FINAL
Remedial Investigation
Quality Assurance Project Plan
Santa Fe Army Aviation Support Facility, New Mexico

Remedial Investigations (RI) / Feasibility Studies (FS), Decision Documents, Time and Non-Time Critical Removal Actions (TCRA/NTCRA) for Per- and Polyfluoroalkyl Substances (PFAS) Impacted Sites, Army National Guard Installations, Nationwide

December 2024

Prepared for:

Army National Guard Bureau
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Acronyms and Abbreviations

%	percent
°C	degrees Celsius
°F	degrees Fahrenheit
A2P JV	AECOM Arcadis PFAS Joint Venture
AASF	Army Aviation Support Facility
AECOM	AECOM Technical Services, Inc.
AEL	Advanced Environmental Laboratories, Inc.
AFCEC	Air Force Civil Engineer Center
AFFF	aqueous film forming foam
AHA	Activity Hazard Analysis
ALS	ALS Environmental
amsl	above mean sea level
amu	atomic mass unit
AOI	Area of Interest
APP	Accident Prevention Plan
ARAR	Applicable or Relevant and Appropriate Requirement
Arcadis	Arcadis U.S., Inc.
ARNG	Army National Guard
ASTM	American Society for Testing and Materials
BA	Bachelor of Arts
BAA	Broad Agency Announcement
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BS	Bachelor of Science
Ca	calcium
CAS	Chemical Abstracts Service
CCB	continuing calibration blank
CCV	continuing calibration verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CoC	chain of custody
COC	chemical of concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CPR	cardiopulmonary resuscitation
CSM	conceptual site model
DA	Department of the Army
DD	Decision Document
DERP	Defense Environmental Restoration Program
DL	detection limit
DMA	Demonstration of Method Applicability

DO	dissolved oxygen
DoD	Department of Defense
DPT	direct-push technology
DQI	data quality indicator
DQL	data quality limit
DQO	data quality objective
DUA	data usability assessment
Dup	duplicate
EA	EA Engineering, Science, and Technology, Inc. PBC
ECF	electrochemical fluorination
EDD	electronic data deliverable
EIS	extracted internal standards
ELAP	Environmental Laboratory Accreditation Program
ELCR	excess lifetime cancer risk
EM	Engineer Manual
EQuIS	Environmental Quality Information System
ERA	ecological risk assessment
ERB	equipment rinsate blank
ESI	electrospray ionization
ESI-L	Environmental Standards International – Low Concentration Tuning Mix
ESTCP	Environmental Security Technology Certification Program
ESV	Ecological Screening Value
EtFOSE	N-ethyl perfluorooctane sulfonamidoethanol
Eurofins	Eurofins Lancaster Laboratory
FAA	Federal Aviation Administration
FD	field duplicate
FHUEA	2H-perfluoro-2-octenoic acid
FOUEA	2H-perfluoro-2-decenoic Acid
FRB	field reagent blank
FS	Feasibility Study
ft	feet
ft2	feet squared
FTOH	Fluorotelomer alcohols
FTS	fluorotelomer sulfonic acid
GC/MS	Gas Chromatograph/Mass Spectrometer
GIS	geographic information systems
GPS	global positioning system
HA	Health Advisory
HAZWOPER	Hazardous Waste Operations and Emergency Response
HDPE	high-density polyethylene
HFPO-DA	hexafluoropropylene oxide dimer acid
HHRA	human health risk assessment
HI	Hazard Index

HRTW	Hazardous, Toxic, and Radioactive Waste
IDQTF	Intergovernmental Data Quality Task Force
ICAL	initial calibration
ICB	initial calibration blank
ICV	initial calibration verification
IDW	investigation-derived waste
ISC	instrument sensitivity check
ITRC	Interstate Technology Regulatory Council
JSAI	John Shomaker & Associates
JV	joint venture
KY	Kentucky
LC/MS/MS	liquid chromatography tandem mass spectrometry
LCS	laboratory control spike
LCSD	laboratory control spike duplicate
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MBA	Master of Business Administration
MD	matrix duplicate
MDL	method detection limit
ME	Maine
mg/L	milligrams per liter
MI	Michigan
mL	milliliter
μg/kg	micrograms per kilograms
MO	Missouri
MPC	measurement performance criteria
MS	Master of Science
MS	matrix spike
μS/cm	micro Siemens per centimeter
MSD	matrix spike duplicate
mV	millivolts
NA	not applicable
NAVD88	North American Vertical Datum 1988
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NDIR	nondispersive infared
NELAP	National Environmental Laboratory Accreditation Program
NEtFOSAA	N-ethyl perfluorooctanesulfonamidoacetic acid
N-Et-FOSE	N-ethyl perfluorooctanesulfonamidoethanol
ng/L	nanograms per liter
NH	New Hampshire
NMARNG	New Mexico Army National Guard
NMED	New Mexico Environmental Department

NMeFOSAA	N-methyl perfluorooctanesulfonamidoacetic acid
NMOSE	New Mexico Office of the Engineer
NOAA	National Oceanic and Atmospheric Administration
No.	Number
NTCRA	Non-Time Critical Removal Action
NTU	nephelometric turbidity unit
OE/AAA	Obstruction Evaluation/Airport Airspace Analysis
OH	Ohio
OPSEC	Operational Security
ORP	oxidation-reduction potential
OSD	Office of the Secretary of Defense
OSHA	Occupational Safety and Health Administration
OWS	oil-water separator
oz	ounce
PA	Preliminary Assessment
Pace	Pace South Carolina
PAO	Public Affairs Office
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity
PE	Professional Engineer
PFAA	perfluoroalkyl acid
PFAS	per- and polyfluoroalkyl substances
PFBA	perfluorobutanoic acid
PFBS	perfluorobutanesulfonic acid
PFCA	perfluoroalkyl carboxylic acid
PFDA	perfluorodecanoic acid
PFDoA	perfluorododecanoic acid
PFDS	perfluorodecanesulfonic acid
PFHpA	perfluoroheptanoic acid
PFHpS	perfluoroheptanesulfonic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexanesulfonic acid
PFMBA	perfluoro-4-methoxybutanoic acid
PFMPA	perfluoro-3-methoxypropanoic acid
PFNA	perfluorononanoic acid
PFNS	perfluorononanesulfonic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PFOSA	perfluorooctanesulfonamide
PFPA	perfluoropentanoic acid
PFPeA	perfluoropentanoic acid
PFPrA	perfluoropropanoic acid
PFSA	perfluoroalkyl sulfonic acid

PFTeDA	perfluorotetradecanoic acid
PFUdA	perfluoroundecanoic acid
PFUnA	Perfluoroundecanoic acid
PG	Professional Geologist
PhD	Doctor of Philosophy
PID	photoionization detector
PM	Project Manager
PMP	Project Management Professional
PP	polypropylene
PPE	personal protective equipment
ppm	parts per million
PQAPP	Programmatic Quality Assurance Project Plan
PRG	Preliminary Remediation Goal
PSC	Pace South Carolina
PVC	poly-vinyl chloride
PWS	Performance Work Statement
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QL	quantitation limit
QSM	Quality Systems Manual
RAGS	Risk Assessment Guidance for Superfund
RF	response factor
RI	Remedial Investigation
ROE	right of entry
RPD	relative percent difference
RSC	Rapid Site Characterization
RSD	relative standard deviation
RSL	Regional Screening Level
RT	retention time
SAF	Santa Fe Regional Airport
SC	specific conductance
SC	South Carolina
SDG	sample delivery group
SERDP	Strategic Environmental Research and Development Program
SGS	SGS North American, Inc.
SI	Site Inspection
SL	Screening Level
SLERA	Screening-Level Ecological Risk Assessment
S/N	signal to noise ratio
SOP	standard operating procedure
SPE	solid phase extraction
SS	Site Supervisor

SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
TAT	turn-around time
TBD	to be determined
TCRA	Time Critical Removal Action
T&E	threatened and endangered
TN	Tennessee
TO	task order
TOC	total organic carbon
TPP	technical project planning
TSA	Technical System Audit
TX	Texas
UCL	upper confidence limit
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
USGS	United States Geological Survey
UU/UE	unlimited use/unrestricted exposure
VA	Virginia
WV	West Virginia
WWTP	wastewater treatment plant

1.0 Introduction

1.1 Project Authorization

This Remedial Investigation (RI) Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP) (also referred to as the "QAPP") addresses RI activities to be completed at the Santa Fe Army Aviation Support Facility (AASF) (also referred to as the "Santa Fe AASF" and the "facility"), in Santa Fe, New Mexico. RI activities for the facility will be conducted over multiple mobilizations, including Prescriptive, Adaptive, and Final Characterization/Monitoring Phases. This UFP-QAPP describes the sampling design for the Prescriptive Phase and overall technical approach for the RI program. Additional planning documents will be prepared for subsequent phases of work.

The Army National Guard (ARNG) G-9 is the lead agency in performing *Remedial Investigations (RIs)/Feasibility Studies (FSs), Decision Documents (DDs), Time and Non-Time Critical Removal Actions (TCRA/NTCRA) for Per- and Polyfluoroalkyl Substances (PFAS) Impacted Sites, ARNG Installations, Nationwide*. Documents and reports for subsequent phases of work including the FS, DDs, and TCRA/NTCRA, will be prepared under separate covers, as applicable. This work is supported by the United States (U.S.) Army Corps of Engineers (USACE) Baltimore District and their contractor AECOM Technical Services, Inc. (AECOM)-Arcadis U.S., Inc. (Arcadis) PFAS Joint Venture (JV; herein referred to as the "A2P JV") under Contract Number W912DR-23-D-0007, Task Order (TO) *W912DR23F0388* issued 27 September 2023, and Performance Work Statement (PWS) dated 25 September 2023 (referred to as TO #02). Execution of this work will be performed by the A2P JV.

Programmatically, the ARNG is assessing the potential environmental impacts primarily from aqueous film forming foam (AFFF) and similar chemical releases suspected at their properties related to processes that used PFAS (e.g., fire training and firefighting). A Preliminary Assessment (PA) and Site Inspection (SI) were performed at each of the facilities associated with these TOs under a separate contract on behalf of the ARNG. The PA determined whether there were potential sources and releases to the environment related to processes that used PFAS-containing materials. Based on the findings of the PAs, certain ARNG facilities moved forward to the SI phase for further evaluation. The SIs evaluated the presence or absence of relevant PFAS concentrations above screening levels (SLs), as established by the Office of the Assistant Secretary of Defense (OSD) policy (Assistant Secretary of Defense, 2023). Based on the findings of the SI, ARNG facilities where the presence of relevant PFAS constituents was confirmed to exceed the SLs moved forward to the RI phase.

The RI project elements will be performed by A2P JV in accordance with the 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 (also referred to as the "National Oil and Hazardous Substances Pollution Contingency Plan [NCP]"; 40 Code of Federal Regulations [CFR] 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 PFAS. The term PFAS will be used throughout this QAPP to encompass all PFAS chemicals being evaluated in the RI. Those PFAS with accepted SLs are considered "relevant compounds" at the time of development of this QAPP and will be assessed and updated accordingly if changes to policy, including screening level updates, are formally accepted by OSD.

1.2 RI Purpose

The objective of the RI is to determine the nature and extent of PFAS above SLs at the Area of Interest (AOI) identified in the PA and the SI where the presence of relevant PFAS was confirmed during the SI.

Additionally, the RI will gather sufficient data to define release areas, potential migration pathways, potential receptors, and associated exposure routes. The data will support informed risk management decisions, including whether, or to what extent, a threat to human health or the environment exists.

1.3 QAPP Document Organization

This QAPP meets the requirements and elements set forth in the UFP for QAPPs (Intergovernmental Data Quality Task Force [IDQTF], 2005a-c) and *EPA Requirements for Quality Assurance Project Plans* (USEPA, 2001). The QAPP is comprehensive to the extent practicable and does not refer to or rely on separate work plans, consistent with the USEPA's intent that the QAPP be the premier planning document for an entire project (IDQTF, 2012). Minimizing the existence of separate work plans maintains consistency across project elements and optimizes the administrative effort required to review and revise project documents. The components that are covered under this QAPP are described in **Table 1-1** below.

Table 1-1 Components of the RI QAPP

QAPP Worksheets
Worksheets #1 & #2 – Title and Approval Page and QAPP Identifying Information
Worksheets #3 & #5 – Project Organization and QAPP Distribution
Worksheets #4, #7, & #8 – Personnel Qualifications and Sign-off Sheet
Worksheet #6 – Communication Pathways
Worksheet #9 – Technical Project Planning Session Summary
Worksheet #10 – Conceptual Site Model
Worksheet #11 – Project/Data Quality Objectives
Worksheet #12 – Measurement Performance Criteria
Worksheet #13 – Secondary Data Uses and Limitations
Worksheets #14 & #16 – Project Tasks and Schedule
Worksheet #15 – Project Data Quality Limits and Laboratory-Specific Detection/Quantitation Limits
Worksheets #17 & #18 – Sampling Design and Rationale
Worksheets #19 & #30 – Sample Containers, Preservation, and Hold Times
Worksheet #20 – Field Quality Control Summary
Worksheet #21 – Field Standard Operating Procedures
Worksheet #22 – Field Equipment Calibration, Maintenance, Testing, and Inspection
Worksheet #23 – Analytical Standard Operating Procedures
Worksheet #24 – Analytical Instrument Calibration
Worksheet #25 – Analytical Instrument and Equipment Maintenance, Testing, and Inspection
Worksheets #26 & #27 – Sample Handling, Custody, and Disposal

QAPP Worksheets
Worksheet #28 – Analytical Quality Control and Corrective Actions
Worksheet #29 – Project Documents and Records
Worksheets #31, #32, & #33 – Assessments and Corrective Action
Worksheet #34 – Data Verification and Validation Inputs
Worksheet #35 – Data Verification Procedures
Worksheet #36 – Data Validation Procedures
Worksheet #37 – Data Usability Assessment

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Worksheets #1 & #2: Title and Approval Page and QAPP Identifying Information

Facility Name/Project Name: Remedial Investigations (RIs)/Feasibility Studies (FSs), Decision Documents (DDs), Time and Non-Time Critical Removal Actions (TCRA/NTCRA) for Per- and Polyfluoroalkyl Substances (PFAS) Impacted Sites, ARNG Installations, Nationwide

Installation: Santa Fe Army Aviation Support Facility, New Mexico

Contract Work Assignment Number: USACE Contract No. W912DR-23-D-0007
Task Order No. W912DR23F0388

Relevant Plans and Reports from Previous Investigations: Relevant plans and reports from previous investigations are identified in the references cited in the introductory text that precedes these worksheets and in subsequent worksheets, as appropriate.

	Mitchell, Claire Digitally signed by Mitchell, Claire DN: cn=Mitchell, Claire, ou=USSTL1, email=claire.mitchell@aecom.com Date: 2024.12.19 10:42:34 -05'00'
Investigative Organization Project Manager Printed Name / Organization	Signature / Date Claire Mitchell, PEPMP / A2P JV Project Manager
	Laurie Stenberg Digitally signed by Laurie Stenberg Date: 2024.12.19 10:56:22 -05'00'
Investigative Organization Quality Manager Printed Name / Organization	Signature / Date Laurie Stenberg PG / A2P JV Program Quality Control Officer
	SOLOMON.JENNIFER.LYNN.1286954568 Digitally signed by SOLOMON.JENNIFER.LYNN.1286954568 Date: 2024.12.19 14:09:53 -05'00'
Federal Project Lead Printed Name / Organization	Signature / Date Jennifer Solomon / Army National Guard G-9 Program Manager
	FRITZSCHE.CHRISTOPHER.EUGENE.1144436837 Digitally signed by FRITZSCHE.CHRISTOPHER.EUGENE.1144436837 Date: 2024.12.19 12:46:16 -07'00'
New Mexico Army National Guard Printed Name / Organization	Signature / Date Christopher Fritzsche / NMARNG Environmental Specialist
	CLINE.EMILY.JORDAN.1536813884 Digitally signed by CLINE.EMILY.JORDAN.1536813884 Date: 2024.12.19 13:18:02 -05'00'
Contract Organization Project Manager Printed Name / Organization	Signature / Date Emily Cline, PG / USACE Baltimore District, Nationwide Program Manager

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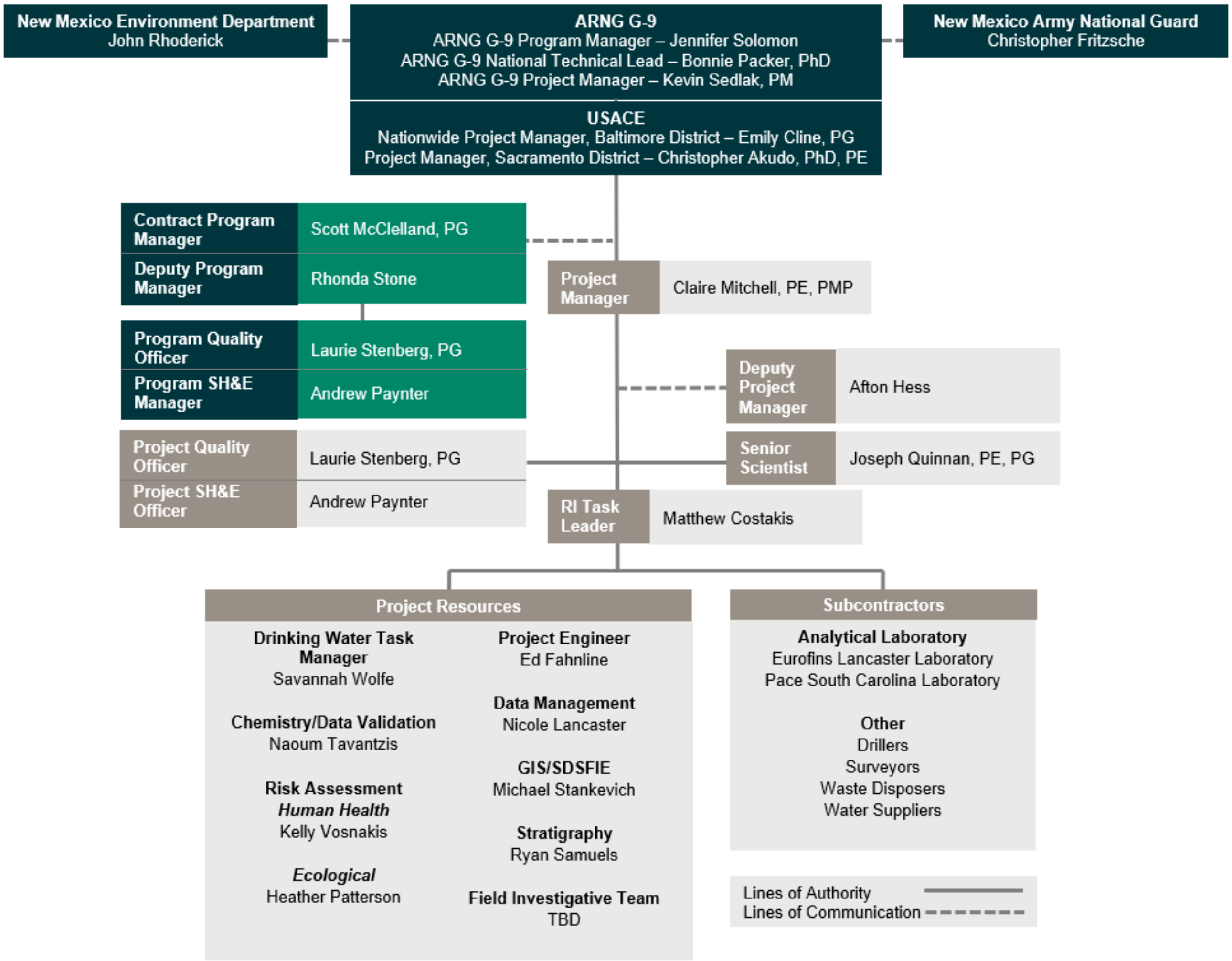
Worksheets #3 & #5: Project Organization and QAPP Distribution

The organization chart in **Figure 3-1** will identify key project personnel, as well as lines of authority and communication for each RI among the ARNG, USACE, prime contractor (A2P JV) and other stakeholders. The QAPP will be distributed to all parties noted in **Figure 3-1**.

Figure 3-1 Project Organizational Chart



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Worksheets #4, #7 & #8: Personnel Qualifications and Sign-off Sheet

This worksheet contains a list of the key project personnel who are identified for performing the tasks that are defined in this QAPP and includes the personnel's organization, project role, education/experience, and specialized training/certifications. The personnel have signed and dated the worksheet to signify that they agree with the information in this QAPP and agree to implement it.

Name	Organization	Project Role	Education/Experience	Specialized Training / Certifications	Signature/Date
Scott McClelland, PG	A2P JV	Contract Program Manager	Education: BA, Geology; MS, Geology Experience. 31+ years; executing and managing environmental investigation and remediation projects including program management of USACE Baltimore contracts.	Professional Geologist, KY AECOM Certified PM OSHA 40hr HAZWOPER OSHA 8hr Refresher	Signature available upon request.
Rhonda Stone, PMP	A2P JV	Deputy Contract Program Manager	Education: BS, Environmental Science Experience: 28+ years of experience. Program Manager/PM for Hazardous, Toxic and Radioactive Waste projects and USAEC Environmental Remediation Multiple Award contracts. Previously a Program Manager for the Army's Operational Range Assessment Program for the USAEC and USACE	PMP Certification Arcadis Certified PM OSHA 40hr HAZWOPER OSHA 8hr Refresher Arcadis PFAS Training	Signature available upon request.
Claire Mitchell, PE, PMP	A2P JV	Project Manager	Education: BS, Civil Engineering Experience: 11+ years; environmental engineering experience, including task management for PFAS investigations for DoD clients; PFAS Technical Practice Lead Verifier.	Professional Engineer, MO PMP Certification AECOM Certified PM OSHA 40hr HAZWOPER OSHA 8hr Refresher AECOM PFAS Sampling Training	Signature available upon request.

Name	Organization	Project Role	Education/Experience	Specialized Training / Certifications	Signature/Date
Afton Hess	A2P JV	Deputy Project Manager	Education: BS, Natural Resources and Environmental Management Experience: 19+ years project scientist/manager working on munitions response projects, PFAS PA/SI for USAEC Active Army projects, and PFAS RI for ARNG projects.	Arcadis Certified PM OSHA 40hr HAZWOPER OSHA 8hr Refresher OSHA 8hr Supervisor Arcadis PFAS Training	Signature available upon request.
Joe Quinnan, PE, PG	A2P JV	Senior Scientist	Education: BS, MS Geological Engineering Experience: 33+ years; served as Global lead for site characterization, North American lead for emerging contaminants and technical lead for US Army PFAS PA/SI program, program technical lead for Army and Air Force PFAS RI program; technical lead for several USACE-led remediation projects for DoD, Principal Investigator for five ESTCP projects and three AFCEC BAA projects.	Professional Engineer, WI Professional Geologist, WI Arcadis PFAS Training	Signature available upon request.
Laurie Stenberg, PG	A2P JV	Project Quality Officer	Education: BA, Geology Experience: 31+ years; served as senior scientist for ORA Phase II Task Orders; experience with PFAS investigations.	Professional Geologist, Pennsylvania AECOM Certified PM OSHA 40hr HAZWOPER OSHA 8hr Refresher AECOM PFAS Sampling Training	Signature available upon request.

Name	Organization	Project Role	Education/Experience	Specialized Training / Certifications	Signature/Date
Andrew Paynter	A2P JV	Federal Program Safety, Health, and Environment Manager	Education: Course Work in Environmental Health and Safety Experience: 19+ years working in the environmental and construction industries, 9+ years managing safety, health, and environment on construction, environmental, and remediation projects.	Construction Health and Safety Technician Safety Trained Supervisor Construction HAZWOPER 40hr Certification HAZWOPER 8hr Supervisor HAZWOPER 8hr Refresher OSHA 30hr Construction Safety Excavation Competent Person Trained Fall Protection Competent Person Trained MSHA 24-Hour NFPA 70 E	Signature available upon request.
Stephanie Tjan, PE	A2P JV	Program Coordinator – Processes	Education: BS, Civil Engineering; MS, Civil and Environmental Engineering Experience: 6+ years working on remediation projects in federal DoD contracts with experience in supporting/leading PFAS Site Inspections and Remedial Investigations.	Professional Engineer, MI OSHA 40hr HAZWOPER OSHA 8hr Refresher OSHA 10hr Construction First Aid/CPR AECOM PFAS Sampling Training	Signature available upon request.
Savannah Wolfe	A2P JV	Program Coordinator – Resources / Drinking Water Task Manager	Education: BS, Chemistry; MS, Chemistry Experience: 5+ years working on remediation projects in federal DoD contracts with experience in supporting/leading PFAS Site Inspections and Remedial Investigations.	AECOM Certified PM OSHA 40hr HAZWOPER OSHA 8hr Refresher First Aid/CPR AECOM PFAS Sampling Training	Signature available upon request.

Name	Organization	Project Role	Education/Experience	Specialized Training / Certifications	Signature/Date
Matthew Costakis, PG	A2P JV	Program Coordinator – Field Work RI Task Manager	Education: BS, Geology Experience: 17+ years managing environmental investigations; senior geologist for multiple PFAS investigations for DoD clients; task lead for multiple PFAS SIs and RIs for DoD clients; Environmental Site Characterization Practice Lead Verifier.	Professional Geologist, VA, TN OSHA 40hr HAZWOPER OSHA 30hr Construction Manager OSHA 8hr Refresher OSHA 8hr Supervisor AECOM PFAS Sampling Training	Signature available upon request.
Carla DaParma	A2P JV	Program Coordinator – Scheduling	Education: BS, Chemical Engineering Experience: 18+ years of experience in environmental investigations and remediation, including direct management experience with USACE for PFAS Investigations at multiple DoD facilities both Active Army, Air Force, and ARNG. Provide project quality control on PFAS investigations for Active Army installations.	Arcadis Certified PM OSHA 40-Hour HAZWOPER OSHA 8-Hour Refresher Arcadis PFAS Training	Signature available upon request.
David Parse, Jr., PG	A2P JV	Conceptual Site Modeling and Sequence Stratigraphy	Education: BA and MS, Geology Experience: 29+ years of executing environmental site investigations and remediation, including PFAS, for DoD clients; CSM Subject Matter Expert, including leading 42 complex Base-wide and/or facility-specific CSMs at DoD installations using sequence stratigraphy; AECOM PRISM® Team Lead.	Professional Geologist, TX AECOM Certified PM OSHA 40hr HAZWOPER OSHA 8hr Refresher 8hr OSHA Supervisor	Signature available upon request.

Name	Organization	Project Role	Education/Experience	Specialized Training / Certifications	Signature/Date
Ryan Samuels, PG	A2P JV	Conceptual Site Modeling and Sequence Stratigraphy	Education: BS, Geology/Applied Mathematics; MS, Sequence Stratigraphy Experience: 6+ years developing integrated hydrogeologic CSMs at some of the DoD's most complex remedial sites, including PFAS RI support. PRISM® subject matter expert.	Professional Geologist, VA OSHA 40hr HAZWOPER OSHA 8hr Refresher AECOM PFAS Sampling Training	Signature available upon request.
Corey Theriault, PE	A2P JV	Feasibility Studies / PFAS Treatment	Education: BS, Chemical Engineering Experience: 21+ years; North American technical expert for PFAS treatment technologies. Engineering manager for PFAS treatment systems at several US DoD installations.	Professional Engineer, ME/NH/OH/SC/WV 40 HR OSHA 8 HR OSHA Refresher Arcadis PFAS Training Trainer	Signature available upon request.
David Liles	A2P JV	Treatability Studies	Education: BS, Biology, MS, Biology Experience: 30+ years with Arcadis Treatability Laboratory; Currently managing Treatability Laboratory.	OSHA 40hr HAZWOPER OSHA 8hr Refresher	Signature available upon request.
Naoum Tavantzis	A2P JV	Project Chemist	Education: BA, Environmental Science; MBA Experience: 15+ years; project chemist for ORA Phase II Tos; PFAS Investigations, data validation, laboratory coordination; project chemist for ANG expanded SIs; PFAS Technical Practice Lead Verifier.	OSHA 40hr HAZWOPER OSHA 8hr Refresher OSHA 8hr Site Supervisor	Signature available upon request.

Name	Organization	Project Role	Education/Experience	Specialized Training / Certifications	Signature/Date
Michael Stankevich	A2P JV	GIS Specialist	Education: BA, Geography – Environmental Track Experience: 14+ years; completed SDSFIE submittals for multiple ARNG installations	NA	Signature available upon request.
Nicole Lancaster	A2P JV	Data Management	Education: BS, Marine Biology; MS, Chemistry Experience: 11+ years, experience with data validation, data management, laboratory coordination, and field sampling.	OSHA 40hr HAZWOPER OSHA 8hr Refresher First Aid/CPR AECOM PFAS Sampling Training	Signature available upon request.
Vanessa Badman	Eurofins Lancaster Laboratories	Laboratory Project Manager	Education: BS Biology Experience: 10 years laboratory and project management experience	NA	Signature available upon request.
Kathy Smith	Pace South Carolina	Laboratory Project Manager	Education: BS Environmental Science Experience: 23 years laboratory and project management experience	NA	Signature available upon request.

Notes:
A2P JV = AECOM Arcadis PFAS Joint Venture
AECOM = AECOM Technical Services, Inc.
AFCEC = Air Force Civil Engineer Center
Arcadis = Arcadis U.S., Inc.
ARNG = Army National Guard
BA = Bachelor of Arts
BAA = Broad Agency Announcement
BS = Bachelor of Science
CPR = cardiopulmonary resuscitation
CSM = Conceptual Site Model
DoD = Department of Defense
DQO = data quality objective
EM = engineering manual
ERA = Ecological Risk Assessment
ESTCP = Environmental Security Technology Certification Program
GIS = Geographic Information System
HAZWOPER = Hazardous Waste Operations and Emergency Response
HHRA = human health risk assessment
KY = Kentucky
MBA = Master of Business Administration
ME = Maine
MI = Michigan
MO = Missouri
MS = Master of Science
MSHA = Mine Safety and Health Administration
NA = not applicable
NFPA = National Fire Protection Association
NH = New Hampshire
NY = New York
OH = Ohio
ORA= Operational Range Assessments
OSHA = Occupational Safety and Health Administration
PA = Preliminary Assessment
PE = Professional Engineer
PFAS = per- and polyfluoroalkyl substances
PG = Professional Geologist
PM = Project Manager
PMP = Project Management Professional
PRISM™ = Predictive Integrated Stratigraphic Modelling
QAPP = Quality Assurance Project Plan

RI = Remedial Investigation
SC = South Carolina
SDSFIE = Spatial Data Standards for Facilities, Infrastructure, and Environment
SI = Site Inspection
SVOC = Semi-volatile organic compounds
TN = Tennessee
TX = Texas
US = United States
USACE = United States Army Corps of Engineers
USAEC = United States Army Environmental Command
VA = Virginia
VOC = Volatile organic compounds
WA = Washington
WI = Wisconsin
WV = West Virginia

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Worksheet #6: Communication Pathways

Worksheet #6 documents the drivers that trigger the need to communicate with other project personnel or stakeholders. The purpose of **Worksheet #6** is to ensure there are procedures in place for providing the appropriate notifications and generating the appropriate documentation when handling important communications, including those involving regulatory interfaces, unexpected events, emergencies, non-conformances, and stop-work orders.

Communication Driver	Organization	Name	Contact Information	Procedure (Timing, Pathway, Documentation)
USACE Program Manager decisions and modification	USACE Baltimore District Nationwide Program Manager	Emily Cline, PG	410-962-7966 emily.j.cline@usace.army.mil	Award work and options. Track project progress through monthly reporting and daily field reporting. Stop work for quality or performance concerns.
USACE Project Manager – technical review and contractual oversight	USACE Sacramento District Project Manager	Christopher Akudo, PhD, PE	916-557-5214 christopher.o.akudo@usace.army.mil	The A2P JV PM will obtain USACE technical review and concurrence of the QAPP and project documents and any field modifications/QAPP changes, as necessary. Approved modifications will be included in QAPP revisions (prior to field work). USACE technical review and comments will be incorporated into the QAPP and project documents and a record of USACE comments saved in project files for documentation.
ARNG Program Manager	ARNG Program Manager	Jennifer Solomon	703-607-7589 jennifer.l.solomon20.civ@army.mil	Receives all deliverables to be filed on the ARNG electronic Administrative Record.
ARNG Nationwide technical review	ARNG Technical Lead	Bonnie Packer, PhD	301-518-0860 bonnie.m.packer.ctr@army.mil	Provides overall programmatic technical reviews.

Communication Driver	Organization	Name	Contact Information	Procedure (Timing, Pathway, Documentation)
ARNG Project Manager and program technical review	ARNG Project Manager	Kevin Sedlak, PG	330-235-2153 kevin.m.sedlak.ctr@army.mil	The A2P JV PM will obtain ARNG technical review and concurrence of the QAPP and project documents and any field modifications/QAPP changes, as necessary. Approved modifications will be included in QAPP revisions (prior to field work). ARNG technical review and comments will be incorporated into the QAPP and project documents and a record of ARNG comments saved in project files for documentation.
Regulatory agency interface				The ARNG G-9 PM will communicate technical approaches and decisions directly to regulatory agencies' representative(s) on an as-needed basis, documented via phone records and emails.
Community/ media interface				The ARNG G-9 PM in coordination with the respective NMARNG Point of Contacts/PAO will communicate information directly to communities or media on an as-needed basis.
Installation interface	NMARNG	Christopher Fritzsche	505-365-4404 christopher.e.fritzsche@nfg.army.mil	Communicate project scope/schedule and coordinate logistics between project team and installation personnel on an as-needed basis, documented via phone records and emails. Additionally, the QAPP and other project deliverables will be provided to the OPSEC and PAO for review.
Manage all project phases Field progress reports Field modifications/QAPP changes	A2P JV Project Manager A2P JV Deputy Project Manager	Claire Mitchell, PE, PMP Afton Hess	716-698-5705 claire.mitchell@aecom.com 717-682-5405 afton.hess@arcadis.com	All materials and information about the project will be forwarded from the A2P JV PM to ARNG/ USACE. The A2P JV PM will obtain ARNG/ USACE approval/ concurrence for field modifications/QAPP changes as necessary. All approved modifications will be included in QAPP revisions (prior to field work) or non-conformance report(s) (during field work), and resolution / corrective action identified.
	A2P JV RI Task Manager	Matthew Costakis, PG	301-944-5915 matt.costakis@aecom.com	Support A2P JV PM in implementing RI tasks/procedures.

Communication Driver	Organization	Name	Contact Information	Procedure (Timing, Pathway, Documentation)
	A2P JV Program Quality Manager	Laurie Stenberg, PG	301-500-4573 laurie.stenberg@aecom.com	Oversees/conducts quality audits to assure field program performed in accordance with approved protocols. Supports A2P JV PM, Technical Task Manager, and Team Leaders to assure quality reviews are completed on project deliverables, including consistency and conformance with applicable regulatory and DoD guidance and with industry practices. Works with Project Chemist to resolve performance problems with contracted analytical laboratory.
Analytical laboratory modifications and performance problems	A2P JV Project Chemist/ Data Validator	Naoum Tavantzis	301-267-8761 naoum.tavantzis@aecom.com	Notify A2P JV PM and Quality Manager in a timely manner of performance problems encountered by the contracted analytical laboratory. PM will secure approval for modifications to the QAPP as necessary from ARNG/ USACE. All approved modifications will be included in non-conformance Reports.
Data verification issues (e.g., incomplete records) and data validation issues (e.g., non-compliance with procedures)				Verify/validate all analytical chemistry sample results from analytical laboratories with criteria developed in this QAPP and deliver to the PM and the Project Task Managers.
Data review corrective actions				Notify Laboratory PMs to identify resolution/corrective actions.

Communication Driver	Organization	Name	Contact Information	Procedure (Timing, Pathway, Documentation)
Sample receipt variances	Eurofins Lancaster Laboratories Pace South Carolina	Vanessa Badman Kathy Smith	717-556-9762 vanessa.badman@eurofinset.com 225-769-4900 kathy.smith@pacelabs.com	Report all project non-conformances and problems to the A2P JV Project Chemist. A2P JV and laboratory chemists will resolve all non-conformances with appropriate error codes in verification processes.
Laboratory QC variances				Report all project non-conformances and problems to the A2P JV Project Chemist. A2P JV and laboratory chemists will resolve all non-conformances with appropriate error codes in verification processes.
Analytical corrective actions				Report all project non-conformances and problems to the A2P JV Project Chemist. A2P JV and laboratory chemists will resolve all non-conformances with appropriate error codes in verification processes.
Laboratory modifications and performance problems				Report all project non-conformances and problems to the laboratory PMs. Laboratory PMs will report to A2P JV Project Chemist. A2P JV and laboratory chemists will resolve all non-conformances with appropriate error codes in verification processes.

Notes:
A2P JV = AECOM Arcadis PFAS Joint Venture
ARNG = Army National Guard
DoD = Department of Defense
NMARNG = New Mexico Army National Guard
PAO = Public Affairs Office
PG = Professional Geologist
PE = Professional Engineer
PhD = Doctor of Philosophy
PM = Project Manager
PMP = Project Management Professional
OPSEC = Operations Security
QAPP = Quality Assurance Project Plan
QC = Quality Control
USACE = US Army Corps of Engineers

Worksheet #9: Technical Project Planning Session Summary

This worksheet will serve as a record of future Technical Project Planning (TPP) sessions. The intent is to provide a concise record of participants, key decisions or agreements reached, and action items. Minutes and the accompanying slide decks will be approved by participants prior to being implemented into the QAPP (**Appendix A**).

A2P JV will implement the TPP process as listed in Engineer Manual (EM) 200-1-2 (USACE, 2016), including facility meetings in a professional and organized manner to obtain consensus on specific Data Quality Objectives (DQOs) for the RI work. Per the PWSs, up to eight TPP meetings per facility will be held, in person or via teleconference, as described below:

- Meeting 1 (6 March 2024) – Introduce project team members and stakeholders to ARNG's PFAS RI program, discuss the overall planned RI approaches, discuss the project schedule, and gain input on stakeholder preferences.
- Meeting 2 (21 October 2024) – Present the QAPP, including planned approaches implementation. Ensure all stakeholders are in agreement with planned investigative strategies, work schedules, and notification procedures to ensure smooth execution of field work.
- Meeting 3 (date TBD) – Present the results for RI Mobilization 1 (Prescriptive Phase), the evaluation of the plume extent to date, and a preview of the anticipated scope for the RI Mobilization 2 (Adaptive Phase).
- Meeting 4 (date TBD) – Resolve comments or concerns about the anticipated scope of work for RI Mobilization 2 or implementation not already addressed during response to comments.
- Meeting 5 (date TBD) – Present findings of the RI (Prescriptive Phase and Adaptive Phase mobilizations) and gain concurrence on presentation of findings in the RI Report.
- Additional Meetings 6 through 8 (as needed; dates TBD) – Additional meetings that may be held based on the findings of the RI or to address any unforeseen issues that require further discussion.

Meeting minutes will be prepared after each TPP meeting and added as an attachment to the corresponding document. TPP meeting minutes are included in **Appendix A**.

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Worksheet #10: Conceptual Site Model

10.1 Facility Location and Description

The Santa Fe AASF is located within the incorporated limits of and approximately 10 miles southwest of downtown Santa Fe, New Mexico. The 33-acre facility is located on the north side of the Santa Fe Regional Airport (SAF) and is leased to the New Mexico Army National Guard (NMARNG) by the City of Santa Fe (City). The land was acquired in 1976, and the original facility was constructed in 1979. The original facility consisted of an AASF building and hangar and a small parking apron for helicopters. In 2012, the facility was renovated with a new, larger AASF building constructed adjacent to the former AASF building, and the former AASF building was converted to the Santa Fe Readiness Center (AECOM, 2020).

The properties immediately surrounding the AASF are also owned by the City, with the Santa Fe Wastewater Treatment Plant (WWTP) to the north, and the Santa Fe Regional Airport immediately to the west, south, and east (**Figure 10-1**) (AECOM, 2020).

10.2 Facility Environmental Setting

The Santa Fe AASF is at an elevation of approximately 6,330 feet (ft) elevation North American Vertical Datum 1988 (NAVD88). The facility is included on the U.S. Geological Survey Turquoise Hill 7.5-minute quadrangle topographic map. The geographic coordinates for the center of the facility are 106°18'31.454"W; 35°37'27.146"N. The facility is predominantly developed, with two large buildings, several nearby support structures, and a helicopter parking apron. One of the large buildings, built in 1979 and renovated in 2012, is the former AASF and the current administration headquarters for the Santa Fe Readiness Center. The second building is the current AASF, which is comprised of a 75,000-square-foot (ft^2) hangar/administration building. A 16,400 ft^2 storage building; a guard house; fuel storage area; and 455,000 ft^2 of concrete airfield paving also exist on the property (AECOM, 2020). Smaller, unpaved areas exist around the periphery of the facility. Topography of the area is displayed in **Figure 10-2**.

10.2.1 Geology

Santa Fe is located in the southern portion of the Española Basin within the Rio Grande Rift. The Rio Grande Rift is a zone of east-west oriented tectonic extension that trends from central Colorado south through New Mexico. The Rift began forming around 25 million years ago due to a change in motion between the North American and Pacific plate boundaries. Extensional forces resulted in crustal thinning, subsequent volcanism, and half-graben mountain/valley complexes that formed New Mexico's structural basins and central mountain ranges. Large amounts of sediment filled these structural basins, including in the southern portion of the Española Basin, with deposits from the southwest flowing ancestral Santa Fe River and alluvial fan deposits sourced from the Sangre De Cristo Mountains east of Santa Fe. Additional sediment derived from the Cerillos Uplift southwest of Santa Fe flowed northeast as alluvial fans and volcaniclastic deposits. These Cerillos Uplift sourced sediments intermingle with those from the ancestral Santa Fe River and Sangre de Cristo Mountains in the western Española Basin along the Santa Fe River, Arroyo Hondo, and La Cienega (Koning et al., 2002). Occasional basaltic lava flows cap the sedimentary deposits throughout the basin. Together, these basin-fill units compose the Santa Fe Group, which thickens to the west and north, ranging from approximately 250 ft thick south of the city to greater than 10,000 ft beneath the Pajarito Plateau west of Española (AECOM, 2020).

Near the Facility, the Pliocene to lower Pleistocene aged Ancha Formation constitutes the upper basin-fill unit of the Santa Fe Group and is bounded from the underlying Tesuque Formation by an angular unconformity. Sediments that compose the Ancha Formation were derived from the

Sangre de Cristo Mountains by southwest-flowing, alluvial slope streams and the ancestral Santa Fe River. As a result, the Ancha Formation consists of poorly sorted gravels and sand from debris flows and braided channel bar deposits, very fine to fine sand from periodic high energy sheet-flood deposits, and silt to silty clay floodplain deposits. Overall, the Ancha Formation gradually thins to the southwest and in the vicinity of the AASF is suspected to range in thickness from less than 100 feet to 200 feet (Johnson and Koning, 2012). It is generally yellow-brown-tan in color, coarser grained, less consolidated, and more permeable than the underlying Tesuque Formation. The regional geologic features at the AASF are shown on **Figure 10-3**.

The late Oligocene to late Miocene aged Tesuque Formation is comprised of multiple coalescing alluvial fans deposited along the flanks of the Sangre de Cristo Mountains and the Cerillos Uplift. The individual alluvial fan deposits have been classified as separate “lithosomes”; beneath the vicinity of the AASF lies “lithosome S”, which was deposited on a west-sloping alluvial fan near the ancestral Santa Fe River (Cavazza, 1986; Koning et al., 2004). The deposits under the facility and surrounding area formed in a region of low slopes between the toes of the west-sloping, ancestral Santa Fe River fluvial fan and the northeast-sloping, volcaniclastic fans from the Cerrillos Uplift. Under these conditions, accommodation – the space available for deposition – was greater than the sediment supply, which resulted in the lower energy deposition of large bodies of silty to clayey floodplain and paludal sediments, silt to fine sand splay deposits, and sandy to pebbly meandering channel bar deposits. The thickness of the Tesuque Formation is thought to be up to 10,000 feet thick within the Santa Fe area. It has been described as red, orange-brown, red-brown, and pinkish (Lazarus and Drako, 1995),and is considerably less permeable than the overlying Ancha Formation.

Soils encountered during the SI were dominated by well-graded sand with interbedded gravel, silt, and clay. The SI boring logs indicate coarser grained, tan to brown deposits over much of the logged section, suggesting that the SI borings were completed primarily within the Ancha Formation. As currently interpreted, the Tesuque Formation was observed only in the deeper SI borings, at depths typically below 150 feet below ground surface (bgs). Samples for grain size analyses were collected at two locations, AOI101-01 and AOI01-02, and analyzed via ASTM International (ASTM) Method D-422. The results indicate that the soil samples are comprised primarily of sand (30.5 to 50.3 percent [%]) and silt (57.3 to 41.3%). These results and field observations are consistent with the reported depositional environment of the region.

10.2.2 Hydrogeology

The Santa Fe Group, the regional aquifer system including the Ancha and Tesuque Formations, is the principal groundwater resource for the cities of Santa Fe, Española, and six Pueblo nations. Though in hydraulic communication and regionally mapped as one unit, the Ancha Formation is coarser grained, less consolidated, and more permeable than the underlying Tesuque Formation, indicating differing groundwater flow regimes at different depths. Available aquifer tests demonstrate that Ancha Formation deposits have hydraulic conductivities 1 to 3 orders of magnitude larger than those of the Tesuque Formation (Johnson and Koning, 2012).

The unconformable base of the Ancha Formation sits on an undulating erosional surface of the Tesuque Formation, creating buried valleys infilled with higher permeability Ancha sediments. As the Santa Fe Group thins to the southwest of the basin, groundwater stored in the Ancha paleo-valleys discharges to the ground surface, creating springs and seeps in La Cienega and Cieneguilla (Johnson et al., 2016). Vertical hydraulic gradients across the Ancha-Tesuque contact vary in direction and magnitude across the basin. At the western basin fringe, neutral or slight downward gradients are documented, though data is sparse near the facility (Johnson et al., 2008). The Santa Fe Group aquifers are in hydraulic communication with Precambrian rocks along the eastern margin of the basin where most of the recharge occurs. Paleozoic limestones underlying the basin-fill aquifers, fractured Tertiary intrusive rocks, and Tertiary volcanics of the Jemez volcanic field also locally produce water. Recharge within the basin is assumed to occur primarily from the higher elevations with little or no recharge from the lower elevations because of high evapotranspiration and low precipitation (AECOM, 2020).

Regional groundwater studies of the Santa Fe Group indicate the Facility is near a groundwater divide and groundwater may travel southwest toward the Santa Fe River or south toward Arroyo Hondo/Cienega Creek (Johnson et al., 2016). This ambiguity in flow direction may be a result of groundwater levels within the Ancha and Tesuque Formations being mapped as a single aquifer (Santa Fe Group), despite their stark permeability contrast. Studies indicate a rise in the “topography” of the Ancha-Tesuque contact south of the Facility, which may some direct groundwater flow west from the Facility towards the Santa Fe River, before turning south towards Cieneguilla (Johnson and Koning, 2012). The vertical connection across the Ancha-Tesuque contact, while understood elsewhere in the basin, is not well defined near the AASF (Johnson et al., 2008).

During the SI, depth to groundwater was observed at 176–185 ft bgs in wells installed in the Tesuque Formation, which is consistent with observations made at city-owned Santa Fe WWTP monitoring wells located east of the facility (New Mexico Environment Department [NMED] Ground Water Quality Bureau, 2011). Measurements made during the SI indicate that groundwater within the Tesuque Formation flows south-southwest with a gradient of 0.001 feet per feet (ft/ft) (**Figure 10-4**). During the SI, perched groundwater was observed on the west side of the facility at depths of 110–111 ft bgs (EA, 2023). Based on the regional understanding of the Ancha-Tesuque contact, and observed lithology in SI borings, this perched water resides in the shallower Ancha Formation. Groundwater flow direction of the perched groundwater could not be calculated since it was encountered in only two drilling locations (**Figure 10-4**). This perched water likely rests on low permeability floodplain and sheet-flood deposits within the Ancha Formation that act as an aquitard. Due to its heterogeneity, the lateral extent of these perching sheet-flood deposits near the Facility is not currently defined.

Numerous wells are located south and southwest of the Facility. The nearest domestic well is located approximately 1 mile southwest of the Facility and based on public records likely pulls groundwater from the Tesuque Formation. A municipal well located at the Santa Fe Airport is located a 0.5 mile southeast of the Facility (New Mexico Office of the Engineer [NMOSE], 2022). These and other wells identified during the PA are displayed on **Figure 10-3**.

The Santa Fe AASF receives its potable water from the City of Santa Fe’s municipal water utility. Santa Fe’s drinking water comes from a nearly even split between groundwater from the Buckman and City Well Fields, and surface water from the Santa Fe and Rio Grande rivers (City of Santa Fe Water, 2023). The City well fields are located within or northeast of Santa Fe (AECOM, 2020), which are hydrologically upgradient of the Facility. Additionally, the community of La Cienega is located adjacent to, and presumed to be downgradient of the Facility. La Cienega residents rely exclusively on groundwater for drinking water, provided by individual residential wells and two public water systems, one of which derives its drinking water from a well approximately 1.8 miles potentially downgradient from the Facility.

10.2.3 Hydrology

The topography at the AASF is relatively flat. It straddles two watersheds; the northern portion of the facility is within the Headwaters Santa Fe River Watershed and the southern portion within the Outlet Santa Fe River Watershed. The surface water flow direction is generally to the southwest on both sides of the watershed divide. The Santa Fe River cuts through undeveloped land approximately 0.5 miles north of the Facility (AECOM, 2020). The regional and facility surface water features are shown on **Figure 10-5**.

Consistent with regional surface water flow directions, historical imagery indicates that stormwater runoff flowed to the southwest from the historical helicopter parking apron and other paved areas. Stormwater also appears to have accumulated on either side of the taxiway historically. The 2012 renovations appear to have made some improvements to stormwater conveyance. Currently, there are two shallow stormwater detention basins that receive runoff from the flight line. A stormwater retention basin was constructed north of the Readiness Center and receives runoff from Readiness Center, current AASF building, and other paved areas of the facility and has an outflow just outside the north facility boundary. The oil-water separator (OWS) outflow for the AASF's fueling point is also located outside the north boundary. Dry drainage features visible from both outflows heading northwest are visible in imagery but appear to dissipate after a short distance. Its assumed there is no direct overland pathway between the AASF and the Santa Fe River, and much of the outflow discharge likely evaporates or infiltrates into the subsurface. Current and historical areas that receive or appear to have received stormwater runoff are displayed in **Figure 10-5**.

The City of Santa Fe's surface water drinking water supply comes from the Santa Fe River and San Juan-Chama Project water via the Rio Grande River. The City of Santa Fe has a license to store up to 3,985-acre ft (combined) of Santa Fe River water in McClure and Nichols Reservoirs, located in the Sangre de Cristo Mountains east of Santa Fe (AECOM, 2020). Water from the Rio Grande River is taken at the Buckman Direct Diversion northwest of Santa Fe (City of Santa Fe Water, 2023). Both are treated through conventional and advanced treatment processes to meet current permit regulations.

10.2.4 Climate

Santa Fe is located in north central New Mexico at an elevation of approximately 7,000 ft above mean sea level (amsl; US Geological Survey [USGS], 2024). January is the coldest month, with an average temperature of 31.6 degrees Fahrenheit (ºF), while July is the hottest month, with an average temperature of 73.8 ºF (National Oceanic and Atmospheric Administration [NOAA], 2023). Santa Fe receives an average of 12.79 inches of precipitation annually, with 5.17 inches falling during summer months (NOAA, 2024). The City receives an annual snowfall amount of 20.2 inches per year (NOAA, 2024).

10.2.5 Current and Future Land Use

Presently, Santa Fe AASF resides on SAF property. The Facility is comprised of one hangar, multiple administrative buildings, a paved parking area, a fueling station, and a small, paved parking area. The current land use is listed as I-1 Light Industrial. Future land use is not anticipated to change (AECOM, 2020). The Facility is fenced and has restricted access. Land directly to the north and east of the Facility is currently a WWTP surface disposal site owned by the City of Santa Fe.

10.2.6 Sensitive Habitat and Threatened / Endangered Species

A wildlife survey has not occurred at the Facility, 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 wildlife are federally-listed (i.e., endangered, threatened, proposed, and/or candidate species) in the vicinity of the facility (U.S. Fish and Wildlife Service, 2024b):

- **Birds:** Mexican Spotted Owl, *Strix occidentalis lucida* (Threatened) and Yellow-billed Cuckoo, *Coccyzus americanus* (Threatened)

- **Fishes:** Rio Grande Cutthroat Trout, *Oncorhynchus clarkii virginalis* (Candidate)
- **Insects:** Monarch Butterfly, *Danaus plexippus* (Candidate)

In addition, state-listed wildlife species were also identified for Santa Fe County, New Mexico (New Mexico Department of Game and Fish, 2024). This list consists of 12 species of birds (including the two identified above), 3 species of mammals, and 1 species of mollusk (see **Appendix E** for further details).

As described in **Worksheet #14**, a habitat assessment will be performed as part of the RI. Trained wildlife biologists will assess the potential for on-facility and off-facility sensitive habitats and species prior to the habitat assessment site visit. The biologists will then direct the habitat assessment completed by field staff.

10.2.7 Cultural and Historical Resources

Cultural and historical resources are not considered present on Santa Fe AASF. The facility, originally constructed in 1979 and renovated most recently in 2012, has been entirely developed and is predominantly covered by buildings and paved surfaces. Should additional information be received from Tribal and State Historical Preservation Officers in response to recent inquires, the information will be added to this document and addressed during RI activities.

10.3 History of AFFF Use and Other PFAS-Containing Materials

Two potential PFAS release areas were identified at the facility during the PA (AECOM, 2020). The areas include the former fire truck bay, in the former AASF building, and former Tri-Max™ 70/30 hand-truck storage area, the latter of which consists of the flight line and paved parking apron. These two potential source areas are adjacent to one another and have co-mingling stormwater surface runoff. As a result, these areas were combined and together comprise AOI 1.

Personnel interviews confirmed that a fire truck parked within the former AASF building stored AFFF. Personnel indicated that the fire truck was never used at the AASF because no one at the Facility was qualified to use it; however, there is a possibility that the fire truck, while stored inside the former AASF Facility, may have leaked AFFF or may have had its AFFF tank flushed out during maintenance. There are no records or recollection of the AFFF stored on the fire truck being used or spilled.

Prior to the 2012 facility renovation, Tri-Max™ 70/30 hand trucks equipped with AFFF were staged in various places around the flight line and paved parking apron. The hand trucks were regularly serviced, which may have resulted in AFFF leaks or incidental discharge while the units were at the facility. According to personnel, the Tri- Max™ hand trucks were only used for 4 to 5 years in the mid-2000s and were turned in because they were too expensive to maintain. There is no recollection or record of any training conducted with these units or nozzle testing performed. A description of AOI 1 and its potential release areas are presented in **Section 10.5.1**.

10.4 Historical PFAS Responses

10.4.1 Summary of Historical PFAS Investigations

In 2020, the ARNG conducted a PA at Santa Fe AASF that identified the two potential PFAS release areas introduced above, designated at AOI 1 (AECOM, 2020). The location of AOI 1 is shown on **Figure 10-6**. Additionally, during the SI planning phase and review of the historical aerial photographs, it was noted that surface disposal of biosolids from the adjacent WWTP extended on to the current Santa Fe AASF lease area to the north end of the current AASF building prior to the 2012 renovations of the Facility. This area was therefore designated for further evaluation under the SI as a historical potential release area. Descriptions of the potential release areas and AOI are presented as part of the preliminary conceptual site model (CSM) in **Section 10.5**. An SI was subsequently conducted at the facility to determine the presence or absence of relevant compounds at the time, perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), perfluorobutanesulfonic acid (PFBS), perfluorohexanesulfonic acid (PFHxS), and perfluorononanoic acid (PFNA), at concentrations at or above the SLs, the applicable standard at the time of the investigation. The SI field work included sampling of surface and subsurface soil and permanent monitoring well installation, development, and sampling. The field effort was conducted during two mobilizations from 7 to 8 February 2022 and from 25 April to 3 June 2022 (EA, 2023). As discussed in section **10.5.2** below, SI results showed that relevant compounds were detected in soil and groundwater at concentrations above the SLs and further evaluation was warranted in an RI.

10.4.2 Drinking Water Sampling

Santa Fe AASF receives its potable water from the City of Santa Fe's municipal water utility. Santa Fe's drinking water comes from four sources: surface water from the Santa Fe and Rio Grande rivers, and groundwater from the Buckman and City Well Fields (City of Santa Fe Water, 2023). Surface water from the Santa Fe River is stored in the McClure and Nichols Reservoirs, both located northeast of the AASF, prior to treatment at the Canyon Road Water Treatment Plant. The Buckman Direct Diversion takes surface water directly from the Rio Grande and treats it at the Buckman Regional Water Treatment Plant (City of Santa Fe Water, 2023). The City Well Field is located close to the Santa Fe River northeast of the AASF and consists of six active well fields within of Santa Fe city limits. The Buckman Well Field consists of 13 wells near the Rio Grande, about 15 miles northwest of Santa Fe (City of Santa Fe Water, 2023). The surface water sources and well fields are hydrologically upgradient of the Facility (AECOM, 2020).

Functioning city supply wells and selected storage tanks were sampled for 18 PFAS compounds in June 2023 for the City of Santa Fe by their contractor. PFAS were analyzed via EPA Method 537. PFAS were not detected in any sample above the detection limit of 1.97 ng/L for individual compounds (John Shomaker & Associates [JSAI], 2023).

The communities of La Cienega and La Cieneguilla are located adjacent to and presumed to be downgradient of the AASF. Residents of these communities rely on groundwater for drinking water, provided by individual residential wells and community owned water systems, one of which derives its drinking water from a well potentially downgradient from the facility. In 2023, Santa Fe County sampled six wells in the community. PFAS were detected in five of the six wells sampled, with PFOS and PFOA detected at concentrations ranging from 1.9 ng/L to 25 ng/L (Santa Fe County, 2023).

10.5 Preliminary Conceptual Site Model

A summary of the preliminary CSM for the Santa Fe AASF is presented below. A description of the primary PFAS release mechanism(s) at AOI 1 is presented in **Section 10.5.1**. The current interpretation of the nature and extent of PFAS contamination at AOI 1 is presented in **Section 10.6.2**. The fate and transport of PFAS in environmental media are discussed in **Section 10.5.3**. Lastly, the potential receptors and exposure pathways are discussed in **Section 10.5.4**. Sampling locations completed during the SI are presented on **Figure 10-7**.

The preliminary 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 receptors. An exposure pathway is considered potentially complete when each of 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. Areas with no identified complete pathway generally warrant no further action; however, the pathway is considered potentially complete if select PFAS are detected.

In their anionic forms, PFAS are water-soluble and can migrate readily from soil to groundwater or surface water via leaching and run-off. Given the length of time since the AFFF releases, PFAS contamination at the AASF may have leached from the soil to groundwater. PFAS migration from soil to surface water via runoff and drainage is not considered a significant transport mechanism due to the semi-arid climate, distance to the nearest surface water body, and absence of defined drainage pathways between the AASF and surface water. Advective-dispersive transport of PFAS in groundwater from potential upgradient source areas may also contribute to potential PFAS contamination at the facility that, combined with PFAS contamination from the AOI, may expose human receptors to PFAS in groundwater at and downgradient from the facility, as well as human and ecological receptors to PFAS in surface water downgradient off-facility.

As described in **Section 10.5.2** PFOA and PFHxS were detected above the SL in groundwater at the AASF. Therefore, the ingestion exposure pathway for groundwater is potentially complete for off-facility residents.

10.5.1 Summary of Potential Release Areas

Based on the findings of the PA, the two potential PFAS release areas were grouped into one AOI based on proximity. During the SI, the historical WWTP biosolid surface disposal site, which extended onto the facility, was also identified as a potential area with PFAS impact from the off-facility WWTP. The AOI and Historical WWTP Biosolid Surface Disposal Site are shown on **Figure 10-6** and described in the subsections below:

- AOI 1: Former Fire Truck Bay and Tri-Max™ Hand Truck Storage Area
- Historical WWTP Biosolid Surface Disposal Site.

Several additional potential off-facility PFAS release areas surround or are near the AASF, the Santa Fe Regional Airport, City of Santa Fe WWTP, and Santa Fe WWTP biosolids surface disposal site. The locations of the sites are also shown on **Figure 10-6** for informational purposes. These locations are off-facility (not under the control of ARNG) and were therefore not previously evaluated as part of the SI.

AOI 1 consists of the Santa Fe AASF Former Fire Truck Bay and Tri-Max™ Hand Truck Storage Area, as described below.

Former Fire Truck Bay

The former AASF building, which is now the current Santa Fe Readiness Center, is located on the western portion of the facility and historically housed a single fire truck within a bay. The fire truck was stored in this bay for an unknown length of time, but it was sold in 2005 to the Santa Fe Fire Department. Personnel interviews confirmed that the fire truck stored AFFF foam, but it was never used because no personnel at the facility were qualified to use it. There are no records or recollection of the use or release of the AFFF stored on the fire truck; however, there is a possibility that the fire truck stored may have leaked AFFF or had its AFFF tank flushed out during maintenance.

The building was renovated in 2012 and received a new roof, exterior wall openings and finishes, interior walls, floor finishes, ceilings, and lighting. Mechanical, electrical, plumbing, fire protection, telecommunication, and security systems were replaced as well. The Former Fire Truck Bay still includes the bay door opening to the southwest corner of the building but has been remodeled with new walls and an equipment cage and is currently used for storage. There is no floor drain in the remodeled bay and no evidence one was previously present. The current Santa Fe Readiness Center building does not currently house any materials containing AFFF (AECOM, 2020).

Former Tri-Max™ Hand Truck Storage Area

The flight line and paved parking apron currently stretch across much of the facility and are directly adjacent to both the current and former AASF buildings. The area was expanded and repaved in 2012 during the construction and renovation of the Facility. Prior to the 2012 renovation, Tri-Max™ 70/30 hand trucks were stored in various places around the flight line and parking apron and were regularly serviced. Service for Tri-Max™ 70/30 hand trucks may include nozzle checks or the transfer of contents that can result in an AFFF discharge. However, there is no recollection or record of any training conducted with these units or nozzle testing performed. According to personnel, the Tri-Max™ hand trucks were only used for 4 to 5 years in the mid-2000s, and their use was discontinued because they were too expensive to maintain. Interviewees were not certain when or where, specifically, the Tri-Max™ units were turned in, but confirmed that the units no longer exist at the facility and have since been replaced with fire extinguishers that do not contain PFAS (AECOM, 2020).

10.5.1.1 Historical WWTP Biosolid Surface Disposal Site

The City of Santa Fe WWTP is located north of the Santa Fe AASF. Areas to the north and east of the Santa Fe AASF are currently used as surface disposal sites for biosolids generated during wastewater treatment. The biosolids surface disposal site also extended onto the current Santa Fe AASF lease area prior to the 2012 renovations. Based on available imagery, the footprint of the biosolids surface disposal site on the AASF extended from the northeast facility boundary to the north end of the current AASF (**Figure 10-7**). Although WWTPs are not usually originating sources of PFAS, sludges and liquids generated through the treatment of sanitary waste at WWTPs can create a secondary source of contamination.

10.5.2 Current Understanding of Nature and Extent of Contamination

The current understanding of the nature and extent of PFAS contamination at Santa Fe AASF is presented in the subsections below. The summaries are based on review and evaluation of available analytical results from historical PFAS investigations, as summarized in **Section 10.4**.

The SI at Santa Fe AASF included multi-interval soil samples and the installation, development, and sampling of monitoring wells. The SI determined that relevant compounds were present in soil and groundwater at concentrations above the SLs and a recommendation was made for further evaluation in an RI (EA, 2023). Analytical results from the SI are presented in **Appendix B**. The SI results are summarized in the subsections below and were reevaluated against the updated November 2023 SLs identified in **Table 11-1**.

AOI 1

Based on the SI findings, relevant compounds were detected at AOI 1.

- In soil, PFOS was detected above the residential soil SL at AOI 1. All other detected compounds in the surface and subsurface soil were below the respective SLs.
    - Soil was sampled from three depth intervals: one surface soil (0-2 feet bgs), one subsurface interval from 13-15 feet bgs, and one subsurface interval just above observed groundwater (sample depths ranging from 109 to 183 feet bgs). PFOS was detected above its SL in surface soil at three locations near the Former Fire Truck Bay (AOI01-02, AOI01-07, and AOI01-08), at a maximum detected concentration of 920 micrograms per kilogram (µg/kg). PFOA, PFHxS, perfluorohexanoic acid (PFHxA), and PFNA were also detected, but at least one order of magnitude below the SLs. Perfluorobutanoic acid (PFBA) and PFBS were not detected in soil at AOI 1.
- In groundwater, PFOA and PFHxS exceed the SLs at AOI 1. All other detected compounds were below the respective groundwater SLs.
    - Groundwater samples at AOI 1 were collected from permanent monitoring wells installed in both the perched and regional groundwater zones; however, relevant compounds were detected only in the perched zone. PFOA exceeded its groundwater SL at AOI01-04 at a concentration of 38 ng/L. PFHxS exceeded the SL at two locations, AOI01-02 and AOI01-04, at a maximum concentration of 230 ng/L. Both AOI01-02 and AOI01-04 are completed in the perched groundwater zone. PFBA, PFBS, and PFHxA were detected below their respective SLs. PFOS and PFNA were not detected in groundwater at AOI 1.

Historical WWTP Biosolid Surface Disposal Site

Based on the SI findings, relevant compounds were detected in soil at the former biosolid application area that extends onto the current AASF.

- Two surface soil samples (0-2 feet bgs) were collected within the footprint of the former biosolid disposal site that extends onto current Santa Fe AASF. PFOA exceeded the SL at SFAASF-02, at a concentration of 33 µg/kg, and was detected at the 19 µg/kg SL at SFAASF-01. PFOS exceeded the SL at both locations, with a maximum concentration of 60 µg/kg detected at AOI01-02. PFOA, PFBS, PFHxA, PFHxS, and PFNA were detected at concentrations below the SLs. PFNA was not detected in soil at the biosolid disposal site. Subsurface soil and groundwater were not sampled in this area during the SI.

East AASF Boundary

Relevant compounds were detected at trace concentrations in surface soil and groundwater at the east facility boundary.

- In soil, PFOA, PFOS, and PFHxA were detected in surface soil. All other compounds in the surface and subsurface soil were not detected.
    - Soil was sampled from three depth intervals: one surface soil (0-2 feet bgs), one subsurface interval from 13-15 feet bgs, and one subsurface interval just above observed groundwater (sample depths ranging from 180 to 183 feet bgs). Relevant compounds were detected only in surface soil. PFOA and PFOS were detected at concentrations less than 1 µg/kg and PFHxA was detected at estimated concentrations below 1 µg/kg.
- In groundwater, PFHxA was the only compound detected.

