Mid-Atlantic
Chesapeake, Virginia

Final

Basewide Per- and Polyfluoroalkyl Substances Site Inspection Addendum Sampling and Analysis Plan

Naval Auxiliary Landing Field Fentress
Chesapeake, Virginia

July 2019

SAP Worksheet #1—Title and Approval Page

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Chesapeake, Virginia

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Basewide Per- and Polyfluoroalkyl Substances Site Inspection Addendum Sampling and Analysis Plan

Naval Auxiliary Landing Field Fentress
Chesapeake, Virginia

July 2019

Prepared for NAVFAC Mid-Atlantic
by CH2M HILL, Inc.
Virginia Beach, Virginia
Contract N62470-16-D-9000
CTO WE01

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Approval Signatures

The following person(s) hereby state that they have reviewed this document and approved this document.

Approval Signatures:

Jones

Angela Jones
Naval Facilities Engineering Command Atlantic
Remedial Project Manger

Steve Mihalko
Virginia Department of Environmental Quality
Remedial Project Manager

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Executive Summary

This Sampling and Analysis Plan (SAP) presents the technical approach for the Basewide Site Inspection (SI) Addendum for per- and polyfluoroalkyl substances (PFAS) to be conducted at Naval Auxiliary Landing Field (NALF) Fentress, in Chesapeake, Virginia. This SI Addednum is being conducted for the Department of the Navy (Navy), Naval Facilities Engineering Command Mid-Atlantic, under the Navy Comprehensive Long-term Environmental Action – Navy (CLEAN) Program.

This SI Addednum SAP has been completed under Contract N62470-16-D-9000, Contract Task Order WE01, in accordance with the Navy's SAP policy guidance to help ensure that environmental data collected are scientifically sound, of known and documented quality, and suitable for intended purposes. The objectives and technical approach included in this SAP were jointly scoped by the Naval Air Station (NAS) Oceana Tier I Partnering Team, which includes representatives from the Navy, United States Environmental Protection Agency (USEPA) Region 3, and Virginia Department of Environmental Quality.

The laboratory information cited in this SAP is specific to Battelle Memorial Institute (Battelle) and Gulf Coast Analytical Laboratories (GCAL). If additional laboratory services are requested requiring modification to the existing SAP, revised SAP worksheets will be submitted to the Navy and regulatory agencies for approval.

NALF Fentress is located in Chesapeake, Virginia, and is a noncontiguous property under the command of NAS Oceana. Established in 1940, the installation encompasses just over 2,500 acres and approximately 8,700 acres in restrictive easements. The facility is used primarily by squadrons stationed at NAS Oceana or Naval Station Norfolk Chambers Field for field carrier landing practice operations. Neither storage nor maintenance of aircraft is routinely performed at NALF Fentress.

Although previous environmental investigations indicated no further action was necessary at NALF Fentress, since that time, PFAS, which were not previously evaluated at Navy sites, have been identified as emerging contaminants that could have been released historically at naval facilities. The initial round of Site Inspection (SI) sampling was completed in December 2015, and involved groundwater monitoring well installation; sampling of groundwater, drinking water, and wastewater at the facility; and completion of basewide water level surveys in the Surficial/Columbia aquifer and Yorktown aquifer. Exceedances of the preliminary health advisories were identified in samples collected from the on-Base drinking water, groundwater, and wastewater. Consequently, sampling of off-Base private drinking water wells was initiated. A total of 59 off-Base private drinking water wells, located within 0.5 mile of the exceedances, were sampled during the first half of 2016 (February through May), with additional data collected at one well in 2017. All samples were analyzed for the six PFAS on the USEPA's Unregulated Contaminant Monitoring Rule 3 list. The SI Report (CH2M, 2018) identified releases of PFAS at levels of concern in groundwater, and an SI Addendum was recommended.

In addition, a pilot study was implemented at seven off-Base private drinking water wells as a result of the detections of perfluorooctanoic acid and/or perfluorooctanesulfonic acid at concentrations exceeding the Lifetime Health Advisory to determine the efficacy of granular activated carbon (GAC) to remove PFAS constituents in drinking water (CH2M, 2017). GAC has been determined to be an effective of removing PFAS constituents in drinking water. However, in accordance with Partnering Team agreement with stakeholder input from residents, the City of Chesapeake, and the Virginia Department of Health, continued sampling of the GAC systems is required. Treatment system sampling will need to be conducted until the long-term solution of the installation of a city water line is implemented (CH2M, 2019).

The objectives of this SI Addendum are:

- Further define the lateral and vertical extent and evaluate the long-term temporal variability of PFAS contamination within the groundwater in both the Columbia and Yorktown aquifers both on- and off-Base, and determine whether there is potentially unacceptable risk to human health and/or ecological receptors.
- Refine understanding of hydraulic characteristics of the aquifers and transport mechanisms for site contaminants.
- Further define the lateral extent of PFAS contamination in soil at areas where soil samples have previously been collected and determine whether there is potentially unacceptable risk to human health and/or ecological receptors.
- If present, determine if PFAS analytes pose a potentially unacceptable risk to human health or ecological receptors due to exposure to soil (where not previously collected), surface water, or sediment.

Determine if GAC continues to be effective in treating off-Base private drinking water.

Activities to be completed to accomplish the objectives of the SI Addendum and to further evaluate the pilot study include:

- Installation of monitoring wells within the Columbia and Yorktown aquifers in known or suspected source areas, downgradient of known or suspected sources areas, and along the perimeter of the Base
- Collection of groundwater samples from existing and new monitoring wells installed in the Columbia and Yorktown aquifers
- Completion of a groundwater level survey of all new and existing monitoring wells
- Collection of co-located surface and subsurface soil samples from known or suspected source areas
- Collection of co-located surface water and sediment samples from drainage areas downgradient of potential source areas and in the vicinity of outfalls from the Base
- Collection of drinking water samples from off-Base residences with private drinking water wells within the designated sampling radius
- Collection of drinking water samples from off-Base GAC treatment systems
- Revision of the human health risk screening and completion of an ecological risk screening[1]

All samples collected will be analyzed for PFAS; sediment samples also will be analyzed for total organic carbon.

This SAP was developed in accordance with the following five guidance documents:

- *Guidance for Quality Assurance Project Plans* (USEPA, 2002)
- *Uniform Federal Policy for Quality Assurance Project Plans* (USEPA, 2005)
- *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA, 2006)
- *Interim Per-and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)* (Navy, 2017)
- *Environmental Restoration Program Manual* (Navy, 2018)

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[1] At the time of this SAP, no USEPA ecological screening values are available for PFAS constituents. Literature-based values are considered in this SAP to ensure data quality. Future ecological risk screening activities will be based on USEPA-issued values available at the time of data receipt. If no screening values have been issued by USEPA when data are received, the ecological risk screening may be delayed until appropriate screening values are available.

This SAP consists of the 37 worksheets specific to the Navy's SAP guidance (Navy, 2018). All figures are included following the worksheets. The field standard operating procedures for this work are included in **Appendix A** and the laboratory Department of Defense Environmental Laboratory Accreditation Program documentation is included in **Appendix B**. The July 2018 Partnering Meeting SAP scoping session presentation is included in **Appendix C.**

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A Field Standard Operating Procedures
B Laboratory DoD ELAP Accreditation Letters
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D PFAS Laboratory Standard Operating Procedures

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1 Potential Source Areas
2 Problem Definitions/Objectives, Environmental Questions, and Project Quality Objectives

Figures

1 Installation Location Map
2 PFOA and PFOS Concentrations in the Columbia/Surficial Aquifer
3 PFOA and PFOS Concentrations in the Yorktown Aquifer
4 PFOA and PFOS Concentrations in Soil Samples
5 PFOA and PFOS Detections and Exceedances from Parcels Located Off-Base
6 Columbia/Surficial Aquifer Groundwater Elevation Contours – May 2017
7 Yorktown Aquifer Groundwater Elevation Contours – May 2017
8 Potential PFOA and PFOS Source Areas Identified in Site Inspection Report
9 Proposed Sample Locations
10 Proposed Area Potable Well Sample Locations

Abbreviations and Acronyms

°C	degrees Celsius
µg/kg	microgram(s) per kilogram
µg/L	microgram(s) per liter
11Cl-PF3OUdS	11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid
ADONA	aluminum 4,8-dioxa-3H-perfluorononanoic acid
AFFF	aqueous film forming foam
AM	Activity Manager
amu	atomic mass unit
AQM	Activity Quality Manager
Battelle	Battelle Memorial Institute
bgs	below ground surface
BTAG	Biological Technical Assistance Group
CA	corrective action
CAS	Chemical Abstracts Service
CCB	continuing calibration blank
CCV	continuing calibration verification
CH2M	CH2M HILL, Inc.
CLEAN	Comprehensive Long-term Environmental Action—Navy
COC	chain of custody
CSM	conceptual site model
DL	detection limit
DO	dissolved oxygen
DoD	Department of Defense
DQI	data quality indicator
DV	Data Validator
EB	equipment blank
EDD	electronic data deliverable
ELAP	Environmental Laboratory Accreditation Program
ESV	ecological screening value
FD	field duplicate
FTL	Field Team Leader
FWI	Foster Wheeler
g	gram(s)
g/L	gram(s) per liter
GAC	granular activated carbon
GCAL	Gulf Coast Analytical Laboratories
H&S	health and safety
HDPE	high density polyethylene
HQ	hazard quotient
HSO	Health and Safety Officer
HSP	Health and Safety Plan

IB	instrument blank
ICV	initial calibration verification
LCL	lower confidence limit
ID	identification
IDW	investigation-derived waste
ISC	instrument sensitivity check
LC-MS/MS	liquid chromatography and tandem mass spectrometry
LFB	laboratory fortified blank
LFSM	laboratory fortified sample matrix
LFSMD	laboratory fortified sample matrix duplicate
LIMS	Laboratory Information Management System
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
mg/kg	milligram(s) per kilogram
mL	milliliter(s)
MPC	Measurement Performance Criteria
MRL	minimum reporting level
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
NALF	Naval Auxiliary Landing Field
NAS	Naval Air Station
NAVFAC	Naval Facilities Engineering Command
Navy	Department of the Navy
NEtFOSAA	n-ethylperfluoroctansulfonamid
ng/L	nanogram(s) per liter
NIRIS	Naval Installation Restoration Information System
NMeFOSAA	n-methyl perfluorooctanesulfonamidoacetic acid
ORP	oxidation-reduction potential
oz	ounce(s)
PA	Preliminary Assessment
PAL	Project Action Limit
PB	procedural blank
PC	Project Chemist
PCB	polychlorinated biphenyl
PFAS	per- and polyfluoroalkyl substances
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
PFTA or PFTeDA	perfluorotetradecanoic acid
PFTrDA	perfluorotridecanoic acid
PFUnA	perfluoroundecanoic acid
PIL	project indicator limit
PM	Project Manager
POC	point of contact
PQL	project quantitation limit
PQO	project quality objective
PVC	polyvinyl chloride
QA	quality assurance
QAO	Quality Assurance Officer
QL	quantitation limit
QC	quality control
QSM	Quality Systems Manual
RCRA	Resource Conservation and Recovery Act
RPD	relative percent difference
RPM	Remedial Project Manager
RSL	regional screening level
SAA	Source Area Assessment
SAP	Sampling and Analysis Plan
SBO	Safe Behavior Observation
SI	Site Investigation
SOP	standard operating procedure
SPE	solid phase extraction
SSC	Site Safety Coordinator
SSL	soil screening level
STC	Senior Technical Consultant
TBD	to be determined
TOC	total organic carbon
UCL	upper control limit
USEPA	United States Environmental Protection Agency
UST	underground storage tank
VDEQ	Virginia Department of Environmental Quality

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SAP Worksheet #2—SAP Identifying Information

Site Name/Number:	Naval Auxiliary Landing Field (NALF) Fentress
Operable Unit:	Not applicable (N/A)
Contractor Name:	CH2M HILL, Inc. (CH2M)
Contract Number:	N62470-16-D-9000, Contract Task Order WE01
Contract Title:	Comprehensive Long-term Environmental Action—Navy (CLEAN) 9000

1. This Sampling and Analysis Plan (SAP) was prepared in accordance with the following guidance documents:
   - *Guidance for Quality Assurance Project Plans* (USEPA, 2002)
   - *Uniform Federal Policy for Quality Assurance Plans* (USEPA, 2005)
   - *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA, 2006)
   - *Interim Per-and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)* (Navy, 2017)
   - *Environmental Restoration Program Manual* (Navy, 2018)
2. Identify regulatory program:
   - Resource Conservation and Recovery Act (RCRA), but following the Comprehensive Environmental Response Compensation, and Liability Act site management process
3. This is a project-specific SAP.
4. List dates if scoping sessions held:
   - July 17 and 18, 2018
5. List organizational partners (stakeholders) and connection with lead organization:

Organization Partners/Stakeholders	Connection
Virginia Department of Environmental Quality (VDEQ)	Lead Regulatory Agency
Department of Defense (DoD)	Land Owner
Naval Facilities Engineering Command (NAVFAC), Mid-Atlantic	Lead Organization

6. If any required SAP elements or required information are not applicable to the project or are provided elsewhere, then note the omitted SAP elements and provide an explanation for their exclusion below:
   - All required information is included in this SAP; therefore, the crosswalk table is not necessary for this project.
7. List dates and titles of any SAP documents written for previous site work that are relevant to the current investigation.
   - *Basewide Per- and Polyfluoroalkyl Substances Site Inspection Report, Naval Air Station Oceana, Virginia Beach, Virginia.* (CH2M, 2018).

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SAP Worksheet #3—Distribution List

Name of SAP Recipients	Title/Role	Organization	Telephone Number	Email Address or Mailing Address	Document Control Number
Angela Jones	Remedial Project Manager (RPM)	NAVFAC Mid-Atlantic	757-341-0485	angela.jones1@navy.mil	
Steve Mihalko	RPM	VDEQ	804-698-4202	stephen.mihalko@deq.virginia.gov	
Bonnie Capito	Librarian	NAVFAC Atlantic	757-322-4785	bonnie.capito@navy.mil	
Nathaniel Price	Activity Manager (AM)	CH2M	757-671-6280	nathaniel.price@jacobs.com	
Stephanie Sawyer	Project Manager (PM)	CH2M	757-671-6273	stephanie.sawyer@jacobs.com	
Megan Morrison	Activity Chemist	CH2M	781-662-0315	Megan.morrison@jacobs.com	
John Tomik	Activity Quality Manager (AQM)	CH2M	757-671-6259	john.tomik@jacobs.com	
Laura Cook	Senior Technical Consultant (STC)	CH2M	757-671-6214	laura.cook1@jacobs.com	
To be determined (TBD)	Field Team Leader (FTL)	CH2M	TBD	TBD	
Jonathan Thorn	Laboratory PM	Battelle Memorial Institute (Battelle)	781-681-5565	thorn@battelle.org	
Liz Martin	Laboratory PM	Gulf Coast Analytical Laboratories (GCAL)	225-769-4900	liz.martin@gcal.com	
TBD	Data Validator (DV)	TBD	TBD	TBD	

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SAP Worksheet #4—Project Personnel Sign-Off Sheet

Name	Organization/Title/Role	Telephone Number (optional)	Signature/Email Receipt
Angela Jones	NAVFAC Mid-Atlantic/RPM	757-341-0485	
Nathaniel Price	CH2M/AM	757-671-6280	
John Tomik	CH2M/AQM	757-671-6259	
Andrew Lairson	CH2M/PC	757-671-6297	
Laura Cook	CH2M/STC	757-671-6214	
Stephanie Sawyer	CH2M/PM	757-671-6273	
Megan Morrison	CH2M/ Activity Chemist	781-662-0315	
Anita Dodson	CH2M/Program Chemist	757-671-6218	
Roni Warren	CH2M/Human Health Risk Assessor	814-364-2454	
Bill Kappleman	CH2M/Ecological Risk Assessor	703-376-5152	
Steve Mihalko	VDEQ/RPM	804-698-4202	
Jonathan Thorn	Battelle/PM	781-681-5565	
Liz Martin	GCAL/PM	225-769-4900	
TBD	TBD/DV	TBD	

Each organization will read the SAP and provide an original copy of the sign-off sheet to the PM for maintenance in the CH2M project file.

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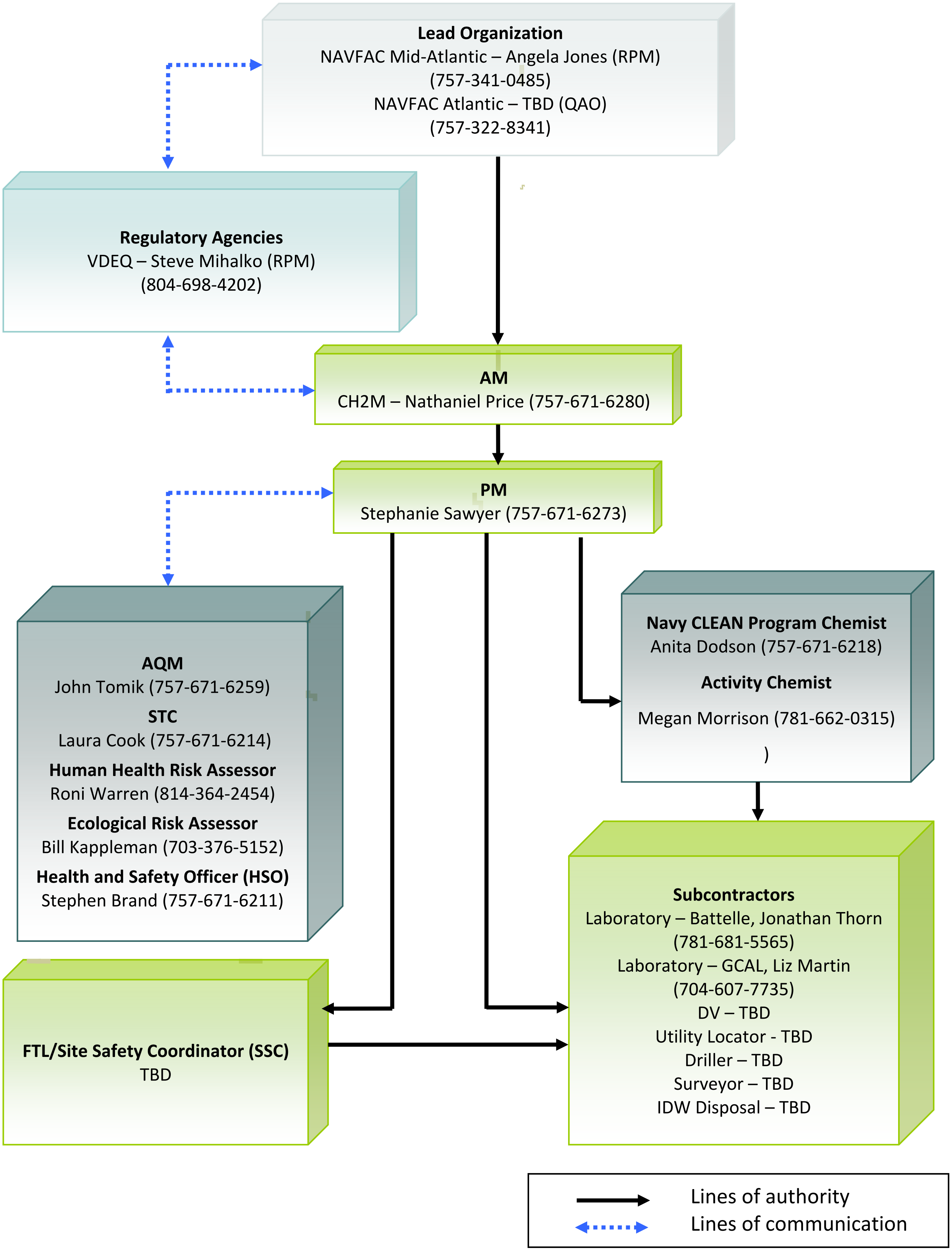
SAP Worksheet #5—Project Organizational Chart



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SAP Worksheet #6—Communication Pathways

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or Email	Procedure
Communication with NAVFAC (lead agency)	Navy RPM	Angela Jones	757-341-0485	Primary point of contact (POC) for Navy; communicates directly with VDEQ and USEPA as needed. Can delegate communication to other internal or external POCs.
Communication with VDEQ	VDEQ RPM	Steve Mihalko	804-698-4202	Primary POC for VDEQ; communicates directly with the Navy and USEPA as needed. Can delegate communication to other internal or external POCs. Upon notification of field changes, VDEQ will have 24 hours to approve or comment on the field changes. All data results will be presented and discussed during partnering meetings.
Department of the Navy (Navy) Quality Assurance (QA)/Quality Control (QC) input	Navy Chemist/QAO	Kenneth Bowers	757-322-8341	Provides review comments to Navy contractor on Pre-draft SAP via the Naval Installation Restoration Information System (NIRIS) submittal. Provides overall Navy guidance via direct communication with Navy contractor chemist, as warranted.
Program QC	CH2M AQM	John Tomik	757-671-6259	Provides quality oversight to the project.
Program Oversight	CH2M STC	Laura Cook	757-671-6214	Provides technical oversight to the project.
Communication to/from Navy contractor (e.g., submission of SAP for review; receipt of regulatory comments, updates on project progress, communication of stakeholder expectations)	CH2M Program SAP reviewer	Janna Staszak	757-671-6256	Provides senior technical oversight of the SAP.
Communication regarding overall project status and implementation and primary POC with Navy RPM, USEPA, and VDEQ	CH2M AM	Nathaniel Price	757-671-6280	Primary POC for stakeholder agency managers; can delegate agency communication to other contract staff, as appropriate. All information and materials about the project will be forwarded to the Partnering Team by the AM. The AM oversees all NAS Oceana projects. If field changes occur during investigation activities, the AM will work with the Navy RPM to communicate the field changes to the Partnering Team via email and/or phone within 24 hours.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or Email	Procedure
Communication regarding overall project status and implementation and primary POC with Navy RPM, USEPA, and VDEQ	CH2M PM	Stephanie Sawyer	757-671-6273	If field changes occur during investigation activities, the PM will work with the AM and Navy RPM to communicate the field changes to the Partnering Team via email and/or phone within 24 hours. All data will be communicated to the Partnering Team via email and meetings. The CH2M PM will communicate project-related information in a consistent manner. Standard monthly progress reports and invoices will be prepared and submitted to the Navy.
Health and Safety (H&S) expectations and procedures	CH2M Health and Safety Officer (HSO)	Stephen Brand	757-671-6211	Review of the Health and Safety Plan (HSP). Direct communication (via email, telephone, hard copy, or in person, will be notified within 24 hours of incident) to/from Navy contractor project staff to ensure implementation of appropriate H&S procedures.
Implementation of sampling activities; SAP changes in the field; field corrective actions (CAs); daily field progress reports	CH2M FTL	TBD	TBD	Documentation of deviations from SAP in field logbooks and rationale for deviations, made within 24 hours of deviation; assistance in material procurement and delivery; groundwater sampling and well installation; deviations made only with approval from contractor PM and/or Environmental Manager. See **Worksheet #32** Assessment Findings and CA Responses and **Worksheet #32-1** CA Form. The FTL will immediately notify the PM of any field issues that would negatively impact the ability to meet project data quality objectives or would negatively impact the project schedule. The AM or PM may notify the Navy RPM. The FTL will email daily field progress reports to contractor PMs weekly; telephone communication with the PM will occur as needed.
Ensure staff H&S in the field	CH2M Site Safety Coordinator (SSC)	TBD	TBD	Daily safety tailgates; daily observations; real-time discussions of observations and changes to be implemented with field staff.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or Email	Procedure
Data tracking from collection through upload to database; management of analytical laboratory and data validation subcontractors; analytical CAs/release of analytical data	CH2M Activity Chemist	Megan Morrison	781-662-0315	Tracks data from sample collection through upload to the database, ensuring SAP requirements are met by laboratory and field staff. Will act as main POC for laboratory QAO. The CH2M AM and PM are informed within 24 hours to pass on communications to Navy and regulators as required. Analytical laboratory CAs will be identified by, or brought to the attention of, the PC as soon as they are discovered. Facilitates resolution on a same-day basis after consulting with the PM and AQM and the Navy chemist (if changes in the SAP are warranted) to ensure SAP requirements are met by the laboratory. Communicates with subcontractors by phone and follows up with email to document decisions and actions. If analytical laboratory issues affect data usability by rendering a significant amount of rejectable or unusable data such that the project completeness goal cannot be obtained, the PC will notify the project team including the Navy RPM and Navy QAO.
Reporting Laboratory Data Quality Issues	Laboratory PM	Jonathan Thorn	781-681-5565	All QA/QC issues with project filed samples will be reported by the laboratory to the PC within 1 business day. Battelle and GCAL are the prime laboratories for this event. All communication will be directed to each of the laboratory's project managers. In the event of significant data quality issues, the AM will notify the Navy RPM. The RPM may notify the Navy chemist at their discretion.
		Liz Martin	225.769.4900	
Communications regarding SAP changes	CH2M Program Chemist	Anita Dodson	757-671-6218	Changes to the project that would prompt a SAP change that would require Navy QAO approval include: the addition of an analytical suite not previously included in the SAP, the addition of an environmental matrix not previously included in the SAP, laboratory accreditation to a new DoD QSM version, inclusion of a new laboratory into the SAP for any reason, or updates to the Conceptual Site Model (CSM) that prompt new DQO's. Updated laboratory LOQ, LOD, DL values will not prompt a SAP update for Navy QAO approval unless those updates negatively impact the ability to meet project action levels.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or Email	Procedure
Field and Analytical CAs	CH2M Program Chemist CH2M Activity Chemist CH2M FTL	Anita Dodson Megan Morrison TBD	757-671-6218 781-662-0315 TBD	The need for CA for field and analytical issues will be determined by the FTL and or contractor chemist.
Stop Work Order	CH2M AM FTL/SSC Field Team Members	Nathaniel Price TBD	757-671-6280 TBD	Any field member can immediately stop work if an unsafe condition that is immediately threatening to human health is observed. The field staff, FTL, or SSC, should notify the CH2M AM/PM immediately along with the Navy RPM. Ultimately, the FTL or AM/PM can stop work for a period of time. NAVFAC Mid-Atlantic can stop work at any time.
Reporting data quality issues	DV	TBD	TBD	The DV reviews and qualifies analytical data as necessary. The data along with a validation narrative are returned to the PC within 14 calendar days.

SAP Worksheet #7—Personnel Responsibilities Table

Name	Title/Role	Organizational Affiliation	Responsibilities
Angela Jones	RPM	NAVFAC	Coordinates all environmental activities at NAS Oceana.
Kenneth Bowers	NAVFAC Chemist/QAO	NAVFAC	Navy Review of SAP and QA input.
Nathaniel Price	AM	CH2M	Responsible for Environmental Restoration Program at NAS Oceana.
Stephanie Sawyer	PM		Responsible for administration; coordinates staffing; monitors project performance; directs and oversees project staff.
John Tomik	AQM		Provides activity level quality review and guidance.
Laura Cook	STC		Provides senior technical oversight.
Anita Dodson	Program Chemist		Provides guidance during preparation of the SAP. Provides program-level review of SAP.
Katie Tippin	Program Level SAP Reviewer		Provides guidance during preparation of the SAP. Provides program-level review of SAP.
Megan Morrison	Activity Chemist		Prepares chemistry-specific SAP worksheets. Ensures proper data tracking and reporting and maintains communication with contracted laboratory. Responsible for coordination of laboratory deliverables. Ensures that laboratory adheres to requirements in the SAP.
Roni Warren	Human Health Risk Assessor		Provides senior technical support for investigative sampling and human health risk screening.
Bill Kappleman	Ecological Risk Assessor		Provides senior technical support for investigative sampling and ecological risk screening.
TBD	FTL		Supervises and coordinates all field activities and is responsible for overseeing subcontractors.
TBD	Field Team Member		Assists with sample collection and helping FTL.
Stephen Brand	HSO		Oversees H&S for field activities.
Jonathan Thorn	Laboratory PM	Battelle	Manages analytical projects from initiation to completion.
Liz Martin	Laboratory PM	GCAL	Manages analytical projects from initiation to completion.
TBD	DV	TBD	Responsible for validation of environmental data.

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SAP Worksheet #8—Special Personnel Training Requirements Table

No specialized training beyond standard H&S training is required for this project.

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SAP Worksheet #9-1—Project Scoping Session Participants Sheet Summary

Project Name: NALF Fentress Basewide PFAS SI Addendum Scoping Session **Projected Date(s) of Sampling:** Winter 2019 **PM:** Stephanie Sawyer	**Site Name:** NALF Fentress **Site Location:** NALF Fentress, Chesapeake, Virginia
Date of Session: July 17 and 18, 2018 **Scoping Sessions Purpose:** To agree to the sampling strategy for the Basewide PFAS SI Addendum at NALF Fentress	

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Note:

[a] Christopher Vallone was the USEPA RPM at the time of this scoping session. Connor O'Loughlin is the current RPM.

[b] Laura Cook was the AM at the time of this scoping session. Nathaniel Price is the current AM.

July 17, 2018

The Navy presented the proposed objectives of the SI Addendum to the team. The objectives as agreed to by the team are as follows:

- Further define the lateral and vertical extent and evaluate the long-term temporal variability of per- and polyfluoroalkyl substances (PFAS) contamination within the groundwater in both the Columbia and Yorktown aquifers both on- and off-Base and determine whether there is potentially unacceptable risk to human health and/or ecological receptors.
- Refine understanding of hydraulic characteristics of the aquifers and transport mechanisms for site contaminants.
- Further define the lateral extent of PFAS contamination in soil at areas where soil samples have previously been collected, and determine whether there is potentially unacceptable risk to human health and/or ecological receptors.
- If present, determine if PFAS analytes pose a potentially unacceptable risk to human health or ecological receptors due to exposure to soil (where not previously collected), surface water, or sediment.

SAP Worksheet #9-1—Project Scoping Session Participants Sheet Summary (continued)

The Navy then presented a proposed sampling strategy to meet the objectives. The team discussed the proposed locations, media, and parameters and agreed upon the following investigation and data evaluation approach:

- Install six shallow monitoring wells.
- Install 13 deep monitoring wells, 6 to be co-located with the shallow monitoring wells. Two wells will be installed at deeper intervals than previously installed wells.
- Complete a groundwater level survey of all new and existing monitoring wells.
- Collect groundwater samples from all previously sampled monitoring wells and all newly installed monitoring wells.
- Collect seven co-located surface (0 to 6 inches below ground surface [bgs]) and subsurface (6 to 24 inches bgs) soil samples.
- Collect co-located surface and subsurface soil samples at all new monitoring well locations (13 total).
- Collect 15 co-located sediment and surface water samples.
- Collect drinking water samples from off-Base residences with private drinking water wells within the designated sampling radius.
- Analyze all samples for 24 PFAS.[2]
- Evaluate potentially unacceptable risks to human receptors and collect data to support an ecological risk screening when appropriate screening values are issued by USEPA.

Follow Up/Follow on:

A Pilot Test Work Plan (CH2M, 2017) was initiated following USEPA and VDEQ approval to determine the efficacy of granular activated carbon (GAC) to remove PFAS constituents in drinking water. While GAC has been determined to be an effective of removing PFAS constituents in drinking water, additional sampling is needed to ensure the continued efficacy of GAC at each off-Base private drinking water well treatment system and to allow for sampling of the 18 constituents in Method 537.1.

Therefore, an additional objective to determine if GAC continues to be effective in treating off-Base private drinking water was added to the SAP. In order to meet this objective, treatment system samples from off-Base residences where perfluorooctanoic acid (PFOA) and/or perfluorooctanesulfonic acid (PFOS) concentrations exceeded the Lifetime Health Advisory during historical off-Base private drinking water sampling will need to be collected until the long-term solution of the installation of a city water line is implemented (CH2M, 2019).

Action Items:

CH2M will continue preparing the SAP.

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[2] Based on Navy policy, this decision was later rescinded. Drinking water samples will be analyzed for the 18 PFAS constituents in USEPA Method 537.1, while all other samples will be analyzed for the 14 PFAS constituents in the original USEPA Method 537. Samples may also be analyzed for the four additional PFAS compounds recently included the updated analytical method for PFAS, USEPA Method 537.1, if the contracted laboratory has a valid Environmental Laboratory Accreditation Program (ELAP) letter for these constituents in other matrices at the time of sampling.

SAP Worksheet #10—Conceptual Site Model

Installation Background

NALF Fentress (**Figure 1**) is located in Chesapeake, Virginia, and is a noncontiguous property under the command of NAS Oceana. Established in 1940, the installation encompasses just over 2,500 acres and approximately 8,700 acres in restrictive easements. The facility is used primarily by squadrons stationed at NAS Oceana or Naval Station Norfolk Chambers Field for field carrier landing practice operations. Neither storage nor maintenance of aircraft is routinely performed at NALF Fentress.

Investigation History

A Basewide PFAS Site Inspection (SI) was completed between December 2015 and November 2017. The SI included collection of on- and off-Base groundwater samples from both the Columbia/Surficial and the Yorktown aquifers, drinking water samples from both on- and off-Base, and on-Base soil samples from potential source areas. All samples were analyzed for the six PFAS on the USEPA's Unregulated Contaminant Monitoring Rule 3 list, which consists of PFOS, PFOA, perfluorobutanesulfonic acid (PFBS), perfluoroheptanoic acid (PFHpA), perfluorohexanesulfonic acid (PFHxS), and perfluorononanoic acid (PFNA). In addition, since off-Base groundwater sampling was conducted after issuance of the September 2017 Navy policy (Navy, 2017), these groundwater samples were analyzed for the 14 PFAS constituents listed in the September 2017 Navy policy: PFOS, PFOA, PFNA, PFHxS, PFHpA, PFBS, perfluorohexanoic acid (PFHxA), perfluorodecanoic acid (PFDA), n-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA), perfluoroundecanoic acid (PFUnA), n-ethylperfluoroctansulfonamid (NEtFOSAA), perfluorododecanoic acid (PFDoA), perfluorotridecanoic acid (PFTrDA), and perfluorotetradecanoic acid (PFTA or PFTeDA) (Navy, 2017). In groundwater, PFOS and PFOA were screened against the Lifetime Health Advisory of 70 nanograms per liter (ng/L) and PFBS was screened against the USEPA Regional Screening Level (RSL) of 400,000 ng/L. Of the 42 groundwater samples collected within the Columbia/Surficial aquifer, PFOS and/or PFOA concentrations in 25 monitoring wells exceeded the Lifetime Health Advisory, PFOS and/or PFOA concentrations in 12 monitoring wells were detected at concentrations below the Lifetime Health Advisory, and PFOS and/or PFOA were not detected in five monitoring wells. Exceedances of the the Lifetime Health Advisory were observed in the northern portion of the Base with the higher detected concentrations near UST 20B and Site 17b. Of the 17 groundwater samples collected within the Yorktown aquifer, PFOS and/or PFOA concentrations in one monitoring well exceeded the Lifetime Health Advisory, PFOS and/or PFOA concentrations in 13 monitoring wells were detected at concentrations below the Lifetime Health Advisory, and PFOS and/or PFOA were not detected in three monitoring wells. The one exceedance of the Lifetime Health Advisory was observed in the Crash Truck Test Area. PFBS concentrations in both the Surficial/Columbia and Yorktown aquifers were not detected in any monitoring well at concentrations above the RSL.

