidental ingestion and inhalation of dust pathways for the Resident and Trespasser/ Recreational User are considered incomplete. The CSM is presented in **Figure 7-1**.

7.2 GROUNDWATER EXPOSURE PATHWAY

The SI results were used to determine whether a potentially complete pathway exists between the source and potential receptors at AOI 1 based on the aforementioned criteria.

7.2.1 AOI 1

Groundwater was not encountered during drilling of boring holes, so no groundwater samples were collected. The Barrigada formation beneath the facility is limestone which has a relatively high permeability. Static depth to groundwater is generally in excess of 300 feet bgs given that the Facility generally rests at elevations above 300 feet msl.

Reported groundwater depths for nearby supply wells are known to range between 290 and 331 feet bgs during drilling and well installations. The general direction of groundwater flow is reported to be to the south, southeast toward the Pacific Ocean. There are no drinking water wells on the Facility. Based on the lack of drinking water wells on the facility, depth to groundwater, and lack of groundwater/surface water interaction, the groundwater pathway is considered incomplete for site workers, and construction workers on the facility.

Multiple production wells surround the Facility to the north, northeast, and southwest. Based on the south/southeastern inferred groundwater direction, some of these production wells may be potentially downgradient from the Facility. Soil sampling in the upper soil layers indicated the presence of “relevant compounds” at levels below SLs; therefore, the groundwater pathway is considered potentially complete for residents downgradient of the facility. Given the depth to groundwater, there is no known groundwater/surface water interaction; therefore, the Trespasser/Recreational User pathway is considered incomplete. The CSM is presented in **Figure 7-1**.

7.3 SURFACE WATER AND SEDIMENT PATHWAY

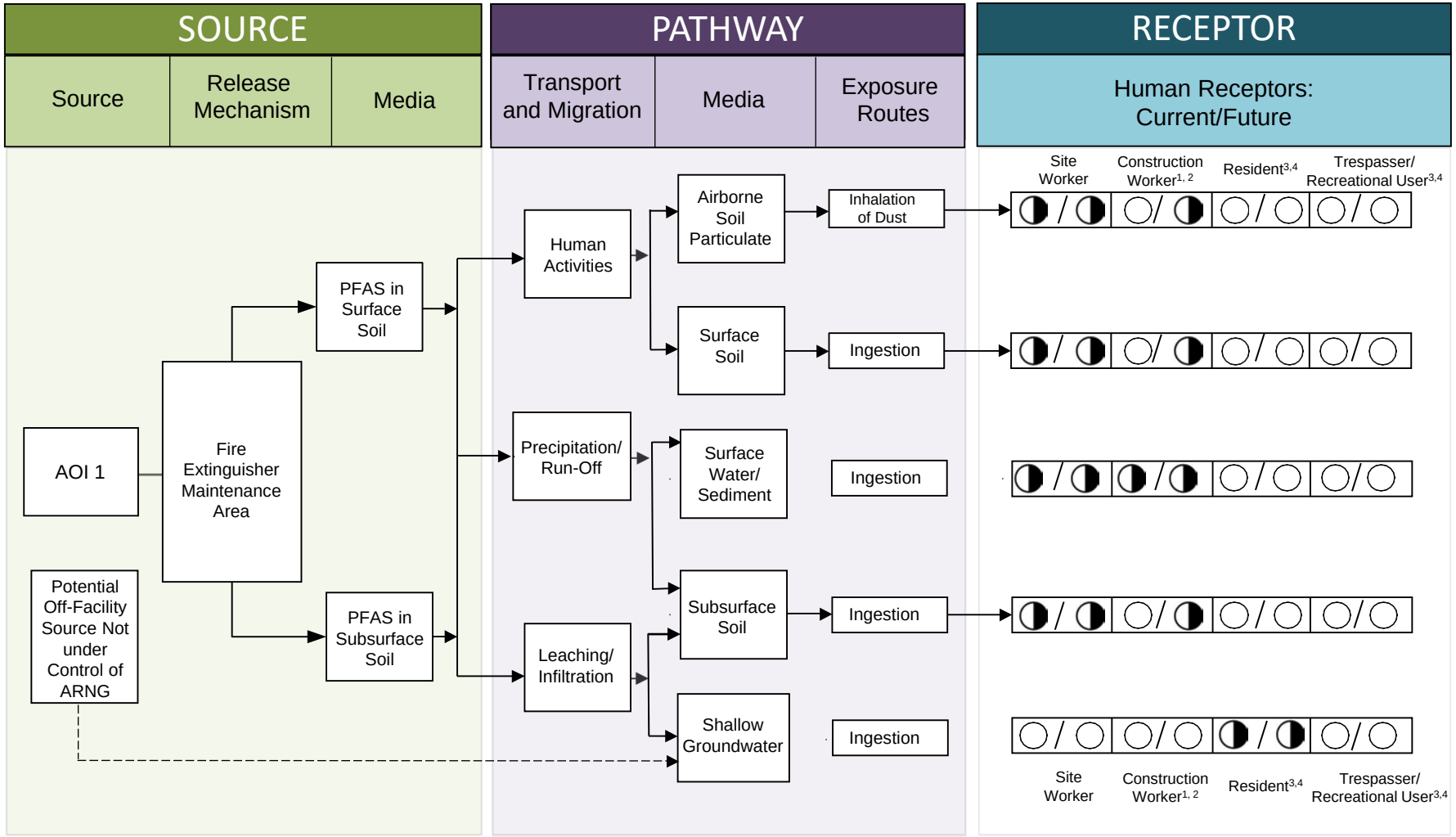
The SI results were used to determine whether a potentially complete pathway exists between the source and potential receptors at AOI 1 based on the aforementioned criteria.