  - Groundwater samples were collected from two permanent wells within the regional groundwater zone. PFHxA was detected at both locations at estimated concentrations less than 1 ng/L. No other compounds were detected.

Data Gaps for PFAS

Based on the evaluation of available data in soil and groundwater, as presented above, the presence of PFAS has been confirmed at Santa Fe AASF with exceedances of the SLs in surface soil and groundwater. The extent of the PFAS releases to soil – including potential on-facility releases not attributable to ARNG activities, the distribution following AASF renovations, and the migration pathways between the release areas, boundaries, and potentially to off-facility receptors are not fully understood. Detailed descriptions of the approach for addressing the PFAS data gaps are presented in the sampling design and rationale tables in **Worksheet #17**.

10.5.3 Fate and Transport of PFAS

Contaminant fate and transport is an evaluation of the changes that occur in constituents and concentrations as they move through different environmental media. Understanding the fate and transport of chemicals is important in evaluating their potential impacts to receptors. Fate is a summary of all the physical and chemical processes that act on the constituents during transport. Transport is the simple movement of the constituents, for example, with the flow of groundwater or surface water.

The primary source of PFAS at Santa Fe AASF is likely from accidental AFFF leaks/releases attributable to ARNG activities, although the historical disposal of WWTP generated biosolid waste to the ground surface within the AASF boundary may also be a source of PFAS. Multiple AFFF formulations have been produced over the years, and the exact composition of any given AFFF used or manufactured in any given year is highly variable (Backe et.al, 2013). AFFF contains highly diverse mixtures of PFAS which may vary based on the production process used: electrochemical fluorination (ECF) or fluorotelomerization. The ECF process results in a PFAS mixture dominated by perfluoroalkyl acids (PFAAs), both perfluoroalkyl sulfonic acid (PFSA) and perfluoroalkyl carboxylic acid (PFCA) homologues, while the fluorotelomerization process produces AFFF formulations dominated by polyfluorinated compounds with lesser amounts of PFAAs (Houtz et al., 2013). In general, ECF-based AFFF is the dominant source of PFAS at AFFF-impacted sites (Interstate Technology Regulatory Council [ITRC], 2018a).

Both the PFSA and PFCA homologues produced as part of AFFF manufacture (including PFOA and PFOS) are long-chain PFAS chemicals that are persistent in the environment, bioaccumulative in wildlife and humans, and are toxic to laboratory animals and wildlife, producing reproductive, developmental, and systemic effects in laboratory tests. Shorter-chain PFSAs, such as PFBS and PFHxS, are generally less toxic and less bioaccumulative in wildlife and humans, and alternative products containing these shorter-chain chemicals have been introduced as replacements for long-chain PFAS. Increasing levels of PFBS and PFHxS in surface water have been observed indicating that short-chain alternatives to PFOA and PFOS are also persistent in the environment (Buck et al., 2011).

Precursors typically are raw materials or intermediary compounds in the PFAS manufacturing process. Generally, they consist of polyfluorinated alkyl compounds that can be biotically and abiotically transformed into PFAA terminal “end-member” compounds (i.e., PFAS) in the environment. Transformation of these precursors to PFAAs has been shown to occur in a variety of environmental media and can result in unexpected temporal and spatial trends in PFAS occurrence. The susceptibility of individual precursors to transformation processes can also influence how each will bioconcentrate and bioaccumulate within various biotic species. The analysis of precursor compounds in surface soils can be used to help identify source release areas because precursor compounds tend to be larger, transform slowly and adsorb more strongly to soil. Fluorotelomer alcohols (FTOHs) and fluorinated sulfonamides, such as N-ethyl perfluorooctane sulfonamidoethanol (EtFOSE), are examples of such precursor compounds (Houtz et al., 2013).

PFAS most commonly detected in the environment typically have a carbon-fluorine "tail" and a nonfluorinated "head" consisting of a polar functional group. The tail is hydrophobic and lipophobic, while the head groups are polar and hydrophilic. These competing tendencies of the head and the tail can lead to a wide distribution in the environment. Important PFAS partitioning mechanisms include hydrophobic and lipophobic effects, electrostatic interactions, and interfacial behaviors. The hydrophobic and lipophobic effects drive the association with organic carbon in soils and sediments (ITRC, 2018a). Because the head and the tail compete, partitioning to interfaces of environmental media such as soil/water, air/water and water/non-aqueous phase liquid co-contaminants can occur (Guelfo and Higgins, 2013; McKenzie et al., 2016; Brusseau, 2018). Preferential accumulation of PFAS above the water table within the vadose zone is a common example of partitioning at the air/water interface.

PFCAs and PFSAs are present as organic anions at most pH levels found in the environment 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, 2018a).

Sorption and retardation of PFAS compounds show correlations with carbon chain length and structure. Sorption generally increases with increasing perfluoroalkyl tail length (Higgins and Luthy, 2006; Guelfo and Higgins, 2013; Sepulvado et al., 2011), indicating that the short-chain PFSAs, like PFBS and PFHxS, are retarded less than longer chain chemicals like PFOA and PFOS. Also, branched versus linear isomers of the same compound display different sorptive behavior, with linear isomers tending to sorb more strongly than their branched counterparts.

Sorption of PFCAs and PFSAs is also affected by soil solution chemistry, with decreased pH and increased levels of polyvalent cations (for example, calcium $[Ca]^{2+}$) leading to increased sorption and retardation (Higgins and Luthy, 2006; McKenzie et al., 2015). Vapor pressures of these compounds are generally low, and water solubilities are high, limiting partitioning from water to air (USEPA, 2000).

Once organic chemicals are released to soils, a variety of processes may occur that cause them to become immobilized or to be mobilized to another environmental medium. Chemicals may be taken up and held on soil particles by adsorption (sticking to a particle surface) or absorption (diffusion into the particle). Chemicals may sorb directly to the soil grains or to organic or metal oxyhydroxide coatings on the grains. The degree of sorption of a particular chemical in the environment is controlled by both soil properties (i.e., organic carbon content, metal oxyhydroxide content, clay content, or specific surface area) and by chemical properties (i.e., partition coefficients, solubility, polarity). PFOS adsorbs to soil and sediment and does not readily desorb once adsorbed to these matrices. The fate properties of PFOS and PFOA are similar and make these compounds less likely to desorb from these matrices than PFBS and PFHxS (ITRC, 2018a).

Chemicals may be transported downward through the soil strata by liquids that infiltrate through the soils or by water from precipitation. Chemicals released to, or transported into, soils beneath the groundwater surface may be leached from the soils by groundwater and transported downgradient in groundwater. Leaching potential is a function of both media properties (for example, pH, redox conditions, and increased partitioning with organic-rich soil) and PFAS structural properties (for example, ionic charge, and chain length) (Gellrich, Stahl, and Knepper

2012). PFAS may be transported to the sediment and surface water through direct discharges from drainage outflows, overland runoff/erosion, and groundwater discharge.

10.5.4 Potential Receptors and Exposure Pathways

As described above, soil and groundwater may have been impacted by PFAS releases associated with historical ARNG and non-ARNG activities at the Santa Fe AASF. In addition, PFAS in these media may have migrated to the on-facility retention basin. Therefore, human and ecological receptors present within the facility may be exposed to PFAS.

The currently understood human health and ecological receptors and potentially complete exposure pathways under current and reasonably anticipated future land use scenarios are summarized below and are presented on **Figure 10-8**. The human health and ecological receptors and exposure pathways identified below may be refined based on data from the Prescriptive Phase of the RI. Further evaluations of the exposure pathways will be considered during future mobilization(s).

Human Health

Current human receptors at the facility include on-facility workers and approved visitors (e.g., National Guard/Army Reserve trainees. Outdoor workers may contact surface soil while performing maintenance or other similar activities. Visitors and trainees may also contact surface soil but are anticipated to have a lower exposure potential as compared to outdoor workers who would presumably be present more frequently and perform more soil-intense activities, such as landscaping. Non-military land uses in off-facility areas adjoining the facility include the SAF and the WWTP.

There are no current recreational uses of the facility. It is assumed that the facility could be used for recreational purposes in the future. Entry to the facility by trespassers is considered unlikely under the current scenario. However, it is conservatively assumed that trespassers may access soil under a future scenario where access is no longer controlled. Construction/utility workers may also be present and access soil in the future if redevelopment or utility activities were to occur. Direct contact with groundwater is not anticipated because groundwater is not present within the top 10 feet of ground surface.

There are two shallow stormwater detention basins that receive water from the flight line and a retention basin north of the Readiness Center with an outflow directed north. These features are dry most of the time and any human exposure to the storm water runoff is expected to be intermittent in nature. Therefore, direct exposure to storm water runoff in the detention and retention basins will not be evaluated. The retention basin outflow to the north of the AASF has a small channel that dissipates not far from the facility. Storm water runoff from the AASF is not likely to reach the Santa Fe River since infiltration and evaporation are considered the dominant processes. If Prescriptive Phase results suggest potential migration to the Santa Fe River, surface water and sediment samples may be collected from the Santa Fe River up- and downstream of potential input from the AASF and the WWTP to identify potential upstream sources during the Adaptive Phase.

As discussed in **Section 10.4.2**, Santa Fe AASF receives its potable water from the City of Santa Fe’s municipal water utility. Sources include surface water and groundwater supply wells upgradient of the Facility. The communities of La Cienega and La Cieneguilla are located adjacent to and presumed to be downgradient of the AASF. Residents of these communities rely on groundwater for drinking water, provided by individual residential wells and community owned water systems, one of which derives its drinking water from a well potentially downgradient from the Facility. County sampling showed PFOS and PFOA concentrations ranging from 1.9 ng/L to 25 ng/L (Santa Fe County, 2024).

Reasonably anticipated future land use is not expected to change from the current land use described above. However, the Human Health Risk Assessment (HHRA) (to be performed as part of the RI following the Adaptive Phase) will conservatively evaluate an unlimited use/unrestricted exposure (UU/UE) scenario to inform future risk-management decisions in the FS, if applicable. This scenario includes the evaluation of a hypothetical future on-facility residential scenario and the evaluation of on-facility groundwater as a source of drinking water. A remedial response will not necessarily be taken based on the results of the future UU/UE scenario, given it is not a reasonably anticipated future use for the facility, per the Department of Defense (DoD) Defense Environmental Restoration Program (DERP) Management Manual, which states “The DoD Component shall consider current and reasonably anticipated future land uses in risk assessments. The DoD Component does not have to assume that the reasonably anticipated future land use is residential” (DoD, 2012).

The receptors and potentially complete exposure pathways that will be considered for a current and/or future use scenario are as follows. For future land-use scenarios that may involve some level of construction to convert the area to the desired use (i.e., worker and residential scenarios) it is assumed that current subsurface soils may be brought to the surface and mixed with surface soil for exposure by future receptors.

Area	Receptor	Exposure Pathway(s)
On-facility	Outdoor Worker	Current: • Exposure to surface soil (0-1 feet bgs)[(a)] through incidental ingestion and dermal contact.
		Future: • Exposure to combined surface and subsurface soil (0 to 10 feet bgs) [(a)] through incidental ingestion and dermal contact. • Exposure to monitoring well groundwater[(b)] via ingestion as drinking water.
	Construction/Utility Worker	Future: • Exposure to combined surface and subsurface soil (0 to 10 feet bgs) [(a)] through incidental ingestion and dermal contact.
	Trespasser (Adolescent)	Future: • Exposure to combined surface and subsurface soil (0 to 10 feet bgs) [(a)] through incidental ingestion and dermal contact.
	On-facility Recreational User (Adult and Child)	Future: • Exposure to combined surface and subsurface soil (0 to 10 feet bgs) [(a)] through incidental ingestion and dermal contact.
	Hypothetical Future Resident (Adult and Child)	Future: • Exposure to combined surface and subsurface soil (0 to 10 feet bgs) [(a)] through incidental ingestion and dermal contact. • Exposure to groundwater[(b)] via ingestion of drinking water and dermal contact during bathing/showering.

Area	Receptor	Exposure Pathway(s)
Off-facility (c)	Off-facility Recreational User (Adult and Child)	Current/Future: - Exposure to surface water and sediment through incidental ingestion and dermal contact if off-facility water body (e.g., the Santa Fe River) used for recreation is potentially affected by installation activities. The fish consumption exposure pathway will be qualitatively evaluated.
	Commercial/Industrial Worker	Current/Future: - Exposure to groundwater(b) via ingestion of drinking water.
	Off-facility Resident (Adult/Child)	Current/Future: - Exposure to groundwater(b) via ingestion of drinking water and dermal contact during bathing/showering.

Notes:

a) If soil samples collected for use in the risk assessments are not collected from the specific horizons noted above, the soil horizons will be adjusted to those most like those listed above.

b) For the purposes of the HHRA, monitoring well groundwater data will be used to evaluate the hypothetical future use of groundwater as potable water scenario.

c) Off-facility sampling is not currently planned. These potential receptors would only be evaluated if off-facility migration pathways for PFAS from installation activities are confirmed and if off-facility data are collected during the Adaptive Phase.

Potential exposure to airborne particles in outdoor air (from soil) will not be quantitatively evaluated because toxicity values for the inhalation exposure route are not available for relevant PFAS from OSD approved sources; therefore, quantitative assessment of the inhalation exposure pathway cannot be performed. The associated uncertainties with the inhalation pathway will be discussed in the HHRA.

Ecological

The majority of the current facility (67%) is paved with limited disturbed non-paved areas (mix of bare soil and scrub vegetation). There are no terrestrial habitats associated with AOI 1, which is located within Readiness Center and the paved helicopter parking apron. Terrestrial habitats in the adjacent disturbed non-paved areas of the facility are limited due to the continuing military land uses. The terrestrial habitats associated with the Historical WWTP Biosolid Surface Disposal Site are likewise limited due to the continuing miliary land uses, pavement covering the western portion of the area, and disturbed land (mix of bare soil and scrub vegetation) covering the remaining area. Although bird and mammal species may access the fragmented, unpaved areas within the facility that surround buildings, roads, and paved areas, these upland habitats generally offer limited ecological foraging resources. Upland habitats that would support significant plant or animal communities are not expected to be present within the facility; however, animal burrows are present along the eastern boundary of the facility. Therefore, it is conservatively assumed that terrestrial plants and soil invertebrates may serve as food sources for birds and mammals that may be present in areas with viable habitat.

The primary exposure pathways for upland areas with viable habitat include:

- Soil invertebrates, terrestrial shallow-rooted plants, reptiles, and amphibians directly exposed to PFAS in surface soil (0 to 1 feet bgs). Deep-rooted plants directly exposed to PFAS in sub-surface soils (1 to 6 feet bgs).

- Terrestrial birds and mammals exposed to PFAS through incidental ingestion of soil and by ingestion of contaminated plant and prey items impacted by surface soil (0-1 feet bgs). In addition, burrowing animals exposed to PFAS in sub-surface soils (1 to 6 feet bgs) through incidental soil ingestion while digging and grooming.

If soil samples collected for use in the risk assessments are not collected from the specific horizons noted above, the soil horizons will be adjusted to those most like those listed above.

There are no perennial surface water bodies within the property boundaries of the Santa Fe AASF (EA, 2023). The facility includes two shallow stormwater detention basins (south of the helicopter parking apron) and a retention basin (north of the Readiness Center). These on-facility stormwater features are dry most of the time, only containing water after storm events and snowmelt. Surface water within the retention basin that does not infiltrate the surface would outflow to the north. Given the ephemeral nature of standing water in these stormwater features and the lack of hydrological connection to natural water features (e.g., upgradient creeks/streams), sediment is only expected to be present seasonally and they are not expected to support a viable aquatic or benthic community. Ground cover in the stormwater features is anticipated to be similar to the terrestrial habitat at other non-paved areas of the facility. Therefore, on-facility surface water and sediment are not planned for collection during the Prescriptive Phase and solid material collected in the stormwater features will be treated as soil for purposes of evaluating ecological exposures to PFAS. Part of the Habitat Assessment will be to confirm the presence/absence of plant species present, whereby the presence of standing water sufficient to support aquatic life and/or wetland plant species would imply an aquatic habitat is seasonally present. If Prescriptive Phase and/or Adaptive Phase results warrant, relevant aquatic habitat media samples may be collected from the on-facility and/or adjacent off-facility stormwater features (e.g., surface water and sediment) and/or off-facility ephemeral surface water features such as the Santa Fe River, Arroyo Hondo and/or Cienega Creek (e.g., sediment, surface water, seep water, and/or porewater) during the Adaptive Phase. If collected, applicable data will be used in the Ecological Risk Assessment (ERA).

In cases where receptor-specific PFAS toxicity information is not available, potential impacts on receptors (e.g., reptiles) will be considered qualitatively in the Screening-Level Ecological Risk Assessment (SLERA).

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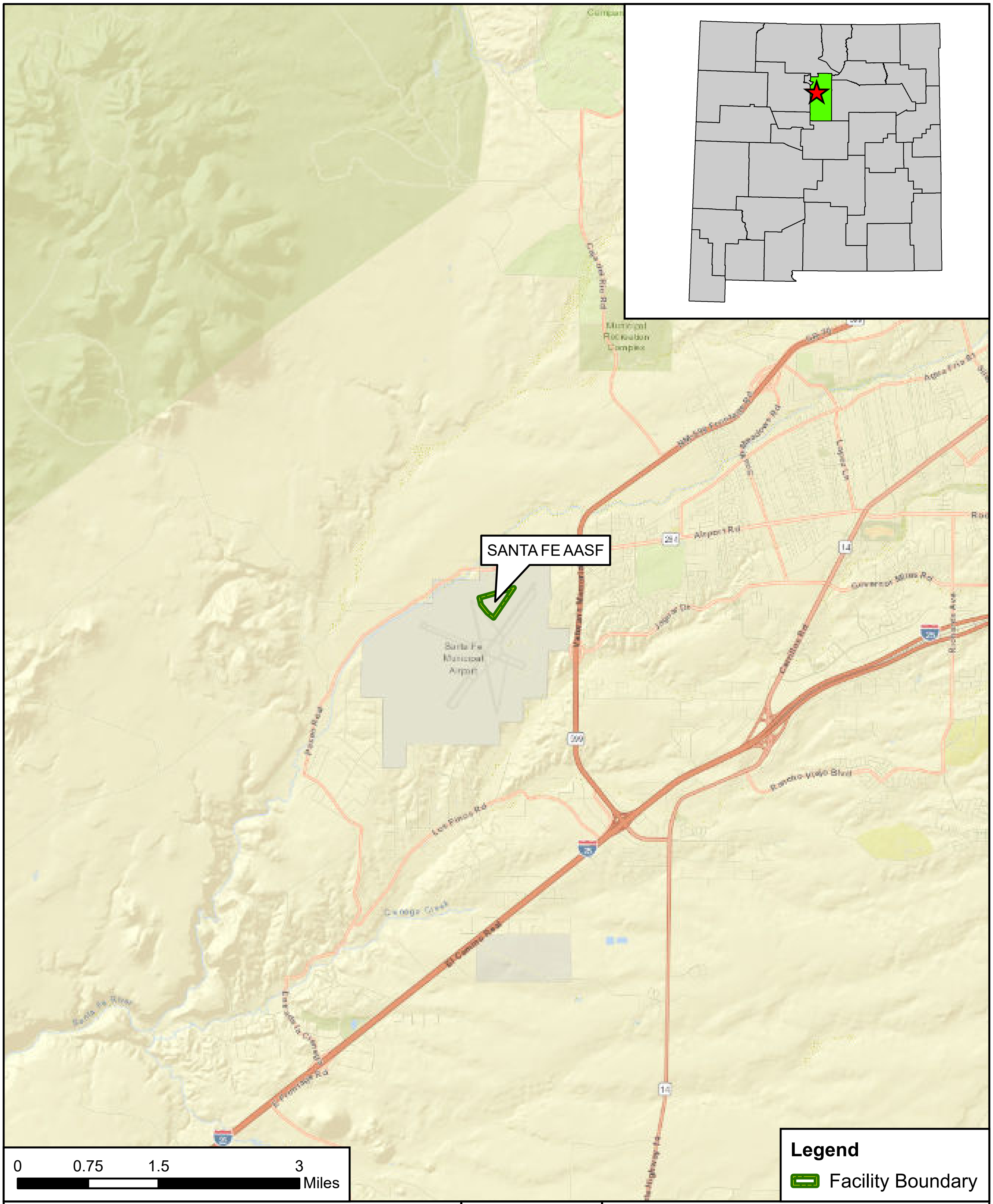
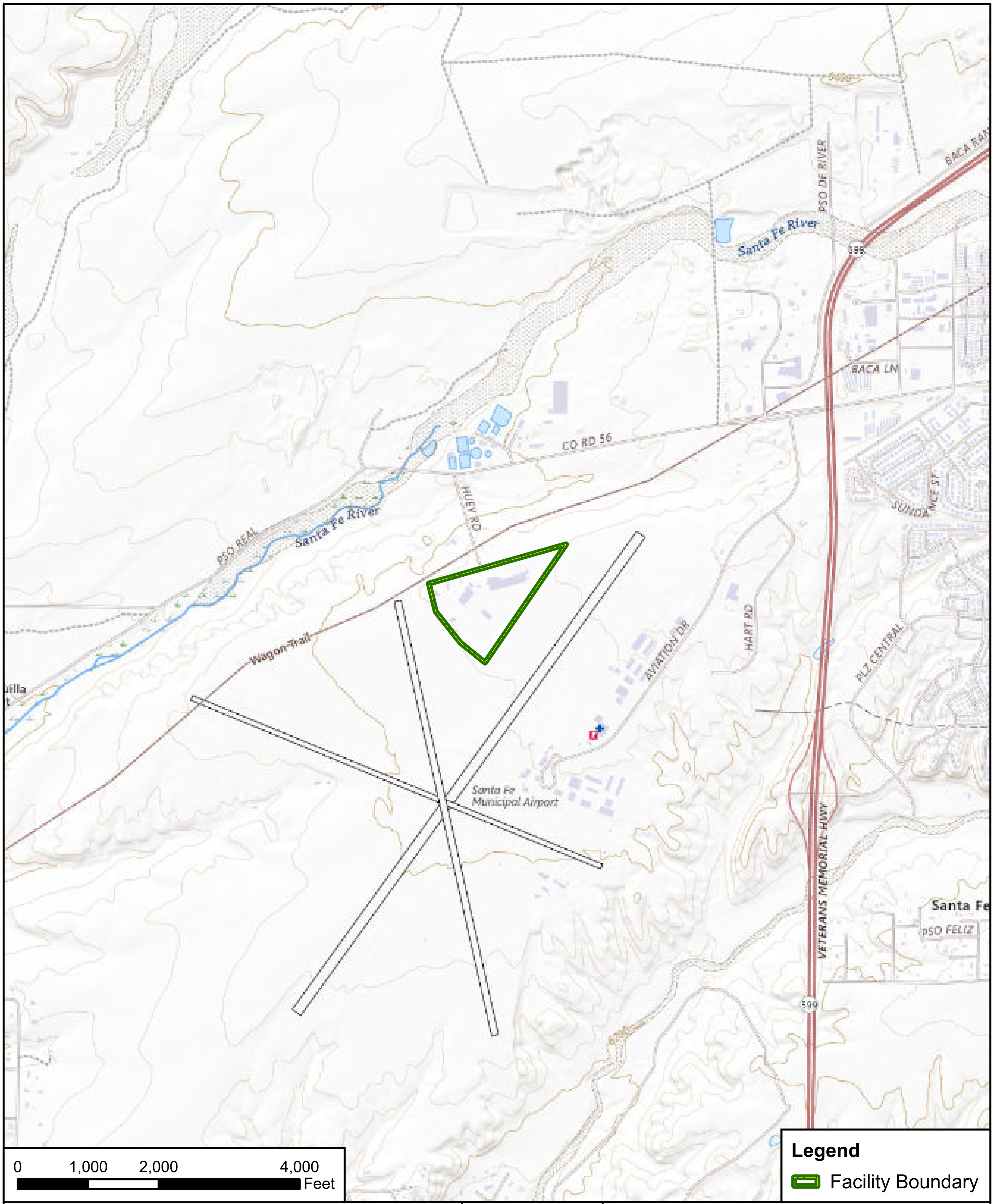


CLIENT	ARNG			
PROJECT	Remedial Investigation at Santa Fe AASF, NM			
REVISED	11/8/2024	GIS BY	MS	11/8/2024
SCALE	1:95,040	CHK BY	ST	11/8/2024
Base Map: World Street Map: Bureau of Land Management, Esri, HERE, Garmin, INCREMENT P, NGA,		PM	CM	11/8/2024

N

Facility Location

Figure 10-1

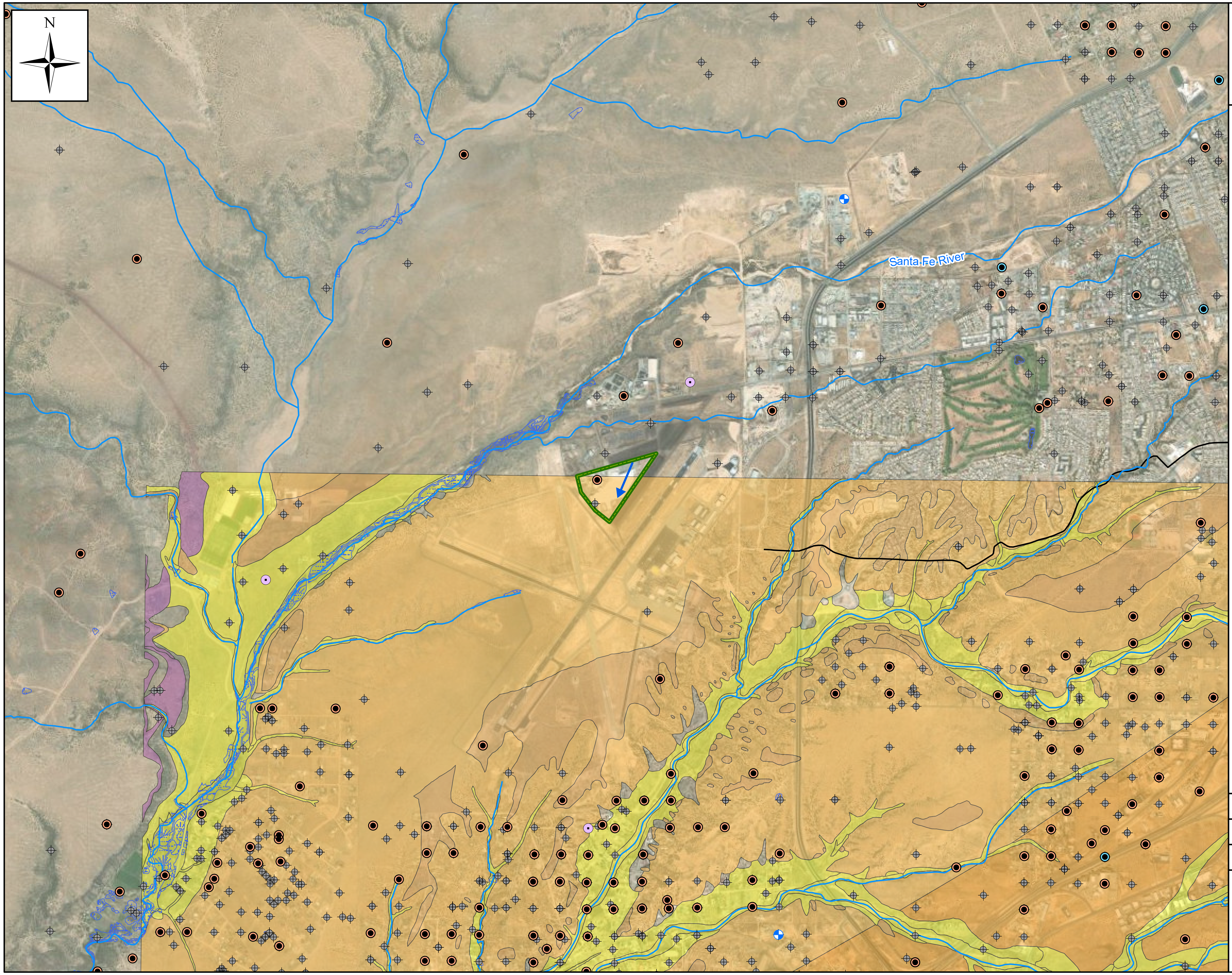


Facility Topographic Map

CLIENT	ARNG			
PROJECT	Remedial Investigation at Santa Fe AASF, NM			
REVISED	11/8/2024	GIS BY	MS	11/8/2024
SCALE	1:24,000	CHK BY	ST	11/8/2024
Base Map: USGSTopo: USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program,		PM	CM	11/8/2024

N

Figure 10-2



Legend

- Facility Boundary
- Wetland
- Pipeline
- River/Stream
- Groundwater Flow Direction (Deep Water-Bearing Zone)

Geology

- Modern & older alluvium; Pleistocene - Holocene
- Terrace deposits; Pleistocene
- Ancha Fm. alluvial slope deposits; Pliocene - Pleistocene
- Ancha Fm. Santa Fe river deposits; Pliocene - Pleistocene
- Basalt flows & tephra; Pliocene - Pleistocene

Wells

- Domestic
- Commercial Water Well
- Irrigation
- Drinking/Sanitary
- Unknown/Other/Drilling

Note:

Turquoise Hill quadrangle geologic map layer shown on figure. Digitized geologic map layers at the same scale unavailable for other areas.

Data Sources:

NMBGMR. 2002. *Geologic map of the Turquoise Hill quadrangle, Santa Fe County, New Mexico.*

New Mexico Office of the State Engineer (NMOSE). 2010. *Currently Active Points of Diversion with Well Drill Dates and Depths.* New Mexico Office of the State Engineer and Interstate Stream Commission (ISC). Date accessed: April 2020.

NMOSE-ISC. 2002. *New Mexico Water Atlas.*
New Mexico Office of the State Engineer and
Interstate Stream Commission. Date accessed: April 2020.

NMOSE. 2019. *Water Wells 2016- NMOSE.*
New Mexico Resource Geographic Information System.
Date accessed: December 2019

Base Map World Imagery: Maxar

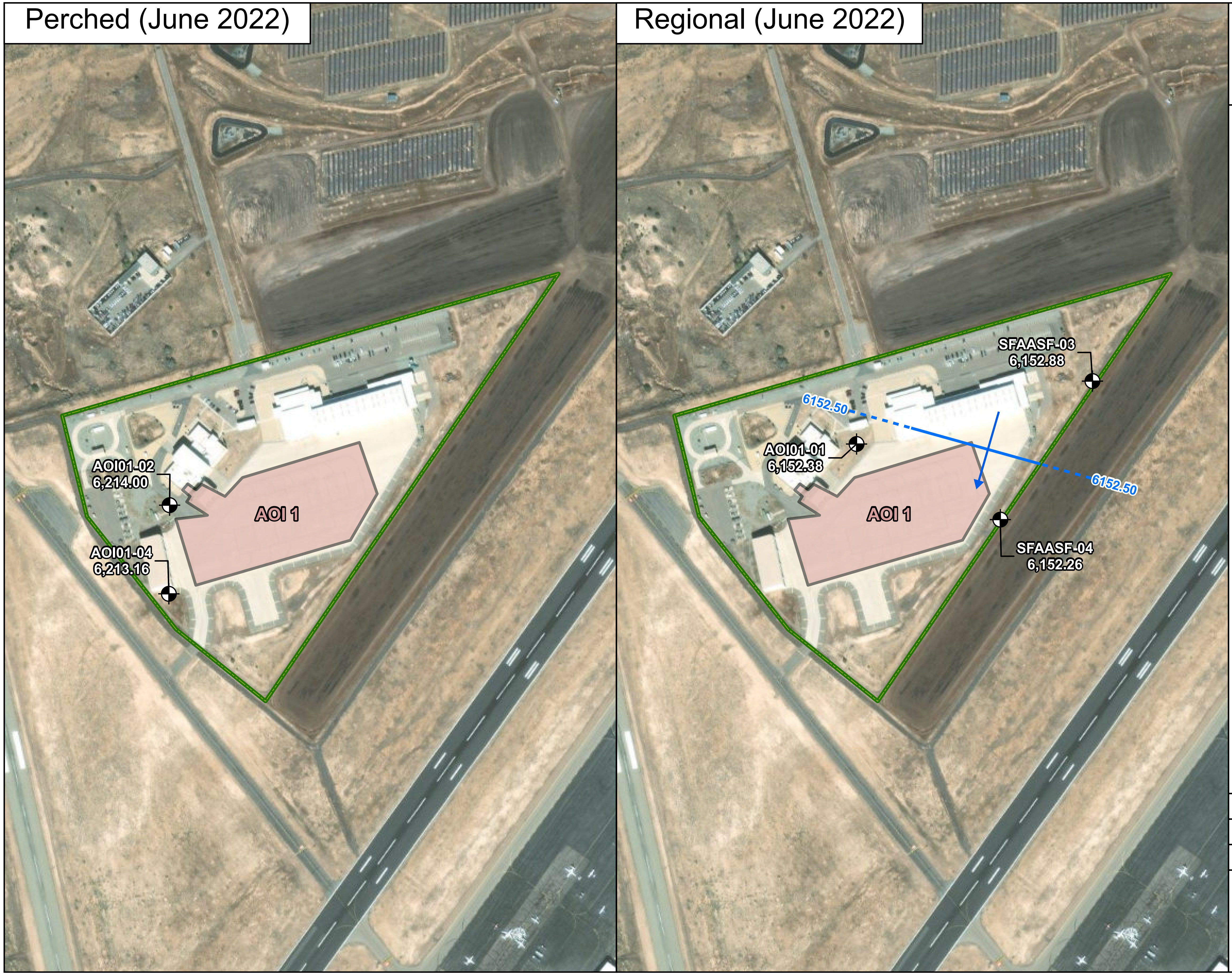
0 1,250 2,500 5,000
Feet

ARNG

Remedial Investigation at Santa Fe AASF, NM

Date: 11/8/2024

Figure 10-3
Groundwater Features



Perched (June 2022)

Regional (June 2022)

Legend

⊕ Monitoring Well

▨ Area of Interest

🟩 Facility Boundary

— Groundwater Elevation Contour - Deep

- - - Inferred Groundwater Elevation Contour - Deep

→ Groundwater Flow Direction - Deep

Notes:
Groundwater Elevations in feet NAVD88.

N

0 200 400 800
Feet

Data Source: Final Site Inspection Report (EA, 2023)

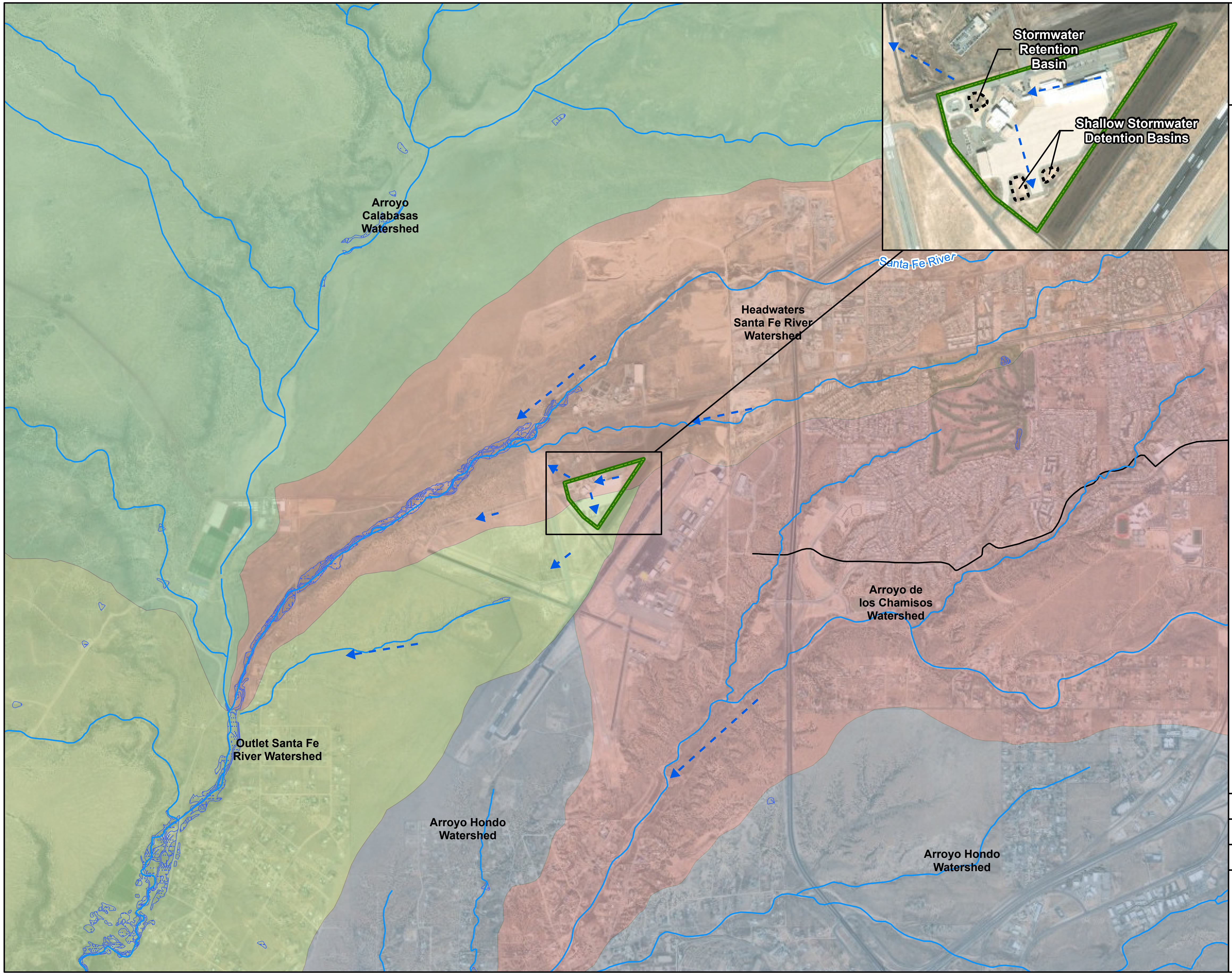
Service Credits Layer: World Imagery: Maxar

ARNG

Remedial Investigation at Santa Fe AASF, NM

Date: 11/8/2024

Figure 10-4
Groundwater Elevation Contours, June 2022



Legend

- ▭ Facility Boundary
- ⬭ Water Body
- ⬭ Wetland
- — Pipeline
- — River/Stream
- ➤ Surface Water Flow Direction

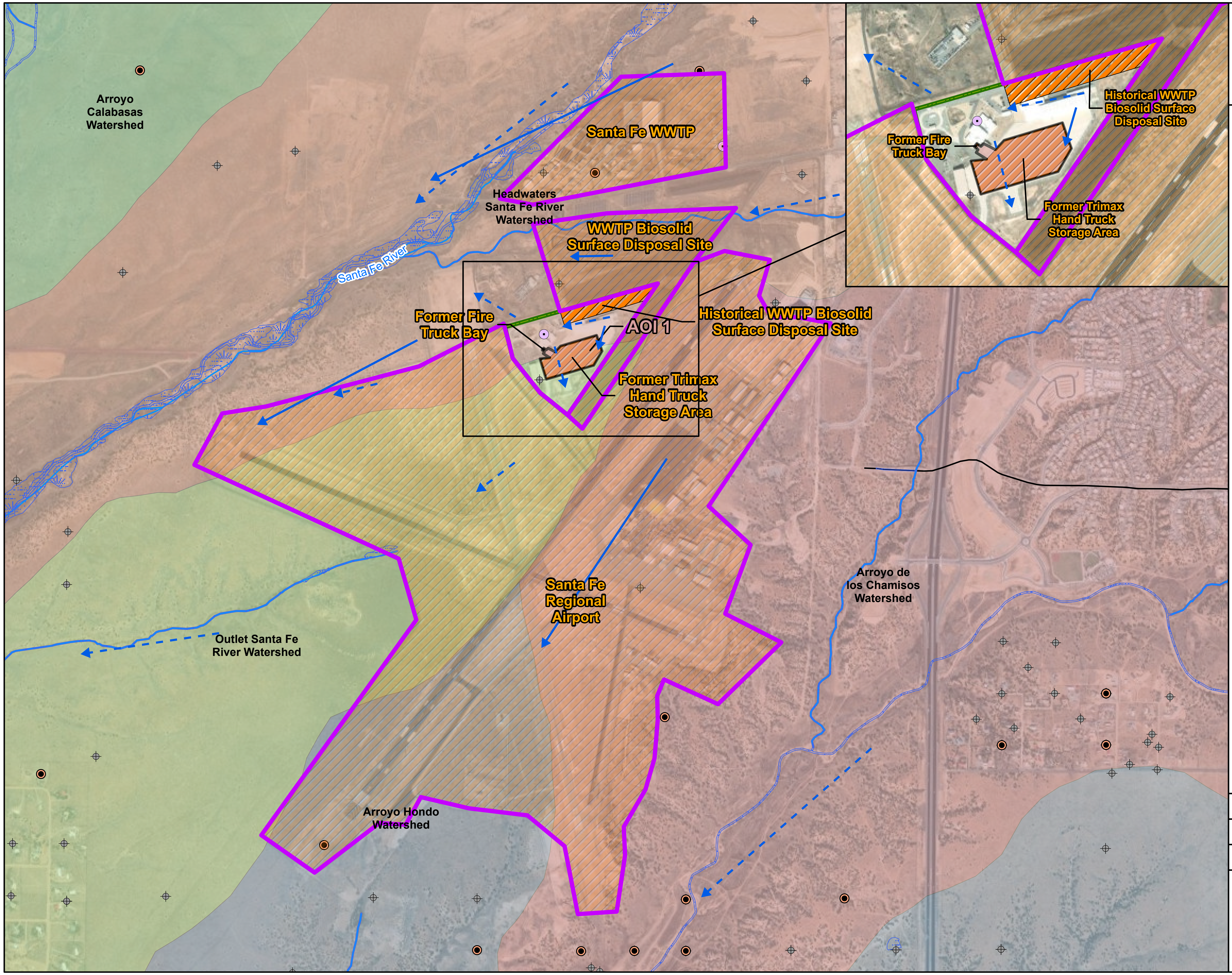
Service Layer Credits: World Imagery: Maxar

ARNG

Remedial Investigation at Santa Fe AASF, NM

Date: 11/8/2024

Figure 10-5
Surface Water Features



Legend

- ▭ Area of Interest
- ▨ Potential Release Area
- ▭ Potential Adjacent Source Area
- ▭ Facility Boundary
- Wetland
- — Pipeline
- — River/Stream
- → Inferred Groundwater Flow Direction
- ⇢ Surface Water Flow Direction

Wells

- ● Domestic
- ⌖ Unknown/Other
- ⊙ Irrigation

Service Layer Credits: World Imagery: Maxar

ARNG

Remedial Investigation at Santa Fe AASF, NM

Date: 11/8/2024

Figure 10-6
Areas of Interest

Legend

- ⊗ DPT Soil Boring
- ⊗ Sonic Soil Boring
- ☒ Hand Auger Soil Boring
- ⊕ Sonic Soil Boring/Monitoring Well
- ▭ Area of Interest
- ▭ Facility Boundary
- - -▶ Surface Water Flow Direction
- ──▶ Groundwater Flow Direction

N

0 100 200 400
Feet

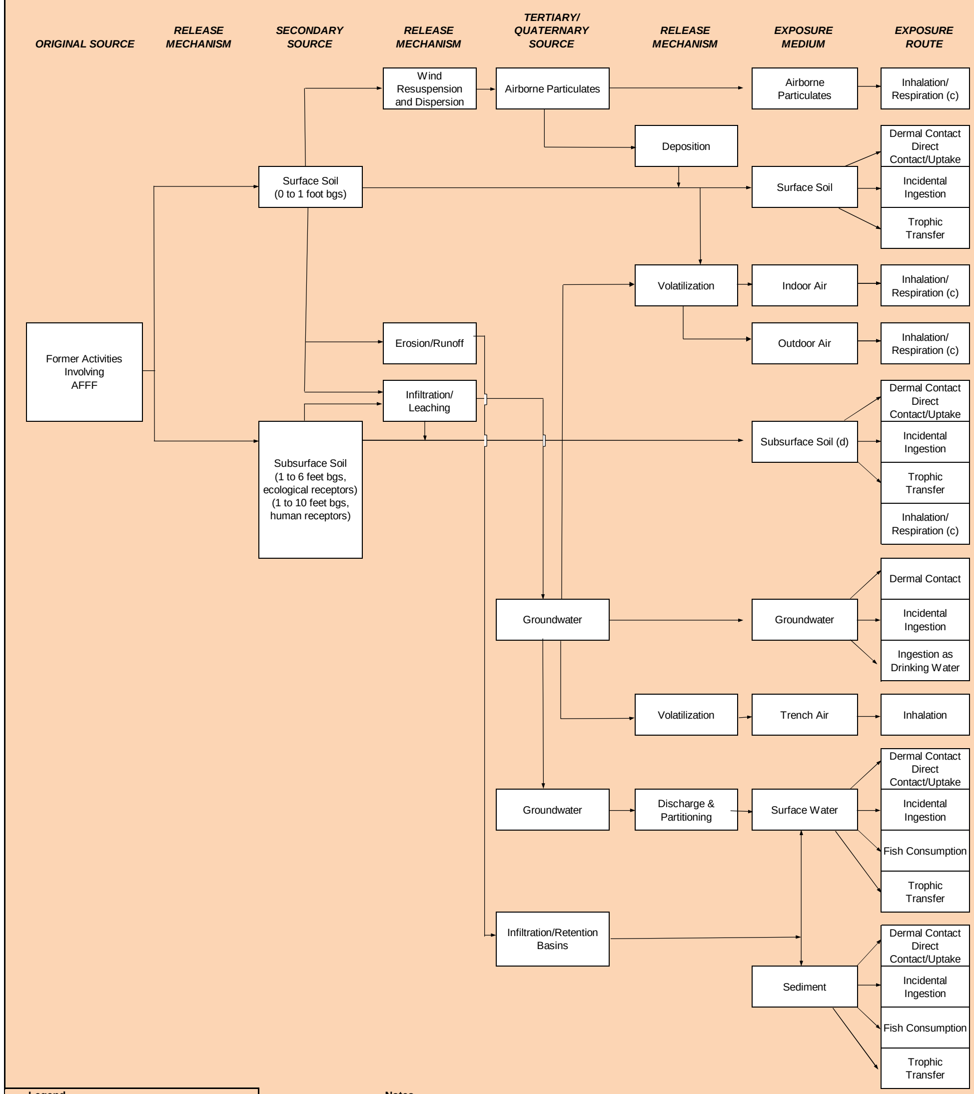
Service Layer Credits: World Imagery: Maxar, Microsoft

ARNG

Remedial Investigation at Santa Fe AASF, NM

Date: 11/8/2024

Figure 10-7
Site Inspection Sample Locations



Human and Ecological Receptors

Exposure Medium	Exposure Route	On-facility (h) Human Receptors (Current) (b)	On-facility (h) Human Receptors (b) (Future)	On-facility (h) Ecological Receptors (b)	Off-facility (a) Human Receptors (b) (Current/Future)	Off-facility (a) Ecological Receptors (b)
Airborne Particulates	Inhalation/ Respiration (c)	◉	◉	○	○	NA
Surface Soil	Dermal Contact Direct Contact/Uptake	●	●	●	○	NA
	Incidental Ingestion	●	●	●	○	NA
	Trophic Transfer	NA	NA	●	NA	NA
Indoor Air	Inhalation/ Respiration (c)	NA	◉	NA	○	NA
Outdoor Air	Inhalation/ Respiration (c)	◉	◉	NA	○	NA
Subsurface Soil (d)	Dermal Contact Direct Contact/Uptake	○	●	●	○	NA
	Incidental Ingestion	○	●	●	○	NA
	Trophic Transfer	NA	NA	◉	NA	NA
	Inhalation/ Respiration (c)	NA	NA	○	NA	NA
Groundwater	Dermal Contact	NA	● (e)	NA	●	NA
	Incidental Ingestion	NA	NA	NA	NA	NA
	Ingestion as Drinking Water	○	● (e)	NA	●	NA
Trench Air	Inhalation	NA	◉	NA	NA	NA
Surface Water	Dermal Contact Direct Contact/Uptake	NA	● (f)	○	●	●
	Incidental Ingestion	NA	● (f)	●	●	●
	Fish Consumption	NA	(g)	NA	(g)	NA
	Trophic Transfer	NA	NA	NA	NA	●
Sediment	Dermal Contact Direct Contact/Uptake	NA	● (f)	○	●	●
	Incidental Ingestion	NA	● (f)	○	●	●
	Fish Consumption	NA	(g)	NA	(g)	NA
	Trophic Transfer	NA	NA	○	NA	●

Legend

- ● **Potentially complete pathway**
- ◉ **Potentially complete pathway but exposure not quantifiable; discussed in the report text.**
- ○ **Incomplete or insignificant pathway**
- **NA Not Applicable**

Notes

AFFF - Aqueous film forming foams.
AOI - Area of Interest.
bgs - below ground surface.
HHRA - human health risk assessment.
PFAS - Per- and polyfluoroalkyl substances.
(a) These potential receptors would only be evaluated if off-facility migration pathways for groundwater and surface water/sediment for PFAS from installation activities are confirmed and if additional off-facility data are collected during the Adaptive Phase.
(b) Not all exposure pathways are complete for all receptors. Refer to Appendix E Figure E-1 for details by specific human receptor and Appendix E Figure E-2 for details by specific ecological receptor.
(c) Potential exposure via inhalation will not be quantitatively evaluated because toxicity values for the inhalation exposure route are not available for PFAS. The associated uncertainties will be discussed in the uncertainty discussion.
(d) For the HHRA, it is conservatively assumed that there could be future redevelopment of the facility, and current subsurface soils may be brought to the surface and become available for exposure under a future use scenario.
(e) The evaluation of on-facility groundwater as a future source of potable water will be performed for informational purposes to represent an unrestricted groundwater use scenario.
(f) There are no on-facility surface water bodies with significant human exposure potential. If the Prescriptive Phase data indicate off-facility impact to waterbodies, additional data may be collected.
(g) The fish consumption pathway will be qualitatively evaluated in the HHRA.
(h) Includes the City of Santa Fe property adjacent to the Santa Fe AASF northern boundary, if determined to be impacted with PFAS via facility outflows.

Project No. 60717766		
Santa Fe AASF	**HUMAN HEALTH AND ECOLOGICAL CONCEPTUAL SITE MODEL**	**Figure 10-8**

Worksheet #11: Project/Data Quality Objectives

DQOs specify the level of data required to support the decision-making process for a project. Specific DQOs have been established for the RI at this facility and are described in this worksheet. These DQOs will follow the USEPA's seven-step iterative process for DQO development. DQOs are influenced by the ongoing project planning discussions with stakeholders and will be updated if new consensus decisions are reached.

RI activities for the facility will be conducted in multiple mobilizations. This QAPP addresses DQOs for an initial Prescriptive Phase mobilization, a secondary Adaptive Phase mobilization, and a Final Characterization/Monitoring Phase. DQOs for the Adaptive Phase may be modified based on analysis of data collected during the Prescriptive Phase. Modifications to the DQOs will be presented in the future planning documents for review and approval by ARNG and USACE.

1. State the Problem

PFAS are classified as emerging environmental contaminants that have garnered 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 implemented a policy to retain facilities within the CERCLA process, comparing PFAS analytical results to SLs derived from the USEPA Regional Screening Levels (RSLs) for soil and tap water (Assistant Secretary of Defense, 2023). The ARNG program follows this policy, recommending AOI(s) for further investigation if PFAS concentrations exceed the SLs during the SI phase. While PFAS concentrations exceeding SLs were confirmed during the SI phase at Santa Fe AASF, the extent of potential risk to human health or the environment remains uncertain. If the results of the risk assessment performed as part of the RI Report identifies potential unacceptable risk as defined under the NCP (40 CFR Part 300.430; USEPA, 1994), then an FS will be recommended to evaluate remedial action alternatives.

The OSD policy instructs the use of USEPA RSLs based on a cancer risk level of 1E-06 and a hazard quotient of 0.1 for soil and groundwater. The OSD updated its website in March 2024 to direct the use of the November 2023 RSLs for specific PFAS (https://www.acq.osd.mil/eie/eer/ecc/pfas/pfas101/rsl.html). Surface water and sediment SLs are multiplied by a factor of 10 from the respective residential tap water and soil RSLs to estimate changes in exposure when assuming a non-residential scenario compared to a residential scenario. If the surface water is an expression of groundwater, a focused point of groundwater recharge, and is used as a source of drinking water or directly discharges into a water body used for drinking water purposes, the factor of 10 will not be added to the tap water RSL. The PFAS on the OSD website that have DoD-approved RSLs and are on the Method 1633 analytical list are summarized in **Table 11-1**. The SLs presented in **Table 11-1** will be used to guide field investigations and evaluate analytical data.

Applicable SLs may change over the contract period. Those PFAS with accepted SLs are considered "relevant compounds" at the time of development of this QAPP and will be assessed and updated accordingly if changes to policy, including screening level updates, are formally accepted by OSD.

Table 11-1 PFAS Screening Levels

Analyte	Residential/ Construction Worker (Soil) (µg/kg)[a, b] 0-2 feet bgs	Industrial/ Commercial Composite Worker (Soil) (µg/kg)[a] 2-15 feet bgs	Tap Water (Groundwater and/or Surface Water) (ng/L)[a, b]
HFPO-DA	23	350	1.5
PFBA	7,800	120,000	1,800
PFBS	1,900	25,000	600
PFHxA	3,200	41,000	990
PFHxS	130	1,600	39
PFNA	19	250	5.9
PFOA	19	250	6.0
PFOS	13	160	4.0

Notes:
bgs = below ground surface; µg/kg = micrograms per kilogram; ng/L = nanograms per liter

[a] USEPA RSL based on a cancer risk level of 1E-06 and a hazard quotient of 0.1 (November 2023). RSLs are used consistent with the memorandum from the OSD, *Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program* (24 August 2023) and the list of RSLs included in Department of Defense Investigations of PFAS as of March 2024 (https://www.acq.osd.mil/eie/eer/ecc/pfas/pfas101/rsl.html).

[b] Note that the OSD memo values are applicable to tap water (groundwater and/or surface water) and soil. Surface water and sediment SLs are multiplied by a factor of 10 from the respective residential tap water and soil RSLs to estimate changes in exposure when assuming a non-residential scenario compared to a residential scenario. If the surface water is an expression of groundwater, a focused point of groundwater recharge, and is used as a source of drinking water or directly discharges into a water body used for drinking water purposes, the factor of 10 will not be added to the tap water RSL.

2. Identify the Goals of the Study

The unique nature of PFAS was considered when establishing goals for the investigation. Because of the very low action levels and highly mobile nature of PFAS, the traditional characterization of nature and extent and definition of boundaries will be modified, focusing on data necessary to evaluate response actions. Additionally, the ubiquitous nature of PFAS was considered when establishing the goals. Many studies have been published that show widespread distribution of certain PFAS, such as PFAAs, in various matrices including sediment, surface water, groundwater, wildlife, and human blood (whole, plasma, and serum) (Kannan et al., 2004; Yamashita et al., 2005; Higgins et al., 2005; Rankin et al., 2016). Some PFAS (such as PFAAs) are found in many places throughout the globe, even in areas well beyond where they were initially used or manufactured (Houde et al., 2011).

The goals of the RI are:

1. Conduct a geological investigation to aid in geologic and hydrogeologic characterization in support of the RI drilling and sampling program. Based on data collected during the SI, the observed geology in borings at the facility supports the understood geology of the region. The heterogeneity of strata noted within the Ancha Formation are a result of the formation's dynamic depositional environment. The less permeable deposits within the Ancha are considered localized downward confining layers over which perched water may accumulate. The shape and orientation of these deposits are likely significant factors in controlling groundwater flow and so understanding them is a key data quality objective for the RI. This investigation will evaluate the extent and thickness of these less permeable deposits forming the

perched groundwater zone observed on the west side of the AASF. Additionally, the RI will assess hydrogeologic conditions in the regional groundwater zone beneath the perched zone and evaluate whether and how the two zones may be in hydraulic communication.

2. Refine the measured groundwater flow direction within the perched and regional groundwater zones. The installation of additional monitoring wells within the perched aquifer zone is needed to measure groundwater levels and calculate flow direction and gradient. Understanding the groundwater regime at the AASF and surrounding area will assist in identifying potential migration pathways to critical downgradient drinking water and surface water (i.e., springs) receptors, and evaluate potential off-facility sources upgradient.
3. Locate the release areas in soil that are attributable to ARNG activities where relevant compounds are linked to groundwater containing these compounds. Evaluate the extent of concentrations observed in soil during the SI at recognized release areas. Evaluate potential on-facility release areas that are not attributable to ARNG activities (i.e., biosolid disposal site) where relevant compounds were observed during the SI. Assess whether surface runoff has impacted soil in on-facility drainage features (e.g., AASF stormwater retention basin) and nearby off-facility. Refine the occurrence of relevant compounds laterally and vertically in soil to the SLs (Assistant Secretary of Defense, 2023). If, due to significant site construction and soil movement, no release area is apparent, collect sufficient soil data to support a quantitative risk assessment. If relevant compounds are detected, further evaluate these results in the risk assessment as part of the comprehensive RI report that will be prepared following completion of RI field activities, as described in Goals 10 and 11 below.
4. Identify potential release areas and refine the extent of relevant compounds attributable to ARNG activities in the perched groundwater zone at concentrations above the SLs at Santa Fe AASF (Assistant Secretary of Defense, 2023). Install monitoring well pairs in the perched and regional groundwater at select locations to evaluate the potential vertical migration of relevant compounds from perched groundwater to the regional groundwater zone. Determine whether the concentrations of these compounds in groundwater are more than likely the result of ARNG activities (originate on the facility). If relevant compounds are detected, conduct preliminary screening and evaluate the results in the HHRA as part of the comprehensive RI report that will be prepared following completion of RI field activities, as indicated in **Section 14.6**, and as described in Goals 10 and 11 below.
5. Evaluate the extent of relevant compounds attributable to ARNG activities in groundwater at concentrations above the SLs downgradient of the Santa Fe AASF (off-facility).
6. Identify possible non-ARNG sources linked to groundwater and evaluate whether PFAS compounds potentially originating from these sources are migrating onto the facility or mixing with groundwater downgradient. Evaluate the presence of relevant compounds in groundwater upgradient of Santa Fe AASF, beneath the WWTP biosolid application areas.
7. Assess surface runoff potential and overland transport to the Santa Fe River. Currently, there are no defined surface water features on-facility or nearby off-facility to assume a pathway to the river. If a surface transport pathway is identified during the RI, surface water and sediment samples may be collected to determine the presence or absence of relevant compounds in these media attributable to ARNG activities. If relevant compounds are detected, further evaluate these results via additional data collection during the adaptive or final characterization phases of the RI to inform the risk

assessment as part of the comprehensive RI report that will be prepared following completion of RI field activities, as described in Goals 10 and 11 below.

8. Collect data to evaluate facility characteristics that influence the fate and transport of relevant compounds, support refinement of the CSM, and inform the potential remedial alternatives evaluation.
9. Collect and document data that is both representative of field conditions and defensible within the precision, accuracy, representativeness, comparability, completeness, and sensitivity (PARCCS) parameters. This includes sufficient field samples to fully characterize field conditions and heterogeneity as well as quality control (QC) samples sufficient to demonstrate data quality. Collect legally defensible samples with an unbroken chain of custody (CoC) maintained from sampling through analysis.
10. Conduct a facility-specific HHRA in accordance with USEPA Risk Assessment Guidance for Superfund (RAGS) and DA risk assessment guidance and policies (DA, 1999; Assistant Secretary of Defense, 2023) as part of the comprehensive RI report that will be prepared following this and subsequent mobilizations, as indicated in **Section 14.6**. If no potential unacceptable risk or hazard to human receptors, as defined in the NCP [40 CFR § 300.430] (USEPA, 1991; USEPA, 1994), is identified, then no further action for human receptors will be recommended. If potential unacceptable risk or hazard to human health, as defined in the NCP [40 CFR § 300.430] (USEPA, 1991; USEPA, 1994), is presented by facility-related concentrations of relevant compounds in soil and groundwater, and potentially sediment and/or surface water, then an FS will be recommended to evaluate remedial action alternatives.
11. If relevant compounds are detected in on-facility media at concentrations exceeding SLs as described in Goals 3, 4, and 7, a SLERA will be conducted following completion of the Adaptive Phase data collection. The SLERA will be conducted in accordance with USEPA Ecological RAGS (USEPA, 1997) and DA risk assessment guidance (DA, 2010) for relevant compounds, as well as other PFAS with relevant ecological screening values (e.g., perfluorododecanoic acid [PFDoA], perfluoroundecanoic acid [PFUdA], perfluorodecanoic acid [PFDA], perfluoroheptanoic acid [PFHpA], PFHxA, perfluoropentanoic acid [PFPeA], and PFBA). An exceedance of an ecological screening value does not necessarily correlate to an effect and a weight of evidence assessment will be used to determine the need for further evaluation. Lower trophic level receptors (e.g., invertebrates, plants) will be evaluated qualitatively on a community level basis. If the SLERA and subsequent SLERA refinement (Step 3a in the USEPA ERA process) identify the potential for adverse effects on ecological receptors due to exposure to PFAS in soil, sediment, or surface water, then a risk management decision will be made by the team regarding the need for further ecological evaluations.

3. Identify Information Inputs

Primary information inputs include:

- Findings from the CERCLA PA completed for Santa Fe AASF (AECOM, 2020). This information was used to identify potential release areas and mechanisms.
- Findings from the CERCLA SI completed for Santa Fe AASF, including PFAS analytical data from groundwater and soil at the AOI and other areas on the facility (EA, 2023). The soil and groundwater data were used to determine the current understanding of nature and extent of contamination in these media, as described in **Worksheet #10**. Additionally, the data were used refine the sampling approach for these media during the Prescriptive Phase, as described in **Worksheets #17 & #18**.

- Supplemental data from city, county, or state agencies may be used to inform the CSM and RI approach. These data will not be used for decision-making or risk assessment purposes but can be useful to help guide early RI activities.
- Responses from State Historic Preservation Officers, United States Fish and Wildlife Service, and/or tribes identifying natural, cultural, or historical items that may be impacted by CERCLA activities.
- Definitive groundwater sample data that will be collected during the RI Prescriptive and Adaptive Phase mobilizations, and the Final Characterization/Monitoring Phase.
- Definitive soil sample data collected during the RI Adaptive Phase mobilization and Final Characterization/Monitoring Phase.
- If warranted based on the Prescriptive or Adaptive Phase findings, definitive surface water, sediment, and/or porewater data collected during the Adaptive Phase and/or Final Characterization/Monitoring Phase.
- Field data collected during the SI and RI Prescriptive, Adaptive, and Final Characterization/Monitoring Phases, including groundwater elevation, water quality parameters, hydraulic conductivity, vertical gradients, and lithology.
- A subset of soil samples will be selected for geotechnical analyses (grain size, total organic carbon [TOC], and pH).
- In addition to soil quality characteristics gathered via geotechnical analyses, a subset of water samples (e.g., surface water, porewater, and/or daylighting groundwater) may be analyzed for water quality parameters (e.g., pH, dissolved organic carbon, temperature, salinity, if applicable), as these types of data may be helpful to understanding exposure and effects in the risk assessment.
- The findings of the habitat assessment to be performed during the RI field activities will be incorporated into the ERA to aid in the biological characterization and receptor selection.
- The CSM, which will be refined based on the field and analytical data collected during the RI Prescriptive, Adaptive, and Final Characterization/Monitoring Phases.

4. Define the Boundaries of the Study

The scope of the RI is horizontally bounded by the Santa Fe AASF facility and surrounding area. PFAS were detected in soil and groundwater samples during the SI. As such, to meet DQOs, additional sampling will be performed to refine the extent of relevant PFAS compounds to the SLs that is attributable to ARNG activities.

Sampling beyond the facility boundaries has been proposed and is detailed in **Worksheets #17 & #18**. Where off-facility sampling is required, the proper stakeholders will be notified, and right of entry (ROE) will be obtained by USACE and ARNG with property owner(s). The vertical boundaries of the investigation will be determined during the Prescriptive Phase. Initially, well pairs will be installed in the perched and regional groundwater zones to determine the hydraulic connectivity of aquifers and potential migration of contamination. The temporal boundaries of the study will be limited by seasonal conditions at Santa Fe AASF; the field work for the scope will be performed over multiple mobilizations and quarterly monitoring will be performed over the course of one year.

5. Develop the Analytic Approach

Samples will be analyzed by a DoD Environmental Laboratory Accreditation Program (ELAP) and National Environmental Laboratory Accreditation Program (NELAP)-certified laboratory. Copies of the laboratory accreditation certificates are included in **Appendix C**. Analytical services are summarized in **Worksheets #19 & #30**. Analyses will be conducted via the final version of USEPA Method 1633 and in accordance the DoD Quality Systems Manual (QSM) Version 5.4 (DoD, 2021) or Version 6.0 (DoD, 2023a), depending on the laboratory's accreditation cycle. Laboratories are in the process of updating their standard operating procedures (SOPs) to be compliant with the final version of USEPA Method 1633 and will update their accreditation to the published DoD QSM 6.0. The laboratories will be required to follow the current version of their SOPs and the QAPP will be updated to reflect DoD QSM 6.0 and 1633 when the laboratories update their accreditation.

Screening-level PFAS data analyses, using the American Society for Testing and Materials (ASTM) D8421, has been approval for use via a Demonstration of Method Applicability (DMA) Study (AECOM, 2024c). These screening-level PFAS data will be used in conjunction with definitive PFAS data as part of the Rapid Site Characterization (RSC) tasks. Details regarding the RSC process for using these screening and definitive data collaboratively are provided in **Worksheets #14 & #16 and Worksheet #17**. A laboratory specification was developed in conjunction with the ARNG and USACE Baltimore in order to provide consistency amongst laboratories conducting these analyses and to provide the appropriate levels of quality assurance (QA)/QC for the screening-level DQOs. The specifications have been incorporated into the appropriate worksheets (as listed below) and is provided along with the ASTM D8421 SOP in **Appendix C**. Confirmation split sampling, at a minimum of 10% frequency of samples for USEPA Method 1633 analyses, will be performed on all samples involving the screening-level PFAS data analyses. Assessment of the confirmation data, along with protocols for corrective action, will be conducted as part of the data validation and data usability assessment tasks in the same manner as the other quality control sample results. Details for these assessments are provided in **Worksheet #12, Worksheet #20,** and **Worksheet #37.**

Chemical analyses will be performed in accordance with the analytical methods identified in **Worksheet #23**. Analytical sensitivity for the methods selected is compared to project screening criteria in **Worksheet #15**. Requirements for laboratory instrument calibration and equipment maintenance and testing are presented in **Worksheet #24** and **Worksheet #25**, respectively. Measurement performance criteria (MPC) for field and laboratory QC samples are presented in **Worksheet #12** and **Worksheet #28**, respectively. The general analytic approach to achieve the goals outlined in Step 2 of this worksheet is described below.