In soil, PFOA and PFOS were screened against the residential soil RSL of 130 micrograms per kilogram (µg/kg). Of the eight surface soil and subsurface soil samples collected at the base, only PFOS was detected in three surface soil and one subsurface soil sample at concentrations above the RSL. Exceedances were observed in the vicinity of UST 20B and the Crash Truck Test Area. There are no screening criteria for PFNA, PFHxS, or PFHpA, PFHxA, PFDA, NMeFOSAA, PFUnA, NEtFOSAA, PFDoA, PFTrDA, PFTA, or PFTeDA. Results of the SI are summarized in **Table 1** and **Figures 2**, **3**, and **4**[3]; additional details can be found in the SI Report (CH2M, 2018).

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[3] Figures 4, 5, and 6 only include PFOA and PFOS results as these are the only PFAS with Lifetime Health Advisory levels.

SAP Worksheet #10—Conceptual Site Model (continued)

In 2016, drinking water samples were collected from 59 off-Base drinking water wells. Seven drinking water wells had exceedances of the Lifetime Health Advisory for PFOS/PFOA. Seventeen drinking water wells had detections of PFOS/PFOA less than the Lifetime Health Advisory. The remaining 35 off-Base drinking water wells sampled did not have any detections of PFAS (**Figure 5**). Based on the findings of the off-Base potable water well sampling, an emergency response action was implemented. Under the emergency response action, bottled water was provided to the residents whose drinking water exceeded the Lifetime Health Advisory, and continues to be provided.

Following implementation of the emergency response action for off-Base drinking water, a pilot test was implemented that consisted of the installation and operation of point of entry GAC systems at the seven drinking water wells with exceedances. Seven off-Base drinking water pilot systems were installed between May and March 2018. Each point of entry GAC system was installed downstream from an existing pressure tank (if present), and water was routed through a 25-micrometer cartridge pre-filter, flowmeter, and two GAC vessels, existing water softening systems (if present), and an ultraviolet (UV) disinfection system before flowing back into existing plumbing. Details of the pilot test installation are included in the *Pilot Test Work Plan: Granular Activated Carbon System Installation on Residential Drinking Water Systems to Remove PFOA and PFOS* (CH2M, 2017).

Physical Characteristics

Topography at NALF Fentress is flat with relief varying by less than 5 feet across the entire installation (CH2M, 1992). Land surface elevations range between 10 and 15 feet above mean sea level. Surface water runoff from the Base is directed to a system of drainage ditches and surface canals, which direct water north and east of the facility toward the Intracoastal Waterway and the marshland surrounding it (**Figure 1**)**.**

NALF Fentress is situated on the outer edge of the Atlantic Coastal Plain physiographic province. The Atlantic Coastal Plain is a broad wedge of unconsolidated sediments that dip and thicken to the east. The sediments consist of several thousand feet of unconsolidated sand, clay, silt, and gravels and are underlain by granite basement rock. From oldest to youngest, the five principal sedimentary units are the Potomac Formation, unnamed Upper Cretaceous deposits, the Pamunkey Group, the Chesapeake Group, and the Columbia Group (FWI, 1994).

The Columbia Group sediments and the uppermost portion of the Chesapeake Group or the Yorktown aquifer, comprise one of the principal aquifers used locally for water supply. Regionally, a layer of silt and clay separates the Yorktown aquifer from the sediments of the Columbia Group. This clay layer has been designated as the Yorktown confining unit by Meng and Harsh (1984) because of its role in the regional hydrogeology.

At NALF Fentress, the Yorktown confining unit was identified as being a layer of olive-gray clay and silty clay 0.5 to 15 feet thick, which was encountered at approximately 30 feet bgs. The Yorktown aquifer was encountered at approximately 45 feet bgs, directly beneath the Yorktown confining unit. The aquifer consists primarily of gray, very fine to medium sand, and in some cases, coarse sand and gravel.

Groundwater flow in the Columbia/Surficial aquifer at NALF Fentress is radial with a higher component of flow to the east and northeast (**Figure 6**). Groundwater flow in the Yorktown aquifer is generally toward the north and east (**Figure 7**). There is a downward vertical gradient between the Columbia/Surficial and Yorktown aquifers. Columbia/Surficial aquifer groundwater at NALF Fentress is generally within 3 to 10 feet of the land surface. Aquifer conditions are unconfined in the Columbia Group and unconfined to semi-confined within the upper Yorktown Formation. In the southern portion of the facility, the confining unit (if present), is no more than 0.5 foot thick, possibly allowing the upper Yorktown and Columbia/Surficial to act as a single, unconfined, hydrogeologic unit. Additionally, in some areas north of the facility, the confining unit is very sandy, possibly resulting in some hydraulic connection between the two aquifers.

SAP Worksheet #10—Conceptual Site Model (continued)

PFAS Source Areas

Table 1 presents the results of the PFAS source areas previously investigated as well as newly identified potential source areas that will be investigated as part of this SI Addendum. These areas are shown on **Figure 8**. Additional details about the previous investigation are available in the SI Report (CH2M, 2018). One additional area, (Site 17c), and has been included in this SI Addendum SAP based on newly available data indicating that the area was used as a fire fighting training area. An evaluation of additional source areas as well as additional information on currently known source areas will be documented in the Basewide PFAS Source Area Assessment (SAA).

Table 1: Potential PFAS Source Areas

Source Areas	Details
Source Areas Investigated During SI	
Site 14 (Fentress Landfill)	The Fentress Landfill was in use from 1945 until 1970 (EarthTech, 1989). PFAS were not analyzed during investigations prior to 2015; therefore, in 2015, Site 14 was identified as an area requiring further evaluation of potential PFAS contamination as aqueous film forming foam (AFFF) may have been disposed of in the Fentress Landfill. During the SI, samples were collected from four monitoring wells screened in the Columbia aquifer and two monitoring well screened in the Yorktown aquifer in the vicinity of Site 14. Concentrations of PFOS and/or PFOA exceeded the Lifetime Health Advisory in the two Columbia aquifer monitoring wells north of the site boundary. PFOS and PFOA concentrations did not exceed the Lifetime Health Advisory and pose potential unacceptable human health risk in the remaining two Columbia aquifer monitoring wells or the Yorktown aquifer monitoring wells located in the vicinity of Site 14 (**Figures 2 and 3**). PFHxS, PFBS, PFHpA, and PFNA also were detected in groundwater with the highest concentrations being detected in the same Columbia aquifer monitoring wells where PFOS and PFOA exceeded the Lifetime Health Advisory. No soil samples were collected. Based on the locations of the PFOS and PFOA Lifetime Health Advisory groundwater exceedances in the vicinity of Site 14, there is some uncertainty as to whether these concentrations are a result of the disposal of AFFF in the landfill. In addition, it is unknown if PFAS has migrated to surface water and sediment within the drainage ditches and surface canals surrounding the site.
Site 17a (Former Firefighter Training Area, estimated date of use: 1959-1963)	Site 17a consists of a burn pit with an earthen berm used to ignite fuel and other wastes for firefighter training exercises (CH2M, 1991). In 2015, Site 17a at NALF Fentress was identified as requiring further evaluation of potential PFAS contamination because of firefighting practices utilizing AFFF at the site. During the initial evaluation of Site 17a to support the PFAS investigation, the site was located using historical documents. During the SI, samples were collected from one monitoring well screened in the Columbia aquifer and one monitoring well screened in the Yorktown aquifer in the vicinity of Site 17a. Concentrations of PFOS and PFOA exceeded the Lifetime Health Advisory and pose potential unacceptable human health risk in the Columbia aquifer monitoring well (**Figure 2**). PFOS and PFOA were detected in the Yorktown aquifer monitoring well (**Figure 3**) but not at concentrations exceeding the Lifetime Health Advisory. PFHxS, PFBS, PFHpA, and PFNA also were detected in groundwater with the highest concentrations detected in the Columbia aquifer. During the SI, one soil sample was collected in the vicinity of Site 17a. PFOS and PFOA were detected in the surface (0-6 inches) and subsurface (6-24 inches) soil but not at concentrations exceeding the soil RSL (**Figure 4**); however, the potential for PFAS in soil to leach into groundwater has not been evaluated. PFBS, PFHxS, PFHpA, and PFNA also were detected at low concentrations in surface and/or subsurface soil. The horizontal and vertical extents of PFAS in groundwater and soil were not delineated during the SI. However, further resolution of the soil and groundwater concentrations are not required.

SAP Worksheet #10—Conceptual Site Model (continued)

Table 1: Potential PFAS Source Areas

Source Areas	Details
Site 17b (Former Firefighter Training Area, estimated date of use: 1982-1994)	Following the initial phase of investigation at Site 17a, historical air photographs were reviewed, and an additional Former Firefighter Training Area location was identified as Site 17b based on ground discoloration. During the SI, samples were collected from four monitoring wells screened in the Columbia aquifer in the vicinity of Site 17b. No monitoring wells in the Yorktown aquifer are present near the site. Concentrations of PFOS and PFOA exceeded the Lifetime Health Advisory and pose potential unacceptable human health risk in all four Columbia aquifer monitoring wells (**Figure 2**). PFHxS, PFBS, PFHpA, and PFNA also were detected in all four Columbia aquifer monitoring wells. No soil samples were collected. The vertical extent of groundwater contamination in the vicinity of Site 17b was not delineated during the SI.
Underground Storage Tank 20B	UST 20B was located south of Building 20 and has been removed. UST 20B was managed under the Petroleum Oil Lubricant program. During the SI, the UST 20B monitoring wells were located and sampled to aid with characterization of the nature and extent of PFAS contamination in groundwater at NALF Fentress. The UST 20B monitoring wells are located near the former AFFF storage area. During the SI, samples were collected from six monitoring wells screened in the Columbia aquifer in the vicinity of UST 20B. No monitoring wells in the Yorktown aquifer are present near the site. Concentrations of PFOS and PFOA exceeded the Lifetime Health Advisory and pose potential unacceptable human health risk in all six Columbia aquifer monitoring wells (**Figure 2**). PFHxS, PFBS, PFHpA, and PFNA also were detected all six Columbia aquifer monitoring wells. During the SI, four soil samples were collected in the vicinity of UST 20B. PFOS and PFOA were detected in the surface (0 to 6 inches) and subsurface (6 to 24 inches) soil, with two of the four locations having soil concentrations exceeding the soil RSL (**Figure 4**). PFBS, PFHxS, PFHpA, and PFNA also were detected at low concentrations in surface and/or subsurface soil. The extent of PFAS in soil is unknown, and the vertical extent of groundwater contamination in the vicinity of UST 20B was not delineated during the SI.
Crash Truck Test Area	This area was used to test AFFF spray nozzles on fire trucks by spraying AFFF directly onto the ground surface. During the SI, samples were collected from one monitoring well screened in the Columbia aquifer and one monitoring well screened in the Yorktown aquifer in the vicinity of the Crash Truck Test Area. Concentrations of PFOS and PFOA exceeded the Lifetime Health Advisory and pose potential unacceptable human health risk in both the Columbia and Yorktown aquifer monitoring wells (**Figures 2** and **3**). PFHxS, PFBS, PFHpA, and PFNA also were detected in groundwater in the Columbia and Yorktown aquifers. During the SI, one soil sample was collected in the vicinity of the Crash Truck Test Area. PFOS and PFOA were detected in the surface (0 to 6 inches) and subsurface (6 to 24 inches) soil, with the surface soil having concentrations exceeding the soil RSL (**Figure 4**). PFBS, PFHxS, PFHpA, and PFNA also were detected at low concentrations in surface and/or subsurface soil. The extent of PFAS in soil is unknown, and the vertical extent of groundwater contamination within the Yorktown aquifer was not delineated during the SI.
Former Irrigation Sprayfield	This area was previously used to apply treated wastewater to the ground surface through spray irrigation. The sprayfield was evaluated as secondary PFAS source areas because the water and wastewater treatment process at the Base was not designed to treat PFAS. During the SI, samples were collected from one monitoring well screened in the Columbia aquifer in the vicinity of the former irrigation sprayfield. No monitoring wells in the Yorktown aquifer are present near the former sprayfield. Concentrations of PFOS and PFOA exceeded the Lifetime Health Advisory and pose potential unacceptable human health risk in the one Columbia aquifer monitoring well within the former irrigation spray field (**Figure 2**). PFNA, PFHxS, PFBS, and PFHpA also were detected in the monitoring well within the former irrigation sprayfield. During the SI, one soil sample was collected in the vicinity of the Former Irrigation Sprayfield. PFOS and PFOA were detected in the surface (0 to 6 inches) and subsurface soil (6 to 24 inches) but not at concentrations exceeding the soil RSL (**Figure 4**); however, the potential for soil concentrations to leach into groundwater has not been evaluated. PFHxS, PFHpA, and PFNA also were detected at low concentrations in surface and/or subsurface soil.

SAP Worksheet #10—Conceptual Site Model (continued)

Table 1: Potential PFAS Source Areas

Source Areas	Details
Current Irrigation Sprayfield	This area is currently being used to apply treated wastewater to the ground surface through spray irrigation. The sprayfield is being evaluated as secondary PFAS source areas because the water and wastewater treatment process at the Base was not designed to treat PFAS. During the SI, samples were collected from two monitoring wells screened in the Columbia aquifer in the vicinity of the current irrigation sprayfield. No monitoring wells in the Yorktown aquifer are present near the current sprayfield. Concentrations of PFOS and PFOA exceeded the Lifetime Health Advisory in one of the two Columbia aquifer monitoring wells within the current irrigation sprayfield (**Figure 2**). PFHxS, PFBS, and PFHpA also were detected both monitoring wells within the current irrigation sprayfield. PFNA was detected in one monitoring well within the current irrigation spray field. During the SI, one soil sample was collected in the vicinity of the Current Irrigation Sprayfield. PFOS and PFOA were detected in the surface (0 to 6 inches) and subsurface (6 to 24 inches) soil but not at concentrations exceeding the soil RSL (**Figure 4**); however, the potential for soil concentrations to leach into groundwater has not been evaluated. PFHxS, PFHpA, and PFNA also were detected at low concentrations in surface and/or subsurface soil. The extent of PFAS is unknown. It is also unknown whether PFAS has migrated to surface water and sediment within the marshland surrounding the Intracoastal Waterway. The vertical extent of groundwater contamination in the vicinity of the current irrigation sprayfield was not delineated during the SI.
Potential Source Area Included in the SI Addendum	
Site 17c (Former Firefighter Training Area, estimated date of use 1961-1982)	Following the initial phase of investigation at Site 17a, historical air photographs were reviewed, and an additional Former Firefighter Training Area location was identified as Site 17c based on ground discoloration. To date, no soil or groundwater samples have been collected from Site 17c.

Potential Contaminant Sources, Transport Pathways, and Receptors

At NALF Fentress, the primary suspected source of PFAS is the use of AFFF. Direct release of PFAS-containing materials to drainage ditches and to surface/subsurface soil may also result in the migration of PFAS via overland flow via stormwater to downgradient areas, including ditches and streams, as well as to groundwater as a result of infiltration from the soil. PFAS compounds are commonly found in groundwater at and downgradient of source areas, as they do not readily adsorb to soils. Currently, there are no known dermal or inhalation hazards associated with PFAS in aqueous media. The potential human receptors are:

Residents

- Current and future residents who use groundwater as a potable water source
- Future residents through dermal contact with surface soil or subsurface soil
- Future residents through incidental ingestion of surface soil, subsurface soil, sediment, and/or surface water

Workers

- Current and future on-Base workers who use groundwater as a potable water source
- Current and future maintenance and construction workers through dermal contact with surface soil, subsurface soil, and/or sediment

SAP Worksheet #10—Conceptual Site Model (continued)

- Current and future industrial and construction workers through incidental ingestion of surface soil, subsurface soil, sediment, and/or surface water

Trespassers/Visitors

- Current and future trespassers and visitors who use groundwater as a potable water source
- Current and future trespassers and visitors through dermal contact with surface soil, subsurface soil and/or sediment
- Current and future trespassers and visitors through incidental ingestion of surface soil, sediment, and/or surface water

Groundwater is not typically an exposure medium for ecological receptors, but ecological exposures may occur if groundwater discharges to a surface water body. In addition, ecological receptors (such as terrestrial and aquatic plants; soil, aquatic, and benthic invertebrates; fish; amphibians; and reptiles) may be directly exposed to PFAS compounds present in surface and shallow subsurface soil, surface water, and/or sediment. There is also evidence that PFAS compounds may enter food webs and thus ecological receptors (such as birds and mammals), and humans, may be exposed to these constituents via this pathway.

Groundwater is used currently as a potable water supply on NALF Fentress and throughout the surrounding area because a public water supply is currently not available. Many properties in the area also utilize well water for crop irrigation and livestock. Bottled water is currently being provided to six private properties because of concentrations of PFAS in their respective seven wells (there are two wells on one private property) exceed the USEPA Lifetime Health Advisory and pose potential unacceptable human health risk.

SAP Worksheet #11—Project Quality Objectives/Systematic Planning Process Statements

Problem Statement and Objectives

The objectives, environmental questions, investigation approach, and project quality objectives (PQOs) for this SI Addendum are presented in **Table 2**.

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SAP Worksheet #11—Project Quality Objectives/ Systematic Planning Process Statements (continued)

Table 2. Problem Definitions/Objectives, Environmental Questions, and Project Quality Objectives

Problem Definition/ Objective	Environmental Question	General Investigation Approach	PQO
Further define the lateral and vertical extent and evaluate the long-term temporal variability of PFAS contamination within the groundwater in both the Columbia and Yorktown aquifers both on- and off-Base and determine whether there is potentially unacceptable risk to human health and/or ecological receptors.[3]	What are the horizontal and vertical extents of PFOS/PFOA greater than the screening criteria at the sites identified in this SAP? What are the current concentrations of PFAS analytes within groundwater in both existing and newly installed monitoring wells? If PFAS analytes are present, do they pose potential unacceptable risks to human and/or ecological receptors[4]? Is PFAS present in off-Base private drinking water wells[5] not previously sampled? Where off-Base private drinking water wells have been sampled, have the PFAS concentrations changed? If so, what are the changes in PFAS concentrations over time?	Approximately six new shallow wells will be installed in the Columbia aquifer downgradient of the source areas at Site 17b, Site 17c, Site 14, UST 20B, and on the eastern and western portions of the Base. Approximately 13 new deep wells will be installed and screened within the Yorktown aquifer around the facility. Two of these wells, in proximity to the Crash Truck Area and the northern base boundary, will be installed to the bottom of the Yorktown aquifer (approximately 100 feet bgs). Groundwater samples will be collected from the 6 new shallow wells, 13 new deep wells, 42 existing shallow wells, and 17 existing deep wells (**Figure 9**) (see **Worksheet #17** for the sampling rationale). All samples will be analyzed for the 18 PFAS analytes included in USEPA Method 537.1. Additional well installation and sampling may be warranted if new source areas, transport or migration pathways, or other relevant information is identified in the SAA, which is currently being conducted. Additional contingency monitoring wells will be installed, and/or additional contingency groundwater samples will be collected if warranted to achieve the objectives of this SI Addendum. If warranted, new sample locations will be presented to the Partnering Team prior to collection. Drinking water samples will be collected from the off-Base private drinking water wells and analyzed for the 18 PFAS analyte list. Drinking water samples will be collected semiannually from off-Base private drinking water wells within 0.5 mile of the known PFOS/PFOA exceedances of the Lifetime Health Advisory in groundwater at NALF Fentress, to provide additional data for temporal comparisons and evaluate spatial variability. Proposed locations are shown on **Figure 10**. Monitoring will be conducted for a minimum of 3 years.	If PFOS/PFOA are detected within new monitoring wells on-Base, the data will be used to conduct human health and ecological risk screenings[3] and scope additional investigation or action, such as the installation of and sample collection from additional monitoring wells or soil sample collection, if warranted to determine the extent of contamination. If PFOS/PFOA concentrations are not detected within the new monitoring wells on-Base, no further action will be taken at that location to determine the extent of contamination. If PFAS concentrations from an existing monitoring well are increasing over time, the team will update the conceptual site model (CSM) and discuss the monitoring network and sampling frequency to be used in future investigations to ensure protectiveness. If PFAS concentrations from an existing monitoring well indicate no trend or are decreasing over time, this information will be used to update the CSM and will be used for decision making in later investigations, as needed. If PFOA and/or PFOS concentrations in any existing or new monitoring well exceed the Lifetime Health Advisory, the off-Base drinking water sampling area will be expanded to include all properties within 0.5 mile of a Lifetime Health Advisory exceedance. If PFOA and /or PFOS concentrations in any existing or new monitoring well do not exceed the Lifetime Health Advisory, the off-Base drinking water sampling area will not need to be revised. If PFOA and/or PFOS concentrations in a sample from an off-Base private drinking water well are non-detect or less than the Lifetime Health Advisory, monitoring will continue in accordance with this SAP. If PFOA and/or PFOS concentrations in a sample from an off-Base private drinking water well exceed the Lifetime Health Advisory, an alternate drinking water source immediately will be (or will continue to be) provided in accordance with the Emergency Response Action Memorandum (Navy, 2017) and the Action Memorandum for Drinking Water (CH2M, 2019). Long-term solutions will be evaluated by the Partnering Team.
Refine understanding of hydraulic characteristics of the aquifers and transport mechanisms for site contaminants.	What are the groundwater flow directions in the Columbia and Yorktown aquifers? What are the hydraulic characteristics for the Columbia and Yorktown aquifers?	After the installation of additional wells around NALF Fentress, all new and existing wells presented in **Figure 9** will be gauged for the depth to groundwater, and groundwater contour maps will be created to further refine the groundwater flow direction and velocity onsite within both the Columbia and Yorktown aquifers. Additional existing monitoring wells may be added to the groundwater elevation map, as needed. A slug test will be completed on at least three of the wells to determine hydraulic conductivity and velocity of groundwater onsite.	This information will be used to assess the potential for on- and off-Base migration of PFAS contamination and will be used to scope additional investigation or action as warranted.

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[4] Screening values for ecological receptors have not yet been released by the USEPA. A risk screening will not be completed until these values are released. The literature-based ecological screening values provided in **Worksheet #15** are included to ensure adequate analytical sensitivity.

[5] The on-Base drinking water will not be sampled as part of this SAP since the provision of drinking water to the Base is regulated by the Virginia Department of Health.

SAP Worksheet #11—Project Quality Objectives/ Systematic Planning Process Statements (continued)

Table 2. Problem Definitions/Objectives, Environmental Questions, and Project Quality Objectives

Problem Definition/ Objective	Environmental Question	General Investigation Approach	PQO
Further define the lateral extent of PFAS contamination in soil at areas where soil samples have previously been collected, and determine whether there is potentially unacceptable risk to human health and/or ecological receptors.	What are the concentrations of PFAS analytes within soil at areas where soil samples have previously been collected, and do these concentrations pose potential unacceptable risks to human and/or ecological receptors?	Soil samples will be collected from potential source areas where soil samples have previously been collected. Proposed soil locations are presented on **Figure 9** (see **Worksheet #17** for the sampling rationale.) Six co-located surface and subsurface soil samples will be collected and analyzed for 18 PFAS analytes to assess whether potential unacceptable risk to human or ecological receptors is present. Additional data may be warranted if new source areas, transport or migration pathways, or other relevant information is identified during the SAA, which is currently being conducted. Additional contingency soil samples will be collected if warranted to achieve the objectives of this SI Addendum. If warranted, new sample locations will be presented to the Partnering Team prior to collection.	If PFOS/PFOA are detected within the new soil samples, the data will be used to conduct human health and ecological risk screenings[3] and scope additional investigation or action, such as the installation of and sample collection from additional monitoring wells or soil sample collection, if warranted. If PFOS/PFOA concentrations are not detected within the new soil samples on-Base, no further action will be taken at that location. If potentially unacceptable risks are identified, the Partnering Team will reconvene to determine an appropriate path forward, which could include additional sampling or a removal action. If PFAS concentrations do not pose a potential unacceptable risk to human and/or ecological receptors in soil, no further action will be taken at that location. However, all PFAS data will be archived for future use, as needed.
If present, determine if PFAS analytes pose a potentially unacceptable risk to human health or ecological receptors due to exposure to soil (where not previously collected), surface water or sediment.	What are the concentrations of PFAS analytes within soil (where not previously collected), surface water and sediment, and do these concentrations pose potential unacceptable risks to human and/or ecological receptors?	Surface water and sediment samples will be collected from potential source areas and downgradient locations. Proposed surface water and sediment locations are presented on **Figure 9** (see **Worksheet #17** for the sampling rationale.) Fourteen co-located surface and subsurface soil samples and 15 co-located surface water and sediment samples will be collected and analyzed for 18 PFAS analytes to assess whether potential unacceptable risk to human or ecological receptors is present. Sediment samples will also be analyzed for total organic carbon (TOC). Additional data may be warranted if new source areas, transport or migration pathways, or other relevant information is identified during the SAA, which is currently being conducted. Additional contingency soil, surface water, and/or sediment samples will be collected if warranted to achieve the objectives of this SI Addendum. If warranted, new sample locations will be presented to the Partnering Team prior to collection.	If PFOS/PFOA are detected within the soil, surface water, and/or sediment, the data will be used to conduct human health and ecological risk screenings[3] and scope additional investigation or action, such as the installation of and sample collection from additional monitoring wells or soil sample collection, if warranted. If PFOS/PFOA concentrations are not detected within the soil, surface water, and/or sediment on-Base, no further action will be taken at that location. If potentially unacceptable risks are identified, the Partnering Team will reconvene to determine an appropriate path forward, which could include additional sampling or a removal action. If PFAS concentrations do not pose a potential unacceptable risk to human and/or ecological receptors in any given media, no further action will be taken at that location. However, all PFAS data will be archived for future use, as needed.
Determine if GAC continues to be effective in treating off-Base private drinking water.	Is GAC continuing to be effective in treating off-Base private drinking water?	Drinking water samples from seven existing GAC drinking water treatment systems will be collected quarterly from influent, midpoint, and effluent sample ports as part of ongoing pilot testing activities (see **Worksheet #17** for the sampling rationale). All samples will be analyzed for the 18 PFAS analytes included in USEPA Method 537.1. In accordance with Partnering Team agreement with stakeholder input from residents, the City of Chesapeake, and the Virginia Department of Health, collection of treatment system samples from off-Base residences where PFOA and/or PFOS concentrations exceeded the Lifetime Health Advisory during historical off-Base private drinking water sampling until the long-term solution of the installation of a city water line is implemented (anticipated to be 3 years).	If PFOA and/or PFOS concentrations in a sample from the influent, midpoint and/or effluent sample ports are non-detect or less than the Lifetime Health Advisory, monitoring will continue in accordance with this SAP to calculate breakthrough curves for the GAC. If PFOA and/or PFOS concentrations in a sample from the influent sample port exceed the Lifetime Health Advisory, monitoring will continue in accordance with this SAP to calculate breakthrough curves. If PFOA and/or PFOS concentrations from the midpoint and/or effluent sample ports exceed one half of the lifetime health advisory (35 ng/L), the GAC will be replaced and monitoring will continue in accordance with this SAP. If PFOA and/or PFOS concentrations from the midpoint and/or effluent sample ports do not exceed one half of the lifetime heath advisory (35 ng/L), the GAC will not need to be replaced and monitoring will continue in accordance with this SAP.

SAP Worksheet #11—Project Quality Objectives/ Systematic Planning Process Statements (continued)

What are the Project Action Limits (PALs)?

The PALs for data collected are provided in **Worksheet #15** and summarized as follows:

- **Groundwater** data will be screened against the following PALs:
  - **Human Health** – The USEPA Lifetime Health Advisory for PFOA and PFOS is 70 ng/L individually; if both chemicals are detected, then 70 ng/L is the Lifetime Health Advisory for the cumulative concentration of the two chemicals. PFBS results will be compared to the current USEPA tap water RSL (based on a hazard quotient [HQ] of 1). The USEPA RSL calculator was used to calculate tap water RSLs for PFOS and PFOA (based on an HQ of 1). There are no PALs for any other analytes; however, data received will be archived for comparison to appropriate screening values if they are available in the future.
  - **Ecological** – The literature-based ecological screening values (ESVs) provided in **Worksheet #15** are included to ensure adequate analytical sensitivity and will not be used to conduct an ecological risk screening. No promulgated ESVs have been issued by USEPA for PFAS at this time. The analytical data will be evaluated for potentially unacceptable risk to ecological receptors once ESVs are issued.
- **Drinking water** data will be screened against the following PALs:
  - **Human Health** – The USEPA Lifetime Health Advisory for PFOA and PFOS is 70 ng/L individually; if both chemicals are detected, then 70 ng/L is the Lifetime Health Advisory for the cumulative concentration of the two chemicals. PFBS results will be compared to the current USEPA tap water RSL (based on a hazard quotient [HQ] of 1). The USEPA RSL calculator was used to calculate tap water RSLs for PFOS and PFOA (based on an HQ of 1). There are no PALs for any other analytes; however, data received will be archived for comparison to appropriate screening values if they are available in the future.
- **Surface and Subsurface Soil** data will be screened against the following PALs:
  - **Human Health** – PFBS results will be compared to the current USEPA residential soil RSL (based on an HQ of 1). The USEPA RSL calculator will be used to calculate residential soil RSLs for PFOS and PFOA (based on an HQ of 1). There are no PALs for any other analytes; however, data received will be archived for comparison to appropriate screening values if they are available in the future.
  - **Ecological** – Literature-based ESVs provided in **Worksheet #15** are included to ensure adequate analytical sensitivity. No formal ESVs have been issued by the USEPA for PFAS. The analytical data will be evaluated for potentially unacceptable risk to ecological receptors once ESVs are issued. ESVs will only be applied to samples collected within 24 inches of the ground surface.
- **Surface Water** data will be screened against the following PALs:
  - **Human Health** – PFBS results will be compared to the current USEPA tap water RSL (based on an HQ of 1) multiplied by 10. The USEPA RSL calculator will be used to calculate tap water RSLs for PFOS and PFOA (based on an HQ of 1), which will then be multiplied by 10. There are no PALs for any other analytes; however, data received will be archived for comparison to appropriate screening values if they are available in the future. The RSLs are multiplied by 10 to account for exposure to surface water, which would be much less than exposure to groundwater.
  - **Ecological** – Literature-based freshwater ESVs provided in **Worksheet #15** are included to ensure adequate analytical sensitivity. No formal ESVs have been issued by USEPA for PFAS. The analytical data will be evaluated for potentially unacceptable risk to ecological receptors once ESVs are issued.

SAP Worksheet #11—Project Quality Objectives/ Systematic Planning Process Statements (continued)

- **Sediment** data will be screened against the following PALs:
  - **Human Health** – PFBS results will be compared to the current USEPA residential soil RSL (based on an HQ of 1) multiplied by 10. The USEPA RSL calculator will be used to calculate residential soil RSLs for PFOS and PFOA (based on an HQ of 1), which will then be multiplied by 10. There are no PALs for any other analytes; however, data received will be archived for comparison to appropriate screening values if they are available in the future. The RSLs are multiplied by 10 to account for exposure to sediment, which would be much lower than exposure to soil.
  - **Ecological** – Literature-based freshwater ESVs provided in **Worksheet #15** are included to ensure adequate analytical sensitivity. No formal ESVs have been issued by USEPA for PFAS. The analytical data will be evaluated for potentially unacceptable risk to ecological receptors once ESVs are issued.

What will the data be used for?

The data will be used by the Navy, its contractors, and the other stakeholder agencies to address the environmental questions and PQOs listed in **Table 2**.

What types of data are needed (matrix, target analytes, analytical groups, field screening, onsite analytical or offsite laboratory techniques, sampling techniques)?

Worksheets #14, #15, #17, and **#18** contain detailed information on the types of data needed for this project.

Where, when, and how should the data be collected/generated?

Worksheets #14, #17, and #18 describe how the groundwater, drinking water, surface and subsurface soil, surface water, and sediment samples will be collected and the parameters for which the samples will be analyzed. Detailed information on how data will be collected is provided on **Worksheet #14**, following the standard operating procedures (SOPs) listed in **Worksheet #21**. The proposed sample locations are illustrated on **Figure 9** and **Figure 10**. The project schedule is provided in **Worksheet #16**.

Are there any special data quality needs, field or laboratory, in order to support environmental decisions?

Offsite laboratory analytical data will be of the quantity and quality necessary to provide technically sound and defensible assessments with respect to the aforementioned project objectives. Additionally, laboratory-specific Limits of Detection (LODs) will be less than the Lifetime Health Advisory level for PFOA and PFOS of 70 ng/L or 0.07 micrograms per liter (µg/L) (for the sum of the two constituents). QC sample requirements are detailed in Worksheet #20. For action decisions, the laboratory will follow the Measurement Performance Criteria (MPC) in **Worksheets #24** and **#28** for laboratory QC samples. These MPC are consistent with the DoD Quality Systems Manual (QSM) (DoD, 2017) as applicable and laboratory in-house limits where the QSM does not apply.

SAP Worksheet #12-1—Measurement Performance Criteria Table for Field QC Samples

Matrix: Drinking Water (Residential and Residential Treatment Systems)
Analytical Group: PFAS

QC Sample[1]	Analytical Group[2]	Frequency	Data Quality Indicators	Measurement Performance Criteria
Field Duplicate	PFAS	1 per 10 field samples for residential samples and 1 per sampling event for residential treatment system samples	Precision	Relative Percent Difference should be < 30%. Greater variability may be observed when field duplicates (FDs) are within a factor of 2 of the limit of quantitation (LOQ). At these concentrations, field duplicates should have relative percent differences (RPDs) that are < 50%.
Cooler Temperature Indicator		1 per cooler to the laboratory	Representativeness	Temperature ≤ 10°C, not frozen.
Field Reagent Blank[3]		1 per drinking water well location (Off-base private drinking water wells)[4] 1 per treatment system (existing GAC drinking water treatment system)	Bias / Contamination	If the method analyte(s) found in the Field Sample is present in the Field Reagent Blank at a concentration greater than 1/3 the LOQ, then all samples collected with that Field Reagent Blank are invalid and must be recollected and reanalyzed.

Notes:

[1] Field QA/QC will be collected separately for each matrix.

[2] Field QA/QC as described in this table will be collected and analyzed for each of the analytical groups listed.

[3] The preservative Trizma is only required for aqueous samples from drinking water sources. Since the field samples are from drinking water sources, the laboratory supplied PFAS-free water for the PFAS Field Reagent Blank, as well as sample containers, will be pre-preserved with Trizma.

[4] Because the 537 Method does not require analysis of FRBs for samples without detections, FRBs from these sample locations may not be analyzed if turn around time and holding time allow for phased analysis.