7.3.1 AOI 1

All stormwater at the Barrigada Complex is directed toward ponding basins located throughout the Facility. All stormwater/surface water at the AOI is directed to the south into a grass culvert where drainage is directed to the south and eventually to the west where is enters a retention basin on the Facility. Soil sampling within the drainage pathway indicated the presence of "relevant compounds" at levels below SLs. Site workers and construction workers could contact constituents in drainage pathways (which are accessible onsite) through incidental ingestion and inhalation of dust. Therefore, the surface water/sediment pathway is considered potentially complete for these receptors.

The Barrigada Complex is fenced and there is no recreational use on the facility or nearby. Also, there are no nearby residential areas and no onsite residential housing; therefore, the stormwater and sediment pathway for trespassers and residents is considered incomplete. The CSM is presented in **Figure 7-1**.

This page intentionally left blank



LEGEND

- Flow-Chart Stops
- Flow-Chart Continues
- Partial / Possible Flow
- Incomplete Pathway
- Potentially Complete Pathway
- Complete Pathway

Notes:

1. Groundwater is generally in excess of 300 ft below ground surface.
2. No current active construction at the facility, but construction is planned.
3. The resident and recreational users refer to off-site receptors.
4. Inhalation of dust for off-site receptors is likely insignificant.

Figure 7-1
Conceptual Site Model
AOI 1 Barrigada AAOF

This page intentionally left blank

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 SITE INSPECTION ACTIVITIES

The SI field activities at the Facility were conducted on 13 January 2022 and 28 June 2022. The SI field activities included soil sample collection. Field activities were conducted in accordance with the UFP-QAPP Addendum (EA 2022), except as previously noted in **Section 5.6**.

To fulfill the project DQOs set forth in the approved SI UFP-QAPP Addendum (EA 2022), samples were collected and analyzed for a subset of 24 compounds by LC/MS/MS compliant with QSM Version 5.3 Table B-15 as follows:

- Twelve soil samples from 9 locations
- Five (5) QA/QC samples.

An SI is conducted when the PA determines an AOI exists based on probable use, storage, and/or disposal of PFAS-containing materials. The SI includes multi-media sampling at AOIs to determine whether or not a release has occurred. The SI may conclude further investigation is warranted, a removal action is required to address immediate threats, or no further action is required. Additionally, the CSM was refined to assess whether a potentially complete pathway exists between the source and potential receptors for potential exposure at the AOI, which is described in **Section 7**.

8.2 OUTCOME

Based on the results of this SI, no further evaluation is warranted for AOI 1 at this time (see **Table 8-1**). No Groundwater sampling was conducted. Based on the CSM developed and revised based on the SI findings, there is no potential for soil exposure to site and construction workers from releases during historical DoD activities at the Facility. Sample analytical concentrations collected during this SI were compared against the project SLs for soil, as described in **Table 6-1**. A summary of the results of the SI data relative to SLs is as follows:

- At AOI 1:
    - The detected concentrations of PFOS, PFHxS, PFNA, and PFOA in soil at AOI 1 were below their respective SLs.