The specific details and rationale for the sampling design, sampling locations, and methods are presented in **Worksheets #17 & #18**.

6. Specify Performance/Acceptance Criteria

The performance and acceptance criteria are established in **Worksheet #12** and **Worksheet #37**. Laboratory data are considered usable if data validation criteria are met, as described in **Worksheet #34**, **Worksheet #35**, and **Worksheet #36**. Analytical data quality will be compared to DoD QSM Version 5.4 (DoD, 2021) specification for PARCCS. The analytical methods will provide the lowest available detection limits (DLs) using standard methods that will allow the data to be screened against the data quality limits (DQLs) in **Worksheet #15**.

If 95% upper confidence limits (UCLs) are calculated using analytical data, USEPA's software (ProUCL) will be used. The software identifies the underlying data distribution and uses an algorithm to select the most appropriate UCL. UCLs will be calculated at the 95% confidence limit, meaning that one can be 95% confident that the population mean is less than the UCL.

The derivation and use of UCLs will be more fully described in the facility-specific risk assessment work plans.

7. Develop the Detailed Plan for Obtaining Data

The detailed plan for obtaining data is established in **Worksheets #17 & #18**.

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Worksheet #12: Measurement Performance Criteria

This worksheet documents the quantitative MPC in terms of precision, bias, and sensitivity for both field and laboratory measurements and is used to guide the selection of appropriate measurement techniques and analytical methods. MPC are developed to ensure collected data will satisfy the DQOs documented in **Worksheet #11**. For analytical methods, MPC are determined for each matrix, analyte, and concentration level. Representative MPCs for PFAS, geotechnical, and other geochemical parameters are detailed below.

Matrix	Groundwater/ Surface Water/ Porewater/ Potable Wells
Analytical Group	PFAS by USEPA Method 1633
Concentration	Low

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling, Analytical, or Both
Accuracy/Bias	LCS/LCSD and MS/MSD shall be spiked with all analytes. Analyte recovery limits per **Worksheet #28**	LCS/LCSD, MS/MSD	S & A
Precision	Laboratory duplicates analysis should have an RPD < 30%	LCS/LCSD, MS/MSD	A
Precision	Values > 5X LOQ: RPD must be ≤ 30%; Absolute difference ≤ 2x the LOQ for Values ≤ 5X LOQ:	Field Duplicates	S
Representativeness	No analytes detected > ½ LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater	Method Blank, Field Reagent Blanks, Equipment Rinsate Blanks	S & A
Accuracy	Extracted Internal Standard Analyte recoveries must be within 20% to 150% of ICAL midpoint standard area	EIS	A
Sensitivity	Verify point of known precision and accuracy at the lowest point of the calibration range (quarterly)	Lowest point of the calibration curve e.g., LOQ Verification	A
Sensitivity	Detection limits ≤ to acceptance criteria, See **Worksheet #15** for specific laboratory reporting limits.	Reported Sample Data	S & A
Sensitivity	Instrument Sensitivity Check concentrations must be within ±30% of their true values	Use of standardized SOPs in field and laboratory	A
Completeness	Completeness criteria will be considered met if 95% of all planned sample data (as requested on CoC in lab reports and EDD; including requested reanalyses) are collected	SOPs	S & A
Representativeness	Based on accuracy and media comparison	Laboratory Receipt Checklist, Cooler Temperature Blank	S

Notes:
% = percent
< = less than
> = greater than
≤ = less than or equal to
A = analytical
CoC = chain of custody
EDD = electronic data deliverable
EIS = Extracted Internal Standards
ICAL = initial calibration
LCS/LCSD = laboratory control spike/ laboratory control spike duplicate
LOQ = limit of quantitation
MS/MSD = matrix spike/ matrix spike duplicate
QC = quality control
RPD = relative percent difference
S = sampling
SOP = Standard Operating Procedure

Matrix Soil/ Sediment
Analytical Group PFAS by USEPA Method 1633
Concentration Low

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling, Analytical, or Both
Accuracy/Bias	LCS/LCSD and MS/MSD shall be spiked with all analytes. Analyte recovery limits per **Worksheet #28**	LCS/LCSD, MS/MSD	S & A
Precision	Laboratory duplicates analysis should have an RPD < 30%	LCS/LCSD, MS/MSD	A
Precision	Values > 5X LOQ: RPD must be ≤ 50%; Absolute difference ≤ 4x the LOQ for Values ≤ 5X LOQ:	Field Duplicates	S
Representativeness	No analytes detected > ½ LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater	Method Blank, Field Reagent Blanks, Equipment Rinsate Blanks	S & A
Accuracy	Extracted Internal Standard Analyte recoveries must be within 20% to 150% of ICAL midpoint standard area	EIS	A
Sensitivity	Verify point of known precision and accuracy at the lowest point of the calibration range (quarterly)	Lowest point of the calibration curve e.g., LOQ Verification	A
Sensitivity	Detection limits ≤ to acceptance criteria, See **Worksheet #15** for specific laboratory reporting limits.	Reported Sample Data	S & A
Sensitivity	Instrument Sensitivity Check concentrations must be within ±30% of their true values	Use of standardized SOPs in field and laboratory	A
Completeness	Completeness criteria will be considered met if 90% of all planned sample data (as requested on CoC in lab reports and EDD; including requested reanalyses) are collected	SOPs	S & A
Representativeness	Based on accuracy and media comparison	Laboratory Receipt Checklist, Cooler Temperature Blank	S

Notes:
% = percent
< = less than
> = greater than
≤ = less than or equal to
A = analytical
CoC = chain of custody
EDD = electronic data deliverable
ICAL = initial calibration
LCS/LCSD = laboratory control spike/ laboratory control spike duplicate
LOQ = limit of quantitation
MS/MSD = matrix spike/ matrix spike duplicate
RPD = relative percent difference
QC = quality control
S = sampling
SOP = Standard Operating Procedure

Matrix Groundwater and Soil
Analytical Group [1]PFAS by ASTM D8421
Concentration Low

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling, Analytical, or Both
Accuracy/Bias	LCS shall be spiked with all analytes. Analyte recovery limits 40%-150%	LCS	S & A
Precision	LCS and field duplicates: Aqueous: LCS/LCSD RPD ≤ 30 Solid: LCS/LCSD RPD ≤ 50	LCS Duplicates and Field Duplicates	S &A
Representativeness	No analytes detected > 1/2 LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater	Method Blank, Field Reagent Blanks, Equipment Rinsate Blanks	S & A
Accuracy	All EIS recovered within 70-130% of expected concentration. Lab will contact project chemist if EIS recovery is below 20% or above 150%.	EIS	A
Sensitivity	Verify point of known precision and accuracy at the lowest point of the calibration range.	Lowest point of the calibration curve e.g., LOQ Verification	A
Sensitivity	Detection limits ≤ to acceptance criteria, See **Worksheet #15** for specific laboratory reporting limits.	Reported Sample Data	S & A
Completeness	Completeness criteria will be considered met if 95% of all planned sample data (as requested on CoC in lab reports and EDD; including requested reanalyses) are collected	SOPs	S & A
Representativeness	Based on accuracy and media comparison	Laboratory Receipt Checklist, Cooler Temperature Blank	S
Representativeness	10% of all samples submitted for ASTM D8421 analysis will be analyzed for USEPA 1633	Quality assurance for ASTM D8421 Data	S & A
Representativeness/ Field Decision Quality	10% of all samples submitted for ASTM D8421 analysis will be analyzed for USEPA 1633. Percent Decision Match > 90%	Confirmation split samples	S & A

Notes:

1) Method modifications and acceptance criteria are based on ASTM D8421 laboratory specification provided in **Appendix C**.

% = percent
< = less than
> = greater than
≤ = less than or equal to
A = analytical
ASTM = American Society for Testing and Materials
CoC = chain of custody
EDD = electronic data deliverable
EIS – Extracted Internal Standards
ICAL = initial calibration
LCS = laboratory control spike
LCSD = laboratory control spike duplicate
LOQ = limit of quantitation
MS/MSD = matrix spike/ matrix spike duplicate
PFAS = per- and polyfluoroalkyl substances
QC = quality control
RPD = relative percent difference
S = sampling
SOP = Standard Operating Procedure

Matrix Soil/ Sediment
Analytical Group TOC

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling, Analytical, or Both
Accuracy/ Bias	LCS/LCSD: See **Worksheet #15** MS/MSD: See **Worksheet #15**	LCS/LCSD and MS/MSD	S & A
Precision	Laboratory duplicates analysis should have RPD ≤ 20% for soil; RPD ≤ 10% for water	Matrix Duplicate	A
Representativeness	Target compound < RL	Method Blank	A
Completeness	Completeness criteria will be considered met if 100% of all planned sample data (as requested on CoC in lab reports and EDD; including requested re-analyses) are collected	Reported Sample Data	S & A
Comparability	Based on accuracy and media comparison	Use of standardized SOPs in field and laboratory	S & A

Notes:
% = percent
A = analytical
CoC = chain of custody
EDD = electronic data deliverable
LCS/LCSD = laboratory control spike/ laboratory control spike duplicate
MS/MSD = matrix spike/ matrix spike duplicate
QC = quality control
RL = reporting limit
RPD = relative percent difference
S = sampling
SOP = standard operating procedure
TOC = total organic carbon

Matrix Soil/ Sediment
Analytical Group pH

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling, Analytical, or Both
Accuracy/ Bias	85-115% for soil	LCS/LCSD	A
Precision	RPD ≤ 20% for soil	Matrix Duplicate	A
Completeness	Completeness criteria will be considered met if 100% of all planned sample data (as requested on CoC in lab reports and EDD; including requested reanalyses) are collected	Reported Sample Data	S & A
Comparability	Based on accuracy and media comparison	Use of standardized SOPs in field and laboratory	S & A

Notes:
% = percent
A = analytical
CoC = chain of custody
EDD = electronic data deliverable
LCS/LCSD = laboratory control spike/ laboratory control spike duplicate
LOQ = limit of quantitation
QC = quality control
RPD = relative percent difference
S = sampling
SOP = standard operating procedure

Matrix	Soil/ Sediment
Analytical Group	Grain Size

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
Precision	RPD ≤ 20%	Sample Duplicate	S & A
Completeness	Completeness criteria will be considered met if 100% of all planned sample data (as requested on CoC in lab reports and EDD; including requested re-analyses) are collected	Reported Sample Data	S & A
Comparability	Based on accuracy and media comparison	Use of standardized SOPs in field and laboratory	S & A

Notes:
% = percent
A = analytical
CoC = chain of custody
EDD = electronic data deliverable
QC = quality control
RPD = relative percent difference
S = sampling
SOP = standard operating procedure

Worksheet #13: Secondary Data Uses and Limitations

Secondary data sources, uses, and limitations are tabulated below. Original source documents were reviewed for uncertainty discussions that may identify additional or more suitable data limitations.

Data Type	Source	Data Uses Relative to Current Project	Factors Affecting Reliability of Data and Limitations on Data Use
Meteorological	National Weather Service	Estimates of seasonal fluctuations in precipitation.	Meteorological data records are available for the weather station at the adjacent Santa Fe Regional Airport. Seasonal weather patterns may be changing and actual facility conditions can vary.
Topographic	USGS	Inferred groundwater flow pathways based on local topography at each facility. Groundwater flow maps will ultimately rely upon groundwater measurements from monitoring wells.	Topography of some facilities may have been altered by building or grading activities.
Soil and groundwater chemistry, groundwater monitoring data, and data gaps identification	Historical facility reports	Applicable to the evaluation of historical facility conditions in soil and groundwater to supplement data being collected under this delivery order.	The data may not represent current conditions because of the age of some of the data. Reliability of second- or third-party data quality.
Historical facility records (i.e., material inventories)	Purchase records, facility inventories, on-facility records, safety data sheets	Applicable to the evaluation of potential constituents of concern and release areas.	Records may be incomplete or inaccurate.
Periodicals (i.e., news articles)	Local newspapers, magazines, or other periodicals	Applicable to the evaluation of the use of potential constituents of concern at off-facility locations or mutual use/ aid agreements with local fire department or other entities.	Records may be incomplete or inaccurate.

Notes:
USGS = United States Geological Survey

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Worksheets #14 & #16: Project Tasks and Schedule

Worksheets #14 & 16 provides the project schedule and details the general project tasks that are expected to be completed as part of the RI. The RI program will include tasks as detailed in the following sections:

- **Section 14.1** – Mobilization
- **Section 14.2** – Field Investigation Activities
- **Section 14.3** – Laboratory Analysis
- **Section 14.4** – Data Management, Review, and Validation
- **Section 14.5** – Human Health and ERA
- **Section 14.6** – Report Preparation

The RI field activities for the Santa Fe AASF will consist of multiple phases. This RI QAPP specifically addresses the activities to be performed during the RI Prescriptive Phase, as developed in conjunction with the data from the SI (EA, 2023). During the Prescriptive Phase, soil and groundwater samples will be collected to further refine the nature and extent of impacts previously identified, as summarized in **Worksheet #10**. Any sample results in exceedance of the screening levels will be considered for ongoing refinement during the RI Adaptive Phase. The Adaptive Phase scope will largely be based on the results of the Prescriptive Phase and will include on- and off-facility step-in and step-out refinement sample locations at sources and evaluate potential off-facility migration. Quick turn-around time (TAT) laboratory analyses or screening techniques may be used for rapid site characterization (RSC) and support data interpretation during the Adaptive Phase; however, RSC is not included in the Prescriptive Phase scope. Technical details of the Adaptive Phase and Final Characterization/Monitoring Phase not shared by the Prescriptive Phase (RSC soil sampling, off-facility well installation, aquifer testing, etc.), along with future phase sampling locations, intervals, additional sample media (e.g., surface water, sediment, and/or porewater), and rationale will be included in future planning documents after completion of the Prescriptive Phase. Future planning documents will include Field Planning Request memoranda with amended UFP-QAPP worksheets. The memos will be provided to USACE and ARNG for review and shared with NMED. Later phase approaches will also be discussed in future TPP meetings.

The specific details and rationale for the Prescriptive Phase sampling design, in addition to sampling locations and methods, are presented in **Worksheets #17 & #18.** Field activities will be completed per the SOPs in **Appendix D**.

Table 14-1 below presents the schedule for the RI as anticipated based on ongoing project planning discussions with stakeholders, to be updated if new consensus decisions materialize.

Table 14-1 RI Schedule

Task	Start Date	End Date
RI QAPP (Prescriptive)	March 2024	November 2024
Pre-mobilization (Prescriptive)	November 2024	December 2024
Mobilization (Prescriptive)	December 2024	February 2025
Field Work (Prescriptive)	December 2024	March 2025
Demobilization (Prescriptive)	March 2025	March 2025

Task	Start Date	End Date
Data Analysis / Data Validation (Prescriptive)	January 2025	April 2025
Field Planning Request (Adaptive)	May 2025	August 2025
Pre-mobilization (Adaptive)	August 2025	August 2025
Field Work (Adaptive)	September 2025	October 2025
Demobilization (Adaptive)	October 2025	October 2025
Data Analysis / Data Validation (Adaptive)	November 2025	February 2026
Field Planning Request (Final Characterization/Monitoring)	February 2026	May 2026
Pre-mobilization (Final Characterization/Monitoring)	July 2026	July 2026
Field Work (Final Characterization/Monitoring)	August 2026	September 2027
Demobilization (Final Characterization/Monitoring)	October 2027	October 2027
Data Analysis / Data Validation (Final Characterization/Monitoring)	October 2027	December 2027
Reporting	December 2027	June 2028

14.1 Mobilization

The following subsections present field tasks that may be completed as part of the mobilization activities.

ROE Documentation Support

ROEs will be necessary to complete the RI field activities during the Prescriptive Phase to accomplish limited off-facility soil sampling and groundwater sampling of existing, non-ARNG owned monitoring wells. ROEs executed during this phase may also consider anticipated future off-facility sampling needs. ROE documentation and property identification will be sent by USACE project manager (PM) at least 60 days prior to entry onto a property. ROE property data will include a property parcel number, legal description, owner name, mailing and physical addresses, phone number, and a map of the property. A2P JV will provide support to USACE developing the parcel property maps. Monitoring wells will be installed within public rights-of-way, to the extent possible. Access will be coordinated with the City of Santa Fe. Additional ROEs may be necessary during the Adaptive Phase.

Health and Safety Requirements

Health and safety requirements for field activities will be specified in the Accident Prevention Plan (APP) (AECOM, 2024a) and Site Safety and Health Plan (SSHP) (AECOM, 2024b). Personnel mobilized to the facility will be required to meet training requirements identified in Federal Regulation 29 CFR 1910.120 and applicable Occupational Safety and Health Administration (OSHA) training, including Hazardous Waste Operations and Emergency Response (HAZWOPER) and medical surveillance requirements. At least two personnel trained in first aid and cardiopulmonary resuscitation (CPR) will be on-facility during intrusive field activities. Training certificates for personnel (HAZWOPER 40-hour training; current HAZWOPER 8-hour refresher training; and first aid/CPR) will be maintained on-facility.

The Site Safety and Health Officer (SSHO) will have completed the 30-hour OSHA General Industry or Construction Industry Safety Class or equivalent, as specified in *EM 385-1-1* (USACE, 2014). For non-construction related field activities (such as groundwater, surface water or sediment sampling) a Hazardous, Toxic, and Radioactive Waste (HTRW) SSHO may be utilized.

The HTRW SSHO must have a minimum of 1 year of experience implementing health and safety programs and meet the training requirements listed in *EM 385-1-1* (USACE, 2014). The SSHO will be responsible for managing, implementing, and enforcing the health and safety program in accordance with the accepted APP/SSHP. The SSHO will be a competent person that can identify existing and predictable hazards in the working environment or working conditions that are dangerous to personnel, and who has authorization to take prompt corrective measures to eliminate them.

The SSHO will also perform as the Site Supervisor (SS), who will have completed the 8-hour OSHA Supervisor training, as specified in EM-385-1-1. The SS will lead field operations, coordinate field activities, and act as the liaison between facility and laboratory personnel, among other responsibilities.

In general, field personnel will wear PFAS-free Level D personal protective equipment (PPE). If elevated levels of PPE are warranted based on facility conditions, it will be established in the SSHP. Detailed Activity Hazard Analysis (AHA) forms identifying the physical, chemical, and biological hazards that may be encountered at the facility and the associated mitigation methods are presented in the APP/SSHP.

Personnel and visitors who enter the facility will be required to review the APP/SSHP and sign the acknowledgement form. Facility workers will be required to sign the daily tailgate safety meeting form and fill out daily AHA forms. Safety issues that arise during implementation of field activities will be addressed during tailgate safety meetings held daily before the workday and will be documented in the daily tailgate safety meeting form.

Additional Personnel Qualifications

In addition to the health and safety requirements specified above, personnel mobilized to the facility will complete the DoD's *Operations Security Awareness for Military Members, DoD Employees, and Contractors* and *Level 1 Antiterrorism Awareness Training*. AECOM employees that will be performing sample collection will also take an internal PFAS sampling guidance training.

Permits and Notifications

Utility clearance is required for intrusive work, regardless of planned intrusive depth. Prior to intrusive activities, existing utility maps will be requested from facility personnel, and a facility walk will be scheduled with the appropriate ARNG personnel and affected property representatives (e.g., City of Santa Fe WWTP personnel), if applicable, to mark out locations of the subsurface utilities. A2P JV or its drilling subcontractor will contact NM811, the local one-call utility location system. Precautionary measures (e.g., geophysical survey, air knifing methods, hand-digging to 5 feet) are required at any location where intrusive activities are proposed to confirm the presence/absence of utilities. A2P JV will subcontract a private utility locator to clear all intrusive locations. The location of utilities will be noted and recorded during the facility visits and referenced when selecting investigation locations. Utility clearance will be conducted in accordance with *SOP 3-01: Utility Clearance* (**Appendix D**).

Federal Aviation Administration (FAA) notifications and determinations will be required for select Prescriptive Phase drilling locations on Santa Fe AASF where the height of the drilling equipment is of concern relative to airport setbacks. An FAA Obstruction Evaluation/Airport Airspace Analysis (OE/AAA) will be completed by submitting the Notice of Proposed Construction or Alternation (Form 7460-1) at least 45-days in advance of drilling activities. Future work phase sample locations not included on the Prescriptive Phase OE/AAA will require additional FAA notifications.

A2P JV will also contact the NMARNG Environmental Manager at least 20 business days prior to the scheduled start of the field activities. Field work will be coordinated with the appropriate contact and/or their designee to ensure investigation activities do not impact facility operations.

Facility Preparation

Preparation activities for the RI field investigation operations include mobilization of field team personnel and equipment. Sensitive habitats, threatened or endangered species, and cultural and historical resources will be researched prior to mobilization for identification and location avoidance. If previously unidentified cultural or historical resources are discovered in the field, the proper authorities will be notified, and field operations will either stop work or relocate outside the impacted area until given further direction. While not anticipated for this RI, traffic control measures will be required to complete investigations at sampling locations at or near roadways. Traffic control procedures will be outlined in the SSHP is determined to be necessary.

14.2 Field Investigation Activities

The following subsections present field tasks that may be completed as part of RI field efforts. Field tasks, including investigative-derived waste (IDW) management will be completed following the SOPs listed in **Worksheet #21** and provided in **Appendix D**. In instances where deviations from the field protocols established in this QAPP need to be made due to unforeseen conditions, a Field Change Request Form will be generated to document the change and request feedback from the A2P JV Task Manager and Project Manager, USACE, and ARNG. In instances where deviations from the field protocols established in this QAPP are made in the field due to encountered conditions that are considered major deviations, a Nonconformance and Corrective Action Report will be generated to document the change after the field work is completed.

Habitat Assessment

A site assessment checklist, including initial habitat assessment, will be performed as part of the Prescriptive Phase to identify representative habitats and species present in the vicinity of the sampling locations. The habitat assessment findings may be used to confirm the receptors and exposure pathways identified in the preliminary CSM (**Worksheet #10**) and may be considered in the characterization of potential adverse impacts, if identified based on comparisons to screening values. Habitats will initially be identified through the review of existing maps, available geographic information system (GIS) data, and aerial images.

It is anticipated that the ecological habitat present on the facility is limited to terrestrial habitat for disturbance-tolerant species, including burrowing animals, because non-paved areas are fragmented, adjacent to high human activity areas, and disturbed (mix of bare soil and scrub vegetation) with sporadic scrub trees (e.g., several scrub trees line the retention basin). The stormwater basins and retention basin are anticipated to likewise provide terrestrial habitat similar to the other non-paved areas at the facility as they only temporarily hold water (i.e., seasonally receive and hold water from the facility after rainfall and snowmelt) and are not hydrologically connected to a natural water feature (i.e., upgradient creek/stream). A site visit will be conducted to identify potential habitat at the AASF. It is anticipated that the assessment of the on-facility stormwater features and the off-facility boundary area(s) to which stormwater outflow is directed will confirm the presence of terrestrial habitat and absence of aquatic habitat. The extent of the stormwater drainage pathway and potential for connectivity to the Santa Fe River and wetlands adjacent to the river will also be evaluated.

Although these assessments are not intended to be threatened and endangered (T&E) species surveys, the biologists directing the visits will be familiar with the habitat requirements and appearance of the federally listed species and any observations of relevant habitats or listed species, as well as other general habitat and species observations, will be recorded.

If needed based on the results of the initial habitat assessment and the evaluation of the data collected during the Prescriptive and Adaptive Phases, additional assessment may be needed during subsequent mobilization(s) of the RI. Risk management decisions related to performing additional receptor or habitat surveys will be made by the project team and additional efforts may include wetland delineation, vegetation surveys, T&E species surveys, or other methods, as needed. If no potential for adverse impacts on ecological receptors are identified, additional, more intensive habitat or receptor survey efforts will not be warranted.

Field Instrument Calibration and Quality Control

Equipment will be checked to ensure its completeness and operational readiness. Any equipment found damaged or defective will be returned to the point of origin, and a replacement will be secured. Instruments and equipment that require routine maintenance and/or calibration will be checked initially upon arrival and then prior to use each day, if needed, to support that day's operations. Equipment calibration and daily checks will be documented in accordance with appropriate SOPs.

This system of checks ensures that the equipment is functioning properly. If an equipment check indicates that any piece of equipment is not operating properly, and field repair cannot be made, the equipment will be tagged and removed from service, and a request for replacement equipment will be placed immediately. Replacement equipment will meet the same specifications for accuracy and precision as the equipment removed from service.

PFAS Site Water Supply Sampling and Sampling Equipment Acceptability

A sample from the potable water source (i.e., decontamination water, drilling water) will be collected prior to mobilization to confirm that it is acceptable for use during field activities. For decontamination purposes, the water source is acceptable for use if the detected concentration of relevant compounds is less than the SL, provided the non-dedicated sampling equipment is given a final decontamination rinse with laboratory grade PFAS-free water. If the water is intended for downhole drilling use (i.e., added drilling water), the water source is acceptable for use if the detected concentration is less than ½ the SL. If the source water has concentrations greater than the appropriate threshold, the project team will determine whether the water is acceptable for its intended use based on facility-specific factors (i.e., drilling methodology, relevant sample media). If the water is deemed unacceptable, water will be brought on-facility from another source confirmed to be suitable for use or will be treated onsite prior to use.

Materials being purchased or rented for field work will be confirmed as acceptable for use in the PFAS sampling environment. A summary of acceptability of materials for use in the PFAS sampling environment is provided in *SOP 3-41: Perfluoroalkyl Substance Field Sampling Protocol* (**Appendix D**). As an additional layer of control, prior to the start of field work each day, a PFAS Sampling Checklist will be completed. The checklist will serve as a reminder to each field team member regarding the allowable materials within the sampling environment. An example of the checklist is included in the SOP.

Additionally, all field staff are required to complete AECOM's internal *PFAS Sampling Training*. This training accounts for correct equipment, prohibited field items, clothing, personal care products, sunscreen, insect repellants, and additional confirmed or suspected sources of environmental sample contamination. The ITRC guidance on *Site Characterization, Considerations, Sampling Precautions, and Laboratory Analytical Methods for PFAS* was referenced in the development of this guidance (ITRC, 2018b).

Surface and Shallow Subsurface Soil Sample Collection

Soil samples will be collected from the surface (0 to 2 feet bgs) and shallow subsurface (2 to 15 feet bgs) at individual boring locations and within biased soil units across the facility. These prescriptive phase soil sample intervals are intended for screening level evaluation of the preliminary extent of PFAS impacts and align with the assumed exposure scenarios used to develop the SLs. The soil intervals used for definitive sample collection, such as those for use in risk assessments, will take into consideration NMED guidance on soil exposure intervals. Hand augers will be used to collect surface soil samples and shallow subsurface samples above 5 feet bgs while the borehole is cleared in accordance with AECOM utility clearance procedures. Soil samples collected at deeper intervals will be collected via direct-push technology (DPT) or rotosonic (sonic) drilling technology. All drilling materials will be PFAS-free.

Biased soil units were assigned to evaluate areas where suspected potential releases may have occurred or where surface runoff from the potential release areas is expected to accumulate in soil. Two soil samples will be collected from each soil unit sample location: surface soil (0-2 feet bgs) and shallow subsurface soil (3-5 feet bgs). Additional individual soil borings will be completed to depths of 15 feet bgs within the soil units to further characterize the shallow subsurface soil profile. Three soil samples will be collected from the individual soil borings: one at the surface (0-2 feet bgs) and two in the shallow subsurface (8-10 feet bgs and 13-15 feet bgs). These soil unit samples will be supplemented with discrete surface soil samples collected near stormwater outflows and soil samples collected from monitoring well borings.

Recovered soil will be continuously logged for lithological descriptions by a field geologist using the Unified Soil Classification System (USCS). Details regarding the air monitoring procedures and specific action levels are provided in the APP (AECOM, 2024a). Observations and measurements will be recorded on field forms and in a non-treated field logbook. Photographs of the recovered cores will also be taken. At a minimum, depth interval, recovery thickness, photoionization detector (PID) concentrations, moisture, relative density, color (using a Munsell soil color chart), and texture (using the USCS) will be recorded. Additional observations to be recorded may include groundwater or perched water depth, organic material, or cultural debris. Refer to *SOP 3-16: Soil and Rock Classification* and *SOP 3-21: Surface and Subsurface Soil Sampling Procedures* (**Appendix D**) for additional details.

Each sample will be collected into laboratory-supplied bottle ware and submitted to the laboratory for analysis of selected parameters. Surface and subsurface samples will be analyzed under standard TAT for the target list of PFAS (ASTM D8421[1] and/or liquid chromatography tandem mass spectrometry [LC/MS/MS] compliant with USEPA Method 1633). Additionally, other geochemical and physical parameters will be analyzed in a subset (10%) of soil samples to support evaluation of PFAS fate and transport, in addition to the remedial alternatives analysis. Two soil samples at each SU, one from each depth interval (0-2 feet bgs and 3-5 feet bgs), will be analyzed for TOC (USEPA Method 9060A), pH (USEPA Method 9045D), and grain size (ASTM D-422). An additional two samples will be collected from a location within SU03 to each the 10% subset target. The laboratory method DLs for these analytes are presented in **Worksheet #15**. The required sample containers, preservatives, and holding times are specified in **Worksheets #19 & #30**. The sampling design and rationale, as well as the sampling locations and methods, are presented in **Worksheets #17 & #18**. However, based on analytical results and the field findings, modifications to these sampling locations and/or the sampling approach may be considered. In this event, a Field Change Request Form will be generated to document the

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[1] The use of the PFAS screening method ASTM D8421 will be dependent on the acceptance of the Demonstration of Method Applicability Study, performed under a separate task order. See **Section 14.3** for additional details.

change and request feedback from the A2P JV Task Manager and Project Manager, USACE, and ARNG.

Permanent Monitoring Well Installation

New permanent monitoring wells will be installed during the Santa Fe AASF Prescriptive Phase mobilization. Well installation will be completed in accordance with *SOP 3-12: Monitoring Well Installation* (**Appendix D**). The specific monitoring locations are shown on **Figure 17-1.** Anticipated well depths and target screen intervals are specified in **Worksheets #17 & #18** and have been determined based on the data gaps identified in the SI monitoring well network. It's anticipated that wells targeting the perched groundwater zone will be between depths of 110 and 130 feet bgs. Depths of wells in the regional groundwater zone will range between 180 and 200 feet. Actual intervals may be modified as necessary based on field observations to meet the data quality objectives. Additional permanent monitoring wells will be installed during the later phases based on the data collected during the Prescriptive Phase. Details pertaining to location, depth, and rationale for the Adaptive Phase will be provided in a future planning document.

Boreholes for permanent monitoring wells will be advanced using rotosonic (sonic) drilling methods. The sonic drill rig will advance a smaller diameter (e.g., 4-inch) core barrel to obtain continuous subsurface samples. After a soil core is obtained from the core barrel, the larger temporary override casing (e.g, 6-inch) will be advanced to the same depth as the core barrel. The core barrel and temporary override casing will be advanced through the subsurface to the target depth. At locations where well pairs are proposed, additional, larger diameter (e.g., 8-inch) override casing will be advanced to temporarily case off the perched aquifer zone and to create sufficient annular space for nested well construction.

Recovered soil will be continuously logged for lithological descriptions by a field geologist using the Unified Soil Classification System (USCS). Observations and measurements will be recorded on field forms and in a non-treated field logbook. Photographs of the recovered cores will also be taken. At a minimum, the depth interval, recovery thickness, PID concentrations, moisture, relative density, color (using a Munsell soil color chart), and texture (using the USCS) will be recorded. Additional observations to be recorded may include groundwater or perched water depth, organic material, or cultural debris. Refer to *SOP 3-16: Soil and Rock Classification* and *SOP 3-21: Surface and Subsurface Soil Sampling Procedures* (**Appendix D**) for additional details.

Up to three soil samples from each boring will be collected: one surface soil (0-2 feet bgs), one just above the saturated water table, and one in the shallow subsurface (8-10 feet bgs). Samples will be collected into laboratory-supplied bottle ware and submitted to the laboratory for analysis of selected parameters. Surface and subsurface samples will be analyzed under standard TAT for the target list of PFAS (ASTM D8421[2] and/ or LC/MS/MS compliant with USEPA Method 1633). Additionally, TOC (USEPA Method 9060A), pH (USEPA Method 9045D), and grain size (ASTM D-422) will be analyzed in a subset (10%) of soil samples to support evaluation of PFAS fate and transport, in addition to the remedial alternatives analysis. The laboratory method DLs for these analytes are presented in **Worksheet #15**. The required sample containers, preservatives, and holding times are specified in **Worksheets #19 & #30**. The sampling design and rationale, as well as the sampling locations and methods, are presented in **Worksheets #17 & #18**. However, based on the analytical results and the field findings, modifications to these sampling locations and/or the sampling approach may be considered. In this event, a Field Change Request Form will be generated to document the change and request feedback from the A2P JV Task Manager and Project Manager, USACE, and ARNG.

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[2] The use of the PFAS screening method ASTM D8421 will be dependent on the acceptance of the Demonstration of Method Applicability Study, performed under a separate task order. See **Section 14.3** for additional details.

Individual monitoring wells will be constructed of 2-inch diameter, schedule 80 poly-vinyl chloride (PVC) 10 to 20-foot long 0.01-inch slotted screens, and 10-foot sections schedule 80 PVC flush threaded riser pipe. Centralizers will be used on deep wells to center the well casing within the borehole during construction. Where nested well pairs are constructed, centralizers will be used for only the deep well where below the shallow well. A silica sand filter pack material will then be placed in the annulus between the well pipe and casing. The height of the filter pack above the top of the screen interval will be 2 feet. As the filter pack is placed in the borehole, the temporary casing will periodically be vibrated and pulled up, allowing the well materials to settle into the annular space. A minimum two-foot-thick bentonite seal will be placed in the annulus above the filter pack using bentonite chips and hydrated for the minimum manufacturer specified time with potable water meeting the PFAS testing requirements described before. Once the bentonite seal has hydrated, cement-bentonite grout will be placed in the annulus via tremie pipe from the top of the bentonite seal up to the ground surface. Cement-bentonite grout placement will continue until the outer casing is removed from the borehole. All well construction activities will be done in a manner to prevent the bridging of materials within the borehole annulus.

Well pairs will be installed as nested construction within the same borehole. Well construction for the deep well will be completed up to the bentonite well seal as described above; however, the seal will extend from the top of the deep well filter pack up to a depth no less than one foot below the shallow well. The intent of the long well seal is to form a seal within the downward confining layer forming the perched groundwater zone above. The temporary casing will be left in place seated within the confining unit while the well seal is allowed adequate time to hydrate before construction of the shallow well begins. A sand base will be placed beneath the shallow well and the remainder of the well will be constructed as normal.

All monitoring wells will be completed as flush mounts (below ground surface) using an 10-inch diameter, bolt-down manhole cover. The manhole will be centered in a 2-foot by 2-foot by 6-inch thick concrete pad.

An exclusion zone will be established with cones surrounding the drilling operation. Air monitoring will be performed during drilling; air monitoring procedures and specific action levels are provided in the APP (AECOM, 2023a). Each well boring will be hand-cleared to 5 feet bgs prior to drilling in accordance with AECOM utility clearance procedures. The drilling team will place plastic sheeting under the drill rig and will pull it up around the tracks to act as a containment barrier. The drill will be advanced through a tub or surface casing at the ground surface.

Permanent Monitoring Well Development

Permanent monitoring wells will be developed a minimum of 24 hours after the completion of well installation or in accordance with state-specific guidance. Development will be completed by a combination of surging and pumping with a submersible pump or Waterra pump and associated tubing, in accordance with *SOP 3-13: Monitoring Well Development* (**Appendix D**).

Following the initial removal of the bulk sedimentation in the well, water clarity will be visually monitored and water quality parameters; including temperature, specific conductance [SC], pH, dissolved oxygen [DO], and oxidation-reduction potential [ORP] will be measured using a flow-through cell every 5 minutes during purging to determine progress of development in accordance with *SOP 3-24: Water Quality Parameter Testing for Groundwater Sampling* (**Appendix D**). The water quality meter will be calibrated initially and periodically throughout its usage each day, as needed. A calibration check will be performed at the end of each day. Each well will be developed until a minimum of three standing well volumes is removed and the well produces clear (silt-free) water with a minimum of 3 stable water quality readings as outlined below:

- pH – within ± 0.2 units

- SC – within ± 3%
- ORP – within ± 10 millivolts (mV)
- Temperature – within ±1 degree Celsius (°C)
- Turbidity – at or below 10 nephelometric turbidity unit (NTU) or within ± 10% if above 10 NTU
- DO readings may be recorded but DO readings will not be used as development completion criteria because DO may not stabilize during development

If the well has slow groundwater recharge and is purged dry, the well will be considered developed when bailed or pumped dry three times in succession and the turbidity has decreased. If any water is added to the borehole during drilling or development, three times the volume of water lost to the borehole (i.e., not returned to the surface during drilling) may also be removed during well development. Alternatively, if certain water quality parameters measured in added drilling water are demonstrably different than those measured in formation water, then recovery of three times the volume added may not be necessary as much of the drilling water may have evaporated or been lost to the formation above groundwater. Excess soil or groundwater generated will be containerized, managed, and disposed of as IDW. Refer to *SOP 3-13: Monitoring Well Development* (**Appendix D**) for more details.

Groundwater Sample Collection from Permanent Monitoring Wells

Permanent monitoring wells will be sampled a minimum of 24 hours after completion of well development, in accordance with *SOP 3-14: Groundwater Sampling* (**Appendix D**). The specific monitoring wells selected for groundwater sample collection are specified in **Worksheets #17 & #18** and shown on **Figure 17-1**. The monitoring wells will be purged following low-flow sampling techniques using a bladder pump equipped with a PFAS-free bladder and disposable tubing that has been determined to be PFAS-free (i.e., high-density polyethylene [HDPE]). The bladder and tubing will be replaced with unused materials at each well location.

Water clarity will be visually monitored and water quality parameters, including DO, SC, ORP, pH, temperature, and turbidity will be measured using a flow-through cell per the *SOP 3-24: Water Quality Parameter Testing for Groundwater Sampling* (**Appendix D**). Readings will be collected every 0.5 to 1.0 liter purged, or approximately every 2 to 5 minutes, depending on the purging rate, until the well produces clear (silt-free) water with a minimum of 3 stable water quality readings, as outlined below:

- pH – within ± 0.2 units
- DO – within ± 10%
- SC – within ± 3%
- ORP – within ± 10 mV
- Temperature – within ±1°C
- Turbidity – at or below 10 NTU or within ± 10% if above 10 NTU and a minimum of 1 hour of purging has been completed.

The multi-parameter water quality meter will be calibrated initially and continually throughout its usage each day, as needed. A calibration check will be performed at the end of each day.

Stabilization monitoring will not begin until a minimum of one tubing and pump volume has been removed. Once the water quality parameters reach stabilization, each groundwater sample will be collected into laboratory-supplied bottleware and submitted to the laboratory for analysis of selected parameters. If the water quality readings do not reach stabilization, samples will be collected after a minimum purging time of two hours. Sample containers will be PFAS-free, and the samples will not be filtered. Groundwater samples from permanent monitoring wells will be analyzed under standard TAT for the target list of PFAS (ASTM D8421 and/or LC/MS/MS compliant with USEPA Method 1633). The laboratory method DLs for these analytes are presented in **Worksheet #15**. The required sample containers, preservatives, and holding times are specified in **Worksheets #19 & #30**. Non-disposable sampling equipment will be decontaminated between each well. Refer to *SOP 3-14: Monitoring Well Sampling* and *SOP 3-24: Water Quality Parameter Testing* (**Appendix D**) for additional details.

In addition, a subsample of each groundwater sample will undergo a shaker test to identify if there is any foaming. If foaming is observed, the observation will be noted on the CoC to notify the laboratory prior to analysis.

Synoptic Groundwater and Surface Water Level Measurements

Synoptic groundwater level measurements will be collected from existing and newly installed groundwater monitoring wells. Synoptic groundwater level measurements from newly installed wells will be collected a minimum of 24 hours after completion of well development. The specific locations of groundwater measurements are specific in **Worksheets #17 & #18**.

The synoptic groundwater gauging round will be conducted within as short a time as reasonably feasible. The water level gauging event will be conducted on a day when little to no precipitation is forecasted, if possible. This is done as standard practice under this program to minimize any potential influence direct surface infiltration may have; however, this is not considered to be a concern at Santa Fe AASF due to the depth of groundwater.

Field Quality Control Samples

Field QC samples will include field duplicates (FDs), matrix spike (MS)/MS duplicates (MSDs), field reagent blanks (FRBs), and temperature blanks. FD samples will be collected at a rate of 10% and analyzed for the same parameters as the accompanying samples. MS/MSD samples will be collected at the rate of 5% and analyzed for the same parameters as the accompanying samples. FRBs will be collected at a rate of one per sampling event for groundwater, soil, surface water, and sediment media, or one per day or one per 10 samples (whichever is more) for drinking water media, as needed based on collection. A temperature blank shall be placed in each cooler to ensure that samples are preserved at or below 6 °C during shipment.

If non-dedicated sampling equipment is used, an equipment blank will be collected at a rate of 5% per sample media, per piece of equipment, and analyzed for the same parameters as the accompanying samples.

Sampling Handling, Storage, and Transport

Samples will be stored on ice, packaged, and submitted to the analytical laboratory for analysis as specified in **Worksheet #15**. **Worksheets #17 & #18**, **Worksheets #19 & #30**, and **Worksheet #20** provide sample identifications, necessary sample volume and preservative requirements, and hold time limitations. Samples will be QC checked by the SS (label correctness and completeness) and recorded on CoC forms. Samples will be packaged on ice and transported via overnight by commercial carrier or a laboratory courier under standard custody procedures to the laboratory. See *SOP 3-04: Sample Handling, Storage, and Shipping* (**Appendix D**) for additional information.

Field Documentation

Field documentation will be performed in accordance with *SOP 3-02: Logbooks* (**Appendix D**). Sample collection information will be recorded in bound field notebooks, tablet computers, or specific field forms. A summary of field activities will be properly recorded in a bound logbook with consecutively numbered pages that cannot be removed. Logbooks will be assigned to field personnel and stored in a secured area when not in use. Entries will be written in indelible ink, and no erasures will be made. If an incorrect entry is made, striking a single line through the incorrect information will correct the text, and the person making the correction will initial and date the change. Sampling forms and other field forms will also be used to document field activities. *See SOP 3-02: Logbooks* (**Appendix D**) for additional information.

Borehole Abandonment & Site Restoration

Boreholes will be abandoned with bentonite chips to within 6 inches of the ground surface and covered with native material. The surface at each location will be restored to match the surrounding area. It is anticipated that most sample locations will be advanced in areas without surface cover; however, penetrations through asphalt will likely be necessary in the AASF parking lot north of the hangar. In these cases, the remainder of the borehole will be patched with an asphalt cold patch. Borings into concrete will be avoided, if possible; however, if borings are advanced into concrete, the upper borehole will be filled with concrete to provide a flush surface. Boring locations on and close to active runways or ramps will be maintained to avoid potential foreign objective debris interfering with ARNG training activities. The field team will make the necessary adjustments if state regulations dictate the use of bentonite or grout to abandon soil borings or monitoring wells. See *SOP 3-15: Monitoring Well and Borehole Abandonment* (**Appendix D**) for more details.

Equipment Decontamination

The team will utilize dedicated and disposable sampling equipment to the extent possible to avoid cross contamination due to inadequate decontamination processes. The dedicated/disposable sampling equipment will include disposable polyethylene tubing, disposable gloves, and laboratory-supplied sample bottles.

Non-disposable or non-dedicated sampling equipment (e.g., water level meters, water quality meters, etc.) will be decontaminated prior to sampling and between sample locations. Decontamination will generally consist of a water rinse station to remove gross contamination, followed by a non-phosphate detergent (e.g., Liquinox®) water rinse, and a double rinse with PFAS-free, de-ionized water. Water used for the initial and non-phosphate rinse (facility water) will be tested prior to use (see **PFAS Site Water Supply Sampling and Sampling Equipment Acceptability** section above). Paper towels containing recycled paper content are prohibited. Large equipment such as drill rigs will be decontaminated using pressure cleaning equipment over a temporary constructed or mobile decontamination pad so that rinse water can be captured and containerized. Decontamination activities will be performed in accordance with *SOP 3-06: Decontamination* (**Appendix D**).

Land Surveying and Geographic Position Measurement

Newly installed permanent monitoring wells will be surveyed by a state-registered surveyor to a horizontal accuracy of 0.1 feet and a vertical accuracy of 0.01 feet. A small notch will be cut on the northern side of the well casing, which will be surveyed. The top of casing and ground surface elevation will be surveyed for each newly installed well. The data will be collected in the Universal Transverse Mercator Zone 13 N projection with WGS84 datum. Refer to *SOP 3-07: Land Surveying* (**Appendix D**) for more details.

Sample locations which are not permanent monitoring wells (i.e., soil borings, surface soil samples) will be documented using a handheld global positioning system (GPS)-enabled device accurate to with 5 meters.

Investigation-Derived Waste Management

IDW generated during the sampling activities will be handled in accordance with *SOP 3-05: Investigation-Derived Waste Management* (**Appendix D**) and relevant guidance as referenced below. A2PJV will coordinate waste profiling and the off-facility transportation and disposal of the IDW. IDW will be transported under manifest signed by NMARNG. All manifests will be retained with the project file and included as an appendix to the RI Report.

Solid IDW (i.e., soil cuttings) generated during RI activities will be containerized in 55-gallon drums or a roll off container for characterization and proper disposal. Solid IDW will not be placed in NMARNG dumpsters or trash cans. Soil IDW will assume the PFAS characteristics of the associated soil samples collected from that source location. A composite soil IDW sample will be collected if boring specific soil data does not exist. Additional analyses may also be required by the disposal facility for proper profiling and handling.

Liquid IDW (e.g., purge water and decontamination fluids) generated during RI activities will be containerized in 55-gallon drums or a frac tank for characterization and proper disposal. The containerized IDW will be segregated based on location, to the extent possible, and the material will assume the characteristics of the associated sample. If the IDW cannot be characterized with analytical results from the field samples, then a composite IDW sample will be collected and analyzed for PFAS. Additional analyses may also be required by the disposal facility for proper profiling and handling.

All solid and liquid IDW will be disposed of at a Resource Conservation and Recovery Act Subtitle C landfill. If facility conditions require an alternative approach be considered, options will be evaluated in accordance with the DoD Memorandum for Interim Guidance on Destruction or Disposal of Materials Containing PFAS Substances in the United States (DoD, 2023b) and/or with methods approved by ARNG legal counsel.

Other solids such as spent PPE, plastic sheeting, tubing, rope, unused monitoring well construction materials, and other environmental media generated during the field activities will be disposed of at a Subtitle D licensed solid waste landfill.

Additional phases of field activities will follow the same technical approach as outlined above. If new guidance requires a modification to this approach, a Field Planning Request form will be submitted for review and approval, documenting the revised approach.

14.3 Laboratory Analysis

Chemical analyses will be performed by one of our primary laboratories, Eurofins Lancaster Laboratories (Eurofins) or Pace South Carolina (Pace), depending on laboratory capacity. Backup laboratories as identified in the Programmatic Quality Assurance Project Plan (PQAPP) (A2P JV, 2024) are SGS North American, Inc. (SGS), Advanced Environmental Laboratories, Inc. (AEL), and ALS Environmental (ALS). All are DoD/ELAP accredited laboratories. Laboratory capacity will be evaluated prior to the field mobilization. Should the primary laboratories not be able to accommodate the volume of samples and provide data within contract required timelines, one of the approved backup laboratories from the PQAPP may be considered. Copies of the laboratory accreditation certificates are included in **Appendix C**. Analytical requirements for containers, preservatives and holding times are summarized in **Worksheets #19 & #30**. PFAS analyses will be conducted in accordance with DoD QSM version to which the laboratory is currently accredited (DoD, 2021) and the current laboratory SOP(s) at the time of the analysis.

A DMA Study (AECOM, 2024c) has been performed under a separate contract to determine the efficacy of a PFAS screening method, ASTM D8421, to meet DQOs as established in **Worksheet #11**. A laboratory specification for the use of ASTM D8421 has been created for this work and is included in **Appendix C**. The RI sampling program will apply both a screening method (ASTM D8421) and/or definitive method (USEPA Method 1633) for PFAS analysis, as defined in **Worksheets #17 & #18**. Where ASTM D8421 is used, confirmation samples will be collected and analyzed by USEPA Method 1633 at a rate of 10%.

Chemical analyses will be performed in accordance with the analytical methods identified in **Worksheet #23**. Analytical sensitivity for the methods selected is compared to project DQLs in **Worksheet #15**. Requirements for laboratory instrument calibration, and equipment maintenance and testing are presented in **Worksheet #24** and **Worksheet #25**, respectively. Measurement performance criteria for field and laboratory QC samples are presented in **Worksheet #12** and **Worksheet #28**, respectively.

The laboratory will provide Contract Laboratory Program-like Level IV data packages. These data packages will include summary forms containing QC information and raw data (Stage IV data packages as described in the DoD QSM Version 5.4).

14.4 Data Management, Review, and Validation

The principal data generated for this project will be from field observations of geologic settings, water quality measurements, habitat characteristics/receptor surveys, and laboratory analytical data. Copies of the field forms, CoC forms, air bills, and logbooks will be placed in the project files after completion of the field program. The field logbooks for this project will be used only for this facility and will also be categorized and maintained in the project files after the completion of the field program. Project records will be maintained in a secure location.

Data Tracking

The RI Task Manager is responsible for the overall tracking and control of data generated for the project. Data are tracked from generation to archiving in the project-specific files. The Project Chemist, or designee, is responsible for tracking the samples collected and shipped to the contracted laboratory. The laboratory will report data using A2P JV format Electronic Data Deliverables (EDDs) along with a hard copy of the laboratory's final data report, which will include supporting documentation such as chromatographs and instrument calibrations. Upon receipt of the data packages from the analytical laboratory, the Project Chemist will oversee the data validation effort, which includes verifying that the data packages are complete and that results for samples have been delivered by the analytical laboratory.

Data Review and Validation

Upon receipt of data packages from the analytical laboratory, the Project Chemist will oversee the data validation effort, which includes verifying data completeness, as specified in **Worksheet #34**. To evaluate whether the analytical results meet the data quality objectives, the laboratory data will undergo verification and validation, as cited in **Worksheet #34**, **Worksheet #35**, and **Worksheet #36.** The usability assessment processes are described in **Worksheet #37**.

Prior to data validation, electronic laboratory data will be verified for accuracy against the hardcopy laboratory report and QAPP using the project-specific criteria defined in **Worksheet #12**, **Worksheets #19 & #30**, and **Worksheet #28**. The laboratory will be requested to resubmit electronic data found to be deficient of critical information and/or inaccurate. Laboratory calibration will be assessed against the criteria presented in **Worksheet #24**.

Data Storage, Archiving, and Retrieval

After the data are validated, the data packages are entered into the file system and archived in secure files. The field records including field logbooks, sample logs, CoC records, and field calibration logs will be submitted by the field team lead to be entered into the file system before archiving in secure project files. Project files will be kept in a secured, limited access area. A2P JV will add electronic data to the existing project database.

Data Security

Laboratory data, provided in electronic format, will be verified for accuracy prior to use and during the data review process. After data are reviewed, the electronic data results will be uploaded into the database for use in data evaluation and subsequent report preparation. The project database will be on a secure network, and access to changing data files will be restricted to qualified personnel. The RI Task Manager, or designee, is responsible for the overall tracking and control of data generated for the project. File and data backup procedures are routinely performed.

14.5 Human Health and Ecological Risk Assessment

A HHRA and SLERA will be conducted in accordance with CERCLA and USACE risk assessment guidance. The results of the SLERA, in conjunction with the SLERA refinement (Step 3a) and the findings of the habitat assessment, will determine whether a Baseline Ecological Risk Assessment (BERA) is needed. A Risk Assessment Work Plan, which provides further detail on the HHRA and SLERA/BERA processes, is included as **Appendix E**. A summary of the risk assessment processes is provided in this section.

The risk assessments may include analytical data for soil, groundwater, surface water, sediment, drinking water, and/or porewater collected as part of the RI field program, as warranted. Except where noted otherwise, soil data collected during the Prescriptive Phase are screening-level data that will not be used in the risk assessments; however, any soil or groundwater definitive data obtained (that analyzed via USEPA Method 1633) during the Prescriptive Phase may be considered in the risk assessments, which will be compiled following the Adaptive Phase. These data will be considered representative of current facility conditions and will be collected to meet DQOs for use in conducting risk assessment. A habitat assessment will be conducted and considered in the SLERA.

Data selected for use in the risk assessments, including consideration of the sample locations, potential exposure media, exposure points, exposure pathways, land use(s), and receptors, as applicable, will be based on the preliminary CSM presented in **Worksheet #10**. Data selected for evaluation in the risk assessments will be grouped into exposure areas, including on-facility and off-facility exposure areas, as applicable, as described in further detail in **Appendix E**.

Human Health Risk Assessment

The primary objective of the HHRA is to evaluate whether chemicals attributable to facility activities have the potential to cause unacceptable adverse health effects to human receptors within the area under investigation. The HHRA will perform quantitative estimation of potential excess lifetime cancer risk (ELCR) and noncancer hazard (as a Hazard Index [HI]) to current and potential future human receptors that may come into contact with facility-related concentrations of chemicals of potential concern (COPCs) in soil, groundwater, surface water, and sediment. Toxicity values for use in the HHRA will be identified in accordance with USEPA guidance (USEPA, 2003) and the memorandum from the OSD (Assistant Secretary of Defense, 2023). For each associated exposure scenario (i.e., receptor/medium) with a cumulative potential ELCR greater than 1E-4 or a total potential HI per target organ greater than 1 (USEPA, 1991), risk-based

Chemicals of Concern (COCs) will be selected from those COPCs significantly contributing to the cumulative ELCR or target organ HI.

The HHRA conclusions will inform risk management decisions. If remedial action of PFAS is determined to be necessary based upon the results of the HHRA, the HHRA will be used to inform the development of risk-based target levels to be considered in conjunction with federal and state-specific Applicable or Relevant and Appropriate Requirements (ARARs) in the selection of Preliminary Remediation Goals (PRGs) in the FS. The HHRA process is detailed in **Appendix E**.

Ecological Risk Assessment

The primary objective of the ERA is to evaluate the potential for adverse effects on ecological receptors due to exposures to PFAS detected in on-facility and off-facility media, including soil, sediment, surface water, and/or porewater, as warranted, and to provide input to remedial decision-making that will protect the health of local populations and communities of biota. The USEPA (1997) and DA (2010) ERA process follows a tiered approach that incorporates different levels of assessment complexity and provides an opportunity to off-ramp from the ERA process prior to proceeding to the next tier based on the available findings. The tiered approach may be implemented in its entirety depending upon the level and magnitude of risk that is determined in prior tiers. This approach consists of the following two tiers as summarized below:

- Tier 1 – SLERA
- Tier 2 – BERA

The primary objective for a SLERA is to determine which, if any, exposure pathways and chemicals of potential ecological concern (COPECs) warrant immediate action or require further evaluation in a more refined ERA. The SLERA includes Steps 1 and 2 of the eight step USEPA ERA (USEPA, 1997) process:

- Identification and summarization of relevant datasets.
- Development of a preliminary CSM.
- Comparison of maximum detected concentrations to ecological SLs to identify COPECs.

Based on the outcome of the SLERA, certain media, COPECs, and pathways may be eliminated from further evaluation due to the level of conservatism built into the SLERA process. In cases where facilities are fully paved, there is no habitat present, soil contamination is below the reach of ecological receptors, or contaminated groundwater does not discharge to surface water habitats, documentation that the potential ecological exposure pathways are incomplete will be sufficient to address ecological concerns. In the event that potentially complete and significant ecological exposure pathways are identified, and maximum concentrations of certain COPECs exceed the generic SLs, additional evaluation may be recommended.

Prior to beginning problem formulation in the BERA (Step 3), the results of the SLERA may be refined in Step 3a, as described below. The decision to continue beyond the SLERA does not indicate that adverse effects are occurring or that risk reduction is necessary, rather it indicates that a more focused evaluation and characterization of the potential for risk and accompanying uncertainty is needed (DA, 2010).

The primary purpose of the BERA is to assess the potential for adverse effects on the focused list of ecological receptors due to exposure to the COPECs identified upon completion of the SLERA. The BERA includes Steps 3 through 7 of the eight step USEPA ERA (USEPA, 1997) process and uses facility-specific information whenever possible:

- Step 3a (SLERA refinement) provides a refinement of the conservative assumptions and resulting risk estimates identified in the SLERA. This step is conducted to refine some of the conservative assumptions used in the SLERA and assess whether more realistic assumptions would reduce the risk estimates to acceptable levels prior to implementing a facility-specific BERA with associated sampling and analyses. A weight-of-evidence evaluation that considers the Step 3a results, available habitat, wildlife management goals for the areas evaluated, and other relevant factors, as appropriate, will be conducted to determine whether a full BERA is recommended.

- Steps 3b through 7 for pathways and COPECs retained after the completion of Step 3a include identifying endpoints to be evaluated, the laboratory and field methods to be used to collect additional data, the statistical analyses to be used for evaluating data, and the methods to be used for estimating and characterizing the potential for adverse effects on ecological receptors.

A full BERA will only be warranted if the results of the SLERA and SLERA refinement indicate that adverse ecological effects are likely. In the event a BERA is warranted, the evaluation will be focused on the key receptors, pathways, and PFAS of potential concern identified following a weight-of-evidence assessment included in the SLERA refinement. The BERA considers more detailed aspects related to the COPECs, receptors, and exposure pathways retained at the end of Step 3a and could include food web modeling, tissue sampling, additional habitat assessments, or collection of other facility-specific data.

If the outcome of the ERA process indicates the need for risk management measures, ecological PRGs may be developed for PFAS that show the potential for adverse effects to guide remedial decision-making. PRGs may be based on available ecological screening values (ESVs), facility-specific background concentrations, calculated values based on food web modeling, and/or facility-specific toxicity data, if available.

The SLERA and BERA processes is detailed in **Appendix E**. Results from the HHRA and SLERA/BERA will be used to update and refine the preliminary RI CSM.

14.6 Report Preparation

Following the completion of data collection, laboratory analysis, and data validation for all RI phases of work, a comprehensive RI Report will be prepared per CERCLA guidance. The RI report will present the methods used for the RI, the refined CSM resulting from the investigation (including exposure pathways and receptors), the results of the site characterization and risk assessment, and a recommendation of whether further remedial action is needed.

The RI Report will include the following elements:

- Restatement of program goals;

- Facility background, environmental setting, previous investigations, current and reasonably expected future land use both on- and off-facility, and potential off-facility PFAS sources;

- Summary of field investigation conducted (e.g., sampling dates, soil samples collected, wells sampled, parameters analyzed, usage of screening-level data, and field procedures);

- Physical characteristics of the study area, including soils, geology, hydrogeology, hydrology, and ecological setting;

- Natural, cultural, and historical items;

- Habitat characterization;

- Deviations from the initial QAPP and/or any QAPP modifications;
- Tables summarizing the samples collected and sample analytical data;
- Figures showing the layout of each sampling area, updated site features, results of geophysical surveys, soil boring locations, and summaries of pertinent analytical results;
- Discussion of data validation and PARCCS;
- Data evaluation;
- Refined CSM with focus on fate and transport, including potential routes of migration, contaminant persistence, and contaminant migration;
- Data uncertainties;
- Summary of the HHRA and SLERA/BERA with full HHRA and SLERA/BERA documentation included as appendices to the RI Report; and,
- Conclusions and summary of the RI findings.

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Worksheet #15: Project Data Quality Limits and Laboratory-Specific Detection/ Quantitation Limits

Worksheet #15 includes tables specifying the list of target analytes for media that may potentially be sampled throughout the RI phases; groundwater, surface water, porewater, soil, and sediment and the associated DQLs and laboratory-specific detection/quantitation limits (QLs) for the target analytes. The analytical laboratory reference limits include the limits of detection [LODs], LOQs, and DLs. The objective is for the laboratory to achieve LOQs low enough to measure analytes at concentrations less than the DQLs to obtain a dataset of known quality and sufficient sensitivity to meet the project DQOs established in **Worksheet #11**. The DQLs represent the lowest of the relevant criteria that may be used in the RI and later stages of the CERCLA process (e.g., FS). These criteria include the applicable state-specific criteria, USEPA health advisories, and human health and ESVs, as further described below. Conservative assumptions were made when selecting screening values for use as DQLs for purposes of achieving an appropriate level of data quality. Facility-specific refinements may be made during application of screening values for use in the evaluation of analytical data. The DQLs are not intended to be used as cleanup levels. Concentrations above the DQLs would not automatically trigger a response action but would suggest further facility-specific consideration is appropriate. Details on the medium-specific DQL selection are provided in the notes below the following media-specific tables.

Target Analyte List for PFAS

A standard target list of 40 PFAS analytes has been established for this project for both the definitive method (USEPA Method 1633) and screening method (ASTM D8421). A shortlist of compounds inclusive of those which OSD has established SLs (Assistant Secretary of Defense, 2023) will be applied to screening samples to expedite analytical laboratory results should RSC groundwater and/or soil sampling be used in the Adaptive or Final Characterization and Monitoring Phases. The RSC samples will be analyzed for a shortlist of eight PFAS: hexafluoropropylene oxide dimer acid (HFPO-DA), PFBA, PFBS, PFHxA, PFHxS, PFNA, PFOA, and PFOS. The RSC shortlist was selected to refine the extent of compounds with SLs in soil and groundwater.

RI Screening Levels for PFAS

The DoD has implemented a policy to retain facilities within the CERCLA process, comparing PFAS analytical results to SLs derived from the USEPA RSLs for soil and tap water (Assistant Secretary of Defense, 2023). The ARNG program under which this RI is being performed follows this DoD policy. The OSD policy instructs the use of USEPA RSLs based on a cancer risk level of 1E-06 and a hazard quotient of 0.1 for soil and groundwater. The OSD updated its website in March 2024 to direct the use of the November 2023 RSLs for specific PFAS (https://www.acq.osd.mil/eie/eer/ecc/pfas/pfas101/rsl.html). Surface water and sediment SLs are multiplied by a factor of 10 from the respective residential tap water and soil RSLs to estimate changes in exposure when assuming a non-residential scenario compared to a residential scenario. If the surface water is an expression of groundwater, a focused point of groundwater recharge, and is used as a source of drinking water or directly discharges into a water body used for drinking water purposes, the factor of 10 will not be added to the tap water RSL. Surface water downgradient of the facility is not used as a drinking water source; therefore, the factor of 10 was added. The PFAS on the OSD website that have DoD-approved RSLs and are on the Method 1633 analytical list are summarized in **Table 11-1**. The SLs will be used in the RI for delineation and to guide field investigations and will be used in the

HHRA for COPC selection. The toxicity values approved by the DoD will be used to calculate site-specific human health risk for COPCs in the HHRA.

Ecological Screening Criteria for PFAS

Ecological screening criteria for PFAS have not been developed by USEPA. Risk-based SLs for ecological receptors to be used in the SLERA are presented in this QAPP and will be included in the selection of DQLs. Ecological risk-based SLs for soil, surface water, and sediment will be identified primarily from the most recent publications from the Interagency Agreement between the U.S. Department of Energy, Air Force Civil Engineer Center (AFCEC), and Argonne National Laboratory (Grippo et al., 2024) as well as Strategic Environmental Research and Development Program (SERDP) guidance documents (Conder, et al., 2020; Divine, et al., 2020). For screening purposes and DQL selection, the most conservative of the three sources will be applied, as appropriate. The final selection of ecological SLs for PFAS will be reviewed during the ERA process to assess whether any new SLs are appropriate to consider.

Eurofins Lancaster Laboratories

Laboratory: Eurofins Lancaster Laboratories
Matrix: Groundwater
Analyte Group: PFAS (40 Compound Target List)
Method: PFAS by LC/MS/MS compliant with USEPA Method 1633

Analyte	Abbreviation	CAS Number	DQL (ng/L)	DQL Source	Achievable Laboratory Limits		
					DL (ng/L)	LOD (ng/L)	LOQ (ng/L)
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11C1-PF3OudS	763051-92-9	--	--	0.500	1.00	2.00
4:2 Fluorotelomer sulfonic acid	4:2 FTS	757124-72-4	--	--	1.00	2.00	4.00
6:2 Fluorotelomer sulfonic acid	6:2 FTS	27619-97-2	--	--	1.00	2.00	4.00
8:2 Fluorotelomer sulfonic acid	8:2 FTS	39108-34-4	--	--	1.00	2.00	4.00
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-493-3	--	--	2.80	5.60	10.0
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	--	--	2.50	5.00	10.0
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	--	--	1.00	2.00	4.00
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	--	--	0.500	1.00	2.00
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9C1-PF3ON	756426-58-1	--	--	0.500	1.00	2.00
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	1.5	HH; Tap Water SL	0.500	0.750	1.50
N-ethyl perfluorooctanesulfonamide	N-Et-FOSA	4151-50-2	--	--	0.500	1.00	2.00
N-ethyl perfluorooctanesulfonamidoethanol	N-Et-FOSE	1691-99-2	--	--	2.50	5.00	10.0
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	--	--	0.500	1.00	2.00
N-methyl perfluorooctanesulfonamide	N-Me-FOSA	31506-32-8	--	--	0.500	1.00	2.00
N-methyl perfluorooctanesulfonamidoethanol	N-Me-FOSE	24448-09-7	--	--	2.50	5.00	10.0
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	--	--	0.500	1.00	2.00
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	--	--	0.500	1.00	2.00
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	--	--	0.500	1.00	2.00
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	--	--	0.500	1.00	2.00
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	--	--	0.500	1.00	2.00
Perfluorobutanesulfonic acid	PFBS	375-73-5	600	HH; Tap Water SL	0.500	1.00	2.00
Perfluorobutanoic acid	PFBA	375-22-4	1800	HH; Tap Water SL	1.10	2.20	4.00
Perfluorodecanesulfonic acid	PFDS	335-77-3	--	--	0.500	1.00	2.00
Perfluorodecanoic acid	PFDA	335-76-2	--	--	0.500	1.00	2.00
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	--	--	0.600	1.20	2.00
Perfluorododecanoic acid	PFDoA	307-55-1	--	--	0.500	1.00	2.00
Perfluoroheptanoic acid	PFHpA	375-85-9	--	--	0.800	1.60	2.00
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	--	--	0.500	1.00	2.00
Perfluorohexanesulfonic acid	PFHxS	355-46-4	39	HH; Tap Water SL	0.800	1.60	2.00
Perfluorohexanoic acid	PFHxA	307-24-4	990	HH; Tap Water SL	0.500	1.00	2.00

Analyte	Abbreviation	CAS Number	DQL (ng/L)	DQL Source	Achievable Laboratory Limits		
					DL (ng/L)	LOD (ng/L)	LOQ (ng/L)
Perfluorononanoic acid	PFNA	375-95-1	5.9	HH; Tap Water SL	0.500	1.00	2.00
Perfluorononanesulfonic acid	PFNS	68259-12-1	--	--	0.500	1.00	2.00
Perfluorooctanesulfonamide	PFOSA	754-91-6	--	--	0.500	1.00	2.00
Perfluorooctanesulfonic acid	PFOS	1763-23-1	4	HH; Tap Water SL	0.500	1.00	2.00
Perfluorooctanoic acid	PFOA	335-67-1	6	HH; Tap Water SL	0.900	1.80	2.00
Perfluoropentanoic acid	PFPA	2706-90-3	--	--	0.600	1.20	2.00
Perfluoropentanesulfonic acid	PFPS	2706-91-4	--	--	0.500	1.00	2.00
Perfluorotetradecanoic acid	PFTeDA	376-06-7	--	--	0.500	1.00	2.00
Perfluorotridecanoic acid	PFTriDA	72629-94-8	--	--	0.500	1.00	2.00
Perfluoroundecanoic acid	PFUnA	2058-94-8	--	--	0.500	1.00	2.00

Notes:

1. DQLs for groundwater were selected based on the lower of the following:

   (a) The human health screening levels selected in accordance with the Memorandum from the OSD, "Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program" (Assistant Secretary of Defense. August 2023), as updated by the DoD in March 2024 (https://www.acq.osd.mil/eie/eer/ecc/pfas/pfas101/rsl.html). The screening levels are equal to the USEPA RSLs for tap water (USEPA, November 2023) based on a target risk of 1E-06 and target HQ of 0.1. The RSLs used are consistent with DoD's list of 'RSLs included in DoD Investigations of PFAS'. (HH; Tap Water SL)

   (b) New Mexico Department of the Environment Tap Water screening levels (Risk Assessment Guidance for Site Investigations and Remediation, Volume I, Soil Screening Guidance for Human Health Risk Assessments, November 2022) were compared to USEPA RSLs. USEPA RSLs are lower and were therefore selected as DQLs.