SAP Worksheet #12-2—Measurement Performance Criteria Table for Field QC Samples

Matrix: Groundwater, Surface Water
Analytical Group: PFAS

QC Sample[1]	Analytical Group[2]	Frequency	Data Quality Indicators	Measurement Performance Criteria
Field Duplicate	PFAS	1 per 10 field samples	Precision	Relative Percent Difference ≤ 30% if both results are ≥ LOQ
Equipment Blank		1 per day of sampling for decontaminated equipment, 1 per lot for disposable equipment	Bias / Contamination	No target compounds > ½ LOQ
Cooler Temperature Indicator		1 per cooler to the laboratory	Representativeness	Temperature ≤ 10°C, not frozen
Field Reagent Blank[3]		1 per week	Bias / Contamination	No target compounds > ½ LOQ

Notes:

[1] Field QA/QC will be collected separately for each matrix.

[2] Field QA/QC as described in this table will be collected and analyzed for each of the analytical groups listed.

[3] The preservative Trizma is only required for aqueous samples from drinking water sources. Since the field samples are not from drinking water sources, the laboratory supplied PFAS-free water for the PFAS Field Reagent Blank, as well as sample containers, do not contain Trizma.

SAP Worksheet #12-3—Measurement Performance Criteria Table for Field QC Samples

Matrix: Soil, Sediment
Analytical Group: PFAS

QC Sample[1]	Analytical Group[2]	Frequency	Data Quality Indicators	Measurement Performance Criteria
Field Duplicate	PFAS	1 per 10 field samples	Precision	Relative Percent Difference ≤ 35% if both results are ≥ LOQ
Equipment Blank		1 per day of sampling for decontaminated equipment, 1 per lot for disposable equipment	Bias / Contamination	No target compounds > ½ LOQ
Cooler Temperature Indicator		1 per cooler to the laboratory	Representativeness	Temperature ≤ 10°C, not frozen
Field Reagent Blank[3]		1 per week	Bias / Contamination	No target analytes detected > ½ LOQ

Notes:

[1] Field QA/QC will be collected separately for each matrix.

[2] Field QA/QC as described in this table will be collected and analyzed for each of the analytical groups listed

[3] The preservative Trizma is only required for aqueous samples from drinking water sources. Since the field samples are not from drinking water sources, the laboratory supplied PFAS-free water for the PFAS Field Reagent Blank, as well as sample containers, do not contain Trizma.

SAP Worksheet #12-4—Measurement Performance Criteria Table for Field QC Samples

Matrix: Sediment
Analytical Group: WCHEM (TOC)

QC Sample	Analytical Group[1]	Frequency	Data Quality Indicators	Measurement Performance Criteria
Cooler Temperature Indicator	WCHEM (TOC)	1 per cooler to the laboratory	Representativeness	Temperature ≤ 6°C, not frozen

Note:
[1] Field QA/QC as described in this table will be collected and analyzed for each of the analytical groups listed.

SAP Worksheet #13—Secondary Data Criteria and Limitations Table

This worksheet identifies all secondary data and information that will be used for the project, including the originating source of the data. This worksheet documents how the existing data will be used and the limitations to the use of the existing data.

Secondary Data	Data Source (originating organization, report title and date)	Data Generator(s) (originating organization, data types, data generation/collection dates)	How Data Will Be Used	Limitations on Data Use
Monitoring well groundwater samples collected for the NALF Fentress Basewide PFAS SI	Final Basewide Per- and Polyfluoroalkyl Substances SI Report (CH2M, 2018)	CH2M collected groundwater samples from multiple wells in PFAS source areas as part of the NALF Fentress Basewide PFAS SI.	The groundwater analytical data from the SI were used to identify additional potential source areas as well as create a basis for installing additional monitoring wells to determine hydraulic characteristics of both the Columbia and Yorktown aquifers and to delineate the PFAS plume. The analytical data from the SI will be used in the risk screenings completed during the SI Addendum.	None.
Soil data collected for the NALF Fentress Basewide PFAS SI	Final Basewide Per- and Polyfluoroalkyl Substances SI Report (CH2M, 2018)	CH2M collected soil samples from multiple locations as part of the NALF Fentress Basewide PFAS SI.	The soil analytical data from the SI were used to identify additional potential source areas as well as to evaluate the potential for PFAS sources to remain in soil at the site. The analytical data from the SI will be used in the risk screenings completed during the SI Addendum.	None.

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SAP Worksheet #14—Summary of Project Tasks

The technical approach for the proposed field activities at NALF Fentress is detailed below. All field work will be completed in accordance with the applicable SOPs tabulated on **Worksheet #21** and provided in **Appendix A.**

Mobilization

Prior to mobilization, NAVFAC Mid-Atlantic, USEPA, and VDEQ will be notified to allow for appropriate oversight and coordination.

As part of the field mobilization, procurement of the following subcontractors to support investigation activities include[6]:

- Utility Locator
- Surveyor
- Driller
- Investigation-derived waste (IDW) subcontractor
- Data validation subcontractor

Battelle and GCAL have already been procured to provide laboratory analytical services. Mobilization for the field effort includes procurement of necessary field equipment and initial transport to the site. Equipment and supplies will be brought to the site when the CH2M field team mobilizes for field activities.

Prior to beginning any phase of work, CH2M and its subcontractors will conduct field meetings to discuss the work items and worker responsibilities, and to familiarize workers with the HSP.

Prior to beginning any intrusive activities, CH2M will coordinate utility clearance with Miss Utility of Virginia and the Base’s approving authority. Additionally, a separate utilities subcontractor will be procured to ensure the accuracy of the utility markings.

Monitoring Well Installation and Development

Monitoring wells will be installed at various locations basewide. Approximately six monitoring wells will be screened in the Columbia aquifer. Each shallow monitoring well will be co-located with a deep monitoring well screened in the Yorktown aquifer and these six shallow and deep well clusters will be installed to the north, east, and south of existing monitoring wells in the directions of groundwater flow. Up to five additional deep monitoring wells screened in the Yorktown aquifer will be installed in locations on-Base where historical groundwater samples collected from shallow monitoring wells screened in the Columbia aquifer have exceeded the Lifetime Health Advisory. Two “extra” deep monitoring wells will be installed in the vicinity of the Crash Truck Test Area and northwest of Site 14 (near the Base boundary) in order to delineate the vertical extent of PFAS levels in groundwater exceeding the Lifetime Health Advisory. Monitoring wells will be installed in accordance with the SOPs. Shallow wells will be installed using a 4.25-inch inner diameter hollow-stem auger and will be drilled to depths of approximately 15 to 30 feet bgs. It is assumed that the well screen interval will intersect the water table. Deep wells will be installed using 6-inch sonic drilling techniques and screened at depths ranging from 50 to 60 feet bgs, while the “extra” deep wells are anticipated to be screened at depths ranging from 90 to 100 feet bgs. No Teflon, Viton, or other PFAS-containing drilling materials will be used during well installation. Drilling greases will be vegetable-based formulations (such as Biolube).

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[6] Multiple contractors may be procured by the Navy to complete the tasks outlined in this SAP. All work will be conducted in accordance with the SOPs included in this SAP, regardless of the contractor who performs the work.

SAP Worksheet #14—Summary of Project Tasks (continued)

During well installation, lithology data will be collected using 4-foot direct-push technology cores, collected continuously. Soil descriptions, including grain size, color, moisture content, relative density, consistency, soil structure, mineralogy, and other relevant information, such as possible evidence of contamination, will be recorded as detailed in the SOP.

Wells will be constructed of 2-inch polyvinyl chloride (PVC) casing and 10-foot-long 0.010 machine-slotted screens based on soil lithology and the depth at which groundwater is encountered. Sand filter pack (DSI #1 or equivalent) will be added to a depth of 2 feet above the screened interval. Two to 4 feet of bentonite pellets or chips will be added and then hydrated in the annular space above the sand pack. The remainder of the annular space will be grouted to the surface. Wells will be completed with steel stick-up casing and four protective bollards. Newly-installed monitoring wells will be developed in accordance with the SOP.

Monitoring wells will be developed using a submersible pump (or equivalent) and surge block with no Teflon, Viton, or other PFAS-containing components. Development pumping and surging will not start until at least 24 hours after grouting of the well has been completed. Field parameters (conductivity, temperature, pH, dissolved oxygen [DO], oxidation-reduction potential [ORP], salinity, and turbidity) will be monitored during development. Field parameters will be collected once one volume of the sampling tubing and flow through cell has been purged. Wells should continue to be developed until a minimum of three well volumes have been removed and turbidity has been reduced to the extent practicable. If field parameters other than turbidity are stable and turbidity values continue to decrease after the removal of three well volumes, monitoring well development activities will continue until turbidity readings have stabilized. Water quality parameters have stabilized over three consecutive readings when subsequent measurements agree as follows:

- pH within 0.1 pH unit
- Conductivity within 3 percent
- DO within 10 percent
- ORP within 10 millivolts
- Turbidity measurement within 10 percent or is minimized to the extent practical for the well

Monitoring Well Groundwater Sampling

Groundwater samples will be collected from new and existing monitoring wells as presented on **Figure 9**. Groundwater samples will be collected using low-flow sampling methodology and in accordance with the SOPs. A peristaltic pump will be used to collect samples for wells with a sampling depth of 30 feet or shallower and a PFAS-free submersible pump will be utilized for wells screened at deeper depths. The peristaltic tubing or pump will be set in the middle of the well screen. Teflon lined tubing will not be used during groundwater sampling to prevent cross contamination with groundwater while sampling for PFAS analytes.

Groundwater quality parameters (pH, conductivity, turbidity, DO, temperature, salinity, and ORP) will be collected during purging of each well using a water quality meter and a flow-through cell. Water quality readings will be collected once one volume of the sampling tube and flow through cell has been purged. Purging will continue until water quality readings collected 5 minutes apart are stabilized to within 10 percent of one another. Once parameters have stabilized, the flow-through cell will be disconnected, and samples will be collected into sample bottles and packed on ice for overnight shipment to Battelle.

SAP Worksheet #14—Summary of Project Tasks (continued)

Soil Sampling

Surface Soil Samples

Surface soil samples will be collected from the locations presented on **Figure 9.** For this investigation, surface soil is defined as 0 to 6 inches bgs (or 0 to 0.5 foot bgs). Surface soil samples will be collected using acetate sleeves (if they are co-located with monitoring well locations) and a stainless-steel hand auger, shovel, fluorine-free plastic disposable scoop, post-hole digger, or other appropriate tool (if they are not co-located with monitoring well locations) following soil sampling protocol.

Shallow Subsurface Soil Samples

Subsurface soil samples will be collected from the locations presented on **Figure 9.** Shallow subsurface soil samples will be collected from a depth of 0.5 foot to 2 feet bgs. Samples will be collected using a stainless-steel hand auger, shovel, fluorine-free plastic disposable scoop, post-hole digger, or other appropriate tool following soil sampling protocol.

Surface Water Sampling

If surface water is present on the day of sampling, samples will be collected at locations identified on **Figure 9**. Prior to collection, water quality readings (pH, conductivity, turbidity, DO, temperature, salinity, and ORP) will be obtained with a Horiba U-52 or similar water quality meter, and water depth and flow rate will be measured. Surface water samples (if identified) will be collected with a peristaltic pump and disposable tubing. All surface water samples, if applicable, will be collected into sample bottles and packed on ice for overnight shipment to the laboratory.

Sediment Sampling

Sediment samples will be collected as identified on **Figure 9**. Sediment samples will be collected from 0 to 6 inches bgs using a stainless-steel trowel, disposable scoop, hand auger, or other appropriate tool, and will be collected regardless of whether water is present. All sediment samples will be collected into approved laboratory containers and analyzed for PFAS and TOC. Cross-contamination of PFAS analytes will be avoided during sampling in accordance with the SOP.

Off-Base Drinking Water Sampling

Finished drinking water samples in the defined sampling area (**Figure 10**) will be collected on a voluntary basis in accordance with the potable water sampling SOP. Water will be sampled by first purging the water supply for 3 to 5 minutes. The sampling port is usually the port at the bottom of a pressure tank. In instances where there is no port or the valve cannot be used without damage or leaking, the next closest pretreatment location will be selected. Samples will be collected directly into laboratory-provided containers. A field reagent blank is collected at the site of collection for the water sample. The field reagent blank is collected by transferring deionized water containing Trizma preservative (prepared at the laboratory) from one bottle to another empty, unpreserved sampling bottle. This blank is used to determine if PFAS analytes are in the air at the sampling location, if any contamination was introduced during the sample management and shipment process, and whether any laboratory errors occurred.

SAP Worksheet #14—Summary of Project Tasks (continued)

GAC Drinking Water Treatment System Sampling

Drinking water samples from seven existing GAC drinking water treatment systems will be collected quarterly from influent, midpoint, and effluent sample ports as part of ongoing pilot testing activities. Before sampling, cold water from a faucet (normally a kitchen or bathroom sink) will be turned on for at least 15 minutes to purge the water supply. After purging, the turbidity, pH, specific conductivity, and temperature of the water will be measured. These parameters will be monitored until three consistent readings are obtained, indicating stabilization. After three consistent readings (within 10 percent of each other) have been obtained, samples from the GAC treatment system influent, midpoint, and effluent sample ports will be collected directly into laboratory-provided containers. One field reagent blank per residence will be collected in the vicinity of the GAC treatment system. The field reagent blank is collected by transferring deionized water containing Trizma preservative (prepared at the laboratory) from one bottle to another empty, unpreserved sampling bottle. This blank is used to determine if PFAS analytes are in the air at the sampling location, if any contamination was introduced during the sample management and shipment process, and whether any laboratory errors occurred.

Water-level Survey

Following monitoring well installation and development, and prior to the start of groundwater sampling or following the completion of all groundwater sampling, a complete water-level survey at all site wells (new and previously existing) will be conducted in accordance with the SOP. An electronic water-level meter with a probe that is not coated with Teflon or other fluorinated polymers will be used to measure the depth to water from the top of casing to the nearest 0.01 foot.

Slug Testing

Slug tests will be conducted on at approximately three site wells installed to determine groundwater velocity for the site. It is anticipated that two of these wells will be the extra deep Yorktown aquifer wells because hydraulic characteristics have not yet been assessed at this depth. A slug test will be performed using solid PVC slugs with clean, PFAS-free bailer rope. A solid 1.5-inch-diameter PVC slug filled with sand, or similar, will be used for the testing. A pressure transducer, such as a MiniTroll transducer/data recorder capable of measuring to 0.01 foot, will be used along with an electronic recording device, such as a RuggedReader handheld personal computer (or similar personal data device), to obtain water-level readings during the slug testing activities. Water levels will be monitored using a 15-pound-per-square-inch pressure transducer and results will be recorded on a 1-second linear scale.

Prior to inserting the slug into the monitoring well, a static water-level measurement will be recorded, a transducer will be installed in the well approximately 1 foot above the total depth of the well, and the water level will be allowed to return to ambient conditions. Each slug-in test will be started by initiating the data recording on the personal digital assistant while simultaneously lowering the slug into the hole. To conduct the falling head test, the PVC slug will be quickly added to the well and the water level allowed to stabilize to within 90 percent of the original static water level. The rising head test will then be started by rapidly removing the PVC slug, which will cause a drop in the water level. The transducer and recording device will be used to record changes in pressure associated with water-level recovery. A slug test will be considered complete when water levels have recovered to 90 percent of its pretest level.

Occasional water-level measurements also will be recorded manually to track the progress of the tests and to provide a data backup. Each test will be performed three times in each well to ensure consistent data are collected. After the testing is completed, the results will be uploaded from the electronic recording device to a laptop computer. Data processing will be completed to convert the recorded head values to feet displacement.

SAP Worksheet #14—Summary of Project Tasks (continued)

Equipment Decontamination

All nondisposable sampling equipment will be decontaminated immediately after each use in accordance with the SOP. Nondisposable equipment will be decontaminated using the following solutions in this order:

1. Distilled water (laboratory certified PFAS-free) and Liquinox solution
2. Distilled water (laboratory certified PFAS-free) rinse - 10 percent isopropanol and distilled water solution and air-dried
3. Laboratory grade deionized water (laboratory certified PFAS-free)

Decontamination fluids will be contained in 55-gallon drums and disposed of offsite as described below.

Cross-contamination of the 14 PFAS analytes in accordance with the SOP will be avoided during equipment decontamination.

Investigation-derived Waste Management

IDW is expected to consist of drill cuttings from the soil borings completed for monitoring well installations, purge water from well development and groundwater sampling, and decontamination fluids. Aqueous and soil IDW will be contained in 55-gallon drums. If PFAS concentrations in aqueous IDW accumulated during field activities exceed the Lifetime Health Advisory of 70 ng/L for individual or combined PFOA or PFOS analytes, the PFAS IDW SOP will be followed. A location at NALF Fentress will be identified prior to initiation of the fieldwork where IDW will be stored temporarily. IDW drums will be labeled in accordance with the SOP.

Disposable equipment, including personal protective equipment, will be decontaminated in accordance with the SOP and disposed of with normal facility trash. The IDW subcontractor has not been selected for this sampling event; however, once the subcontractor is identified, the Navy will be notified.

PFAS Field Reagent Blank Collection

To collect a PFAS field reagent blank for non-drinking water samples, PFAS-free laboratory supplied water will be slowly poured directly into Trizma-free laboratory provided sample containers (**Worksheet #19**). The preservative Trizma is only required for aqueous samples collected from drinking water sources. Since the field samples are not from drinking water sources, the laboratory supplied PFAS-free water for the PFAS field reagent blanks for non-drinking water samples, as well as the sample containers, do not contain Trizma.

PFAS FRB Collection for drinking water

To collect a PFAS FRB associated with the sample collected from a potable water supply, slowly pour pre-preserved (with Trizma) PFAS-free laboratory supplied water directly into unpreserved containers. Trizma sequesters free chlorine and is required for sampling of drinking water sources. Therefore, the laboratory supplied PFAS-free water for the PFAS FRB as well as the sample containers for the drinking water, contain Trizma.

Surveying

Each new monitoring well will be surveyed by a licensed surveyor both vertically and horizontally using the Virginia State Plane Coordinate System. Specifically, the elevation for each monitoring well will be established at the top of the monitoring well’s inner PVC casing (this elevation point will be designated by a permanent notch placed on the top of each well’s inner casing) and at ground surface. The surveying subcontractor has not been selected for this sampling event; however, once the subcontractor is identified, the Navy will be notified.

SAP Worksheet #14—Summary of Project Tasks (continued)

Analytical and Validation Tasks

- **Quality Control**
  - SOPs for field (**Appendix A**) and laboratory activities being performed will be implemented.
  - QC samples to be collected are outlined on **Worksheet #20**.
- **Analytical Tasks**
  - The laboratory will maintain, test, inspect, and calibrate analytical instruments (**Worksheets #24** and **#25**).
  - The laboratory will process and prepare samples for analysis.
  - The laboratory will analyze samples as shown on **Worksheet #18**.
- **Procedures for recording data, including guidelines for recording and correcting data**
  - Project Assessment and Audit (**Worksheets #31** and **#32**)
  - Data Review
    - Data Validation (**Worksheets #35** and **#36**)
    - Data Usability Assessment (**Worksheet #37**)

- **Procedures for recording data, including guidelines for recording and correcting data**
  - Project Assessment and Audit (**Worksheets #31** and **#32**)
  - Data Review
    - Data Validation (**Worksheets #35** and **#36**)
    - Data Usability Assessment (**Worksheet #37**)

SAP Worksheet #15-1—Reference Limits and Evaluation Table for Aqueous Media

Matrix: Drinking Water (residential and residential treatment system locations)
Analytical Group: PFAS
All units are µg/L (unless otherwise specified)

Analyte	CAS #	PALs[1]		Project QL Goal[2]	Laboratory Limits			LFB and LFSM/LFSMD Recovery Limits and RPD[3](%)		
		Tap Water RSL, HQ = 1.0	USEPA Lifetime Health Advisory		LOQ	LOD	DL	LCL	UCL	RPD[4]
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	0.401	0.07	0.035	0.00250	0.00050	0.00015	**70**	**130**	**30**
Perfluorooctanoic acid (PFOA)	335-67-1	0.401	0.07	0.035	0.00250	0.00050	0.00020	**70**	**130**	
Perfluorobutanesulfonic acid (PFBS)	375-73-5	400	--	200	0.00250	0.00040	0.00012	**70**	**130**	
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	--	--	--	0.00250	0.00050	0.00017	**70**	**130**	
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	--	--	--	0.00250	0.00050	0.00020	**70**	**130**	
Perfluorodecanoic acid (PFDA)	335-76-2	--	--	--	0.00250	0.00040	0.00011	**70**	**130**	
Perfluorododecanoic acid (PFDoA)	307-55-1	--	--	--	0.00250	0.00050	0.00014	**70**	**130**	
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	--	--	0.00250	0.00050	0.00023	**70**	**130**	
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	--	--	--	0.00250	0.00040	0.00012	**70**	**130**	
Perfluorohexanoic acid (PFHxA)	307-24-4	--	--	--	0.00250	0.00050	0.00023	**70**	**130**	
Perfluorononanoic acid (PFNA)	375-95-1	--	--	--	0.00250	0.00040	0.00012	**70**	**130**	
Perfluorotetradecanoic acid (PFTA)	376-06-7	--	--	--	0.00250	0.00050	0.00022	**70**	**130**	
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	--	--	0.00250	0.00040	0.00010	**70**	**130**	
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	--	--	0.00250	0.00040	0.00010	**70**	**130**	
Aluminum 4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	--	--	--	0.00250	0.00040	0.00012	**70**	**130**	
9-chlorohexadecafluoro-3-oxanone-1-sulfonic (9Cl-PF3ONS)	756426-58-1	--	--	--	0.00250	0.00040	0.00012	**70**	**130**	
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	--	--	--	0.00250	0.00040	0.00010	**70**	**130**	
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	--	--	--	0.00250	0.00040	0.00009	**70**	**130**	
Total PFOS and PFAS	--	--	0.07	--	--	--	--	**--**	**--**	**--**

Notes:

[1] Refer to **Worksheet #11** for a discussion of PALs by matrix. PFOS and PFOA RSLs were derived using USEPA's RSL calculator on July 10, 2018; all based on a target risk of 10^{-6} and target HQ of 1.0.

[2] Project QL goals are equal to half of the minimum applicable screening level.

[3] Analytes detected less than the limit of detection (LOQ) must be 50-150% of the true value rather than 70-130% of the true value.

[4] RPDs for LFMS/LFMSD must be <30% for samples fortified at or above their native concentration. Greater variability may be observed when LFSMs are fortified at analyte concentrations that are within a factor of 2 of the LOQ. LFSMs fortified at these concentrations must have RPDs that are <50% for samples fortified at or above their native concentration.

Bolded values represent method specified limits, specific to EPA 537.1.

If PFOS and PFOA are both detected, then the sum of the results for that sample will be compared to the USEPA Lifetime Health Advisory of 0.07 µg/L.

CAS = Chemical Abstracts Service
DL = detection limit
LCL = lower confidence limit
LFB = laboratory fortified blank
LFSM/ LFSMD = laboratory fortified sample matrix /laboratory fortified sample matrix duplicate
LOD = limit of detection
LOQ = limit of quantitation
MS = matrix spike
MSD = matrix spike duplicate
QL = quantitation limit
UCL = upper control limit

SAP Worksheet #15-2—Reference Limits and Evaluation Table for Aqueous Media

Matrix: Groundwater
Analytical Group: PFAS
All units are µg/L (unless otherwise specified)

Analyte	CAS #	PALs[a]						Project QL Goal[b]	Laboratory Limits			LCS and MS/MSD Recovery Limits and RPD(%)		
		Tap Water RSL, HQ = 1.0	USEPA Lifetime Health Advisory	Surface Water ESVs[c]	Willow Grove Surface Water ESVs (Aquatic Invertebrates)[c]	Willow Grove Surface Water ESVs (Birds)[c]	Willow Grove Surface Water ESVs (Mammals)[d]		LOQ	LOD	DL	LCL	UCL	RPD
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	0.401	0.07	5.1[c]	5.1	0.047	0.0026[d]	0.035	0.005	0.0005	0.00019	**40**	**144**	**30**
Perfluorooctanoic acid (PFOA)	335-67-1	0.401	0.07	2,900[c]	2,900	--	--	0.035	0.005	0.0005	0.00018	**49**	**141**	
Perfluorobutanesulfonic acid (PFBS)	375-73-5	400	--	24,000[c]	--	--	--	200	0.005	0.0005	0.00013	**56**	**134**	
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	--	--	--	--	--	--	--	0.005	0.001	0.00049	**51**	**131**	
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	--	--	--	--	--	--	--	0.005	0.0025	0.00056	**50**	**146**	
Perfluorodecanoic acid (PFDA)	335-76-2	--	--	--	--	--	--	--	0.005	0.0005	0.00016	**59**	**135**	
Perfluorododecanoic acid (PFDoA)	307-55-1	--	--	--	--	--	--	--	0.005	0.0005	0.00018	**75**	**131**	
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	--	--	--	--	--	--	0.005	0.0005	0.00016	**48**	**136**	
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	--	--	--	--	--	--	--	0.005	0.0005	0.00011	**52**	**128**	
Perfluorohexanoic acid (PFHxA)	307-24-4	--	--	--	--	--	--	--	0.005	0.0005	0.00019	**51**	**137**	
Perfluorononanoic acid (PFNA)	375-95-1	--	--	--	--	--	--	--	0.005	0.001	0.00026	**58**	**122**	
Perfluorotetradecanoic acid (PFTA)	376-06-7	--	--	--	--	--	--	--	0.005	0.001	0.00025	**42**	**158**	
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	--	--	--	--	--	--	0.005	0.0005	0.00015	**42**	**148**	
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	--	--	--	--	--	--	0.005	0.001	0.00029	**64**	**134**	
Aluminum 4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	--	--	--	--	--	--	--	0.005	0.0004	0.00018	**70**	**130**	
9-chlorohexadecafluoro-3-oxanone-1-sulfonic (9Cl-PF3ONS)	756426-58-1	--	--	--	--	--	--	--	0.005	0.0004	0.0001	**70**	**130**	
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	--	--	--	--	--	--	--	0.005	0.0004	0.00018	**70**	**130**	
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	--	--	--	--	--	--	--	0.005	0.0004	0.0002	**70**	**130**	
Total PFOS and PFAS	--	--	0.07	--	--	--	--	--	--	--	--	**--**	**--**	**--**

Notes:

[a] Refer to **Worksheet #11** for a discussion of PALs by matrix. PFOS and PFOA RSLs were derived using USEPA's RSL calculator on July 10, 2018; all based on a target risk of 10-6 and target HQ of 1.0. ESV used at the Warminster and Willow Grove site are included in conjunction with other literature-based values to ensure adequate analytical sensitivity. The literature-based ESVs provided in this Worksheet will not be used to conduct an ecological risk screening. No promulgated ESVs have been issued by USEPA for PFAS at this time. The analytical data will be evaluated for potentially unacceptable risk to ecological receptors. The most current ESVs will be used for data evaluation. once ESVs are issued.

[b] PQL goals are equal to half of the minimum applicable screening level.

[c] Giesy J.P., J.E. Naile, J.S. Khim, P.D. Jones, and J.L. Newsted. 2010. Aquatic toxicology of perfluorinated chemicals. *Reviews of Environmental Contamination and Toxicology*. 202:1–52.

[d] Proposed PFOS and PFOA Ecological Screening Values; Naval Air Station Oceana, Virginia Beach, VA (USEPA 2018)

Bolded values represent in-house limits.

SAP Worksheet #15-3—Reference Limits and Evaluation Table for Aqueous Media

Matrix: Surface Water

Analytical Group: PFAS

All units are µg/L (unless otherwise specified)

Analyte	**CAS #**	**PALs[a]**					**Project QL Goal[b]**	**Laboratory Limits**			**LCS and MS/MSD Recovery Limits and RPD(%)**		
		RSLs Tap X 10 for SW HQ=1.0	**Surface Water ESVs[c]**	**WG Surface Water ESVs (Aquatic Invertebrates)[c]**	**WG Surface Water ESVs (Birds)[c]**	**WG Surface Water ESVs (Mammals)[d]**		**LOQ**	**LOD**	**DL**	**LCL**	**UCL**	**RPD**
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	40.1	5.1[c]	5.1[c]	0.047[c]	0.0026[d]	0.0013	0.005	0.0005	0.00019	**40**	**144**	**30**
Perfluorooctanoic acid (PFOA)	335-67-1	40.1	2,900[c]	2,900[c]	--	--	20.05	0.005	0.0005	0.00018	**49**	**141**	
Perfluorobutanesulfonic acid (PFBS)	375-73-5	4,000	24,000[c]	--	--	--	2005	0.005	0.0005	0.00013	**56**	**134**	
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	--	--	--	--	--	--	0.005	0.001	0.00049	**51**	**131**	
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	--	--	--	--	--	--	0.005	0.0025	0.00056	**50**	**146**	
Perfluorodecanoic acid (PFDA)	335-76-2	--	--	--	--	--	--	0.005	0.0005	0.00016	**59**	**135**	
Perfluorododecanoic acid (PFDoA)	307-55-1	--	--	--	--	--	--	0.005	0.0005	0.00018	**75**	**131**	
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	--	--	--	--	--	0.005	0.0005	0.00016	**48**	**136**	
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	--	--	--	--	--	--	0.005	0.0005	0.00011	**52**	**128**	
Perfluorohexanoic acid (PFHxA)	307-24-4	--	--	--	--	--	--	0.005	0.0005	0.00019	**51**	**137**	
Perfluorononanoic acid (PFNA)	375-95-1	--	--	--	--	--	--	0.005	0.001	0.00026	**58**	**122**	
Perfluorotetradecanoic acid (PFTA)	376-06-7	--	--	--	--	--	--	0.005	0.001	0.00025	**42**	**158**	
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	--	--	--	--	--	0.005	0.0005	0.00015	**42**	**148**	
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	--	--	--	--	--	0.005	0.001	0.00029	**64**	**134**	
Aluminum 4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	--	--	--	--	--	--	0.005	0.0004	0.00018	**70**	**130**	
9-chlorohexadecafluoro-3-oxanone-1-sulfonic (9Cl-PF3ONS)	756426-58-1	--	--	--	--	--	--	0.005	0.0004	0.0001	**70**	**130**	
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	--	--	--	--	--	--	0.005	0.0004	0.00018	**70**	**130**	
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	--	--	--	--	--	--	0.005	0.0004	0.0002	**70**	**130**	

Notes:

[a] Refer to **Worksheet #11** for a discussion of PALs by matrix. PFOS and PFOA RSLs were derived using USEPA's RSL calculator on July 10, 2018; all based on a target risk of 10^{-6} and target HQ of 1.0. ESVs used at the Warminster and Willow Grove site are included in conjunction with other literature-based values to ensure adequate analytical sensitivity. The most current ESVs will be used for data evaluation. The literature-based ESVs provided in this Worksheet will not be used to conduct an ecological risk screening. No promulgated ESVs have been issued by USEPA for PFAS at this time. The analytical data will be evaluated for potentially unacceptable risk to ecological receptors once ESVs are issued.

[b] PQL goals are equal to half of the minimum applicable screening level.

[c] Giesy J.P., J.E. Naile, J.S. Khim, P.D. Jones, and J.L. Newsted. 2010. Aquatic toxicology of perfluorinated chemicals. Reviews of Environmental Contamination and Toxicology. 202:1–52.

[d] Proposed PFOS and PFOA Ecological Screening Values; Naval Air Station Oceana, Virginia Beach, VA (USEPA 2018)

SAP Worksheet #15-4—Reference Limits and Evaluation Table for Solid Media

Matrix: Soil

Analytical Group: PFAS

All units are µg/kg (unless otherwise specified)

Analyte	CAS #	PALs[a]						Project QL Goal[b]	Laboratory Limits			LCS and MS/MSD Recovery Limits and RPD(%)		
		RSLs Residential Soil HQ=1.0	RSLs Industrial Soil HQ=1.0	Soil ESVs (Plant)[c]	Soil ESVs (Invertebrate)[d]	Soil ESVs WM and WG (Terrestrial Plant)[d]	Soil ESVs WM and WG (Invertebrate)[d]		LOQ	LOD	DL	LCL	UCL	RPD
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	1,260	18,200	4,600[c]	10,000[d]	39[d]	100[d]	630	5	1	0.27	**50**	**130**	**30**
Perfluorooctanoic acid (PFOA)	335-67-1	1,260	18,200	--	16,000[d]	--	160[d]	630	5	1	0.5	**56**	**136**	
Perfluorobutanesulfonic acid (PFBS)	375-73-5	1,300,000	16,000,000	--	--	--	--	650,000	5	1	0.36	**57**	**145**	
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	--	--	--	--	--	--	--	5	2	0.57	**54**	**124**	
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	--	--	--	--	--	--	--	5	2.5	1.12	**52**	**146**	
Perfluorodecanoic acid (PFDA)	335-76-2	--	--	--	--	--	--	--	5	1	0.27	**55**	**141**	
Perfluorododecanoic acid (PFDoA)	307-55-1	--	--	--	--	--	--	--	5	0.5	0.24	**62**	**134**	
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	--	--	--	--	--	--	5	1	0.44	**60**	**128**	
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	--	--	--	--	--	--	--	5	0.5	0.22	**52**	**132**	
Perfluorohexanoic acid (PFHxA)	307-24-4	--	--	--	--	--	--	--	5	1	0.33	**45**	**135**	
Perfluorononanoic acid (PFNA)	375-95-1	--	--	--	--	--	--	--	5	1	0.43	**54**	**130**	
Perfluorotetradecanoic acid (PFTA)	376-06-7	--	--	--	--	--	--	--	5	2	0.63	**34**	**162**	
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	--	--	--	--	--	--	5	1	0.28	**51**	**127**	
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	--	--	--	--	--	--	5	1	0.41	**57**	**137**	
Aluminum 4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	--	--	--	--	--	--	--	5	1	0.32	**70**	**130**	
9-chlorohexadecafluoro-3-oxanone-1-sulfonic (9Cl-PF3ONS)	756426-58-1	--	--	--	--	--	--	--	5	1	0.45	**70**	**130**	
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	--	--	--	--	--	--	--	5	1	0.4	**70**	**130**	
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	--	--	--	--	--	--	--	5	2	0.57	**70**	**130**	

Notes:

[a] Refer to **Worksheet #11** for a discussion of PALs by matrix. PFOS and PFOA RSLs were derived using USEPA's RSL calculator on July 10, 2018; all based on a target risk of 10-6 and target HQ of 1.0. ESVs used at the Warminster and Willow Grove site are included in conjunction with other literature-based values to ensure adequate analytical sensitivity. The most current ESVs will be used for data evaluation. The literature-based ESVs provided in this Worksheet will not be used to conduct an ecological risk screening. No promulgated ESVs have been issued by USEPA for PFAS at this time. The analytical data will be evaluated for potentially unacceptable risk to ecological receptors once ESVs are issued.

[b] Project QL goals are equal to half of the minimum applicable screening level.

[c] Beach, S.A., J.L. Newsted, K. Coady, and J.P. Giesy. 2006. Ecotoxicological Evaluation of Perfluorooctanesulfonate (PFOS). *Reviews of Environmental Contamination and Toxicology*. 186:133-174.

[d] Proposed PFOS and PFOA Ecological Screening Values; Naval Air Station Oceana, Virginia Beach, VA (USEPA 2018)

Bolded values represent in-house limits.