Of the six PFAS compounds presented in the 6 July 2022 OSD memorandum, HFPO-DA (commonly referred to as GenX) was not included as an analyte at the time of this SI. Based on the CSM developed during the PA and revised based on SI findings, the presence of HFPO-DA is not anticipated at the facility because HFPO-DA is generally not a component of MIL-SPEC

AFFF and based on its history including distribution limitations that restricted use of GenX, it is generally not a component of other products the military used. In addition, it is unlikely that GenX would be an individual chemical of concern in the absence of other PFAS.

Table 8-1 summarizes the SI results for soil used to determine if an AOI should be considered for further investigation under CERCLA and undergo an RI.

Table 8-1. Summary of Site Inspection Findings and Recommendations

AOI	Potential Release Area	Soil Source Area	Future Action
1	Fire Extinguisher Maintenance Area	◐	No further action

Legend:

● = Detected; exceedance of screening levels

◐ = Detected; no exceedance of screening levels

○ = Not detected

9. REFERENCES

AECOM Technical Services, Inc. (AECOM). 2021a. *Final Preliminary Assessment Report, Barrigada Readiness Center, Guam*. January.

———. 2021b. *Final Preliminary Assessment and Focused Site Inspection of Per- and Polyfluoroalkyl Substances, Naval Base Guam, Guam NAVACTS Basewide*. January.

Assistant Secretary of Defense. July 2022. *Risk-Based Screening Levels in Groundwater and Soil using EPA's Regional Screening Level Calculator. Hazard Quotient (HQ)=0.1*. May 2022

Assistant Secretary of Defense. 2022. *Investigation Per- and Polyfluoroalkyl Substances within The Department of Defense Cleanup Program*. United States Department of Defense. 6 July.

Department of the Army. 2016. *EM-200-1-2, Environmental Quality, Technical Project Planning Process*. 29 February.

———. 2019a. *Department of Defense (DoD), Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.3*. May.

———. 2019b. *General Data Validation Guidelines*. November.

———. 2020. *Data Validation Guidelines Module 3: Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-15*. May.

EA Engineering, Science, and Technology, PBC (EA). 2020a. *Final Programmatic Uniform Federal Policy Quality Assurance Project Plan, Site Inspections for Per- and Polyfluoroalkyl Substances Impacted Sites, ARNG Installations, Nationwide*. December.

———. 2020b. *Final Programmatic Accident Prevention Plan, Revision 1*. November.

———. 2021. *Final Site Safety and Health Plan, Barrigada Army Aviation Operations Facility*. November.

———.2022. *Final Site Inspection Uniform Federal Policy Quality Assurance Project Plan (UFP-QAPP) Addendum, Barrigada Army Aviation Operations Facility Guam, Barrigada, Guam, Per- and Polyfluoroalkyl Substances Impacted Sites ARNG Installations, Nationwide*. February.

Guelfo, J.L. and C.P. Higgins. 2013. *Subsurface transport potential of perfluoroalkyl acids and aqueous film-forming foam (AFFF)-impacted sites*. Environmental Science and Technology 47(9):4164-71.

Higgins, C.P., and R.G. Luthy. 2006. *Sorption of perfluorinated surfactants on sediments*. Environmental Science and Technology 40 (23): 7251-7256.

Interstate Technology Regulatory Council (ITRC). 2018. *Environmental Fate and Transport for Per- and Polyfluoroalkyl Substances*. March.

KHLG & Associates Inc., 2023. *Guam Army National Guard Final Spill Prevention, Control, and Countermeasure Plan.* January.

U.S. Environmental Protection Agency (USEPA). 1980. *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).* 11 December.

———. 1994. *National Oil and Hazardous Substances Pollution Contingency Plan (Final Rule).* 40 Code of Federal Regulations Part 300; 59 Federal Register 47384. September.

———. 2001. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation* Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments). December.

———. 2017. National Functional Guidelines for Organic Superfund Data Review. OLEM 9355.0-136, EPA-540-R-2017-002. Office of Superfund Remediation and Technology Innovation. January.

U.S. Fish and Wildlife Services (USFWS). 2022. Endangered Species. *https://ipac.ecosphere.fws.gov/location/O2E3HGNZR5GRZNKUIDLLFQJOEQ/resources*. Accessed 21 December.

Xiao, F., M. F. Simcik, T.R. Halbach, and J.S Gulliver. 2015, *Perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) in soils and groundwater of a U.S. metropolitan area: Migration and implications for human exposure*. Water Research 72:64-74.