CAS = Chemical Abstracts Service
DL = detection limit
DQL = data quality limit
HH = human health based DQL
LC/MS/MS = liquid chromatography tandem mass spectrometry
LOD = limit of detection
LOQ = limit of quantification
ng/L = nanograms per liter
PFAS = per- and polyfluoroalkyl substances
SL = screening level
USEPA = United States Environmental Protection Agency

Laboratory: Eurofins Lancaster Laboratories
Matrix: Surface Water
Analyte Group: PFAS (40 Compound Target List)
Method: PFAS by LC/MS/MS compliant with USEPA Method 1633

Analyte	Abbreviation	CAS Number	DQL (ng/L)	DQL Source	Achievable Laboratory Limits		
					DL (ng/L)	LOD (ng/L)	LOQ (ng/L)
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11C1-PF3OudS	763051-92-9	--	--	0.500	1.00	2.00
4:2 Fluorotelomer sulfonic acid	4:2 FTS	757124-72-4	--	--	1.00	2.00	4.00
6:2 Fluorotelomer sulfonic acid	6:2 FTS	27619-97-2	--	--	1.00	2.00	4.00
8:2 Fluorotelomer sulfonic acid	8:2 FTS	39108-34-4	--	--	1.00	2.00	4.00
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-493-3	--	--	2.80	5.60	10.0
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	--	--	2.50	5.00	10.0
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	--	--	1.00	2.00	4.00
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	--	--	0.500	1.00	2.00
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9C1-PF3ON	756426-58-1	69000	Eco; RWQ RBSL	0.500	1.00	2.00
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	15	HH; Tap Water SL x 10	0.500	0.750	1.50
N-ethyl perfluorooctanesulfonamide	N-Et-FOSA	4151-50-2	--	--	0.500	1.00	2.00
N-ethyl perfluorooctanesulfonamidoethanol	N-Et-FOSE	1691-99-2	--	--	2.50	5.00	10.0
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	--	--	0.500	1.00	2.00
N-methyl perfluorooctanesulfonamide	N-Me-FOSA	31506-32-8	--	--	0.500	1.00	2.00
N-methyl perfluorooctanesulfonamidoethanol	N-Me-FOSE	24448-09-7	--	--	2.50	5.00	10.0
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	--	--	0.500	1.00	2.00
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	--	--	0.500	1.00	2.00
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	--	--	0.500	1.00	2.00
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	--	--	0.500	1.00	2.00
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	--	--	0.500	1.00	2.00
Perfluorobutanesulfonic acid	PFBS	375-73-5	6000	HH; Tap Water SL x 10	0.500	1.00	2.00
Perfluorobutanoic acid	PFBA	375-22-4	18000	HH; Tap Water SL x 10	1.10	2.20	4.00
Perfluorodecanesulfonic acid	PFDS	335-77-3	--	--	0.500	1.00	2.00
Perfluorodecanoic acid	PFDA	335-76-2	660	Eco; Wildlife ESV	0.500	1.00	2.00
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	--	--	0.600	1.20	2.00
Perfluorododecanoic acid	PFDoA	307-55-1	72000	Eco; RWQ RBSL	0.500	1.00	2.00
Perfluoroheptanoic acid	PFHpA	375-85-9	870000	Eco; RWQ RBSL	0.800	1.60	2.00
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	--	--	0.500	1.00	2.00
Perfluorohexanesulfonic acid	PFHxS	355-46-4	390	HH; Tap Water SL x 10	0.800	1.60	2.00
Perfluorohexanoic acid	PFHxA	307-24-4	9900	HH; Tap Water SL x 10	0.500	1.00	2.00

Analyte	Abbreviation	CAS Number	DQL (ng/L)	DQL Source	Achievable Laboratory Limits		
					DL (ng/L)	LOD (ng/L)	LOQ (ng/L)
Perfluorononanoic acid	PFNA	375-95-1	59	HH; Tap Water SL x 10	0.500	1.00	2.00
Perfluorononanesulfonic acid	PFNS	68259-12-1	--	--	0.500	1.00	2.00
Perfluorooctanesulfonamide	PFOSA	754-91-6	--	--	0.500	1.00	2.00
Perfluorooctanesulfonic acid	PFOS	1763-23-1	40	HH; Tap Water SL x 10	0.500	1.00	2.00
Perfluorooctanoic acid	PFOA	335-67-1	60	HH; Tap Water SL x 10	0.900	1.80	2.00
Perfluoropentanoic acid	PFPA	2706-90-3	140000	Eco; RWQ RBSL	0.600	1.20	2.00
Perfluoropentanesulfonic acid	PFPS	2706-91-4	--	--	0.500	1.00	2.00
Perfluorotetradecanoic acid	PFTeDA	376-06-7	--	--	0.500	1.00	2.00
Perfluorotridecanoic acid	PFTriDA	72629-94-8	--	--	0.500	1.00	2.00
Perfluoroundecanoic acid	PFUnA	2058-94-8	49000	Eco; RWQ RBSL	0.500	1.00	2.00

Notes:

1. DQLs for surface water were selected based on the lower of the following:
   - (a) For human health, the groundwater DQL (see worksheet for groundwater) multiplied by a factor of 10 was used to estimate changes in exposure when assuming a non-residential scenario compared to a residential scenario (HH; Tap water SL x 10 or HH; MN HBV x 10).
   - (b) Guidance for Assessing the Ecological Risks of PFAS to Threatened and Endangered Species at Aqueous Film Forming Foam-Impacted Sites (Conder et al., 2020). Ecological aquatic life 5% hazardous concentration.
   - (c) Approach for Assessing PFAS Risk to Threatened and Endangered Species (Divine et al., 2020). The following values were used:
     - Lowest NOAEL RBSL for surface water for aquatic wildlife (Wildlife RBSL).
     - Freshwater chronic screening level for aquatic life (RWQ RBSL).
   - (d) Derivation of PFAS Ecological Screening Values. Argonne National Laboratory (Grippo, et al., 2021). The following values were used:
     - Surface water ESV for aquatic-dependent wildlife (Wildlife ESV).
     - Freshwater chronic ESV for aquatic life (Aquatic life ESV).

CAS = Chemical Abstracts Service
DL = detection limit
DQL = data quality limit
Eco = ecological based DQL
ESV = ecological screening value
HH = human health based DQL
LC/MS/MS = liquid chromatography tandem mass spectrometry
LOD = limit of detection
LOQ = limit of quantification
ng/L = nanograms per liter
PFAS = per- and polyfluoroalkyl substances
RBSL = risk based screening level
RWQ = recommended water quality
SL = screening level
USEPA = United States Environmental Protection Agency

Laboratory: Eurofins Lancaster Laboratories
Matrix: Porewater
Analyte Group: PFAS (40 Compound Target List)
Method: PFAS by LC/MS/MS compliant with USEPA Method 1633

Analyte	Abbreviation	CAS Number	DQL (ng/L)	DQL Source	Achievable Laboratory Limits		
					DL (ng/L)	LOD (ng/L)	LOQ (ng/L)
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11C1-PF3OudS	763051-92-9	--	--	0.500	1.00	2.00
4:2 Fluorotelomer sulfonic acid	4:2 FTS	757124-72-4	--	--	1.00	2.00	4.00
6:2 Fluorotelomer sulfonic acid	6:2 FTS	27619-97-2	--	--	1.00	2.00	4.00
8:2 Fluorotelomer sulfonic acid	8:2 FTS	39108-34-4	--	--	1.00	2.00	4.00
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-493-3	--	--	2.80	5.60	10.0
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	--	--	2.50	5.00	10.0
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	--	--	1.00	2.00	4.00
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	--	--	0.500	1.00	2.00
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9C1-PF3ON	756426-58-1	69000	Eco; RWQ RBSL	0.500	1.00	2.00
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	--	--	0.500	0.750	1.50
N-ethyl perfluorooctanesulfonamide	N-Et-FOSA	4151-50-2	--	--	0.500	1.00	2.00
N-ethyl perfluorooctanesulfonamidoethanol	N-Et-FOSE	1691-99-2	--	--	2.50	5.00	10.0
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	--	--	0.500	1.00	2.00
N-methyl perfluorooctanesulfonamide	N-Me-FOSA	31506-32-8	--	--	0.500	1.00	2.00
N-methyl perfluorooctanesulfonamidoethanol	N-Me-FOSE	24448-09-7	--	--	2.50	5.00	10.0
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	--	--	0.500	1.00	2.00
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	--	--	0.500	1.00	2.00
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	--	--	0.500	1.00	2.00
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	--	--	0.500	1.00	2.00
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	--	--	0.500	1.00	2.00
Perfluorobutanesulfonic acid	PFBS	375-73-5	400000	Eco; Aquatic Life ESV	0.500	1.00	2.00
Perfluorobutanoic acid	PFBA	375-22-4	64600	Eco; Aquatic Life ESV	1.10	2.20	4.00
Perfluorodecanesulfonic acid	PFDS	335-77-3	--	--	0.500	1.00	2.00
Perfluorodecanoic acid	PFDA	335-76-2	660	Eco; Wildlife ESV	0.500	1.00	2.00
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	--	--	0.600	1.20	2.00
Perfluorododecanoic acid	PFDoA	307-55-1	72000	Eco; RWQ RBSL	0.500	1.00	2.00
Perfluoroheptanoic acid	PFHpA	375-85-9	870000	Eco; RWQ RBSL	0.800	1.60	2.00
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	--	--	0.500	1.00	2.00
Perfluorohexanesulfonic acid	PFHxS	355-46-4	5500	Eco; Wildlife ESV	0.800	1.60	2.00
Perfluorohexanoic acid	PFHxA	307-24-4	28800	Eco; Aquatic Life ESV	0.500	1.00	2.00

Analyte	Abbreviation	CAS Number	DQL (ng/L)	DQL Source	Achievable Laboratory Limits		
					DL (ng/L)	LOD (ng/L)	LOQ (ng/L)
Perfluorononanoic acid	PFNA	375-95-1	2080	Eco; Wildlife ESV	0.500	1.00	2.00
Perfluorononanesulfonic acid	PFNS	68259-12-1	--	--	0.500	1.00	2.00
Perfluorooctanesulfonamide	PFOSA	754-91-6	--	--	0.500	1.00	2.00
Perfluorooctanesulfonic acid	PFOS	1763-23-1	75	Eco; Wildlife RBSL	0.500	1.00	2.00
Perfluorooctanoic acid	PFOA	335-67-1	4400	Eco; Wildlife RBSL	0.900	1.80	2.00
Perfluoropentanoic acid	PFPA	2706-90-3	140000	Eco; RWQ RBSL	0.600	1.20	2.00
Perfluoropentanesulfonic acid	PFPS	2706-91-4	--	--	0.500	1.00	2.00
Perfluorotetradecanoic acid	PFTeDA	376-06-7	--	--	0.500	1.00	2.00
Perfluorotridecanoic acid	PFTriDA	72629-94-8	--	--	0.500	1.00	2.00
Perfluoroundecanoic acid	PFUnA	2058-94-8	49000	Eco; RWQ RBSL	0.500	1.00	2.00

Notes:

(1) DQLs for porewater were selected based on the lower of the following:
(a) Guidance for Assessing the Ecological Risks of PFAS to Threatened and Endangered Species at Aqueous Film Forming Foam-Impacted Sites (Conder et al., 2020). Ecological aquatic life 5% hazardous concentration.
(b) Approach for Assessing PFAS Risk to Threatened and Endangered Species (Divine et al., 2020). The following values were used:
-Lowest NOAEL RBSL for surface water for aquatic wildlife (Wildlife RBSL).
-Freshwater chronic screening level for aquatic life (RWQ RBSL).
(c) Derivation of PFAS Ecological Screening Values. Argonne National Laboratory (Grippo, et al., 2021). The following values were used:
-Surface water ESV for aquatic-dependent wildlife (Wildlife ESV).
-Freshwater chronic ESV for aquatic life (Aquatic life ESV).

CAS = Chemical Abstracts Service
DL = detection limit
DQL = data quality limit
Eco = ecological based DQL
ESV = ecological screening value
LC/MS/MS = liquid chromatography tandem mass spectrometry
LOD = limit of detection
LOQ = limit of quantification
ng/L = nanograms per liter
PFAS = per- and polyfluoroalkyl substances
RBSL = risk based screening level
RWQ = recommended water quality
SL = screening level
USEPA = United States Environmental Protection Agency

Laboratory: Eurofins Lancaster Laboratories
Matrix: Soil
Analyte Group: PFAS (40 Compound Target List)
Method: PFAS by LC/MS/MS compliant with USEPA Method 1633

Analyte	Abbreviation	CAS Number	DQL (µg/kg)	DQL Source	Achievable Laboratory Limits		
					DL (µg/kg)	LOD (µg/kg)	LOQ (µg/kg)
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11C1-PF3OudS	763051-92-9	--	--	0.200	0.400	0.800
4:2 Fluorotelomer sulfonic acid	4:2 FTS	757124-72-4	--	--	0.200	0.400	0.800
6:2 Fluorotelomer sulfonic acid	6:2 FTS	27619-97-2	--	--	0.350	0.800	1.00
8:2 Fluorotelomer sulfonic acid	8:2 FTS	39108-34-4	--	--	0.350	0.800	1.00
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-493-3	--	--	1.00	2.50	5.00
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	--	--	1.00	2.50	5.00
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	--	--	0.250	0.500	1.00
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	--	--	0.200	0.400	0.800
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9C1-PF3ON	756426-58-1	--	--	0.200	0.400	0.800
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	23	HH; Residential Soil SL	0.300	0.600	0.800
N-ethyl perfluorooctanesulfonamide	N-Et-FOSA	4151-50-2	--	--	0.0500	0.100	0.200
N-ethyl perfluorooctanesulfonamidoethanol	N-Et-FOSE	1691-99-2	--	--	0.500	1.00	2.00
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	--	--	0.0500	0.100	0.200
N-methyl perfluorooctanesulfonamide	N-Me-FOSA	31506-32-8	--	--	0.0500	0.100	0.200
N-methyl perfluorooctanesulfonamidoethanol	N-Me-FOSE	24448-09-7	--	--	0.500	1.00	2.00
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	--	--	0.0500	0.100	0.200
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	--	--	0.104	0.200	0.400
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	--	--	0.100	0.200	0.400
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	--	--	0.100	0.200	0.400
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	--	--	0.100	0.200	0.400
Perfluorobutanesulfonic acid	PFBS	375-73-5	817	Eco; Wildlife ESV	0.0500	0.100	0.200
Perfluorobutanoic acid	PFBA	375-22-4	2980	Eco; Wildlife ESV	0.100	0.400	0.800
Perfluorodecanesulfonic acid	PFDS	335-77-3	--	--	0.0500	0.100	0.200
Perfluorodecanoic acid	PFDA	335-76-2	67.7	Eco; Wildlife ESV	0.0500	0.100	0.200
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	--	--	0.0500	0.100	0.200
Perfluorododecanoic acid	PFDoA	307-55-1	--	--	0.0500	0.100	0.200
Perfluoroheptanoic acid	PFHpA	375-85-9	1000	Eco; Invertebrate NOEC	0.0900	0.180	0.200
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	--	--	0.0500	0.100	0.200
Perfluorohexanesulfonic acid	PFHxS	355-46-4	2.8	Eco; Wildlife ESV	0.0500	0.100	0.200
Perfluorohexanoic acid	PFHxA	307-24-4	3200	HH; Residential Soil SL	0.0900	0.180	0.200

Analyte	Abbreviation	CAS Number	DQL (µg/kg)	DQL Source	Achievable Laboratory Limits		
					DL (µg/kg)	LOD (µg/kg)	LOQ (µg/kg)
Perfluorononanoic acid	PFNA	375-95-1	19	HH; Residential Soil SL	0.0500	0.100	0.200
Perfluorononanesulfonic acid	PFNS	68259-12-1	--	--	0.0500	0.100	0.200
Perfluorooctanesulfonamide	PFOSA	754-91-6	--	--	0.0900	0.180	0.200
Perfluorooctanesulfonic acid	PFOS	1763-23-1	8.7	Eco; Wildlife ESV	0.210	0.420	0.500
Perfluorooctanoic acid	PFOA	335-67-1	19	HH; Residential Soil SL	0.0510	0.100	0.200
Perfluoropentanoic acid	PFPA	2706-90-3	--	--	0.100	0.200	0.400
Perfluoropentanesulfonic acid	PFPS	2706-91-4	--	--	0.0500	0.100	0.200
Perfluorotetradecanoic acid	PFTeDA	376-06-7	--	--	0.0500	0.100	0.200
Perfluorotridecanoic acid	PFTriDA	72629-94-8	--	--	0.0500	0.100	0.200
Perfluoroundecanoic acid	PFUnA	2058-94-8	--	--	0.0500	0.100	0.200

Notes:

1.) DQLs for soil were selected based on the lower of the following:

(a) The human health screening levels selected in accordance with the Memorandum from the OSD, “Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program” (Assistant Secretary of Defense. August 2023), as updated by the DoD in March 2024 (https://www.acq.osd.mil/eie/eer/ecc/pfas/pfas101/rsl.html). The screening levels are equal to the USEPA RSLs for residential soil (USEPA, November 2023) based on a target risk of 1E-06 and target HQ of 0.1. The RSLs used are consistent with DoD’s list of ‘RSLs included in DoD Investigations of PFAS’. (HH; Residential Soil SL)

(b) New Mexico Department of the Environment Tap Water screening levels (Risk Assessment Guidance for Site Investigations and Remediation, Volume I, Soil Screening Guidance for Human Health Risk Assessments, November 2022) were compared to USEPA RSLs. USEPA RSLs are lower and were therefore selected as DQLs.

(c) Guidance for Assessing the Ecological Risks of PFAS to Threatened and Endangered Species at Aqueous Film Forming Foam-Impacted Sites (Conder et al., 2020). Recommended Toxicity Benchmarks for Terrestrial Plants and Invertebrates; based on NOECs (Plant Tox. and Invert. Tox.).

(c) Approach for Assessing PFAS Risk to Threatened and Endangered Species (Divine et al., 2020). The following values were used:

- Lowest NOAEL-based RBSL for soil for terrestrial wildlife (Wildlife RBSL).
- NOEC-based soil screening level for plants (Plant NOEC).
- NOEC-based soil screening level for invertebrates (Invert. NOEC).

(e) Derivation of PFAS Ecological Screening Values. Argonne National Laboratory (Grippo, et al., 2021). The following values were used:

- Lowest soil ESV for birds and mammals (Wildlife ESV).
- Soil ESV for terrestrial plants (Plant ESV).
- Soil ESV for terrestrial invertebrates (Invert. ESV).

µg/kg = micrograms per kilogram
CAS = Chemical Abstracts Service
DL = detection limit
DQL = data quality limit
Eco = ecological based DQL
ESV = ecological screening value
HH = human health based DQL
LC/MS/MS = liquid chromatography tandem mass spectrometry
LOD = limit of detection
LOQ = limit of quantification
NOAEL = no observed adverse effect level
NOEC = no observed effect concentration
OSD = Office of the Secretary of Defense
RBSL = risk based screening level
RSL = regional screening level
PFAS = per- and polyfluoroalkyl substances
SL = screening level
USEPA = United States Environmental Protection Agency

Laboratory: Eurofins Lancaster Laboratories

Matrix: Sediment
Analyte Group: PFAS (40 Compound Target List)
Method: PFAS by LC/MS/MS compliant with USEPA Method 1633

Analyte	Abbreviation	CAS Number	DQL (µg/kg)	DQL Source	Achievable Laboratory Limits		
					DL (µg/kg)	LOD (µg/kg)	LOQ (µg/kg)
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11C1-PF3OudS	763051-92-9	--	--	0.200	0.400	0.800
4:2 Fluorotelomer sulfonic acid	4:2 FTS	757124-72-4	--	--	0.200	0.400	0.800
6:2 Fluorotelomer sulfonic acid	6:2 FTS	27619-97-2	--	--	0.350	0.800	1.00
8:2 Fluorotelomer sulfonic acid	8:2 FTS	39108-34-4	--	--	0.350	0.800	1.00
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-493-3	--	--	1.00	2.50	5.00
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	--	--	1.00	2.50	5.00
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	--	--	0.250	0.500	1.00
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	--	--	0.200	0.400	0.800
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9C1-PF3ON	756426-58-1	--	--	0.200	0.400	0.800
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	230	HH; Residential Soil SL x 10	0.300	0.600	0.800
N-ethyl perfluorooctanesulfonamide	N-Et-FOSA	4151-50-2	--	--	0.0500	0.100	0.200
N-ethyl perfluorooctanesulfonamidoethanol	N-Et-FOSE	1691-99-2	--	--	0.500	1.00	2.00
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	--	--	0.0500	0.100	0.200
N-methyl perfluorooctanesulfonamide	N-Me-FOSA	31506-32-8	--	--	0.0500	0.100	0.200
N-methyl perfluorooctanesulfonamidoethanol	N-Me-FOSE	24448-09-7	--	--	0.500	1.00	2.00
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	--	--	0.0500	0.100	0.200
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	--	--	0.104	0.200	0.400
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	--	--	0.100	0.200	0.400
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	--	--	0.100	0.200	0.400
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	--	--	0.100	0.200	0.400
Perfluorobutanesulfonic acid	PFBS	375-73-5	730	Eco; Wildlife RBSL	0.0500	0.100	0.200
Perfluorobutanoic acid	PFBA	375-22-4	1600	Eco; Wildlife RBSL	0.100	0.400	0.800
Perfluorodecanesulfonic acid	PFDS	335-77-3	--	--	0.0500	0.100	0.200
Perfluorodecanoic acid	PFDA	335-76-2	--	--	0.0500	0.100	0.200
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	--	--	0.0500	0.100	0.200
Perfluorododecanoic acid	PFDoA	307-55-1	--	--	0.0500	0.100	0.200
Perfluoroheptanoic acid	PFHpA	375-85-9	--	--	0.0900	0.180	0.200
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	--	--	0.0500	0.100	0.200
Perfluorohexanesulfonic acid	PFHxS	355-46-4	1300	HH; Residential Soil SL x 10	0.0500	0.100	0.200

Analyte	Abbreviation	CAS Number	DQL (µg/kg)	DQL Source	Achievable Laboratory Limits		
					DL (µg/kg)	LOD (µg/kg)	LOQ (µg/kg)
Perfluorohexanoic acid	PFHxA	307-24-4	1800	Eco; Wildlife RBSL	0.0900	0.180	0.200
Perfluorononanoic acid	PFNA	375-95-1	10	Eco; Wildlife RBSL	0.0500	0.100	0.200
Perfluorononanesulfonic acid	PFNS	68259-12-1	--	--	0.0500	0.100	0.200
Perfluorooctanesulfonamide	PFOSA	754-91-6	--	--	0.0900	0.180	0.200
Perfluorooctanesulfonic acid	PFOS	1763-23-1	1.4	Eco; Wildlife RBSL	0.210	0.420	0.500
Perfluorooctanoic acid	PFOA	335-67-1	6	Eco; Wildlife RBSL	0.0510	0.100	0.200
Perfluoropentanoic acid	PFPA	2706-90-3	--	--	0.100	0.200	0.400
Perfluoropentanesulfonic acid	PFPS	2706-91-4	--	--	0.0500	0.100	0.200
Perfluorotetradecanoic acid	PFTeDA	376-06-7	--	--	0.0500	0.100	0.200
Perfluorotridecanoic acid	PFTriDA	72629-94-8	--	--	0.0500	0.100	0.200
Perfluoroundecanoic acid	PFUnA	2058-94-8	--	--	0.0500	0.100	0.200

Notes:

(1) DQLs for sediment were selected based on the lower of the following:

(a) For human health, the soil SL (see worksheet for soil) multiplied by a factor of 10 was used to estimate changes in exposure when assuming a non-residential scenario compared to a residential scenario (HH; Residential Soil SL x 10).

(b) Approach for Assessing PFAS Risk to Threatened and Endangered Species (Divine et al., 2020). Lowest NOAEL-based RBSL for sediment for aquatic wildlife (Wildlife RBSL).

µg/kg = micrograms per kilogram
CAS = Chemical Abstracts Service
DL = detection limit
DQL = data quality limit
Eco = ecological based DQL
HH = human health based DQL
LC/MS/MS = liquid chromatography tandem mass spectrometry
LOD = limit of detection
LOQ = limit of quantification
NOAEL = no observed adverse effect level
TBD = to be determined
PFAS = per- and polyfluoroalkyl substances
RBSL = risk-based screening level
SL = screening level
USEPA = United States Environmental Protection Agency

Laboratory: Eurofins Lancaster Laboratories
Matrix: Solid (Soil/ Sediment)
Analyte Groups: General Chemistry (TOC, pH, Grain Size)

Analyte	Method	Units	DQL	Achievable Laboratory Limits		
				DL	LOD	LOQ
Total Organic Carbon	USEPA 9060A	mg/kg	N/A	500	900	1000
pH	USEPA 9045D	STU	N/A	0.1	1.0	1.0
Grain Size	ASTM D422	% Passing	N/A	0.1	0.1	0.1

Notes:
% = percent
ASTM = American Society for Testing Materials
DL = detection limit
DQL = data quality limit
LOD = limit of detection
LOQ = limit of quantification
mg/kg = millligrams per kilogram
N/A = not applicable
STU = standard unit
TOC = total organic carbon
USEPA = United States Environmental Protection Agency

Pace South Carolina

Laboratory: Pace South Carolina
Matrix: Groundwater
Analyte Group: PFAS (40 Compound Target List)
Method: PFAS by LC/MS/MS compliant with USEPA Method 1633

Analyte	Abbreviation	CAS Number	DQL (ng/L)	DQL Source	Achievable Laboratory Limits		
					DL (ng/L)	LOD (ng/L)	LOQ (ng/L)
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11C1-PF3OudS	763051-92-9	--	--	0.94	2.0	4.0
4:2 Fluorotelomer sulfonic acid	4:2 FTS	757124-72-4	--	--	0.63	2.0	4.0
6:2 Fluorotelomer sulfonic acid	6:2 FTS	27619-97-2	--	--	0.95	2.0	4.0
8:2 Fluorotelomer sulfonic acid	8:2 FTS	39108-34-4	--	--	0.54	2.0	4.0
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-493-3	--	--	1.9	6.0	25
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	--	--	2.6	10	25
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	--	--	1.5	3.0	5.0
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	--	--	0.57	2.0	4.0
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9C1-PF3ON	756426-58-1	--	--	0.73	2.0	4.0
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	1.5	HH; Tap Water SL	0.89	2.0	4.0
N-ethyl perfluorooctanesulfonamide	N-Et-FOSA	4151-50-2	--	--	0.14	0.50	1.0
N-ethyl perfluorooctanesulfonamidoethanol	N-Et-FOSE	1691-99-2	--	--	2.4	5.0	10
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	--	--	0.28	0.75	1.0
N-methyl perfluorooctanesulfonamide	N-Me-FOSA	31506-32-8	--	--	0.15	0.50	1.0
N-methyl perfluorooctanesulfonamidoethanol	N-Me-FOSE	24448-09-7	--	--	1.5	5.0	10
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	--	--	0.19	0.50	1.0
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	--	--	0.49	1.0	2.0
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	--	--	0.48	1.0	2.0
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	--	--	0.32	1.0	2.0
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	--	--	0.30	1.0	2.0
Perfluorobutanesulfonic acid	PFBS	375-73-5	600	HH; Tap Water SL	0.10	0.50	1.0
Perfluorobutanoic acid	PFBA	375-22-4	1800	HH; Tap Water SL	0.55	2.0	4.0
Perfluorodecanesulfonic acid	PFDS	335-77-3	--	--	0.15	0.50	1.0
Perfluorodecanoic acid	PFDA	335-76-2	--	--	0.18	0.50	1.0
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	--	--	0.34	0.50	1.0
Perfluorododecanoic acid	PFDoA	307-55-1	--	--	0.17	0.50	1.0
Perfluoroheptanoic acid	PFHpA	375-85-9	--	--	0.16	0.50	1.0
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	--	--	0.11	0.50	1.0
Perfluorohexanesulfonic acid	PFHxS	355-46-4	39	HH; Tap Water SL	0.17	0.50	1.0

Analyte	Abbreviation	CAS Number	DQL (ng/L)	DQL Source	Achievable Laboratory Limits		
					DL (ng/L)	LOD (ng/L)	LOQ (ng/L)
Perfluorohexanoic acid	PFHxA	307-24-4	990	HH; Tap Water SL	0.13	0.50	1.0
Perfluorononanoic acid	PFNA	375-95-1	5.9	HH; Tap Water SL	0.17	0.50	1.0
Perfluorononanesulfonic acid	PFNS	68259-12-1	--	--	0.22	0.50	1.0
Perfluorooctanesulfonamide	PFOSA	754-91-6	--	--	0.15	0.50	1.0
Perfluorooctanesulfonic acid	PFOS	1763-23-1	4	HH; Tap Water SL	0.26	0.75	1.0
Perfluorooctanoic acid	PFOA	335-67-1	6	HH; Tap Water SL	0.16	0.50	1.0
Perfluoropentanoic acid	PFPA	2706-90-3	--	--	0.29	1.0	2.0
Perfluoropentanesulfonic acid	PFPS	2706-91-4	--	--	0.12	0.50	1.0
Perfluorotetradecanoic acid	PFTeDA	376-06-7	--	--	0.17	0.50	1.0
Perfluorotridecanoic acid	PFTriDA	72629-94-8	--	--	0.20	0.50	1.0
Perfluoroundecanoic acid	PFUnA	2058-94-8	--	--	0.18	0.50	1.0

Notes:

1. DQLs for groundwater were selected based on the lower of the following:

   (a) The human health screening levels selected in accordance with the Memorandum from the OSD, “Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program” (Assistant Secretary of Defense. August 2023), as updated by the DoD in March 2024 (https://www.acq.osd.mil/eie/eer/ecc/pfas/pfas101/rsl.html). The screening levels are equal to the USEPA RSLs for tap water (USEPA, November 2023) based on a target risk of 1E-06 and target HQ of 0.1. The RSLs used are consistent with DoD’s list of ‘RSLs included in DoD Investigations of PFAS’. (HH; Tap Water SL)

   (b) New Mexico Department of the Environment Tap Water screening levels (Risk Assessment Guidance for Site Investigations and Remediation, Volume I, Soil Screening Guidance for Human Health Risk Assessments, November 2022) were compared to USEPA RSLs. USEPA RSLs are lower and were therefore selected as DQLs.

CAS = Chemical Abstracts Service
DL = detection limit
DQL = data quality limit
HH = human health based DQL
LC/MS/MS = liquid chromatography tandem mass spectrometry
LOD = limit of detection
LOQ = limit of quantification
ng/L = nanograms per liter
PFAS = per- and polyfluoroalkyl substances
RSL = regional screening level
SL = screening level
USEPA = United States Environmental Protection Agency

Laboratory: Pace South Carolina
Matrix: Surface Water
Analyte Group: PFAS (40 Compound Target List)
Method: PFAS by LC/MS/MS compliant with USEPA Method 1633

Analyte	Abbreviation	CAS Number	DQL (ng/L)	DQL Source	Achievable Laboratory Limits		
					DL (ng/L)	LOD (ng/L)	LOQ (ng/L)
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11C1-PF3OudS	763051-92-9	--	--	0.94	2.0	4.0
4:2 Fluorotelomer sulfonic acid	4:2 FTS	757124-72-4	--	--	0.63	2.0	4.0
6:2 Fluorotelomer sulfonic acid	6:2 FTS	27619-97-2	--	--	0.95	2.0	4.0
8:2 Fluorotelomer sulfonic acid	8:2 FTS	39108-34-4	--	--	0.54	2.0	4.0
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-493-3	--	--	1.9	6.0	25
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	--	--	2.6	10	25
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	--	--	1.5	3.0	5.0
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	--	--	0.57	2.0	4.0
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9C1-PF3ON	756426-58-1	69000	Eco; RWQ RBSL	0.73	2.0	4.0
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	15	HH; Tap Water SL x 10	0.89	2.0	4.0
N-ethyl perfluorooctanesulfonamide	N-Et-FOSA	4151-50-2	--	--	0.14	0.50	1.0
N-ethyl perfluorooctanesulfonamidoethanol	N-Et-FOSE	1691-99-2	--	--	2.4	5.0	10
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	--	--	0.28	0.75	1.0
N-methyl perfluorooctanesulfonamide	N-Me-FOSA	31506-32-8	--	--	0.15	0.50	1.0
N-methyl perfluorooctanesulfonamidoethanol	N-Me-FOSE	24448-09-7	--	--	1.5	5.0	10
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	--	--	0.19	0.50	1.0
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	--	--	0.49	1.0	2.0
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	--	--	0.48	1.0	2.0
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	--	--	0.32	1.0	2.0
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	--	--	0.30	1.0	2.0
Perfluorobutanesulfonic acid	PFBS	375-73-5	6000	HH; Tap Water SL x 10	0.10	0.50	1.0
Perfluorobutanoic acid	PFBA	375-22-4	18000	HH; Tap Water SL x 10	0.55	2.0	4.0
Perfluorodecanesulfonic acid	PFDS	335-77-3	--	--	0.15	0.50	1.0
Perfluorodecanoic acid	PFDA	335-76-2	660	Eco; Wildlife ESV	0.18	0.50	1.0
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	--	--	0.34	0.50	1.0
Perfluorododecanoic acid	PFDoA	307-55-1	72000	Eco; RWQ RBSL	0.17	0.50	1.0
Perfluoroheptanoic acid	PFHpA	375-85-9	870000	Eco; RWQ RBSL	0.16	0.50	1.0
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	--	--	0.11	0.50	1.0
Perfluorohexanesulfonic acid	PFHxS	355-46-4	390	HH; Tap Water SL x 10	0.17	0.50	1.0

Analyte	Abbreviation	CAS Number	DQL (ng/L)	DQL Source	Achievable Laboratory Limits		
					DL (ng/L)	LOD (ng/L)	LOQ (ng/L)
Perfluorohexanoic acid	PFHxA	307-24-4	9900	HH; Tap Water SL x 10	0.13	0.50	1.0
Perfluorononanoic acid	PFNA	375-95-1	59	HH; Tap Water SL x 10	0.17	0.50	1.0
Perfluorononanesulfonic acid	PFNS	68259-12-1	--	--	0.22	0.50	1.0
Perfluorooctanesulfonamide	PFOSA	754-91-6	--	--	0.15	0.50	1.0
Perfluorooctanesulfonic acid	PFOS	1763-23-1	40	HH; Tap Water SL x 10	0.26	0.75	1.0
Perfluorooctanoic acid	PFOA	335-67-1	60	HH; Tap Water SL x 10	0.16	0.50	1.0
Perfluoropentanoic acid	PFPA	2706-90-3	140000	Eco; RWQ RBSL	0.29	1.0	2.0
Perfluoropentanesulfonic acid	PFPS	2706-91-4	--	--	0.12	0.50	1.0
Perfluorotetradecanoic acid	PFTeDA	376-06-7	--	--	0.17	0.50	1.0
Perfluorotridecanoic acid	PFTriDA	72629-94-8	--	--	0.20	0.50	1.0
Perfluoroundecanoic acid	PFUnA	2058-94-8	49000	Eco; RWQ RBSL	0.18	0.50	1.0

Notes:

1 DQLs for surface water were selected based on the lower of the following:

(a) For human health, the groundwater DQL (see worksheet for groundwater) multiplied by a factor of 10 was used to estimate changes in exposure when assuming a non-residential scenario compared to a residential scenario (HH; Tap water SL x 10 or HH; MN HBV x 10).

(b) Guidance for Assessing the Ecological Risks of PFAS to Threatened and Endangered Species at Aqueous Film Forming Foam-Impacted Sites (Conder et al., 2020). Ecological aquatic life 5% hazardous concentration.

(c) Approach for Assessing PFAS Risk to Threatened and Endangered Species (Divine et al., 2020). The following values were used:
- Lowest NOAEL RBSL for surface water for aquatic wildlife (Wildlife RBSL).
- Freshwater chronic screening level for aquatic life (RWQ RBSL).

(d) Derivation of PFAS Ecological Screening Values. Argonne National Laboratory (Grippo, et al., 2021). The following values were used:
- Surface water ESV for aquatic-dependent wildlife (Wildlife ESV).
- Freshwater chronic ESV for aquatic life (Aquatic life ESV).

CAS = Chemical Abstracts Service
DL = detection limit
DQL = data quality limit
Eco = ecological based DQL
ESV = ecological screening value
HH = human health based DQL
LC/MS/MS = liquid chromatography tandem mass spectrometry
LOD = limit of detection

LOQ = limit of quantification
ng/L = nanograms per liter
PFAS = per- and polyfluoroalkyl substances
RBSL = risk based screening level
RWQ = recommended water quality
SL = screening level
USEPA = United States Environmental Protection Agency

Laboratory: Pace South Carolina

Matrix: Porewater
Analyte Group: PFAS (40 Compound Target List)
Method: PFAS by LC/MS/MS compliant with USEPA Method 1633

Analyte	Abbreviation	CAS Number	DQL (ng/L)	DQL Source	Achievable Laboratory Limits		
					DL (ng/L)	LOD (ng/L)	LOQ (ng/L)
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11C1-PF3OudS	763051-92-9	--	--	0.94	2.0	4.0
4:2 Fluorotelomer sulfonic acid	4:2 FTS	757124-72-4	--	--	0.63	2.0	4.0
6:2 Fluorotelomer sulfonic acid	6:2 FTS	27619-97-2	--	--	0.95	2.0	4.0
8:2 Fluorotelomer sulfonic acid	8:2 FTS	39108-34-4	--	--	0.54	2.0	4.0
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-493-3	--	--	1.9	6.0	25
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	--	--	2.6	10	25
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	--	--	1.5	3.0	5.0
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	--	--	0.57	2.0	4.0
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9C1-PF3ON	756426-58-1	69000	Eco; RWQ RBSL	0.73	2.0	4.0
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	--	--	0.89	2.0	4.0
N-ethyl perfluorooctanesulfonamide	N-Et-FOSA	4151-50-2	--	--	0.14	0.50	1.0
N-ethyl perfluorooctanesulfonamidoethanol	N-Et-FOSE	1691-99-2	--	--	2.4	5.0	10
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	--	--	0.28	0.75	1.0
N-methyl perfluorooctanesulfonamide	N-Me-FOSA	31506-32-8	--	--	0.15	0.50	1.0
N-methyl perfluorooctanesulfonamidoethanol	N-Me-FOSE	24448-09-7	--	--	1.5	5.0	10
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	--	--	0.19	0.50	1.0
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	--	--	0.49	1.0	2.0
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	--	--	0.48	1.0	2.0
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	--	--	0.32	1.0	2.0
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	--	--	0.30	1.0	2.0
Perfluorobutanesulfonic acid	PFBS	375-73-5	400000	Eco; Aquatic Life ESV	0.10	0.50	1.0
Perfluorobutanoic acid	PFBA	375-22-4	64600	Eco; Aquatic Life ESV	0.55	2.0	4.0
Perfluorodecanesulfonic acid	PFDS	335-77-3	--	--	0.15	0.50	1.0
Perfluorodecanoic acid	PFDA	335-76-2	660	Eco; Wildlife ESV	0.18	0.50	1.0
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	--	--	0.34	0.50	1.0
Perfluorododecanoic acid	PFDoA	307-55-1	72000	Eco; RWQ RBSL	0.17	0.50	1.0
Perfluoroheptanoic acid	PFHpA	375-85-9	870000	Eco; RWQ RBSL	0.16	0.50	1.0
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	--	--	0.11	0.50	1.0
Perfluorohexanesulfonic acid	PFHxS	355-46-4	5500	Eco; Wildlife ESV	0.17	0.50	1.0

Analyte	Abbreviation	CAS Number	DQL (ng/L)	DQL Source	Achievable Laboratory Limits		
					DL (ng/L)	LOD (ng/L)	LOQ (ng/L)
Perfluorohexanoic acid	PFHxA	307-24-4	28800	Eco; Aquatic Life ESV	0.13	0.50	1.0
Perfluorononanoic acid	PFNA	375-95-1	2080	Eco; Wildlife ESV	0.17	0.50	1.0
Perfluorononanesulfonic acid	PFNS	68259-12-1	--	--	0.22	0.50	1.0
Perfluorooctanesulfonamide	PFOSA	754-91-6	--	--	0.15	0.50	1.0
Perfluorooctanesulfonic acid	PFOS	1763-23-1	75	Eco; Wildlife RBSL	0.26	0.75	1.0
Perfluorooctanoic acid	PFOA	335-67-1	4400	Eco; Wildlife RBSL	0.16	0.50	1.0
Perfluoropentanoic acid	PFPA	2706-90-3	140000	Eco; RWQ RBSL	0.29	1.0	2.0
Perfluoropentanesulfonic acid	PFPS	2706-91-4	--	--	0.12	0.50	1.0
Perfluorotetradecanoic acid	PFTeDA	376-06-7	--	--	0.17	0.50	1.0
Perfluorotridecanoic acid	PFTriDA	72629-94-8	--	--	0.20	0.50	1.0
Perfluoroundecanoic acid	PFUnA	2058-94-8	49000	Eco; RWQ RBSL	0.18	0.50	1.0

Notes:

(1) DQLs for porewater were selected based on the lower of the following:

(a) Guidance for Assessing the Ecological Risks of PFAS to Threatened and Endangered Species at Aqueous Film Forming Foam-Impacted Sites (Conder et al., 2020). Ecological aquatic life 5% hazardous concentration.

(b) Approach for Assessing PFAS Risk to Threatened and Endangered Species (Divine et al., 2020). The following values were used:
-Lowest NOAEL RBSL for surface water for aquatic wildlife (Wildlife RBSL).
-Freshwater chronic screening level for aquatic life (RWQ RBSL).

(c) Derivation of PFAS Ecological Screening Values. Argonne National Laboratory (Grippo, et al., 2021). The following values were used:
-Surface water ESV for aquatic-dependent wildlife (Wildlife ESV).
-Freshwater chronic ESV for aquatic life (Aquatic life ESV).

CAS = Chemical Abstracts Service
DL = detection limit
DQL = data quality limit
Eco = ecological based DQL
ESV = ecological screening value
LC/MS/MS = liquid chromatography tandem mass spectrometry
LOD = limit of detection
LOQ = limit of quantification
ng/L = nanograms per liter
PFAS = per- and polyfluoroalkyl substances
RBSL = risk based screening level
RWQ = recommended water quality
SL = screening level
USEPA = United States Environmental Protection Agency

Laboratory: Pace South Carolina
Matrix: Soil
Analyte Group: PFAS (40 Compound Target List)
Method: PFAS by LC/MS/MS compliant with USEPA Method 1633

Analyte	Abbreviation	CAS Number	DQL (µg/kg)	DQL Source	Achievable Laboratory Limits		
					DL (µg/kg)	LOD (µg/kg)	LOQ (µg/kg)
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11C1-PF3OudS	763051-92-9	--	--	0.11	0.40	0.80
4:2 Fluorotelomer sulfonic acid	4:2 FTS	757124-72-4	--	--	0.15	0.40	0.80
6:2 Fluorotelomer sulfonic acid	6:2 FTS	27619-97-2	--	--	0.14	0.40	0.80
8:2 Fluorotelomer sulfonic acid	8:2 FTS	39108-34-4	--	--	0.13	0.40	0.80
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-493-3	--	--	1.1	2.5	5.0
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	--	--	0.10	2.5	5.0
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	--	--	0.21	0.50	1.0
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	--	--	0.10	0.40	0.80
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9C1-PF3ON	756426-58-1	--	--	0.081	0.40	0.80
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	23	HH; Residential Soil SL	0.10	0.40	0.80
N-ethyl perfluorooctanesulfonamide	N-Et-FOSA	4151-50-2	--	--	0.059	0.15	0.20
N-ethyl perfluorooctanesulfonamidoethanol	N-Et-FOSE	1691-99-2	--	--	0.44	1.0	2.0
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	--	--	0.026	0.10	0.20
N-methyl perfluorooctanesulfonamide	N-Me-FOSA	31506-32-8	--	--	0.034	0.10	0.20
N-methyl perfluorooctanesulfonamidoethanol	N-Me-FOSE	24448-09-7	--	--	0.40	1.0	2.0
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	--	--	0.049	0.10	0.20
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	--	--	0.060	0.20	0.40
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	--	--	0.048	0.20	0.40
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	--	--	0.042	0.20	0.40
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	--	--	0.038	0.20	0.40
Perfluorobutanesulfonic acid	PFBS	375-73-5	817	Eco; Wildlife ESV	0.027	0.10	0.20
Perfluorobutanoic acid	PFBA	375-22-4	2980	Eco; Wildlife ESV	0.14	0.40	0.80
Perfluorodecanesulfonic acid	PFDS	335-77-3	--	--	0.033	0.10	0.20
Perfluorodecanoic acid	PFDA	335-76-2	67.7	Eco; Wildlife ESV	0.038	0.10	0.20
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	--	--	0.028	0.10	0..20
Perfluorododecanoic acid	PFDoA	307-55-1	--	--	0.038	0.10	0.20
Perfluoroheptanoic acid	PFHpA	375-85-9	1000	Eco; Invertebrate NOEC	0.030	0.10	0.20
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	--	--	0.0249	0.10	0.20
Perfluorohexanesulfonic acid	PFHxS	355-46-4	2.8	Eco; Wildlife ESV	0.0328	0.10	0.20

Analyte	Abbreviation	CAS Number	DQL (µg/kg)	DQL Source	Achievable Laboratory Limits		
					DL (µg/kg)	LOD (µg/kg)	LOQ (µg/kg)
Perfluorohexanoic acid	PFHxA	307-24-4	3200	HH; Residential Soil SL	0.078	0.16	0.20
Perfluorononanoic acid	PFNA	375-95-1	19	HH; Residential Soil SL	0.044	0.10	0.20
Perfluorononanesulfonic acid	PFNS	68259-12-1	--	--	0.040	0.10	0.20
Perfluorooctanesulfonamide	PFOSA	754-91-6	--	--	0.047	0.10	0.20
Perfluorooctanesulfonic acid	PFOS	1763-23-1	8.7	Eco; Wildlife ESV	0.052	0.15	0.20
Perfluorooctanoic acid	PFOA	335-67-1	19	HH; Residential Soil SL	0.036	0.10	0.20
Perfluoropentanoic acid	PFPA	2706-90-3	--	--	0.062	0.20	0.40
Perfluoropentanesulfonic acid	PFPS	2706-91-4	--	--	0.032	0.10	0.20
Perfluorotetradecanoic acid	PFTeDA	376-06-7	--	--	0.030	0.10	0.20
Perfluorotridecanoic acid	PFTriDA	72629-94-8	--	--	0.031	0.10	0.20
Perfluoroundecanoic acid	PFUnA	2058-94-8	--	--	0.030	0.10	0.20

Notes:

2 DQLs for soil were selected based on the lower of the following:

(a) The human health screening levels selected in accordance with the Memorandum from the OSD, “Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program” (Assistant Secretary of Defense. August 2023), as updated by the DoD in March 2024 (https://www.acq.osd.mil/eie/eer/ecc/pfas/pfas101/rsl.html). The screening levels are equal to the USEPA RSLs for residential soil (USEPA, November 2023) based on a target risk of 1E-06 and target HQ of 0.1. The RSLs used are consistent with DoD’s list of ‘RSLs included in DoD Investigations of PFAS’. (HH; Residential Soil SL)

(b) New Mexico Department of the Environment Tap Water screening levels (Risk Assessment Guidance for Site Investigations and Remediation, Volume I, Soil Screening Guidance for Human Health Risk Assessments, November 2022) were compared to USEPA RSLs. USEPA RSLs are lower and were therefore selected as DQLs.

(c) Guidance for Assessing the Ecological Risks of PFAS to Threatened and Endangered Species at Aqueous Film Forming Foam-Impacted Sites (Conder et al., 2020). Recommended Toxicity Benchmarks for Terrestrial Plants and Invertebrates; based on NOECs (Plant Tox. and Invert. Tox.).

(c) Approach for Assessing PFAS Risk to Threatened and Endangered Species (Divine et al., 2020). The following values were used:

- Lowest NOAEL-based RBSL for soil for terrestrial wildlife (Wildlife RBSL).
- NOEC-based soil screening level for plants (Plant NOEC).
- NOEC-based soil screening level for invertebrates (Invert. NOEC).

(e) Derivation of PFAS Ecological Screening Values. Argonne National Laboratory (Grippo, et al., 2021). The following values were used:

- Lowest soil ESV for birds and mammals (Wildlife ESV).
- Soil ESV for terrestrial plants (Plant ESV).
- Soil ESV for terrestrial invertebrates (Invert. ESV).

µg/kg = micrograms per kilogram
CAS = Chemical Abstracts Service
DL = detection limit
DQL = data quality limit
Eco = ecological based DQL
ESV = ecological screening value
HH = human health based DQL
LC/MS/MS = liquid chromatography tandem mass spectrometry
LOD = limit of detection
LOQ = limit of quantification
NOAEL = no observed adverse effect level
NOEC = no observed effect concentration
OSD = Office of the Secretary of Defense
RBSL = risk based screening level
RSL = regional screening level
PFAS = per- and polyfluoroalkyl substances
SL = screening level
USEPA = United States Environmental Protection Agency

Laboratory: Pace South Carolina
Matrix: Sediment
Analyte Group: PFAS (40 Compound Target List)
Method: PFAS by LC/MS/MS compliant with USEPA Method 1633

Analyte	Abbreviation	CAS Number	DQL (µg/kg)	DQL Source	Achievable Laboratory Limits		
					DL (µg/kg)	LOD (µg/kg)	LOQ (µg/kg)
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11C1-PF3OudS	763051-92-9	--	--	0.11	0.40	0.80
4:2 Fluorotelomer sulfonic acid	4:2 FTS	757124-72-4	--	--	0.15	0.40	0.80
6:2 Fluorotelomer sulfonic acid	6:2 FTS	27619-97-2	--	--	0.14	0.40	0.80
8:2 Fluorotelomer sulfonic acid	8:2 FTS	39108-34-4	--	--	0.13	0.40	0.80
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-493-3	--	--	1.1	2.5	5.0
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	--	--	0.10	2.5	5.0
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	--	--	0.21	0.50	1.0
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	--	--	0.10	0.40	0.80
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9C1-PF3ON	756426-58-1	--	--	0.081	0.40	0.80
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	230	HH; Residential Soil SL x 10	0.10	0.40	0.80
N-ethyl perfluorooctanesulfonamide	N-Et-FOSA	4151-50-2	--	--	0.059	0.15	0.20
N-ethyl perfluorooctanesulfonamidoethanol	N-Et-FOSE	1691-99-2	--	--	0.44	1.0	2.0
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	--	--	0.026	0.10	0.20
N-methyl perfluorooctanesulfonamide	N-Me-FOSA	31506-32-8	--	--	0.034	0.10	0.20
N-methyl perfluorooctanesulfonamidoethanol	N-Me-FOSE	24448-09-7	--	--	0.40	1.0	2.0
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	--	--	0.049	0.10	0.20
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	--	--	0.060	0.20	0.40
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	--	--	0.048	0.20	0.40
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	--	--	0.042	0.20	0.40
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	--	--	0.038	0.20	0.40
Perfluorobutanesulfonic acid	PFBS	375-73-5	730	Eco; Wildlife RBSL	0.027	0.10	0.20
Perfluorobutanoic acid	PFBA	375-22-4	1600	Eco; Wildlife RBSL	0.14	0.40	0.80
Perfluorodecanesulfonic acid	PFDS	335-77-3	--	--	0.033	0.10	0.20
Perfluorodecanoic acid	PFDA	335-76-2	--	--	0.038	0.10	0.20
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	--	--	0.028	0.10	0..20
Perfluorododecanoic acid	PFDoA	307-55-1	--	--	0.038	0.10	0.20
Perfluoroheptanoic acid	PFHpA	375-85-9	--	--	0.030	0.10	0.20
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	--	--	0.0249	0.10	0.20

Analyte	Abbreviation	CAS Number	DQL (µg/kg)	DQL Source	Achievable Laboratory Limits		
					DL (µg/kg)	LOD (µg/kg)	LOQ (µg/kg)
Perfluorohexanesulfonic acid	PFHxS	355-46-4	1300	HH; Residential Soil SL x 10	0.0328	0.10	0.20
Perfluorohexanoic acid	PFHxA	307-24-4	1800	Eco; Wildlife RBSL	0.078	0.16	0.20
Perfluorononanoic acid	PFNA	375-95-1	10	Eco; Wildlife RBSL	0.044	0.10	0.20
Perfluorononanesulfonic acid	PFNS	68259-12-1	--	--	0.040	0.10	0.20
Perfluorooctanesulfonamide	PFOSA	754-91-6	--	--	0.047	0.10	0.20
Perfluorooctanesulfonic acid	PFOS	1763-23-1	1.4	Eco; Wildlife RBSL	0.052	0.15	0.20
Perfluorooctanoic acid	PFOA	335-67-1	6	Eco; Wildlife RBSL	0.036	0.10	0.20
Perfluoropentanoic acid	PFPA	2706-90-3	--	--	0.062	0.20	0.40
Perfluoropentanesulfonic acid	PFPS	2706-91-4	--	--	0.032	0.10	0.20
Perfluorotetradecanoic acid	PFTeDA	376-06-7	--	--	0.030	0.10	0.20
Perfluorotridecanoic acid	PFTriDA	72629-94-8	--	--	0.031	0.10	0.20
Perfluoroundecanoic acid	PFUnA	2058-94-8	--	--	0.030	0.10	0.20

Notes:

1 DQLs for sediment were selected based on the lower of the following:

(a) For human health, the soil SL (see worksheet for soil) multiplied by a factor of 10 was used to estimate changes in exposure when assuming a non-residential scenario compared to a residential scenario (HH; Residential Soil SL x 10).

(b) Approach for Assessing PFAS Risk to Threatened and Endangered Species (Divine et al., 2020). Lowest NOAEL-based RBSL for sediment for aquatic wildlife (Wildlife RBSL).

µg/kg = micrograms per kilogram
CAS = Chemical Abstracts Service
DL = detection limit
DQL = data quality limit
Eco = ecological based DQL
HH = human health based DQL
LC/MS/MS = liquid chromatography tandem mass spectrometry
LOD = limit of detection
LOQ = limit of quantification
NOAEL = no observed adverse effect level
TBD = to be determined
PFAS = per- and polyfluoroalkyl substances
RBSL = risk-based screening level
SL = screening level
USEPA = United States Environmental Protection Agency

Laboratory: Pace South Carolina
Matrix: Groundwater
Analytical Group: PFAS (40 Compound Target List)
Analytical Method: ASTM D8421

Analyte	Acronym	CAS Number	Detection Limit (DL) ng/L	Limit of Quantitation (LOQ) ng/L
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OudS	763051-92-9	3.0	10
4:2 Fluorotelomer sulfonic acid	4:2 FTS	757124-72-4	1.9	10
6:2 Fluorotelomer sulfonic acid	6:2 FTS	27619-97-2	4.4	20
8:2 Fluorotelomer sulfonic acid	8:2 FTS	39108-34-4	5.2	10
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-49-3	4.9	40
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	2.7	40
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	5.0	40
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	1.7	10
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS	756426-58-1	1.8	10
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	2.4	10
N-ethyl perfluorooctanesulfonamide	N-Et-FOSA	4151-50-2	2.6	10
N-ethyl perfluorooctanesulfonamidoethanol	N-Et-FOSE	1691-99-2	2.6	10
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	3.5	10
N-methyl perfluorooctanesulfonamide	N-Me-FOSA	31506-32-8	2.1	10
N-methyl perfluorooctanesulfonamidoethanol	N-Me-FOSE	24448-09-7	4.5	10
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	2.7	10
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	1.8	10
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	1.0	10
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	1.4	10
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	2.0	10
Perfluorobutanesulfonic acid	PFBS	375-73-5	3.5	10
Perfluorobutanoic acid	PFBA	375-22-4	8.3	50
Perfluorodecanesulfonic acid	PFDS	335-77-3	2.6	10
Perfluorodecanoic acid	PFDA	335-76-2	2.2	10
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	50(1)	50
Perfluorododecanoic acid	PFDoA	307-55-1	2.0	10
Perfluoroheptanoic acid	PFHpA	375-85-9	3.2	10
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	1.6	10

Analyte	Acronym	CAS Number	Detection Limit (DL) ng/L	Limit of Quantitation (LOQ) ng/L
Perfluorohexanesulfonic acid	PFHxS	355-46-4	1.6	10
Perfluorohexanoic acid	PFHxA	307-24-4	1.4	10
Perfluorononanoic acid	PFNA	375-95-1	2.2	10
Perfluorononanesulfonic acid	PFNS	68259-12-1	1.9	10
Perfluorooctanesulfonamide	PFOSA	754-91-6	1.6	10
Perfluorooctanesulfonic acid	PFOS	1763-23-1	1.6	10
Perfluorooctanoic acid	PFOA	335-67-1	4.1	10
Perfluoropentanoic acid	PFPA	2706-90-3	14	50
Perfluoropentansulfonic acid	PFPS	2706-91-4	2.9	10
Perfluorotetradecanoic acid	PFTeDA	376-06-7	50(1)	50
Perfluorotridecanoic acid	PFTriDA	72629-94-8	5.8	10
Perfluoroundecanoic acid	PFUnA	2058-94-8	1.4	10

Notes:

1.) A method detection limit for this compound could not be established. As such, the laboratory will report to the LOQ.

ASTM = American Society for Testing and Materials
CAS = Chemical Abstracts Service
DL = detection limit
LOQ = limit of quantification
ng/l = nanograms per liter

Laboratory: Pace South Carolina
Matrix: Soil
Analytical Group: PFAS (40 Compound Target List)
Analytical Method: ASTM D8421

Analyte	Acronym	CAS Number	Detection Limit (DL) µg/kg	Limit of Quantitation (LOQ)[2] µg/kg
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OudS	763051-92-9	0.0043	0.10
4:2 Fluorotelomer sulfonic acid	4:2 FTS	757124-72-4	0.010	0.10
6:2 Fluorotelomer sulfonic acid	6:2 FTS	27619-97-2	0.035	0.20
8:2 Fluorotelomer sulfonic acid	8:2 FTS	39108-34-4	0.023	0.10
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-49-3	0.018	0.40
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	0.013	0.40
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	0.014	0.40
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	0.0052	0.10
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS	756426-58-1	0.0036	0.10
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	0.0040	0.10
N-ethyl perfluorooctanesulfonamide	N-Et-FOSA	4151-50-2	0.0042	0.10
N-ethyl perfluorooctanesulfonamidoethanol	N-Et-FOSE	1691-99-2	0.0038	0.10
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	0.013	0.10
N-methyl perfluorooctanesulfonamide	N-Me-FOSA	31506-32-8	0.0058	0.10
N-methyl perfluorooctanesulfonamidoethanol	N-Me-FOSE	24448-09-7	0.013	0.10
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	0.011	0.10
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	0.0079	0.10
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	0.0046	0.10
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	0.0034	0.10
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	0.0031	0.10
Perfluorobutanesulfonic acid	PFBS	375-73-5	0.0073	0.10
Perfluorobutanoic acid	PFBA	375-22-4	0.013	0.50
Perfluorodecanesulfonic acid	PFDS	335-77-3	0.0062	0.10
Perfluorodecanoic acid	PFDA	335-76-2	0.015	0.10
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	0.50 (1)	0.50
Perfluorododecanoic acid	PFDoA	307-55-1	0.0061	0.10
Perfluoroheptanoic acid	PFHpA	375-85-9	0.0097	0.10
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	0.0063	0.10

Analyte	Acronym	CAS Number	Detection Limit (DL) µg/kg	Limit of Quantitation (LOQ)^2 µg/kg
Perfluorohexanesulfonic acid	PFHxS	355-46-4	0.0045	0.10
Perfluorohexanoic acid	PFHxA	307-24-4	0.0035	0.10
Perfluorononanoic acid	PFNA	375-95-1	0.0060	0.10
Perfluorononanesulfonic acid	PFNS	68259-12-1	0.0047	0.10
Perfluorooctanesulfonamide	PFOSA	754-91-6	0.0031	0.10
Perfluorooctanesulfonic acid	PFOS	1763-23-1	0.0040	0.10
Perfluorooctanoic acid	PFOA	335-67-1	0.013	0.10
Perfluoropentanoic acid	PFPA	2706-90-3	0.031	0.50
Perfluoropentansulfonic acid	PFPS	2706-91-4	0.0066	0.10
Perfluorotetradecanoic acid	PFTeDA	376-06-7	0.50 (1)	0.50
Perfluorotridecanoic acid	PFTriDA	72629-94-8	0.0083	0.10
Perfluoroundecanoic acid	PFUnA	2058-94-8	0.0079	0.10

Notes:

1.) A method detection limit for this compound could not be established. As such, the laboratory will report to the LOQ.
2.) ASTM 8421 is not a DoD/ELAP certified method. As such no quarterly LODs are performed, and two levels of reporting limits are used.

ASTM = American Society for Testing and Materials
CAS = Chemical Abstracts Service
DL = detection limit
DoD = Department of Defense
ELAP = Environmental Laboratory Accreditation Program
FTS = fluorotelomer sulfonic acid
LOD = limit of detection
LOQ = limit of quantification
µg/kg = micrograms per kilogram

Laboratory: Pace South Carolina

Matrix: Solid (Soil/ Sediment)

Analyte Groups: General Chemistry (TOC, pH, Grain Size)

Analyte	Method	Units	DQL	Achievable Laboratory Limits		
				DL	LOD	LOQ
Total Organic Carbon	USEPA 9060	mg/kg	N/A	50	100	100
pH	USEPA 9045D	STU	N/A	0.10	1.0	1.0
Grain Size	ASTM D422	% Passing	N/A	0.10	0.10	0.10

Notes:

% = percent
ASTM = American Society for Testing and Materials
DL = detection limit
DQL = data quality limit
LOD = limit of detection
LOQ = limit of quantification
mg/kg = milligrams per kilogram
N/A = not applicable
STU = standard unit
TOC = total organic carbon
USEPA = United States Environmental Protection Agency

Worksheets #17 & #18: Sampling Design and Rationale

Worksheets #17 & #18 provide the sampling design and rationale, in addition to the sampling locations and methods, for the Santa Fe AASF RI. The sampling program was designed to meet the DQOs established in **Worksheet #11**, while considering the CSM summarized in **Worksheet #10**. As discussed in **Worksheet #10**, one AOI with exceedances of the SL was identified at the facility during the SI (EA, 2023). Additionally, an area on the AASF where PFAS releases may have occurred that are not associated with historical ARNG activities will be evaluated during the RI:

- AOI 1: Former Fire Truck Bay and Tri-Max™ Hand Truck Storage Area
- Historical WWTP Biosolid Surface Disposal Site.

The RI field activities for the Santa Fe AASF will be conducted over three phases. During the Prescriptive Phase, soil and groundwater samples will be collected and analyzed for PFAS from multiple intervals at biased sampling locations near known impacts as identified during the SI. Data collected during the Prescriptive Phase will be used as a preliminary evaluation of the extent of PFAS in these areas and to refine the sampling approach for the subsequent Adaptive Phase. Depending on the Prescriptive Phase results, anticipated Adaptive Phase activities may include RSC to identify and delineate on-facility source areas, off-facility permanent monitoring well installation, off-facility surface water, sediment, and/or porewater/seep samples. The Final Characterization/Monitoring Phase will include the installation of additional permanent groundwater monitoring wells, if determined necessary based on the results of the Adaptive Phase, aquifer testing, and quarterly sampling of the final monitoring well network for one year. This worksheet describes the sampling design and rationale for the initial Prescriptive Phase.

The sampling program for the Prescriptive Phase will include:

- Collection of surface and subsurface soil samples within soil units;
- Collection of surface soil samples beneath facility stormwater outflows;
- Installation of new on-facility permanent monitoring wells;
- Collection of low-flow groundwater samples from new monitoring wells and existing on- and off-facility monitoring wells.

The following subsections provide the specific sampling design and rationale for the selection of sampling locations for the Prescriptive Phase. The proposed locations of samples to be collected are presented on **Figures 17-1** through **17-4**. The specific design rationale for each task, in addition to the sample locations and methods for, are included in **Table 17-1** and **Table 17-2**. Analytical requirements to achieve project objectives and support the quantification of potential risks are detailed in **Worksheet #15**. Field activities will be completed in accordance with the procedures outlined in **Worksheet #14** and the SOPs in **Appendix D**.

In instances when deviations from this sampling design and rationale are made necessary due to unforeseen conditions, a Field Change Request Form will be generated to document the change and request feedback from the A2P JV Task Manager and Project Manager, USACE, and ARNG.

17.1 Soil Sampling Design and Rationale

The overall soil sampling approach has been designed to meet the RI objectives as presented in **Worksheet #11**. Soil samples will be collected in accordance with the procedures presented in

Worksheet #14 and further detailed in *SOP 3-21: Surface and Subsurface Soil Sampling Procedures* (**Appendix D**). Soil samples will be analyzed for PFAS as specified in **Worksheet #15**. Detailed figures depicting proposed Prescriptive Phase soil sampling locations at the AASF are shown in **Figures 17-1** through **17-3.** The rationale for the proposed sample locations is provided in **Table 17-1.**

AFFF was historically stored within the fire truck staged at the former AASF building. No known releases from the fire truck occurred; however, it's possible that AFFF may have leaked from the truck or was flushed out during maintenance activities. Tri-Max™ 70/30 mobile fire extinguisher units equipped with AFFF were staged on the flight line during the mid-2000s. The units were regularly serviced, which may have resulted in potential AFFF leaks or incidental discharge; however, no releases or nozzle testing are known to have occurred based on interviews with AASF personnel. The City of Santa Fe WWTP disposes of biosolids through application to the ground surface to the northwest, north, and east of the AASF. A former WWTP biosolids application area extends onto the northeast part of the AASF that is now partially covered by the AASF parking lot.