SAP Worksheet #15-5—Reference Limits and Evaluation Table for Solid Media

Matrix: Sediment

Analytical Group: PFAS

All units are µg/kg (unless otherwise specified)

Analyte	CAS #	Screening Levels[a]			Project QL Goal[b]	Laboratory Limits			LCS and MS/MSD Recovery Limits and RPD(%)		
		RSLs Res Soil X 10 for SD HQ=1.0	Fresh Sediment ESVs[c]	Sediment ESVs WG[d]		LOQ	LOD	DL	LCL	UCL	RPD
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	12,600	220[c]	**84**[d]	42	5	1	0.27	**50**	**130**	**30**
Perfluorooctanoic acid (PFOA)	335-67-1	12,600	--	**--**	6,300	5	1	0.5	**56**	**136**	
Perfluorobutanesulfonic acid (PFBS)	375-73-5	13,000,000	--	**--**	6,500,000	5	1	0.36	**57**	**145**	
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	--	--	**--**	--	5	2	0.57	**54**	**124**	
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	--	--	**--**	--	5	2.5	1.12	**52**	**146**	
Perfluorodecanoic acid (PFDA)	335-76-2	--	--	**--**	--	5	1	0.27	**55**	**141**	
Perfluorododecanoic acid (PFDoA)	307-55-1	--	--	**--**	--	5	0.5	0.24	**62**	**134**	
Perfluoroheptanoic acid (PFHpA)	375-85-9	--	--	**--**	--	5	1	0.44	**60**	**128**	
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	--	--	**--**	--	5	0.5	0.22	**52**	**132**	
Perfluorohexanoic acid (PFHxA)	307-24-4	--	--	**--**	--	5	1	0.33	**45**	**135**	
Perfluorononanoic acid (PFNA)	375-95-1	--	--	**--**	--	5	1	0.43	**54**	**130**	
Perfluorotetradecanoic acid (PFTA)	376-06-7	--	--	**--**	--	5	2	0.63	**34**	**162**	
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	--	--	**--**	--	5	1	0.28	**51**	**127**	
Perfluoroundecanoic acid (PFUnA)	2058-94-8	--	--	--	--	5	1	0.41	**57**	**137**	
Aluminum 4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	--	--	--	--	5	1	0.32	**70**	**130**	
9-chlorohexadecafluoro-3-oxanone-1-sulfonic (9Cl-PF3ONS)	756426-58-1	--	--	--	--	5	1	0.45	**70**	**130**	
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	--	--	--	--	5	1	0.4	**70**	**130**	
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	--	--	--	--	5	2	0.57	**70**	**130**	

Notes:

[a] Refer to **Worksheet #11** for a discussion of PALs by matrix. PFOS and PFOA RSLs were derived using USEPA's RSL calculator on July 10, 2018; all based on a target risk of 10-6 and target HQ of 1.0. ESVs used at the Warminster and Willow Grove site are included in conjunction with other literature-based values to ensure adequate analytical sensitivity. The most current ESVs will be used for data evaluation. The literature-based ESVs provided in this Worksheet will not be used to conduct an ecological risk screening. No promulgated ESVs have been issued by USEPA for PFAS at this time. The analytical data will be evaluated for potentially unacceptable risk to ecological receptors once ESVs are issued.

[b] Project QL goals are equal to half of the minimum applicable screening level.

[c] Norwegian Pollution Control Authority (NPCA). 2008. *Screening of Polyfluorinated Organic Compounds at Four Fire Training Facilities in Norway*. TA-2444/2008. December.

[d] Proposed PFOS and PFOA Ecological Screening Values; Naval Air Station Oceana, Virginia Beach, VA (USEPA 2018)

Bolded values represent in-house limits.

SAP Worksheet #15-6—Reference Limits and Evaluation Table

Matrix: Sediment

Analytical Group: WCHEM

Analyte	CAS[1]	PIL	Laboratory Limits			LCS and MS/MSD Recovery Limits and RPD(%)		
			LOQ	LOD	DL	Accuracy Control Limit		RPD
Total Organic Carbon (mg/kg)	TOC	--	**250**	**200**	**153**	**90**	**110**	**20**

Notes:

[1] Some CAS numbers are contractor-specific.

Bolded values represent in-house limits.

TOC is being performed to determine if sediment ESVs for PFAS can be TOC normalized.

PIL = project indicator limit

SAP Worksheet #16—Project Schedule/Timeline Table

Activities	**Dates**	
	Anticipated Date(s) of Initiation	**Anticipated Date of Completion**
Submit Pre-Draft SAP		March 2019
Base and Navy Review of SAP	March 2019	June 2019
Prepare and Submit Draft SAP	June 2019	June 2019
USEPA and VDEQ Review of SAP	June 2019	July 2019
Prepare and Submit Final SAP	July 2019	July 2019
Anticipated Fieldwork	July 2019	August 2019

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SAP Worksheet #17—Sampling Design and Rationale

Matrix	Depth of Samples	Analyses	Method	Approximate Number of Samples	Strategy and Rationale
Groundwater	Middle of screen (**Worksheet #18**)	PFAS (**Worksheet #15-2**)	Liquid chromatography and tandem mass spectrometry (LC-MS/MS) compliant with QSM 5.1 Table B-15 or most recent version of the QSM for which the laboratory is accredited at the time of sample collection	20	Groundwater samples will be collected from shallow and deep monitoring wells to evaluate and monitor concentrations of PFAS and further delineate the extent of PFAS contamination from potential and known source areas. Samples will be collected from existing and newly installed monitoring wells as presented on **Figure 9** and as follows: • Site 17b – 4 existing shallow monitoring wells: OF17-MW01, OF17-MW02, OF17-MW03, and OF17-MW04 – 2 new deep monitoring wells (to provide additional vertical delineation) • Site 17c – 1 new shallow monitoring well (to assess concentrations within the former firefighting training area) – 1 new deep monitoring well (to assess concentrations within the former firefighting training area) • Site 14 – 4 existing shallow monitoring wells: OF14-MW04, OF14-MW05, OF14-MW06S, and OF14-MW07S – 2 existing deep monitoring wells: OF14-MW06D and OF14-MW07D – 1 new shallow monitoring well (to better assess concentrations on the northern boundary of the site) – 1 new deep monitoring well (to better assess concentrations on the northern boundary of the site) • UST 20B – 6 existing shallow monitoring wells: OFPOL-MW-2, OFPOL-MW-3, OFPOL-MW-4, OFPOL-MW-6, OFPOL-MW-7, and OFPOL-MW-8 – 1 new deep monitoring well (to provide vertical delineation) • Current Irrigation Sprayfield – 2 existing shallow monitoring wells: OF-MW16 and OF-MW17 – 2 new deep monitoring wells (to provide vertical delineation) • Former Irrigation Sprayfield – 1 existing shallow monitirng well (OF-MW24) • Crash Truck Test Area – 1 existing shallow monitoring well: OF-MW08 – 1 existing deep monitoring well: OF-MW08D – 1 new extra deep monitoring well (to provide vertical delineation) Additional groundwater samples may be collected if warranted to achieve the objectives of this SI Addendum.
	Middle of screen (**Worksheet #18**)	PFAS (**Worksheet #15-2**)	LC-MS/MS Compliant with QSM 5.1 Table B-15 or most recent version of the QSM for which the laboratory is accredited at the time of sample collection	58	Groundwater samples will be collected from shallow and deep monitoring wells to evaluate concentrations of PFAS downgradient from potential and known source areas. Samples will be collected from existing and newly installed monitoring wells as presented on **Figure 9** and as follows: • 25 existing basewide shallow monitoring wells: OF-MW09, OF-MW10, OF-MW11, OF-MW12, OF-MW13, OF-MW14, OF-MW15, OF-MW19, OF-MW20, OF-MW21, OF-MW22, OF-MW25, OF-MW27, OF-MW28, OF-MW29, OF-MW30, OF-MW31, OF-MW32, OF-MW33, OF-MW34 and OF-SOW-09A, OF-SOW-09D, OF-SOW-09L, OF-SOW-09K, and OF-SOW-09M • 14 existing basewide deep monitoring wells: OF-MW09D, OF-MW10D, OF-MW11D, OF-MW12D, OF-MW13D, OF-MW15D, OF-MW19D, OF-MW22D, OF-MW28D, OF-MW30D, OF-MW31D, OF-MW32D, OF-MW33D, and OF-MW34D • 4 new shallow monitoring wells (to refine the extent of the PFOS and PFOA plume on-Base) • 5 new deep monitoring wells, (to refine the extent of the PFOS and PFOA plume on-Base) • 1 new extra deep monitoring well (to provide vertical delineation)
Surface Soil	0 to 6 inches	PFAS (**Worksheet #15-4**)	LC-MS/MS Compliant with QSM 5.1 Table B-15 or most recent version of the QSM for which the laboratory is accredited at the time of sample collection	20	Six surface soil samples (co-located with subsurface soil samples) will be collected from potential source areas where soil samples have previously been collected to evaluate and determine the nature and extent of contamination in surface soil. Three samples will be collected in the vicinity of the current irrigation spray field, one will be collected in the vicinity of UST 20B; and two will be collected in the vicinity of the crash test area. Nine surface soil sampels (co-located with subsurface soil samples) will be collected from potential source areas where soil samples have not previously been collected to evaluate and determine the nature and extent of contamination in surface soil. Seven samples will be collected from the vicinity of Site 17b; one will be collected in the vicinity of Site 17c and one will be collected in the vicinity of Site 14. In addition, five surface soil samples (co-located with subsurface soil samples) will be co-located with new basewide monitoring well locations. Proposed sample locations are presented on **Figure 9**. Additional contingency soil samples will be collected if warranted to achieve the objectives of this SI Addendum.

SAP Worksheet #17—Sampling Design and Rationale (continued)

Matrix	Depth of Samples	Analyses	Method	Approximate Number of Samples	Strategy and Rationale
Subsurface Soil	6 to 24 inches	PFAS (**Worksheet #15-4**)	LC-MS/MS Compliant with QSM 5.1 Table B-15 or most recent version of the QSM for which the laboratory is accredited at the time of sample collection	20	Six subsurface soil samples (co-located with surface soil samples) will be collected from potential source areas where soil samples have previously been collected to evaluate and determine the nature and extent of contamination in surface soil. Three samples will be collected in the vicinity of the current irrigation spray field; one will be collected in the vicinity of UST 20B and two will be collected in the vicinity of the crash test area. Nine subsurface soil samples (co-located with surface soil samples) will be collected form potential source areas where soil samples have not previously been collected to evaluate and determine the nature and extent of contamination in surface soil. Seven samples will be collected from the vicinity of Site 17b, one sample will be collected in the vicinity of Site 17c, and one sample will be collected in the vicinity of Site 14. In addition, five subsurface soils samples (co-located with surface soil samples will be co-located with new basewide monitoring well locations. Proposed sample locations are presented on **Figure 9**. Additional contingency soil samples will be collected if warranted to achieve the objectives of this SI Addendum.
Surface Water	First encountered surface water	PFAS (**Worksheet #15-3**)	LC-MS/MS Compliant with QSM 5.1 Table B-15 or most recent version of the QSM for which the laboratory is accredited at the time of sample collection	15	Fifteen surface water samples (co-located with sediment samples) will be collected from eight locations within Site 14 and from an additional seven locations downgradient of the current irrigation sprayfield in the northern most corner of the NALF Fentress boundary to evaluate the potential impact of PFAS to surface water. Sample locations are presented on **Figure 9**. Additional contingency soil samples will be collected if warranted to achieve the objectives of this SI Addendum.
Sediment	0 to 6 inches	PFAS (**Worksheet #15-5**)	LC-MS/MS Compliant with QSM 5.1 Table B-15 or most recent version of the QSM for which the laboratory is accredited at the time of sample collection	15	Fifteen sediment samples (co-located with surface water samples) will be collected from eight locations within Site 14 and from an additional seven locations downgradient of the current irrigation sprayfield in the northern most corner of the NALF Fentress boundary to evaluate the potential impact of PFAS to sediment. Sample locations are presented on **Figure 9**. Additional contingency soil samples will be collected if warranted to achieve the objectives of this SI Addendum.
Drinking Water	N/A	PFAS (**Worksheet #15-1**)	EPA 537.1	Approximately 35[7]	Drinking water samples will be collected semiannually on a voluntary basis (or at a frequency agreed to by the Partnering Team) from private off-Base drinking water wells within 0.5 mile of the known PFOS and/or PFOA exceedances of the Lifetime Health Advisory in groundwater at NALF Fentress to provide additional data for temporal comparisons and evaluate spatial variability. Parcels within the designated sampling area are shown on **Figure 10**. The duration of the monitoring period will be at least 3 years but monitoring may be conducted longer.
Drinking Water	N/A	PFAS (**Worksheet #15-1**)	EPA 537.1	21 per event	Seven residential treatment system samples will be collected quarterly from influent, midpoint, and effluent sample ports as part of ongoing pilot testing activities to ensure the continued efficacy of GAC at each off-Base private drinking water well. In accordance with Partnering Team agreement with stakeholder input from residents, the City of Chesapeake, and the Virginia Department of Health, collection of treatment system samples from off-Base residences where PFOA and/or PFOS concentrations exceeded the Lifetime Health Advisory during historical off-Base private drinking water sampling will continue until the long-term solution of the installation of a city water line is implemented.

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[7] The number of drinking water samples is estimated and may increase or decrease depending on homeowner participation. In addition, the number of samples may increase if the drinking water sampling area increases as a result of the sampling activities outlined in this SAP.

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table

Sampling Station	Sample ID[1]	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference
Existing Monitoring Wells						
OF-MW08	OF-MW08-MMYY	Groundwater	19-29	PFAS	2 (FD)	Refer to **Worksheet #21**
	OF-MW08P-MMYY					
OF-MW08D	OF-MW08D-MMYY		45-55		3 (MS/MSD)	
	OF-MW08D-MMYY-MS					
	OF-MW08D-MMYY-MSD					
OF-MW09	OF-MW09-MMYY		17-27		1	
OF-MW09D	OF-MW09D-MMYY		50-60		1	
OF-MW10	OF-MW10-MMYY		17-27		1	
OF-MW10D	OF-MW10D-MMYY		53-63		1	
OF-MW11	OF-MW11-MMYY		17-27		1	
OF-MW11D	OF-MW11D-MMYY		50-60		1	
OF-MW12	OF-MW12-MMYY		15-25		1	
OF-MW12D	OF-MW12D-MMYY		54-64		1	
OF-MW13	OF-MW13-MMYY		15-25		1	
OF-MW13D	OF-MW13D-MMYY		50-60		1	
OF-MW14	OF-MW14-MMYY		17-27		1	
OF-MW15	OF-MW15-MMYY		20-30		1	
OF-MW15D	OF-MW15D-MMYY		51-61		1	
OF-MW16	OF-MW16-MMYY		5-15		1	
OF-MW17	OF-MW17-MMYY		5-15		1	
OF-MW19	OF-MW19-MMYY		17-27		1	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (continued)

Sampling Station	Sample ID[1]	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference
OF-MW19D	OF-MW19D-MMYY	Groundwater	51-61	PFAS	2 (FD)	Refer to **Worksheet #21**
	OF-MW19DP-MMYY					
OF-MW20	OF-MW20-MMYY		15-25		1	
OF-MW21	OF-MW21-MMYY		17-27		1	
OF-MW22	OF-MW22-MMYY		15-25		1	
OF-MW22D	OF-MW22D-MMYY		120-130		1	
OF-MW24	OF-MW24-MMYY		19-29		1	
OF-MW25	OF-MW25-MMYY		18.5-28.5		1	
OF-MW27	OF-MW27-MMYY		22-32		1	
OF-MW28	OF-MW28-MMYY		15.5-25.5		1	
OF-MW28D	OF-MW28D-MMYY		44-54		1	
OF-MW29	OF-MW29-MMYY		20-30		2 (FD)	
	OF-MW29P-MMYY					
OF-MW30	OF-MW30-MMYY		19.5-29.5		3 (MS/MSD)	
	OF-MW30-MMYY-MS					
	OF-MW30-MMYY-MSD					
OF-MW30D	OF-MW30D-MMYY		50-60		1	
OF-MW31	OF-MW31-MMYY		21-31		1	
OF-MW31D	OF-MW31D-MMYY		48-58		1	
OF-MW32	OF-MW32-MMYY		14-24		1	
OF-MW32D	OF-MW32D-MMYY		40-50		1	
OF-MW33	OF-MW33-MMYY		20-30		1	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (continued)

Sampling Station	Sample ID[1]	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference
OF-MW33D	OF-MW33D-MMYY	Groundwater	51-61	PFAS	1	Refer to **Worksheet #21**
OF-MW34	OF-MW34-MMYY		30-40		1	
OF-MW34D	OF-MW34D-MMYY		50-60		1	
OF-SOW-091A	OF-SOW-091A-MMYY		66-76		2 (FD)	
	OF-SOW-091AP-MMYY					
OF-SOW-091D	OF-SOW-091D-MMYY		17-22		1	
OF-SOW-091K	OF-SOW-091K-MMYY		88-98		1	
OF-SOW-091L	OF-SOW-091L-MMYY		57-67		1	
OF-SOW-091M	OF-SOW-091M-MMYY		10-20		1	
OF14-MW04	OF14-MW04-MMYY		10-20		1	
OF14-MW05	OF14-MW05-MMYY		10-20		1	
OF14-MW06S	OF14-MW06S-MMYY		9-19		1	
OF14-MW06D	OF14-MW06D-MMYY		46-56		1	
OF14-MW07S	OF14-MW07S-MMYY		7.5-17.5		1	
OF14-MW07D	OF14-MW07D-MMYY		45-55		1	
OF17-MW01	OF17-MW01-MMYY		9-19		2 (FD)	
	OF17-MW01P-MMYY					
OF17-MW02	OF17-MW02-MMYY		10-20		3 (MS/MSD)	
	OF17-MW02-MMYY-MS					
	OF17-MW02-MMYY-MSD					
OF17-MW03	OF17-MW03-MMYY		10-20		1	
OF17-MW04	OF17-MW04-MMYY		16-30		1	
OFPOL-MW-2	OFPOL-MW-2-MMYY		2.57-12.07		1	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (continued)

Sampling Station	Sample ID[1]	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference
OFPOL-MW-3	OFPOL-MW-3-MMYY	Groundwater	1.91-11.58	PFAS	1	Refer to **Worksheet #21**
OFPOL-MW-4	OFPOL-MW-4-MMYY		2.49-12.05		1	
OFPOL-MW-6	OFPOL-MW-6-MMYY		2.06-11.55		1	
OFPOL-MW-7	OFPOL-MW-7-MMYY		2.06-11.55		1	
OFPOL-MW-8	OFPOL-MW-8-MMYY		2.42-12.11		1	
Proposed Monitoring Wells						
OF-MW35	OF-MW35-MMYY	Groundwater	Center of Screen	PFAS	1	Refer to **Worksheet #21**
OF-MW35D	OF-MW35D-MMYY				1	
OF-MW36	OF-MW36-MMYY				2 (FD)	
	OF-MW36P-MMYY					
OF-MW36D	OF-MW36D-MMYY				3 (MS/MSD)	
	OF-MW36D-MMYY-MS					
	OF-MW36D-MMYY-MSD					
OF-MW37	OF-MW37-MMYY				1	
OF-MW37D	OF-MW37D-MMYY				1	
OF-MW38	OF-MW38-MMYY				1	
OF-MW38D	OF-MW38D-MMYY				1	
OF-MW39	OF-MW39-MMYY				1	
OF-MW39D	OF-MW39D-MMYY				1	
OF14-MW08	OF14-MW08-MMYY				1	
OF14-MW08D	OF14-MW08D-MMYY				1	
OF17-MW14D	OF17-MW14D-MMYY				2 (FD)	
	OF17-MW14DP-MMYY					

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (continued)

Sampling Station	Sample ID[1]	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference
OF17-MW15D	OF17-MW15D-MMYY	Groundwater	Center of Screen	PFAS	1	Refer to **Worksheet #21**
OFPOL-MW-9	OFPOL-MW-9D-MMYY				1	
OF-MW40D	OF-MW40D-MMYY				1	
OF-MW41D	OF-MW41D-MMYY				2 (FD)	
	OF-MW41DP-MMYY					
OF-MW42DD	OF-MW42DD-MMYY				1	
OF-MW43DD	OF-MW43DD-MMYY				1	
Surface and Subsurface Soil Sampling						
OF-SO06	OF-SS06-000H-MMYY	Surface Soil	0-6	PFAS	2 (FD)	Refer to **Worksheet #21**
	OF-SS06P-000H-MMYY					
	OF-SB06-0H02-MMYY	Subsurface Soil	6-24		1	
OF-SO07	OF-SS07-000H-MMYY	Surface Soil	0-6		1	
	OF-SB07-0H02-MMYY	Subsurface Soil	6-24		2 (FD)	
	OF-SB07P-0H02-MMYY					
OF-SO08	OF-SS08-000H-MMYY	Surface Soil	0-6		1	
	OF-SB08-0H02-MMYY	Subsurface Soil	6-24		1	
OF-SO09	OF-SS09-000H-MMYY	Surface Soil	0-6		1	
	OF-SB09-0H02-MMYY	Subsurface Soil	6-24		1	
OF-SO10	OF-SS10-000H-MMYY	Surface Soil	0-6		3 (MS/MSD)	
	OF-SS10-000H-MMYY-MS					
	OF-SS10-000H-MMYY-MSD					
	OF-SB10-0H02-MMYY	Subsurface Soil	6-24		1	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (continued)

Sampling Station	Sample ID[1]	Matrix	Depth (inches bgs)	Analytical Group	Number of Samples	Sampling SOP Reference
OFPOL-SO08	OFPOL-SS08-000H-MMYY	Surface Soil	0-6	PFAS	1	Refer to **Worksheet #21**
	OFPOL-SB08-0H02-MMYY	Subsurface Soil	6-24		3 (MS/MSD)	
	OFPOL-SB08-0H02-MMYY-MS					
	OFPOL-SB08-0H02-MMYY-MSD					
OF17C-SO01	OF17C-SS01-000H-MMYY	Surface Soil	0-6		1	
	OF17C-SB01-0H02-MMYY	Subsurface Soil	6-24		1	
OF17B-SO01	OF17B-SS01-000H-MMYY	Surface Soil	0-6		1	
	OF17B-SB01-0H02-MMYY	Subsurface Soil	6-24		1	
OF17B-SO02	OF17B-SS02-000H-MMYY	Surface Soil	0-6		1	
	OF17B-SB02-0H02-MMYY	Subsurface Soil	6-24		1	
OF17B-SO03	OF17B-SS03-000H-MMYY	Surface Soil	0-6		1	
	OF17B-SB03-0H02-MMYY	Subsurface Soil	6-24		1	
OF17B-SO04	OF17B-SS04-000H-MMYY	Surface Soil	0-6		2 (FD)	
	OF17B-SS04P-000H-MMYY	Surface Soil	0-6			
	OF17B-SB04-0H02-MMYY	Subsurface Soil	6-24		1	
OF17B-SO05	OF17B-SS05-000H-MMYY	Surface Soil	0-6		1	
	OF17B-SB05-0H02-MMYY	Subsurface Soil	6-24		2 (FD)	
	OF17B-SB05P-0H02-MMYY	Subsurface Soil	6-24			
OF17B-SO06	OF17B-SS06-000H-MMYY	Surface Soil	0-6		1	
	OF17B-SB06-0H02-MMYY	Subsurface Soil	6-24		1	
OF17B-SO07	OF17B-SS07-000H-MMYY	Surface Soil	0-6		1	
	OF17B-SB07-0H02-MMYY	Subsurface Soil	6-24		1	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (continued)

Sampling Station	Sample ID[1]	Matrix	Depth (inches bgs)	Analytical Group	Number of Samples	Sampling SOP Reference
OF17B-SO08	OF17B-SS08-000H-MMYY	Surface Soil	0-6	PFAS	1	Refer to **Worksheet #21**
	OF17B-SB08-0H02-MMYY	Subsurface Soil	6-24		1	
OF17B-SO09	OF17B-SS09-000H-MMYY	Surface Soil	0-6		1	
	OF17B-SB09-0H02-MMYY	Subsurface Soil	6-24		1	
OF17B-SO10	OF17B-SS10-000H-MMYY	Surface Soil	0-6		1	
	OF17B-SB10-0H02-MMYY	Subsurface Soil	6-24		1	
OF17B-SO11	OF17B-SS11-000H-MMYY	Surface Soil	0-6		1	
	OF17B-SB11-0H02-MMYY	Subsurface Soil	6-24		1	
OF17B-SO12	OF17B-SS12-000H-MMYY	Surface Soil	0-6		1	
	OF17B-SB12-0H02-MMYY	Subsurface Soil	6-24		1	
OF14-SO01	OF14-SS01-000H-MMYY	Surface Soil	0-6		1	
	OF14-SB01-0H02-MMYY	Subsurface Soil	6-24		1	
Surface Water Sampling						
OF-SWSD01	OF-SW01-MMYY	Surface Water	--	PFAS	2 (FD)	Refer to **Worksheet #21**
	OF-SW01P-MMYY					
OF-SWSD02	OF-SW02-MMYY				3 (MS/MSD)	
	OF-SW02-MMYY-MS					
	OF-SW02-MMYY-MSD					
OF-SWSD03	OF-SW03-MMYY				1	
OF-SWSD04	OF-SW04-MMYY				1	
OF-SWSD05	OF-SW05-MMYY				1	
OF-SWSD06	OF-SW06-MMYY				1	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (continued)

Sampling Station	Sample ID[1]	Matrix	Depth (inches)	Analytical Group	Number of Samples	Sampling SOP Reference
OF-SWSD07	OF-SW07-MMYY	Surface Water	--	PFAS	1	Refer to **Worksheet #21**
OF14-SWSD01	OF14-SW01-MMYY				1	
OF14-SWSD02	OF14-SW02-MMYY				1	
OF14-SWSD03	OF14-SW03-MMYY				1	
OF14-SWSD04	OF14-SW04-MMYY				2 (FD)	
	OF14-SW04P-MMYY					
OF14-SWSD05	OF14-SW05-MMYY				1	
OF14-SWSD06	OF14-SW06-MMYY				1	
OF14-SWSD07	OF14-SW07-MMYY				1	
OF14-SWSD08	OF14-SW08-MMYY				1	
Sediment Sampling						
OF-SWSD01	OF-SD01-MMYY	Sediment	0-6	PFAS, TOC (note that field QC is not required for TOC)	2 (FD)	Refer to **Worksheet #21**
	OF-SD01P-MMYY					
OF-SWSD02	OF-SD02-MMYY				3 (MS/MSD)	
	OF-SD02-MMYY-MS					
	OF-SD02-MMYY-MSD					
OF-SWSD03	OF-SD03-MMYY				1	
OF-SWSD04	OF-SD04-MMYY				1	
OF-SWSD05	OF-SD05-MMYY				1	
OF-SWSD06	OF-SD06-MMYY				1	
OF-SWSD07	OF-SD07-MMYY				1	
OF14-SWSD01	OF14-SD01-MMYY				1	

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (continued)

Sampling Station	Sample ID[1]	Matrix	Depth(inches)	Analytical Group	Number of Samples	Sampling SOP Reference
OF14-SWSD02	OF14-SD02-MMYY	Sediment	0-6	PFAS, TOC (note that field QC is not required for TOC)	1	Refer to **Worksheet #21**
OF14-SWSD03	OF14-SD03-MMYY				1	
OF14-SWSD04	OF14-SD04-MMYY				2 (FD)	
	OF14-SD04P-MMYY					
OF14-SWSD05	OF14-SD05-MMYY				1	
OF14-SWSD06	OF14-SD06-MMYY				1	
OF14-SWSD07	OF14-SD07-MMYY				1	
OF14-SWSD08	OF14-SD08-MMYY				1	
Residential Treatment System Drinking Water Sampling						
OF-RWXX-INF01	OF-RWXX-INF01-MMYY	DW	NA	PFAS	TBD	Refer to **Worksheet #21**
	OF-RWXXP-INF01-MMYY				1 duplicate per sampling event	
OF-RWXX-MID01	OF-RWXX-MID01-MMYY				TBD	
	OF-RWXX-MID01-MMYY-MS				1 MS/MSD per sampling event	
	OF-RWXX-MID01-MMYY-MSD					
OF-RWXX-EFF01	OF-RWXX-EFF01-MMYY				TBD	
Residential Treatment System Drinking Water QC Samples						
OF-RWXX-FB01	OF-RWXX-FB01-MMYY	QC	NA	PFAS	1 per residence for treatment system well sampling	Refer to **Worksheet #21**
Residential Drinking Water Sampling						
OF-RWXX	OF-RWXX-MMYY	DW	NA	PFAS	TBD	Refer to **Worksheet #21**
OF-RWXX	OF-RWXXPP-MMYY	Duplicate	NA	PFAS	1	Refer to **Worksheet #21**

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table (continued)

Sampling Station	Sample ID[1]	Matrix	Depth(inches)	Analytical Group	Number of Samples	Sampling SOP Reference
Residential Drinking Water QC Samples						
OF-QC	OF-FBXX-MMYY	QC	NA	PFAS	1 per normal drinking water sample.	Refer to **Worksheet #21**
Quality Control Samples (Applies to GW, SS, SB, SW, SD)						
OF-QC	OF-EB-MMDDYY-GW OF-EB-MMDDYY-SW OF-EB-MMDDYY-SO OF-EB-MMDDYY-SD	QC	NA	PFAS	Refer to appropriate version of Worksheet #12 for each matrix.	Refer to **Worksheet #21**
	OF-FB-MMDDYY		NA		Refer to appropriate version of Worksheet #12 for each matrix.	

Notes:

[1] Additional sample identification (ID) instructions are as follows:

- Field duplicates will have "P" added after the sample number, for example: OF-SW21P-MMYY.
- For all sample IDs, "MMYY" will be replaced with the two-digit month and year in which the sample was collected.
- Equipment blanks (EB) and field duplicates (FD) will be identified with the two-digit month, day, and year, for example: OF-EB-MMDDYY.
- Equipment blanks will have a suffix such as -GW, -SW, -SO, -SD to indicate which type of sampling equipment each blank is associated with.
- RW indicates residential drinking well locations; XX refers to the residential location number. The number of residential locations will be determined in the field as this a voluntary sampling effort.
- Residential Treatment System samples will be collected from 7 residences per quarterly event. RW indicates residential drinking well locations; XX refers to the residential location number.

Please note that additional samples may be added pending analytical results.

SAP Worksheet #19—Analytical SOP Requirements Table

Matrix	Analytical Group	Preparation and Analytical Method / SOP Reference	Containers	Minimum Sample Amount Required for Analysis	Preservation Requirements	Maximum Holding Time
Groundwater, Surface Water	PFAS	LC-MS/MS Compliant with QSM 5.1 Table B-15/ Extraction SOP 5-370-07, Analysis SOP 5-369-06 or most recent version of the QSM for which the laboratory is accredited at the time of sample collection	Two X 250-milliliter (mL) High-Density Polyethylene (HDPE) bottle	250 mL	Samples are stored at or below 10°C until extraction	14 days to extraction; 28 days after extraction to analysis
Soil, Sediment	PFAS	LC-MS/MS Compliant with QSM 5.1 Table B-15/ Extraction SOP 5-370-07, Analysis SOP 5-369-06 or most recent version of the QSM for which the laboratory is accredited at the time of sample collection	One 8-ounce (oz) HDPE jar	30 grams (g)	Samples are stored at or below 10°C until extraction or frozen	14 days to extraction (1 year if frozen); 28 days after extraction to analysis
Sediment	TOC	USEPA 9060A, SM 5310 B-2011/WL-057	One 4-oz Polyethylene or Amber Glass Jar	0.1 g	Cool, 0-6°C	28 days
Drinking Water	PFAS	USEPA Method 537.1/5-371-04	Two X 250-mL Polypropylene bottle with polypropylene screw cap	250 mL	Samples are stored at or below 10°C until extraction; 5.0 grams per liter (g/L) of Trizma	14 days to extraction; 28 days after extraction to analysis

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SAP Worksheet #20—Field Quality Control Sample Summary Table

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates[1]	No. of MS/MSD Pairs[1]	No. of Equipment Blanks[1]	Number of Field Reagent Blanks[1]	Total No. of Samples to Laboratory[1]
Site-specific samples							
Groundwater	PFAS	72	8	4	6	6	100
Surface Water	PFAS	15	1	1	2	2	22
Surface Soil	PFAS	20	2	1	3	3	30
Subsurface Soil	PFAS	20	2	1	3	3	30
Sediment	PFAS	15	1	1	2	2	22
	TOC	15	--	--	--	--	15
Drinking Water	PFAS	TBD	TBD	TBD	TBD	TBD	TBD
Contingency Samples							
Groundwater	PFAS	TBD	TBD	TBD	TBD	TBD	TBD
Surface Water	PFAS	TBD	TBD	TBD	TBD	TBD	TBD
Surface Soil	PFAS	TBD	TBD	TBD	TBD	TBD	TBD
Subsurface Soil	PFAS	TBD	TBD	TBD	TBD	TBD	TBD
Sediment	PFAS	TBD	TBD	TBD	TBD	TBD	TBD

Notes:

[1] The number of field QC samples to be collected is dependent on the number of parent samples and the number of days of the sampling event.

- Field duplicates are collected at a frequency of 1 per 10 field samples per matrix.
- MS/MSD pairs are collected at a frequency of 1 per 20 samples per matrix sent to the laboratory (including duplicates).
- Equipment Blanks for deconned equipment are collected once per day of sampling, per type of equipment. Equipment Blanks for disposable equipment are collected once per lot.
- Field reagent blanks for non-drinking water samples will be collected once per week and will not contain the preservative Trizma.
- Field reagent blanks for drinking water samples will be collected one per normal sample/ residence as per WS 12-1.

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SAP Worksheet #21—Project Sampling SOP References Table

Title, Revision Date, and / or Number[1]	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
Drinking Water Sampling when Analyzing for Per- and Polyfluoroalkyl Substances (PFASs), QCed and revised 11/2018	CH2M	Sample bottles, gloves, sampling equipment and clothing without potential to contain PFAS, as per SOP	N	
Decontamination of Personnel and Equipment, QCed and revised 10/2018	CH2M	Deionized water, distilled water, potable water, 2.5% Liquinox and water solution, methanol, plastic pails, 55-gallon drum for waste, nitrile gloves, decontamination pad, steam cleaner	N	
Disposal of Waste Fluids and Solids, QCed and reviewed 10/2018	CH2M	Fluids: 55-gallon drum, tools to secure drum, funnel, labels, marking pen (not Sharpies or other PFAS-containing pens), seals for drum Solids: 55-gallon drum, tools to secure drum, plastic sheets, labels, marking pen (not Sharpies or other PFAS-containing pens)	N	
Decontamination of Drilling Rigs and Equipment, QCed and reviewed 10/2018	CH2M	Steam cleaner, potable water, Liquinox, buckets, brushes, distilled water, methanol, deionized water, aluminum foil (non-coated foil)	N	
Logging of Soil Borings, QCed and reviewed 10/2018	CH2M	Indelible pens (not Sharpies or other PFAS-containing pens), tape measure, loose leaf paper and clipboard, spatula, hydrochloric acid, 10% solution, squirt bottle, rock or soil color chart, grain size chart, hand lens, Unified Soil Classification System index charts and tables	N	
Preparing Field Log Books, QCed and reviewed 10/2018	CH2M	Loose leaf paper and clip board, black indelible pen (not Sharpies or other PFAS-containing pens)	N	
Chain-of-Custody, QCed and reviewed 10/2018	CH2M	Chain-of-custody, indelible pen (not Sharpies or other PFAS-containing pens)	N	
Locating and Clearing Underground Utilities, QCed and revised 10/2018	CH2M	Utility location subcontractor to provide all equipment, phone number for Miss Utility	N	
Equipment Blank and Field Blank Preparation, QCed and reviewed 10/2018	CH2M	Plastic sample bottles, nitrile gloves, blank liquid, preservatives	Y[1]	
Field Measurement of pH, Specific Conductance, Turbidity, DO, ORP, and Temperature Using A Water Quality Parameter Meter with Flow-through Cell, QCed and reviewed 09/2018	CH2M	Water Quality Parameter Meter such as a Horiba U-22 Water Quality Monitoring System or YSI with flow-through cell, distilled water in squirt bottle, Horiba U-22 Auto-Calibration Standard Solution	N	
Water-Level Measurements, QCed and reviewed 10/2018	CH2M	PFAS-free electronic water-level meter with 100-foot tape, interface probe	N	
General Guidance for Monitoring Well Installation, QCed and reviewed 10/2018	CH2M	Drilling rig, PFAS-free well construction materials, development equipment	N	
Installation of Monitoring Wells by Sonic Drilling, QCed and reviewed 10/2018	CH2M	Sonic Drill Rig, PFAS-free bentonite, cement-bentonite grout, Schedule 40 PVC, factory-slotted well screen, PVC cap, silica sand, well casing (flush-mount or stickup), surge block, pump, 55-gallon drum, Horiba U-22, water level	N	
Soil Sampling for PFAS, QCed and reviewed 11/2018	CH2M	Stainless steel auger and extensions, stainless steel spoon or spatula, pin flags, measuring tape and PFAS-free shipping materials and equipment	N	
Surface Water Sampling for PFAS, QCed and reviewed 11/2018	CH2M	Gloves, sample containers, meters for DO, pH, etc., and PFAS-free shipping materials and equipment	N	
Aquifer Slug Testing, QCed and reviewed 10/2018	CH2M	In situ data loggers (or equivalent), well-testing assembly (including packer, fittings for pressure transducers, fittings for air supply, release valve), compressed air, computer and associated equipment, and solid displacement device with rope. No PFAS-containing materials will be utilized	N	

SAP Worksheet #21—Project Sampling SOP References Table (continued)

Title, Revision Date, and / or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
Sediment Sampling for PFAS, QCed and reviewed 11/2018	CH2M	Sample collection device, stainless steel spoon, measuring tape, materials for classifying soils, sample jars, PFAS free shipping materials and equipment	N	
Groundwater Sampling for PFAS, QCed and reviewed 1/2019	CH2M	Flow-through cell, water level indicator, filter (if necessary), adjustable rate, PFAS-free pump, Teflon-free tubing, plastic sheets, well construction info, measuring cup, bucket, PFAS free sample containers and PFAS free shipping materials and equipment	N	
Sampling Contents of Tanks and Drums, QCed and reviewed 10/2018	CH2M	Drum/tank, sampling instrument, gloves, plastic sheets, labels, monitoring instrument	N	
Management of Liquid Waste Containing Per- and Polyfluoroalkyl Substances (PFAS), QCed and reviewed 11/2018	CH2M	Drum/tank, sampling instrument, gloves, plastic sheets, labels, monitoring instrument	N	

Note:

[1] Field reagent blanks will be collected in place of field blanks. Laboratory-supplied, PFAS-free water will be used in place of ASTM International Type II or laboratory grade water to prepare the PFAS Field Reagent Blanks. Field reagent blank water for drinking water samples will contain Trizma preservative.

SAP Worksheet #22—Field Equipment Calibration, Maintenance, Testing, and Inspection Table

Field Equipment	Activity[a]	Frequency	Acceptance Criteria	CA	Responsible Person	Comments
Horiba U-22 pH probe	Calibration and verification of calibration	Calibrate daily, before use and verify if the pH readings are outside of the acceptance criteria	pH reads 4.0 ± 3%	Clean probe with deionized water and calibrate again. Do not use instrument if not able to calibrate properly.	FTL	**Worksheet #21** and **Appendix A**
Horiba U-22 Specific conductance probe	Calibration and verification of calibration	Calibrate daily, before use and verify if the conductivity readings are outside of the acceptance criteria	Conductivity reads 4.49 ± 3%	Clean probe with deionized water and calibrate again. Do not use instrument if not able to calibrate properly.	FTL	**Worksheet #21** and **Appendix A**
Horiba U-22 Turbidity probe	Calibration and verification of calibration	Calibrate daily, before use and verify if the turbidity readings are outside of the acceptance criteria	Turbidity reads 0 ± 3%	Clean probe with deionized water and calibrate again. Do not use instrument if not able to calibrate properly.	FTL	**Worksheet #21** and **Appendix A**
Horiba U-22 DO and Temperature Probes	Calibration and verification of calibration	Calibrate daily, before use and verify if the DO and temperature readings are outside of the acceptance criteria	Consistent with the current atmospheric pressure and ambient temperature	Clean probe with deionized water and calibrate again. Do not use instrument if not able to calibrate properly.	FTL	**Worksheet #21** and **Appendix A**
Horiba U-22	Maintenance – Check mechanical and electronic parts, verify system continuity, check battery, and clean probes Calibration check	Daily before use, at the end of the day, and when unstable readings occur	Stable readings after 3 minutes pH reads 4.0 ± 3% Conductivity reads 4.49 ± 3% Turbidity reads 0 ± 3%	Clean probe with deionized water and calibrate again. Do not use instrument if not able to calibrate properly.	FTL	**Worksheet #21** and **Appendix A**

Note:

[a] Activities may include: calibration, verification, testing, and/or maintenance.

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SAP Worksheet #23—Analytical SOP References Table

Laboratory SOP Number	Title, Revision Date, and Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Laboratory Performing Analysis	Variance to QSM	Modified for Project Work?
4	Analysis of Poly And Perfluorlyalkyl Substances in Drinking Water Samples by Liquid Chromatography and Tandem Mass Spectrometry (LC-MS/MS) Following USEPA Method 537.1, January 21, 2019	Definitive	DW/PFAS	LC-MS/MS	Battelle (Appendix D)	N	N
5-369-06	PFAS Analytical, 5/11/2018, revision 6	Definitive	GW, SW, SO, SD/PFAS	LC-MS/MS	Battelle (Appendix D)	N	N
5-370-07	PFAS sample preparation, 10/16/2018, revision 6	--	GW, SW, SO, SD/PFAS	--	Battelle (Appendix D)	N	N
6-010-18	Sample Receipt, Custody, 4/5/2018, and Handling, revision 18	--	--	--	Battelle	N	N
WL-057	SOP for Total Organic Carbon (TOC), 05/09/18, Revision 07.1	Screening	SD / TOC	TOC Analyzer	Gulf Coast Analytical Laboratories	N	N
SAD-001	Sample Receiving and LIMS Log-In, 01/05/2017, Revision 28	--	--	--	Gulf Coast Analytical Laboratories	N	N
SAD-002	Sample Chain of Custody and Sample Integrity, 10/18/2017, Revision 15.1	--	--	--	Gulf Coast Analytical Laboratories	N	N
SD-902	Sample Receipt and Internal Control, 09/17, Revision 12.	--	--	--	Gulf Coast Analytical Laboratories	N	N
SD-903	Sample Disposal, 09/17, Revision 6.	--	--	--	Gulf Coast Analytical Laboratories	N	N

Notes:

DoD Environmental Laboratory Accreditation Program (ELAP) certification is required for analyses that will generate definitive data. Battelle's DoD ELAP certification expires February 28, 2021. GCAL's DoD ELAP current certification expires December 27, 2020.

DW = drinking water
GW = groundwater
LIMS = Laboratory Information Management System
SD = sediment
SO = soil
SW = surface water

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SAP Worksheet #24—Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
LC-MS/MS (PFAS)[2]	Aqueous Sample Preparation	Each sample and associated batch QC samples.	Solid Phase Extraction (SPE) must be used unless samples are known to contain high PFAS concentrations (e.g., AFFF formulations). Inline SPE is acceptable. Samples of known high PFAS concentrations can be prepared by serial dilution instead of SPE, with documented project approval.	--	Analyst and laboratory project manager	5-369
	Soil and Sediment Sample Preparation	Each sample and associated batch QC samples.	Entire sample received by the laboratory must be homogenized prior to subsampling.	--	Analyst and laboratory project manager	5-369
	Sample Cleanup Procedure using ENVI-Carb™ or equivalent	Each sample and associated batch QC samples. Not applicable to AFFF formulation samples.	Removal of interferences from matrix.	--	Analyst and laboratory project manager	5-369
	Mass Calibration	Initially prior to use and after performing major maintenance, as required to maintain documented instrument sensitivity and stability performance.	Calibrate the mass scale of the MS with calibration compounds and procedures described by the manufacturer. Entire range needs to be mass calibrated.	--	Analyst and laboratory project manager	5-369
	Tune Check	When the masses fall outside of the ±0.5 amu of the true value (as determined by the product ion formulas).	Mass assignments of tuning standard within 0.5 amu of true value.	Retune instrument and verify. If the tuning will not meet acceptance criteria, an instrument mass calibration must be performed and the tune check repeated.	Analyst and laboratory project manager	5-369
	Mass Spectral Acquisition Rate	Each analyte, extracted internal standard analyte, and injection internal standard analyte.	A minimum of 10 spectra scans are acquired across each chromatographic peak.	--	Analyst and laboratory project manager	5-369
	Calibration, Calibration Verification, and Spiking Standards	All analytes	Standards containing both branched and linear isomers must be used when commercially available. If not available, the total response of the analyte must be integrated (i.e., accounting for peaks that are identified as linear and branched isomers) and quantitated using a calibration curve which includes the linear isomer only for that analyte (e.g., PFOA).	--	Analyst and laboratory project manager	5-369
	Ion Transitions (Parent-> Product)	Prior to method implementation	The chemical derivation of the ion transitions, both those used for quantitation and those used for confirmation, must be documented. Two transitions and the ion transition ratio per analyte shall be monitored and documented with the exception of PFBA and PFPeA. 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).	--	Analyst and laboratory project manager	5-369

SAP Worksheet #24—Analytical Instrument Calibration Table (continued)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
LC-MS/MS (PFAS)[2]	Initial Calibration (ICAL)	At instrument set-up and after ICV or CCV failure, prior to sample analysis.	The isotopically labeled analog of an analyte (Extracted Internal Standard Analyte) must be used for quantitation if commercially available (Isotope Dilution Quantitation). If a labeled analog is not commercially available, the Extracted Internal Standard Analyte with the closest retention time to the analyte must be used for quantitation. (Internal Standard Quantitation) S/N Ratio: ≥ 10:1 for all ions used for quantification. For analytes having a promulgated standard, (e.g., HA levels for PFOA and PFOS), the qualitative (confirmation) transition ion must have a S/N Ratio of ≥ 3:1. The %RSD of the RFs for all analytes must be <20%. Linear or nonlinear calibrations must have $r^2 \geq 0.99$ for each analyte. Analytes must be within 70-130% of their true value for each calibration standard.	Correct problem and repeat ICAL.	Analyst and laboratory project manager	5-369
	Instrument Sensitivity Check (ISC)	Prior to analysis and at least once every 12 hours.	Analyte concentrations must be at LOQ; concentrations must be within ±30% of their true values.	Correct problem, rerun ISC. If problem persists, repeat ICAL.	Analyst and laboratory project manager	5-369
	Initial Calibration Verification (ICV)	Once after each ICAL, analysis of a second source standard prior to sample analysis	Concentration of each analyte must be ≤ ½ the LOQ.	Correct problem, rerun ICV. If problem persists, repeat ICAL.	Analyst and laboratory project manager	5-369
	Continuing Calibration Verification (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 CCVs cannot be run, perform corrective action(s) and repeat CCV and all associated samples since last successful CCV. Alternately, recalibrate if necessary; then reanalyze all associated samples since the last acceptable CCV.	Analyst and laboratory project manager	5-369
	Instrument Blanks (IB)	Immediately following the highest standard analyzed and daily prior to sample analysis.	Concentration of each analyte < ½ the LOQ.	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. If acceptance criteria are not met after the highest standard which is not included in the calibration, the standard cannot be used to determine the highest concentration in samples at which carry over does not occur. If acceptance criteria are not met after sample, additional instrument blanks must be analyzed until acceptance criteria are met. Additional samples shall not be analyzed until acceptance criteria are met.	Analyst and laboratory project manager	5-369
LC-MS/MS (PFAS for Drinking Water)[3]	Mass Spectral Acquisition Rate	Each analyte, extracted internal standard analyte, and injection internal standard analyte.	A minimum of 10 spectra scans are acquired across each chromatographic peak.	--	Analyst and project manager	5-371
	Ion Transitions (Parent-> Product)	Prior to method implementation	See Attachment 2 of SOP 5-371	--		

SAP Worksheet #24—Analytical Instrument Calibration Table (continued)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
	Signal to noise ratio	Required for all ion transitions used for quantification	Minimum signal to noise ratio of 3:1	--		
	Peak Asymmetry Factor	Calculate the peak asymmetry factor for the first two eluting chromatographic peaks in a mid-level ICAL standard every time a calibration curve is generated	Peak asymmetry factor of 0.8 – 1.5	--		
	Initial Calibration (ICAL)	Prior to analysis of samples	R^2> 0.99 for each analyte. Minimum 5 point linear calibration, 1/x weighting. Each target and labelled analyte must be recovered between 70% and 130% of true value (50% and 150% for the low point). Internal standard area for the first point and last point of the calibration must be less than 20% Relative percent difference.	If these requirements are not met for the ICAL, corrective action is performed and the calibration is repeated.		
	Initial Calibration Check(ICC)	Immediately after the ICAL	Target and surrogate concentrations must be between 70% and 130% of the true value. Internal standards area within 50-150% of the average area in the ICAL.	If the criteria are not met, reanalyze the ICC. If the second ICC fails, a new ICAL must be performed or justification for continuing must be documented.		
	Continuing Calibration Verification (CCV)	Beginning of each sample analysis sequence (if not preceded by an ICAL and ICC), after 10 injections during analysis sequence, and at the end of each batch.	Target and surrogate concentrations must be between 70% and 130% of the true value (50% and 150% for the low point). IS area within 70-140% of the area of the last CCV. IS area within 50-150% of the average area in the ICAL.	When a CCV fails to meet any of the above criteria, two additional CCVs are analyzed consecutively. If both additional CCVs pass criteria, the samples can be reported. If either of the two additional CCVs fail criteria or cannot be analyzed all samples that were analyzed after the prior acceptable CCV must be re-analyzed. If a CCV fails because a target analyte exceeded the acceptance limit defined above (over response only) and that analyte was not detected in any samples, then the samples do not need to be reanalyzed. In all other cases, the sample must be reanalyzed after an acceptable CCV has been established or justification for continuing is approved by the project manager and documented.		
TOC Analyzer (TOC)[4]	Initial Calibration (ICAL)	Analyzed and evaluated before any result can be quantitated	The correlation coefficient must be 0.995 or greater.	Correct problem; recalibrate instrument, new calibration verified.	Analyst, Supervisor, QA Manager	WL-043, WL-057
	Independent Calibration Verification (ICV)	Immediately following the ICAL	±10% (90-110% of true value).	Instrument maintenance, reanalysis of ICV or initial calibration or re-preparation of the standards.		
	Continuing Calibration Verification (CCV)	Each day that an ICAL is not performed a CCV must be performed before sample analysis, Also analyze every 10 samples and at the end of analytical batch.	±10 % (90-110% of true value).	Instrument maintenance, reanalysis of ICV or initial calibration or re-preparation of the standards.		
	Continuing Calibration Blank (CCB)	Analyzed after every 10 samples or more frequently and at the end of analytical batch	Concentration must be less than the LOQ.	Correct problem; recalibrate instrument.		

Notes:

[1] Refer to **Worksheet #23** for a complete reference to relevant analytical SOPs.

[2] The specifications in this table meet the requirements of DoD QSM 5.1 Table B-15 for PFAS. For TOC, specifications are as per the laboratory's SOPs.

[3] The specifications in this table meet the requirements of EPA Method 537.1

[4] The specifications in this table are from the laboratory SOP and analytical method

amu = atomic mass unit

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SAP Worksheet #25—Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
LC-MS/MS (EPA 537.1 and QSM 5.1 Table B-15)	Clean Curtain Plate	LC-MS/MS	Visual inspection of curtain plate for residue.	As needed when curtain plate has visible residue present	No visible residue on curtain plate	Remove and clean the instrument curtain plate	Analyst	5-369-06, 5-371-04
	Preventative Maintenance		Degradation of instrument performance	Every six months or when instrument performance deteriorates	ICAL within acceptance criteria on **Worksheet #24** and internal standards (IS) recovery within acceptance criteria on **Worksheet #28**	Service provider performs Preventative Maintenance and mass calibration. Run tune check. Reanalyze samples with new ICAL, ICC, ISC, and instrument blank.		
	Replace analytical column		Review peak shape, retention times, and peak separation on ICAL, ICC, and CCV samples.	Performed when chromatography deteriorates	ICAL within acceptance criteria on **Worksheet #24** and internal standards (IS) recovery within acceptance criteria on **Worksheet #28**	Replace analytical column. Reanalyze samples with new ICAL, ICC, ISC, and instrument blank.		
Balance	Verification	Weight	--	Daily	± 0.02 gram or ± 0.1% of calibration weight used (whichever is greater)	Refer to manufacturer's instruction manual	Analyst	5-369-06, 5-371-04
			--	Annually	Per manufacturer	Remove from service, repair, replace		
Pipette	Verification	Volume	--	Daily	± 2% difference from true value, < 1% relative standard deviation (n=3)	Remove from service, repair, replace	Analyst Analyst	5-369-06, 5-371-04
Pipette	Calibration		--	Quarterly	Per manufacturer	Remove from service, repair, replace		
TOC Analyzer (TOC)	Change injection needle, change catalyst	TOC	Monitor instrument performance via Continuing Calibration Verification	As Needed	No instrument error message	Clean or replace as necessary	Analyst/ Supervisor	WL-057

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SAP Worksheet #26—Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT

Sample Collection (Personnel/Organization): Field Team/CH2M

Sample Packaging (Personnel/Organization): FTL/CH2M

Coordination of Shipment (Personnel/Organization): FTL/CH2M

Type of Shipment/Carrier: Overnight Carrier/FedEx

SAMPLE RECEIPT AND ANALYSIS

Sample Receipt (Personnel/Organization): Logins/Battelle, Gulf Coast Analytical Laboratories

Sample Custody and Storage (Personnel/Organization): Logins/Battelle, Gulf Coast Analytical Laboratories

Sample Preparation (Personnel/Organization): Inorganic and Organic Prep/Battelle, Gulf Coast Analytical Laboratories

Sample Determinative Analysis (Personnel/Organization): Analysts/ Battelle, Gulf Coast Analytical Laboratories

SAMPLE ARCHIVING

Field Sample Storage (No. of days from sample collection): 45

Sample Extract/Digestate Storage (No. of days from extraction/digestion): 45

Microbial Sample Storage (No. of days from sample collection): Not applicable.

SAMPLE DISPOSAL

Personnel/Organization: Sample Custody Personnel/Battelle, Gulf Coast Analytical Laboratories

Number of Days from Analysis: 45

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SAP Worksheet #27—Sample Custody Requirements Table

Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory): Samples will be collected by field team members under the supervision of the FTL. As samples are collected, they will be placed into containers and labeled. Labels will be taped to the containers to ensure they do not separate. Samples will be cushioned with packaging material and placed into coolers containing enough ice to keep the samples <6 °C (<10 °C for PFAS) until they are received by the laboratory. The chain of custody (COC) will be placed into the cooler in a Ziploc bag. Coolers will be taped up and shipped to the laboratories via Fed Ex overnight, with the air bill number indicated on the COC (to relinquish custody). Upon delivery, the laboratory will log in each cooler and report the status of the samples to CH2M. See **Worksheet #21** for SOPs containing sample custody guidance. All PFAS samples will be shipped to Battelle. All TOC will be sent to GCAL. Laboratory custody procedures can be found in the laboratory SOPs, which are referenced in **Worksheet #23**.
Sample Identification Procedures: Sample labels will include, at a minimum, client name, site, sample ID, date/time collected, analysis group or method, preservation, and sampler's initials. The field logbook will identify the sample ID with the location and time collected and the parameters requested. The laboratory will assign each field sample a laboratory sample ID based on information in the COC and **Worksheet #18**. The laboratory will send sample log-in forms to the PC to check that sample IDs and parameters are correct.
COC Procedures: COCs will include, at a minimum, laboratory contact information, client contact information, sample information, and relinquished by/received by information. Sample information will include sample ID, date/time collected, number and type of containers, preservative information, analysis method, and comments. The chain-of-custody will link location of the sample from the field logbook to the laboratory receipt of the sample. The laboratory will use the sample information to populate the LIMS database for each sample.

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SAP Worksheet #28-1—Laboratory QC Samples Table

Matrix: Drinking Water
Analytical Group: PFAS
Analytical Method/SOP Reference: USEPA Method 537.1/5-371-04

QC Sample	Frequency / Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator (DQI)	Measurement Performance Criteria
Surrogates	Every field sample, standard, blank, and QC sample	Within 70% to 130% of true value.	Correct the problem, if required, re-prep and reanalyze the samples. If insufficient sample is available to reprocess, report as suspect / SIS recovery.	Analyst and Laboratory Project Manager	Accuracy	Same as Method / SOP QC Acceptance Limits
Internal Standards	Every field sample, standard, blank, and QC sample	Peak areas within ± 50% of the average area of the ICAL and 70-140% from the most recent CCV.	If peak areas are unacceptable, correct the problem and re-analyze. If second analysis meets acceptance criteria, report the second analysis. If it fails, either analysis may be reported with the appropriate flags.		Accuracy	
Method Blank/Procedural Blank (PB)	Daily or 1 per batch of 20 samples, whichever is more frequent	No analyte at a concentration greater than 1/3 LOQ.	Correct the problem, if required, re-prep and reanalyze the MB/PB and all the QC samples and field samples processed with the contaminated blank.		Bias/Contamination	
Laboratory Fortified Blank (LFB)	1 per batch of 20 samples	Spiked between low, medium, and high concentrations. All recoveries between 70%-130% (50% - 150% for the low point of the calibration).	Correct the problem, then re-prep and reanalyze the LFB and all samples in the associated preparatory batch for failed analytes if sufficient sample material is available.		Accuracy/Bias/Precision	
Laboratory Fortified Sample Matrix (LFSM)	1 per batch of 20 samples for residential drinking water samples 1 per sampling event for residential treatment system samples	For samples fortified at or above their native concentration, recoveries should range between 70-130%, except for low-level fortification near or at the minimum reporting level (MRL) (within a factor of 2-times the MRL concentration) where 50-150% recoveries are acceptable.	Contact the client as to additional measures to be taken.		Accuracy/Bias/Precision	
Laboratory Fortified Sample Matrix Duplicate (LFSMD)	1 per batch of 20 samples for residential drinking water samples 1 per sampling event for residential treatment system samples	RPDs for duplicate Matrix Spikes should be ≤30% for samples fortified at or above their native concentration. Greater variability may be observed when Matrix Spikes are fortified at analyte concentrations that are within a factor of 2 of the MRL. Matrix Spikes fortified at these concentrations should have RPDs that are ≤50% for samples fortified at or above their native concentration.	Examine the project-specific requirements. Contact the client as to additional measures to be taken.		Accuracy/Bias/Precision	

Notes:

USEPA Method 537.1 is the basis for specifications on this table.

SAP Worksheet #28-2—Laboratory QC Samples Table

Matrix: Groundwater, Surface Water, Soil, Sediment
Analytical Group: PFAS
Analytical Method/SOP Reference: LC-MS/MS Compliant with QSM 5.1 Table B-15/5-369-06

QC Sample	Frequency / Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator (DQI)	Measurement Performance Criteria
Extracted Internal Standards	Every field sample, standard, blank, and QC sample	Added to sample prior to extraction. For aqueous samples prepared by serial dilution instead of SPE, added to samples prior to analysis. Extracted Internal Standard Analyte recoveries must be within 50% to 150% of the true value.	If recoveries are acceptable for QC samples, but not field samples, the field samples must be reprepped and reanalyzed (greater dilution may be needed). If recoveries are unacceptable for QC samples, correct problem, and reanalyze all associated failed field samples. If recoveries are unacceptable for the QC samples, correct the problem, and reanalyze all associated field samples.	Analyst and Laboratory Project Manager	Accuracy	Same as Method / SOP QC Acceptance Limits
Injection Internal Standards	Every field sample, standard, blank, and QC sample	Added to aliquot of sample dilutions, QC samples, and standards just prior to analysis. Peak areas must be within -50% to +50% of the area measured in the ICAL midpoint standard. On days when ICAL is not performed, the peak areas must be within -50% to +50% of the peak area measured in daily initial CCV.	If peak areas are unacceptable, analyze a second aliquot of the extract or sample if enough extract remains. If there is not enough extract, reanalyze the first aliquot. If second analysis meets acceptance criteria, report the second analysis. If it fails, either analysis may be reported with the appropriate flags.		Accuracy	
Method Blank (MB)	One per preparatory batch	No analyte at a concentration greater than ½ LOQ or 1/10th of any sample concentration or 1/10th of regulatory limit (whichever is greater).	Correct the problem, if required, re-prep and reanalyze the MB and all the QC samples and field samples processed with the contaminated blank.		Bias/Contamination	
Laboratory Control Sample (LCS)	One per preparatory batch	See Worksheets 15-2 through 15-5.	Correct the problem, then re-prep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes if sufficient sample material is available.		Accuracy/Bias/Precision	
Matrix Spike (MS)	One per preparatory batch. Not required for aqueous samples prepared by serial dilution instead of SPE.	See Worksheets 15-2 through 15-5. Sample spiked with all analytes at a concentration ≥ LOQ and ≤ the mid-level calibration concentration.	Examine the project-specific requirements. Contact the client as to additional measures to be taken.		Accuracy/Bias/Precision	
Matrix Spike Duplicate (MSD) or Matrix Duplicate (MD)	For MSD: One per preparatory batch. For MD: Each aqueous sample prepared by serial dilution instead of SPE.	See Worksheets 15-2 through 15-5. Sample spiked with all analytes at a concentration ≥ LOQ and ≤ the mid-level calibration concentration. RPD ≤ 30% (between MS and MSD or sample and MD).	Contact the client as to additional measures to be taken.		Accuracy/Bias/Precision	
Post Spike Sample	Only applies to aqueous samples prepared by serial dilution instead of SPE that have reported value of "<LOQ" for analyte(s).	Spike aliquot(s) of sample at the final dilution(s) reported for sample with all analytes that have reported value of "<LOQ" in the final dilution. The spike must be at the LOQ concentration to be reported with the sample (the "<LOQ" value). When analyte concentrations are calculated as "<LOQ," the spike must recover within 70-130% of its true value.	When analyte concentrations are calculated as "<LOQ," and the spike recovery does not meet the 70-130% acceptance criteria, the sample, sample duplicate, and post spike sample must be reanalyzed at consecutively higher dilutions until the criteria is met.		Accuracy/Bias/Precision	

Notes:

DoD QSM 5.1 Table B-15 is the basis for specifications on this table.

SAP Worksheet #28-3—Laboratory QC Samples Table

Matrix: Sediment
Analytical Group: TOC
Analytical Method/SOP Reference: SW-846 9060A/WL-057

QC Sample	Frequency / Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank (MB)	One per preparatory batch, maximum of 20 samples.	Concentration shall not be > 1/2 the LOQ or 1/10 the amount of sample	The source of contamination should be investigated and samples should be reanalyzed. If, additional sample is not available, report with narrative.	Analyst, Supervisor, QA Manager	Bias/ Contamination	Same as Method / SOP QC Acceptance Limits
Laboratory Control Sample (LCS)	One per preparatory batch, maximum of 20 samples.	90-110%	If LCS fails to meet laboratory criteria, the source of inaccuracy should be investigated and samples reanalyzed. If additional sample is not available, report in a narrative.		Accuracy/Bias	
Matrix Spike	One pair per batch (assuming sufficient volume exists) if deemed necessary by the laboratory.	80-120%	If recovery is outside control limits and a laboratory error suspected, repeat the MS determination. If the LCS is within control limits and the matrix interference is indicated, analyze a post digestion spike and report results with a narrative.		Accuracy/Bias	
Matrix Spike Duplicate	One pair per batch (assuming sufficient volume exists) if deemed necessary by the laboratory.	RPD should be ≤20 %	Investigate the source of the precision error. A source of precision error in the DUP/MSD may be the homogenous nature of the sample. If laboratory error is suspected, repeat analysis. If matrix issue is indicated, report with a narrative.		Precision	

Notes:

Laboratory SOPs are the basis for specifications on this table.

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SAP Worksheet #29—Project Documents and Records Table

Document	Where Maintained[a]
• Field Notebooks • Chain-of-Custody Records • Air Bills • Custody Seals • CA Forms • Electronic data deliverable (EDDs) • Identification of QC Samples • Meteorological Data from Field • Sampling instrument calibration logs • Sampling locations and sampling plan • Sampling notes and drilling logs • Water Quality Parameters • Sample Receipt, Chain-of-Custody, and Tracking Records • Standard Traceability Logs • Equipment Calibration Logs • Sample Prep Logs • Run Logs • Equipment Maintenance, Testing, and Inspection Logs • CA Forms • Reported Field Sample Results • Reported Result for Standards, QC Checks, and QC Samples • Instrument printouts (raw data) for Field Samples, Standards, QC Checks, and QC Samples • Data Package Completeness Checklists • Sample Disposal Records • Extraction/Cleanup Records • Raw Data (stored on disk) • Data Validation Reports • CA Forms • Method Detection Limit Study Information	• Field data deliverables (logbooks entries, chains-of-custody, air bills, EDDs) will be kept on CH2M's local intranet server. • Field parameter data will be loaded with the analytical data into Data Warehouse. • Analytical laboratory hardcopy deliverables and data validation reports will be saved on the network server. • Electronic data from the laboratory will be loaded into the Data Warehouse and NIRIS. (Note: residential drinking water and treatment system drinking water data will be uploaded to the Data Warehouse only at this time. It may be uploaded to NIRIS at another time if needed, upon request).

Note:

[a] Offsite documents, except for analytical laboratory data, are archived with Iron Mountain Inc., which is headquartered at 1000 Campus Drive. Collegeville, PA 19426. Analytical laboratory data are archived with the Federal Records Center.

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SAP Worksheet #30—Analytical Services Table

Matrix	Analytical Group	Sample Locations / ID Number	Analytical Method	Data Package Turnaround Time	Laboratory / Organization
Drinking Water	PFAS	See Worksheet #18	USEPA Unmodified 537.1/ 5-371-04 or most recent version of the QSM for which the laboratory is accredited at the time of sample collection	28 days for GW, SW, SO, SD samples 14 days for DW samples	Battelle 141 Longwater Drive, Suite 202 Norwell, MA 02061 (614) 458-6917 POC: Jon Thorn
Groundwater	PFAS		LC-MS/MS Compliant with QSM 5.1 Table B-15/ 5-369-06 or most recent version of the QSM for which the laboratory is accredited at the time of sample collection		
Surface Water	PFAS				
Soil	PFAS				
Sediment	PFAS				
	Total Organic Carbon (TOC)		USEPA 9060A, SM 5310 B-2011/WL-057		Gulf Coast Analytical Laboratories 7979 Innovation Park Dr. Baton Rouge Louisiana (225) 214-7068 POC: Liz Martin

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SAP Worksheet #31—Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person Responsible for Performing Assessment	Person Responsible for Responding to Assessment Findings	Person Responsible for Identifying and Implementing CA	Person Responsible for Monitoring Effectiveness of CA
Offsite Laboratory Technical Systems Audit (applies to definitive data only)	Laboratory must have current DoD ELAP accreditation letter, which will identify the period of performance. The laboratory must be re-evaluated prior to expiration of period of performance.	External	Third-party accrediting body	Third-party accrediting body	Respective Laboratory QAO	Respective Laboratory QAO	Third-party accrediting body
Field Performance Audit	One during each sampling event.	Internal	CH2M	PM CH2M	FTL CH2M	PM CH2M	PM CH2M
Safe Behavior Observation	One during each sampling event.	Internal	CH2M	SSC CH2M	Field Team Member observed CH2M	Health and Safety Manager CH2M	SSC CH2M
Field Document Review	Daily during each sampling event.	Internal	CH2M	PM or Task Manager CH2M	FTL CH2M	PM CH2M	PM CH2M

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SAP Worksheet #32—Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings	Timeframe of Notification	Nature of CA Response Documentation	Individual(s) Receiving CA Response	Timeframe for Response
Project Review	Checklist	Stephanie Sawyer, PM, CH2M	Within 1 week of audit	Memorandum	John Tomik, AQM	Within 1 week of receipt of CA Form
Laboratory CA	Written Audit Report	Andrew Lairson, Project Chemist, CH2M	As soon as possible after initial finding.	Memorandum	Anita Dodson, Program Chemist	Within 2 months of receipt of initial notification
Safe Behavior Observation (SBO)	SBO Form	TBD SSC, CH2M	Within 1 week of SBO	Memorandum	TBD Field Team Member, CH2M	Immediately
Field Document Review	Markup copy of field documentation	TBD FTL, CH2M	Within 1 day of review	Verbal and Memorandum	TBD FTL, CH2M	Within 1 day of receipt of markup

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SAP Worksheet #32-1—Laboratory Corrective Action Form

Person initiating corrective action (CA)____________________________ **Date** ______________________________

Description of problem and when identified: ____

____

____

____

Cause of problem, if known or suspected: ____

____

____

Sequence of CA: (including date implemented, action planned and personnel/data affected) _________________

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CA implemented by: ____ **Date** ____________________________

CA initially approved by: ____ **Date** ____________________________

Follow-up date: ____

Final CA approved by: ____ **Date** ____________________________

Information copies to:

Anita Dodson/CH2M Navy CLEAN Program Chemist

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SAP Worksheet #32-2—Field Performance Audit Checklist

Project Responsibilities

Project No.: ____________________ **Date:** ____________________

Project Location: ____________________ **Signature:** ____________________

Team Members

Yes No 1) Is the approved work plan being followed?
Comments ____________________
____

Yes No 2) Was a briefing held for project participants?
Comments ____________________
____

Yes No 3) Were additional instructions given to project participants?
Comments ____________________
____

Sample Collection

Yes No 1) Is there a written list of sampling locations and descriptions?
Comments ____________________
____

Yes No 2) Are samples collected as stated in the Master SOPs?
Comments ____________________
____

Yes No 3) Are samples collected in the type of containers specified in the work plan?
Comments ____________________
____

Yes No 4) Are samples preserved as specified in the work plan?
Comments ____________________
____

Yes No 5) Are the number, frequency, and type of samples collected as specified in the work plan?
Comments ____________________
____

SAP Worksheet #32-2—Field Performance Audit Checklist (continued)

Yes No 6) Are QA checks performed as specified in the work plan?