AFFF released at AOI 1 may have been washed from the paved areas to the nearby ground surface where it would infiltrate to the subsurface. Runoff from residual surface soil impacts may also have been conveyed by the AASF's stormwater infrastructure and accumulated in areas (e.g., retention basin) on- and nearby off-facility. SI results at AOI 1 show PFOS SL exceedances in surface soil at sample locations near the Former Fire Truck Bay. Additionally, historical biosolids spreading not associated with ARNG activities resulted in treated WWTP biosolids, which could have potentially been impacted with PFAS, being spread within the current AASF boundary Surface soil samples collected within the former WWTP biosolids application area on the AASF had detections of PFOA and PFOS above the relevant SLs. Detections of PFOS and other relevant PFAS compounds below the SLs were observed in the surface and subsurface soil elsewhere surrounding the AOI and in the biosolids application area.

Soil Unit Sampling

During the Prescriptive Phase, surface and shallow subsurface soil samples will be collected to fill data gaps in both the horizontal and vertical distribution of PFAS in soil. Soil samples will be collected within biased soil units using hand augers and DPT or sonic boring methods. The soil units will focus around suspected release areas to provide a preliminary evaluation of the lateral and vertical extent of PFAS. Individual sample locations within these units are also biased to target areas where AFFF or other PFAS containing materials would most likely encounter and/or accumulate in soil (i.e., at the edges of pavement or within surficial drainage features), and to provide sufficient sample coverage within the unit. Later phases of the RI will use step-in/step-out samples to refine the source area boundaries and collect unbiased data for evaluation during the comprehensive HHRA and ERA.

A total of 28 soil unit sample locations are proposed among four (4) soil units (SU01 through SU04). The location, orientation, and boundaries of the prescribed soil units were determined based on the currently understood conceptual site model and suspected release mechanisms. The size of the soil units and number of sample locations within each is based on the nature of the suspected release (e.g., localized vs. dispersed). Surface soil (0 to 2 feet bgs) and shallow subsurface soil (3 to 5 feet bgs) samples will be collected at each soil unit location using a hand auger. Additionally, nine (9) supplemental soil borings will be advanced within the soil units to a depth of 15 feet bgs via DPT or sonic drilling methods. A depth of 15 feet bgs corresponds with the maximum assumed extent of construction activities for the industrial/commercial worker exposure scenario used to develop the SLs. The soil borings results will be used as a preliminary evaluation of the lateral and vertical extent of PFAS in surface and shallow subsurface soil.

Supplemental Soil Sampling

Supplemental soil samples will be collected at discrete locations to lend supplemental data to help inform the CSM. Two off-facility surface soil samples (0-2 feet bgs) will be collected on the City of Santa Fe property just north of the AASF boundary, beneath the individual outflows for the AASF retention pond and OWS. These samples will be used to evaluate whether residual soil impacts have migrated off-facility via the current stormwater system and if overland transport of PFAS is a potential exposure route for off-facility receptors. Though visible drainage scars are present at both locations, the drainages appear to be dry throughout most of the year. These samples will be evaluated as surface soil because water is not present for any duration to support aquatic habitat.

Soil borings will be advanced to the regional groundwater zone, anticipated between 180 and 200 feet bgs, at proposed monitoring well locations to further evaluate subsurface conditions across the AASF. In addition to guiding well construction, these borings will inform the CSM by helping define the lateral (i.e., how widespread?) and vertical (i.e., how thick?) extent of the downward confining unit observed during the SI along the west side of the AASF. Soil samples will be collected at all boring locations prior to the construction of the monitoring wells. These samples will provide added data density within soil units and, where outside of a soil units, corresponding soil data to each future groundwater sampling location. Soil samples will be collected at the surface (0 to 2 feet bgs), shallow subsurface soil (8-10 feet bgs), and approximately 1 foot above the observed water table.

Soil unit and shallow boring samples will be analyzed under standard TAT for the target list of PFAS by ASTM D8421[3], as specified in **Worksheet #15**, to support screening level evaluation of the extent of PFAS impacts. Soil samples collected from the monitoring well borings will be analyzed under standard TAT for the target list of 40 PFAS by LC/MS/MS compliant with USEPA Method 1633, so that data collected at these locations and depths may be used in later decision making without costly resampling efforts. Additionally, other geochemical and physical parameters will be analyzed in a subset of samples to support evaluation of PFAS fate and transport, in addition to the remedial alternatives analysis.

17.2 Groundwater Sampling Design and Rationale

The overall groundwater sampling approach has been designed to meet the RI objectives as presented in **Worksheet #11**. Sampling activities will be conducted in accordance with the procedures established in **Worksheet #14** and further detailed in the SOPs (**Appendix D**). Groundwater samples will be analyzed for PFAS as specified in **Worksheet #15**. The sample locations are shown on **Figure 17-1** and **Figure 17-4**. The sampling design and rationale for the groundwater sample locations are provided in **Table 17-2**.

AFFF is suspected to have been released to the ground surface at AOI 1 during historical ARNG activities. Subsurface infiltration is assumed to be the dominant migration mechanism based on site conditions and the semi-arid climate of Santa Fe, leaving the potential for PFAS migration through the subsurface to groundwater. Groundwater was observed during the SI in two distinct zones; the perched groundwater zone measured at approximately 110 feet bgs (around 6,210 feet amsl), and the deeper regional groundwater zone measured below 175 feet bgs (6,150 feet amsl). Groundwater samples collected during the SI found concentrations of PFOA and PFHxS exceeding the SLs in the perched groundwater zone observed only along the west side of the AASF. Detections of PFOS and PFBS were also measured in perched zone wells. Relevant PFAS

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[3] The use of the PFAS screening method ASTM D8421 will be dependent on the acceptance of the Demonstration of Method Applicability Study, performed under a separate task order. See **Section 14.3** for additional details.

compounds were not detected in samples collected from wells screened in the regional groundwater zone, except for estimated concentrations of PFHxA less than 1 ng/L.

On-facility Groundwater Sampling

Permanent monitoring wells will be installed on the AASF during the RI Prescriptive Phase to address data gaps recognized in the SI. Up to three shallow and deep monitoring well pairs will be installed at locations on the west end of the AASF where the confining unit creates perched groundwater conditions. The shallow well of each pair will be screened above the confining unit to assess perched groundwater. The deep well will be screened below the confining unit to evaluate groundwater conditions in the regional groundwater, directly beneath the perched zone well. Well pairs will be installed using sonic drilling methods that employ temporary override casing to case off the perched groundwater water zone while penetrating the downward confining unit to reach regional groundwater. Additional wells will be installed in the regional zone elsewhere on the AASF where the perched zone is not suspected to be present. These individual deep well locations will be placed along the upgradient facility boundary to evaluate regional groundwater coming onto the facility. Samples will be collected from the five existing SI monitoring wells in conjunction with the proposed wells to temporally evaluate groundwater facility-wide. Results of the Prescriptive Phase groundwater sampling will be used to refine the approach for the Adaptive Phase, which is anticipated to include downgradient, off-facility monitoring well installation to evaluate potential PFAS migration to known receptors.

Off-facility Groundwater Sampling

The City of Santa Fe maintains a well network for discharge permit monitoring associated with the land application of biosolids. The city-owned wells are located in the presumed up, side, and downgradient direction of the AASF and are screened within the regional aquifer based on well details and groundwater elevations provided in recent discharge monitoring reports. As part of the RI Prescriptive Phase sampling effort, groundwater samples will be collected from these wells for supplemental evaluation of regional groundwater around the AASF. Data will be used only for screening-level evaluation due to uncertainties in the materials and construction of the city-owned wells. However, this initial characterization will assist in determining off-facility well installation in future RI phases, with data collected in those phases used for definitive purposes (e.g., delineation, risk assessment).

During the Prescriptive Phase, low-flow groundwater samples will be collected from all monitoring wells. Groundwater samples will be analyzed under standard TAT for the target list of PFAS by LC/MS/MS compliant with USEPA Method 1633, as specified in **Worksheet #15**. Sampling results will be evaluated following the Prescriptive Phase event and used to inform the Adaptive Phase groundwater sampling scope along with other RI findings (e.g., groundwater flow direction).

17.3 Groundwater Gauging Design and Rationale

As part of the Prescriptive Phase, groundwater levels will be collected from all permanent groundwater monitoring wells, including the off-facility city-owned wells. The purpose is to determine the potentiometric surface and calculation of the groundwater gradient in the perched and regional groundwater zones at the facility. The groundwater gauging round will be conducted within as short a time period as reasonably feasible. The monitoring well locations are shown in **Figure 17-1** and **Figure 17-4**. The procedures for collection of water levels from monitoring wells are presented in **Worksheet #14**.

Legend

- Existing Monitoring Well
- Proposed Regional Groundwater Monitoring Well
- Proposed Perched & Regional Groundwater Monitoring Well Nested Pair
- ◇ Proposed Soil Boring
- ☒ Proposed Surface Soil
- ▭ Proposed Soil Unit
- 🟩 Facility Boundary

Note:

Proposed off-facility groundwater sample locations are shown on Figure 17-4

Service Layer Credits: World Imagery: Maxar, Microsoft

ARNG

Remedial Investigation at Santa Fe AASF, NM

Date: 11/8/2024

Figure 17-1
Proposed Prescriptive Phase Sample Locations

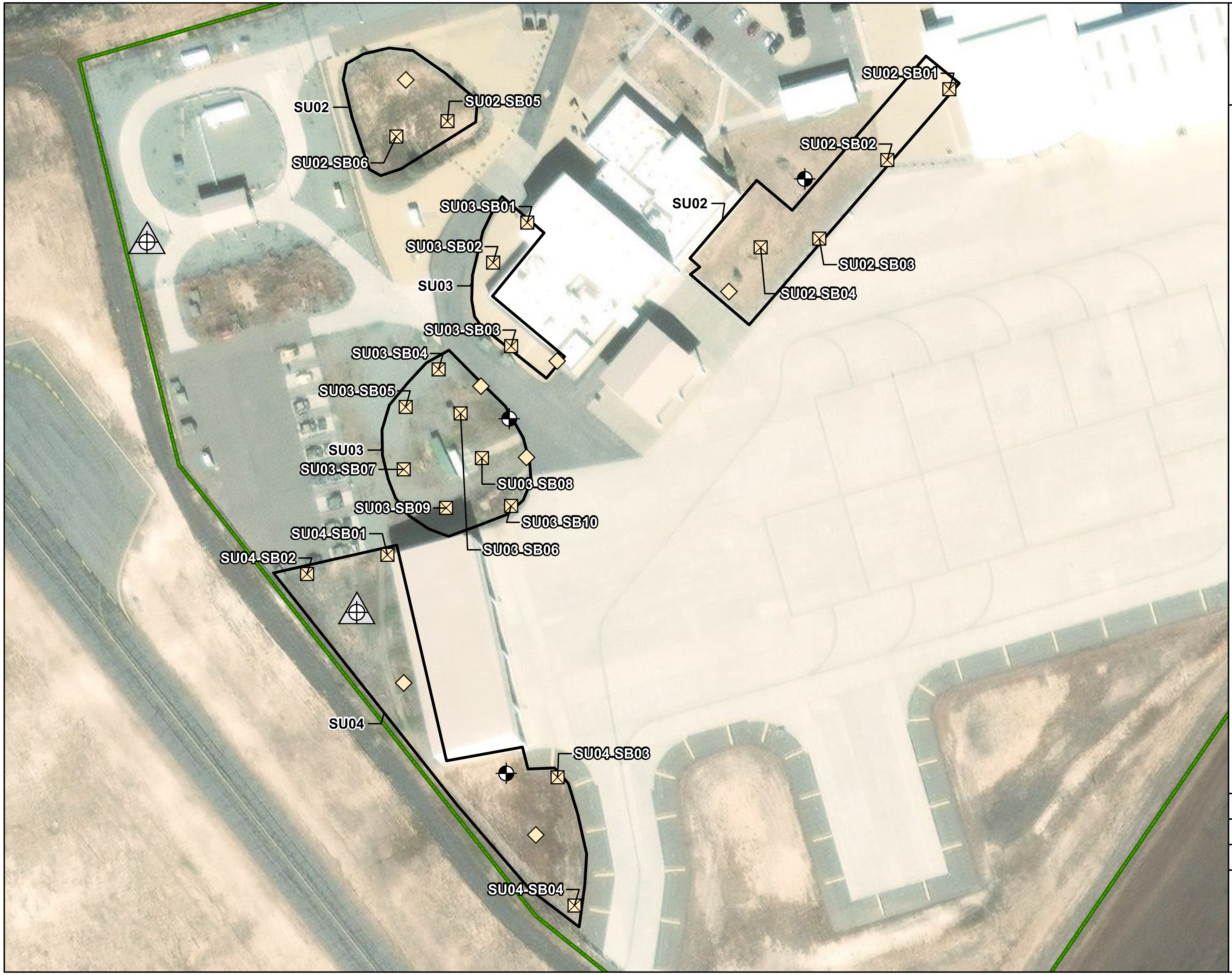
Service Layer Credits: World Imagery: Maxar, Microsoft

ARNG

Remedial Investigation at Santa Fe AASF, NM

Date: 11/8/2024

Figure 17-2
Proposed Prescriptive Phase
Soil Unit SU01



Legend

⊕ Existing Monitoring Well

△ Proposed Perched & Regional Groundwater Monitoring Well Nested Pair

◇ Proposed Soil Boring

☒ Proposed Soil Unit Sample

▭ Proposed Soil Unit

🟩 Facility Boundary

N

0 50 100 200 Feet

Service Layer Credits: World Imagery: Maxar, Microsoft

ARNG

Remedial Investigation at Santa Fe AASF, NM

Date: 11/8/2024

Figure 17-3
Proposed Prescriptive Phase Soil Units SU02, SU03, SU04

Legend

- Existing Monitoring Well
- Proposed Regional Groundwater Monitoring Well
- Proposed Perched & Regional Groundwater Monitoring Well Nested Pair
- 🟩 Facility Boundary

N

0 200 400 800 Feet

Service Layer Credits: World Imagery: Maxar

ARNG

Remedial Investigation at Santa Fe AASF, NM

Date: 11/8/2024

**Figure 17-4
Proposed Prescriptive Phase
Off-facility Monitoring Well Samples**

Table 17-1: Soil Sampling Design and Rationale
Santa Fe AASF, NM

Target Area	Location Identifier	Sample Identifier	Number of Samples	Target Sample Depth (feet bgs)	Matrix	Sampling Tool	Analyte Group	Rationale
Historical WWTP Biosolid Surface Disposal Site	SU01-SB01	SU01-SB01-0-2	2	0–2	Surface and shallow subsurface soil	Hand Auger	PFAS, Target PFAS, Target 40 Compound List (ASTM D8421)[1] Limited Sample Selection (10% of samples): PFAS, Target 40 Compound List (USEPA Method 1633, QSM 5.4 Table B-24) One Sample per Depth Interval in Each SU, Two at SU03 (10%): TOC (USEPA Method 9060A), pH (USEPA Method 9045D), Grain Size (ASTM D-422)	Evaluate the horizontal extent of PFAS in surface and shallow subsurface soil that may be attributed to the City of Santa Fe WWTP biosolids spreading area extending onto the current AASF.
		SU01-SB01-3-5		3–5				
	SU01-SB02	SU01-SB02-0-2	2	0–2				
		SU01-SB02-3-5		3–5				
	SU01-SB03	SU01-SB03-0-2	2	0–2				
		SU01-SB03-3-5		3–5				
	SU01-SB04	SU01-SB04-0-2	2	0–2				
		SU01-SB04-3-5		3–5				
	SU01-SB05	SU01-SB05-0-2	2	0–2				
		SU01-SB05-3-5		3–5				
	SU01-SB06	SU01-SB06-0-2	2	0–2				
		SU01-SB06-3-5		3–5				
	SU01-SB07	SU01-SB07-0-2	2	0–2				
		SU01-SB07-3-5		3–5				
	SU01-SB08	SU01-SB08-0-2	2	0–2				
		SU01-SB08-3-5		3–5				
AOI 1	SU02-SB01	SU02-SB01-0-2	2	0–2				Evaluate the horizontal extent of PFAS in surface and shallow subsurface soil near AOI 1, in the area adjacent to the former AASF building and north side of the flight line, where runoff from paved surfaces would have encountered ground surface.
		SU02-SB01-3-5		3–5				
	SU02-SB02	SU02-SB02-0-2	2	0–2				
		SU02-SB02-3-5		3–5				
	SU02-SB03	SU02-SB03-0-2	2	0–2				
		SU02-SB03-3-5		3–5				
	SU02-SB04	SU02-SB04-0-2	2	0–2				
		SU02-SB04-3-5		3–5				
Facility-wide	SU02-SB05	SU02-SB05-0-2	2	0–2				Evaluate PFAS in surface and shallow subsurface soil within the dry stormwater retention basin. The basin was constructed when the AASF was renovated, after AFFF was present, but may capture runoff from residual soil impacts.
		SU02-SB05-3-5		3–5				
	SU02-SB06	SU02-SB06-0-2	2	0–2				
		SU02-SB06-3-5		3–5				
AOI 1	SU03-SB01	SU03-SB01-0-2	2	0–2				Evaluate PFAS in surface and subsurface soil in the unpaved area on the west side of the former AASF building, where rinse runoff from bay doors would have encountered ground surface. Evaluate extent of maximum observed PFAS exceedances detected in surface soil at locations AOI01-07 and AOI01-08 during the SI.
		SU03-SB01-3-5		3–5				
	SU03-SB02	SU03-SB02-0-2	2	0–2				
		SU03-SB02-3-5		3–5				
	SU03-SB03	SU03-SB03-0-2	2	0–2				
		SU03-SB03-3-5		3–5				
	SU03-SB04	SU03-SB04-0-2	2	0–2				Evaluate horizontal extent of PFAS in surface and subsurface soil in the open area across from the former fire truck bay. Evaluate extent of observed PFOS exceedance in surface soil at SI location AOI01-02, where rinse runoff from the bay would have encountered ground surface. Soil unit fans out to west to assess whether unknown nozzle checks may have been performed in this area.
		SU03-SB04-3-5		3–5				
	SU03-SB05	SU03-SB05-0-2	2	0–2				
		SU03-SB05-3-5		3–5				
	SU03-SB06	SU03-SB06-0-2	2	0–2				
		SU03-SB06-3-5		3–5				
	SU03-SB07	SU03-SB07-0-2	2	0–2				
		SU03-SB07-3-5		3–5				
	SU03-SB08	SU03-SB08-0-2	2	0–2				
		SU03-SB08-3-5		3–5				
	SU03-SB09	SU03-SB09-0-2	2	0–2				
		SU03-SB09-3-5		3–5				
	SU03-SB10	SU03-SB10-0-2	2	0–2				
		SU03-SB10-3-5		3–5				

Table 17-1: Soil Sampling Design and Rationale
Santa Fe AASF, NM

Target Area	Location Identifier	Sample Identifier	Number of Samples	Target Sample Depth (feet bgs)	Matrix	Sampling Tool	Analyte Group	Rationale
Facility-wide	SU04-SB01	SU04-SB01-0-2	2	0–2	Surface and shallow subsurface soil	Hand Auger	PFAS, Target PFAS, Target 40 Compound List (ASTM D8421)1 Limited Sample Selection (10% of samples): PFAS, Target 40 Compound List (USEPA Method 1633, QSM 5.4 Table B-24) One Sample per Depth Interval in Each SU, Two at SU03 (10%): TOC (USEPA Method 9060A), pH (USEPA Method 9045D), Grain Size (ASTM D-422)	Evaluate extent of PFAS in surface and shallow subsurface soil near the west AASF boundary. SI results found PFAS in this area below the soil SLs, but exceeded the groundwater SLs in corresponding samples collected from the perched zone. Assess whether potentially unknown source material may be present in this area.
		SU04-SB01-3-5		3–5				
	SU04-SB02	SU04-SB02-0-2	2	0–2				
		SU04-SB02-3-5		3–5				
	SU04-SB03	SU04-SB03-0-2	2	0–2				
		SU04-SB03-3-5		3–5				
	SU04-SB04	SU04-SB04-0-2	2	0–2				
		SU04-SB04-3-5		3–5				
Historical WWTP Biosolid Surface Disposal Site	SFE-01	SFE-01-0-2	3	0–2	Surface and shallow subsurface soil	Hand Auger	PFAS, Target PFAS, Target 40 Compound List (ASTM D8421)1 Limited Sample Selection (10% of samples): PFAS, Target 40 Compound List (USEPA Method 1633, QSM 5.4 Table B-24)	Characterize PFAS vertically in surface and shallow subsurface soil within the former City of Santa Fe WWTP biosolids spreading area extending onto the current AASF.
		SFE-01-8-10		8–10		DPT or Sonic		
		SFE-01-13-15		13–15				
	SFE-02	SFE-02-0-2	3	0–2		Hand Auger		
		SFE-02-8-10		8–10		DPT or Sonic		
		SFE-02-13-15		13–15				
AOI 1	SFE-03	SFE-03-0-2	3	0–2		Hand Auger		Characterize PFAS vertically within the surface and subsurface soil near AOI 1, in the area adjacent to the former AASF building and north side of the flight line.
		SFE-03-8-10		8–10		DPT or Sonic		
		SFE-03-13-15		13–15				
Facility-wide	SFE-04	SFE-04-0-2	3	0–2		Hand Auger		Characterize PFAS vertically within the surface and subsurface soil in the dry stormwater retention pond.
		SFE-04-8-10		8–10		DPT or Sonic		
		SFE-04-13-15		13–15				
AOI 1	SFE-05	SFE-05-0-2	3	0–2		Hand Auger		Characterize PFAS vertically in the surface and subsurface soil at AOI 1, at or near locations where the highest surface soil detections were observed in the SI. Evaluate the vertical migration of PFAS in soil above perched groundwater where PFAS impacts were observed during the SI. Define the vertical extent of PFAS concentrations exceeding the SLs at these locations.
		SFE-05-8-10		8–10		DPT or Sonic		
		SFE-05-13-15		13–15				
	SFE-06	SFE-06-0-2	3	0–2		Hand Auger		
		SFE-06-8-10		8–10		DPT or Sonic		
		SFE-06-13-15		13–15				
	SFE-07	SFE-07-0-2	3	0–2		Hand Auger		
		SFE-07-8-10		8–10		DPT or Sonic		
		SFE-07-13-15		13–15				
Facility-wide	SFE-08	SFE-08-0-2	3	0–2		Hand Auger		Characterize PFAS vertically in surface and shallow subsurface soil near the west AASF boundary. Evaluate the vertical migration of PFAS in soil above perched groundwater where PFAS impacts were observed during the SI.
		SFE-08-8-10		8–10		DPT or Sonic		
		SFE-08-13-15		13–15				
	SFE-09	SFE-09-0-2	3	0–2		Hand Auger		
		SFE-09-8-10		8–10		DPT or Sonic		
		SFE-09-13-15		13–15				
	SFE-10	SFE-10-0-2	1	0–2	Surface Soil	Hand Auger		Evaluate potential off-facility impacts resulting from AASF runoff by sampling surface soil just below the retention pond and OWS outfow outside the north facility boundary
	SFE-11	SFE-11-0-2	1	0–2				

Table 17-1: Soil Sampling Design and Rationale
Santa Fe AASF, NM

Target Area	Location Identifier	Sample Identifier	Number of Samples	Target Sample Depth (feet bgs)	Matrix	Sampling Tool	Analyte Group	Rationale
Historical WWTP Biosolid Surface Disposal Site	SFE-MW001	SFE-MW001-0-2	3	0–2	Surface, shallow, and deep subsurface soil	Hand Auger	PFAS, Target 40 Compound List (USEPA Method 1633, QSM 5.4 Table B-24)	Characterize lithology along the northeast AASF boundary beneath the former WWTP biosolids spreading area extending onto the current AASF. Complete detailed borehole logging to refine current understanding of geologic and hydrogeologic components of the CSM. Evaluate PFAS in surface and shallow subsurface soil, and in the vadose zone of the regional groundwater zone.
		SFE-MW001-8-10		8-10		Sonic		
		SFE-MW001-[Start Depth]-[End Depth]		1 foot above groundwater				
	SFE-MW002	SFE-MW002-0-2	3	0–2		Hand Auger		
		SFE-MW002-8-10		8-10		Sonic		
		SFE-MW002-[Start Depth]-[End Depth]		1 foot above groundwater				
Facility-wide	SFE-MW003	SFE-MW003-0-2	3	0–2		Hand Auger		Characterize lithology along the west AASF boundary. Evaluate the horizontal and vertical extent of the downward confining unit observed in SI borings to better define the lithology of the perched and regional groundwater zones. Complete detailed borehole logging to refine current understanding of geologic and hydrogeologic components of the CSM. Evaluate PFAS in surface and shallow subsurface soil, and in the vadose zone of the perched groundwater zone.
		SFE-MW003-8-10		8-10		Sonic		
		SFE-MW003-[Start Depth]-[End Depth]		1 foot above groundwater				
	SFE-MW004	SFE-MW004-0-2	3	0–2		Hand Auger		
		SFE-MW004-8-10		8-10		Sonic		
		SFE-MW004-[Start Depth]-[End Depth]		1 foot above groundwater				
	SFE-MW005	SFE-MW005-0-2	3	0–2		Hand Auger		
		SFE-MW005-8-10		8-10		Sonic		
		SFE-MW005-[Start Depth]-[End Depth]		1 foot above groundwater				
		Total (not including QC)	**100**					

Notes:

1.) The use of the PFAS screening method ASTM D8421 will be dependent on the acceptance of the Demonstration of Method Applicability Study, performed under a separate task order.

2.) The quantity of RSC soil samples included in this table includes the 12 proposed RSC locations and 10 additional step-out locations. Additional locations may be warranted based on the results of the RSC.

3.) RSC surface soil samples for PFAS will be analyzed for a shortlist of 12 PFAS, as specified in **Worksheet #15**.

AOI = area of interest
ASTM = American Society for Testing and Materials
bgs = below ground surface
PFAS = per- and polyfluoroalkyl substances

QC = quality control
QSM = Quality Systems Manual
SB = soil boring
SU = soil unit

TOC = total organic carbon
USEPA = United States Environmental Protection Agency
WWTP = wastewater treatment plant

Table 17-2: Prescriptive Phase Groundwater Sampling Design and Rationale
Santa Fe AASF, NM

Location Identifier	Monitoring Well Identifier	Well Status	Target Screen Interval (feet bgs)	Sample Identifier	Number of Samples	Matrix	Sampling Tool	Analyte Group	Rationale
AOI01-01	AOI01-01	Existing	170-190	AOI01-01-[MMDDYY]	1	Groundwater	Bladder Pump	PFAS, Target 40 Compound List (USEPA Method 1633, QSM 5.4 Table B-24)	Evaluate PFAS in the perched (~110 ft bgs) and regional (~180 ft bgs) groundwater zones. Existing well network will be leveraged to provide sampling coverage across the AASF. Gauging data will used to confirm placement of proposed well network.
AOI01-02	AOI01-02	Existing	107-117	AOI01-02-[MMDDYY]	1				
AOI01-04	AOI01-04	Existing	105-115	AOI01-04-[MMDDYY]	1				
SFAASF-03	SFAASF-03	Existing	175-195	SFAASF-03-[MMDDYY]	1				
SFAASF-04	SFAASF-04	Existing	171-191	SFAASF-04-[MMDDYY]	1				
SFE-MW001	SFE-MW001-[End Depth]	Proposed	TBD	SFE-MW001-[End Depth]-[MMDDYY]	1				Evaluate PFAS in the regional groundwater zone at the upgradient AASF boundary, beneath the WWTP biosolid spreading area. Results will be used along with results from upgradient city-owned wells to assess whether PFAS may be migrating onto the AASF.
SFE-MW002	SFE-MW002-[End Depth]	Proposed	TBD	SFE-MW002-[End Depth]-[MMDDYY]	1				
SFE-MW003	SFE-MW003-[End Depth]	Proposed	TBD	SFE-MW003-[End Depth]-[MMDDYY]	2				Evaluate the horizontal on-facility extent of PFAS impacts in perched groundwater observed during the SI. Construct co-located shallow (perched) and deep (regional) well pairs to evaluate groundwater in the regional aquifer beneath observed perched zone impacts. Determine groundwater flow direction in perched groundwater and refine understanding of groundwater flow in the regional aquifer.
	SFE-MW003-[End Depth]		TBD	SFE-MW003-[End Depth]-[MMDDYY]					
SFE-MW004	SFE-MW004-[End Depth]	Proposed	TBD	SFE-MW004-[End Depth]-[MMDDYY]	2				
	SFE-MW004-[End Depth]		TBD	SFE-MW004-[End Depth]-[MMDDYY]					
SFE-MW005	SFE-MW005-[End Depth]	Proposed	TBD	SFE-MW005-[End Depth]-[MMDDYY]	2				
	SFE-MW005-[End Depth]		TBD	SFE-MW005-[End Depth]-[MMDDYY]					
WWTP-MW-1	WWTP-MW-1	Existing (City-owned)		WWTP-MW-1-[MMDDYY]	1				Complete screening level evaluation of groundwater conditions in the regional groundwater zone off-facility, using existing city-owned wells in the inferred up-, side-, and downgradient directions. Gauging data will be used to supplement on-facility data to refine understanding of groundwater flow in the regional zone.
WWTP-MW-2	WWTP-MW-2	Existing (City-owned)		WWTP-MW-2-[MMDDYY]	1				
WWTP-MW-3	WWTP-MW-3	Existing (City-owned)		WWTP-MW-3-[MMDDYY]	1				
WWTP-MW-5	WWTP-MW-5	Existing (City-owned)		WWTP-MW-5-[MMDDYY]	1				
WWTP-MW-6	WWTP-MW-6	Existing (City-owned)		WWTP-MW-6-[MMDDYY]	1				
WWTP-MW-7	WWTP-MW-7	Existing (City-owned)		WWTP-MW-7-[MMDDYY]	1				
				Total Samples (not including QC)	**19**				

Notes:

1.) The use of the PFAS screening method ASTM D8421 will be dependent on the acceptance of the Demonstration of Method Applicability Study, performed under a separate task order.

AOI = area of interest
ASTM = American Society for Testing and Materials
bgs = below ground surface
MMDDYY = two-digit month, day, year
MW = Monitoring Well
PFAS = per- and polyfluoroalkyl substances
QC = quality control
QSM = Quality Systems Manual
RI = Remedial Investigation
RSC = rapid site characterization
TBD = to be determined
WWTP = wastewater treatment plant

Worksheets #19 & #30: Sample Containers, Preservation, and Hold Times

Laboratory: Eurofins Lancaster Laboratories
2425 New Holland Pike
Lancaster, PA 17601
856-534-3953
List any required accreditations/certifications: DoD ELAP
Back-up Laboratory: Pace South Carolina
Sample Delivery Method: FedEx

Analyte/ Analyte Group	Matrix	Method/SOP	Accreditation Expiration Date	Container(s) (number, size & type per sample)	Preservation	Preparation Holding Time	Analytical Holding Time	Data Package Turnaround
PFAS	Aqueous	USEPA Method 1633, QSM 6.0 Table B-24 / WI72427	DoD-ELAP: 11/30/2024	(2) 125-mL unpreserved, HDPE	Cool, 0-6°C Freeze, ≤ -20°C	28 days 90 days	28 days	Project Specific
PFAS	Solid	USEPA Method 1633, QSM 6.0 Table B-24/ WI724278	DoD-ELAP: 11/30/2024	4 oz. PP specimen containers with polyethylene screw caps	None, 0-6°C	28 days at 0-6°C and 90 days at -20°C	90 days	Standard
Total Organic Carbon	Solid	SW-846 9060A/ WI11627	DoD-ELAP: 11/30/2024	4-oz glass jar	Cool, 0-6°C	NA	28 days	28 days
pH	Solid	SW-846 9045C modified; 29-22 WI11518	DoD-ELAP 11/30/2024	4-oz glass jar	Cool, 0-6°C	NA	NA	28 days
Grain Size	Solid	ASTM D422; WI11514	DoD-ELAP: 11/30/2024	16-oz glass jar	Cool, 0-6°C	NA	NA	28 days

Notes:

°C = degrees Celsius
ASTM = American Society for Testing and Materials
DoD = Department of Defense
ELAP = Environmental Laboratory Accreditation Program
HDPE = high-density polyethylene
mL = milliliter
NA = not applicable
oz = ounce
PFAS = per- and polyfluoroalkyl substances
PP = polypropylene
QSM = Quality Systems Manual
SOP = standard operating procedure
USEPA = United States Environmental Protection Agency

Laboratory: Pace South Carolina
106 Vantage Point Drive
West Columbia, SC 29172
803-791-9700
List any required accreditations/certifications: DoD ELAP
Back-up Laboratory: NA
Sample Delivery Method: FedEx

Analyte/ Analyte Group	Matrix	Method/SOP	Accreditation Expiration Date	Container(s) (number, size & type per sample)	Preservation	Preparation Holding Time	Analytical Holding Time	Data Package Turnaround
PFAS	Aqueous	USEPA Method 1633/ ENV-SOP-WCOL-0158	11/18/2025	HDPE w/ PP linerless cap 2 x 500 mL 1 x 125 mL	Cool, 0-6°C Freeze, ≤ -20°C	28 days 90 days	28 days	28 days
PFAS	Aqueous	D8421/ D7968/ ENV-SOP-WCOL-0164	N/A (1)	PP w/PP linerless cap 3 x 15 mL PP (2)	<6°C	28 days	28 days	48-hour upon agreement
PFAS	Solid	USEPA Method 1633/ ENV-SOP-WCOL-0158	11/18/2025	1 x 2 oz	Cool, 0-6°C Freeze, ≤ -20°C	90 days 90 days	90 days	21 days
PFAS	Solid	D8421/ D7968/ ENV-SOP-WCOL-0164	N/A (1)	90 mL PP	<6°C	28 days	28 days	48-hour upon agreement
pH	Solid	9045D/ENV-SOP-WCOL-0149	11/18/2025	Polyethylene, Glass 1 x 2 oz	None, ≤6°C	NA	ASAP	21 days
Grain Size (Schnabel Engineering)	Solid	Standard Operating Procedure Grain Size Determined by Sedimentation Analysis (Hydrometer)/ ASTM D7928	N/A	1 – Gallon Ziploc	None, ≤6°C	6 Months	6 Months	28 days
TOC	Solid	Walkley-Black/ENV-SOP-WCOL-0149	11/18/2025	1 – 4 oz. Amber Glass	None, ≤6°C	N/A	28 days	21 days

Notes:

1) Validated in inter-laboratory study
2) For aqueous samples, do NOT fill the entire 15 mL tube. Each 15 mL container should contain 5 mL (± 1 mL) of sample volume.

°C = degrees Celsius
≤ = less than or equal to
< = less than
ASTM = American Society for Testing and Materials
DoD = Department of Defense
ELAP = Environmental Laboratory Accreditation Program
HDPE = high-density polyethylene
LC/MS/MS = liquid chromatography tandem mass spectrometry
mL = milliliter
NA = not applicable
oz = ounce
PFAS = per- and polyfluoroalkyl substances
PP = polypropylene
QAPP = Quality Assurance Project Plan
QSM = Quality Systems Manual
SOP = standard operating procedure
TOC = total organic carbon

Worksheet #20: Field Quality Control Summary

The table below provides a summary of the quantities of field QC samples to be collected. The remaining tables in **Worksheet #20** establish the Measurement Performance Criteria.

Matrix	Analytical Group	Field Samples	Field Duplicates	Matrix Spikes	Matrix Spike Duplicates	Field Reagent Blanks	Equipment Rinsate Blanks[3]	Total Samples
Prescriptive Phase Samples								
Groundwater	PFAS, Screening[1]	0	0	0	0	0	0	0
	PFAS, Definitive[2]	19	2	1	1	1	1	25
Soil	PFAS, Screening[1]	85	9	5	5	0	5	109
	PFAS, Definitive[2]	24	3	2	2	0	2	33
	pH, TOC	9	1	1	1	0	0	12
	Grain Size	9	1	1	1	0	0	12
Decontamination Water	PFAS, Definitive[2]	3	0	0	0	0	0	0

Notes:
1.) Screening samples will be collected per ASTM D8421 method and may be analyzed for a shortlist of PFAS analytes, as specified in **Worksheet #15**.
2.) Definitive samples will be collected per USEPA 1633 method.
3.) ERBs apply only if use of non-dedicated sampling equipment is necessary. ERBs for solid matrices are aqueous samples.

ERB = equipment rinsate blank
PFAS = per- and polyfluoroalkyl substances
TOC = total organic carbon

Measurement Performance Criteria Table — Field Quality Control Samples				
QC Sample	**Analytical Group**	**Frequency**	**Data Quality Indicators**	**MPC**
Matrix: Aqueous (Groundwater/ Surface Water/ Porewater/ Potable Wells)				
Field Duplicate	PFAS	One per 10 field samples	Precision	Values > 5X LOQ: RPD must be ≤ 30% Values ≤ 5X LOQ: Absolute difference ≤ 2x the LOQ
Matrix Spike/Matrix Spike Duplicate[5]	PFAS	One per 20 field samples[1]	Bias/Accuracy/Precision (lab)	RPD ≤ 30%; Refer to **Worksheet #28** for recovery criteria
Equipment Rinsate Blank	PFAS	One per 20 field samples per type of reusable equipment used[2]	Accuracy/ Bias	No target analytes ≥ ½ LOQ, unless target analytes in field samples are > 10x those in rinsate blank. Laboratory-certified PFAS-free water will be used to collect ERBs.
Field Reagent Blank	PFAS	One per sampling event[3]	Accuracy/ Bias	No target analytes ≥ ½ LOQ, unless target analytes in field samples are > 10x those in rinsate blank
Cooler Temperature Blank	PFAS	One per cooler	Representativeness	Temperature must be above freezing and ≤ 6 °C
Confirmation sample	PFAS	10% of screening-level samples analyzed by USEPA Method 1633	Representativeness/ Field Decision Quality	Percent Decision Match >90%
Matrix: Solid (Soil and Sediment)				
Field Duplicate	PFAS, TOC	One per 10 field samples	Precision	Values > 5X LOQ: RPD must be ≤ 30% Values ≤ 5X LOQ: Absolute difference ≤ 2x the LOQ
Matrix Spike/Matrix Spike Duplicate[5]	PFAS, TOC	One per 20 field samples[1]	Bias/Accuracy/Precision (lab)	RPD ≤ 30%; Refer to **Worksheet #28** for recovery criteria
Field Reagent Blank	PFAS	One per sampling event[3]	Accuracy/ Bias	No target analytes ≥ ½ LOQ, unless target analytes in field samples are > 10x those in rinsate blank
Equipment Rinsate Blank	PFAS	One per 20 field samples per type of reusable equipment used[2]	Accuracy/ Bias	No target analytes ≥ ½ LOQ, unless target analytes in field samples are > 10x those in rinsate blank

Measurement Performance Criteria Table — Field Quality Control Samples				
QC Sample	**Analytical Group**	**Frequency**	**Data Quality Indicators**	**MPC**
Cooler Temperature Blank	PFAS	One per cooler	Representativeness	Temperature must be above freezing and ≤ 6 °C
Confirmation sample	PFAS	10% of screening-level samples analyzed by USEPA Method 1633	Representativeness/ Field Decision Quality	Percent Decision Match >90%

Notes:
1.) Analyzed more frequently than one per twenty samples or per sample delivery group.
2.) Only for re-usable equipment, not for disposable equipment/ supplies.
3.) Regardless of matrix.
4.) Field Reagent Blank – An aliquot of reagent water that is placed in a sample container in the laboratory and treated as a sample in all respects, including shipment to the sampling site, exposure to sampling site conditions, storage, preservation, and analytical procedures. The purpose of the FRB is to determine if method analytes or other interferences are present in the field environment.
5) MS/MSD samples are not required for the ASTM D8421 samples analyses, as per the laboratory specification included in **Appendix C**.

> = greater than
≥ = greater than or equal to
≤ = less than or equal to
% = percent
°C = degrees Celsius
ERB = equipment rinsate blank
LOQ = limit of quantitation
MPC = measurement performance criteria
PFAS = per- and polyfluoroalkyl substances
QC = quality control
RPD = relative percent difference

Worksheet #21: Field Standard Operating Procedures

A summary of SOPs is provided in the table below which can be found in **Appendix D**. The JV partner firms will follow their respective SOPs as noted in the table below. Field staff will be trained through internal PFAS sampling training prior to performing any sampling activities.

Reference Number	Title, Revision Date, and/or Number	Originating Organization	Modified for Project Work?	Comments
3-01	*Utility Clearance*	AECOM	Y	Modified for programmatic details
3-02	*Logbooks*	AECOM	Y	Modified for PFAS sampling and programmatic details
3-03	*Recordkeeping, Sample Labeling and Chain of Custody*	AECOM	Y	Modified for PFAS sampling and programmatic details
3-04	*Sample Handling, Storage, and Shipping*	AECOM	Y	Modified for PFAS sampling and programmatic details
3-05	*Investigation-Derived Waste Management*	AECOM	Y	Modified for programmatic details
3-06	*Equipment Decontamination*	AECOM	Y	Modified for PFAS sampling and programmatic details
3-07	*Land Surveying*	AECOM	Y	Modified for programmatic details
3-12	*Monitoring Well Installation*	AECOM	Y	Modified for PFAS sampling and programmatic details
3-13	*Monitoring Well Development*	AECOM	Y	Modified for PFAS sampling and programmatic details
3-14	*Monitoring Well Sampling*	AECOM	Y	Modified for PFAS sampling and programmatic details
3-15	*Monitoring Well Abandonment*	AECOM	Y	Modified for programmatic details
3-16	*Soil and Rock Classification*	AECOM	Y	Modified for programmatic details
3-17	*Direct Push Sampling Techniques*	AECOM	Y	Modified for PFAS sampling and programmatic details
3-20	*Operation and Calibration of Photoionization Detector*	AECOM	Y	Modified for programmatic details
3-21	*Surface and Subsurface Soil Sampling Procedures*	AECOM	Y	Modified for PFAS sampling and programmatic details
3-24	*Water Quality Parameter Testing for Groundwater Sampling*	AECOM	Y	Modified for PFAS sampling and programmatic details

Reference Number	Title, Revision Date, and/or Number	Originating Organization	Modified for Project Work?	Comments
3-37	*Grab Groundwater Sampling Techniques*	AECOM	Y	Modified for PFAS sampling and programmatic details
3-41	*Per- and Polyfluoroalkyl Substance Field Sampling Protocol*	AECOM	Y	Modified for PFAS sampling and programmatic details

Notes:
PFAS = per- and polyfluoroalkyl substances
Y = yes

Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection

Worksheet #22 addresses procedures for calibrating, maintaining, testing, and/or inspecting field equipment (e.g., tools, pumps, gauges, pH meters, water-level measurement devices). **Equipment that will come into contact with sample media will be evaluated for PFAS-containing components prior to use.**

Field Equipment	Calibration Activity	Maintenance Activity	SOP Reference	Testing Activity	Inspection Activity	Title or Position of Responsible Person	Frequency	Calibration Acceptance Criteria	Corrective Action
Water Quality Meter (i.e., YSI®, Horiba, or equivalent) (pH, ORP, DO, conductivity, temperature, turbidity)	Calibrate with standard solutions	Per page 8 of SOP 3-24	SOP 3-24	Operational equipment check and calibration	Visually inspect for cleanliness and obvious defects (broken/missing parts)	Field Technician Lead	Prior to use	pH: ± 0.01 pH units Conductivity: ± 0.01 µS/cm Turbidity: ± 0.01 NTU DO: ± 0.01 mg/L Temperature: ± 0.01 °C	Minor: Repair Major: Replace instrument
MiniRAE 2000 (PID)	Calibrate with fresh air and isobutylene calibration gas	Per page 4 of SOP 3-20	SOP 3-20	Operational equipment check and calibration	Visually inspect for cleanliness and obvious defects (broken/missing parts)	Field Technician Lead	Prior to use	0-99 ppm ± 0.1 ppm 100-1,999 ppm ± 1.0 ppm 2000-10,000 ppm ± 10 ppm	Minor: Repair Major: Replace instrument
QED MP10 Controller (Bladder Pump Controller Box)	NA	NA	SOP 3-14	Operational equipment check	Visually inspect for cleanliness and obvious defects (broken/missing parts)	Field Technician Lead	Prior to use	NA	Minor: Repair Major: Replace instrument
QED SamplePro (Stainless Steel Submersible Bladder Pump)	NA	Per page 7 of SOP 3-14	SOP 3-14	Operational equipment check	Visually inspect for cleanliness and obvious defects (broken/missing parts)	Field Technician Lead	Prior to use	NA	Minor: Repair Major: Replace instrument

Field Equipment	Calibration Activity	Maintenance Activity	SOP Reference	Testing Activity	Inspection Activity	Title or Position of Responsible Person	Frequency	Calibration Acceptance Criteria	Corrective Action
Solinst 101 (Water Level Meter)	NA	Per page 5 of SOP 3-14	SOP 3-14	Operational equipment check	Visually inspect for cleanliness and obvious defects (broken/missing parts)	Field Technician Lead	Prior to use	NA	Minor: Repair Major: Replace instrument
Geotech GeoPump (Peristaltic Pump)	NA	NA	SOP 3-14	Operational equipment check	Visually inspect for cleanliness and obvious defects (broken/missing parts)	Field Technician Lead	Prior to use	NA	Minor: Repair Major: Replace instrument
Well Development Equipment (Surge Block, Bailer, Electric Submersible Pump, Waterra® System)	NA	NA	SOP 3-13	Operational equipment check	Visually inspect for cleanliness and obvious defects (broken/missing parts)	Field Technician Lead	Prior to use	NA	Minor: Repair Major: Replace instrument

Notes:
°C = degrees Celsius
DO = dissolved oxygen
mg/L = milligrams per liter
NA = not applicable
NTU = nephelometric turbidity unit
ORP = oxidation-reduction potential
PFAS = per- and polyfluoroalkyl substances
PID = photoionization detector
ppm = parts per million
SOP = standard operating procedure
µS/cm = micro Siemens per centimeter

Worksheet #23: Analytical Standard Operating Procedures

Lab SOP Number	Title, Revision Date, and / or Number	Definitive or Screening Data[1]	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
WI72427	Aqueous PFAS Prep by SPE and Analysis by LC-MS-MS by EPA 1633/QSM 6.0 Table B-24, Ver 1, Eff 25-Jun-2024, Rev. 1, 06-25-24	Definitive	Aqueous/PFAS	LC/MS/MS	Eurofins	N
WI72428	Solid PFAS Prep by Sonication and Analysis by LC-MS-MS by EPA 1633/QSM 6.0 Table B-24, Rev. 1, 06-25-24	Definitive	Solid/PFAS	LC/MS/MS	Eurofins	N
WI21568	Environmental Monitoring in the PFAS Lab, Rev. 8, 03-06-24	N/A	N/A	LC/MS/MS	Eurofins	N
WI23588	Preventative and Corrective Maintenance for the AB Sciex Liquid Chromatograph Mass Spectrometers (LC/MS/MS), Rev. 5, 06/18/24	N/A	Maintenance	LC/MS/MS	Eurofins	N
WI11627	TOC and TC in Solids and Sludges by Combustion by SW-846 9060/9060A, Lloyd Kahn, Rev. 20, 03/12/24	Definitive	TOC	TOC Analyzer	Eurofins	N
WI11518	pH by EPA 9045C, 9045D and Corrosivity by SW-846 Chap 7 of Solids, Soils, and Solvents using Electrometric Methods, Rev. 15, 11/15/23	Definitive	pH	pH meter	Eurofins	N
WI11514	Particle Size Distribution of Soils and Solids/Grain Size Classification by ASTM D-422-63, Rev 10, 01/24/19	Definitive	Grain Size	Hydrometer	Eurofins	N
ENV-SOP-WCOL-0158	PFAS by Method 1633, Rev. 4, 04/19/24	Definitive	Water/PFAS Solid/PFAS	LC/MS/MS	Pace South Carolina	N
ENV-SOP-WCOL-0164	PFAS by D8421-ID, Rev. 2, 07/23/23	Screening	PFAS	Sciex 5500 Triple Quad LC/MS/MS	Pace South Carolina	N
ENV-SOP-WCOL-0149	Total Organic Carbon (TOC) Walkley-Black, Rev.3, 04/18/24	Definitive	Solid/TOC	NDIR	Pace South Carolina	N
ENV-SOP-WCOL-0138	pH by Electrometric Measurement / pH Paper Method SM4500-H B-2011 / 9040C / 150.1 / 9041A / 9045D, Rev.3, 06/16/23	Definitive	Inorganic Non-Metals – Aqueous/Solid	Meter	Pace South Carolina	N

Lab SOP Number	Title, Revision Date, and / or Number	Definitive or Screening Data[1]	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
Grain Size Determined by Sedimentation Analysis	Grain Size Determined by Sedimentation Analysis (Hydrometer), 01/21/22	Definitive	Solid/Grain Size	Hydrometer	Pace South Carolina (sub)	N

Notes:

1.) Definitive or screening data are defined per the Part 2B, Quality Assurance/Quality Control Compendium: Minimum QA/QC Activities (IDQTF, 2005c):
Screening data can support an intermediate or preliminary decision but should eventually be supported by definitive data before a project is complete.
Definitive data should be suitable for final decision-making (of the appropriate level of precision and accuracy, as well as legally defensible).

Eff = effective
EPA = Environmental Protection Agency
LC/MS/MS = liquid chromatography tandem mass spectrometry
N = no
N/A = not applicable
NDIR = Nondispersive infrared
PFAS = per- and polyfluoroalkyl substances
QSM = Quality System Manual
Rev = revision
SOP = standard operating procedure
SPE = solid phase extraction
TC = total carbon
TOC = total organic carbon

Worksheet #24: Analytical Instrument Calibrations

Instrument/ Equipment	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person(s) Responsible	SOP Reference
LC/MS/MS	Mass Calibration	Instrument must have a valid mass calibration prior to any sample analysis. Mass calibration is verified after each mass calibration, prior to ICAL.	Calibrate the mass scale of the MS with calibration compounds and procedures described by the manufacturer. Mass calibration range must bracket the ion masses of interest. The most recent mass calibration must be used for every acquisition in an analytical run. Mass calibration must be verified to be ± 0.5 amu of the true value, by acquiring a full scan continuum mass spectrum of a PFAS stock standard.	If the mass calibration fails, then recalibrate. If it fails again, consult manufacturer instructions on corrective maintenance.	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158
LC/MS/MS	Mass Spectral Acquisition Rate	Each analyte, EIS Analyte.	A minimum of 10 spectra scans are acquired across each chromatographic peak.	NA	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158

Instrument/ Equipment	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person(s) Responsible	SOP Reference
LC/MS/MS	CCV and Spiking Standards	All analytes.	Standards containing both branched and linear isomers must be used when commercially available. PFAS method analytes may consist of both branched and linear isomers, but quantitative standard that contain the linear and branched isomers do not exist for all method analytes. For PFAS that do not have a quantitative branched and linear standard, identify the branched isomers by analyzing a qualitative standard that includes both linear and branched isomers and determine RTs, transitions, and transition ion ratios. Quantitate samples by integrating the total response (i.e., accounting for peaks that are identified as linear and branched isomers) and relying on the initial calibration that uses the linear isomer quantitative standard.	NA	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158
LC/MS/MS	Bile Salt Interference Check	After an initial calibration and during each analytical sequence	The RT of the bile salts in the standard in Section 7.5 must fall at least one minute outside the RT window for any of the linear or branched PFOS isomers	NA	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158
LC/MS/MS	Non-Extracted Internal Standard	All calibration standards, batch QC, and field samples	The NIS areas in the field samples and QC samples must be within 50 to 200% of the mean area of the corresponding NIS in the most recent initial calibration	Reanalysis. If the areas are low for all the field samples and QC samples in the batch, it suggests a loss of instrument sensitivity, while low areas in only some field or QC samples suggests a possible bad injection.	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158

Instrument/ Equipment	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person(s) Responsible	SOP Reference
LC/MS/MS	Sample PFAS Identification	All analytes detected in a sample.	The chemical derivation of the ion transitions must be documented. A minimum of two ion transitions (Precursor → quant ion and precursor → confirmation ion) and the ion transitions ration per analyte are required for confirmation. Exception is made for analytes where two transitions do not exist (PFBA and PFPeA). Documentation of the primary and confirmation transitions and the ion ratio is required. In-house acceptance criteria for evaluation of ion ratios must be used and must not exceed 50-150%. Signal to Noise Ratio (S/N) must be ≥ 10 for all ions used for quantification and must be ≥ 3 for all ions sued for confirmation. Quant ion and confirmation ion must be present and must maximize simultaneously (± 2 seconds). For all positive results, the Ion Abundance Ratio (IAR) must fall within ±50% of the IAR observed in the mid-point of the initial calibration standard (or if below the LOQ, ±50% of the initial calibration verification)	NA	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158

Instrument/ Equipment	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person(s) Responsible	SOP Reference
LC/MS/MS	Ion Transitions (Precursor → Product)	Every field sample, standard, blank, and QC sample.	In order to avoid biasing results high due to known interferences for some transitions, the following transitions must be used for the quantification of the following analytes: PFOA: 413 → 369 PFOS: 499 → 80 PFHxS: 399 → 80 PFBS: 299 → 80 4:2 FTS: 327 → 307 6:2 FTS: 427 → 407 8:2 FTS: 527 → 507 NEtFOSAA: 584 → 419 NMeFOSAA: 570 → 419 If these transitions are not used, the reason must be technically justified and documented (e.g., alternate transition was used due to observed interferences).	NA	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158

Instrument/ Equipment	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person(s) Responsible	SOP Reference
LC/MS/MS	Ion Ratio	Every field sample, standard, blank, and QC sample.	For concentrations at or above the LOQ, the ion abundance ratio must fall within ±50% of the ion abundance ratio observed in the mid-point initial calibration standard. For sample concentrations below the LOQ, the ion abundance ratio must fall within ±50% of the ion abundance ratio observed in either the mid-point initial calibration standard or the initial calibration verification. The total response of all isomers (branched and linear) in the quantitative standards must be used to define the ion abundance ratio (EPA 1633 Section 15.1.3)	Ratio requirement does not apply to PFBA, PFPeA, NMeFOSE, NEtFOSE, PFMPA, and PFMBA because suitable secondary transitions are not available Typical Ion Ratios are identified in Table 10 of Method 1633 Apply "I" flag to data with ion ratio outside criteria.	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158

Instrument/ Equipment	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person(s) Responsible	SOP Reference
LC/MS/MS	ICAL	At instrument set-up and after ICV or CCV failure, prior to sample analysis.	The isotopically labeled analog of an analyte (EIS Analyte) must be used for quantitation if commercially available. (Isotope Dilution Quantitation). Commercial PFAS standards available as salts are acceptable providing the measured mass is corrected to the neutral acid concentration. Results shall be reported as the neutral acid with appropriate CAS number. If a labeled analog is not commercially available, the Extracted Internal Standard Analyte with the closest (RT or chemical similarity to the analyte must be used for quantitation. (Internal Standard Quantitation). Analytes must be within 70-130% of their true value for each calibration. ICAL must meet one of the two options below: Option1: The RSD of the RFs for all analytes must be ≤ 20%. Option 2: Linear or non-linear calibrations must have $r^2 \geq 0.99$ for each analyte.	Correct problem, then repeat ICAL.	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158
LC/MS/MS	RT window position establishment	Once per ICAL and at the beginning of the analytical sequence.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	NA	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158

Instrument/ Equipment	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person(s) Responsible	SOP Reference
LC/MS/MS	RT window width	Every field sample, standard, blank, and QC sample.	RT of each analyte and EIS analyte must fall within 0.4 minutes of the predicted RTs from the daily calibration verification or, on days when ICAL is performed, from the midpoint standard of the ICAL. Analytes must elute within 0.1 minutes of the associated EIS. This criterion applies only to analyte and labeled analog pairs.	Correct problem and reanalyze samples.	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158
LC/MS/MS	ISC	Prior to analysis	Analyte concentrations must be at LOQ; concentrations must be within ± 30% of their true value. S/N must be greater than 3:1 Ion Abundance Ratio (IAR) must fall within ±50% of the IAR observed in the mid-point of the initial calibration standard	Correct problem, rerun ISC. If problem persists, repeat ICAL.	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158
LC/MS/MS	ICV	Once after each ICAL, analysis of a second source standard prior to sample analysis.	All analyte concentrations must be within ± 30% of their true value.	Correct problem, rerun ICV. If problem persists, repeat ICAL.	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158

Instrument/ Equipment	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person(s) Responsible	SOP Reference
LC/MS/MS	Instrument Blank	At the beginning of the analytical sequence and after the analysis of high concentration samples and standards (e.g., customer samples, highest calibration standard, calibration verification standard).	No analytes detected > ½ the LOQ	If acceptance criteria are not met after the highest calibration standard, calibration shall be performed using a lower concentration for the highest standard until acceptance criteria is met. If field sample analyte concentrations exceed the highest calibration standard and the same analytes in the following field sample or in consecutive following field samples also exceed the IB acceptance criteria (i.e., > ½ LOQ), the affected samples shall be reanalyzed using a fresh aliquot of the sample extract. If the extract cannot be reanalyzed and re-extraction is not possible, apply qualifier to affected results and explain in the case narrative.	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158
LC/MS/MS	CCV	Prior to sample analysis, after every 10 field samples, and at the end of the analytical sequence.	Concentration of analytes must range from the LOQ to the mid-level calibration concentration. Analyte concentrations must be within ± 30% of their true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, or if two consecutive CCV's cannot be run, perform corrective action(s) and repeat CCV and all associated samples since last successful CCV. Alternatively, recalibrate if necessary; then reanalyze all associated samples since the last acceptable CCV.	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158

Instrument/ Equipment	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person(s) Responsible	SOP Reference
LC/MS/MS	Tune check	Daily, prior to sample analysis, only once per analytical batch. No time constraints.	Manufacturer recommended criteria which includes delta and FWHM tolerance checks of 6 m/z's over the spectrum of the detector.	Retune instrument and repeat check tune. Maintenance may be required.	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158
LC/MS/MS	LOD/LOQ verification	Quarterly	LOD meets method qualitative requirements or is at least 3x higher than noise; LOQ is recovered within LCS criteria.	Perform instrument maintenance and repeat failed LOD or LOQ study passing two consecutive tests or perform new DL study.	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158
TOC Analyzer: TOC (9060A; 5310B)	Initial calibration with a minimum 4 points	Monthly or after continuing calibration fails	r^2 ≥0.995	Perform more aggressive instrument maintenance and recalibrate	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158
TOC Analyzer: TOC (9060A; 5310B)	ICB Standard	After each initial calibration	No analytes detected > LOQ	Perform more aggressive instrument maintenance and recalibrate	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158
TOC Analyzer: TOC (9060A; 5310B)	ICV Standard	After each initial calibration	Within +/- 10% of the nominal concentration	Reanalyze the ICV. If ICV fails again do system maintenance and recalibrate.	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158
TOC Analyzer: TOC (9060A; 5310B)	MDL Standard	Yearly	All compounds must be detected	Repeat ICAL procedure prior to analyzing samples. Repeat maintenance if needed.	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158
TOC Analyzer: TOC (9060A; 5310B)	CCV Standard	If instrument is idle > 4 hours, after every 10 field samples, and at the end of the sequence	Within +/- 10% of the nominal concentration	All affected samples are reanalyzed	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158

Instrument/ Equipment	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person(s) Responsible	SOP Reference
TOC Analyzer: TOC (9060A; 5310B)	CCB Standard	If instrument is idle > 4 hours, after every 10 field samples, and at the end of the sequence	All affected samples are reanalyzed	All affected samples are reanalyzed	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158
pH solid	3-point calibration	Each new run and continuing calibration per 10 samples	Independent and continuing calibration verification CCV within ±10%. CCB < RL.	Recalibrate, perform instrument maintenance if calibration cannot conform to criteria, recalibrate	Analyst, Supervisor, QA Manager	Eurofins: W172427, WI72428 PSC: ENV-SOP-WCOL-0158
LC/MS/MS	Mass Calibration	Instrument must have a valid mass calibration prior to any sample analysis. Mass calibration is verified after each mass calibration, prior to ICAL.	Calibrate the mass scale of the MS with calibration compounds and procedures described by the manufacturer. Mass calibration range must bracket the ion masses of interest. The most recent mass calibration must be used for every acquisition in an analytical run. Mass calibration must be verified to be ±0.5 amu of the true value, by acquiring a full scan continuum mass spectrum of a PFAS stock standard.	If the mass calibration fails, then recalibrate. If it fails again, consult manufacturer instructions on corrective maintenance.	Analyst, Supervisor, QA Manager	PSC: ENV-SOP-WCOL-0164[1]

Instrument/ Equipment	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person(s) Responsible	SOP Reference
LC/MS/MS	Calibration, CCV, and Spiking Standards	All analytes. Note: Standards containing both branched and linear isomers are to be used during method validation and when reestablishing RTs, to ensure the total response is quantitated for that analyte. Technical grade standards cannot be used for quantitative analysis.	PFAS method analytes may consist of both branched and linear isomers, but quantitative standards that contain the linear and branched isomers do not exist for all method analytes. For PFAS that do not have a quantitative branched and linear standard, identify the branched isomers by analyzing a qualitative standard that includes both linear and branched isomers and determine RT, transitions and transition ion ratios. Quantitate samples by integrating the total response (i.e., accounting for peaks that are identified as linear and branched isomers) and relying on the initial calibration that uses the linear isomer quantitative standard.	NA	Analyst, supervisor	PSC: ENV-SOP-WCOL-0164[1]
LC/MS/MS	Mass Spectral Acquisition Rate	Each analyte, EIS analyte.	A minimum of 10 spectra scans should be acquired across each chromatographic peak.	NA	Analyst, supervisor	PSC: ENV-SOP-WCOL-0164[1]
LC/MS/MS	ICAL; Calibration can be linear (minimum of 5 standards); weighting is allowed.	Prior to sample analysis: at instrument set-up and after major maintenance and/or ICV or CCV failure.	ICAL must meet one of the two options below: Option 1: The %RSD of the RFs for all analytes must be ≤20%. Option 2: Linear or non-linear calibrations must have r2 ≤0.99 for all compounds. The isotopically labeled analog of an analyte (EIS Analyte) must be used for quantitation if commercially available (Isotope Dilution Quantitation).	Perform maintenance, if necessary, and repeat calibration if criterion is not met. No samples shall be analyzed until ICAL has passed.	Analyst, supervisor	PSC: ENV-SOP-WCOL-0164[1]

Instrument/ Equipment	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person(s) Responsible	SOP Reference
LC/MS/MS	Instrument blank (IBLK)	Immediately following the highest standard analyzed during ICAL and daily, prior to sample analysis.	Concentration of each analyte must be ≤½ the LOQ. Instrument Blank must contain EIS to enable quantitation of contamination.	If acceptance criteria are not met after the highest calibration standard, calibration must be performed using a lower concentration for the highest standard until acceptance criteria is met.	Analyst, supervisor	PSC: ENV-SOP-WCOL-0164[1]
LC/MS/MS	ICV	Only required if ICAL is not prepared using a Certified Reference Standard.	Analyte concentrations must be within ± 30% of their true value.	Correct problem and verify second source standard; rerun second source verification. If that fails, correct problem and repeat ICAL.	Analyst, supervisor	PSC: ENV-SOP-WCOL-0164[1]
LC/MS/MS	CCV	An opening CCV at the LOQ on days when the ICAL is not analyzed and a CCV the end of each batch of 20 or fewer field samples.	All analytes recovered within ±30% of the expected concentration for mid-level CCVs and ±50% for the LOQ level-CCV.	Correct the problem, reanalyze the CCV. If the problem persists, repeat the ICAL. Reprepare and reanalyze all samples associated with the failing CCV.	Analyst, supervisor	PSC: ENV-SOP-WCOL-0164[1]

Notes:

1) Modifications to the acceptance criteria and corrective actions are applied as per the ASTM D8421 laboratory specification that has been developed for this work. Full specification details are provided in **Appendix C**.