Comments ____________________

____

Yes No 7) Are photographs taken and documented?

Comments ____________________

____

Document Control

Yes No 1) Have any accountable documents been lost?

Comments ____________________

____

Yes No 2) Have any accountable documents been voided?

Comments ____________________

____

Yes No 3) Have any accountable documents been disposed of?

Comments ____________________

____

Yes No 4) Are the samples identified with sample tags?

Comments ____________________

____

Yes No 5) Are blank and duplicate samples properly identified?

Comments ____________________

____

Yes No 6) Are samples listed on a chain-of-custody record?

Comments ____________________

____

Yes No 7) Is chain-of-custody documented and maintained?

Comments ____________________

____

SAP Worksheet #32-3—Safe Behavior Observation Form

☐ Federal or ☐ Commercial Sector (check one)		☐ Construction or ☐ Consulting (check one)	
Project Number:		Client/Program:	
Project Name:		Observer:	Date:
Position/Title of worker observed:		Background Information/comments:	
Task/Observation Observed:			

- ❖ Identify and reinforce safe work practices/behaviors
- ❖ Identify and improve on at-risk practices/acts
- ❖ Identify and improve on practices, conditions, controls, and compliance that eliminate or reduce hazards
- ❖ Proactive PM support facilitates eliminating/reducing hazards (do you have what you need?)
- ❖ Positive, corrective, cooperative, collaborative feedback/recommendations

Actions & Behaviors	**Safe**	**At-Risk**	**Observations/Comments**
Current and accurate Pre-Task Planning/ Briefing (for example, Project Safety Plan, Safety Training and Consulting, Activity Hazard Analysis, Pre-task Safety Plan, tailgate briefing, as needed)			**Positive Observations/Safe Work Practices:**
Properly trained/qualified/experienced			
Tools/equipment available and adequate			
Proper use of tools			**Questionable Activity/Unsafe Condition Observed:**
Barricades/work zone control			
Housekeeping			
Communication			
Work approach/habits			
Attitude			**Observer's CAs/Comments:**
Focus/attentiveness			
Pace			
Uncomfortable/unsafe position			
Inconvenient/unsafe location			
Position/line of fire			**Observed Worker's CAs/Comments:**
Apparel (hair, loose clothing, jewelry)			
Repetitive motion			
Other…			

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SAP Worksheet #33—Quality Assurance Management Reports Table

Type of Report	Frequency	Projected Delivery Date	Person Responsible for Report Preparation	Report Recipient(s)
Final Addendum SI Report	Post-field Event	November 2019	Stephanie Sawyer/CH2M	Stakeholders; see **Worksheet #4**

Note:

The SI Addendum Report will address the following:

- Summary of project QA/QC requirements/procedures
- Conformance of project to SAP requirements/procedures
- Status of project schedule
- Deviations from the SAP and approved amendments that were made
- Results of data review activities (how much usable data were generated)
- CAs if needed and their effectiveness
- Data usability with regard to precision, accuracy, representativeness, completeness, comparability, and sensitivity
- Limitations on data use

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SAP Worksheets #34 through #36—Data Verification and Validation (Steps I and IIa/IIb) Process Table

Data Review Input	Description	Responsible for Verification or Validation[a]	Step I / IIa / IIb [a]	Internal/ External[b]
Field Notebooks	Field notebooks will be reviewed internally and placed into the project file for archival at project closeout.	Field Team Leader / CH2M	Step I	Internal
Chain-of-Custody and Shipping Forms	Chain-of-custody 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 chain-of-custody form will be initialed by the reviewer, a copy of the chains-of-custody retained in the site file, and the original and remaining copies taped inside the cooler for shipment. Chains-of-custody will also be reviewed for adherence to the SAP by the project chemist.	Field Team Leader / CH2M Project Chemist / CH2M	Step I	Internal & External
Sample Condition upon Receipt	Any discrepancies, missing, or broken containers will be communicated to the project chemist in the form of laboratory logins.	Project Chemist / CH2M	Step I	External
Documentation of Laboratory Method Deviations	Laboratory Method Deviations will be discussed and approved by the project chemist. Documentation will be incorporated into the case narrative which becomes part of the final hardcopy data package.	Project Chemist / CH2M	Step I	External
Electronic Data Deliverables	EDDs will be compared against hardcopy laboratory results (10% check). If discrepancies between the EDD and hardcopy data package are encountered a deeper review of 25% will be conducted.	Project Chemist / CH2M	Step I	External
Case Narrative	Case narratives will be reviewed by the DV during the data validation process. This is verification that they were generated and applicable to the data packages.	DV / TBD	Step I	External
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal.	Respective Laboratory QAO	Step I	Internal
Laboratory Data	The data will be verified for completeness by the project chemist. In order to ensure completeness, EDDs will be compared to the SAP. This is a verification that all samples were included in the laboratory data and that correct analyte lists were reported.	Project Chemist / CH2M	Step I	External
Audit Reports	Upon report completion, a copy of all audit reports will be placed in the site file. If corrective actions are required, a copy of the documented corrective action taken will be attached to the appropriate audit report in the QA site file. Periodically, and at the completion of site work, site file audit reports and corrective action forms will be reviewed internally to ensure that all appropriate corrective actions have been taken and that corrective action reports are attached. If corrective actions have not been taken, the site manager will be notified to ensure action is taken.	Project Manager / CH2M Project Chemist / CH2M	Step I	Internal
Corrective Action Reports	Corrective action reports will be reviewed by the project chemist or PM and placed into the project file for archival at project closeout.	Project Manager / CH2M Project Chemist / CH2M	Step I	External
Laboratory Methods	During the pre-validation check, ensure that the laboratory analyzed samples using the correct methods specified in the SAP. If methods other than those specified in the SAP were used, the reason will be determined and documented.	Project Chemist / CH2M	Step IIa	External
Target Compound List and Target Analyte List	During the pre-validation check, ensure that the laboratory reported all analytes from each analysis group as per **Worksheet #15**. If the target compound list is not correct, then it must be corrected prior to sending the data for validation. Once the checks are complete, the project manager is notified via email.	Project Chemist / CH2M	Step IIa	External
Reporting Limits	Ensure the laboratory met the project-designated quantitation limits as per **Worksheet #15**. If quantitation limits were not met, the reason will be determined and documented.	Project Chemist / CH2M	Step IIb	External
Field SOPs	Ensure that all field SOPs were followed.	Field Team Leader /CH2M	Step I	Internal
Laboratory SOPs	Ensure that approved analytical laboratory SOPs were followed.	Respective Laboratory QAO	Step IIa	Internal
Raw Data	10 percent Stage 4 review of raw data to confirm laboratory calculations and manual integrations. For a recalculated result, the DV attempts to re-create the reported numerical value. The laboratory is asked for clarification if a discrepancy is identified which cannot reasonably be attributed to rounding. In general, this is outside 5% difference. The remaining 90 percent of data will receive Stage 2B review.	DV / TBD	Step IIa	External
Onsite Screening	All non-analytical field data will be reviewed against SAP requirements for completeness and accuracy based on the field calibration records.	Field Team Leader / CH2M	Step IIb	Internal
Documentation of Method QC Results	Establish that all required QC samples were run and met limits.	DV / TBD	Step IIa	External

SAP Worksheets #34 through #36—Data Verification and Validation (Steps I and IIa/IIb) Process Table (continued)

Data Review Input	Description	Responsible for Verification or Validation[a]	Step I / IIa / IIb [a]	Internal/ External[b]
Documentation of Field QC Sample Results	Establish that all required QC samples were run and met limits.	Project Chemist / CH2M	Step IIa	Internal
DoD ELAP Evaluation	Ensure that each laboratory is DoD ELAP Certified for the analyses they are to perform. Ensure evaluation timeframe does not expire.	Project Chemist / CH2M	Step I	External
Analytical data for PFAS in all samples	Analytical methods and laboratory SOPs will be evaluated against QA/QC criteria to ensure compliance, as presented in this SAP. QA/QC criteria for field QC samples are presented in **Worksheet #12**. LOQs, LODs, and DLs are presented in **Worksheet #15**. QA/QC criteria for calibrations are presented in Laboratory SOPs (referenced in **Worksheet #23**). QA/QC criteria for laboratory QC samples are presented in **Worksheet #28**. Data may be qualified if QA/QC exceedances have occurred. Guidance and qualifiers from "United States Department of Defense General Data Validation Guidelines" (DoD, 2018) will be applied as appropriate. As specific modules for the analytical methods in this project are published, the DVs will refer to those modules for guidance. In the meantime, if specific guidance is not given for these methods in the General Data Validation Guidelines, the DV may adapt the guidance from "National Functional Guidelines for Superfund Organic Methods Data Review (SOM02.4)" (USEPA, 2017b), and "National Functional Guidelines for Inorganic Superfund Data Review (ISM02.4)" (USEPA, 2017a) may also be applicable. For drinking water samples, the data validator will reference "EPA Data Review and Validation Guidelines for Perfluoroalkyl Substances (PFASs) Analyzed Using EPA Method 537" (USEPA, 2018a).	DV / TBD	Step IIa and IIb	External
Analytical data for WCHEM, in all samples	Wet chemistry data will not undergo third-party data validation but are subject to all other data review protocols detailed above.	N/A	Step IIa and IIb	N/A

Notes:

[a] Verification (Step I) is a completeness check that is performed before the data review process continues in order to determine whether the required information (complete data package) is available for further review. Validation (Step IIa) is a review that the data generated is in compliance with analytical methods, procedures, and contracts. Validation (Step IIb) is a comparison of generated data against measurement performance criteria in the SAP (both sampling and analytical). Should CH2M find discrepancies during the verification or validation procedures above, an email documenting the issue will be circulated to the internal project team, and a Corrections to File Memo will be prepared identifying the issues and the corrective action needed. This memo will be sent to the laboratory, or applicable party, and maintained in the project file.

[b] Internal or external is in relation to the data generator.

SAP Worksheet #37—Usability Assessment

Summarize the usability assessment process and all procedures, including interim steps and any statistics, equations, and computer algorithms that will be used:

- Non-detected site contaminants will be evaluated to ensure that PQL goals in **Worksheet #15** were achieved. If PQLs were achieved and the verification and validation steps yielded acceptable data, then the data are considered usable.
- During verification and validation steps, data may be qualified as estimated with the following qualifiers: J, J+, J-, or UJ. These qualifiers represent minor QC deficiencies that will not affect the usability of the data. When major QC deficiencies are encountered, data will be qualified with an R and in most cases is not considered usable for project decisions. If R-qualified data are used in evaluations and, ultimately, project decisions, the rationale for their use will be included in the investigation report
    - J = Analyte present. Reported value may or may not be accurate or precise.
    - UJ = Analyte not detected. QL may be inaccurate or imprecise.
    - J+ = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
    - J- = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
    - X = Recommend rejected result by data validator.
    - R = Rejected result by project team. Result not reliable. Project team as a whole will determine if the final qualifier will become an R qualifier for rejection or will be qualified as estimated with one of the qualifiers listed above.
- If statistical comparisons are necessary, non-detect values will be represented by a concentration equal to one-half the sample reporting limit. For duplicate sample results, the most conservative value will be used for project decisions.
- Additional qualifiers that may be given by the validator are:
    - N = Tentative identification. Consider present. Special methods may be needed to confirm its presence or absence in future sampling efforts
    - NJ = Qualitative identification questionable due to poor resolution. Presumptively present at approximate quantity.
    - U = Not detected.
- Analytical data will be checked to ensure the values and any qualifiers are appropriately transferred to the electronic database. These checks include comparison of hardcopy data and qualifiers to the EDD. Once the data has been uploaded into the electronic database, another check will be performed to ensure all results were loaded accurately.
- Field and laboratory precision will be compared as RPD between the two results.
- Deviations from the SAP will be reviewed to assess whether CA is warranted and to assess impacts to achievement of project objectives.
- Describe the evaluative procedures used to assess overall measurement error associated with the project.
- To assess whether a sufficient quantity of acceptable data are available for decision making, the data will be compared to a 95 percent completeness goal and will be reconciled with MPC following validation and review of DQIs.

SAP Worksheet #37—Usability Assessment (continued)

- If significant biases are detected with laboratory QA/QC samples, results will be evaluated to assess impact on decision-making. Low biases will be described in detail as they represent a possible inability to detect compounds that may be present at the site.
- If significant deviations are noted between laboratory and field precision, the cause will be further evaluated to assess impact on decision making.

Describe the documentation that will be generated during the usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies:

- Data tables will be produced to reflect detected and non-detected analytes. Data qualifiers will be reflected in the tables and discussed in the data quality evaluation.
- A data quality evaluation will be provided as part of the SI Addendum Report.
- The SI Addendum Report will identify any data usability limitations and make recommendations for CA if necessary.

Identify the personnel responsible for performing the usability assessment.

The PM, PC, and other team members will be responsible for compiling the data. The data will then be presented to the NAS Oceana Partnering Team, who will evaluate the data usability according to project objectives.

References

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Figures

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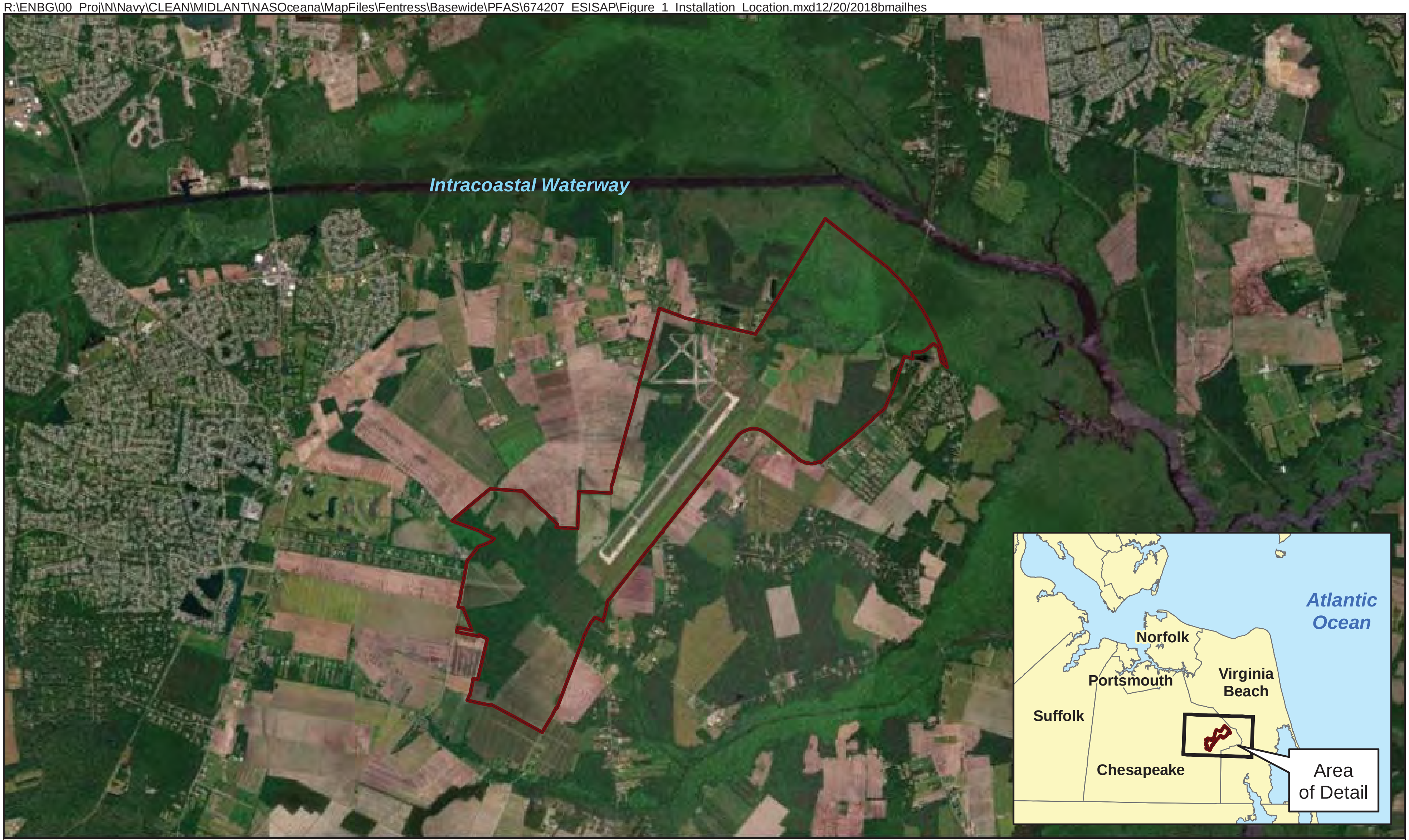

Legend

▭ Fentress Boundary

1 inch = 1 mile

Imagery Source: ©2017 Esri

Figure 1
Installation Location Map
Basewide Per- and Polyfluoroalkyl Substances Expanded Site Inspection
NALF Fentress, Chesapeake, Virginia

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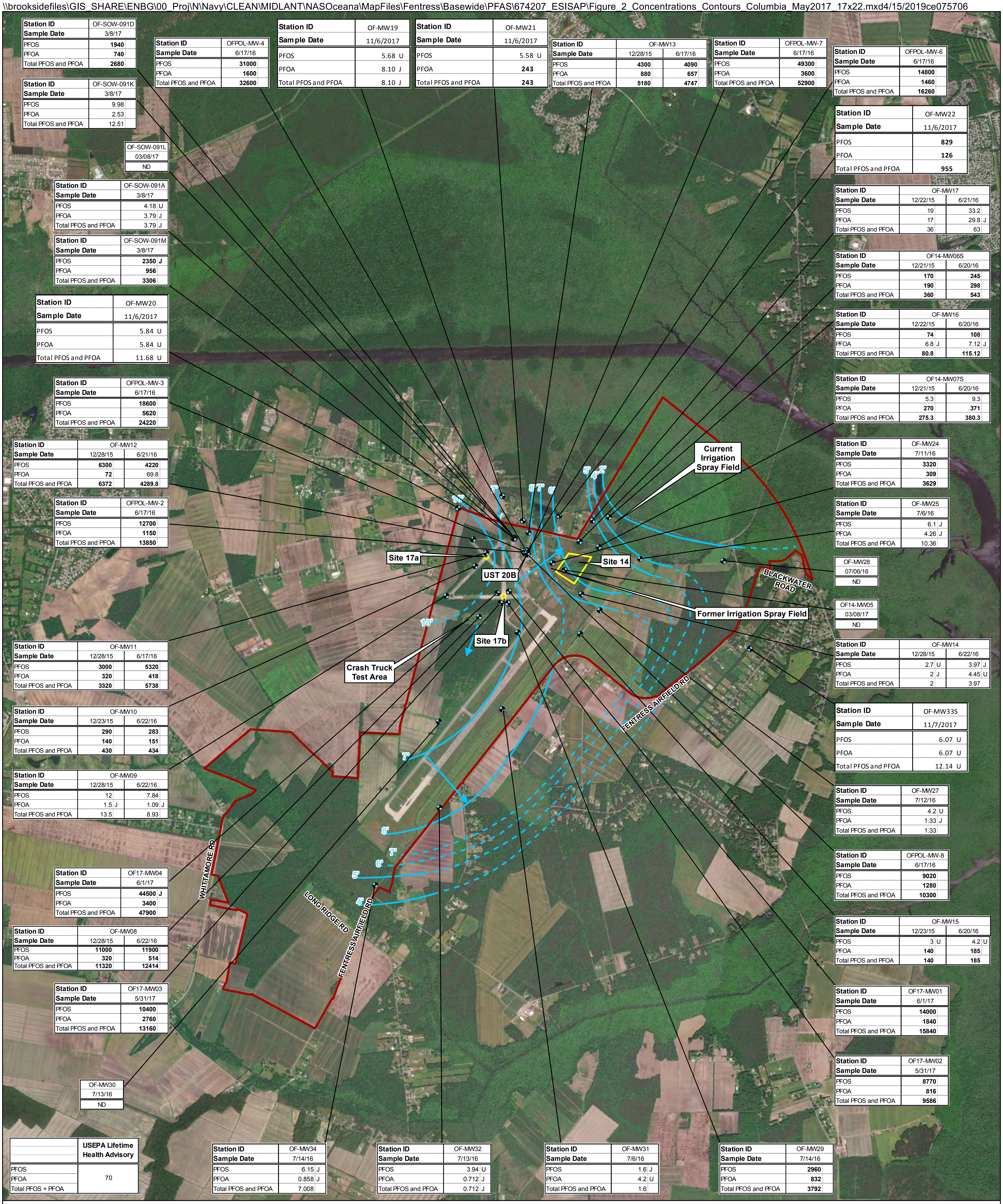


Station ID	OF-SOW-091D
Sample Date	3/8/17
PFOS	**1940**
PFOA	**740**
Total PFOS and PFOA	**2680**

Station ID	OF-SOW-091K
Sample Date	3/8/17
PFOS	9.98
PFOA	2.53
Total PFOS and PFOA	12.51

Station ID	OFPOL-MW-4
Sample Date	6/17/16
PFOS	**31000**
PFOA	**1600**
Total PFOS and PFOA	**32600**

Station ID	OF-MW19
Sample Date	11/6/2017
PFOS	5.68 U
PFOA	8.10 J
Total PFOS and PFOA	8.10 J

Station ID	OF-MW21
Sample Date	11/6/2017
PFOS	5.58 U
PFOA	**243**
Total PFOS and PFOA	**243**

Station ID	OF-MW13	
Sample Date	12/28/15	6/17/16
PFOS	**4300**	**4090**
PFOA	**880**	**657**
Total PFOS and PFOA	**5180**	**4747**

Station ID	OFPOL-MW-7
Sample Date	6/17/16
PFOS	**49300**
PFOA	**3600**
Total PFOS and PFOA	**52900**

Station ID	OFPOL-MW-6
Sample Date	6/17/16
PFOS	**14800**
PFOA	**1460**
Total PFOS and PFOA	**16260**

Station ID	OF-MW22
Sample Date	11/6/2017
PFOS	**829**
PFOA	**126**
Total PFOS and PFOA	**955**

OF-SOW-091L
03/08/17
ND

Station ID	OF-SOW-091A
Sample Date	3/8/17
PFOS	4.18 U
PFOA	3.79 J
Total PFOS and PFOA	3.79 J

Station ID	OF-SOW-091M
Sample Date	3/8/17
PFOS	**2350 J**
PFOA	**956**
Total PFOS and PFOA	**3306**

Station ID	OF-MW20
Sample Date	11/6/2017
PFOS	5.84 U
PFOA	5.84 U
Total PFOS and PFOA	11.68 U

Station ID	OFPOL-MW-3
Sample Date	6/17/16
PFOS	**18600**
PFOA	**5620**
Total PFOS and PFOA	**24220**

Station ID	OF-MW12	
Sample Date	12/28/15	6/21/16
PFOS	**6300**	**4220**
PFOA	**72**	69.8
Total PFOS and PFOA	**6372**	**4289.8**

Station ID	OFPOL-MW-2
Sample Date	6/17/16
PFOS	**12700**
PFOA	**1150**
Total PFOS and PFOA	**13850**

Station ID	OF-MW11	
Sample Date	12/28/15	6/17/16
PFOS	**3000**	**5320**
PFOA	**320**	**418**
Total PFOS and PFOA	**3320**	**5738**

Station ID	OF-MW10	
Sample Date	12/23/15	6/22/16
PFOS	**290**	**283**
PFOA	**140**	**151**
Total PFOS and PFOA	**430**	**434**

Station ID	OF-MW09	
Sample Date	12/28/15	6/22/16
PFOS	12	7.84
PFOA	1.5 J	1.09 J
Total PFOS and PFOA	13.5	8.93

Station ID	OF17-MW04
Sample Date	6/1/17
PFOS	**44500 J**
PFOA	**3400**
Total PFOS and PFOA	**47900**

Station ID	OF-MW08	
Sample Date	12/28/15	6/22/16
PFOS	**11000**	**11900**
PFOA	**320**	**514**
Total PFOS and PFOA	**11320**	**12414**

Station ID	OF17-MW03
Sample Date	5/31/17
PFOS	**10400**
PFOA	**2760**
Total PFOS and PFOA	**13160**

OF-MW30
7/13/16
ND

Station ID	OF-MW17	
Sample Date	12/22/15	6/21/16
PFOS	19	33.2
PFOA	17	29.8 J
Total PFOS and PFOA	36	63

Station ID	OF14-MW06S	
Sample Date	12/21/15	6/20/16
PFOS	**170**	**245**
PFOA	**190**	**298**
Total PFOS and PFOA	**360**	**543**

Station ID	OF-MW16	
Sample Date	12/22/15	6/20/16
PFOS	**74**	**108**
PFOA	6.8 J	7.12 J
Total PFOS and PFOA	**80.8**	**115.12**

Station ID	OF14-MW07S	
Sample Date	12/21/15	6/20/16
PFOS	5.3	9.3
PFOA	**270**	**371**
Total PFOS and PFOA	**275.3**	**380.3**

Station ID	OF-MW24
Sample Date	7/11/16
PFOS	**3320**
PFOA	**309**
Total PFOS and PFOA	**3629**

Station ID	OF-MW25
Sample Date	7/6/16
PFOS	6.1 J
PFOA	4.26 J
Total PFOS and PFOA	10.36

OF-MW28
07/06/16
ND

OF14-MW05
03/08/17
ND

Station ID	OF-MW14	
Sample Date	12/28/15	6/22/16
PFOS	2.7 U	3.97 J
PFOA	2 J	4.45 U
Total PFOS and PFOA	2	3.97

Station ID	OF-MW33S
Sample Date	11/7/2017
PFOS	6.07 U
PFOA	6.07 U
Total PFOS and PFOA	12.14 U

Station ID	OF-MW27
Sample Date	7/12/16
PFOS	4.2 U
PFOA	1.33 J
Total PFOS and PFOA	1.33

Station ID	OFPOL-MW-8
Sample Date	6/17/16
PFOS	**9020**
PFOA	**1280**
Total PFOS and PFOA	**10300**

Station ID	OF-MW15	
Sample Date	12/23/15	6/20/16
PFOS	3 U	4.2 U
PFOA	**140**	**185**
Total PFOS and PFOA	**140**	**185**

Station ID	OF17-MW01
Sample Date	6/1/17
PFOS	**14000**
PFOA	**1840**
Total PFOS and PFOA	**15840**

Station ID	OF17-MW02
Sample Date	5/31/17
PFOS	**8770**
PFOA	**816**
Total PFOS and PFOA	**9586**

	USEPA Lifetime Health Advisory
PFOS	70
PFOA	
Total PFOS + PFOA	

Station ID	OF-MW34
Sample Date	7/14/16
PFOS	6.15 J
PFOA	0.858 J
Total PFOS and PFOA	7.008

Station ID	OF-MW32
Sample Date	7/13/16
PFOS	3.94 U
PFOA	0.712 J
Total PFOS and PFOA	0.712 J

Station ID	OF-MW31
Sample Date	7/6/16
PFOS	1.6 J
PFOA	4.2 U
Total PFOS and PFOA	1.6

Station ID	OF-MW29
Sample Date	7/14/16
PFOS	**2960**
PFOA	**832**
Total PFOS and PFOA	**3792**

Legend

- ● Existing Monitoring Well Location
- — Groundwater Potentiometric Surface
- - - Inferred Groundwater Potentiometric Surface
- → Groundwater Flow Direction
- ▭ Site Boundary
- ▭ Fentress Boundary

N

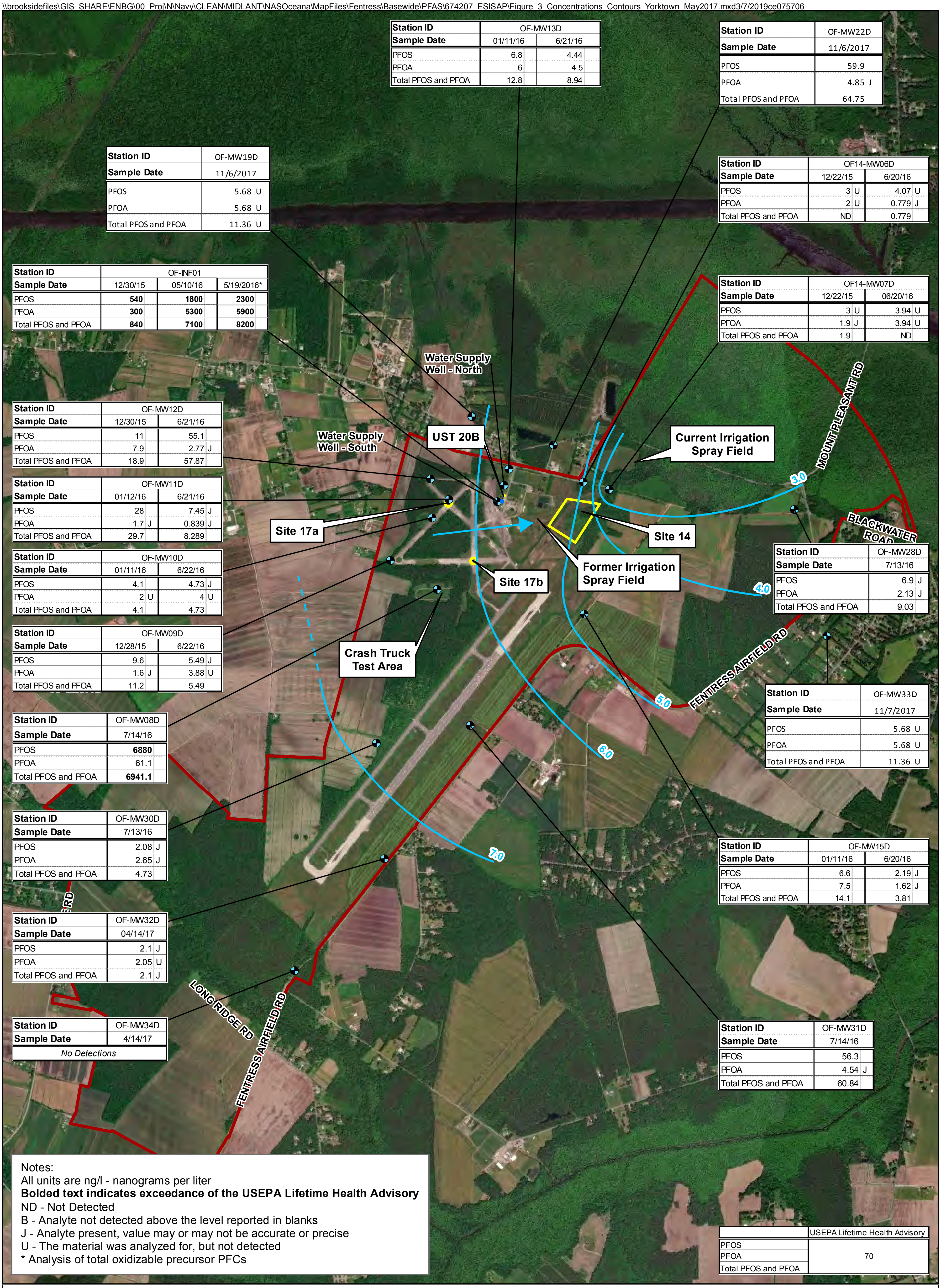
0 1,000 2,000 Feet

Imagery Source: ©2017 Esri

Notes:
All units are ng/l - nanograms per liter
Bolded text indicates exceedance of the USEPA Lifetime Health Advisory
ND - Not Detected
B - Analyte not detected above the level reported in blanks
J - Analyte present, value may or may not be accurate or precise
J- - Analyte present, value may be biased low, value may be higher
U - The material was analyzed for, but not detected

Figure 2
PFOA and PFOS Concentrations in the Columbia/Surficial Aquifer
Basewide Per- and Polyfluoroalkyl Substances Expanded Site Inspection
NALF Fentress, Chesapeake, Virginia

ch2m



Station ID	OF-MW13D	
Sample Date	01/11/16	6/21/16
PFOS	6.8	4.44
PFOA	6	4.5
Total PFOS and PFOA	12.8	8.94

Station ID	OF-MW22D
Sample Date	11/6/2017
PFOS	59.9
PFOA	4.85 J
Total PFOS and PFOA	64.75

Station ID	OF-MW19D
Sample Date	11/6/2017
PFOS	5.68 U
PFOA	5.68 U
Total PFOS and PFOA	11.36 U

Station ID	OF14-MW06D	
Sample Date	12/22/15	6/20/16
PFOS	3 U	4.07 U
PFOA	2 U	0.779 J
Total PFOS and PFOA	ND	0.779

Station ID	OF-INF01		
Sample Date	12/30/15	05/10/16	5/19/2016*
PFOS	**540**	**1800**	**2300**
PFOA	**300**	**5300**	**5900**
Total PFOS and PFOA	**840**	**7100**	**8200**

Station ID	OF14-MW07D	
Sample Date	12/22/15	06/20/16
PFOS	3 U	3.94 U
PFOA	1.9 J	3.94 U
Total PFOS and PFOA	1.9	ND

Station ID	OF-MW12D	
Sample Date	12/30/15	6/21/16
PFOS	11	55.1
PFOA	7.9	2.77 J
Total PFOS and PFOA	18.9	57.87

Station ID	OF-MW11D	
Sample Date	01/12/16	6/21/16
PFOS	28	7.45 J
PFOA	1.7 J	0.839 J
Total PFOS and PFOA	29.7	8.289

Station ID	OF-MW10D	
Sample Date	01/11/16	6/22/16
PFOS	4.1	4.73 J
PFOA	2 U	4 U
Total PFOS and PFOA	4.1	4.73

Station ID	OF-MW28D
Sample Date	7/13/16
PFOS	6.9 J
PFOA	2.13 J
Total PFOS and PFOA	9.03

Station ID	OF-MW09D	
Sample Date	12/28/15	6/22/16
PFOS	9.6	5.49 J
PFOA	1.6 J	3.88 U
Total PFOS and PFOA	11.2	5.49

Station ID	OF-MW33D
Sample Date	11/7/2017
PFOS	5.68 U
PFOA	5.68 U
Total PFOS and PFOA	11.36 U

Station ID	OF-MW08D
Sample Date	7/14/16
PFOS	**6880**
PFOA	61.1
Total PFOS and PFOA	**6941.1**

Station ID	OF-MW30D
Sample Date	7/13/16
PFOS	2.08 J
PFOA	2.65 J
Total PFOS and PFOA	4.73

Station ID	OF-MW15D	
Sample Date	01/11/16	6/20/16
PFOS	6.6	2.19 J
PFOA	7.5	1.62 J
Total PFOS and PFOA	14.1	3.81

Station ID	OF-MW32D
Sample Date	04/14/17
PFOS	2.1 J
PFOA	2.05 U
Total PFOS and PFOA	2.1 J

Station ID	OF-MW34D
Sample Date	4/14/17
No Detections	

Station ID	OF-MW31D
Sample Date	7/14/16
PFOS	56.3
PFOA	4.54 J
Total PFOS and PFOA	60.84

Notes:
All units are ng/l - nanograms per liter
Bolded text indicates exceedance of the USEPA Lifetime Health Advisory
ND - Not Detected
B - Analyte not detected above the level reported in blanks
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
* Analysis of total oxidizable precursor PFCs

	USEPA Lifetime Health Advisory
PFOS PFOA Total PFOS and PFOA	70

Legend
- ● Existing Monitoring Well Location
- — Groundwater Potentiometric Surface
- - - Inferred Groundwater Potentiometric Surface
- ➔ Groundwater Flow Direction
- ☐ Water Treatment Plant
- ☐ Site Boundary
- ☐ Fentress Boundary

N

0 1,000 2,000
Feet

Imagery Source: ©2017 Esri

Figure 3
PFOA and PFOS Concentrations in the Yorktown Aquifer
Basewide Per- and Polyfluoroalkyl Substances Expanded Site Inspection
NALF Fentress, Chesapeake, Virginia

ch2m

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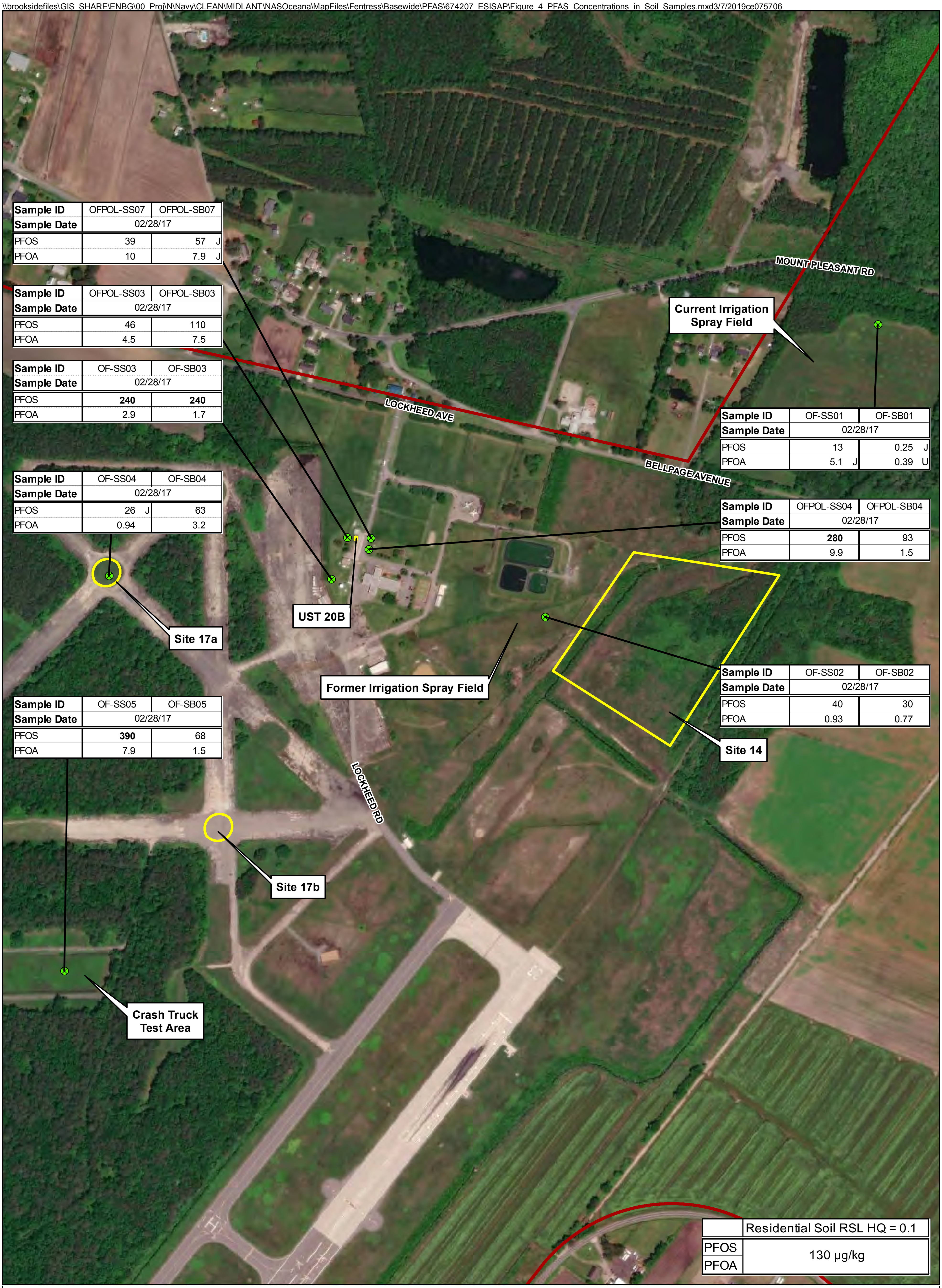


Sample ID	OFPOL-SS07	OFPOL-SB07
Sample Date	02/28/17	
PFOS	39	57 J
PFOA	10	7.9 J

Sample ID	OFPOL-SS03	OFPOL-SB03
Sample Date	02/28/17	
PFOS	46	110
PFOA	4.5	7.5

Sample ID	OF-SS03	OF-SB03
Sample Date	02/28/17	
PFOS	**240**	**240**
PFOA	2.9	1.7

Sample ID	OF-SS04	OF-SB04
Sample Date	02/28/17	
PFOS	26 J	63
PFOA	0.94	3.2

Sample ID	OF-SS05	OF-SB05
Sample Date	02/28/17	
PFOS	**390**	68
PFOA	7.9	1.5

Sample ID	OF-SS01	OF-SB01
Sample Date	02/28/17	
PFOS	13	0.25 J
PFOA	5.1 J	0.39 U

Sample ID	OFPOL-SS04	OFPOL-SB04
Sample Date	02/28/17	
PFOS	**280**	93
PFOA	9.9	1.5

Sample ID	OF-SS02	OF-SB02
Sample Date	02/28/17	
PFOS	40	30
PFOA	0.93	0.77

	Residential Soil RSL HQ = 0.1
PFOS PFOA	130 µg/kg

Legend
- ⊗ Soil Sample Location
- ▭ Site Boundary
- ▭ Fentress Boundary

N

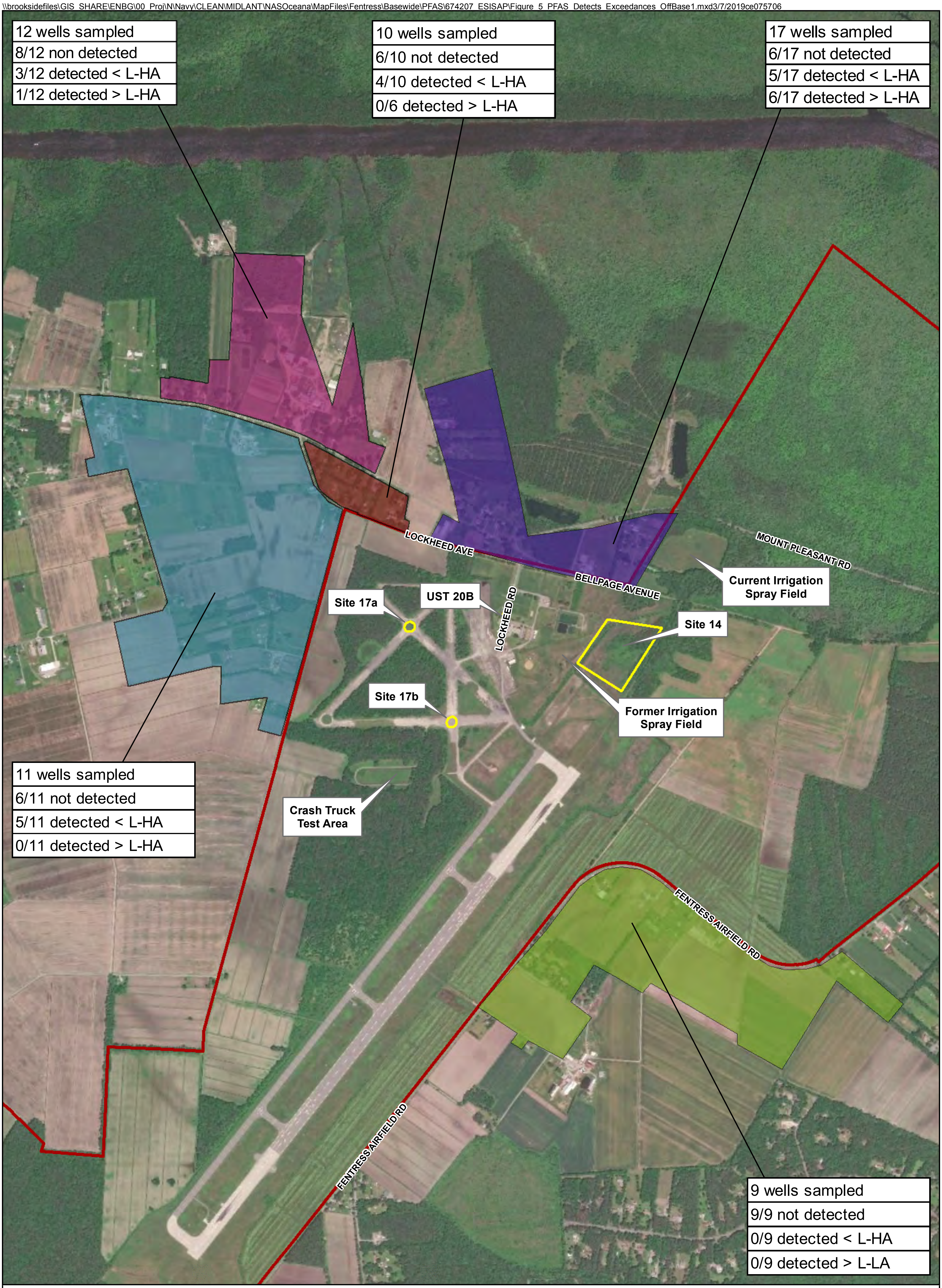
0 225 450 Feet

Imagery Source: ©2017 Esri

Figure 4
PFOA and PFOS Concentrations in Soil Samples
Basewide Per- and Polyfluoroalkyl Substances Expanded Site Inspection
NALF Fentress, Chesapeake, Virginia

Notes:
All units are µg/kg - micrograms per kilogram
Bolded text indicates exceedance of Residential Soil RSLs HQ = 0.1
B - Analyte not detected above the level reported in blanks
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected

ch2m



Legend

🟨 Site Boundary

🟥 Fentress Boundary

N

0 600 1,200 Feet

Imagery Source: ©2017 Esri

Figure 5
PFOA and PFOS Detections and Exceedances from Parcels Located Off-Base
Basewide Per- and Polyfluoroalkyl Substances Expanded Site Inspection
NALF Fentress, Chesapeake, Virginia

ch2m

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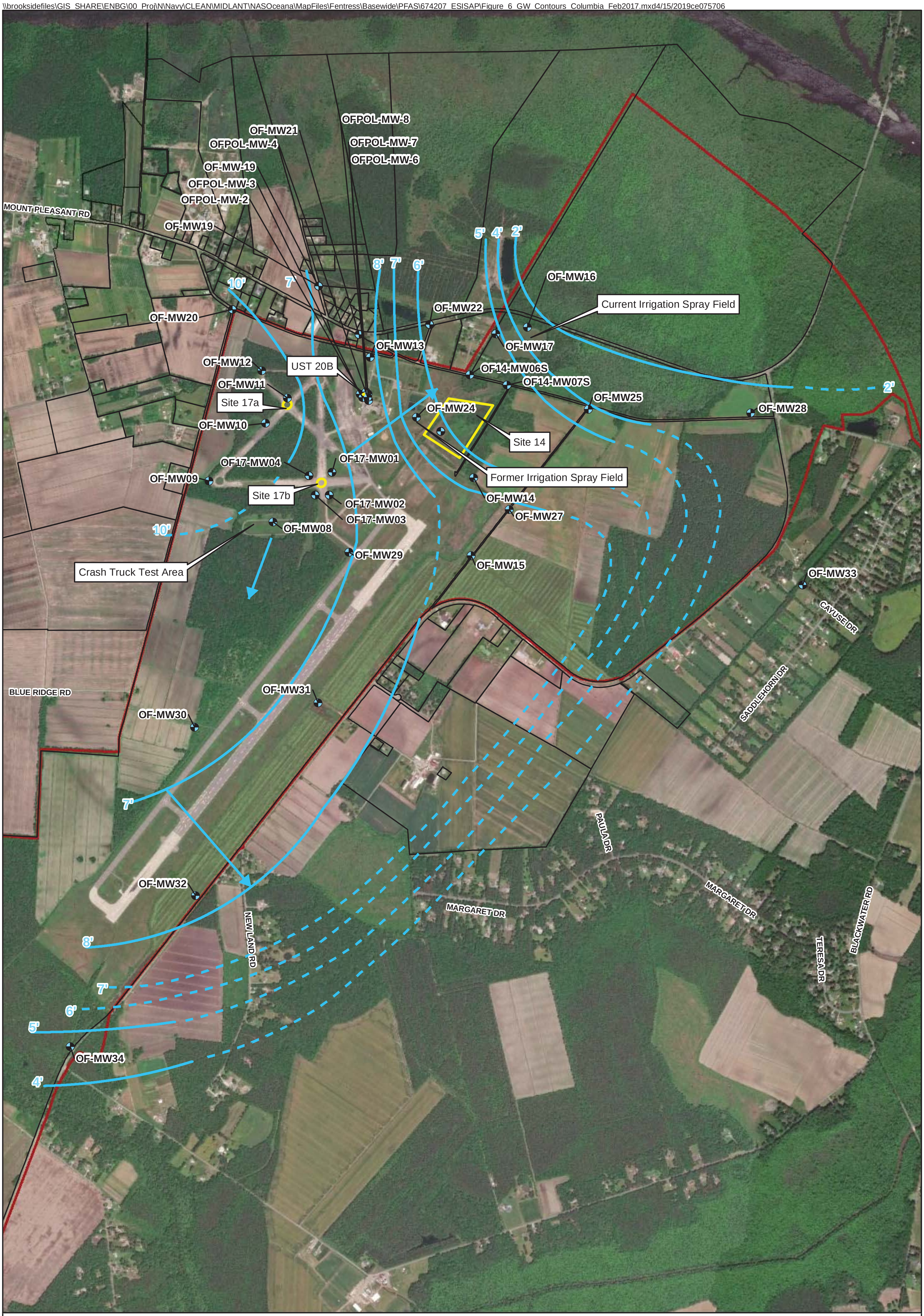


Legend

- ● Existing Monitoring Well Location
- ➔ Groundwater Flow Direction
- — Groundwater Potentiometric Surface
- - - Inferred Groundwater Potentiometric Surface
- ☐ Parcel Boundary
- ☐ Site Boundary
- ☐ Fentress Boundary

N

0 750 1,500 Feet

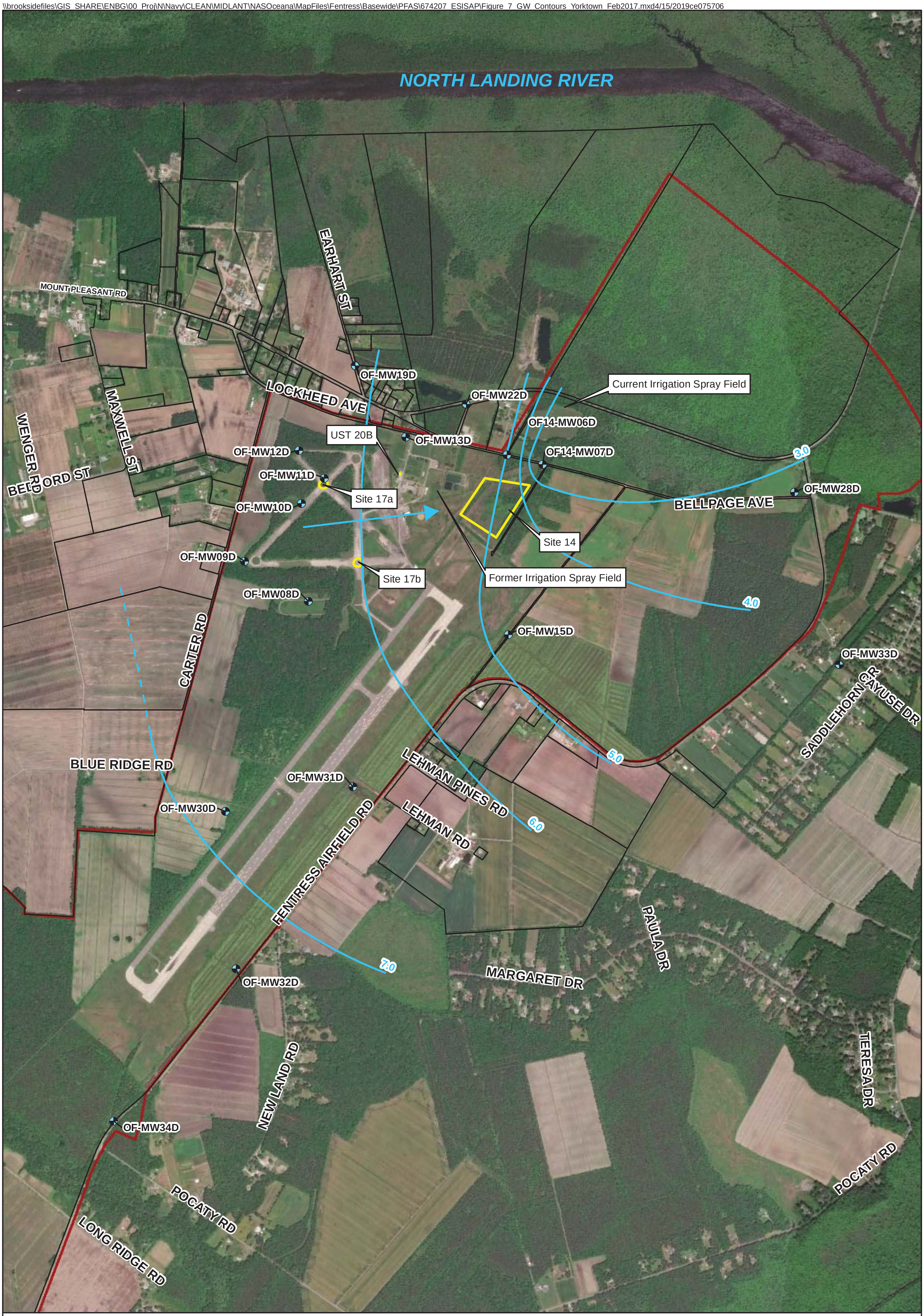
1 inch = 1,500 feet

Imagery Source: ESRI 2017

5.78 *Groundwater elevations measured in feet above mean sea level (ft amsl)*

Figure 6
Columbia/Surficial Aquifer Groundwater Elevation Contours - February 2019
Basewide Per- and Polyfluoroalkyl Substances Expanded Site Inspection
NALF Fentress, Chesapeake, Virginia

ch2m



Legend

- ◍ Existing Monitoring Well Location
- — Groundwater Potentiometric Surface
- - - Inferred Groundwater Potentiometric Surface
- ➔ Groundwater Flow Direction
- ▭ Parcel Boundary
- ▭ Site Boundary
- ▭ Fentress Boundary

N

0 750 1,500

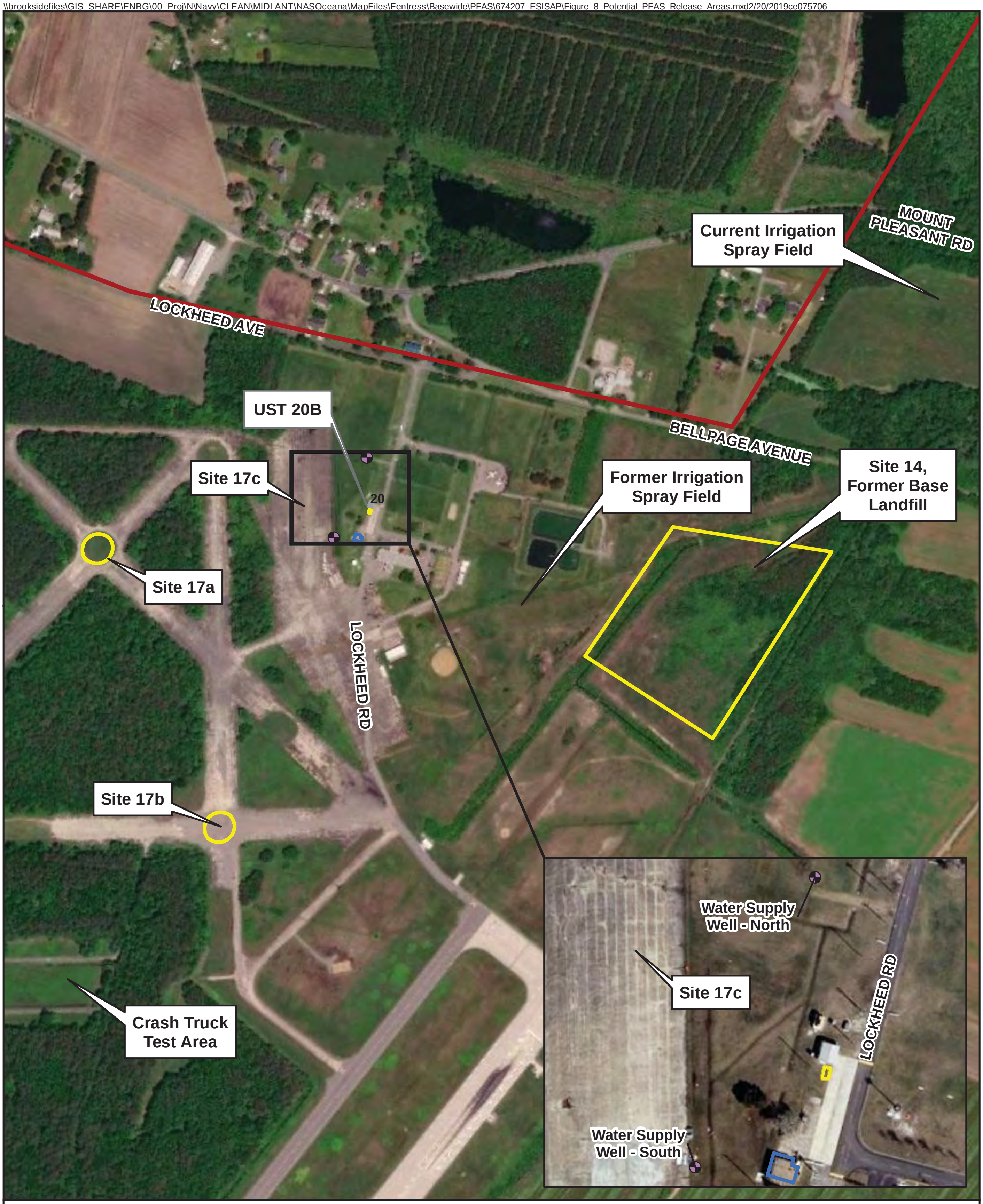
Feet

1 inch = 1,500 feet

Imagery Source: ESRI 2017

Figure 7
Yorktown Aquifer Groundwater Elevation Contours - February 2019
Basewide Per- and Polyfluoroalkyl Substances Expanded Site Inspection
NALF Fentress, Chesapeake, Virginia

ch2m:



Legend

- ● Water Supply Well Location
- 🟨 Site Boundary
- 🟦 Water Treatment Plant
- 🟥 Fentress Boundary

N

0 300 600 Feet

Imagery Source: ©2017, Esri

Figure 8
Potential PFOA and PFOS Source Areas Identified in Site Inspection Report
Basewide Per- and Polyfluoroalkyl Substances Expanded Site Inspection
NALF Fentress, Chesapeake, Virginia

ch2m

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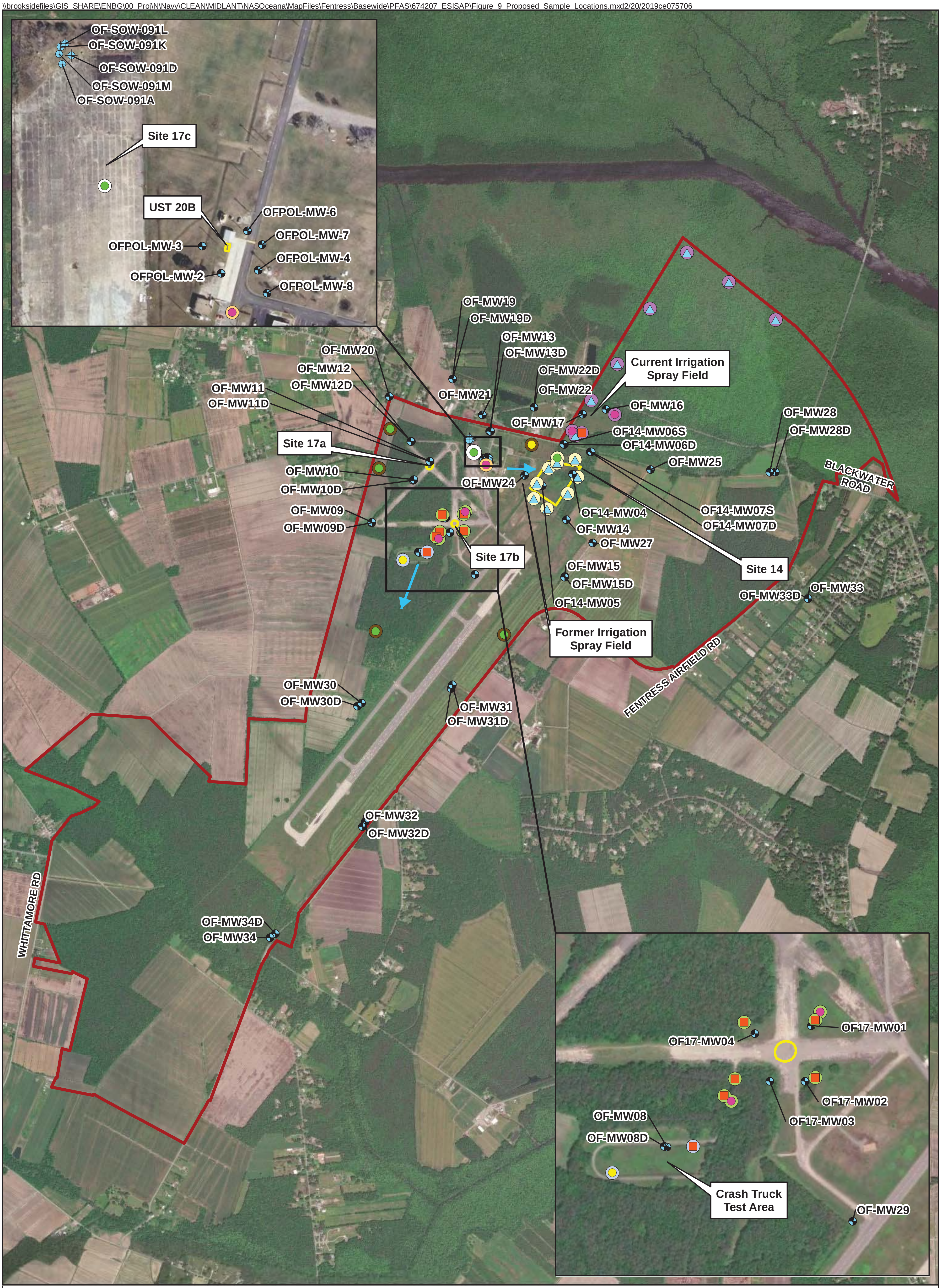

Legend

- ⊕ State Water Control Board Well Location
- ◑ Monitoring Well Sample Location

Proposed Locations

- ● Shallow/Deep Well and Surface/Subsurface Soil Location
- ● Deep Well and Surface/Subsurface Soil Location
- ● Extra Deep Well and Surface/Subsurface Soil Location
- ■ Surface/Subsurface Soil Location
- ▲ Sediment/Surface Water Sample Location

Site Specific Wells

- ○ Basewide
- ○ Crash Truck Area
- ○ Site 14
- ○ Site 17B
- ○ Site 17C
- ○ Spray Field
- ○ UST 20B

- → Columbia/Surficial Groundwater Flow Direction
- ▭ Site Boundary
- ▭ Fentress Boundary

N

0 1,000 2,000 Feet

Imagery: Esri, 2017

Figure 9
Proposed Sample Locations
Basewide Per- and Polyfluoroalkyl
Substances Expanded Site Investigation
NALF Fentress, Chesapeake, Virginia

ch2m.

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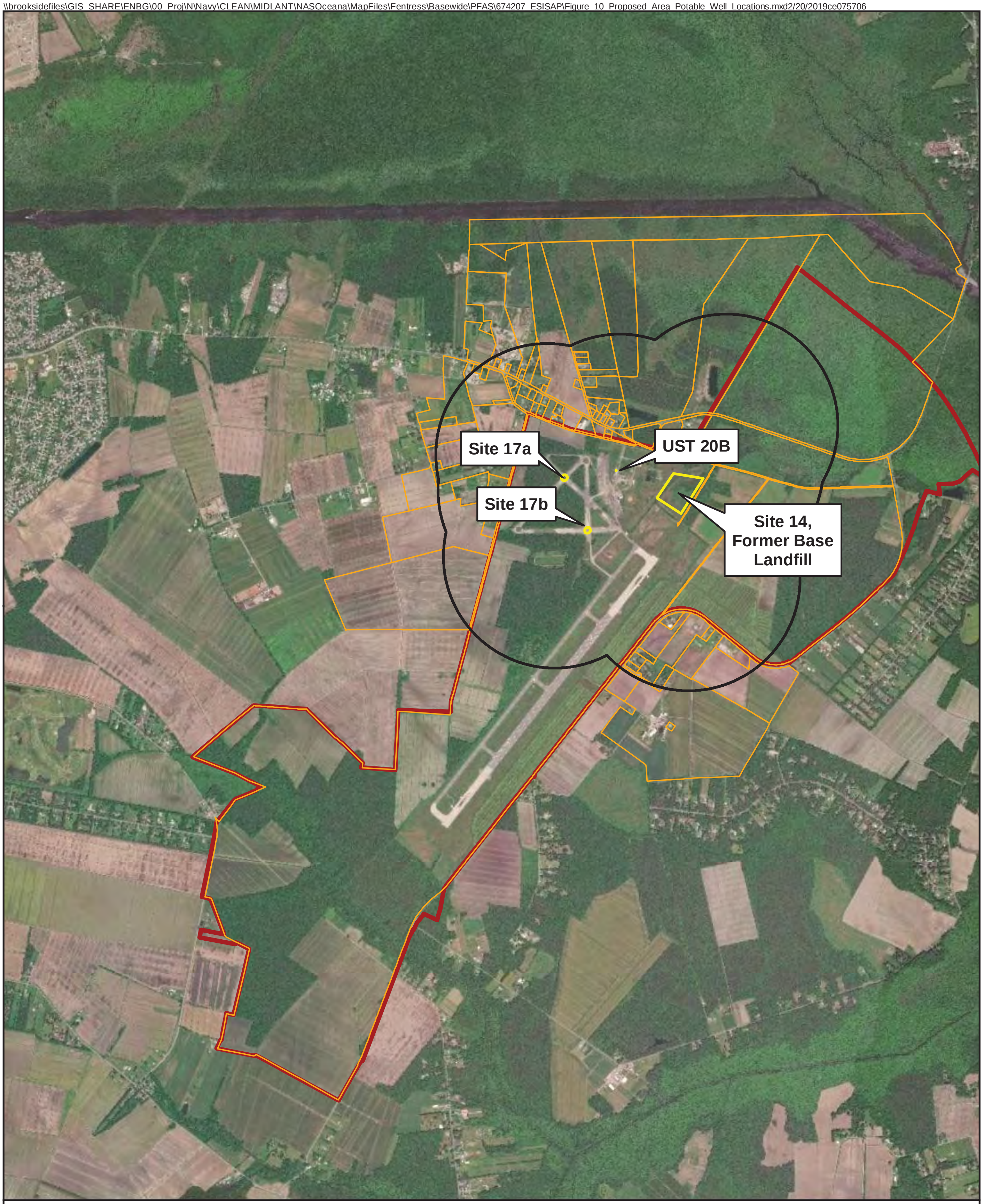

Legend

- ⬜ 0.5 mile radius of Known PFOS/PFOA Exceedances
- 🟧 Parcels 0.5 mile from On-Base Exceedance Locations
- 🟨 Site Boundary
- 🟥 Fentress Boundary

Imagery: Google Earth 2017

Figure 10
Proposed Area Potable Well Sample Locations
Basewide Per- and Polyfluoroalkyl Substances
Expanded Site Inspection
NALF Fentress, Chesapeake, Virginia

ch2m:

Appendix A
Field SOPs

STANDARD OPERATING PROCEDURE – Navy CLEAN PROGRAM

Drinking Water Sampling when Analyzing for Per- and Polyfluoroalkyl Substances (PFASs)

I. Purpose and Scope

This SOP provides guidelines for drinking water sample collection for samples that will be analyzed for per- and polyfluoroalklyl substances (PFAS), aka perfluorinated compounds (PFCs), including perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) via EPA Method 537 (not modified).

Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000.

II. Equipment and Materials

Equipment and Materials Required

- Drinking water sample containers (polypropylene bottle with polypropylene screw cap and Trizma preservative)
- Laboratory pre-filled polypropylene bottles containing field reagent blank water and Trizma preservative
- Field Reagent Blank sample containers (polypropylene bottle with polypropylene screw cap and no preservative)
- Shipping supplies (labels [if available][1], coolers, and ice)
- Loose leaf paper without waterproof coating
- Clip board
- Pen (not Sharpie)
- Nitrile or latex gloves

Equipment and Materials to Avoid During Sampling

Equipment and materials used to collect drinking water samples should not contain any fluorinated compounds, including polytetrafluoroethylene (PTFE), Teflon® or synthetic rubber with fluoropolymer elastomers (e.g., Viton®).

Specifically, the following material should be avoided during sampling:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard® brand or similar water repellent, fluoropolymer-coated Tyvek®, wrinkle-resistant fabrics, and fire resistant clothing with fluorochemical treatment or anything advertised as water repellant.

---

[1] Efforts will be made to obtain PFAS-free labels; however, information on labels is scarce and labels are frequently mounted on PFAS-coated paper to allow for easy removal.

- Weather-proof log books with fluorochemical coatings

The sample collection area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers
- Aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Sample bottles should be polypropylene in accordance with Method 537. PFAS have a tendency to adhere to glass surfaces. Contact the project manager (PM) if the lab sends glass bottles. Sample vials should not have PTFE/Teflon® lined bottles or caps.

III. Procedures and Guidelines

A. Setup

1. Obtain well construction information from homeowner, if available, in accordance with homeowner questionnaire developed for your project.