> = greater than
< = less than
≥ = greater than or equal to
≤ = less than or equal to
% = percent
amu = atomic mass unit
CCB = continuing calibration blank
CCV = continuing calibration verification
DL = detection limit
EIS = extracted internal standard
ESI-L = Environmental Standards International – Low Concentration Tuning Mix
FTS = fluorotelomer sulfonic acid
IAR = Ion Abundance Ratio
IB = instrument blank
ICAL = initial calibration
ICB= Initial Calibration Blank
ICV = initial calibration verification
ISC = instrument sensitivity check
LC/MS/MS = liquid chromatography tandem mass spectrometry
LOD = limit of detection
LOQ = limit of quantitation
MDL= Method Detection Limit
m/z = mass-to-change ratio
NA = not applicable
N-Et-FOSE = N-ethyl perfluorooctanesulfonamidoethanol
N-Me-FOSE = N-methyl perfluorooctanesulfonamidoethanol
PFAS = per- and polyfluoroalkyl substances
PFOA = perfluorooctanoic acid
PFOS = perfluorooctanesulfonic acid
PFHxS = perfluorohexanesulfonic acid
PFBS = perfluorobutanesulfonic acid
PFMBA = perfluoro-4-methoxybutanoic acid
PFMPA = perfluoro-3-methoxypropanoic acid
PFPeA = perfluoropentanoic acid
PSC = Pace South Carolina
QA = quality assurance
QC = quality control
RF = response factor
RSD = relative standard deviation
RT = retention time
S/N = signal to noise ratio
SOP = standard operating procedure
TBD = to be determined
TOC = total organic carbon

Worksheet #25: Analytical Instrument and Equipment Maintenance, Testing, and Inspection

Laboratory: Eurofins Lancaster Laboratories

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
LC/MS/MS	Backflush of column, injection port and pre-columns, cleaning of ion spray cone, adjustment of collision energies, others as needed	Calibration Check	Visual	As Needed	Initial calibration or calibration verification passes method specifications	Perform additional maintenance prior to instrument calibration or calibration verification	Analysts	WI72427 WI72428
TOC Analyzer	Change injection needle, change catalyst	TOC	Monitor instrument performance via CCV	As needed or replace as necessary, loss of sensitivity or failing resolutions, erratic response	No maintenance is required as long as instrument QC meets criteria	Perform instrument maintenance, clean injection needle, change catalyst	Analyst, Supervisor, QA Manager	WI11627
Orion 720 pH Meter	Check electrode	pH	Flush and refill electrode; clean electrode with methanol	As needed	No instrument error message	Clean or replace as necessary	Analyst, Supervisor QA Manager	WI11518

Notes:

CCV = continuing calibration verification
LC/MS/MS = liquid chromatography tandem mass spectrometry
QC = quality control
QA = quality assurance
SOP = standard operating procedure
TOC = total organic carbon

Laboratory: Pace South Carolina

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
LC/MS/MS	Check column pressure and mobile phase levels/expirations daily. Perform the following as needed: prepare aqueous mobile phase, clean/replace injection needle, replace guard cartridge, backflush/replace column, replace injector seat, clean curtain/orifice plate, retune MS.	PFAS	Inspect all tubing connections at time of maintenance to assure no leaks present. Monitor instrument performance via calibrations, CCVs, and blanks.	Initially, after major maintenance, CCV not meeting 2X	Same as initial calibration and CCV	Same as initial calibration and CCV	Analyst/ Supervisor	ENV-SOP-WCOL-0158
pH Meter	Daily Calibration	pH	initial/continuing calibration/blank	daily	10%	recalibrate	Group Leader	ENV-SOP-WCOL-0138
TOC Analyzer	Change injection needle, change catalyst	TOC	Monitor instrument performance via CCV	As needed or replace as necessary, loss of sensitivity or failing resolutions, erratic response	No maintenance is required as long as instrument QC meets criteria	Perform instrument maintenance, clean injection needle, change catalyst	Analyst, Supervisor, QA Manager	ENV-SOP-WCOL-0149
LC/MS/MS	Check column pressure and mobile phase levels/ expirations daily. Perform the following as needed: prepare aqueous mobile phase, clean/replace injection needle, replace guard cartridge, backflush/replace column, replace injector seat, clean curtain/orifice plate, retune MS.	PFAS	Inspect all tubing connections at time of maintenance to assure no leaks present. Monitor instrument performance via calibrations, CCVs, and blanks.	Initially, after major maintenance, CCV not meeting 2X.	Same as initial calibration and continuing calibration verification	Same as initial calibration and CCV	Analyst/ Supervisor	ENV-SOP-WCOL-0164

Notes:
% = percent
CCV = continuing calibration verification
ESI = electrospray ionization
LC/MS/MS = liquid chromatography tandem mass spectrometry
NA = not applicable
PFAS= per- and polyfluoroalkyl substances
QC = quality control
SOP = standard operating procedure
TOC = total organic carbon

Worksheets #26 & #27: Sample Handling, Custody, and Disposal

Sampling Organization: A2P JV
Laboratory: Various (see below)
Method of sample delivery (shipper/carrier): FedEx
Number of days from reporting until sample disposal: 60 Days

Activity	Organization and title or position of person responsible for the activity	SOP reference
Sample labeling	A2P JV	*SOP 3-03 Recordkeeping, Sample Labeling, and Chain of Custody*
CoC form completion	A2P JV	
Packaging	A2P JV	*SOP 3-04 Sample Handling, Storage, and Shipping*
Shipping coordination	A2P JV	
Sample receipt, inspection, and log-in	Eurofins Lancaster Laboratories Sample Custodian	S-SA-WI10725: Environmental Sample Receipt and Unpacking
Sample custody and storage	Eurofins Lancaster Laboratories Sample Custodian	S-SS-WI12042: Automated Storage Retrieval and Discarding of Samples
Sample disposal	Eurofins Lancaster Laboratories Sample Custodian	S-SS-WI12042: Automated Storage Retrieval and Discarding of Samples
Sample receipt, inspection, and log-in	Pace South Carolina Sample Custodian	SAD-001: Sample Receiving and Laboratory Information Management System Log-In
Sample custody and storage	Pace South Carolina Sample Custodian	SAD-002: Sample Chain of Custody and Sample Integrity
Sample disposal	Pace South Carolina Sample Custodian	GEN-009: Waste Collection, Storage, Disposal

Notes:
A2P JV = AECOM Arcadis PFAS Joint Venture
CoC = chain of custody
SOP = standard operating procedure

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Worksheet #28: Analytical Quality Control and Corrective Actions

Worksheet #28 includes laboratory preparation information as per USEPA Method 1633 and DoD QSM B-24. Requirements will be updated when new requirements are promulgated and laboratories will update to the appropriate certified method when applicable. QC requirements will be consistent between laboratories.

Matrix: Solid & Aqueous
Analytical Group: PFAS by QSM 5.4
Analytical Method: PFAS by LC/MS/MS compliant with USEPA Method 1633
Certification Status: DoD ELAP/NELAP Certification

QC Sample	Frequency/Number	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible	Data Quality Indicator
EIS Analytes	Every field sample, standard, blank, and QC sample	Isotopically labeled analogs of analytes shall be used when they are commercially available. As per Table 6 and Table 8 of Method 1633 Where Method 1633 does not provide EIS recovery acceptance criteria for the sample matrix under evaluation, a laboratory shall use laboratory-developed recovery acceptance criteria no wider than any acceptance criteria provided by the customer. Preliminary laboratory-developed acceptance criteria of 20-150% shall be used until laboratory acceptance criteria are developed in accordance with Method 1633. Where Method 1633 does not provide EIS recovery acceptance criteria for the sample matrix under evaluation, the lower limit of the laboratory-developed acceptance criteria cannot be < 20%.	For all PFAS compounds if EIS recovery is <50%, check for laboratory error and correct if identified. If no laboratory error is identified, additional corrective action will be performed if EIS recovery is <10%. If EIS recovery is >10% and samples have detections above the reporting limit, no additional corrective action is performed. If EIS recovery is >10% and samples have no detections for associated native analytes, the native analyte response will be evaluated to confirm the validity of the reporting limit. Reporting limits will be proportionately increased as necessary and appropriate to ensure that reported values accurately reflect the sensitivity of the analysis. For all PFAS compounds, if EIS recovery is >150%, check for laboratory error and correct if identified. If no laboratory error is identified, additional corrective action will be performed only when field samples have detections above the reporting limits for the associated native target analytes and EIS recovery is >200%. If persistent matrix effects are observed for multiple samples from a given project that necessitate a high rate of additional corrective actions, these matrix effects will be mitigated prior to sample preparation and analysis, typically by processing a smaller sample mass or volume.	Analyst, Supervisor, QA Manager	Accuracy/Bias

QC Sample	Frequency/Number	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible	Data Quality Indicator
MB	One per preparatory batch	No analytes detected > 1/2 LOQ	Correct problem. If required, re-extract and reanalyze MB and all QC samples and field samples processed with the contamination blank. If the samples cannot be reprepared and analyzed, apply qualifier to affected analyte results of all samples in the associated preparatory batch and explain in the case narrative.	Analyst, Supervisor, QA Manager	Bias/Contamination
LCS and Low-Level Laboratory Control Sample (LLLCS)	One set per preparatory batch. Shall contain all EIS, NIS, and all analytes to be reported. These are equivalent to 1633 Ongoing Precision and Recovery Standard (OPR) and Low-Level OPR	Preliminary acceptance criteria of 40-150% shall be used until acceptance criteria are developed by the laboratory in accordance with Method 1633 Tables 5 and 7 Where Method 1633 does not provide LCS and LLLCS recovery acceptance criteria for the sample matrix under evaluation, the laboratory-developed acceptance criteria shall not be < 40%.	Correct problem. If required, reprepare and analyze the LCS and/or LLLCS and all affected QC samples and field samples in the associated preparatory batch for failed analytes if sufficient sample material is available. If the samples cannot be reprepared and analyzed, apply qualifier to affected analyte results of all samples in the associated preparatory batch and explain in the case narrative.	Analyst, Supervisor, QA Manager	Accuracy/Bias
MSD or MD	For MSD: One per preparatory batch. For MD: Each aqueous sample prepared by serial dilution instead of SPE.	For MSD: Sample spiked with all analytes at a concentration ≥ LOQ and ≤ mid-level calibration standard. Recovery limits are the same as the LCS limits. RPD ≤ 30% (between MS and MSD or sample and MD).	Examine the project specific requirements. Contact the client as to additional measures to be taken.	Analyst, Supervisor, QA Manager	Accuracy/Bias

QC Sample	Frequency/Number	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible	Data Quality Indicator
Sample PFAS Identification	All analytes detected in a sample	The chemical derivation of the ion transitions must be documented. A minimum of two ion transitions (Precursor → quant ion and precursor → confirmation ion) and the ion transitions ratio per analyte are required for confirmation. Exception is made for analytes where two transitions do not exist (PFBA and PFPeA). Documentation of the primary and confirmation transitions and the ion ratio is required. In-house acceptance criteria for evaluation of ion ratios must be used and must not exceed 50-150%. S/N must be ≥ 10 for all ions used for quantification and must be ≥ 3 for all ions used for confirmation. Quant ion and confirmation ion must be present and must maximize simultaneously (±2 seconds).	NA	Analyst, Supervisor, QA Manager	Comparability

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Notes:
> = greater than
< = less than
≥ = greater than or equal to
≤ = less than or equal to
% = percent
AAAF = aqueous film forming foam
CCV = continuing calibration verification
DoD = Department of Defense
EIS = extracted internal standards
ICAL = initial calibration
LC/MS/MS = liquid chromatography tandem mass spectrometry
LCS = laboratory control spike
LOQ = limit of quantitation
MD = matrix duplicate
MS = matrix spike
MSD = matrix spike duplicate
NA = not applicable
NELAP = National Environmental Laboratory Accreditation Program
QA = quality assurance
QC = quality control
QSM = Quality Systems Manual
PFAS = per- and polyfluoroalkyl substances
PFBA = perfluorobutanoic acid
PFPeA = perfluoropentanoic acid
RPD = relative percent difference
SOP = standard operating procedure
S/N = signal to noise ratio
SPE = solid phase extraction
USEPA = United States Environmental Protection Agency

Laboratory: Eurofins Lancaster Laboratories
Matrix: Solid & Aqueous
Analytical Group: PFAS by QSM 6.0
Analytical Method: PFAS by LC/MS/MS complaint with USEPA Method 1633
SOP Reference: W172427 & W172428
Certification Status: DoD ELAP/NELAP Certification

QC Sample	Frequency/Number	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible	Data Quality Indicator
MB	One per extraction batch of no more than 20 field samples	No analytes detected >1/2 LOQ.	Correct problem. Re-prepare and analyze MB and all QC samples and affected field samples processed with the contaminated blank if sufficient sample material is available. If the samples cannot be re-prepared and analyzed, apply qualifier to affected analyte results of all samples in the associated preparatory batch and explain in the case narrative.	Analyst	Accuracy/Lab Contamination
LLCS	One per extraction batch of no more than 20 field samples	Acceptance criteria defined in Tables 5 and 6 of Method 1633 For analytes not listed in Method 1633, the laboratory must use statistically-derived limits. The lower limit cannot be <40%. Preliminary limits of 40-150% may be used until sufficient data is available.	Correct problem. If required, re-prepare and analyze the LLCS and all affected QC samples and field samples in the associated preparatory batch for failed analytes if sufficient sample material is available. If the samples cannot be re-prepared and analyzed, apply qualifier to affected analyte results of all samples in the associated preparatory batch and explain in the case narrative.	Analyst	Accuracy/Bias/Precision

QC Sample	Frequency/Number	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible	Data Quality Indicator
Mid-Level LCS and, if needed, LCSD	One per extraction batch of no more than 20 field samples When no MS/MSD, and LCSD is required	Acceptance criteria defined in Tables 5 and 6 of Method 1633 For analytes not listed in Method 1633, the laboratory must use statistically-derived limits. The lower limit cannot be <40%. Preliminary limits of 40-150% may be used until sufficient data is available.	Correct problem. If required, re-prepare and analyze the LCS and all affected QC samples and field samples in the associated preparatory batch for failed analytes if sufficient sample material is available. If the samples cannot be re-prepared and analyzed, apply qualifier to affected analyte results of all samples in the associated preparatory batch and explain in the case narrative.	Analyst	Accuracy/Bias/Precision
MS/MSD	at client request, one set per extraction batch of no more than 20 field samples	Acceptance criteria defined in Tables 5 and 6 of Method 1633 For analytes not listed in Method 1633, the laboratory must use statistically-derived limits. The lower limit cannot be <40%. Preliminary limits of 40-150% may be used until sufficient data is available. RPD less than 30%	If outside the acceptance windows, consult a supervisor to determine the appropriate course of action based on batch and sample results.	Analyst	Accuracy/Bias/Precision
EIS or IDA, added prior to extraction	per sample (including MB, LCS, LCSD) prior to extraction	Acceptance criteria defined in Table 6 of Method 1633 For analytes not listed in Method 1633, the laboratory must use statistically-derived limits. The lower limit cannot be <20%. Preliminary limits of 20-150% may be used until sufficient data is available.	Apply qualifier to affected analyte results and explain in the case narrative.	Analyst	Accuracy

QC Sample	Frequency/Number	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible	Data Quality Indicator
NIS added following extraction and prior to analysis	per sample (including MB, LCS, LCSD) prior to extraction	NIS areas 50-200% of the area of the continuing calibration standard in undiluted sample extracts and sample extracts that require NIS to be added.	If fails high, check for errors and report. If fails low, re-analyze fresh aliquot of sample. If in control, report. If the failure confirms report the initial analysis and narrate.	Analyst	Accuracy

Notes:

\> = greater than
< = less than
≥ = greater than or equal to
≤ = less than or equal to
% = percent
AAAF = aqueous film forming foam
CCV = continuing calibration verification
DoD = Department of Defense
EIS = extracted internal standards
ICAL = initial calibration
IDA = Isotope Dilution Analyte
LC/MS/MS = liquid chromatography tandem mass spectrometry
LCS = laboratory control spike
LCSD = laboratory control spike duplicate
LLCS = low-level laboratory control spike
LOQ = limit of quantitation
MD = matrix duplicate
MS = matrix spike
MSD = matrix spike duplicate
MB = method blank
NA = not applicable
NELAP = National Environmental Laboratory Accreditation Program
NIS = non-extracted internal standards
QA = quality assurance
QC = quality control
QSM = Quality Systems Manual
RPD = relative percent difference
SOP = standard operating procedure
S/N = signal to noise ratio
USEPA = United States Environmental Protection Agency

Matrix: Solid
Analytical Group: TOC
Analytical Method: 9060 or Walkley-Black
Certification Status: DoD ELAP/NELAP Certification

QC Sample	Frequency/Number	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible	Data Quality Indicator
MB	One per digestion batch of 20 or fewer samples	≤ ½ LOQ	Reanalyze, and/or stop the run and determine the source of contamination, or document why the data are acceptable.	Analyst, Supervisor, QA Manager	Bias/ Contamination
LCS or BS	One for each batch of up to 20 samples	Laboratory-specific limits	Evaluate and reanalyze if possible. If LCS recoveries are high but the sample results are < LOQ, narrate. Otherwise, re-prepare and reanalyze.	Analyst, Supervisor, QA Manager	Accuracy/Bias
MS/MSD	10% of matrix	Laboratory-specific limits	Determine and correct the problem, reanalyze samples and MS/MSD, or document why data are acceptable	Analyst, Supervisor, QA Manager	Accuracy/Bias

Notes:
< = less than
≤ = less than or equal to
% = percent
BS = blank spike
DoD = Department of Defense
ELAP = Environmental Laboratory Accreditation Program
LCS = laboratory control spike
LOQ = limit of quantitation
MB = method blank
MS/MSD = matrix spike/matrix spike duplicate
NELAP = National Environmental Laboratory Accreditation Program
QA = quality assurance
QC = quality control
RPD = relative percent difference
TOC = total organic carbon

Matrix: Solid
Analytical Group: pH
Analytical Method: 9045D/SM4500
Certification Status: DoD ELAP/NELAP Certification

QC Sample	Frequency/Number	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible	Data Quality Indicator
Sample Dup	One per preparation batch of 20 samples of similar matrix	Within 0.1 pH su	Determine and correct cause of the poor reproducibility	Analyst, Department Manager	Bias/ Contamination

Notes:
DoD = Department of Defense
Dup = duplicate
ELAP = Environmental Laboratory Accreditation Program
NELAP = National Environmental Laboratory Accreditation Program
QC = quality control

Laboratory: Pace South Carolina
Matrix: Solid & Aqueous
Analytical Group: PFAS
Analytical Method: ASTM D8421
SOP Reference: ENV-SOP-WCOL-0164
Certification Status: DoD ELAP/NELAP Certification

QC Sample	Frequency/ Number	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible	Data Quality Indicator	Measurement Performance Criteria
Sample PFAS Identification	All analytes detected in a sample	A minimum of two ion transitions (Precursor →quant ion and precursor →confirmation ion) and the ion transitions ratio per analyte are required for confirmation. Exception is made for analytes where two transitions do not exist (PFPrA, PFBA, PFOSA, N-Me-FOSE, N-Et-FOSE, PFMPA, PFMBA, FHUEA, and FOUEA). Ion ratio within 50-150% of the average ion ratio calculated for each initial calibration. Signal to Noise Ratio (S/N) must be ≥3 for all ions used for quantification and must be ≥3 for all ions used for confirmation.	Apply "I" flag to data with ion ratio outside criteria.	Analyst	Sample PFAS Identification	All analytes detected in a sample
RT window position establishment	Once per ICAL	Position shall be set using the midpoint standard of the ICAL curve	NA	NA	NA	NA
RT window width	Every field sample standard, blank, and QC sample.	RT of each analyte and EIS analyte must fall within 0.4 minutes or 5% (whichever is greater) of the predicted RTs from the midpoint standard of the ICAL. Analytes must elute within 0.1 minutes of the associated EIS; this criterion applies only to analyte and labeled analog pairs.	Correct problem and reanalyze samples	Analyst	NA	NA

QC Sample	Frequency/ Number	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible	Data Quality Indicator	Measurement Performance Criteria
EIS Analytes (aka SUR)	Every field sample, standard, blank, and QC sample	Basic procedure for aqueous samples: Add EIS standards to a 5 mL sample aliquot, add 5 mL MeOH, shake, optional carbon cleanup, filter, adjust pH with acetic acid for analysis. Basic procedure for solid samples: Add EIS to 2 g sample, add 10 mL 50% H20/50% MeOH, tumble 1 hour, centrifuge, optional carbon cleanup, filter adjust pH with acetic acid for analysis. All analytes recovered within 70-130% of expected concentration.	Qualify data associated with EIS if recovery exceeds 70-130%. If EIS recovery is below 20% or above 150%, identify and correct the problem. Reprepare and re-analyze if sufficient sample volume is available, contact the client as to additional measures to be taken.	Analyst, supervisor	Apply "Q" flag to the specific associated analyte if recovery exceeds 70-130%. Non-compliant EIS recoveries must be discussed in the case narrative.	Failing analytes shall be thoroughly documented in the Case Narrative
MB	One per batch of 20 or fewer field samples	No analytes detected > ½ LOQ	Correct problem. If required, re-prepare and reanalyze MB and all QC samples and field samples processed with the contaminated blank. Contact the client as to additional measures to be taken.	Analyst, supervisor	If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply "B" flag to all results for the specific analyte(s) in all samples in the associated preparatory batch.	Results may not be reported without a valid MB. Flagging is only appropriate in cases where the samples cannot be reanalyzed.

QC Sample	Frequency/ Number	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible	Data Quality Indicator	Measurement Performance Criteria
LCS	One per batch of 20 or fewer field samples	Blank spiked with all analytes at a concentration near the mid-level calibration concentration. All analytes recovered within 40-150% of expected concentration. Laboratory established recovery limits based upon historical data may be used if more stringent than 40-150%.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes if sufficient sample material is available. Contact the client as to additional measures to be taken.	Analyst, supervisor	If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. Apply “Q” flag to specific analyte(s) in all samples in the associated preparatory batch.	Must contain all target compounds.
LCSD	One per batch of 20 or fewer field samples.	Aqueous: LCS/LCSD RPD ≤ 30 Solid: LCS/LCSD RPD ≤ 50	Investigate and correct the problem. Reprepare and reanalyze all samples associated with the failing LCS if sufficient material is available.	Analyst, supervisor	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply a "Q" flag to all results for the specific analyte(s) in all samples associated with the failing LCSD.	Must contain all target compounds. Spike concentration must be identical to LCS. .
MS/MSD	NA	NA	NA	NA	NA	NA

Notes:

1) Method acceptance limits and corrective actions are based on the ASTM D8421 laboratory specification included in **Appendix C.**

> = greater than
≥ = greater than or equal to
≤ = less than or equal to
% = percent
EIS = extracted internal standard
FHUEA = 2H-perfluoro-2-octenoic acid
FOUEA = 2H-perfluoro-2-decenoic Acid
ICAL = initial calibration for all analytes
LCS = laboratory control spike
LCSD = laboratory control spike duplicate
LOQ = limit of quantitation
MB = method blank
MS = matrix spike
MSD = matrix spike duplicate
NA = not applicable
N-Et-FOSE = N-ethyl perfluorooctanesulfonamidoethanol
N-Me-FOSE = N-methyl perfluorooctanesulfonamidoethanol
PFAS = per- and polyfluoroalkyl substances
PFBA = perfluorobutanoic acid
PFMBA = perfluoro-4-methoxybutanoic acid
PFMPA = perfluoro-3-methoxypropanoic acid
PFOSA = perfluorooctanesulfonamide
PFPeA = perfluoropentanoic acid
PFPrA = perfluoropropanoic acid
QC = quality control
RPD = relative percent difference
RT = retention time
S/N = signal to noise
SOP = standard operating procedure

Worksheet #29: Project Documents and Records

Sample Collection Documents and Records	On-facility Analysis Documents and Records	Offsite Analysis Documents and Records	Data Assessment Documents and Records
Field Logbook	Field Logbook	Sample receipt, custody, and tracking records	Field sampling audit records
CoC Records	Field Sampling Forms	Sample prep logs	Laboratory audit records
Air Bills	Equipment Inspection Forms	Equipment calibration logs	Data validation reports
Custody Seals	Boring Logs	Run logs	Data usability assessment reports
Corrective Action Forms	Corrective Action Forms	Equipment maintenance test, and inspection logs	Corrective Action Forms
Field Sampling Forms	Daily Tailgate SH&E Sign In Sheet	Corrective Action Forms	Field Change Request Form
Sample location and depth data	APP/SSHP Acknowledgement	Reported analytical results	Non-Conformance Reports
Field equipment calibration logs	Dig Permits	Data package completeness checklists	Field Planning Request Form
Utility Clearance Checklist		Sample disposal records	
		Extraction/cleanup records	
		Raw data	
		EQuIS™	
		ROE Agreements	
		Photographic Logs	

Notes:
APP = Accident Prevention Plan
CoC = chain of custody
EQuIS = Environmental Quality Information System
NA = not applicable
ROE = right of entry
SH&E = Safety, Health, and Environment
SSHP = Site Safety and Health Plan
Other project documents and records may be produced as the need is identified.

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Worksheets #31, #32 & #33: Assessments and Corrective Action

This worksheet is used to document responsibilities for conducting project assessments, responding to assessment findings, and implementing corrective action. Appropriately scheduled assessments allow management to implement corrective action in a timely manner, thereby correcting non-conformances and minimizing their impact on DQOs/Project Quality Objectives.

Assessments:

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (A2P JV)	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing Corrective Action	Person(s) Responsible for Monitoring Effectiveness of Corrective Action
PM Review	Monthly (for field efforts that are longer than one month)	Internal	A2P JV	PM	Field Sampling Team Leader	Field Sampling Team Leader	Project Manager
Review of CoC forms	Daily	Internal	A2P JV	Project Chemist	Field Sampling Team Leader	Field Sampling Team Leader	Project Chemist
Laboratory Data Assessment (validation)	Once	Internal	A2P JV	Data Validator	Laboratory Chemist	Laboratory QA Manager	Project Chemist
Daily QC Audits	Daily	Internal	A2P JV	Field Sampling Team Leader	Field Sampling Team Leader	Field Sampling Team Leader	QA Officer
Field TSAs	Daily	Internal	A2P JV	Field Sampling Team Leader	Field Sampling Team Leader/ A2P JV	Field Sampling Team Leader/ A2P JV	QA Officer
Field Performance Audits	Weekly	Internal	A2P JV	PM	Field Sampling Team Leader	Field Sampling Team Leader/ A2P JV	Project Manager

Notes:
A2P JV = AECOM Arcadis PFAS Joint Venture
CoC = chain of custody
PM = project manager
QA = quality assurance
QC = quality control
TSA = technical system audit

Assessment Response and Corrective Action:

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (A2P JV)	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response	Timeframe for Response
Field Sampling Audit	Email	Field Sampling Team Leader/ PM	Immediate	Daily QC Report/ Email	Project Quality Manager/ PM	24 hours after notification
PM Review	Email	Field Sampling Team Leader/ PM	Immediate	Daily QC Report/ Email	PM	24 hours after notification
Review of CoC forms	Email	Field Sampling Team Leader/ PM	Immediate	Daily QC Report/ Email	Project Chemist	24 hours after notification
Laboratory Data Assessment (validation)	Written Audit Report	Laboratory QA Manager; A2P JV Project Chemists	Within 24 hours after audit	Email	Data Validator; A2P JV Project Chemists	Up to 1 week after notification
Daily QC Audits	Email/ Daily QC Report	Field Sampling Team Leader/ PM	Immediate	Daily QC Report/ Email	PM	24 hours after notification
Field TSAs	Email/ Daily QC Report	Field Sampling Team Leader/ PM	Immediate	Daily QC Report/ Email	PM	24 hours after notification
Field Performance Audits	Email	Field Sampling Team Leader	Immediate	Daily QC Report/ Email	PM	24 hours after notification

Notes:
A2P JV = AECOM Arcadis PFAS Joint Venture
CoC = chain of custody
PM = project manager
QA = quality assurance
QC = quality control
TSA = technical system audit

Laboratory Assessments

Assessment Type	Responsible Party & Organization	Number/ Frequency	Estimated Dates	Assessment Deliverable	Deliverable Due Date
DoD/ELAP Accreditation	Accreditation body	Every 2 Years	NA	Certification	NA
Performance testing samples	Laboratory QA Manager	Accreditation	Per Accrediting Authority	Per Accrediting Authority	Per Accrediting Authority
Data Review	Naoum Tavantzis and Dennis Capria, A2P JV	Once	45 days after receipt of data	Validation Report	45 days after receipt of data
External Laboratory Audit	Accreditation Body	Bi-annually	NA	Written Audit Report	NA
Internal Laboratory Audit	Contracted Laboratory	Annually	NA	Written Audit Report	NA

Notes:
A2P JV = AECOM Arcadis PFAS Joint Venture
DoD = Department of Defense
ELAP = Environmental Laboratory Accreditation Program
NA = not applicable
QA = quality assurance

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Worksheet #34: Data Verification and Validation Inputs

Item	Description	Verification (Completeness)	Validation (Conformance to Specifications)
Planning Documents/Records			
1	Approved QAPP	X	
2	Contract	X	
3	Field planning request forms	X	
4	Field SOPs	X	
5	Laboratory SOPs	X	
Field Records			
6	Field logbooks	X	
7	Equipment calibration records	X	
8	CoC Forms	X	X
9	Sampling diagrams/surveys	X	
10	Drilling logs	X	
11	Relevant correspondence	X	
12	Change orders/deviations	X	
13	Field audit reports	X	
14	Field change request forms / non-conformance corrective action reports	X	
15	Non-conformance corrective action reports	X	
Analytical Data Package			
16	Cover sheet (laboratory identifying information)	X	X
17	Case narrative	X	X
18	Internal laboratory CoC	X	X
19	Sample receipt records	X	X
20	Sample chronology (i.e., dates and times of receipt, preparation, and analysis)	X	X
21	Communication records	X	X
22	LOD/LOQ establishment and verification	X	X
23	Standards traceability	X	X
24	Instrument calibration records	X	X
25	Definition of laboratory qualifiers	X	X
26	Results reporting forms	X	X
27	QC sample results	X	X
28	Corrective action reports	X	X
29	Raw data	X	X
30	Electronic data deliverable	X	X

Notes:
CoC = chain of custody
LOD = limit of detection
LOQ = limit of quantitation
QAPP = Quality Assurance Project Plan
QC = quality control
SOP = standard operating procedure

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Worksheet #35: Data Verification Procedure

This worksheet documents procedures that will be used to verify project data. The procedures apply to both field and laboratory records. Data verification is a completeness check to confirm that all required activities are conducted, all specified records are present, and the contents of the records are complete. As illustrated in the following example, verification often is performed at more than one step by more than one person.

Records Reviewed	Requirement Documents	Process Description	Responsible Person, Organization
CoC forms and shipping forms	CoC, Shipping Documents	CoC forms and shipping documentation will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the CoC should be initialled by the reviewer, a copy of the CoC retained in the site file, and the original and remaining copies taped inside the cooler for shipment.	Appropriate Field Sampling Team Leaders for the individual medias
Review of field logbooks	Field Logbooks	Review for completeness and accuracy.	Appropriate field Sampling Team Leaders
Field sampling TSAs	TSA Reports	Assessment of field sampling process prior to start of, or as close to the start of sampling as possible.	QA Manager or designee
Fixed laboratory analytical data review	Laboratory Data Package	Data controls are compared to this QAPP and DoD QSM 5.4 (Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-24) in a Three-Tiered process using a minimum 100% peer review.	PM or QA Manager
Fixed laboratory TSAs	Laboratory Data Package	ELAP audit and internal quality audits.	QA Manager
Fixed laboratory data verification	Data Validation Reports	100% data verification/validation for water and soil.	A2P JV Project Chemists
Fixed laboratory data validation	Data Validation Reports	Calculate and assess laboratory DQIs.	QA Manager, or designee

Notes:
% = percent
A2P JV = AECOM Arcadis PFAS Joint Venture
CoC = chain of custody
DoD = Department of Defense
DQI = data quality indicator
ELAP = Environmental Laboratory Accreditation Program
PFAS = per- and polyfluoroalkyl substances
PM = Project Manager
QA = quality assurance
QAPP = Quality Assurance Project Plan
QSM = Quality Systems Manual
TSA = technical system audit
USEPA = United States Environmental Protection Agency

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Worksheet #36: Data Validation Procedures

Data Validator: A2P JV

Analytical Group/Method	PFAS Definitive Analytical Data	RSC PFAS Data and all other Analytical Methods
Analytical specifications	**Worksheet #24**, **Worksheet #28** & Laboratory SOPs	
Measurement performance criteria	**Worksheet #12**, **Worksheet #15**, and **Worksheet #28**	
Percent of data packages to be validated	100%	100%
Percent of raw data reviewed	10%	0%
Percent of results to be recalculated	10%	0%
Validation procedure and qualification	General Data Validation Guidelines (DoD, 2019), Data Validation Guidelines Module 6: Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-24 (DoD, 2022), this QAPP, DoD QSM Version 6.0 (DoD, 2023), and the laboratory SOPs. Data validation reports are produced for each sample delivery group incorporating all sample analyses.	
Validation code	S2bVEM/S2bVM (10% S4VM)	S2aVM (100% Stage 2a prior to any use followed by 10% Stage 2b for ASTM D8421)
Electronic validation program/version	A2P JV EarthSoft EQuIS™ Automated Validation Assistant and Data Quality Module A2P JV will also complete manual data validation	

Notes:
% = percent
A2P JV = AECOM Arcadis PFAS Joint Venture
DoD = Department of Defense
EQuIS = Environmental Quality Information System
PFAS = per- and polyfluoroalkyl substances
QAPP = Quality Assurance Project Plan
SOP = standard operating procedure
USEPA = United States Environmental Protection Agency

The following data validation flags will be used for the project:

Flag	Interpretation
U	The analyte was not detected and was reported as less than the LOD or as defined by the customer. The LOD has been adjusted for any dilution or concentration of the sample.
J+	The result was an estimated quantity, but the result may be biased high.
J-	The result was an estimated quantity, but the result may be biased low.
J	The reported result was an estimated value with an unknown bias.
N	The analysis indicates the presence of an analyte for which there was presumptive evidence to make a "tentative identification."
NJ	The analyte has been “tentatively identified” or “presumptively” as present and the associated numerical value was the estimated concentration in the sample.
UJ	The analyte was not detected and was reported as less than the LOD or as defined by the customer. However, the associated numerical value is approximate.
X *	The sample results (including non-detects) were affected by serious deficiencies in the ability to analyze the sample and to meet published method and project quality control criteria. The presence or absence of the analyte cannot be substantiated by the data provided. Acceptance or rejection of the data should be decided by the project team (which should include a project chemist), but exclusion of the data is recommended.

* “R” flag or “UJ” flag applied by project team to replace X-flag in a final decision

When a result is initially X-flagged, data reviewer will first see if there is a more acceptable result that can be recommended for data use. In many instances a result that has the potential to be X-flagged is associated with failing QC that per the QAPP would require re-extraction or reanalysis. In these instances, the other non-X flagged result will be selected. In instances where this is not an option, the result will remain "X" flagged and the project team will decide if the point is usable during the DUA process.

Worksheet #37: 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 will determine whether project execution and the resulting data the DQOs established in **Worksheet #11** were achieved. Both sampling and analytical activities will be considered with the ultimate goal to assess whether the final, qualified results support the decisions to be made with the data.

The following personnel are responsible for participating in the DUA:

- Project Manager: Claire Mitchell
- Project Chemist: Naoum Tavantzis
- Human Health Risk Assessor: Kelly Vosnakis
- Ecological Health Risk Assessor: Heather Patterson
- RI Task Manager: Matt Costakis

The DUA will be documented as a discussion within the RI Report and refer to the Data Validation Report that will appear in an appendix of the RI Reports. The Data Validation Report will follow the procedures given in **Worksheet #36**.

The following steps summarize the processes used to determine whether the collected data are of the right type, quality, and quantity to support the environmental decision-making for ARNG related to PFAS contamination at certain facility’s and describe how data quality issues will be addressed and how limitations on the use of the data will be handled.

Step 1	**Review the project’s objectives and sampling design** The key components established in the DQOs (**Worksheet #11**) will be reviewed to ensure that they are still applicable. Also, the sampling design and how it was implemented in the field will be reviewed for consistency with the stated objectives. For example, this step in the DUA will: • Reevaluate whether comparison criteria (i.e., SL; **Worksheet #15**) were updated since PQAPP generation and if laboratory QLs were sensitive enough for those changes (e.g., QLs remain lower than new criteria). It is important to note several states are in various stages of developing or finalizing limits for PFAS chemicals for different media; therefore, it is critical that SLs are regularly evaluated over the course of the project to ensure the SLs remain current. Additionally, project data must meet the MPC for sensitivity and project QLs specified in **Worksheets #15** and **#28**. • Discuss the limitations and impact on the use of project data if validation reports indicate that project specific sensitivity goals or QLs were not achieved for a specific sampling or laboratory group, dataset or sample delivery group (SDG), matrix, analytical group, or concentration level. • Evaluate the impact of any Field Change Request Forms and Nonconformance and Corrective Action Reports against established DQOs in **Worksheet #11** and usability of data. Examples of deviations that may impact usability of data include: o Sampling Locations Deviation: Determine if alterations to sample locations continue to satisfy the project objectives. o Chain-of-Custody Deviation: Establish that any problems with documentation or custody procedures do not prevent the data from being used for the intended purpose. o Holding Times Deviation: Determine the acceptability of data where holding times were exceeded. o Damaged Samples Deviation: Determine whether the data from damaged samples are usable. If the data cannot be used, determine whether resampling is necessary. o SOPs and Methods Deviation: Evaluate the impact of deviations from SOPs and specified methods on data.
Step 2	**Review the data verification and data validation outputs** Available QA reports, including both field and laboratory generated forms, will be reviewed for deviations from planned activities identified in Step 1 (e.g., number and locations of samples, holding time exceedances, damaged samples, non-compliant proficiency testing sample results, and SOP deviations) and determine their impacts on the data usability. Validated data will be summarized and/or compiled to identify patterns, trends, and anomalies as they relate to the data quality indicators (DQIs) precision, accuracy/bias, representativeness, comparability, completeness, and sensitivity. Descriptions of each DQI and examples of how each may be incorporated into the usability report follow.
	Precision Precision is the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. Precision is usually expressed as standard deviation, variance, percent difference, or range, in either absolute or relative terms. QC measures for precision include field duplicates, laboratory duplicates, MSDs, analytical replicates, and surrogates. To meet the needs of the data users, RI project data must meet the MPC for precision specified in **Worksheet #12** of this PQAPP. Precision errors may be the result of one or more of the following: PFAS cross-contamination, field instrument variation, analytical measurement variation, poor sampling technique, sample transport problems, or spatial variation (heterogeneous sample matrices). To identify the cause of imprecision, the field sampling design rationale and sampling techniques will be evaluated by the reviewer, and both field and analytical duplicate/replicate sample results will be compared. For example, if poor precision is indicated in both the field and analytical duplicates/replicates, then the laboratory may be the source of error. If poor precision is limited to the field duplicate/replicate results, then the sampling technique, PFAS contamination, field instrument variation, sample transport, medium inhomogeneity, or spatial variability may be the source of error. If data validation reports indicate that analytical imprecision exists for a particular dataset or SDG, then the impact of that imprecision on usability will be discussed in the usability report.

Step 2 (cont.)	**Accuracy/Bias** Accuracy is the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) due to sampling and analytical operations. Examples of QC measures for accuracy include MSs, Laboratory Control Samples, and equipment rinsate blanks (ERBs). A measurement is accurate when the reported value does not differ from the true value or known concentration of the spike or standard. To meet the needs of the data users, project data must meet the MPC for accuracy/bias specified in **Worksheet #12** of this PQAPP. The usability report for each facility will: • Discuss and compare data on contamination and accuracy/bias (when bias is observable) for each matrix, analytical group, and concentration level. • Describe the limitations on the use of project data if extensive contamination, inaccuracy, or bias exists, or when inaccuracy is limited to a specific sampling or laboratory group, dataset or SDG, matrix, or concentration level. • Discuss the impact of any qualitative and quantitative trends in bias on the sample data. • Discuss if inaccuracy due to field equipment calibration exists and its impact on groundwater chemistry.
	Representativeness Representativeness is the measure of the degree to which data accurately and precisely represent a characteristic of a population, a parameter variation at a sampling point, a process condition, or an environmental condition, and it is achieved through a well-designed sampling program and by using standardized sampling strategies, techniques, and analytical procedures. To meet the needs of the data users, project data must meet the MPC for sample representativeness specified in **Worksheet #12** of this PQAPP. **Worksheet #28** and **Worksheet #35** discusses how the QA/QC activities (e.g., review of sampling design and SOPs, field sampling Technical System Audits (TSAs), and analysis audits) and QC sample data will be reviewed to assess sample representativeness. For example, if field duplicate precision checks indicate potential spatial variability, additional scoping meetings and subsequent resampling may be needed to collect data that are more representative of a nonhomogeneous site. The usability report for each facility will: • Discuss the impact of field duplicate imprecision onsite representativeness. For example, when data variability is high among field duplicate datasets (i.e., high relative standard deviation), calculation of the 95% UCL of the population mean is more likely to overestimate the true mean and therefore achieve better statistical coverage. • Discuss the impact of laboratory and field sampling methods, sampling personnel, and field equipment on sampling results and how they reflect site conditions. • If screening data will be confirmed by definitive methods, document the specific method and percent difference formula that will be used to assess comparability for individual data points. • Discuss the effect of site heterogeneity on sampling results in light of sampling methods used. • Describe the limitations on the use of project data when sampling results are non-representative for all data or for a specific sampling, group, dataset or SDG, matrix, analytical group, or concentration level.
	Comparability Comparability is the degree to which different methods, datasets, and decisions agree or can be represented as similar. Comparability describes the confidence (expressed qualitatively or quantitatively) that two datasets can contribute to a common analysis and interpolation. The RI results will be used as benchmarks for determining comparability for data collected during any future sampling events at the various facilities using the same or similar field sampling and analytical SOPs. At this time, data will not be compared to other datasets or data using different sampling or analytical SOPs.

Step 2 (cont.)	Screening Data Assessment: Screening-level analyses may be used for informing field decisions regarding adaptive sampling and analytical strategies. Assessment of the screening-level data will be based on a percent decision match (USACE, 2013) assessment, also referred to as “a reliability assessment”, of the screening level results and confirmation split sample results, as established in the ASTM D8421 DMA Work Plan (AECOM, 2024c) and outlined in **Worksheet #12**. To ensure future comparability of data generated for the facilities, standard sample collection procedures and approved analytical methods will be used. Sample analyses will be performed by the laboratory using approved methods and procedures. Comparability criteria will be considered met for the project if, based on data reviewed, the sample collection and analytical procedures (such as use of alternate preparation if indicated by a positive field shake test) are determined to have been followed or defined to show that variations did not affect the values reported. Deviations to sampling scope will be documented in sampling nonconformance reports which may contain some of the discussion of comparability. As applicable, the usability report may also: • Describe the limitations on the use of project data when project-required data comparability is not achieved for the overall project or is limited to a specific sampling or laboratory group, dataset or SDG, matrix, analytical group, or concentration level. • Document the failure to meet screening/confirmatory comparability criteria and discuss the impact on usability. • Discuss anomalies detected in the data that may reflect a changing environment or indicate sampling and/or analytical error.
	Completeness Completeness is a measure of the amount of valid data obtained from a measurement system compared with the amount that was expected to be obtained under correct, normal circumstances. To meet the needs of the data users, project data must meet the MPC for data completeness. Completeness criteria will be considered met if 95% of all planned PFAS sample data are collected. As applicable, the usability report may also: • Describe how the amount of valid data will be determined as a percentage of the number of valid measurements for each matrix, analytical group, and concentration level. • Describe how critical data were assessed for completeness when certain sample locations or analytes and matrices are more critical than others in making project decisions. • Evaluate the impact of missing information. Ensure that enough information was obtained for the data to be usable to meet the DQOs (**Worksheet #11**).
	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, a DL study, LOD/LOQ Verifications, and Instrument Sensitivity Checks (ISC). To meet the needs of the data users, project data must meet the MPC for sensitivity and project QLs specified in **Worksheets #15** and **#28** of this PQAPP. If appropriate, the usability report may also: • Discuss and compare sensitivity and DL/LOD/LOQ from the datasets collected for the project for each matrix, analytical group, and concentration level. • Discuss the impact of a lack of sensitivity or higher DL/LOD/LOQ on data usability, if validation reports indicate that sensitivity goals or DL/LOD/LOQ goals were not achieved. • Describe the limitations on the use of project data when sampling results are non-representative for all data or for a specific sampling, group, dataset or SDG, matrix, analytical group, or concentration level.

Step 3	**Verify the assumptions of the selected statistical method** The use of statistical methods for data assessment for this project may include, but are not limited to, estimating a 95% UCL (or mean as appropriate for the analyte) for the assessment of risks.
Step 4	**Implement the statistical method** Where statistical methods are used, the underlying assumptions will be assessed during the DUA. The consequences of selecting the incorrect alternative will be discussed, and uncertainty tolerances will be considered.
Step 5	**Document data usability and draw conclusions** The DUA will determine and document whether the data can be used as intended given any deviations and corrective actions that may have occurred. Limitations on data use will be considered and discussed as appropriate, and the performance of the sampling design assessed. Conclusions will be drawn taking any data limitations into consideration and documented in the RI Report.

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2.0 References

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Appendix A
Technical Project Planning Meeting Minutes

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Attachment A - TPP 1 & 2 Briefing Slides

Attachment A - TPP 1 & 2 Briefing Slides

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Attachment A - TPP 2 Briefing Slides

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Appendix B
SI Analytical Tables and Figures

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Appendix C
Analytical Laboratory Documentation

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Appendix D
Field Standard Operating Procedures

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Appendix E
Risk Assessment Work Plan

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FINAL

Human Health and Ecological Risk Assessment Work Plan Santa Fe Army Aviation Support Facility, NM

Remedial Investigations (RI) / Feasibility Studies (FS), Decision Documents, Time and Non-Time Critical Removal Actions (TCRA/NTCRA) for Per- and Polyfluoroalkyl Substances (PFAS) Impacted Sites, Army National Guard Installations, Nationwide

December 2024

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Acronyms and Abbreviations

%	percent
µg/kg	micrograms per kilogram
AASF	Army Aviation Support facility
AECOM	AECOM Technical Services, Inc.
AFFF	aqueous film forming foam
AOI	area of interest
ARAR	Applicable or Relevant and Appropriate Requirement
Argonne	Argonne National Laboratory
ARNG	Army National Guard
ATSDR	Agency for Toxic Substances and Disease Registry
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	chemicals of concern
COPC	chemicals of potential concern
COPEC	chemicals of potential ecological concern
CSM	conceptual site model
CTE	central tendency exposure
DA	Department of the Army
DERP	Defense Environmental Restoration Program
DoD	Department of Defense
EA	EA Engineering, Science, and Technology, Inc., PBC
ELCR	excess lifetime cancer risk
EPC	exposure point concentration
ERA	Ecological Risk Assessment
ESTCP	Environmental Security Technology Certification Program
ESV	ecological screening values
FOD	frequency of detection
FS	feasibility study
GLI	Great Lakes Initiative
HEAST	Health Effects Assessment Summary Tables
HFPO-DA	hexafluoropropylene oxide dimer acid
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IPaC	Information for Planning and Consultation
IRIS	Integrated Risk Information System
MCL	maximum contaminant level

mg/day	milligram per day
LOAEL	lowest-observed-adverse-effect levels
MRL	minimal risk level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ng/L	nanogram per liter
NMED	New Mexico Environment Department
NOAEL	no observed adverse effect level
NOEC	No-observed effect concentration
OEHHA	Office of Environmental Health and Hazard Assessment
OSD	Office of the Assistant Secretary of Defense
OSWER	Office of Solid Waste and Emergency Response
PA	Preliminary Assessment
PC99	99% protection concentration
PFAS	per- and polyfluoroalkyl substances
PFBA	perfluorobutanoic acid
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
PFUdA	perfluoroundecanoic acid
PPRTV	Provisional Peer-Reviewed Toxicity Value
PRG	preliminary remediation goal
QAPP	Uniform Federal Policy Quality Assurance Project Plan
RAWP	risk assessment work plan
RBSL	risk-based screening level
RME	reasonable maximum exposure
RI	remedial investigation
RSL	regional screening level
SERDP	Strategic Environmental Research and Development Program
SI	Site Inspection
SL	Screening Level
SLERA	screening level ecological risk assessment
TRV	toxicity reference value
TSERAWG	Tri-Services Environmental Risk Assessment Work Group

UCL	upper confidence limit
UFP-QAPP	Uniform Federal Policy Quality Assurance Project Plan
US	United States
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USPFO	United States Property and Fiscal Office
UU/UE	unlimited use/unrestricted exposure
WWTP	wastewater treatment plant

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1.0 Introduction

This Risk Assessment Work Plan (RAWP) is provided as Appendix E of the Remedial Investigation (RI) Uniform Federal Policy Quality Assurance Project Plan (UFP QAPP) (also referred to as the "QAPP") for RI activities investigating the potential impacts of per- and polyfluoroalkyl substances (PFAS) associated with historical activities at the Santa Fe Army Aviation Support facility (AASF) (also referred to as the "facility") in Santa Fe, New Mexico, approximately 10 miles southwest of downtown. The facility is located on the northwest corner of the Santa Fe Regional Airport (SAF) and is leased to the New Mexico Army National Guard (NMARNG) by the City of Santa Fe (City). The facility location is shown on QAPP Figure 10-1.

The Army National Guard (ARNG) conducted a Preliminary Assessment (PA) at Santa Fe AASF in 2020 that identified one potential release area (AECOM Technical Services, Inc. [AECOM], 2020). Two potential PFAS release areas (Former Fire Truck Bay and TriMAX™ Hand Truck Storage Area) were grouped into one Area of Interest (AOI) based on proximity and inferred surface and groundwater flow directions. Based on the findings of the PA, the facility moved forward to the SI phase.

A Site Inspection (SI) was subsequently conducted at the facility to determine the presence or absence of perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), perfluorobutanesulfonic acid (PFBS), perfluorohexanesulfonic acid (PFHxS), and perfluorononanoic acid (PFNA) at each AOI (EA Engineering, Science, and Technology, Inc., PBC [EA], 2023). The SI evaluated if the relevant PFAS were present at concentrations greater than or less than the screening levels (SLs), as established by the Office of the Assistant Secretary of Defense (OSD). The SLs adopted for the SI were obtained from an OSD memorandum dated 6 July 2022 (Assistant Secretary of Defense, 2022), the applicable standard at the time of the investigation. The SI report identified PFAS in exceedance of the SLs at the City-operated Historical Wastewater Treatment Plant (WWTP) Biosolid Surface Disposal Site which extended onto the AASF. The AOI and historical potential release area are shown on QAPP Figure 10-6.

The SI report identified two AOIs listed below for further investigation in the RI.

- AOI 1 – Former Fire Truck Bay and TriMax™ Hand Truck Storage Area
- Historical WWTP Biosolid Surface Disposal Site

OSD released a revised memorandum in August 2023 directing the use of the May 2023 United States Environmental Protection Agency (USEPA) Regional Screening Levels (RSLs) as SLs for determining whether PFAS require further investigation (Assistant Secretary of Defense, 2023a). The memorandum further stated that it would not be updated again and that future RSL updates would be posted to the OSD website once they are approved for use by OSD. The OSD website was updated in March 2024 to direct the use of the November 2023 RSLs for a specific list of PFAS (https://www.acq.osd.mil/eie/eer/ecc/pfas/pfas101/rsl.html). Note that the updated memorandum did not result in a change to the SI conclusions or recommendations. The most recent RSLs posted to the OSD website at the time the risk assessment is conducted will be used in the human health risk assessment (HHRA).

The term "PFAS" will be used herein to encompass the 40 PFAS included in USEPA Method 1633 (as listed in QAPP Worksheet #15). The term "relevant PFAS" will be used herein to encompass all PFAS on the Method 1633 list with USEPA RSLs on the OSD website, which includes the following eight PFAS per the March 2024 update:

- Hexafluoropropylene oxide dimer acid (HFPO-DA)
- Perfluorobutanesulfonic acid (PFBS)

  - Perfluorobutanoic acid (PFBA)
  - Perfluorohexanesulfonic acid (PFHxS)
  - Perfluorohexanoic acid (PFHxA)
  - Perfluorononanoic acid (PFNA)
  - Perfluorooctanoic acid (PFOA)
  - Perfluorooctanesulfonic acid (PFOS)

The RI project elements will be performed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; USEPA, 1980), as amended, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP; 40 Code of Federal Regulations [CFR] Part 300; USEPA, 1994), and in compliance with United States (US) Department of the Army (DA) requirements and guidance for field investigations, including specific requirements for sampling for PFAS. New Mexico Environment Department (NMED) guidance and policies will also be consulted (NMED, 2017, 2022). Where differences between New Mexico regulations and guidance occur, USEPA and Department of Defense (DoD) policy/guidance will be followed.

The RI field activities for Santa Fe AASF will be conducted over multiple phases, including Prescriptive and Adaptive Phases, and Final Characterization/Monitoring. The QAPP describes the sampling design for the Prescriptive Phase and overall technical approach for the RI program. Future planning documents will describe additional activities to be conducted under future phases. If changes to the RAWP methodology are necessary after all phases are complete, changes will be noted in a RAWP deviation section of the risk assessment.

The objective of this RAWP is to provide the approach for the HHRA and ecological risk assessment (ERA) performed as part of the RI. These objectives include identifying the human and ecological receptors and exposure pathways to be evaluated and the sources to be used to identify appropriate SLs, exposure assumptions, and toxicity values. The risk assessment approach was developed in accordance with the USEPA and DA risk assessment guidance, as referenced in this RAWP. The RAWP was developed to provide the framework and high-level approach for the risk assessments, because as noted above, several phases of sampling are planned. Therefore, it is not known at this time what the final dataset will include and the conceptual site model (CSM) will be refined as more data are collected and evaluated.

This risk assessment approach may be updated as new guidance, reference values, matrices, exposure scenarios, or exposure pathways that warrant an update are identified. In cases where more current reference sources and/or values are available at the time the HHRA or ERA calculations are being performed, the more current sources and values will be applied, as appropriate.

Additional background information and a CSM for the study area are provided in QAPP Worksheet #10.

1.1 Facility Description

The Santa Fe AASF property encompasses approximately 33 acres within Santa Fe County. The facility is located within the incorporated limits of and approximately 10 miles southwest of downtown Santa Fe, New Mexico. As noted previously, the facility is on the SAF and leased from the City. The land was acquired in 1976, and the original facility was constructed in 1979. The original facility consisted of an AASF building and hangar and a small parking apron for helicopters. In 2012, the facility was completely renovated with a new, larger AASF building constructed adjacent to the former AASF building, and the former AASF building converted to the Santa Fe Readiness Center (AECOM, 2020). The facility is comprised of one hangar, multiple administrative buildings, a fueling station, and a small, paved parking area. The current land use is listed as Light Industrial. The facility is fenced and has restricted access. Future land use is not anticipated to change (AECOM, 2020).

The properties immediately surrounding the AASF are also owned by the City, with the Santa Fe WWTP to the north, and the SAF immediately to the west, south, and east (QAPP Figure 10-1).

QAPP Worksheet #10 provides a discussion of the facility's environmental setting, including geology, hydrogeology, hydrology, climate, and land use. The following is a general summary to provide context for the risk assessments; please refer to QAPP Worksheet #10 and **Section 3.1.1** for greater detail.

Regional groundwater studies indicate that the facility is near a groundwater divide and that groundwater may travel southwest toward the Santa Fe River or south toward Arroyo Hondo/Cienega Creek (Johnson et al., 2016). This ambiguity in flow direction may be a result of groundwater levels within the Ancha and Tesuque Formations being mapped as a single aquifer (Santa Fe Group), despite their stark permeability contrast. Based on the SI, regional groundwater, suspected to have been measured within the Tesuque Formation, flows south-southwest at the facility. Numerous wells are located south and southwest of the facility. The nearest domestic well is located approximately 1 mile southwest of the facility. A municipal well located at SAF is located a 0.5 mile southeast of the facility (New Mexico Office of the Engineer [NMOSE], 2022). These and other wells identified during the PA are displayed on QAPP Figure 10-3. Potable water supply is discussed in **Section 2.2.1.**

During the SI, perched groundwater was observed on the west side of the facility at depths of 110 to 111 feet below ground surface (bgs) (EA, 2023). Groundwater flow direction of the perched groundwater could not be calculated since it was encountered in only two drilling locations (QAPP Figure 10-4). Depth to regional groundwater was observed at 176 to 185 feet bgs, which is consistent with observations made at Santa Fe WWTP monitoring wells located east of the facility (NMED Ground Water Quality Bureau, 2011). Measurements made during the SI indicate that regional groundwater flows south-southwest (QAPP Figure 10-4).

The facility's topography is relatively flat. It straddles two watersheds with the northern portion within the Headwaters Santa Fe River Watershed and the southern portion within the Outlet Santa Fe River Watershed. The surface water flow direction is generally to the southwest on both sides of the watershed divide. The Santa Fe River cuts through undeveloped land approximately 0.5 miles northwest of the facility (AECOM, 2020). Surface water features near the facility are shown in QAPP Figure 10-5.

Consistent with regional surface water flow directions, historical imagery indicates that stormwater flowed to the southwest from the historical helicopter parking apron and other paved areas. Stormwater also appears to have accumulated on either side of the taxiway historically. There are two shallow stormwater detention basins that currently receive water from the tarmac. A stormwater retention basin north of the Santa Fe Readiness Center currently receives runoff from the paved areas of the facility and has an outflow that is directed off-facility to the north. The oil water separator (OWS) outflow for the AASF's fueling point is also located outside the north AASF boundary. Dry drainage features visible from both outfalls heading northwest are apparent in imagery but appear to dissipate after a short distance. As such, it is assumed there is no direct overland pathway between the AASF and the Santa Fe River, and much of the outflow discharge likely infiltrates into the subsurface. Current and historical areas that receive or appear to have received stormwater runoff are displayed in QAPP Figure 10-5.

As noted previously, one AOI was identified, comprised of the Former Fire Truck Bay and TriMAX^{TM} Hand Truck Storage Area. The Historical WWTP Biosolid Surface Disposal Site, which extended onto the Santa Fe AASF, was also identified as a potential area with PFAS impact from the off-facility WWTP. These areas are shown on QAPP Figure 10-6 and described below.

AOI 1

Former Fire Truck Bay – The former AASF building, which is now the current Santa Fe Readiness Center, is located on the western portion of the facility and historically housed a single fire truck within a bay. The fire truck was stored in this bay for an unknown length of time, but it was sold in 2005 to the Santa Fe Fire Department. Personnel interviews confirmed that the fire truck stored AFFF, but it was never used because no personnel at the facility were qualified to use it. There are no records or recollection of the use or release of the AFFF stored on the fire truck; however, there is a possibility that the fire truck may have leaked AFFF or had its AFFF tank flushed out during maintenance.

The building was renovated in 2012 and received a new roof, exterior wall openings and finishes, interior walls, floor finishes, ceilings, and lighting. Mechanical, electrical, plumbing, fire protection, telecommunication, and security systems were replaced as well. The Former Fire Truck Bay still includes the bay door opening to the southwest corner of the building but has been remodeled with new walls and an equipment cage and is currently used for storage. There is no floor drain in the remodeled bay and no evidence one was previously present. The current Santa Fe Readiness Center building does not currently house any materials containing AFFF (AECOM, 2020).

Tri-Max™ Hand Truck Storage Area – The flight line and paved parking apron currently stretch across much of the facility and are directly adjacent to both the current and former AASF buildings. The area was expanded and repaved in 2012 during the construction and renovation of the facility. Prior to the 2012 facility renovation, Tri-Max™ 70/30 hand trucks equipped with AFFF were staged in various places around the flight line and paved parking apron. The hand trucks were regularly serviced, which may have resulted in AFFF leaks or incidental discharge while the units were at the facility. According to personnel, the Tri- Max™ hand trucks were only used for 4 to 5 years in the mid-2000s and were turned in because they were too expensive to maintain. There is no recollection or record of any training conducted with these units or nozzle testing performed. Interviewees were not certain when or where, specifically, the Tri-Max™ units were turned in, but confirmed that the units no longer exist at the facility and have since been replaced with fire extinguishers that do not contain PFAS (AECOM, 2020).

Historical WWTP Biosolid Surface Disposal Site

The Santa Fe WWTP is located north of the Santa Fe AASF. Areas to the north and east of the Santa Fe AASF are currently used as surface disposal sites for the surface disposal of biosolids. The biosolids surface disposal site also extended onto the current Santa Fe AASF lease area prior to the 2012 renovations. Based on available imagery, the footprint of the biosolids surface disposal site on the AASF extended from the northeast facility boundary to the north end of the current AASF (QAPP Figure 10-6). Although WWTPs are not usually primary potential release areas of PFAS, sludges and liquids generated through the treatment of sanitary waste at WWTPs can create a secondary source of contamination.

1.2 Data Selection and Evaluation

Samples collected during the SI (EA, 2023) were analyzed for a subset of 18 PFAS (including all the relevant PFAS listed in **Section 1.0** except HFPO-DA) by liquid chromatography with tandem mass spectrometry compliant with Quality Systems Manual (QSM) 5.3 Table B-15 (DoD, 2019).

SI data will not be used in the risk assessments; per OSD (Assistant Secretary of Defense 2024), methods other than USEPA Method 1633 cannot be used for risk assessment purposes. Analytical data from the SI within the AOIs and across the facility were used to refine the approach for the Prescriptive Phase as described in the QAPP.

As described in **Section 1.0**, the RI activities for the facility will be conducted over multiple mobilizations. During the Prescriptive Phase, soil and groundwater samples will be collected and analyzed for PFAS from multiple intervals at biased sampling locations surrounding known impacted areas as identified during the SI. Prescriptive Phase samples will be analyzed using ASTM D8421, a screening level method. Confirmation samples using USEPA Method 1633 will be collected at a rate of 10%. The ASTM screening level data will not be used in the risk assessments, consistent with OSD policy (Assistant Secretary of Defense 2024). The screening level data will be used to refine and inform the Adaptive Phase, in which the USEPA Method 1633 data necessary for the risk assessments will be collected. Worksheet #11 of the QAPP discusses data quality objectives for the program.

The Adaptive Phase scope will largely be based on the results of the Prescriptive Phase and will include on-site step-in and step-out refinement borings/wells at sources where warranted. The previous detections of PFAS at the facility are summarized in QAPP Worksheet #10, and the full analyte lists for the RI are identified in QAPP Worksheet #15. Final data selection for evaluation in the risk assessments will be conducted after all the analytical data are available. QAPP Worksheet #14 describes the field sampling tasks for the Prescriptive Phase, and QAPP Worksheet #17 provides the sampling design and rationale for each medium and area for the Prescriptive Phase. The following summarizes the general approach for evaluating the USEPA Method 1633 data for the risk assessments.

Groundwater

The HHRA will only use data from permanent monitoring wells (USEPA, 2014b) and only results from samples analyzed using USEPA Method 1633. The ERA will not utilize groundwater data given that there are no complete exposure pathways directly between groundwater and ecological receptors (depth to groundwater observed during the SI ranged from 110 to 185 feet bgs) (EA, 2023).

Soil

Soil data collected for the risk assessments (USEPA Method 1633) will be divided into multiple depth intervals for evaluation in the risk assessments, as applicable. Surface soil for the HHRA and ERA will be defined as soil collected at a depth within 0 to 1-foot bgs. Subsurface soil for the HHRA will be defined as soil collected at a depth between 1 and 10 feet bgs. For future HHRA scenarios in which development of the area may occur, the surface soil and subsurface soil will be combined into a total soil column for future scenario evaluations (i.e., assume that land redevelopment occurs at the facility). In the ERA, subsurface soils from 1 to 6 feet bgs will be evaluated to assess direct exposure for deep-rooted plants and to assess potential exposures for burrowing animals that occur primarily through incidental soil ingestion while digging and grooming. If soil is not collected from the 1 to 6 feet bgs horizon, the shallowest subsurface soil horizon will be considered for deep-rooted plants and burrowing animals. If soil samples collected for use in the risk assessment are not collected from the specific horizons noted above, the soil horizons will be adjusted to those most like those listed above.

Exposure areas consisting of more than one AOIs may be developed depending on proximity, similarity of potential exposure, and similarity of PFAS concentrations.

Sediment, Surface Water, Porewater, Seep Water

The need for surface water and sediment sampling during the Adaptive Phase will be evaluated after review of the soil and groundwater data from the Prescriptive Phase. If additional data are deemed necessary and collected during the Adaptive Phase, applicable USEPA Method 1633 data will be used in both the HHRA and the ERA.

1.3 Summary Statistics

For each medium/exposure area, the data will be compiled into summary statistics as discussed below for evaluation in the risk assessments, using the aggregation reporting functions within Earthsoft's EQuIS software (i.e., the software used for analytical data management). For each chemical detected at least once within an area/medium/depth interval (i.e., surface soil, subsurface soil, etc.), the summary statistics will include the minimum and maximum detected concentrations, average detected concentration, location of maximum detected concentration, frequency of detection (FOD), and the range of detection limits calculated in accordance with USEPA Risk Assessment Guidance for Superfund (USEPA, 1989).

For sample locations in which a duplicate sample was also collected, the duplicate sample results for each chemical/medium/area combination will be processed prior to the calculation of summary statistics. Duplicates will be resolved as follows:

- When both the sample and duplicate are detected, the average of field and duplicate will be used to calculate summary statistics;
- When both the sample and duplicate are non-detects, the sample with the lower limit of detection will be used; and
- When one of the pair is reported as not detected and the other is detected, the detected result will be used.

2.0 Human Health Risk Assessment

A facility specific HHRA will be conducted to evaluate whether exposure to PFAS attributable to past operations may pose a potential cancer risk and/or noncancer hazard to human health above USEPA target levels defined in the NCP [40 US CFR § 300.430] (USEPA, 1991; USEPA, 1994). The evaluation will include quantitative estimation of potential cancer risk and noncancer hazard to current and potential future human receptors that may come into contact with facility related PFAS in soil and groundwater, as well as sediment and surface water if collected. The HHRA will be conducted in accordance with the USEPA, DoD, and DA risk assessment guidance and policies, as applicable, and as referenced throughout this RAWP. Guidance/policies include, but are not limited to, the following:

- USEPA. 1989. *Risk Assessment Guidance for Superfund: Volume I. Human Health Evaluation Manual (Part A).* Interim Final. Office of Emergency and Remedial Response. US Environmental Protection Agency, Washington, D.C. EPA 540/1-89/002.
- USEPA. 1991. *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions.* Office of Solid Waste and Emergency Response (OSWER) Directive #9355.0-30. April.
- USEPA. 2003. *Human Health Toxicity Values in Superfund Risk Assessments.* OSWER Directive 9285.7-53. Washington, DC. 5 December.
- USEPA. 2001a. *Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments).* Final. Publication 9285.7-047. December.
- USEPA. 2004. *Risk Assessment Guidance for Superfund: Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment).* Final. OSWER No. 9285.7-02 EP. Office of Emergency and Remedial Response. August.
- USEPA. 2014a. *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors.* Office of Superfund Remediation and Technology Innovation. OSWER Directive 9200.1-120. February 2014, updated September 2015.
- DoD. 2012. *Defense Environmental Restoration Program (DERP) Management Manual*, DoDM 4715.20. 9 March.
- Assistant Secretary of Defense. 2023a. *Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program.* United States Office of the Assistant Secretary of Defense. August.
- DA. 1999. *Risk Assessment Handbook, Volume I: Human Health Evaluation.* Engineer Manual. Department of the Army, U.S. Army Corps of Engineers. Washington, DC 20314-1000. EM 200-1-4. 31 January.

NMED risk assessment guidance (NMED, 2022, 2017) will also be consulted. Because the facility is being managed under CERCLA USEPA and DoD policy/guidance take precedence over state guidance.

The HHRA conclusions will inform risk management decisions. If the results of the HHRA indicate potential risk/hazard above USEPA's target levels, as defined in the NCP [40 CFR § 300.430] (USEPA, 1991; USEPA, 1994), federal and state cleanup standards will be evaluated to determine if they are Applicable or Relevant and Appropriate Requirements (ARARs) as part of the

Feasibility Study (FS). A weight of evidence evaluation that considers the HHRA results and ARARs will be conducted to determine the final list of Chemicals of Concern (COCs) for remedial action. The HHRA will be used to inform the development of risk-based target levels to be considered in conjunction with federal and state-specific ARARs in the selection of Preliminary Remediation Goals (PRGs) in the FS.

References cited herein are based on the most current versions of sources available as of the date of this RAWP. In the case that updates to references become available, the most current version of the references available at the time the HHRA is initiated will be used and appropriately referenced in the HHRA.

USEPA's four step HHRA paradigm (USEPA, 1989) will be followed to conduct the HHRA, as follows. Each of the HHRA steps is discussed in further detail in the following subsections.

- Data Evaluation and Hazard Identification
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization

2.1 Data Evaluation/Hazard Identification

The data evaluation and hazard identification step involves identification and summarization of facility data appropriate for use in the HHRA (described in **Section 1.2** for both the HHRA and the ERA) as well as the selection of chemicals of potential concern (COPCs) for quantitative evaluation in the HHRA, described below. Analytical data from several AOIs may be grouped into exposure areas depending on proximity and similarity of potential exposure.

COPCs are a subset of the complete list of chemicals detected in environmental media (e.g., soil, groundwater) that are carried through the quantitative risk assessment process. The HHRA COPC selection process may consider low FOD, low toxicity and low concentration, consistency with background (if available), and whether the chemical is likely to be present due to laboratory contamination. PFAS are the only potential facility related COPCs being evaluated under the scope of this RI. A background evaluation will not be conducted at this time for the facility. The COPC selection process is described below.

Chemicals will not be eliminated as COPCs based on low FOD alone, consistent with USEPA guidance (USEPA, 1989). Other lines of evidence to be considered include whether a COPC is also identified in other facility media and if historical and/or current facility-related activities support the presence of the chemical in the affected medium.

Preliminary PFAS COPCs will be identified based on a comparison of the maximum detected concentrations of individual PFAS per media/area/depth interval (as applicable) to human health SLs. As discussed previously, if cleanup action is determined to be necessary based upon the results of the HHRA, federal and state ARARs will be incorporated into the selection of PRGs in the FS.

The SLs and toxicity values current at the time the HHRA is conducted will be used (i.e., based on the RSLs posted to the OSD website, as described in **Section 1.0**). The potential risks associated with PFAS lacking final toxicity values from USEPA's hierarchy of sources will be discussed qualitatively in the Uncertainty Analysis of the HHRA. Relevant PFAS (i.e., those with final toxicity values approved for use by DoD at the time the HHRA is initiated) detected at concentrations greater than the associated SLs will be identified as COPCs and will be quantitatively evaluated in the HHRA. Relevant PFAS that are either not detected in a particular medium or that are detected at concentrations less than the associated SLs will be excluded from being COPCs and will not be evaluated further in the HHRA.

The human health SLs to be used in the COPC selection are discussed by media below. SLs are discussed for soil and groundwater, sediment, and surface water. While the Prescriptive Phase will not include sediment and surface water samples, SLs are discussed in the event samples are collected during later phases. **Section 2.2** provides a more detailed discussion of the human health CSM and the potential exposure pathways.

Soil SLs

Soil SLs used in the HHRA will be equal to the USEPA RSLs for residential soil, in accordance with the memorandum from the OSD (Assistant Secretary of Defense, 2023a) and any updates based on the OSD website. The RSLs will be based on a target risk level of 1E-6 and a target hazard quotient (HQ) of 0.1 (where both are available, the lower value will be selected) to account for potential cumulative effects per target organ. If the USEPA RSLs are updated, the most current version referenced on the OSD website will be used in the HHRA, as applicable. This method is considered conservative for the nonresidential exposure scenarios, where receptors are assumed to be exposed to soil fewer days per year and for fewer years than what is assumed for a residential scenario.

A comparison to SLs protective of the soil to groundwater migration pathway will not be included in the HHRA. Analytical groundwater data will be available and evaluated directly. Soil COPCs will be compared with groundwater COPCs to serve as an indicator of whether PFAS are potentially migrating from soil to groundwater.

Groundwater SLs

Groundwater SLs used in the HHRA will be equal to the USEPA RSLs for tap water, in accordance with the memorandum from the OSD (Assistant Secretary of Defense, 2023a) and any updates based on the OSD website. The tap water RSLs based on a target HQ of 0.1 or a cancer risk level of 1E-6 (where both are available, the lower value will be selected) will be used to select COPCs in groundwater. This method is considered conservative for the non-drinking water exposure scenarios.

Sediment SLs

Published human health sediment SLs for PFAS are not available from the DoD (Assistant Secretary of Defense, 2023a) or USEPA (2023a). Proxy sediment SLs for COPC selection will be set to the residential soil RSLs described above multiplied by a factor of 10 to estimate changes in exposure (e.g., reduced ingestion rate, lower exposure frequency) when assuming a recreational or occupational scenario compared to a residential scenario.

Surface Water SLs

Published human health surface water SLs for PFAS are not available from the DoD (Assistant Secretary of Defense, 2023a) or USEPA (2023a). If the surface water is an expression of groundwater, a focused point of groundwater recharge, and is used as a source of drinking water or directly discharges into a water body used for drinking water purposes, surface water COPCs will be selected based on the tap water RSLs described above. Otherwise, surface water COPCs will be selected using the tap water RSLs multiplied by a factor of 10 to estimate changes in exposure (e.g., reduced ingestion rate, lower exposure frequency) when assuming a recreational or occupational exposure scenario compared to a residential exposure scenario. Surface water downgradient of the facility is not used as a source of drinking water. Therefore, the factor of 10 will be applied to the tap water RSLs.

2.2 Exposure Assessment

The purpose of the exposure assessment is to provide a quantitative estimate of the magnitude and frequency of potential exposure to COPCs by a receptor. Potentially exposed individuals and the pathways through which those individuals may be exposed to COPCs are identified based on the physical characteristics as well as the current and reasonably foreseeable future uses of the facility. The extent of a receptor's exposure is estimated by constructing exposure scenarios that describe the potential pathways of exposure to COPCs and the activities and behaviors of individuals that might lead to contact with COPCs in the environment. This information is identified based on the preliminary facility-specific CSM, which is presented in the QAPP Worksheet #10 and summarized below.

2.2.1 Summary of Human Health CSM

As discussed in **Section 1.1**, the facility is approximately 33 acres on property leased from the City within the SAF and is a controlled access facility surrounded by a fence. The facility is mostly covered by pavement and buildings (approximately 22 acres), leaving few areas of exposed soil and little potential for soil exposure. Therefore, human exposure to PFAS in AOI soil is expected to be low under the current scenario. Soil contact is possible in the future if ground-disturbing activities take place or if there is redevelopment. Non-military land uses in off-facility areas adjoining the facility include the SAF and the WWTP.

Current human receptors in the AOIs include on-facility workers and approved visitors (e.g., National Guard/Army Reserve trainees. Outdoor workers may contact surface soil while performing maintenance or other similar activities. Visitors and trainees may also contact surface soil but are anticipated to have a lower exposure potential as compared to outdoor workers who would presumably be present more frequently and perform more soil-intense activities, such as landscaping. As noted previously, two off-facility surface soil samples will be collected during the Prescriptive Phase to evaluate the potential for off-facility migration to the adjacent property to the north. If PFAS COPCs are identified in the adjacent off-facility soils, the same exposure pathways identified for on-facility soil will be included for the off-facility soil.

There are no current recreational uses of the facility. It is assumed that the facility could be used for recreational purposes in the future. Entry to the facility by trespassers is considered unlikely under the current scenario. However, it is conservatively assumed that trespassers may access soil under a future scenario where access is no longer controlled. Construction/utility workers may also be present and access soil in the future if redevelopment or utility activities were to occur. Direct contact with groundwater is not anticipated because groundwater is not present within the top 15 feet of ground surface.

Santa Fe AASF receives its potable water from the City’s municipal water utility. Santa Fe’s drinking water comes from four sources: surface water from the Santa Fe and Rio Grande rivers, and groundwater from the Buckman and City Well Fields (City of Santa Fe Water, 2023). Surface water from the Santa Fe River is stored in the McClure and Nichols Reservoirs, both located northeast of the AASF, prior to treatment at the Canyon Road Water Treatment Plant. The Buckman Direct Diversion takes surface water directly from the Rio Grande and treats it at the Buckman Regional Water Treatment Plant (City of Santa Fe Water, 2023). The City Well Field is located close to the Santa Fe River and consists of 6 active well fields within the City limits. The Buckman Well Field consists of 13 wells near the Rio Grande, about 15 miles northwest of Santa

Fe (City of Santa Fe Water, 2023). The surface water sources and well fields are hydrologically upgradient of the facility (AECOM, 2020).

Functioning City supply wells and selected storage tanks were sampled for 18 PFAS compounds in June 2023 for the City by their contractor. PFAS were analyzed via USEPA Method 537. PFAS were not detected in any sample above the detection limit of 1.97 nanograms per liter (ng/L) for individual compounds (John Shomaker & Associates [JSAI], 2023).

The communities of La Cienega and La Cieneguilla are located adjacent to and presumed to be downgradient of the AASF. Residents of these communities rely on groundwater for drinking water, provided by individual residential wells and community owned water systems, one of which derives its drinking water from a well potentially downgradient from the facility. In 2023, Santa Fe County sampled six wells in the community. PFAS were detected in five of the six wells sampled, with PFOS and PFOA detected concentrations ranging from 1.9 ng/L to 25 ng/L (Santa Fe County, 2024).

As noted previously, there are two shallow stormwater detention basins that receive runoff from the tarmac and a retention basin north of the Santa Fe Readiness Center that receives runoff from the paved areas of the facility and has an outflow just outside the north facility boundary. These features are dry most of the time and any human exposure to surface water is expected to be intermittent in nature. Therefore, direct exposure to surface water will not be evaluated for the stormwater detention basis or the retention basin. If Prescriptive Phase and/or Adaptive Phase results warrant, sediment, surface water, porewater, and/or seep water samples may be collected from the on-facility stormwater features and/or off-facility surface water features (e.g., Santa Fe River, Arroyo Hondo, Cienega Creek). If warranted, relevant media will be collected from the Santa Fe River and/or Cienega Creek up- and downstream of potential input from the AASF and the WWTP to identify potential upstream sources during the Adaptive Phase. If collected, applicable data will be used in the HHRA.

The HHRA will conservatively evaluate an unlimited use/unrestricted exposure (UU/UE) scenario to inform future risk-management decisions in the FS, if applicable. This scenario includes the evaluation of a hypothetical future on-facility residential scenario and the evaluation of groundwater data collected from permanent monitoring wells as a source of drinking water. A remedial response will not necessarily be taken based on the results of the future UU/UE scenario, given it is not a reasonably anticipated future use for the facility, per the DoD DERP Management Manual, which states “The DoD Component shall consider current and reasonably anticipated future land uses in risk assessments. The DoD Component does not have to assume that the reasonably anticipated future land use is residential.” (DoD, 2012).

2.2.2 Potential Exposure Scenarios

The receptors and exposure pathways that may be evaluated in the HHRA are presented in the table below. They were identified based on current and potential future land use based on the facility specific CSM. Because the CSM will be refined during each sampling phase, the table below presents some scenarios that may ultimately be incomplete. For example, surface water and sediment samples will not be collected under the Prescriptive Phase but may potentially be collected during the Adaptive Phase. Therefore, potential surface water and sediment exposure pathways are listed. If these pathways are determined to be complete, they will be evaluated in the HHRA. If the pathways are not complete, they will not be evaluated quantitatively.

For purposes of the HHRA, it is conservatively assumed that future land-use scenarios may involve some level of construction to convert the area to the desired use (e.g., commercial, other industrial, recreational, residential). Under this scenario, it is assumed that current subsurface soils may be brought to the surface and become available for exposure by future receptors.

Potential exposure to airborne particles in outdoor air (from soil) will not be quantitatively evaluated in the HHRA because toxicity values for the inhalation exposure route are not available for relevant PFAS from OSD approved sources; therefore, quantitative assessment of the inhalation exposure pathway cannot be performed. The associated uncertainties will be qualitatively discussed in the HHRA.

Area	Receptor	Exposure Pathway(s)
On-facility/ adjacent to facility [(b)]	Outdoor Worker	Current: - Exposure to surface soil (0-1 feet bgs) through incidental ingestion and dermal contact.
		Future: - Exposure to combined surface and subsurface soil (0 to 10 feet bgs) through incidental ingestion and dermal contact. - Exposure to monitoring well groundwater[(a)] via ingestion as drinking water.
	Construction/Utility Worker	Future: - Exposure to combined surface and subsurface soil (0 to 10 feet bgs) through incidental ingestion and dermal contact.
	Trespasser (Adolescent)	Future: - Exposure to combined surface and subsurface soil (0 to 10 feet bgs) through incidental ingestion and dermal contact.
	On-facility Recreational User (Adult and Child)	Future: - Exposure to combined surface and subsurface soil (0 to 10 feet bgs through incidental ingestion and dermal contact.
	Hypothetical Future Resident (Adult and Child)	Future: - Exposure to combined surface and subsurface soil (0 to 10 feet bgs through incidental ingestion and dermal contact. - Exposure to groundwater[(a)] via ingestion of drinking water and dermal contact during bathing/showering.

Area	Receptor	Exposure Pathway(s)
Downgradient Off-facility (c)	Off-facility Recreational User (Adult and Child)	Current/Future: • Exposure to surface water and sediment through incidental ingestion and dermal contact if off-facility water body (e.g., the Santa Fe River, Cienega Creek, Arroyo Hondo) that could be used for recreation is potentially affected by installation activities. The fish consumption exposure pathway will be qualitatively evaluated.
	Commercial/ Industrial Worker (including airport workers)	Current/Future: • Exposure to groundwater(a) via ingestion of drinking water.
	Off-facility Resident (Adult/Child)	Current/Future: • Exposure to groundwater(a) via ingestion of drinking water and dermal contact during bathing/showering.

Notes:

(a) As noted previously, potable water samples will not be included in the HHRA. For the purposes of the HHRA, it is assumed that monitoring well groundwater is used as a potable water source.

(b) Includes the City of Santa Fe property adjacent to the AASF northern boundary, if determined to be impacted with PFAS via facility outflows.

(c) These potential receptors would only be evaluated if off-facility migration pathways for groundwater and surface water/sediment for PFAS from installation activities are confirmed and if additional off-facility data are collected during the Adaptive Phase.

The quantitative exposure assumptions for the reasonable maximum exposure (RME) scenario that will be used in the HHRA were selected in accordance with USEPA guidance (e.g., USEPA, 1989, 2002a, 2004, 2011, 2014a, 2017, 2019a, 2019b). The RME provides an estimate of the upper range of exposure in a population (the 90th percentile or greater of expected exposure, consistent with USEPA, 2019b) and is based on a combination of the upper-bound and central estimates of exposure parameters. USEPA guidance states that regulatory decisions are made using the results of the RME evaluation (USEPA, 1989). Exposure assumptions may differ from default values to factor in facility-specific considerations. For example, exposure assumptions are included for both swimming and wading scenarios for the recreational receptor. Depending on the water body evaluated, one or both scenarios may be included. Adjustments to the proposed exposure assumptions may be made based on additional facility-specific information and refinement of the human health CSM during the HHRA. If changes to the proposed exposure assumptions are made, the associated rationale will be provided in the HHRA report. **Figure 1** presents the human receptors, exposure areas, exposure media, and exposure pathways that will be evaluated in the HHRA. **Table 1** through **Table 7** present the quantitative exposure assumptions that will be used for the RME scenario.

A central tendency exposure (CTE) scenario, which uses average exposure parameters to calculate an average exposure to an individual, may be considered in the HHRA if (1) the RME scenario for the associated receptor indicates a potential risk/hazard in excess of USEPA target levels, as defined by the NCP [40 CFR § 300.430] (USEPA, 1991; USEPA, 1994); and (2) the CTE scenario is more reflective of the site-specific exposure scenario. If the CTE scenario is included, site-specific exposure parameters will be developed and documented in the HHRA report.

For each receptor and exposure area, the RME exposure dose will be estimated for each COPC via each exposure pathway by which the receptor is assumed to be exposed. Exposure doses for oral and dermal exposure will be calculated using the following USEPA guidance (USEPA 1989 and 2004). In the absence of dermal toxicity values, oral toxicity values will be utilized with appropriate adjustments (USEPA, 2004). The potential uncertainty associated with this assumption will be discussed in the HHRA.

2.2.3 Exposure Point Concentrations

Exposure point concentrations (EPCs) for evaluation of soil, groundwater, surface water (if collected), and sediment (if collected) will generally be equal to the 95 percent (%) upper confidence limit (UCL) on the arithmetic mean concentration (USEPA, 2002b) per exposure area. Detection limits for results reported as not detected will be entered into the software without adjustment; ProUCL uses statistical methods to evaluate non-detects versus simple substitution (e.g., one-half detection limit). For datasets in which a reliable 95% UCL cannot be calculated using USEPA's ProUCL software (USEPA, 2022b), in which case it provides a warning or other message indicating a UCL is not recommended, the maximum detected concentration will be used as the EPC for evaluation of the RME scenario.

The most current version of USEPA's ProUCL software available at the time the HHRA starts will be used to calculate the ProUCL-recommended UCL (currently USEPA, 2022b). The general approach to be used for calculation of EPCs is discussed with respect to media, as presented below. Because the sampling will occur over several phases, the total number of samples and the locations of samples that may be available for use in the HHRA are not currently known. The approach for developing EPCs will be refined after all the data to be used in the HHRA are available.

Soil

Soil EPCs will be calculated for COPCs in surface soil (0-1 feet bgs) and total soil (i.e., combined surface and subsurface soil, 0-10 feet bgs, for each exposure area. The Prescriptive Phase soil sampling design is described in QAPP Worksheet #17. The Prescriptive Phase Data will not be used in the risk assessments but will be used to refine the approach for the Adaptive Phase. Sample density for risk assessment will be considered in the sampling design for the Adaptive Phase.

Groundwater

In accordance with USEPA guidance (USEPA, 2014b), facility-wide groundwater EPCs will be calculated for COPCs in groundwater using analytical groundwater data from permanent monitoring wells identified as being within the core of the plume, if present. In the absence of a clearly defined plume, professional judgment will be used to determine the appropriate dataset for calculation of reasonably conservative groundwater EPCs.

Surface Water and Sediment

Surface water and sediment sampling is not planned for the Prescriptive Phase. If the data indicate a need for sampling under the Adaptive Phase, sample density for risk assessment will be considered in the sampling design.

2.3 Toxicity Assessment

The purpose of the toxicity or dose-response assessment is to identify the types of adverse health effects a chemical may potentially cause and to define the relationship between the dose of a chemical and the likelihood or magnitude of an adverse effect (response) (USEPA, 1989). The USEPA's guidance regarding the hierarchy of sources of human health dose-response values in risk assessment will be followed (USEPA, 2003):

- Tier 1: USEPA's Integrated Risk Information System (IRIS).
- Tier 2: Provisional Peer-Reviewed Toxicity Values (PPRTVs) obtained from USEPA via the USEPA National Center for Environmental Assessment in Cincinnati, Ohio.
- Tier 3: Other sources of dose-response values will be selected in accordance with USEPA guidance (USEPA, 2013) and include, but are not limited to, California Environmental Protection Agency's Office of Environmental Health and Hazard Assessment (OEHHA) Toxicity Criteria Database, Minimal Risk Levels (MRLs) published by the Agency for Toxic Substances and Disease Registry (ATSDR). The Health Effects Assessment Summary Tables (HEAST) are a Tier 3 source but are no longer updated and therefore not relevant to PFAS.

Only PFAS with final toxicity values that have been adopted by both USEPA and DoD will be considered in the HHRA (i.e., draft values will not be used).

USEPA guidance for early life exposure to carcinogens (USEPA, 2005a) requires that potential cancer risks from chemicals that act by a mutagenic mode of action be calculated differently than chemicals that do not act via a mutagenic mode of action. PFOA, currently the only PFAS with a USEPA cancer toxicity value approved for use by DoD, is not currently considered to be mutagenic; therefore, adjustments to the calculation of potential risks will not be required.

Default values provided by USEPA's RSL table (USEPA, 2023a) will be used for the gastrointestinal absorption fraction (1 or 100%) and dermal absorption factor (0.1 or 10%) to assess potential risk to PFAS COPCs in soil. Similarly, default values from the RSL table will be used for the dermal contact with water pathway. These estimates are uncertain and may result in an overestimation or underestimation of potential risk. Dermal exposure to PFAS is considered a minor exposure pathway due to studies that suggest dermal absorption of these chemicals is slow and does not result in significant absorption (ATSDR, 2021). The uncertainties associated with the toxicity values used will be discussed in the HHRA.

2.4 Risk Characterization

Risk characterization combines estimates of exposure with toxicity data to develop estimates of the probability that an adverse effect will occur under the specified conditions of exposure. Estimates of potential carcinogenic risks are expressed as probabilities of developing cancer reported as excess lifetime cancer risk (ELCR). Current HHRA practice considers carcinogenic risks to be additive when assessing exposure to a mixture of hazardous substances. Non-carcinogenic hazards are reported as pathway-specific hazard indices (HIs), which are the sum of individual COPC HQs for that pathway. A total HI is calculated for each receptor by summing the pathway-specific HIs within each media (e.g., summing dermal and ingestion soil HI estimates). As a first approximation, all COPCs will be conservatively assumed to have additive effects. If the total HI assuming additive effects is greater than USEPA's target level, HIs will be calculated separately for COPCs that have similar systemic effects (i.e., per target organ endpoint).

USEPA (1991) states that where the cumulative incremental current or future potential ELCR to an individual is less than 1E-4, action generally is not warranted unless there are adverse environmental impacts. USEPA also considers noncancer hazards by using a target HI per target organ of 1 (USEPA, 1991). For each associated exposure scenario (i.e., receptor/medium/exposure area) with a potential ELCR greater than 1E-4 and/or a HI greater than 1, preliminary COCs will be selected from those COPCs contributing the most to the cumulative ELCR greater than 1E-4 or target organ HI greater than 1 (at one significant figure).

A weight-of-evidence approach will be used to determine final COCs. Other lines of evidence that may be considered in selecting final COCs include nature and extent, other regulatory requirements, and background. If final COCs are identified, then additional action may be warranted, such as an FS (not included under the scope of this RI). PRGs would be derived in the FS such that the resulting cumulative cancer risk is less than 1E-4 and the target organ HI is less than 1.

2.5 Uncertainty Analysis

Within any of the steps of the HHRA process, assumptions must be made due to a lack of absolute scientific knowledge. Some of the assumptions are supported by considerable scientific evidence, while others have less support. Every assumption introduces some degree of uncertainty into the HHRA process. Regulatory HHRA methodology requires that conservative assumptions be made throughout the HHRA to ensure that public health is protected. Therefore, when all the assumptions are combined, it is much more likely that potential risks are overestimated rather than underestimated.

The assumptions that introduce the greatest amount of uncertainty in the HHRA, both facility-specific and those inherent to the HHRA process, will be discussed in the uncertainty section of the HHRA. Examples of facility-specific uncertainties are those associated with sampling/analysis methods, the COPC selection process, estimation of EPCs, representativeness of the exposure scenarios and input parameters, the availability of toxicity values, etc. Examples of uncertainties inherent to the HHRA process are the extrapolation of toxicity from animal studies to humans, from high to low doses, and the specific models used to develop dose-response values; the combination of upper-bound exposure estimates with upper-bound toxicity estimates, etc. Most of the uncertainties associated with the HHRA will be discussed in qualitative terms because, for most of the assumptions, there is not enough information to assign a numerical value to the uncertainty that can be factored into the calculation of potential risk.

3.0 Ecological Risk Assessment

The purpose of the ERA will be to evaluate potential ecological effects of exposures to facility-related PFAS detected in on- and off-facility media, which will include soil and may include sediment, surface water, porewater, and/or seep water, as applicable. The outcome of the ERA will provide input to remedial decision-making that will protect the health of local populations and communities of biota. The ERA will be conducted in accordance with USEPA and USACE risk assessment guidance and policies, as applicable.

The framework for the ERA will be consistent with USEPA methodology based on the following key guidance documents:

- USEPA. 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments - Interim Final.* US Environmental Protection Agency, OSWER, Office of Emergency and Remedial Response. EPA 540/R-97/006. June.
- USEPA. 1998. *Guidelines for Ecological Risk Assessment*. US Environmental Protection Agency, Washington, D.C. EPA/630/R-95/002F. April.
- USEPA. 2001b. *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments*. ECO Update, Intermittent Bulletin. US Environmental Protection Agency, OSWER. EPA 540/F-01/014. Publication 9345.0-14.
- Tri-Services Environmental Risk Assessment Work Group (TSERAWG). 2008. *A Guide to Screening Level Ecological Risk Assessment*. TSERAWG TG-090801.
- USEPA. 2005b. *Guidance for Developing Ecological Soil Screening Levels – Revised Draft*, OSWER Directive 9285.7-55. February.
- DA. 2010. *Risk Assessment Handbook, Volume II: Environmental Evaluation*. Engineer Manual. Department of the Army, U.S. Army Corps of Engineers. Washington, DC 20314-1000. EM 200-1-4. 31 December.

The PFAS technical documents and tools developed by the DoD Environmental Security Technology Certification Program (ESTCP) and Strategic Environmental Research and Development Program (SERDP) and the recently published guidance from the Argonne National Laboratory (Argonne) will also be considered for assessing ecological risk due to exposure to PFAS:

- Grippo, M., J. Hayse, I. Hlohowskyj, and K. Picel. 2021. *Derivation of PFAS Ecological Screening Values.* Argonne National Laboratory. September.
- Conder, J., J. Arblaster, E. Larson, J. Brown, and C. Higgins. 2020. *Guidance for Assessing the Ecological Risks of PFASs to Threatened and Endangered Species at Aqueous Film Forming Foam-Impacted Sites*. SERDP Project ER18-1614. January.
- Divine, C., J. Zodrow, M. Frenchmeyer, K. Dally, E. Osborn, and P. Anderson. 2020. *Approach for Assessing PFAS Risk to Threatened and Endangered Species.* SERDP Project ER18-1653. March.

The Argonne report (Grippo et al. 2021) is the most recently released ERA guidance for PFAS. The ecological screening values (ESVs) derived in the Argonne report were developed in consultation with an interagency team of subject-matter experts from across the DoD services through the DoD Tri-Services ERA Work Group, including experts from the USEPA ERA Forum, to support screening-level assessments at US Air Force, Navy, Army, and other DoD sites.

Although the latter two guidance documents listed above emphasize protection of threatened and endangered species, which may or may not be relevant to a given site, information provided therein can also be applied in ERAs for common species. These documents represent the most comprehensive ERA tools currently available. New ecotoxicity data are continuously being generated for PFAS, and additional sources of screening benchmarks and toxicity reference values (TRVs) will be consulted at the time of the ERA to ensure that the most recent toxicity data are used in the risk characterization.

Given the rapidly evolving nature of PFAS ecotoxicity and exposure evaluation methods, and regulatory and DoD guidance, significant developments may occur within the project's timeframe. To the extent reasonable and relevant, such developments will be incorporated in the proposed ERA.

A tiered approach will be followed that incorporates different levels of assessment complexity and provides an opportunity to off-ramp from the ERA process prior to proceeding to the next tier based on the available findings. The tiered approach may be implemented in its entirety depending on the level and magnitude of risk that is determined in prior tiers. This approach consists of the following two tiers as summarized below:

- Tier 1 – Screening-Level Ecological Risk Assessment (SLERA) and
- Tier 2 – Baseline Ecological Risk Assessment (BERA).

Tier 1 – Screening-Level Ecological Risk Assessment

The primary objective for a SLERA is to determine which, if any, exposure pathways and chemicals of potential ecological concern (COPECs) warrant immediate action or require further evaluation in a more refined ERA. The SLERA consists of Steps 1 and 2 of the eight-step EPA ERA (USEPA, 1997) process and includes the following activities:

- Identification and summarization of relevant datasets,
- Development of a CSM that identifies potentially complete exposure pathways for ecological receptors, and
- Comparison of EPCs to ecological SLs to identify COPECs.

Based on the outcome of the SLERA, certain media, COPECs, and pathways may be eliminated from further evaluation due to the level of conservatism built into the SLERA process. If potentially complete and significant ecological exposure pathways are identified, and maximum concentrations of certain COPECs exceed the generic SLs, additional evaluation may be recommended.

Prior to beginning problem formulation in the BERA (Step 3), the results of the SLERA may be refined in Step 3a, as described below. The decision to continue beyond the SLERA does not indicate the potential for adverse ecological effects or that risk reduction is necessary; rather, it indicates that a more focused evaluation and characterization of the potential for risk and accompanying uncertainty is needed (DA, 2010).

Tier 2 – Baseline Ecological Risk Assessment

The primary purpose of the BERA is to assess the potential for adverse effects on the focused list of ecological receptors due to exposure to the COPECs identified upon completion of the SLERA. The BERA includes Steps 3 through 7 of the eight-step EPA ERA process (USEPA, 1997) and uses facility-specific information whenever possible:

Step 3a provides a refinement of the conservative assumptions and resulting risk estimates (e.g., HQs) identified in the SLERA. This step is conducted to refine some of the conservative assumptions used in the SLERA and assess whether more realistic assumptions would reduce the HQs to below unity prior to implementing a facility specific BERA with associated sampling and analyses. A weight-of-evidence evaluation that considers the Step 3a results, available habitat, wildlife management goals for the areas evaluated, and other relevant factors as appropriate will be conducted to determine whether a full BERA is recommended.

Steps 3b through 7 are conducted for pathways and COPECs retained after the completion of Step 3a. These steps include refining the endpoints to be evaluated, the laboratory and field methods to be used to collect additional data, the statistical analyses to be used for evaluating data, and the methods to be used for estimating and characterizing the potential for adverse effects on ecological receptors.

For the Santa Fe AASF evaluation, it is anticipated that a SLERA and Step 3a SLERA refinement will be completed, as needed, using the data collected under the SI and RI. If Step 3a identifies the need for further evaluation, an additional sampling effort may be proposed to support the BERA and additional BERA details will be provided prior to the sampling effort. Risk management decisions related to performing a full BERA and the need for additional facility-specific sampling efforts to support a BERA will be made by the project team.

The following sections provide additional details for the ERA in the context of the following fundamental ERA components:

- Problem Formulation,
- Ecological Effects Assessment and Exposure Assessment, and
- Risk Characterization.

Facility-specific details are provided in the CSM presented in the QAPP (Worksheet #10) and in the ecological CSM figure (**Figure 2**).

3.1 Problem Formulation

The Problem Formulation provides the framework for the ERA and serves to define the risk assessment objectives and identify the ecological receptors, exposure pathways, and endpoints to be evaluated. These components are presented in the following sections.

3.1.1 Environmental Setting

Sections 1.0 and 1.1 provide a facility description, including land use, hydrogeology, and hydrology. The environmental setting information provided below was primarily obtained from the SI Report completed by EA in October 2023. As discussed in **Section 1.1**, the overall facility encompasses approximately 33 acres (0.05 square miles) within Santa Fe County, of which 22 acres are covered by pavement and buildings and 11 acres consist of disturbed, non-paved land surrounding the buildings and paved areas. AOI 1 is within the paved helicopter parking apron, which is centrally located within the facility and adjacent to buildings, additional pavement, and disturbed land (mix of scrub vegetation and bare soil). Therefore, ecological exposures to PFAS in AOI 1 soil adjacent to the apron are expected to be low under current conditions. The historical potential release area (WWTP Biosolid Surface Disposal Site) is in the northeastern portion of the facility, consisting of a paved vehicle parking area and disturbed land (mix of vegetation and bare soil). Thus, ecological exposures to PFAS in soil within this area are also expected to be low under current conditions.

The facility's topography is relatively flat. As previously discussed, stormwater from the historical helicopter parking apron and other paved areas historically flowed to the southwest, as well as potentially accumulating on either side of the taxiway. Currently, there are two shallow stormwater detention basins south of the helicopter parking apron that receive water from the tarmac and a retention basin north of the Readiness Center that receives runoff from the paved areas of the facility and has an outflow just outside the north facility boundary. The OWS outflow for the AASF's fueling point is also located outside the north boundary.

During the SI, perched groundwater was encountered on the west side of the facility at depths of 110-111 feet bgs (flow direction could not be ascertained), while regional groundwater was observed at 176-185 feet bgs and flows southwest at the facility (see Section 1.1 and QAPP Figure 10-4).

Terrestrial habitat for wildlife on-facility is limited to disturbed land adjacent to the tarmac, buildings, and other paved areas within the fenced facility due to continuing military activities. The AOI and over half of the Historical WWTP Biosolid Surface Disposal Site are paved, with the remaining portion of the biosolid disposal site and the surrounding land comprised of disturbed land with a mix of scrub vegetation and bare soil. Although the facility does not have any significant areas of ecological habitat and the fragmented areas of disturbed land that surround the tarmac, buildings, and other paved areas are expected to offer limited habitat for foraging by ecological receptors, there is evidence of ecological use by burrowing animals (i.e., burrows are present along the eastern portion of the facility) which may attract other wildlife (e.g., birds of prey). Therefore, it is conservatively assumed that plants and soil invertebrates in these maintained areas could serve as minimal food sources for small birds and mammals if they forage there. Animal species that may occur in these marginal terrestrial habitats include the black-tailed prairie dog (*Cynomys ludovicianus*) or Gunnison's prairie dog (*Cynomys gunnisoni*), European starling (*Sturnus vulgaris*), house sparrow (*Passer domesticus*), and potentially burrowing owl (*Athene cunicularia*). As discussed in Section 1.2, two off-facility surface soil samples will be collected during the Prescriptive Phase to evaluate the potential for off-facility migration to the adjacent City of Santa Fe property to the north. If the Prescriptive Phase results indicate PFAS impacts from the facility have occurred to this adjacent off-facility area, then it will also be assumed that this area would support ecological receptors like those described above for on-facility.

The stormwater detention basins and retention basin are dry most of the time, except during and after rainfall events and snowmelt. It is anticipated that these stormwater features provide terrestrial habitat similar to surrounding areas (i.e., disturbed land with mix of bare soil and scrub vegetation). Given the ephemeral nature of water in these stormwater features, the soil substrate may be considered sediment only seasonally. Additionally, due to the lack of hydrological connection to natural water features (e.g., upgradient creeks/streams), these on-facility stormwater features are not anticipated to support a viable aquatic or sediment community (e.g., aquatic invertebrates, benthic invertebrates) (Nadeau and Rains, 2007; USEPA, 2008).

The Santa Fe River is located approximately 0.5 miles northwest of the facility. This segment of the river is a seasonally flooded riverine habitat (i.e., ephemeral) that intermittently provides aquatic habitat, flowing northwest to southwest when water is present. Habitats adjacent to the river include seasonally flooded and semi-permanently flooded freshwater wetlands and riparian forest/shrub areas (USFWS, 2024a). In addition, Arroyo Hondo and Cienega Creek, both of which are ephemeral (i.e., seasonally contain water after rain or snowmelt), are located south/southeast of the facility (≥1 mile). These off-facility habitats are expected to support a community of terrestrial and (seasonally) aquatic-dependent wildlife. Potential PFAS impacts from the facility have not been established and migration pathways will be assessed during the RI. If Prescriptive Phase and/or Adaptive Phase results warrant, surface water and sediment samples may be collected from the on-facility stormwater features (if sufficient standing water is present to support aquatic life and wetland plant species are present). If Prescriptive Phase and/or Adaptive Phase results warrant, sediment, surface water, porewater, and/or seep water may be collected from off-facility water features (e.g., ephemeral surface water features such as Santa Fe River, Arroyo Hondo, Cienega Creek) (see Section 1.2).

As described in QAPP Worksheet #14, a habitat assessment will be performed as part of the RI. The habitat assessment will occur within the same timeframe as the field sampling. Field staff will assess the characteristics of the available habitats associated with the AOI sampling locations and downgradient areas where PFAS may have migrated. The habitat assessment will be used to evaluate potential terrestrial habitat at the facility (i.e., vegetation cover in and around the facility), as well as potential semi-aquatic and aquatic habitat that may be affected by PFAS from the facility, such as the on-facility stormwater features and off-facility aquatic habitats (e.g., ephemeral surface water features such as Santa Fe River, Arroyo Hondo, Cienega Creek). In particular, the habitat assessment will confirm the presence/absence of standing water sufficient to support aquatic life and wetland plant species within the stormwater features, information that will be used to determine whether ephemeral aquatic habitat is present. If only terrestrial habitat is confirmed for the stormwater features (i.e., lack of ephemeral aquatic plants), the substrate collected within the stormwater features will be considered soil and evaluated as terrestrial habitat.

Field staff will record any observations of common species (including the presence of burrows, scat, nests, etc.) and characteristics of vegetation communities and habitats in the area. Field staff will also be familiar with the habitat requirements and appearance of the federal and state listed species previously identified as having the potential to occur in the area and will record any related observations.

3.1.1.1 Threatened/Endangered Species and Critical Habitat

Santa Fe AASF is a highly developed facility with limited disturbed land (mix of scrub vegetation and bare soil) and is unlikely to provide habitat for rare species. To verify, a desktop review was conducted for information regarding the potential presence of and habitat for threatened, endangered, or other special concern species near the Santa Fe AASF. To evaluate federal listed species occurring in the vicinity of the facility, the United States Fish and Wildlife Service (USFWS) online *Information for Planning and Consultation* (IPaC) system (USFWS, 2024b) was queried for a list of federal endangered, threatened, proposed, or candidate species and designated critical habitats that may occur in the vicinity. The IPaC report is included in **Attachment A-1**. The following table identifies the species from the IPaC report and evaluates for each species the potential for suitable habitat to be present at the AOIs.

The table below identifies the federally listed species with the potential to occur in the vicinity of the facility and whether the AOIs are likely to provide suitable habitat for those species.

Species [a]	Federal Status [a,b]	Preferred Habitat [c]	Notes Regarding Suitability of Available Habitat at AOIs [d]	Suitable Habitat at AOIs?
Mexican Spotted Owl (*Strix occidentalis lucida*)	T	Uses old-growth or mature forests that possess complex structural components, including uneven aged stands, high canopy closure, multi-storied levels, high tree density, or canyons with riparian or conifer communities.	The developed facility does not provide suitable habitat. Suitable habitat may be present off-facility along the riparian forest/shrub habitat adjacent to the Santa Fe River.	No
Yellow-billed Cuckoo (*Coccyzus americanus*)	T	Uses wooded habitat with dense cover and water nearby, including woodland with low, scrubby, vegetation; overgrown orchards; abandoned farmland; and dense thickets along streams and marshes.	The developed facility does not provide suitable habitat. Suitable habitat may be present off-facility along the riparian forest/shrub habitat adjacent to the Santa Fe River.	No
Rio Grande Cutthroat Trout (*Oncorhynchus clarkii virginalis*)	C	Occurs in the Rio Grande, Pecos, and possible the Canadian River Basins.	The developed facility does not provide suitable habitat. Suitable habitat may intermittently be present off-facility within the Santa Fe River (i.e., during seasonal flooding).	No
Monarch butterfly (*Danaus plexippus*)	C	Fields and other open areas with herbaceous vegetation. Caterpillars feed only on milkweed (*Asclepias* species). Adults feed on nectar of milkweed and other flowering plants.	The developed facility does not provide suitable habitat. Preferred habitat and milkweed may occur off-facility.	No

Notes:

(a) Source: *Information for Planning and Consultation* (IPaC) report for the facility (USFWS, 2024b)
(b) Listing status: T = threatened; C = candidate for listing
(c) Source: Habitat information accessed via links to species profiles provided in IPaC report (USFWS, 2024b)
(d) Source: interpretation of aerial and site visit photos

The closest designated critical habitat for the Mexican spotted owl is approximately 12 miles to the northwest of Santa Fe AASF, while the closest critical habitat for the yellow-billed cuckoo is more than 30 miles from the facility. No critical habitat has been designated by USFWS for the Rio Grande cutthroat trout or monarch butterfly (USFWS, 2024b).

Attachment A-2 includes a list of rare species with state listing status (endangered, threatened, or special concern) and recorded occurrences in Santa Fe County from the Biota System of New Mexico (BISON-M) (New Mexico Department of Game and Fish, 2024). This list consists of 12 species of birds, 3 species of mammals, and 1 species of mollusk. Of the bird species, the

Mexican spotted owl and yellow-billed cuckoo, which are also federally listed, were discussed above. In addition, the meadow jumping mouse (*Zapus luteus luteus*) and southwestern willow flycatcher (*Empidonax traillii extimus*) are also federally listed but were not identified via the IPaC report and are not likely to occur at the facility due to lack of suitable riparian/wetland habitat at or adjacent to the facility, but suitable habitat may be present off-facility along the riparian and wetland habitat adjacent to the Santa Fe River (i.e., 0.5 miles northwest of the facility). Given their habitat requirements, none of the remaining species with state status are likely to occur at or in close proximity to the facility. However, the Santa Fe River provides riparian forest/scrub and wetland habitat, while the Santa Fe River, Arroyo Hondo, and Cienega Creek provide seasonally aquatic habitat that may support several species with state status, including broad-billed hummingbird (*Cynanthus latirostris*), violet-crowned hummingbird (*Leucolia violiceps*), least tern (*Sternula antillarum*), peregrine falcon (*Falco peregrinus*), gray vireo (*Vireo vicinior*).

As noted above, field staff conducting habitat assessments will be familiar with the habitat requirements and appearance of the federal and state listed species identified as having the potential to occur in the vicinity of the facility and will record any observations regarding their presence or absence.

3.1.2 Selection of Receptors and Exposure Pathways

Potentially complete exposure pathways for ecological receptors to facility-related PFAS detected in on- and off-facility media will be evaluated in the SLERA. Each exposure pathway includes a potential source of COPECs, an environmental medium, and a potential exposure route. In accordance with agency guidance, incomplete routes of exposure will not be evaluated. This approach is used to focus the assessment on exposure pathways that are considered potentially complete and for which there are adequate data pertaining to the receptors, their exposures, and their susceptibility to toxic effects.

Soil and groundwater may have been impacted by PFAS releases associated with historical ARNG activities on the facility. Unless the habitat assessment indicates otherwise, it is anticipated that the on-facility stormwater features will be evaluated as terrestrial habitat and the collected substrate treated as soil given the ephemeral nature of water in these stormwater features, the lack of hydrological connection to natural water features (e.g., upgradient creeks/streams), and because they are not anticipated to support sediment- or aquatic-dependent receptors (e.g., benthic or aquatic invertebrates).

The primary exposure pathways for ecological receptors in upland areas with viable terrestrial habitat are exposures through direct contact with surface soil by terrestrial receptors (e.g., plants, soil invertebrates, amphibians, reptiles, birds, and/or mammals). Indirect contact (via bioaccumulation) is a potentially complete pathway of exposure for amphibians, reptiles, birds, and mammals through ingestion of plants and prey contaminated by uptake of PFAS from soil. Incidental ingestion of soil is also a potentially complete exposure pathway for terrestrial animals. While most terrestrial ecological exposures occur within surface soil (USEPA, 2015), burrowing wildlife (e.g., birds, mammals, reptiles), soil invertebrates, or deeply rooted vegetation, if present, may also be exposed to subsurface soil. It is conservatively assumed that ecological receptors may contact PFAS in soil within terrestrial habitats at the facility.

Aquatic habitat media (sediment, surface water, porewater, and/or seep water) will not be collected during the Prescriptive Phase. If Prescriptive Phase and/or Adaptive Phase results warrant, surface water and sediment samples may be collected from the on-facility stormwater features (if sufficient standing water is present to support aquatic life and wetland plant species are identified). If Prescriptive Phase and/or Adaptive Phase results warrant, sediment, surface water, porewater, and/or seep water may be collected from off-facility surface water features (e.g., ephemeral surface water features such as Santa Fe River, Arroyo Hondo, Cienega Creek).

Therefore, potential surface water and sediment exposure pathways are discussed below. If these pathways are determined to be complete and applicable data collected, they will be evaluated in the SLERA. If the pathways are not complete, they will not be evaluated quantitatively.

The primary exposure pathways for receptors in the potential semi-aquatic habitats associated with the stormwater features (if identified by the habitat assessment) and/or the off-facility aquatic habitat (e.g., ephemeral surface water features such as Santa Fe River, Arroyo Hondo, and/or Cienega Creek) are exposures through direct contact with sediment and surface water by amphibians, reptiles, benthic invertebrates, and aquatic organisms (e.g., aquatic plants, invertebrates). Indirect contact (via bioaccumulation) is also a potentially complete pathway of exposure for amphibians, reptiles, aquatic organisms (e.g., invertebrates and fish), benthic invertebrates, and aquatic-dependent birds and mammals consuming plants and prey that accumulate PFAS. Fish would not be present in the on-facility stormwater features, but fish in the Santa Fe River may be exposed to PFAS if off-facility migration pathways to the river are complete. In addition, sediment porewater and/or seep water may also be media collected, if warranted, for evaluation of the surface water and sediment exposure pathways at off-facility aquatic habitats.

PFAS may have migrated from AOI 1 and/or the Historical the WWTP Biosolid Surface Disposal Site via stormwater into off-facility drainage features. The stormwater detention basins south of the helicopter parking apron do not appear to have any outflow, and stormwater infiltrates the substrate. The retention basin north of the Readiness Center has an outflow just outside the north facility boundary, and the OWS outfall for the AASF's fueling point is also located outside the north boundary. Dry drainage features visible from both outfalls heading northwest are apparent in imagery but appear to dissipate after a short distance. As such, it is assumed there is no direct overland pathway between the AASF and off-facility water features (e.g., the Santa Fe River, Arroyo Hondo, Cienega Creek), and much of the outfall discharge likely infiltrates into the subsurface. If the habitat assessment indicates that semi-aquatic habitat is present in the on-facility stormwater features or adjacent off-facility drainage features to which the facility retention basin outflows and the OWS outflow discharges (to the north of the facility), then ecological receptors may seasonally contact PFAS in surface water and sediment within these semi-aquatic habitats.

There are no complete pathways for direct exposure of ecological receptors to groundwater at Santa Fe AASF. However, exposure to PFAS present in groundwater may occur when groundwater discharges or seeps into a surface water body (e.g., off-facility ephemeral water features such as the Santa Fe River, Arroyo Hondo, Cienega Creek). Given the length of time since the AFFF releases, PFAS contamination at the AASF may have leached to groundwater. As discussed in Sections 1.1 and 3.1.1, measurements made during the SI indicate that regional groundwater flows south-southwest toward the Santa Fe River, while the flow of perched groundwater is unknown. The potential for PFAS present in groundwater to discharge to off-facility water features will be investigated during the RI. If the groundwater-to-surface water migration pathway from Santa Fe AASF in confirmed, then ecological receptors may contact PFAS in the aquatic habitat media (sediment, surface water, porewater, and/or seep water) within the off-facility water features.

The following exposure pathways will be evaluated in the SLERA:

- Soil invertebrates, amphibians, and reptiles exposed to PFAS in surface soil (0 to 1-foot bgs) via direct contact and incidental ingestion.
- Terrestrial plants exposed to PFAS in surface soil via root uptake, as well as deeply rooted plants (shrubs/trees) exposed to PFAS in sub-surface soils (1 to 6 feet bgs) via root uptake.

- Terrestrial birds and mammals exposed to PFAS through incidental ingestion of surface soil and by ingestion of contaminated plants and prey items impacted by bioaccumulation of PFAS from surface soil. In addition, burrowing animals may be exposed to PFAS in sub-surface soils through incidental soil ingestion while digging and grooming.

The following exposure pathways may be evaluated in the SLERA, if they are determined to be complete:

- Terrestrial and aquatic-dependent birds and mammals may be exposed to PFAS through ingestion of surface water as drinking water if surface water is ephemerally present within the stormwater features.
- Amphibians, reptiles, and aquatic organisms (e.g., aquatic plants, aquatic invertebrates) exposed to PFAS in surface water associated with stormwater features and/or exposed to PFAS in surface water and/or seep water in off-facility water features via direct contact, ingestion, or bioaccumulation.
- Amphibians, reptiles, aquatic organisms (e.g., aquatic plants, aquatic invertebrates), and benthic invertebrates exposed to PFAS in sediment associated with stormwater features and/or to PFAS in sediment and/or sediment porewater associated with off-facility water features via direct contact, ingestion, or bioaccumulation.
- Aquatic-dependent birds and mammals exposed to PFAS through incidental ingestion of sediment, incidental or intentional ingestion of surface water, and ingestion of contaminated plant and prey items impacted by bioaccumulation of PFAS from media associated with stormwater features and/or off-facility water features (e.g., sediment, surface water, porewater, and/or seep water).

Some potentially complete exposure pathways may be considered qualitatively in the SLERA if appropriate methods for quantifying exposure or effects are not available. These include most exposure pathways for amphibians, reptiles, and benthic invertebrates (due to a lack of receptor-specific toxicity data for most PFAS) and trophic transfer/bioaccumulation exposure pathways for aquatic organisms and benthic invertebrates (due to a lack of pathway-specific exposure and toxicity data).

3.1.3 Selection of Ecological Endpoints

Based on the identification of potentially complete exposure pathways, assessment endpoints and measures of effect were identified. Assessment endpoints describe the characteristics of an ecosystem that have an intrinsic environmental value to be protected. Typically, assessment endpoints and receptors are selected based on consideration of their potential for exposure, susceptibility to toxic effects, ecological significance, economic importance, and/or societal relevance. Assessment endpoints usually focus on protection at the population level for common species and at the individual level only for rare species (e.g., federal or state listed species). The SLERA represents a very conservative, screening-level assessment that considers the available habitat within the exposure areas (e.g., AOI 1, Historical WWTP Biosolid Surface Disposal Site, downgradient areas) and the management goals of the facility, as appropriate. The assessment endpoints are stated in generic terms in the SLERA. More specific assessment endpoints will be developed in a BERA, as needed.

Based on the general exposure pathways identified at the facility, the assessment endpoints on the table below and their associated measures of effect will be addressed in the SLERA through comparison of media concentrations to appropriate screening values. In an ERA, the potential for adverse effects is typically evaluated at the population or community level rather than the individual level. Protection at the individual level will be afforded to special status species if present in the vicinity of areas impacted by PFAS. Field staff will assess the available habitats and potential for the presence of special status species as part of the habitat assessment conducted in the vicinity of the sampling locations.

In the SLERA, an exceedance of a screening value does not indicate that an adverse effect is occurring, only that further evaluation is needed. If concentrations of certain PFAS exceed available screening values, additional evaluation may be conducted in a SLERA refinement step (referred to as Step 3a and described in **Section 3.5**). Observations made during the habitat assessment described in QAPP Worksheet #14 may be considered in the characterization of potential adverse effects, if identified, based on comparisons to screening values.

Assessment Endpoint	Measure of Effect
Protection and maintenance of indigenous terrestrial plant and soil invertebrate communities within viable upland habitat at levels similar to those of nearby communities not exposed to facility related PFAS.	Comparison of concentrations of PFAS in surface soil to soil screening values derived for the protection of soil invertebrates. Comparison of concentrations of PFAS in surface soil and subsurface soil to soil screening values derived for the protection of plants. PFAS with detected concentrations above screening values will be identified as preliminary COPECs for plants and soil invertebrates that warrant further evaluation in Step 3a.
Protection and maintenance of terrestrial bird populations, including burrowing birds, that may forage within viable upland habitat at levels similar to those of nearby populations not exposed to facility related PFAS.	Comparison of concentrations of PFAS in surface soil and subsurface soil to soil screening values derived for the protection of birds. PFAS with detected concentrations above screening values will be identified as preliminary COPECs for terrestrial birds that warrant further evaluation in Step 3a.
Protection and maintenance of terrestrial mammal populations, including burrowing mammals, that may forage within viable upland habitat at levels similar to those of nearby populations not exposed to facility related PFAS.	Comparison of concentrations of PFAS in surface soil and subsurface soil[1] to soil screening values derived for the protection of mammals. PFAS with detected concentrations above screening values will be identified as preliminary COPECs for terrestrial mammals that warrant further evaluation in Step 3a.
Protection and maintenance of benthic invertebrate communities, if present in aquatic habitats and the aquatic exposure pathway is complete, at levels similar to those of nearby communities not exposed to facility related PFAS.[1]	Comparison of concentrations of PFAS in sediment from aquatic habitats, if collected, to freshwater sediment screening values derived for the protection of invertebrates. PFAS with detected concentrations above screening values will be identified as preliminary COPECs for benthic invertebrates that warrant further evaluation in Step 3a.
Protection and maintenance of aquatic organism communities (e.g., plants, invertebrates, amphibians), if present in aquatic habitats and the aquatic exposure pathway is complete, at levels similar to those of nearby communities not exposed to facility related PFAS.[1]	Comparison of concentrations of PFAS in surface water, porewater, and/or seep water from aquatic habitats, if collected, to freshwater surface water screening values. PFAS with detected concentrations above screening values will be identified as preliminary COPECs for aquatic organisms that warrant further evaluation in Step 3a.

Assessment Endpoint	Measure of Effect
Protection and maintenance of aquatic-dependent wildlife populations (i.e., birds and mammals) that may forage within aquatic habitats, if the aquatic exposure pathway is complete (i.e., determined to be potentially impacted), at levels similar to those of nearby populations not exposed to facility related PFAS.[1]	Comparison of concentrations of PFAS in sediment, surface water, porewater, and/or seep water from aquatic habitats, if collected, to surface water and sediment screening values derived for the protection of birds and mammals. PFAS with detected concentrations above screening values will be identified as preliminary COPECs for aquatic-dependent wildlife that warrant further evaluation in Step 3a.

[1] Fish are not expected to be present within the stormwater features but may be seasonally present in an off-facility aquatic habitat.

In cases where receptor-specific PFAS screening values are not available, exposure pathways will be discussed qualitatively. For example, screening values for reptiles or amphibians are generally not available so quantitative evaluations are not possible.

3.1.4 Conceptual Site Model

The problem formulation step supports the development of an ecological CSM that describes the origin, fate and transport, exposure pathways, and receptors of concern for the COPECs identified. The ecological CSM provides a clear and concise description of how ecological receptors may contact facility related COPECs via release mechanisms and exposure to soil, sediment, surface water, porewater, and/or seep water. The ecological CSM provides the framework for the ERA and will be used to identify appropriate exposure pathways and receptors for evaluation. **Figure 2** provides the ecological CSM for the terrestrial and aquatic habitats potentially associated with the AOI. Because the CSM will be refined during each sampling phase, the CSM figure may identify potentially complete pathways that may ultimately be incomplete.

As described in QAPP Worksheet #10, PFAS are water soluble and can migrate readily from soil to groundwater or surface water via leaching and run-off. The ERA will not utilize groundwater data given that there are no complete exposure pathways between groundwater and ecological receptors. If migration pathways from Santa Fe AASF groundwater to surface water are confirmed, sediment, surface water, porewater, and/or seep water samples may be collected from the potentially impacted off-facility water feature (e.g., the Santa Fe River, Arroyo Hondo, Cienega Creek) during the Adaptive Phase in a later mobilization that would be described in future planning documents. If collected, the sediment, surface water, porewater, and/or seep water data would be used to assess ecological risk to aquatic and/or aquatic-dependent ecological receptors.

PFAS in surface soil (0 to 1-foot bgs) may be contacted directly by terrestrial plants, soil invertebrates, amphibians, reptiles, birds, and mammals living in the soil or on the soil surface. Terrestrial wildlife could be exposed to PFAS in surface soil through incidental ingestion of soil while foraging, feeding, or grooming and through ingestion of contaminated plants and prey. Deep-rooted shrubs or trees may be directly exposed to subsurface soil (1 to 6 feet bgs). Burrowing wildlife may also be exposed to subsurface soil through incidental soil ingestion while digging and grooming.

PFAS in surface water and sediment within the potential semi-aquatic habitat associated with the stormwater features (if sufficient standing water is present to support aquatic life and wetland plants are present) and in sediment, surface water, porewater, and/or seep water from off-facility aquatic habitat (if identified as potentially impacted by PFAS containing groundwater) may be contacted directly by aquatic plants, aquatic and benthic invertebrates, and fish (only potentially seasonally in Santa Fe River), as well as by aquatic-dependent wildlife (amphibians, reptiles, birds, and mammals). Wildlife foraging within aquatic habitats could also be exposed to chemicals in these media through incidental ingestion of sediment, intentional ingestion of water by drinking, and by ingestion of contaminated plants and prey. Incidental ingestion and bioaccumulation are also potentially complete exposure pathways for amphibians, reptiles, aquatic organisms (e.g., invertebrates and fish), and benthic invertebrates.

The findings of the habitat assessment described in QAPP Worksheet #14 will be used to refine or confirm the receptors and exposure pathways identified in the CSM.

3.2 Screening-Level Ecological Effects Assessment and Exposure Assessment

This phase of the SLERA is based on the CSM developed in the problem formulation and characterizes potential ecological exposures and corresponding effects. The ecological exposure assessment involves the identification of potential exposure pathways and an evaluation of the magnitude of exposure by identified ecological receptors. The ecological effects assessment describes the potential adverse effects to ecological receptors from exposure to COPECs in environmental media. The data and methods that will be used to identify and characterize ecological exposure and effects are described in the following subsections.

3.2.1 Data Evaluation and Identification of COPECs

COPECs will be identified by comparing media-specific concentrations to ESVs protective of a range of ecological receptors. Analytical data will be grouped and evaluated for inclusion in the SLERA, as discussed in **Section 1.2**. COPECs will be identified by exposure area, medium, and depth interval (as appropriate). The soil sampling design for the Prescriptive Phase of sampling is described in QAPP Worksheet #17. As noted previously, sediment, surface water, porewater, and seep water will not be collected during the Prescriptive Phase. If warranted based on the results of the Prescriptive Phase and/or Adaptive Phase, sediment, surface water, porewater, and/or seep water samples may be collected during the Adaptive Phase in a later mobilization that would be described in future planning documents. Similar to the HHRA COPC selection process, preliminary PFAS COPECs will be identified in the SLERA based on a comparison of the maximum detected concentrations of each detected PFAS per medium/area/depth interval (as applicable) to the relevant ESVs. UCLs calculated using the most current version of USEPA's ProUCL software (USEPA, 2022b) may be used to refine the SLERA findings in Step 3a (as described in **Section 3.5**). The ESVs used for preliminary screening of soil, sediment, surface water, porewater, and/or seep water concentrations will be based on conservative endpoints and sensitive ecological effects data so that they are protective of a wide range of potential ecological receptors.

PFAS detected at concentrations above the ESVs will be identified as preliminary COPECs for further evaluation in the Tier 2 Step 3a refinement (as described in **Section 3.5**).

3.2.2 Ecological Effects Assessment

The preliminary ecological effects evaluation is an investigation of the relationship between the exposure to a chemical and the potential for adverse effects resulting from exposure. In this step, conservative ESVs for the ecological media of interest are identified.

Receptor- and media-specific ESVs will be used in the SLERA to identify preliminary COPECs and evaluate the potential for adverse effects on ecological receptors. These ESVs will be based on conservative endpoints and sensitive ecological effects data and will be used for a preliminary screening of PFAS levels to determine if there is a need to conduct further analyses or investigations.

The selected ESVs will focus on protecting most of the exposed receptors (e.g., 95% of exposed taxa) from adverse effects related to survival, growth, and reproduction under conditions of chronic or sensitive life-stage exposure. Currently, ESVs for PFAS are still evolving and lack general consensus; however, there is extensive and increasing literature on biological uptake, bioaccumulation, and ecological toxicity of PFAS. USEPA has not published ESVs for PFAS[1], but DoD-funded studies under the ESTCP and SERDP have resulted in recent publications containing ecological SLs for soil, sediment, and surface water. In addition, PFAS ESVs have been developed under the Interagency Agreement between the U.S. Department of Energy, Air Force Civil Engineer Center, and Argonne (Grippo et al., 2021). These will be the primary sources used to identify ESVs.

The following key sources will be used to select the ESVs for the various media to be sampled. While the Prescriptive Phase will not include sediment, surface water, porewater, and/or seep water samples, relevant SLs are discussed in the event samples are collected during later phases. In the event that porewater and/or seep water are collected, they will be compared to surface water ESVs. The lowest of the available ESVs for each medium will be selected for the SLERA, and the more facility-specific of these ESVs will be considered for the Tier 2 Step 3a refinement, as needed. ESVs derived by Conder et al. (2020) and Divine et al. (2020) emphasize protection of threatened and endangered species, which may or may not be relevant to all sites. The use of these ESVs will be evaluated in the Tier 2 Step 3a refinement.

Soil

- Conder et al., 2020 and Divine et al., 2020. No-observed-effect concentration (NOEC) values based on survival, reproduction, or growth as the endpoint for terrestrial plants and soil invertebrates.
- Grippo et al., 2021. Geometric mean NOEC values with regard to growth or germination as the typical endpoint for terrestrial plants; and survival, reproduction, or growth as the endpoint for soil invertebrates.
- Divine et al., 2020. Risk-based screening levels (RBSLs) derived using no-observed-adverse-effect levels (NOAELs) for terrestrial wildlife and food-web models based on consumption of plant and prey items impacted by PFAS in soil. RBSLs were derived for the meadow vole (*Microtus pennsylvanicus*), short-tailed shrew (*Blarina brevicauda*), little brown bat (*Myotis lucifugus*), long-tailed weasel (*Mustela frenata*), American goldfinch (*Spinus tristis*), house wren (*Troglodytes aedon*), and red-tailed hawk (*Buteo jamaicensis*).
- Grippo et al., 2021. Geometric mean NOAEL-based ESV for terrestrial wildlife derived using food web models based on consumption of plant and prey items impacted by PFAS in soil. ESVs were derived for the meadow vole, short-tailed shrew, long-tailed weasel, mourning dove (*Zenaida macroura*), American woodcock (*Scolopax minor*), and red-tailed hawk.

Surface Water

- Conder et al., 2020. Freshwater aquatic life protection values referred to as the 5% hazardous concentration. These values are protective of 95% of aquatic species, which

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[1] USEPA published draft aquatic life ambient water quality criteria for PFOS and PFOA in April 2022. These criteria will be considered in the ERA if they are finalized before the ERA is initiated.

reflects the level of protection afforded by USEPA's National Recommended Water Quality Criteria for Aquatic Organisms (USEPA, 2022c).

- Divine et al., 2020. Chronic recommended water quality RBSLs for aquatic life derived using USEPA's Water Quality Guidance for the Great Lakes System methodology (USEPA, 2012).
- Grippo et al., 2021. Freshwater ESVs for aquatic life derived by following the two-tiered approach described in the Great Lakes Initiative (GLI) guidance (USEPA, 1995a, 1995b, 1995c). Final chronic freshwater ESVs for PFOA and PFOS are Tier I ESVs, while the remaining are Tier II ESVs.
- Divine et al., 2020. NOAEL-based RBSLs for aquatic wildlife derived using food-web models based on consumption of plant and prey items impacted by PFAS in water. RBSLs were derived for the muskrat (*Ondatra zibethicus*), little brown bat, river otter (*Lontra canadensis*), harbor seal (*Phoca vitulina*), mink (*Neovison vison*), red-winged blackbird (*Agelaius phoeniceus*), tree swallow (*Tachycineta bicolor*), and brown pelican (*Pelecanus occidentalis*).
- Grippo et al., 2021. Geometric mean NOAEL-based ESV for aquatic-dependent birds and mammals derived using food web models based on consumption of plants and prey items impacted by PFAS in surface water. A two-tiered methodology was used to develop the ESVs, based on the 1995 GLI Tier I and Tier II guidance for deriving water quality criteria to protect wildlife (USEPA, 1995b, 1995c). ESVs were derived for the belted kingfisher (*Megaceryle alcyon*), herring gull (*Larus argentatus*), osprey (*Pandion haliaetus*), mallard (*Anas platyrhynchos*), spotted sandpiper (*Actitis macularius*), mink, and river otter.
- USEPA, 2022d. USEPA's draft chronic ambient water quality criteria for PFOS and PFOA will be considered in the SLERA if they are finalized before the SLERA is performed.

Sediment

- Grippo et al., 2021. ESVs were not developed for sediment because they found that the science is not yet mature enough to develop them. Recent literature from Conder et al. (2020) and Divine et al. (2020) were reviewed and, likewise, lacked available data for deriving empirically-based SLs for benthic invertebrates.
- Divine et al., 2020. NOAEL-based RBSLs for aquatic wildlife derived using food web models based on consumption of plant and prey items impacted by PFAS in sediment. RBSLs were derived for the same aquatic-dependent wildlife listed above for surface water.

The Argonne ESV guidance (Grippo et al., 2021) is a living document that is expected to undergo revisions as the state of the science progresses, and key updates may or may not be completed by the time the SLERA is performed. In that case, the selection of Argonne ESVs will consider scientific confidence in the Argonne ESVs and new developments in PFAS ecotoxicity.

In addition to the sources of screening levels listed above, new literature sources may be considered given the ongoing research and publications on PFAS ecotoxicity. Based on a lack of toxicity information, not all individual PFAS compounds can be evaluated quantitatively in the SLERA. The basis of the selected ESVs and associated data limitations (e.g., ESVs based on limited data) will be discussed in the uncertainty section of the SLERA report.

In general, PFOS has been the focus of most regulatory interest with less toxicity data available for PFOA, PFBS, and other PFAS chemicals. In the recent SERDP studies cited above (Conder et al., 2020 and Divine et al., 2020) and Argonne report (Grippo et al. 2021), toxicity data, and other chemical-specific parameters necessary to develop terrestrial and aquatic ecological benchmarks were compiled to establish SLs for several additional PFAS chemicals.

In soil, in addition to PFOA, PFOS, and PFBS, screening values are also available for perfluorodecanoic acid (PFDA), PFNA, perfluoroheptanoic acid (PFHpA), PFHxS, PFBA, and PFHxA. For sediment and surface water, wildlife-based screening values are available for PFOA, PFOS, PFBS, PFNA, PFHxA, PFHxS (surface water only) and PFBA. For aquatic life, screening values are available for a longer list of PFAS chemicals in addition to PFOS, PFOA, and PFBS: perfluorododecanoic acid (PFDoA), perfluoroundecanoic acid (PFUdA), PFDA, PFNA, PFHxS, PFHpA, PFHxA, perfluoropentanoic acid (PFPeA), and PFBA..

Table 8 presents the PFAS ESVs for soil for plants and invertebrates. **Table 9** presents the wildlife-ESVs for soil, surface water, and sediment. **Table 10** presents the surface water ESVs for aquatic life.

There is notable uncertainty inherent in the food-chain-based ESVs protective of birds and mammals, which tend to be overly stringent. For example, surface water SLs available in the literature incorporate conservative bioaccumulation factors and biomagnification factors to estimate tissue levels in fish from water, are based on conservative avian and mammalian toxicity values, and typically assume receptors consume an exclusive diet of contaminated fish (Divine et al., 2020; Giesy et al., 2010; Dutch National Institute for Public Health and the Environment, 2010). Similarly, a soil ESV based on a small mammal consuming a diet of contaminated earthworms is also likely to be overly conservative for most sites (Divine et al., 2020; Environment and Climate Change Canada, 2017). The uncertainties related to the selected ESVs will be discussed in the context of the potential to result in an over- or under-prediction of potential adverse effects in the exposure areas.

3.2.3 Ecological Exposure Assessment

In order to conclude whether a chemical has the potential to impact an ecological receptor, a relevant chemical concentration or dose must first be determined. That concentration or dose is then compared to the ecological effects levels presented above (i.e., the ESVs). For the SLERA, the maximum detected concentration will be evaluated as the EPC. In the Tier 2 Step 3a refinement, a more realistic estimate of receptor exposures will be considered (e.g., using concentrations based on the 95% UCL).

Mechanisms for exposure of a representative species to PFAS depend on the physical and behavioral characteristics of the organism. Most exposure mechanisms for aquatic/benthic invertebrates, soil invertebrates, and plants can be loosely termed “direct contact.” Soil invertebrates can absorb chemicals from moist soil through external body surfaces or by intake of food or soil.

Wildlife species may be exposed to PFAS in soil, sediment, and surface water directly through ingestion (incidental or intentional) of these media or indirectly by ingestion of food organisms contaminated by direct uptake or food-web transfer. Most biological activity occurs at the soil surface, with deep-rooted plants and burrowing animals potentially contacting soil below the surface.

Step 2 of the of the eight-step ERA process is the screening-level exposure estimate and comparison to risk-based ESVs. In this step, the maximum detected concentrations in the relevant media will be compared to the associated ESVs. Data treatment and calculation of summary statistics for the ERA will be consistent with the rules described in **Section 1.3**. Maximum detected concentrations will be identified per exposure area and medium and will be used as the EPC for all ecological receptors in the SLERA.

3.2.4 SLERA Calculations

HQs will be calculated for each PFAS analyte in each medium (e.g., surface soil, subsurface soil, sediment, surface water, porewater, and/or seep water) by dividing the maximum detected concentrations by the relevant ESVs for terrestrial and aquatic ecological receptors using the following formula:

$$\text{HQ} = \text{Maximum detected concentration} \div \text{ESV}$$

Individual PFAS that exceed their respective ESVs (i.e., HQs > 1), and analytes, media, and receptor groups without ESVs, will be retained for further evaluation in the Tier 2 Step 3a COPEC refinement.

Due to the consistently applied conservative assumptions implicit in a SLERA, an HQ above 1 based on the maximum detected concentration as the EPC does not necessarily indicate unacceptable ecological risk. It merely indicates that a potential for adverse effects exists, and that additional consideration is warranted. If the resulting HQ is equal to or less than 1, the potential for adverse effects due to that chemical can be considered negligible and, therefore, may be dropped from further consideration for that exposure pathway (DA, 2010).

The selection of preliminary COPECs is the final part of the SLERA. Chemicals selected as preliminary COPECs based on an ESV exceedance will be further evaluated in Step 3a to determine if they should be retained as final COPECs. The preliminary COPECs will be selected if the comparison of data from the exposure media to relevant ESVs results in HQs above 1. The COPEC refinement process in Step 3a is discussed in **Section 3.5**.

3.3 Screening-Level Risk Characterization

The results of the ecological effects assessment and exposure assessment will be analyzed and interpreted to determine whether particular exposure pathways, receptors, and chemicals can be eliminated from further evaluation. The screening-level risk characterization will integrate the results of the effects assessment and exposure assessment through the calculation of HQs and provide interpretation of the ecological significance of the findings. Aspects of ecological significance that may be considered to help place the SLERA results into a broader ecological context include the management goal plans in place for the facility, the nature and magnitude of effects, the spatial and temporal patterns of effects, and the potential for recovery once a stressor has been removed. If the potential for adverse effects on ecological receptors is implied through the screening process using literature-based inputs, facility-specific validation studies (e.g., toxicity testing) conducted in the field or laboratory may be needed to verify these findings in a subsequent step of the BERA.

The documentation of the risk characterization will include a summary of assumptions, uncertainties (both generic and facility-specific), strengths and weaknesses of the analysis phase of work, and justification of conclusions regarding the ecological significance of the estimated (i.e., risk of harm) or actual (i.e., evidence of harm) potential for adverse effects. Some uncertainties bias the results of the risk assessment toward excessive (unacceptable) risk, while others may result in bias toward insignificant (acceptable) risk. All discussions of uncertainty will include examination and review of several aspects of the SLERA including, but not limited to, sampling, data quality, study design, selection of representative species, estimates of exposure, and selection of ESVs. The uncertainty section of the SLERA will identify limitations and assumptions and relate them to the potential effects these uncertainties may have on the overall conclusions of the ERA. As mentioned previously, the assumptions inherent in the derivation of ESVs for PFAS that are protective of birds and mammals, which may be highly conservative, are of particular interest in the uncertainty assessment. This is due to the strong influence of facility-specific conditions on the bioaccumulation and bioavailability potential of PFAS, as well as the relevance of the types of species upon which the ESVs are based relative to the avian and mammalian species actually present at or near the facility.

3.4 SLERA Scientific/Management Decision Point

Consistent with USEPA guidance (1997), a scientific/management decision point will be determined based on the outcome of the SLERA (Steps 1 and 2 of the eight-step USEPA process) to establish that (1) there is adequate information to conclude that ecological risks are negligible and therefore there is no need for remediation on the basis of ecological risk, (2) the information is not adequate to make a decision and the ecological risk process will continue to Step 3, or (3) the information indicates a potential for adverse ecological effects, and a more thorough assessment is warranted (e.g., additional sampling or analysis).

If the decision is made that further investigation is warranted for any specific receptors/pathways, a sub-tier of Step 3 (Step 3a) of the USEPA's eight-step ERA process may be conducted. USEPA (2001b) and DoD guidance (TSERAWG, 2008; DA, 2010) provide the basis to introduce sub-tiers into the SLERA process and the approach is described in the following sub-section.

3.5 BERA Step 3a SLERA Refinement

Step 3a, a sub-tier of Step 3 (referred to as a refinement of the SLERA by TSERAWG [2008] and DA [2010]), serves to refine the list of preliminary COPECs identified in the conservative evaluation conducted in Steps 1 and 2 by considering additional facility-specific factors. It is anticipated that any preliminary COPECs identified in soil, sediment, surface water, porewater, or seep water will be further evaluated in Step 3a. The refinement step may include comparisons against background concentrations (if available) or re-evaluation of parameters considered in the SLERA (e.g., the assumption of 100% bioavailability).

Only COPECs, pathways, and receptors retained after the Step 3a refinement process would potentially be considered for further evaluation in a BERA. In many cases, the Step 3a refinement provides the basis for defining potential risk drivers, which may be further evaluated for remedial decisions, or alternatively, a complete BERA may be initiated, which applies USEPA Step 3b through Step 8 of the ERA process. It is currently unknown if Step 3a will be warranted for any ecological receptors evaluated in the SLERA, but if so, the following discussion provides the proposed approach.

The purpose of Step 3a is to re-evaluate preliminary COPECs identified in the SLERA to identify and eliminate from further consideration those preliminary COPECs that were identified due to the use of overly conservative exposure scenarios (e.g., maximum concentrations) or effects levels (e.g., NOAEL-based ESVs). Using more realistic Step 3a assumptions, the SLERA HQs described in **Section 3.2.4** will be recalculated for the pathways and preliminary COPECs retained at the end of the SLERA, and a qualitative weight-of-evidence evaluation will be conducted to determine whether a BERA is recommended.

It is anticipated that the Step 3a re-evaluation/refinement process will include these steps:

- Calculate alternative EPCs based on 95% UCLs (rather than maximum concentrations).
- Revise ESV comparisons for community level receptors (e.g., plants and invertebrates) using alternative EPCs and alternative, less-conservative ESVs, if available, for the

particular medium and receptor group (e.g., lowest-observed-effect concentrations rather than NOECs).

- Evaluate food-web exposure assumptions and TRVs upon which the bird and mammal ESVs are based to identify exposure and effects inputs that may not be applicable to facility conditions. These inputs may include uptake factors, exposure durations, area use factors, and both NOAEL-based TRVs and TRVs based on lowest-observed-adverse-effect levels (LOAELs). Sources for uptake factors and LOAEL-based TRVs will include those used to derive NOAEL-based RBSLs considered in the SLERA as well as other sources available in the literature (e.g., Zodrow, et al., 2020; Narizzano, et al., 2021).
- Revise ESV comparisons for avian and mammalian receptors using alternative EPCs and less conservative avian and mammalian ESVs (e.g., ESVs adjusted to be more representative of receptors or conditions present at the facility). The development of facility-specific dose and hazard estimates for wildlife receptors may also be considered.
- Identify COPECs with HQs less than 1 in the Step 3a ESV comparisons and eliminate these COPECs from further evaluation.
- For COPECs with an HQ greater than 1, compare media concentrations to background levels (if available). Identify COPECs present at concentrations below or consistent with background levels and propose these for elimination from further evaluation.
- For COPECs with an HQ greater than 1, consider bioavailability; identify COPECs likely to be biologically unavailable, and propose these for elimination from further evaluation.
- Review FOD to identify COPECs with low detection frequencies (and sufficient data for acceptable exposure area characterization). If a COPEC was detected in only a very small percentage of the samples collected (5% or less), the potential for adverse effects identified in the SLERA may be overestimated, and further evaluation of the COPEC may not be warranted.
- Conduct a qualitative weight-of-evidence evaluation that considers the Step 3a ESV comparisons, available habitat within the areas evaluated, wildlife management goals for the areas evaluated, and other relevant factors, as appropriate, to determine whether a BERA is recommended.

After the re-evaluation/refinement, the decision criteria for Step 3a include:

- If the Step 3a refinement does not identify the potential for adverse effects associated with the preliminary COPECs, then a no further action designation is warranted, and the facility exits the ERA process.
- If the re-evaluation of the conservative exposure assumptions identifies the potential for adverse effects associated with the preliminary COPECs, the BERA process continues to Step 3b and subsequent steps, or to remedial decisions.

In the event a BERA is warranted, this evaluation will be focused on only those receptors, pathways, and PFAS of potential concern identified following the weight-of-evidence assessment in Step 3a. The BERA would consider more detailed aspects related to the COPECs, receptors, and exposure pathways retained at the end of Step 3a and could include food-web modelling, toxicity testing, additional habitat assessments, or collection of other facility-specific data.

3.6 Completing Steps 3b through Step 7

It is anticipated that the ERA for the exposure areas will be completed through the Step 3a phase, and a full Tier 2 BERA will not be warranted. If this is not the case, risk management decisions related to performing a BERA and the need for additional facility-specific sampling efforts to support a BERA will be made by the project team.

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Figures

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Tables

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Table 1
Values Used for Daily Intake Calculations - Soil
Reasonable Maximum Exposure
Human Health Risk Assessment
Santa Fe AASF, NM

Scenario Timeframe(s):	Current; Future
Medium:	Soil
Exposure Media:	Surface soil; Combined Surface and Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point(s)	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Incidental Ingestion	Outdoor Worker	Adult	On-facility	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
	Current/Future			IR	Ingestion Rate	100	mg/day	USEPA, 2014	CS x IR x EF x ED x CF x FI x RBA
				EF	Exposure Frequency	250	days/yr	USEPA, 2014	BW x AT
				ED	Exposure Duration	25	year	USEPA, 2014	
				FI	Fraction Ingested from Site	1	unitless	(1)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				RBA	Relative Bioavailability Factor	Chemical Specific	unitless	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	9,125	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
Incidental Ingestion	Resident	Adult	On-facility	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
	Future			IR	Ingestion Rate	100	mg/day	USEPA, 2014	CS x IR x EF x ED x CF x FI x RBA
				EF	Exposure Frequency	350	days/yr	USEPA, 2014	BW x AT
				ED	Exposure Duration	20	years	USEPA, 2014	
				FI	Fraction Ingested from Site	1	unitless	(1)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				RBA	Relative Bioavailability Factor	Chemical Specific	unitless	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
		Child	On-facility	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
				IR	Ingestion Rate	200	mg/day	USEPA, 2014	CS x IR x EF x ED x CF x FI x RBA
				EF	Exposure Frequency	350	days/yr	USEPA, 2014	BW x AT
				ED	Exposure Duration	6	years	USEPA, 2014	
				FI	Fraction Ingested from Site	1	unitless	(1)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				RBA	Relative Bioavailability Factor	Chemical Specific	unitless	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
Incidental Ingestion	Trespasser	Adolescent	On-facility	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
	Future	(7 to <16 years)		IR	Ingestion Rate	100	mg/day	USEPA, 2014 (2)	CS x IR x EF x ED x CF x FI x RBA
				EF	Exposure Frequency	52	days/yr	(3)	BW x AT
				ED	Exposure Duration	9	years	(4)	
				FI	Fraction Ingested from Site	0.5	unitless	(5)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				RBA	Relative Bioavailability Factor	Chemical Specific	unitless	--	
				BW	Body Weight	44	kg	USEPA, 2011 (6)	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	
				ATnc	Averaging Time - noncancer	3,285	days	USEPA, 2014	
Incidental Ingestion	Recreational User	Adult	On-facility	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
	Future			IR	Ingestion Rate	100	mg/day	USEPA, 2014 (2)	CS x IR x EF x ED x CF x FI x RBA
				EF	Exposure Frequency	70	days/yr	(7)	BW x AT
				ED	Exposure Duration	20	years	USEPA, 2014 (2)	
				FI	Fraction Ingested from Site	0.5	unitless	(5)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				RBA	Relative Bioavailability Factor	Chemical Specific	unitless	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
Incidental Ingestion	Recreational User	Child	On-facility	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
	Future			IR	Ingestion Rate	200	mg/day	USEPA, 2014 (8)	CS x IR x EF x ED x CF x FI x RBA
				EF	Exposure Frequency	70	days/yr	(7)	BW x AT
				ED	Exposure Duration	6	years	USEPA, 2014 (8)	
				FI	Fraction Ingested from Site	0.5	unitless	(5)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				RBA	Relative Bioavailability Factor	Chemical Specific	unitless	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 2014	ATnc = ED (year) x 365 days/year

Table 1
Values Used for Daily Intake Calculations - Soil
Reasonable Maximum Exposure
Human Health Risk Assessment
Santa Fe AASF, NM

Scenario Timeframe(s):	Current; Future
Medium:	Soil
Exposure Media:	Surface soil; Combined Surface and Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point(s)	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Incidental Ingestion	Construction/Utility Worker	Adult	On-facility	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
	Future			IR	Ingestion Rate	330	mg/day	USEPA, 2002	CS x IR x EF x ED x CF x FI x RBA
				EF	Exposure Frequency	125	days/yr	(9)	BW x AT
				ED	Exposure Duration	0.5	year	(9)	
				FI	Fraction Ingested from Site	1	unitless	(1)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				RBA	Relative Bioavailability Factor	Chemical Specific	unitless	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 1989	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	183	days	USEPA, 1989	ATnc = ED (year) x 365 days/year
Dermal Contact	Outdoor Worker	Adult	On-facility	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
	Current/Future			SA	Surface Area	3,527	cm^2	USEPA, 2014 (10)	CS x SA x AF x ABS x EV x EF x ED x CF
				AF	Adherence Factor	0.12	mg/cm^2-event	USEPA, 2014 (11)	BW x AT
				ABS	Dermal absorption fraction	Chemical Specific	unitless	--	
				EV	Event Frequency	1	event/day	(12)	
				EF	Exposure Frequency	250	days/yr	USEPA, 2014	
				ED	Exposure Duration	25	year	USEPA, 2014	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	9,125	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
Dermal Contact	Resident	Adult	On-facility	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
	Future			SA	Surface Area	6,032	cm^2	USEPA, 2014 (13)	CS x SA x AF x ABS x EV x EF x ED x CF
				AF	Adherence Factor	0.07	mg/cm^2-event	USEPA, 2014 (14)	BW x AT
				ABS	Dermal absorption fraction	Chemical Specific	unitless	--	
				EV	Event Frequency	1	event/day	(12)	
				EF	Exposure Frequency	350	days/yr	USEPA, 2014	
				ED	Exposure Duration	20	years	USEPA, 2014	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 2014	
		Child	On-facility	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
				SA	Surface Area	2,373	cm^2	USEPA, 2014 (15)	CS x SA x AF x ABS x EV x EF x ED x CF
				AF	Adherence Factor	0.2	mg/cm^2-event	USEPA, 2014 (16)	BW x AT
				ABS	Dermal absorption fraction	Chemical Specific	unitless	--	
				EV	Event Frequency	1	event/day	(12)	
				EF	Exposure Frequency	350	days/yr	USEPA, 2014	
				ED	Exposure Duration	6	years	USEPA, 2014	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
Dermal Contact	Trespasser	Adolescent	On-facility	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
	Future	(7 to <16 years)		SA	Surface Area	3,693	cm^2	USEPA, 2011 (17)	CS x SA x AF x ABS x EV x EF x ED x CF
				AF	Adherence Factor	0.07	mg/cm^2-event	USEPA, 2004 (18)	BW x AT
				ABS	Dermal absorption fraction	Chemical Specific	unitless	--	
				EV	Event Frequency	1	event/day	(12)	
				EF	Exposure Frequency	52	days/yr	(3)	
				ED	Exposure Duration	9	years	(4)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	44	kg	USEPA, 2011 (6)	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	3,285	days	USEPA, 2014	ATnc = ED (year) x 365 days/year

Table 1
Values Used for Daily Intake Calculations - Soil
Reasonable Maximum Exposure
Human Health Risk Assessment
Santa Fe AASF, NM

Scenario Timeframe(s):	Current; Future
Medium:	Soil
Exposure Media:	Surface soil; Combined Surface and Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point(s)	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal Contact	Recreational User	Adult	On-facility	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	--	Intake (mg/kg-day) = $\frac{CS \times SA \times AF \times ABS \times EV \times EF \times ED \times CF}{BW \times AT}$
	Future			SA	Surface Area	6,032	cm^2	USEPA, 2014 (13)	
				AF	Adherence Factor	0.07	mg/cm^2-event	USEPA, 2014 (14)	
				ABS	Dermal absorption fraction	Chemical Specific	unitless	--	
				EV	Event Frequency	1	event/day	(12)	
				EF	Exposure Frequency	70	days/yr	(7)	
				ED	Exposure Duration	20	years	USEPA, 2014 (2)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
		Child	On-facility	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	--	Intake (mg/kg-day) = $\frac{CS \times SA \times AF \times ABS \times EV \times EF \times ED \times CF}{BW \times AT}$
				SA	Surface Area	2,373	cm^2	USEPA, 2014 (15)	
				AF	Adherence Factor	0.2	mg/cm^2-event	USEPA, 2014 (16)	
				ABS	Dermal absorption fraction	Chemical Specific	unitless	--	
				EV	Event Frequency	1	event/day	(12)	
				EF	Exposure Frequency	70	days/yr	(7)	
				ED	Exposure Duration	6	years	USEPA, 2014 (8)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
Dermal Contact	Construction/Utility Worker	Adult	On-facility	CS	Chemical Concentration in Soil	Chemical Specific	mg/kg	--	Intake (mg/kg-day) = $\frac{CS \times SA \times AF \times ABS \times EV \times EF \times ED \times CF}{BW \times AT}$
	Future			SA	Surface Area	3,527	cm^2	USEPA, 2014 (10)	
				AF	Adherence Factor	0.3	mg/cm^2-event	USEPA, 2004 (18)	
				ABS	Dermal absorption fraction	Chemical Specific	unitless	--	
				EV	Event Frequency	1	event/day	(12)	
				EF	Exposure Frequency	125	days/yr	(9)	
				ED	Exposure Duration	0.5	year	(9)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	183	days	USEPA, 2014	ATnc = ED (year) x 365 days/year

Notes:
< = Less than.
USEPA = United States Environmental Protection Agency.
(1) Professional judgment; conservatively assumes 100 percent of soil ingested is from the Site.
(2) Default value for adult resident.
(3) Assumes exposure to soil may occur for an average of 1.5 days per week for 8 months of the year (i.e., April through November; 35 weeks) when the ground is not frozen or snow-covered, based on professional judgment.
(4) Exposure duration reflects age-range of 7 to <16 years.
(5) Assumes 50 percent of soil ingested is from the associated area, based on professional judgment.
(6) Weighted average body weight for adolescent ages 6 to <16 years old used to represent the 7 to <16 year old adolescent.
(7) Assumes exposure to soil may occur for 2 days per week for 8 months of the year (i.e., April through November; 35 weeks) when the ground is not frozen or snow-covered, based on professional judgment.
(8) Default value for child resident.
(9) Construction/utility activities are assumed to occur for 125 days over the course of a 6 month period, based on professional judgment.
(10) Represents the weighted mean surface area for males and females ages 21+, including head, hands, and forearms (USEPA, 2011; Table 7-2).
(11) Represents the arithmetic mean of weighted average of body-specific (hands, forearms, and face) mean adherence factors for adult commercial/industrial activities (USEPA, 2011; Table 7-20).
(12) Professional judgement; assumes one event per day.
(13) Represents the weighted mean surface area for male and female adults, including head, hands, forearms, and lower legs (USEPA, 2011; Table 7-2).
(14) Represents the geometric mean (50th percentile) of weighted average body-specific (hands, forearms, lower legs, and head) adherence factors for gardeners (USEPA, 2004; Exhibit C-2).
(15) Represents the weighted mean surface area for males and females ages 0 to <6 years old, including head, hands, forearms, lower legs, and feet (USEPA, 2011; Table 7-2).
(16) Represents the geometric mean (50th percentile) of weighted average body-specific (hands, forearms, lower legs and face) adherence factors for children playing (wet soil) (USEPA, 2004; Exhibit C-2).
(17) Represents the weighted mean surface area for males and females ages 7 to <16 years old, including hands, forearms, lower legs, and head (USEPA, 2011; Table 7-2). See Table 5 for calculation.
(18) Represents the geometric mean (50th percentile) of weighted average body-specific (face, forearms, and hands) adherence factors for construction workers (USEPA, 2004; Exhibit C-2).

Sources:
USEPA, 1989. Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.
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Table 2
Values Used for Daily Intake Calculations - Groundwater
Reasonable Maximum Exposure
Human Health Risk Assessment
Santa Fe AASF, NM

Scenario Timeframe(s): Current; Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point(s)	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Outdoor Worker	Adult	On-facility	CW	Chemical Concentration in Water	Chemical Specific	ug/L	--	Intake (mg/kg-day) =
	Future			IR	Ingestion Rate	1.25	liters/day	USEPA, 2014 (1)	CW x IR x EF x ED x CF
				EF	Exposure Frequency	250	days/yr	USEPA, 2014	BW x AT
				ED	Exposure Duration	25	years	USEPA, 2014	
				CF	Conversion Factor	0.001	mg/ug	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	9,125	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
Ingestion	Commercial/Industrial Worker	Adult	Off-facility**	CW	Chemical Concentration in Water	Chemical Specific	ug/L	--	Intake (mg/kg-day) =
	Current/Future			IR	Ingestion Rate	1.25	liters/day	USEPA, 2014 (1)	CW x IR x EF x ED x CF
				EF	Exposure Frequency	250	days/yr	USEPA, 2014	BW x AT
				ED	Exposure Duration	25	years	USEPA, 2014	
				CF	Conversion Factor	0.001	mg/ug	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	9,125	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
Ingestion	Resident	Adult	On-facility	CW	Chemical Concentration in Water	Chemical Specific	ug/L	--	Intake (mg/kg-day) =
	On-facility (Future)		Off-facility**	IR	Ingestion Rate	2.5	liters/day	USEPA, 2014	CW x IR x EF x ED x CF
	Off-facility (Current/Future)**			EF	Exposure Frequency	350	days/yr	USEPA, 2014	BW x AT
				ED	Exposure Duration	20	years	USEPA, 2014	
				CF	Conversion Factor	0.001	mg/ug	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
		Child	On-facility	CW	Chemical Concentration in Water	Chemical Specific	ug/L	--	Intake (mg/kg-day) =
			Off-facility**	IR	Ingestion Rate	0.78	liters/day	USEPA, 2014	CW x IR x EF x ED x CF
				EF	Exposure Frequency	350	days/yr	USEPA, 2014	BW x AT
				ED	Exposure Duration	6	years	USEPA, 2014	
				CF	Conversion Factor	0.001	mg/ug	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 2014	ATnc = ED (year) x 365 days/year

Table 2
Values Used for Daily Intake Calculations - Groundwater
Reasonable Maximum Exposure
Human Health Risk Assessment
Santa Fe AASF, NM

Scenario Timeframe(s):	Current; Future
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point(s)	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal Contact	Resident	Adult	On-facility	CW	Chemical Concentration in Water	Chemical Specific	ug/L	--	
	On-facility (Future)		Off-facility**	DA_{event}	Dermal Absorbed Dose per Event	Chemical Specific	mg/cm^2-event	USEPA, 2004	Intake (mg/kg/day) =
	Off-facility (Current/Future)**			SA	Surface Area	19,652	cm^2	USEPA, 2014	
				ET	Event Time	0.71	hour/event	USEPA, 2014	$\frac{\text{DAevent x SA x EV x EF x ED}}{\text{BW x AT}}$
				EV	Event Frequency	1	event/day	USEPA, 2004	
				EF	Exposure Frequency	350	days/year	USEPA, 2004	
				ED	Exposure Duration	20	years	USEPA, 2014	See below for DAevent equations
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
Dermal Contact	Resident	Child	On-facility	CW	Chemical Concentration in Water	Chemical Specific	ug/L	--	
	On-facility (Future)		Off-facility**	DA_{event}	Dermal Absorbed Dose per Event	Chemical Specific	mg/cm^2-event	USEPA, 2004	Intake (mg/kg/day) =
	Off-facility (Current/Future)**			SA	Surface Area	6,365	cm^2	USEPA, 2014	
				ET	Event Time	0.54	hour/event	USEPA, 2014	$\frac{\text{DAevent x SA x EV x EF x ED}}{\text{BW x AT}}$
				EV	Event Frequency	1	event/day	USEPA, 2004	
				EF	Exposure Frequency	350	days/year	USEPA, 2004	
				ED	Exposure Duration	6	years	USEPA, 2014	See below for DAevent equations
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 2014	ATnc = ED (year) x 365 days/year

Notes:
USEPA = United States Environmental Protection Agency.
*** Off-facility sampling is not currently planned. These potential receptors would only be evaluated if off-facility migration pathways for PFAS are confirmed and if off-facility data are collected during the Adaptive Phase.*
(1) Equal to half of the default ingestion rate for a residential adult recommended by USEPA (2014).

DAevent will be calculated in accordance with the equations below from USEPA, 2004 (Note that CW units were converted to ug/L).

Equation 3.2, Organics, ET < t*:
DA-event (Absorbed dose per event[mg/cm²-event]) =
$$2 \times FA \times Kp \times CW \times \text{Square Root}\left[(6 \times \tau_{event} \times ET)/\pi\right]$$

Equation 3.3, Organics, ET >t*:
DA-event (Absorbed dose per event[mg/cm²-event]) =
$$FA \times Kp \times CW \times \{[ET / (1 + B)] + (2 \times \tau_{event}) \times [(1 + 3B + 3B^2) / (1 + B)^2]\}$$

Daevent Equation parameters not defined in table above:
Kp - Dermal Permeability Coefficient
B - Relative Contribution of Permeability Coefficient
FA - Fraction Absorbed
t* - Time To Steady State
τ_{event} - Lag Time

Sources:
USEPA, 2004. Risk Assessment Guidance for Superfund. Part E, Supplemental Guidance for Dermal Risk Assessment. Final. EPA/540/R/99/005.
USEPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Revised September 2015.

Table 3
Values Used for Daily Intake Calculations - Sediment
Reasonable Maximum Exposure
Human Health Risk Assessment
Santa Fe AASF, NM

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point(s)	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Incidental Ingestion	Recreational Swimmer	Adult	To be determined**	CS	Chemical Concentration in Sediment	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
				IR	Ingestion Rate	50	mg/day	USEPA, 2017 (1)	CS x IR x EF x ED x CF x FI x RBA
				EF	Exposure Frequency	52	days/yr	(2)	BW x AT
				ED	Exposure Duration	20	years	USEPA, 2014	
				FI	Fraction Ingested from Site	0.5	unitless	(3)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				RBA	Relative Bioavailability Factor	Chemical Specific	unitless	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
		Child	To be determined**	CS	Chemical Concentration in Sediment	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
				IR	Ingestion Rate	90	mg/day	USEPA, 2017 (1)	CS x IR x EF x ED x CF x FI x RBA
				EF	Exposure Frequency	52	days/yr	(2)	BW x AT
				ED	Exposure Duration	6	years	USEPA, 2014	
				FI	Fraction Ingested from Site	0.5	unitless	(3)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				RBA	Relative Bioavailability Factor	chemical Specific	unitless	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
Incidental Ingestion	Recreational Wader	Adult	To be determined**	CS	Chemical Concentration in Sediment	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
				IR	Ingestion Rate	50	mg/day	USEPA, 2017 (1)	CS x IR x EF x ED x CF x FI x RBA
				EF	Exposure Frequency	35	days/yr	(4)	BW x AT
				ED	Exposure Duration	20	years	USEPA, 2014	
				FI	Fraction Ingested from Site	0.5	unitless	(3)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				RBA	Relative Bioavailability Factor	Chemical Specific	unitless	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
		Child	To be determined**	CS	Chemical Concentration in Sediment	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
				IR	Ingestion Rate	90	mg/day	USEPA, 2017 (1)	CS x IR x EF x ED x CF x FI x RBA
				EF	Exposure Frequency	35	days/yr	(4)	BW x AT
				ED	Exposure Duration	6	years	USEPA, 2014	
				FI	Fraction Ingested from Site	0.5	unitless	(3)	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				RBA	Relative Bioavailability Factor	1	unitless	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
Dermal	Recreational Swimmer	Adult	To be determined**	CS	Chemical Concentration in Sediment	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
				SA	Surface Area	4,780	cm^2	USEPA, 2011 (5)	CS x SA x AF x ABS x EV x EF x ED x CF
				AF	Adherence Factor	0.4	mg/cm^2-event	USEPA, 2011 (6)	BW x AT
				ABS	Dermal absorption fraction	Chemical Specific	unitless	--	
				EV	Event Frequency	1	event/day	(7)	
				EF	Exposure Frequency	52	days/yr	(2)	
				ED	Exposure Duration	20	years	USEPA, 2014	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 2014	ATnc = ED (year) x 365 days/year

Table 3
Values Used for Daily Intake Calculations - Sediment
Reasonable Maximum Exposure
Human Health Risk Assessment
Santa Fe AASF, NM

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point(s)	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Recreational Swimmer	Child	To be determined**	CS	Chemical Concentration in Sediment	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
				SA	Surface Area	2,057	cm^2	USEPA, 2011 (8)	CS x SA x AF x ABS x EV x EF x ED x CF
				AF	Adherence Factor	0.3	mg/cm^2-event	USEPA, 2004 (9)	BW x AT
				ABS	Dermal absorption fraction	Chemical Specific	unitless	--	
				EV	Event Frequency	1	event/day	(7)	
				EF	Exposure Frequency	52	days/yr	(2)	
				ED	Exposure Duration	6	years	USEPA, 2014	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
Dermal	Recreational Wader	Adult	To be determined**	CS	Chemical Concentration in Sediment	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
				SA	Surface Area	2,275	cm^2	USEPA, 2011 (10)	CS x SA x AF x ABS x EV x EF x ED x CF
				AF	Adherence Factor	0.6	mg/cm^2-event	USEPA, 2011 (11)	BW x AT
				ABS	Dermal absorption fraction	Chemical Specific	unitless	--	
				EV	Event Frequency	1	event/day	(7)	
				EF	Exposure Frequency	35	days/yr	(4)	
				ED	Exposure Duration	20	years	USEPA, 2014	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
		Child	To be determined**	CS	Chemical Concentration in Sediment	Chemical Specific	mg/kg	--	Intake (mg/kg-day) =
				SA	Surface Area	852	cm^2	USEPA, 2011 (12)	CS x SA x AF x ABS x EV x EF x ED x CF
				AF	Adherence Factor	0.7	mg/cm^2-event	USEPA, 2004 (13)	BW x AT
				ABS	Dermal absorption fraction	Chemical Specific	unitless	--	
				EV	Event Frequency	1	event/day	(7)	
				EF	Exposure Frequency	35	days/yr	(4)	
				ED	Exposure Duration	6	years	USEPA, 2014	
				CF	Conversion Factor	1.00E-06	kg/mg	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 2014	ATnc = ED (year) x 365 days/year

Notes:

*** There are no AOIs within the areas of the facility used for recreational purposes, and off-facility sampling is not currently planned. If the Prescriptive Phase data indicate potential off-AOI or off-facility impact to waterbodies used recreationally, additional data may be collected. Parameters are presented for both a wader and a swimmer. Exposure parameters will be refined to be specific to the water body of interest.*

< = Less than.

AOI = Area of Interest.

USEPA = United States Environmental Protection Agency.

(1) Equal to the recommended upper percentile daily soil ingestion rates for soil for children and adults (as applicable) (USEPA, 2017; Table 5-1). Value does not include indoor settled dust component which is not applicable to sediment.

(2) Assumes swimming may occur for 2 days per week for the 6 warmest months (i.e., May through October; 26 weeks) per year.

(3) Assumes 50 percent of sediment ingested is from the associated area, based on professional judgment.

(4) Assumes wading 1 day per week for 8 months out of the year (35 weeks) from April through November (when ground is not frozen or covered with snow).

(5) Represents the weighted mean surface area for male and female adults (USEPA, 2011; Table 7-12 and 7-13). Assumes contact with sediment by hands, lower legs, and feet. See Table 6 for calculation.

(6) Represents the geometric mean weighted adherence factor for reed gatherers (USEPA (2011, Table 7-20). Assumes contact with sediment by hands, lower legs, and feet. See Table 6 for calculation.

(7) Professional judgment; assumes one event per day.

(8) Represents the weighted mean surface area for males and females ages 0 to <6 years old (USEPA, 2011; Table 7-2). Assumes contact with sediment by hands, forearms, lower legs, and feet. The skin surface area for a 1 to <7 year old child is used to represent potential exposure by a recreational child, since a <1 year old child is likely to have limited exposure to sediment. See Table 7 for calculation.

(9) Represents the geometric mean weighted adherence factor for children playing in wet soil (USEPA, 2004; Exhibit 3-3). Assumes contact with sediment by hands, forearms, lower legs, and feet. See Table 7 for calculation.

(10) Represents the weighted mean surface area for male and female adults (USEPA, 2011; Table 7-12 and 7-13). Assumes contact with sediment by hands and feet. See Table 6 for calculation.

(11) Represents the geometric mean weighted adherence factor for reed gatherers (USEPA (2011, Table 7-20). Assumes contact with sediment by hands and feet. See Table 6 for calculation.

(12) Represents the weighted mean surface area for males and females ages 0 to <6 years old (USEPA, 2011; Table 7-2). Assumes contact with sediment by hands and feet. The skin surface area for a 1 to <7 year old child is used to represent potential exposure by a recreational child, since a <1 year old child is likely to have limited exposure to sediment. See Table 7 for calculation.

(13) Represents the geometric mean weighted adherence factor for children playing in wet soil (USEPA, 2004; Exhibit 3-3). Assumes contact with sediment by hands and feet. See Table 7 for calculation.

Sources:

USEPA, 2004. Risk Assessment Guidance for Superfund. Part E, Supplemental Guidance for Dermal Risk Assessment. Final. EPA/540/R/99/005.
USEPA, 2011. Exposure Factors Handbook. September 2011.
USEPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Revised September 2015.
USEPA, 2017. Update for Chapter 5 of the Exposure Factors Handbook. Soil and Dust Ingestion. EPA/600/R-17/384F. September.

Table 4
Values Used for Daily Intake Calculations - Surface Water
Reasonable Maximum Exposure
Human Health Risk Assessment
Santa Fe AASF, NM

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point(s)	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Incidental Ingestion	Recreational Swimmer	Adult	To be determined**	CW	Chemical Concentration in Water	Chemical Specific	ug/L	--	Intake (mg/kg-day) =
				IR	Ingestion Rate	0.286	liters/day	(1)	CW x IR x EF x ED x CF
				EF	Exposure Frequency	52	days/yr	(2)	BW x AT
				ED	Exposure Duration	20	years	USEPA, 2014	
				CF	Conversion Factor	0.001	mg/ug	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
		Child	To be determined**	CW	Chemical Concentration in Water	Chemical Specific	ug/L	--	Intake (mg/kg-day) =
				IR	Ingestion Rate	0.250	liters/day	(3)	CW x IR x EF x ED x CF
				EF	Exposure Frequency	52	days/yr	(2)	BW x AT
				ED	Exposure Duration	6	years	USEPA, 2014	
				CF	Conversion Factor	0.001	mg/ug	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
Incidental Ingestion	Recreational Wader	Adult	To be determined**	CW	Chemical Concentration in Water	Chemical Specific	ug/L	--	Intake (mg/kg-day) =
				IR	Ingestion Rate	0.0224	liters/day	USEPA, 2019 (4)	CW x IR x EF x ED x CF
				EF	Exposure Frequency	35	days/yr	(5)	BW x AT
				ED	Exposure Duration	20	years	USEPA, 2014	
				CF	Conversion Factor	0.001	mg/ug	--	
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
		Child	To be determined**	CW	Chemical Concentration in Water	Chemical Specific	ug/L	--	Intake (mg/kg-day) =
				IR	Ingestion Rate	0.0224	liters/day	USEPA, 2019 (4)	CW x IR x EF x ED x CF
				EF	Exposure Frequency	35	days/yr	(5)	BW x AT
				ED	Exposure Duration	6	years	USEPA, 2014	
				CF	Conversion Factor	0.001	mg/ug	--	
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
Dermal	Recreational Swimmer	Adult	To be determined**	CW	Chemical Concentration in Water	Chemical Specific	ug/L	--	
				DA	Dose Absorbed per Unit Area per Event	Chemical Specific	mg/cm^2-event	--	Intake (mg/kg/day) =
				SA	Surface Area	19,652	cm^2	USEPA, 2014	
				ET	Event Time	2.6	hour/event	USEPA, 1989	DAevent x SA x EV x EF x ED
				EV	Event Frequency	1	event/day	USEPA, 2004	BW x AT
				EF	Exposure Frequency	52	days/yr	(2)	
				ED	Exposure Duration	20	years	USEPA, 2014	See below for DAevent equations
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
		Child	To be determined**	CW	Chemical Concentration in Water	Chemical Specific	ug/L	--	
				DA	Dose Absorbed per Unit Area per Event	Chemical Specific	mg/cm^2-event	--	Intake (mg/kg/day) =
				SA	Surface Area	6,365	cm^2	USEPA, 2014	
				ET	Event Time	2.6	hour/event	USEPA, 1989	DAevent x SA x EV x EF x ED
				EV	Event Frequency	1	event/day	USEPA, 2004	BW x AT
				EF	Exposure Frequency	52	days/yr	(2)	
				ED	Exposure Duration	6	years	USEPA, 2014	See below for DAevent equations
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 2014	ATnc = ED (year) x 365 days/year

Table 4
Values Used for Daily Intake Calculations - Surface Water
Reasonable Maximum Exposure
Human Health Risk Assessment
Santa Fe AASF, NM

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point(s)	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Recreational Wader	Adult	To be determined**	CW	Chemical Concentration in Water	Chemical Specific	ug/L	--	
				DA	Dose Absorbed per Unit Area per Event	Chemical Specific	mg/cm^2-event	--	Intake (mg/kg/day) =
				SA	Surface Area	6,077	cm^2	USEPA, 2011 (6)	
				ET	Event Time	2	hour/event	(5)	DAevent x SA x EV x EF x ED
				EV	Event Frequency	1	event/day	USEPA, 2004	BW x AT
				EF	Exposure Frequency	35	days/yr	(5)	
				ED	Exposure Duration	20	years	USEPA, 2014	See below for DAevent equations
				BW	Body Weight	80	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	7,300	days	USEPA, 2014	ATnc = ED (year) x 365 days/year
		Child	To be determined**	CW	Chemical Concentration in Water	Chemical Specific	ug/L	--	
				DA	Dose Absorbed per Unit Area per Event	Chemical Specific	mg/cm^2-event	--	Intake (mg/kg/day) =
				SA	Surface Area	2,057	cm^2	USEPA, 2011 (7)	
				ET	Event Time	2	hour/event	(5)	DAevent x SA x EV x EF x ED
				EV	Event Frequency	1	event/day	USEPA, 2004	BW x AT
				EF	Exposure Frequency	35	days/yr	(5)	
				ED	Exposure Duration	6	years	USEPA, 2014	See below for DAevent equations
				BW	Body Weight	15	kg	USEPA, 2014	
				ATc	Averaging Time - cancer	25,550	days	USEPA, 2014	ATc = Lifetime (70 years) x 365 days/year
				ATnc	Averaging Time - noncancer	2,190	days	USEPA, 2014	ATnc = ED (year) x 365 days/year

Notes:
AOI = Area of Interest.
USEPA = United States Environmental Protection Agency.
*** There are no AOIs within the areas of the facility used for recreational purposes, and off-facility sampling is not currently planned. If the Prescriptive Phase data indicate potential off-AOI or off-facility impact to waterbodies used recreationally, additional data may be collected*
Parameters are presented for both a wader and a swimmer. Exposure parameters will be refined to be specific to the water body of interest.
(1) Based on the age-weighted upper percentile water ingestion rate for a 20 year exposure duration from age 6 to 21+ (USEPA, 2019; Table 3-7) of 0.11 L/hr multiplied by swimming event time (see dermal assumptions).
(2) Assumes swimming may occur for 2 days per week for the 6 warmest months (i.e., May through October; 26 weeks) per year.
(3) Based on the upper percentile water ingestion rate for children (ages 6 to 11) of 0.096 liters/hour (USEPA, 2019; Table 3-7) mulitplied by swimming event time (see dermal assumptions).
(4) Upper percentile value for wading/splashing, mulitplied by wading event time (see dermal assumptions). Value obtained from Dorevitch et al, 2011, and recommended by USEPA (2019; Table 3-96).
(5) Assumes wading for 1 day per week for 8 months out of the year (35 weeks) for 2 hours per day from April through November (when ground is not frozen or covered with snow).
(6) Represents the weighted mean surface area for males and females (USEPA, 2011). Assumes contact with surface water by hands, forearms, lower legs, and feet. See Table 6 for calculation.
(7) Represents the weighted mean surface area for young child (1 - <7 years, USEPA, 2011). Assumes contact with surface water by hands, forearms, lower legs, and feet. See Table 7 for calculation.

DAevent will be calculated in accordance with the equations below from USEPA, 2004 (Note that CW units were converted to ug/L).

Equation 3.2, Organics, ET < t*:
DA-event (Absorbed dose per event[mg/cm²-event]) =
$2 \times FA \times Kp \times CW \times \text{Square Root } [(6 \times \tau_{event} \times ET)/\pi]$

Equation 3.3, Organics, ET >t*:
DA-event (Absorbed dose per event[mg/cm²-event]) =
$FA \times Kp \times CW \times \{[ET / (1 + B)] + (2 \times \tau_{event}) \times [(1 + 3B + 3B^2) / (1 + B)^2]\}$

Daevent Equation parameters not defined in table above:
Kp - Dermal Permeability Coefficient
B - Relative Contribution of Permeability Coefficient
FA - Fraction Absorbed
t* - Time To Steady State
τ_{event} - Lag Time

Sources:
Dorevitch et al, 2011. Water ingestion during water recreation. Water Res 45(5):2020−2028.
USEPA, 1989. Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.
USEPA, 2004. Risk Assessment Guidance for Superfund. Part E, Supplemental Guidance for Dermal Risk Assessment. Final. EPA/540/R/99/005.
USEPA, 2011. Exposure Factors Handbook. September 2011.
USEPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Revised September 2015.
USEPA, 2019. Update for Chapter 3 of the Exposure Factors Handbook. Ingestion of Water and Other Selected Liquids. EPA/600/R-18/259F. February 2019.

Table 5

Calculation of Body Surface Area Exposed and Soil Adherence Factor for Future Trespasser (Adolescent)

Human Health Risk Assessment
Santa Fe AASF, NM

Adolescent (7 to <16 years, from 7th birthday to the day before 16th birthday)										
Mean Surface Area by Body Part, m^2 (EFH, Table 7-2, USEPA, 2011)										
Age	**legs**	**lower legs (a)**		**feet**	**head**	**face (j)**	**hands**	**arms**	**forearms**	
7<8 (data 6<11)	0.311	0.124	(b)	0.073	0.066	0.022	0.051	0.151	0.059	(d)
8<9 (data 6<11)	0.311	0.124	(b)	0.073	0.066	0.022	0.051	0.151	0.059	(d)
9<10 (data 6<11)	0.311	0.124	(b)	0.073	0.066	0.022	0.051	0.151	0.059	(d)
10<11 (data 6<11)	0.311	0.124	(b)	0.073	0.066	0.022	0.051	0.151	0.059	(d)
11<12 (data 11<16)	0.483	0.193	(c)	0.105	0.073	0.024	0.072	0.227	0.086	(e)
12<13 (data 11<16)	0.483	0.193	(c)	0.105	0.073	0.024	0.072	0.227	0.086	(e)
13<14 (data 11<16)	0.483	0.193	(c)	0.105	0.073	0.024	0.072	0.227	0.086	(e)
14<15 (data 11<16)	0.483	0.193	(c)	0.105	0.073	0.024	0.072	0.227	0.086	(e)
15<16 (data 11<16)	0.483	0.193	(c)	0.105	0.073	0.024	0.072	0.227	0.086	(e)
Average (age 7 to <16) (cm^2)	**4,066**	**1,626**		**908**	**699**	**233**	**627**	**1,932**	**741**	
								Soil: hands, forearms, lower legs, and head (cm^2) =	**3,693**	

Body Part	**Body Surface Area Exposed to Soil (cm^2)**	**Soil Loading Rate (f) (mg/cm^2)**		**Total Soil Mass (mg)**
Head	699	0.052	(g)	36
Hands	627	0.190		119
Forearms	741	0.052	(h)	39
Lower legs (a)	1,626	0.033	(i)	54
Total	3,693	–		248
Area-Weighted Adherence Factor (mg/cm^2) = Soil mass/Surface area =				**0.07**

Notes:
EFH - 2011 Edition of the Exposure Factors Handbook (USEPA, 2011).
(a) Lower leg surface area = leg surface area x average of the ratios of the lower leg to the leg (EFH Table 7-8), average of male and female, consistent with methods used in USEPA, 2014.
(b) Ratios of the lower leg to the leg for the 6, 8 and 10 year-olds (0.4) (Table 7-8).
(c) Ratio of the lower leg to the leg for the 12 and 14 year-olds (0.4) (Table 7-8).
(d) Surface area for the arm x average of the ratios of the forearm to the arm for 6, 8 and 10 year-olds (0.39) (EFH Table 7-8).
(e) Surface area for the arm x average of the ratios of the forearm to the arm for 12 and 14 year-olds (0.38) (EFH Table 7-8).
(f) Data from USEPA (2004, Exhibit C-2). Geometric mean value, children playing in wet soil.
(g) Data for head are not available. Therefore, face data are used as a proxy.
(h) Data for forearms are not available. Therefore, arm data are used as a proxy.
(i) Data for lower legs are not available. Therefore, leg data are used as a proxy.
(j) Surface area of the face is assumed to be one-third of the head.

Sources:

USEPA, 2004. Risk Assessment Guidance for Superfund. Part E, Supplemental Guidance for Dermal Risk Assessment. Final. EPA/540/R/99/005.
USEPA, 2011. Exposure Factors Handbook. September 2011.
USEPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Revised September 2015.

Table 6

Calculation of Body Surface Area Exposed and Sediment Adherence Factor for Future Recreational Adult

Human Health Risk Assessment
Santa Fe AASF, NM

Adult (21 years and older)			
	Mean Body Surface Area for Adult		Average of Males and Females
Body Part	Male m^2	Female m^2	cm^2
Head	0.136	0.114	1,250
Face	0.045	0.038 (c)	417
Upper extremities			
Arms	0.314	0.237	2,755
Upper arms	0.172	0.13035 (a)	1,512
Forearms	0.148	0.11139 (a)	1,297
Hands	0.107	0.089	980
Lower extremities			
Legs	0.682	0.598	6,400
Lower legs	0.268	0.233	2,505
Feet	0.137	0.122	1,295
Recreational Swimmer: hands, lower legs, and feet =			**4,780**
Recreational Wader: hands and feet =			**2,275**

Adult Recreational Swimmer (Sediment)			
Body Part	Body Surface Area Exposed to Sediment (cm^2)	Soil Loading Rate (b) (mg/cm^2)	Total Sediment Mass (mg)
Hands	980	0.66	647
Lower Legs	2,505	0.16 (d)	401
Feet	1,295	0.63	816
Total	4,780	–	1,863
Area-Weighted Adherence Factor (mg/cm^2) = Sediment mass/Surface area =			**0.4**

Adult Recreational Wader (Sediment)			
Body Part	Body Surface Area Exposed to Sediment (cm^2)	Soil Loading Rate (b) (mg/cm^2)	Total Sediment Mass (mg)
Hands	980	0.66	647
Feet	1,295	0.63	816
Total	2,275	–	1,463
Area-Weighted Adherence Factor (mg/cm^2) = Sediment mass/Surface area =			**0.6**

Notes:
EFH - 2011 Edition of the Exposure Factors Handbook (USEPA, 2011).
(a) In accordance with USEPA 2014 OSWER Directive on Recommended Default Exposure Factors (USEPA, 2014), the female forearms and upper arms surface areas were calculated as follows:
Female arms [0.237] x (Male forearm/Male arms) [0.47]
Female arms [0.237] x (Male upper arms/Male arms) [0.55]
(b) Data from USEPA (2011) Table 7-20. Geometric mean of values for reed gatherers.
(c) Per USEPA (2011) Section 7.2.2, the face is assumed to be 1/3 the surface area of the head.
(d) Data for forearms and lower legs are not available. Therefore, arm and leg data are used as a proxy.

Sources:
USEPA, 2011. Exposure Factors Handbook. September 2011.

USEPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Revised September 2015.

Table 7

Calculation of Body Surface Area Exposed and Sediment Adherence Factor for Future Recreational Child

Human Health Risk Assessment
Santa Fe AASF, NM

Young Child (1 to <7 years, from 1st birthday to the day before 7th birthday) (l)

Mean Surface Area by Body Part, m^2 (EFH, Table 7-2)

Age	hands	arms	forearms (a)	legs	lower legs (a)	feet
1<2	0.030	0.069	0.028 (b)	0.122	0.051 (e)	0.033
2<3	0.028	0.088	0.035 (b)	0.154	0.065 (e)	0.038
3<4 (data 3<6)	0.037	0.106	0.042 (c)	0.195	0.078 (f)	0.049
4<5 (data 3<6)	0.037	0.106	0.042 (c)	0.195	0.078 (f)	0.049
5<6 (data 3<6)	0.037	0.106	0.042 (c)	0.195	0.078 (g)	0.049
6<7 (data 6<11)	0.051	0.151	0.059 (d)	0.311	0.124 (g)	0.073
Average (cm^2)	**367**	**1,043**	**415**	**1,953**	**791**	**485**
Recreational Swimmer: hands, forearms, lower legs, and feet =						**2,057**
Recreational Wader: hands and feet =						**852**

Child Recreational Swimmer (Sediment)

Body Part	**Body Surface Area Exposed to Sediment (cm^2)**	**Soil Loading Rate (h) (mg/cm^2)**	**Total Sediment Mass (mg)**
Hands	367	0.656	241
Forearms	415	0.015 (k)	6
Lower Legs	791	0.026 (j)	21
Feet	485	0.656 (i)	318
Total	2,057	–	585
Area-Weighted Adherence Factor (mg/cm^2) = Sediment mass/Surface area =			**0.3**

Child Recreational Wader (Sediment)

Body Part	**Body Surface Area Exposed to Sediment (cm^2)**	**Soil Loading Rate (h) (mg/cm^2)**	**Total Sediment Mass (mg)**
Hands	367	0.656	241
Feet	485	0.656 (i)	318
Total	852	–	559
Area-Weighted Adherence Factor (mg/cm^2) = Sediment mass/Surface area =			**0.7**

Notes:
EFH - 2011 Edition of the Exposure Factors Handbook (USEPA, 2011).
(a) Lower leg surface area = leg surface area x average of the ratios of the lower leg to the leg
Forearm surface area = arm surface area x ratio of the forearm to the arm
(EFH Table 7-8), average of male and female, consistent with methods used in USEPA, 2014.
(b) Ratio of the forearm to the arm for the 2-year old, average of male and female (0.4) (EFH Table 7-8).
(c) Ratio of the forearm to the arm for the 4-year old, average of male and female (0.4) (EFH Table 7-8).
(d) Ratio of the forearm to the arm for 6, 8 and 10 year-olds (0.39) (EFH Table 7-8).
(e) Ratio of the lower leg to the leg for the 2-year old, average of male and female (0.42) (EFH Table 7-8).
(f) Ratio of the lower leg to the leg for the 4-year old, average of male and female (0.4) (EFH Table 7-8).
(g) Ratio of the lower leg to the leg for the 6, 8 and 10 year-olds (0.4) (EFH Table 7-8).
(h) Data from USEPA (2004, Exhibit C-2). Geometric mean value, children playing in wet soil.
(i) Data for feet are not available. Therefore, hand data are used as a proxy.
(j) Data for lower legs are not available. Therefore, legs data are used as a proxy.
(k) Data for forearms are not available. Therefore, arms data are used as a proxy.
(l) The skin surface area for a 1 to <7 year old child is used to represent potential exposure by a recreational child, since a <1 year old child is likely to have limited expoure to sediment.

Sources:
USEPA, 2004. Risk Assessment Guidance for Superfund. Part E, Supplemental Guidance for Dermal Risk Assessment. Final. EPA/540/R/99/005.
USEPA, 2011. Exposure Factors Handbook. September 2011.
USEPA, 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Revised September 2015.

Table 8
PFAS Soil Screening Levels For Terrestrial Plants And Invertebrates
Ecological Risk Assessment
Santa Fe AASF, NM

		Terrestrial Plant Screening Level				Terrestrial Invertebrate Screening Level			
		Argonne Values	SERDP Values			Argonne Values	SERDP Values		
Constituent	**Abbreviation**	**NOEC-based ESVs (mg/kg soil) [1]**	**NOEC Soil Screening Level (mg/kg soil) [2]**	**LOEC Soil Screening Level (mg/kg soil) [2]**	**Toxicity Benchmark (NOEC Based) (mg/kg soil) [3]**	**NOEC-based ESVs (mg/kg soil) [1]**	**NOEC Soil Screening Level (mg/kg soil) [2]**	**LOEC Soil Screening Level (mg/kg soil) [2]**	**Toxicity Benchmark (NOEC Based) (mg/kg soil) [3]**
Perfluorooctane sulfonic acid	PFOS	40.2	11	33	3.9	48.1	7.7	141	80
Perfluorooctanoic acid	PFOA	79.5	0.084	0.84	84	22.4	50	NA	10
Perfluorononanoic acid	PFNA	NA	46	NA	NA	10	1	100	NA
Perfluorohexanesulfonic acid	PFHxS	NA	NA	NA	NA	10	1	100	NA
Perfluoroheptanoic acid	PFHpA	NA	NA	NA	NA	NA	1	100	NA
Perfluorobutanesulfonic acid	PFBS	NA	NA	NA	NA	100	10	NA	NA
Perfluorodecanoic acid	PFDA	NA	51	NA	NA	NA	NA	NA	NA
Perfluorobutanoic acid	PFBA	NA	642	NA	NA	NA	NA	NA	NA

Notes:

Shading shows preliminary values to be considered in the Screening Level Ecological Risk Assessment (lowest value).

Other values may be used in Step 3a, as needed.

Argonne - Argonne National Laboratory

ESV - Ecological Screening Value

LOEC - Lowest Observed Effect Concentration.

mg/kg - milligram per kilogram.

NA - Not Available.

NOEC - No Observed Effect Concentration.

SERDP - Strategic Environmental Research and Development Program

Sources:

1 - Grippo, M., J. Hayse, I. Hlohowskyj, and K. Picel, 2021. Derivation of PFAS Ecological Screening Values. Argonne National Laboratory, Environmental Science Division. Completed under Interagency Agreement between the U.S. Department of Energy, Argonne National Laboratory, and the Air Force Civil Engineer Center. September. Final.

2 - Divine, C., Frenchmeyer, M., Dally, K., Osborn, E., Anderson, P., Zodrow, J., 2020. Approach for Assessing PFAS Risk to Threatened and Endangered Species. Final Report. SERDP Project ER18-1653. March.

3 - Conder, J., Arblaster, J., Larson, E., Brown, J., Higgins, C., 2020. Guidance for Assessing the Ecological Risks of PFAS to Threatened and Endangered Species at Aqueous Film Forming Foam-Impacted Sites. Guidance Document. SERDP Project ER18-1614. January.

Table 9
PFAS Screening Levels for Wildlife Receptors
Ecological Risk Assessment
Santa Fe AASF, NM

		Terrestrial Wildlife Screening Level for Soil								
		ANL Wildlife Values [1]		SERDP Wildlife RBSL [2]						
Feeding Guild				Herbivore	Invertivore	Insectivore	Carnivore	Herbivore	Insectivore	Carnivore
Receptor		ESV for Terrestrial Mammals	ESV for Terrestrial Birds	Meadow Vole	Short-Tailed Shrew	Little Brown Bat	Long-Tailed Weasel	American Goldfinch	House Wren	Red-Tailed Hawk
NOAEL-based RBSLs (mg/kg soil)										
Perfluorooctane sulfonic acid	PFOS	0.0087	0.0386	0.31	0.048	0.03	0.17	0.38	0.013	0.087
Perfluorooctanoic acid	PFOA	3.84	NA	5.8	1.3	0.84	0.57	NA	NA	NA
Perfluorononanoic acid	PFNA	0.0242	NA	2.3	1.5	1	1.5	NA	NA	NA
Perfluorohexanesulfonic acid	PFHxS	0.0028	NA	NA	NA	NA	NA	NA	NA	NA
Perfluorobutanesulfonic acid	PFBS	0.817	15.8	38	14	9.1	78	89	9.3	100
Perfluorodecanoic acid	PFDA	0.0677	NA	NA	NA	NA	NA	NA	NA	NA
Perfluorohexanoic acid	PFHxA	6.2	NA	120	340	250	160	NA	NA	NA
Perfluorobutanoic acid	PFBA	2.98	NA	29	78	58	130	NA	NA	NA
LOAEL-based RBSLs (mg/kg soil)										
Perfluorooctane sulfonic acid	PFOS	NA	NA	0.51	0.079	0.05	0.28	3.8	0.13	0.87
Perfluorooctanoic acid	PFOA	NA	NA	12	2.6	1.7	1.1	NA	NA	NA
Perfluorononanoic acid	PFNA	NA	NA	3	2	1.3	2	NA	NA	NA
Perfluorobutanesulfonic acid	PFBS	NA	NA	150	57	36	310	150	15	170
Perfluorohexanoic acid	PFHxA	NA	NA	260	700	530	330	NA	NA	NA
Perfluorobutanoic acid	PFBA	NA	NA	70	190	140	320	NA	NA	NA

		Aquatic-dependent Wildlife Screening Level for Sediment									
		ANL Wildlife Values [1]		SERDP Wildlife RBSL [2]							
Feeding Guild				Herbivore	Insectivore	Carnivore	Carnivore	Carnivore	Omnivore	Invertivore	Piscivore
Receptor		ESV Aquatic Mammals	ESV Aquatic Birds	Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink	Red-Winged Blackbird	Tree Swallow	Brown Pelican
NOAEL-based RBSLs (mg/kg sediment)											
Perfluorooctane sulfonic acid	PFOS	NA	NA	0.023	0.0053	0.047	0.046	0.038	0.007	0.0014	0.014
Perfluorooctanoic acid	PFOA	NA	NA	1.2	0.006	0.28	0.19	0.4	NA	NA	NA
Perfluorononanoic acid	PFNA	NA	NA	3.6	0.01	0.24	0.2	0.25	NA	NA	NA
Perfluorobutanesulfonic acid	PFBS	NA	NA	370	1.1	18	16	15	24	0.73	13
Perfluorohexanoic acid	PFHxA	NA	NA	240	1.8	29	26	25	NA	NA	NA
Perfluorobutanoic acid	PFBA	NA	NA	160	1.6	26	23	22	NA	NA	NA
LOAEL-based RBSLs (mg/kg sediment)											
Perfluorooctane sulfonic acid	PFOS	NA	NA	0.038	0.0088	0.077	0.077	0.063	0.07	0.014	0.14
Perfluorooctanoic acid	PFOA	NA	NA	2.3	0.012	0.57	0.39	0.8	NA	NA	NA
Perfluorononanoic acid	PFNA	NA	NA	4.7	0.013	0.32	0.27	0.33	NA	NA	NA
Perfluorobutanesulfonic acid	PFBS	NA	NA	1500	4.3	70	63	60	40	1.2	22
Perfluorohexanoic acid	PFHxA	NA	NA	510	3.8	61	55	53	NA	NA	NA
Perfluorobutanoic acid	PFBA	NA	NA	380	3.8	61	55	53	NA	NA	NA

Table 9
PFAS Screening Levels for Wildlife Receptors
Ecological Risk Assessment
Santa Fe AASF, NM

		Aquatic-dependent Wildlife Screening Level for Surface Water									
		Argonne Wildlife Values		SERDP Wildlife RBSL [2]							
Feeding Guild				Herbivore	Insectivore	Carnivore	Carnivore	Carnivore	Omnivore	Invertivore	Piscivore
Receptor		ESV Aquatic Mammals	ESV Aquatic Birds	Muskrat	Little Brown Bat	River Otter	Harbor Seal	Mink	Red-Winged Blackbird	Tree Swallow	Brown Pelican
NOAEL-based RBSLs (mg/L water)											
Perfluorooctane sulfonic acid	PFOS	0.000117	0.00257	0.0011	0.00036	0.00028	0.00031	0.00021	0.00034	0.000091	0.000075
Perfluorooctanoic acid	PFOA	1.58	NA	0.018	0.0044	0.012	0.013	0.0094	NA	NA	NA
Perfluorononanoic acid	PFNA	0.00208	NA	0.0022	0.0047	0.0092	0.0097	0.0068	NA	NA	NA
Perfluorohexanesulfonic acid	PFHxS	0.0055	NA	NA	NA	NA	NA	NA	NA	NA	NA
Perfluorobutanesulfonic acid	PFBS	5.71	88.6	76	0.94	2	2.1	1.5	17	0.64	1.3
Perfluorodecanoic acid	PFDA	0.00066	NA	NA	NA	NA	NA	NA	NA	NA	NA
Perfluorohexanoic acid	PFHxA	2.21	NA	6.1	0.21	6.4	5	6.9	NA	NA	NA
Perfluorobutanoic acid	PFBA	8.37	NA	49	1.4	0.86	0.93	0.66	NA	NA	NA
LOAEL-based RBSLs (mg/L water)											
Perfluorooctane sulfonic acid	PFOS	NA	NA	0.0018	0.0006	0.00047	0.00051	0.00036	0.0034	0.00091	0.00075
Perfluorooctanoic acid	PFOA	NA	NA	0.036	0.0089	0.024	0.026	0.019	NA	NA	NA
Perfluorononanoic acid	PFNA	NA	NA	0.0029	0.0063	0.012	0.013	0.009	NA	NA	NA
Perfluorobutanesulfonic acid	PFBS	NA	NA	300	3.8	8	8.5	6	29	1.1	2.1
Perfluorohexanoic acid	PFHxA	NA	NA	13	0.44	13	10	14	NA	NA	NA
Perfluorobutanoic acid	PFBA	NA	NA	120	3.3	2.1	2.2	1.6	NA	NA	NA

Notes:

Shading shows values to be considered in the Screening Level Ecological Risk Assessment (lowest value).

These wildlife-based values do not reflect Site-specific receptors or conditions. If an exceedance of these values is noted in the Screening Level Ecological Risk Assessment, additional screening conducted in Step 3a will consider receptors and assumptions appropriate to the exposure areas.

Argonne - Argonne National Laboratory
ESV - Ecological Screening Value
LOAEL - Lowest Observed Adverse Effects Level.
mg/kg - milligram per kilogram.
mg/L - milligrams per liter.
NA - Not Available.
NOAEL - No Observed Adverse Effects Level.
RBSL - Risk-Based Screening Level.
SERDP - Strategic Environmental Research and Development Program

Sources:

1 - Grippo, M., J. Hayse, I. Hlohowskyj, and K. Picel, 2021. Derivation of PFAS Ecological Screening Values. Argonne National Laboratory, Environmental Science Division. Completed under Interagency Agreement between the U.S. Department of Energy, Argonne National Laboratory, and the Air Force Civil Engineer Center. September. Final.

2 - Divine, C., Frenchmeyer, M., Dally, K., Osborn, E., Anderson, P., Zodrow, J., 2020. Approach for Assessing PFAS Risk to Threatened and Endangered Species. Final Report. SERDP Project ER18-1653. March.

Table 10
PFAS Surface Water Screening Leels for Aquatic Life
Ecological Risk Assessment
Santa Fe AASF, NM

		Aquatic Life for Surface Water			
		Argonne Values	SERDP Values		USEPA Values
		Aquatic Life ESV [1]	Water Quality RBSL [2]	Aquatic Life Protection Values [3]	Aquatic Life Criteria [4]
Constituent	**Abbreviation**	**Freshwater Chronic (ug/L)**	**Freshwater Chronic (ug/L)**	**Freshwater - HC5 (ug/L)**	**Freshwater Chronic (ug/L)**
Perfluorooctane sulfonic acid	PFOS	22.6	51	5.85	8.4
Perfluorooctanoic acid	PFOA	307	3900	1112	94
Perfluorononanoic acid	PFNA	16.4	120	NA	NA
Perfluorohexanesulfonic acid	PFHxS	65.3	NA	NA	NA
Perfluoroheptanoic acid	PFHpA	NA	870	NA	NA
Perfluorobutanesulfonic acid	PFBS	400	3400	NA	NA
Perfluorodecanoic acid	PFDA	2.94	140	NA	NA
Perfluorododecanoic acid	PFDoA	NA	72	NA	NA
Perfluorohexanoic acid	PFHxA	28.8	2300	NA	NA
Perfluoroundecanoic acid	PFUnA	NA	49	NA	NA
Perfluorobutanoic acid	PFBA	64.6	470	NA	NA
Perfluoropentanoic acid	PFPA	NA	140	NA	NA

Notes:

Shading shows values to be considered in the Screening Level Ecological Risk Assessment (lowest value).

Argonne - Argonne National Laboratory	ug/L - microgram per liter
ESV - Ecological Screening Value	RBSL - Risk-Based Screening Level.
HC5 - 5% Hazardous Concentration.	SERDP - Strategic Environmental Research and Development Program
NA - Not Available.	USEPA - United States Environmental Protection Agency.

Sources:

1 - Grippo, M., J. Hayse, I. Hlohowskyj, and K. Picel, 2021. Derivation of PFAS Ecological Screening Values. Argonne National Laboratory, Environmental Science Division. Completed under Interagency Agreement between the U.S. Department of Energy, Argonne National Laboratory, and the Air Force Civil Engineer Center. September. Final.

2 - Divine, C., Frenchmeyer, M., Dally, K., Osborn, E., Anderson, P., Zodrow, J., 2020. Approach for Assessing PFAS Risk to Threatened and Endangered Species. Final Report. SERDP Project ER18-1653. March. Marine screening levels were not derived.

3 - Conder, J., Arblaster, J., Larson, E., Brown, J., Higgins, C., 2020. Guidance for Assessing the Ecological Risks of PFAS to Threatened and Endangered Species at Aqueous Film Forming Foam-Impacted Sites. Guidance Document. SERDP Project ER18-1614. January.

4 - USEPA. 2022. Fact Sheet: Draft 2022 Aquatic Life Ambient Water Quality Criteria for Perfluorooctanoic acid (PFOA) and Perfluorooctane Sulfonic Acid (PFOS). EPA, Office of Water, EPA 842-D-22-005. April 2022. Final, not draft, values will be used in the Screening Level Ecological Risk Assessment.

Attachment A Threatened, Endangered, or Other Special Concern Species

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Attachment A-1: USFWS IPaC Report

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Attachment A-2: State Listed Species

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