2. Record personnel onsite, address, homeowner name, and designated sample ID in the field notes. Sample IDs should not contain identifying information about the property location due to potential privacy issues, so be sure both address and designated ID are carefully recorded for tracking. Sample IDs and addresses on the sample labels and in the sample notes must be checked by both field team members and the address in the field notes should be confirmed with the homeowner or resident.

3. As feasible, select a sampling collection point prior to any treatment system installed by the homeowner. For example, if the homeowner has a point of use reverse osmosis or granular activated carbon filter in their kitchen sink, collect at the bathroom sink. If there is a point of entry filtration system, ask if there is a sampling port between the well and the system. If there is no way to bypass the existing treatment system without disconnecting pump components or potentially damaging the system, collect a treated sample and note that the sample was collected post-treatment. Avoid collecting samples through hoses. Instead, disconnect the hose and sample from the spigot if an outside collection station is selected.

3. Wash hands before sampling with dish detergent and don nitrile gloves.

4. Open the cold water tap and allow the system to flush for three to five minutes. Do not open bottles until you are ready to sample. Do not sample from the hot water tap, as a hot water sample may have been contained for in a hot water heater and may not reflect water quality of water drawn directly from the private well.

B. Sample Collection

Once flushing is complete, samples can be collected.

The steps to be followed for sample collection are as follows:

1. Turn the tap off briefly. Remove the cap from the sample bottle. Position the sample bottle under the tap and turn the tap on.
2. Fill the bottle, taking care not to flush out the sample preservative. Samples do not need to be collected headspace free.
3. After collecting the sample, cap the bottle and agitate by hand until the preservative is dissolved.
4. Affix labels immediately after bottles have been closed; collect home sample prior to field reagent blank to avoid mislabeling.
5. Pack the sample on ice immediately for shipment to the offsite laboratory.

C. Field Reagent Blank Collection

A field reagent blank is required at each drinking water sampling location and is to be collected immediately following collection of the drinking water sample. The steps to complete collection of the field reagent blank are as follows:

1. A preserved field reagent blank for each sample location will be provided by the laboratory along with empty bottles for the field reagent blanks. While still at the drinking water sample collection point, open the preserved field reagent blank water bottle and an empty unpreserved sample bottle.
2. Pour the preserved reagent blank water from the preserved bottle into the unpreserved blank container.
3. Affix the label to the field reagent blank bottle and pack in the same cooler as the associated drinking water sampling for shipment to the offsite laboratory.

V. References

United States Environmental Protection Agency (USEPA), 2009. *Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)*. September

STANDARD OPERATING PROCEDURE

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized ("DI") water (specifically, ASTM Type II water or lab-grade DI water)
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- 2.5% (W/W) Liquinox® and water solution
- Concentrated (V/V) pesticide grade isopropanol (DO NOT USE ACETONE)
- Large plastic pails or tubs for Liquinox® and water, scrub brushes, squirt bottles for Liquinox® solution, methanol and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Personal Protective Equipment as specified by the Health and Safety Plan
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. PERSONNEL DECONTAMINATION

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in Liquinox® solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with Liquinox® solution, remove, and discard into DOT-approved 55-gallon drum.
2. Wash outer gloves in Liquinox® solution, rinse, remove, and discard into DOT-approved 55-gallon drum.
3. Remove disposable coveralls ("Tyveks") and discard into DOT-approved 55-gallon drum.
4. Remove respirator (if worn).
5. Remove inner gloves and discard.
6. At the end of the work day, shower entire body, including hair, either at the work site or at home.
7. Sanitize respirator if worn.

B. SAMPLING EQUIPMENT DECONTAMINATION—GROUNDWATER SAMPLING PUMPS

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Spread plastic on the ground to keep equipment from touching the ground
3. Turn off pump after sampling. Remove pump from well and remove and dispose of tubing. Place pump in decontamination tube.
4. Turn pump back on and pump 1 gallon of Liquinox® solution through the sampling pump.
5. Rinse with 1 gallon of 10% isopropanol solution pumped through the pump. (DO NOT USE ACETONE). (Optional)
6. Rinse with 1 gallon of tap water. (deionized water may be substituted for tap water)
7. Rinse with 1 gallon of deionized water.
8. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.
9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in either DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

C. SAMPLING EQUIPMENT DECONTAMINATION—OTHER EQUIPMENT

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Before entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.
4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with Liquinox® solution.
5. Rinse with potable water.
6. Rinse with distilled or potable water and isopropanol solution (DO NOT USE ACETONE). (Optional)
7. Air dry.
8. Rinse with deionized water.
9. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
10. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
11. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

D. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with Liquinox® solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

E. SAMPLE CONTAINER DECONTAMINATION

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with Liquinox® solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.
2. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

F. HEAVY EQUIPMENT AND TOOLS

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by the Facility
2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of Liquinox®, Liquinox® solution (optional), and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

STANDARD OPERATING PROCEDURE

Disposal of Waste Fluids and Solids

I. Purpose and Scope

This SOP describes the procedures used to dispose of hazardous fluid and solid materials generated as a result of the site operations. This SOP does not provide guidance on the details of Department of Transportation regulations pertaining to the transport of hazardous wastes; the appropriate Code of Federal Regulations (49 CFR 171 through 177) should be referenced. Also, the site investigation-derived waste management plan should be consulted for additional information and should take precedence over this SOP.

II. Equipment and Materials

A. Fluids

- DOT-approved 55-gallon steel drums or frac tanks
- Tools for securing drum lids
- Funnel for transferring liquid into drum
- Labels
- Paint Pens
- Marking pen for appropriate labels
- Seals for 55-gallon steel drums

B. Solids

- DOT-approved 55-gallon steel drums or rolloffs
- Tools for securing drum lids
- Paint Pens
- Plastic sheets
- Labels
- Marking pen for appropriate labels

III. Procedures and Guidelines

A. Methodology

Clean, empty drums or roll-offs or frac tanks will be brought to the site by the drilling subcontractor for soil and groundwater collection and storage. The empty drums will be located at the field staging area and moved to drilling locations as required. The drums will be filled with the drilling and well installation wastes, capped, sealed, and moved to the onsite drum storage area by the drilling subcontractor. The full drums will separate types of wastes by media. The drums will be labeled as they are filled in the field and labels indicating that the contents are pending analysis affixed.

The drum contents will be sampled to determine the disposal requirements of the drilling wastes. Check with the Environmental Manager (EM) assigned to the project prior to sample collection for frequency and analysis. Unless otherwise specified by the EM, the drum sampling will be accomplished through the collection and submittal of composite samples, one sample per 10 drums (check with disposal facility to determine sample frequency) containing the same media. Similar compositing will be performed in each rolloff to obtain a representative sample. The compositing of the sample will be accomplished by collecting a specific volume of the material in each drum into a large sample container. When samples from each of the drums being sampled in a single compositing are collected, the sample will be submitted for TCLP, ignitability, corrosivity, and reactivity analysis. Additional analysis may be required by your EM.

If rolloffs are used, compositing and sampling of soil will comply with applicable state and federal regulations.

B. Labels

Drums and other containers used for storing wastes from drilling operations will be labeled when accumulation in the container begins. Analysis pending labels should be used initially. Labels will include the following minimum information:

- Container number
- Container contents
- Origin (source area including individuals wells, piezometers, and soil borings)
- Date that accumulation began
- Date that accumulation ended
- Generator Contact Information
- When laboratory results are received, drum labels will be completed or revised to indicate the hazardous waste constituents in compliance with Title 40 of the Code of Federal Regulations, Part 262, Subpart C if the results indicate hazardous waste or labeled as non-hazardous if applicable.

C. Fluids

Drilling fluids generated during soil boring and groundwater discharged during development and purging of the monitoring wells will be collected in 55-gallon, closed-top drums. When a drum is filled, the bung will be secured tightly. Fluids may also be transferred to frac tanks after being temporarily contained in drums to minimize the amount of drums used.

When development and purging is completed, the water will be tested for appropriate hazardous waste constituents as per instruction from the project EM. Compositing and sampling of fluids will comply with applicable state and federal regulations.

D. Solids

The soil cuttings from well and boring drilling will constitute a large portion of the solids to be disposed of.

The solid waste stream also will include plastic sheeting used for decontamination pads, Tyveks, disposable sampling materials, and any other disposable material used during the field operations that appears to be contaminated. These materials will be placed in designated drums.

E. Storage and Disposal

The wastes generated at the site at individual locations will be transported to the drum storage area by the drilling services subcontractor. Drums should be stored on plastic sheeting with a short berm wall (hay bales or 2 x 4 planks or equivalent) to capture small spills. The drums should be staged such that the labels are all visible and there should be enough room to walk between rows of drums if applicable.

Waste solid materials that contain hazardous constituents will be disposed of at an offsite location in a manner consistent with applicable solid waste, hazardous waste, and water quality regulations. Transport and disposal will be performed by a commercial firm under subcontract.

The liquid wastes meeting acceptable levels of discharge contamination may be disposed of through the sanitary sewer system at the site. However, prior to disposal to the sanitary sewer system, approval and contract arrangements will be made with the appropriate authorities. Wastes exceeding acceptable levels for disposal through the sanitary sewer system will be disposed of through contract with a commercial transport and disposal firm.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- Contact the project Environmental Manager prior to containerizing waste to determine containerization method and sampling frequency and analysis.
- Check that representative samples of the containerized materials are obtained.
- Be sure that all state and federal regulations are considered when classifying waste for disposal.

STANDARD OPERATING PROCEDURE

Decontamination of Drilling Rigs and Equipment

I. Purpose and Scope

The purpose of this guideline is to provide methods for the decontamination of drilling rigs, downhole drilling tools, and water-level measurement equipment. Personnel decontamination procedures are not addressed in this SOP; refer to the site safety plan and SOP *Decontamination of Personnel and Equipment*. Sample bottles will not be field decontaminated; instead they will be purchased with certification of laboratory sterilization.

II. Equipment and Materials

- Portable steam cleaner and related equipment
- Potable water
- Phosphate-free detergent such as Liquinox®
- Buckets
- Brushes
- Isopropanol, pesticide grade
- Personal Protective Equipment as specified by the Health and Safety Plan
- ASTM–Type II grade water or Lab Grade DI Water
- Aluminum foil

III. Procedures and Guidelines

A. Drilling Rigs and Monitoring Well Materials

Before the onset of drilling, after each borehole, before drilling through permanent isolation casing, and before leaving the site, heavy equipment and machinery will be decontaminated by steam cleaning at a designated area. The steam-cleaning area will be designed to contain decontamination wastes and waste waters and can be an HDPE-lined, bermed pad. A pumping system will be used to convey decontaminated water from the pad to drums.

Surface casings may be steam cleaned in the field if they are exposed to contamination at the site prior to use.

B. Downhole Drilling Tools

Downhole tools will be steam cleaned before the onset of drilling, prior to drilling through permanent isolation casing, between boreholes, and prior to leaving the site. This will include, but is not limited to, rods, split spoons or similar samplers, coring equipment, augers, and casing.

Before the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for physical characterization, the sampler shall be cleaned by scrubbing with a detergent solution followed by a potable water rinse.

Before the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for chemical analysis, the sampler shall be decontaminated following the procedures outlined in the following subsection.

C. Field Analytical Equipment

1. Water Level Indicators

   Water level indicators that consist of a probe that comes into contact with the groundwater must be decontaminated using the following steps:

   a. Rinse with tap water
   b. Rinse with de-ionized water
   c. Solvent rinse with isopropanol (Optional)
   d. Rinse with de-ionized water

2. Probes

   Probes, for example, pH or specific ion electrodes, geophysical probes, or thermometers that would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise. For probes that make no direct contact, for example, PID equipment, the probe will be wiped with clean paper-towels or cloth wetted with isopropanol.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- The effectiveness of field cleaning procedures may be monitored by rinsing decontaminated equipment with organic-free water and submitting the rinse water in standard sample containers for analysis.

STANDARD OPERATING PROCEDURE

Logging of Soil Borings

I. Purpose and Scope

This SOP provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

II. Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCL, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart (e.g., Munsell)
- Grain-size chart
- Hand lens
- Unified Soil Classification System (USCS) index charts and tables to help with soil classification (attached)

III. Procedures and Guidelines

This section covers several aspects of soil characterization: instructions for completing the soil boring log form (attached), field classification of soil, and standard penetration test procedures.

A. Instructions for Completing Soil Boring Logs

Soil boring logs will be completed in the field log books or on separate soil boring log sheets. Information collected will be consistent with that required for ASTM D1586 (attached), a standard soil boring log form (attached), or an equivalent form that supplies the same information.

The information collected in the field to perform the soil characterization is described below.

Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both sample jar labels and on the log sheets.

B. Heading Information

Boring/Well Number. Enter the boring/well number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring.

Location. If station, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as "approximate" or "estimated" as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities through a survey.

Drilling Contractor. Enter the name of the drilling company and the city and state where the company is based.

Drilling Method and Equipment. Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger, sonic). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.

Date of Start and Finish. Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.

Logger. Enter the first and last name.

C. Technical Data

Depth Below Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Note the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. SS-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.

Sample Recovery. Enter the length to the nearest 0.1-foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement. Record soil recovery in feet.

Standard Penetration Test Results. In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as "WOH."

Samples should be collected using a 140-pound hammer and 2-inch diameter split spoons. Samples may be collected using direct push sampling equipment. However, blow counts will not be available. A pocket penetrometer may be used instead to determine relative soil consistency of fine grained materials (silts and clays).

Sample also may be collected using a 300-pound hammer or 3-inch-diameter split-spoon samples at the site. However, use of either of these sample collection devices invalidates standard penetration test results and should be noted in the comments section of the log. The 300-pound hammer should only be used for collection of 3-inch-diameter split-spoon samples. Blow counts should be recorded for collection of samples using either a 3-inch split-spoon, or a 300-pound hammer. An "N" value need not be calculated.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection below.

Comments. Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Health and safety monitoring data
- Drilling interval through a boulder

D. Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488, Visual-Manual Procedure for Description and Identification of Soils (attached).

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488). In addition, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D 2488 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example "POORLY-GRADED SAND."
2. Group symbol, in parentheses, for example, "(SP)."
3. Color, using Munsell color designation
4. Moisture content
5. Relative density or consistency
6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488.

E. Soil Name

The basic name of a soil should be the ASTM D 2488 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as "Interlayered Sand and Silt," should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488.

F. Group Symbol

The appropriate group symbol from ASTM D 2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

G. Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

H. Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 2.

I. Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586 [attached]). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in Tables 3 and 4.

J. Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

K. Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586. The split-barrel sampler should measure 2-inch or 3-inch OD, and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is "A" rod (1-5/8-inch OD). A stiffer rod, such as an "N" rod (2-5/8-inch OD), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound or 300-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

IV. Attachments

Soil Boring Log (Sample Soil Boring Log.xls)

Soil Boring Log Form with a completed example (Soil_Log_Examp.pdf)

ASTM D 2488 *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)* (ASTM D2488.pdf)

ASTM 1586 *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils* (ASTM D1586.pdf)

Tables 1 through 4 (Tables 1-4.pdf)

V. Key Checks and Preventive Maintenance

- Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later.
- Check that sample numbers and intervals are properly specified.
- Check that drilling and sampling equipment is decontaminated using the procedures defined in SOP *Decontamination of Drilling Rigs and Equipment*.

STANDARD OPERATING PROCEDURE

Preparing Field Log Books

I. Purpose

This SOP provides general guidelines for entering field data into log books during site investigation and remediation activities.

II. Scope

This is a general description of data requirements and format for field log books. Log books are needed to properly document all field activities in support of data evaluation and possible legal activities.

III. Equipment and Materials

- Log book
- Indelible pen

IV. Procedures and Guidelines

Properly completed field log books are a requirement for all of the work we perform under the Navy CLEAN contract. Log books are legal documents and, as such, must be prepared following specific procedures and must contain required information to ensure their integrity and legitimacy. This SOP describes the basic requirements for field log book entries.

A. PROCEDURES FOR COMPLETING FIELD LOG BOOKS

1. Field notes commonly are kept in bound, hard-cover logbooks used by surveyors and produced, for example, by Peninsular Publishing Company and Sesco, Inc. Pages should be water resistant and notes should be taken only with water-proof, non-erasable permanent ink, such as that provided in Rite in the Rain® or Sanford Sharpie® permanent markers. **Note:** for sites where PFC is being analyzed for, Rite-in-the-Rain®, Sanford Sharpie®, or anything water-resistant or with Teflon® cannot be used in the field. All field book materials must be "fluorine free". Acceptable substitutes would be a sewn notebook without a plastic cover, or loose-leaf notebook paper.
2. On the inside cover of the log book the following information should be included:
   - Company name and address

- Log-holders name if log book was assigned specifically to that person
- Activity or location
- Project name
- Project manager's name
- Phone numbers of the company, supervisors, emergency response, etc.

3. All lines of all pages should be used to prevent later additions of text, which could later be questioned. Any line not used should be marked through with a line and initialed and dated. Any pages not used should be marked through with a line, the author's initials, the date, and the note "Intentionally Left Blank."
4. If errors are made in the log book, cross a single line through the error and enter the correct information. All corrections shall be initialed and dated by the personnel performing the correction. If possible, all corrections should be made by the individual who made the error.
5. Daily entries will be made chronologically.
6. Information will be recorded directly in the field log book during the work activity. Information will not be written on a separate sheet and then later transcribed into the log book.
7. Each page of the log book will have the date of the work and the note takers initials.
8. The final page of each day's notes will include the note-takers signature as well as the date.
9. Only information relevant to the subject project will be added to the log book.
10. The field notes will be copied and the copies sent to the Project Manager or designee in a timely manner (at least by the end of each week of work being performed).

B. INFORMATION TO BE INCLUDED IN FIELD LOG BOOKS

1. Entries into the log book should be as detailed and descriptive as possible so that a particular situation can be recalled without reliance on the collector's memory. Entries must be legible and complete.
2. General project information will be recorded at the beginning of each field project. This will include the project title, the project number, and project staff.
3. Scope: Describe the general scope of work to be performed each day.

4. Weather: Record the weather conditions and any significant changes in the weather during the day.

5. Tail Gate Safety Meetings: Record time and location of meeting, who was present, topics discussed, issues/problems/concerns identified, and corrective actions or adjustments made to address concerns/ problems, and other pertinent information.

6. Standard Health and Safety Procedures: Record level of personal protection being used (e.g., level D PPE), record air monitoring data on a regular basis and note where data were recording (e.g., reading in borehole, reading in breathing zone, etc). Also record other required health and safety procedures as specified in the project specific health and safety plan.

7. Instrument Calibration; Record calibration information for each piece of health and safety and field equipment.

8. Personnel: Record names of all personnel present during field activities and list their roles and their affiliation. Record when personnel and visitors enter and leave a project site and their level of personal protection.

9. Communications: Record communications with project manager, subcontractors, regulators, facility personnel, and others that impact performance of the project.

10. Time: Keep a running time log explaining field activities as they occur chronologically throughout the day.

11. Deviations from the Work Plan: Record any deviations from the work plan and document why these were required and any communications authorizing these deviations.

12. Heath and Safety Incidents: Record any health and safety incidents and immediately report any incidents to the Project Manager.

13. Subcontractor Information: Record name of company, record names and roles of subcontractor personnel, list type of equipment being used and general scope of work. List times of starting and stopping work and quantities of consumable equipment used if it is to be billed to the project.

14. Problems and Corrective Actions: Clearly describe any problems encountered during the field work and the corrective actions taken to address these problems.

15. Technical and Project Information: Describe the details of the work being performed. The technical information recorded will vary significantly between projects. The project work plan will describe the specific activities to be performed and may also list requirements for note taking. Discuss note-taking expectations with the Project

Manager prior to beginning the field work.

16. Any conditions that might adversely affect the work or any data obtained (e.g., nearby construction that might have introduced excessive amounts of dust into the air).

17. Sampling Information; Specific information that will be relevant to most sampling jobs includes the following:

    - Description of the general sampling area – site name, buildings and streets in the area, etc.
    - Station/Location identifier
    - Description of the sample location – estimate location in comparison to two fixed points – draw a diagram in the field log book indicating sample location relative to these fixed points – include distances in feet.
    - Sample matrix and type
    - Sample date and time
    - Sample identifier
    - Draw a box around the sample ID so that it stands out in the field notes
    - Information on how the sample was collected – distinguish between “grab,” “composite,” and “discrete” samples
    - Number and type of sample containers collected
    - Record of any field measurements taken (i.e. pH, turbidity, dissolved oxygen, and temperature, and conductivity)
    - Parameters to be analyzed for, if appropriate
    - Descriptions of soil samples and drilling cuttings can be entered in depth sequence, along with PID readings and other observations. Include any unusual appearances of the samples.

C. SUGGESTED FORMAT FOR RECORDING FIELD DATA

1. Use the left side border to record times and the remainder of the page to record information (see attached example).

2. Use tables to record sampling information and field data from multiple samples.

3. Sketch sampling locations and other pertinent information.

4. Sketch well construction diagrams.

V. Attachments

Example field notes.

STANDARD OPERATING PROCEDURE

Chain-of-Custody

I Purpose

The purpose of this SOP is to provide information on chain-of-custody procedures to be used under the CLEAN Program.

II Scope

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities (except wellhead samples taken for measurement of field parameters). Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This procedure identifies the necessary custody records and describes their completion. This procedure does not take precedence over region specific or site-specific requirements for chain-of-custody.

III Definitions

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. One copy of the form must be retained in the project file.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under one's custody if:

- It is in one's actual possession.
- It is in one's view, after being in one's physical possession.
- It was in one's physical possession and then he/she locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

IV. Procedures

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is valid. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom, as well as providing security for the evidence as it is moved and/or passed from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain-of-possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

Sample Identification

The method of identification of a sample depends on the type of measurement or analysis performed. When *in situ* measurements are made, the data are recorded directly in bound logbooks or other field data records with identifying information.

Information which shall be recorded in the field logbook, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s),
- Contract Task Order (CTO) Number,
- Project Sample Number,
- Sample location or sampling station number,
- Date and time of sample collection and/or measurement,
- Field observations,
- Equipment used to collect samples and measurements, and
- Calibration data for equipment used

Measurements and observations shall be recorded using waterproof ink.

Sample Label

Samples, other than for *in situ* measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling and Analysis Plan. Each sample container is identified by a sample label (see Attachment A). Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project – Name of project site.

- Sample Identification - The unique sample number identifying this sample.

- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 05/21/17).

- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- Medium - Water, soil, sediment, sludge, waste, etc.
- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By - Printed name or initials of the sampler.
- Remarks - Any pertinent additional information.

The field team should always follow the sample ID system prepared by the Project Chemist and reviewed by the Project Manager.

Chain-of-Custody Procedures

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed.

Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.

- A Chain-of-Custody Record will be prepared for each individual cooler shipped and will include ***only*** the samples contained within that particular cooler. The Chain-of-Custody Record for that cooler will then be sealed in a zip-log bag and placed in the cooler prior to sealing. This ensures that the laboratory properly attributes trip blanks with the correct cooler and allows for easier tracking should a cooler become lost during transit.

- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once downloaded to the server or developed, the electronic files or photographic prints shall be serially numbered, corresponding to the logbook descriptions; photographic prints will be stored in the project files. To identify sample locations in photographs, an easily read sign with the appropriate sample location number should be included.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions (e.g., a logbook notation would explain that a pencil was used to fill out the sample label if the pen would not function in freezing weather.)

Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. **A Chain-of-Custody Record Form must be completed for each cooler and should include only the samples contained within that cooler**. A Chain-of-Custody Record Form example is shown in Attachment B. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below:

- Enter header information (CTO number, samplers, and project name).
- Enter sample specific information (sample number, media, sample analysis required and analytical method grab or composite, number and type of sample containers, and date/time sample was collected).
- Sign, date, and enter the time under "Relinquished by" entry.
- Have the person receiving the sample sign the "Received by" entry. If shipping samples by a common carrier, print the carrier to be used and enter the airbill number under "Remarks," in the bottom right corner;
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample-shipping package. Retain the copy with field records.
- Sign and date the custody seal, a 1-inch by 3-inch white paper label with black lettering and an adhesive backing. Attachment C is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.
- Place the seal across the shipping container opening (front and back) so that it would be broken if the container were to be opened.
- Complete other carrier-required shipping papers.

The custody record is completed using waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the shipping container (enclosed with other documentation in a plastic zipper-type bag). As long as custody forms are sealed inside the shipping container and the custody seals are intact, commercial carriers are not required to sign the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

V Quality Assurance Records

Once samples have been packaged and shipped, the Chain-of-Custody copy and airbill receipt become part of the quality assurance record.

VI Attachments

A. Sample Label
B. Chain of Custody Form
C. Custody Seal

VII References

USEPA. *User's Guide to the Contract Laboratory Program*. Office of Emergency and Remedial Response, Washington, D.C. (EPA/540/P-91/002), January 1991.

Standard Operating Procedure

Locating and Clearing Underground Utilities

I. Purpose

The purpose of this SOP is to provide general guidelines and specific procedures that must be followed on Navy CLEAN projects for locating underground utilities and clearing dig locations in order to maximize our ability to avoid hitting underground utilities and to minimize liabilities to CH2M and its subcontractors and health and safety risks to our project staff.

This SOP shall be used by Activity Managers and Project Managers to, in-turn, develop Activity-specific and project-specific utility location procedures. The activity and project-specific procedures will become part of work plans and project instructions and will be used to prepare scopes of work (SOWs) for the procurement of utility location subcontractors to meet the needs of individual projects.

This SOP also identifies the types of utility locating services that are available from subcontractors and the various tools that are used to locate utilities, and discusses when each type of service and tool may or may not be applicable.

II. Scope

Depending on the Navy/Marine Activity we typically find ourselves in one of two scenarios:

Scenario 1

The Activity provides utility locating (or dig clearance) services through the public works department or similar organization, or has a contract with an outside utility clearance service. Some of these services are provided in the form of dig permits which are required before you can dig or drill. In other cases no official permit is required and the process is somewhat vague.

Scenario 2

The Activity does not get involved in any utility locating processes aside from possibly providing the most recent utility maps, and relies on CH2M to clear the dig locations.

Table 1 provides an up to date summary of which scenarios apply to the various primary Activities served under the Navy CLEAN program.

Scenario 1 is preferred because under this scenario the Navy tends to assume the responsibility if the location is improperly cleared, a utility is struck, and property damage results. However, our experience has been that the clearance services provided by the Navy do not meet the standards that we consider to be adequate, in that they often simply rely on available base maps to mark utilities and do not verify locations using field geophysics. And if they do use locating tools, they do not provide adequate documentation or marking to confirm that a location has been cleared. So while the Navy's process may protect us from liability for property damage, it does not adequately protect our staff and subcontractors from health risks nor does it compensate us for down time, should a utility be hit.

Therefore, regardless of what services the Navy provides, in most cases we still need to supplement this effort with clearance services from our own third party utility location subcontractor following the procedures and guideline outlined in Section IV of this SOP. The cost implications of providing this service will range from $500 to several $1,000 depending on the size of the project.

The scope of services that we ask our subcontractors to provide can involve utility marking/mapping or the clearing of individual dig locations. In the former we ask our subs to mark all utilities within a "site" and often ask them to prepare a map based on their work. In the later, we ask them to clear (identify if there are any utilities within) a certain radius of a proposed dig/drill location.

The appropriate requested scope of services for a project will depend on the project. Clearing individual boreholes is often less expensive and allows the sub to concentrate their efforts on a limited area. However if the scope of the investigation is fluid (all borehole locations are not predetermined) it may be best to mark and map an entire site or keep the subcontractor on call.

Clearance of individual dig locations should be done to a minimum 20 foot radius around the location.

An example SOW for a utility subcontractor procurement is provided in Attachment A.

III. Services and Equipment

This section provides a general description of the services available to help us locate subsurface utilities and describes the types of equipment that these services may (or may not) use to perform their work. It identifies the capabilities of each type of equipment to help the PM specify what they should require from our utility location subs.

Services

The services that are available to us for identifying and marking underground utilities are:

- The local public/private utility-run service such as Miss Utility
- Utility location subcontractors (hired by us)

Attachment B provides a detailed description of each type of organization. It also provides contact numbers and web sites for the various Miss-Utility-type organizations in the areas where we do work for the Navy and contacts and services provided by several subcontractors that we have used or spoken to in the past.

Equipment

Attachment C provides a summary of the various types of equipment used for subsurface utility location. It describes the capabilities and limitations of each in order to help the PM determine if the equipment being used by a subcontractor is adequate.

It is important to make the potential subcontractors aware of the possible types of utilities (and utility materials) that are at the site, and to have them explain in their bid what types of equipment they will use to locate utilities /clear dig locations, and what the limitations of these equipment are.

A list of in-house experts that can be used to help you evaluate bids or answer questions you may have is provided in **Appendix C.**

IV. Procedures and Guidelines

This section presents specific procedures to be followed for the utility location work to be conducted by CH2M and our subcontractors. In addition, a PM will have to follow the procedures required by the Activity to obtain their approvals, clearances and dig permits where necessary. These "dig permit" requirements vary by Activity and must be added to the project-specific SOP, or project instructions. It is preferable that the Activity perform their clearance processes before we follow up with our clearance work.

Activity Notification and Dig Permit Procedures

Identify Activity-specific permit and/or procedural requirements for excavation and drilling activities. Contact the Base Civil Engineer and obtain the appropriate form to begin the clearance process.

Activity Specific: To be provided by Activity or Project Manager

CH2M Utility Clearance Procedures

Do not begin subsurface construction activities (e.g., trenching, excavation, drilling, etc.) until a check for underground utilities and similar obstructions has been conducted by CH2M as a follow-up to the services provided by the Navy. The use of as-built drawings and utility company searches must be supplemented with a geophysical or other survey by a qualified, independent survey contractor (subcontracted to CH2M) to identify additional and undiscovered buried utilities.

Examples of the type of geophysical technologies include (these are further described in Attachment C):

- **Ground Penetrating Radar (GPR),** which can detect pipes, including gas pipes, tanks, conduits, cables etc, both metallic and non-metallic at depths up to 30 feet depending on equipment. Sensitivity for both minimum object size and maximum depth detectable depends on equipment selected, soil conditions, etc.
- **Radio Frequency (RF),** involves inducing an RF signal in the pipe or cable and using a receiver to trace it. Some electric and telephone lines emit RF naturally and can be

detected without an induced signal. This method requires knowing where the conductive utility can be accessed to induce RF field if necessary.

- **Dual RF**, a modified version of RF detection using multiple frequencies to enhance sensitivity but with similar limitations to RF
- **Ferromagnetic Detectors**, are metal detectors that will detect ferrous and non-ferrous utilities. Sensitivity is limited, e.g. a 100 mm iron disk to a depth of about one meter or a 25 mm steel paper clip to a depth of about 20 cm.
- **Electronic markers,** are emerging technologies that impart a unique electronic signature to materials such as polyethylene pipe to facilitate location and tracing after installation. Promising for future installations but not of help for most existing utilities already in place.

The following procedures shall be used to identify and mark underground utilities during subsurface construction activities on the project:

- Contact utility companies or the state/regional utility protection service (such as Miss Utility) at least two (2) working days prior to intrusive activities to advise of the proposed work, and ask them to establish the location of the utility underground installations prior to the start of actual excavation: this is a law. These services will only mark the location of public-utility-owned lines and not Navy-owned utilities. In many cases there will not be any public-utility-owned lines on the Activity. There may also be Base-access issues to overcome.
- Procure and schedule the independent survey.
- The survey contractor shall determine the most appropriate geophysical technique or combinations of techniques to identify the buried utilities on the project site, based on the survey contractor's experience and expertise, types of utilities anticipated to be present and specific site conditions. ***The types of utilities must be provided to the bidding subcontractors in the SOW and procedures to be used must be specified by the bidder in their bid. It is extremely helpful to provide the sub with utility maps, with the caveat that all utilities are not necessarily depicted.***
- The survey subcontractor shall employ the same geophysical techniques used to identify the buried utilities, to survey the proposed path of subsurface investigation/construction work to confirm no buried utilities are present.
- Obtain utility clearances for subsurface work on both public and private property.
- Clearances provided by both the "Miss Utility" service and the CH2M-subcontracted service are to be in writing, signed by the party conducting the clearance. The Miss Utility service will have standard notification forms/letters which typically simply state that they have been to the site and have done their work. The CH2M subcontractor shall be required to fill out the form provided in Attachment D (this can be modified for a particular project) indicating that each dig/drill location has been addressed. ***This documentation requirement (with a copy of the form) needs to be provided in the subcontractor SOW.***

- Marking shall be done using the color coding presented in Attachment E. The type of material used for marking must be approved by the Activity prior to marking. Some base commanders have particular issues with persistent spray paint on their sidewalks and streets. ***Any particular marking requirements need to be provided in the subcontractor SOW.***
- Protect and preserve the markings of approximate locations of facilities until the markings are no longer required for safe and proper excavations. If the markings of utility locations are destroyed or removed before excavation commences or is completed, the Project Manager must notify the utility company or utility protection service to inform them that the markings have been destroyed.
- Perform a field check prior to drilling/digging (preferably while the utility location sub is still at the site) to see if field utility markings coincide with locations on utility maps. Look for fire hydrants, valves, manholes, light poles, lighted signs, etc to see if they coincide with utilities identified by the subcontractor.
- Underground utility locations must be physically verified (or dig locations must be physically cleared) by hand digging using wood or fiberglass-handled tools, air knifing, or by some other acceptable means approved by CH2M, when the dig location (e.g. mechanical drilling, excavating) is expected to be within 5 feet of a marked underground system. Hand clearance shall be done to a depth of four feet unless a utility cross-section is available that indicates the utility is at a greater depth. In that event, the hand clearance shall proceed until the documented depth of the utility is reached.
- Conduct a site briefing for employees at the start of the intrusive work regarding the hazards associated with working near the utilities and the means by which the operation will maintain a safe working environment. Detail the method used to isolate the utility and the hazards presented by breaching the isolation.
- Monitor for signs of utilities during advancement of intrusive work (e.g., sudden change in advancement of auger or split spoon during drilling or change in color, texture or density during excavation that could indicate the ground has been previously disturbed).

IV. Attachments

A- Example SOW for Utility Location Subcontractor Procurement
B - Services Available for Identifying and Marking Underground Utilities
C – Equipment Used for Identifying Underground Utilities
D – Utility Clearance Documentation Form
E – Utility Marking Color Codes

Attachment A – Example SOW for Subcontracting Underground Utilities Locating Services

CTO-XXX

Scope of Work

Subsurface Utility Locating

Site XX

Navy Activity

City, State

A licensed and insured utility locator will be subcontracted to identify and mark out subsurface utilities for an environmental investigation/remediation project at Site XX of <<insert name of base, city, and state>>. The subcontractor will need to be available beginning at <<insert time>> on <<insert date>>. It is estimated that the work can be completed within XX days.

Proposed Scope of Work

The subcontractor will identify and mark all subsurface utilities (CHOOSE 1) that lie within a radius of 20 feet of each of XX sampling locations at Site XX shown on the attached Figure 1; (OR) that lie within the bounds of Site XX as delineated on the attached Figure 1. (If multiple sites are to be cleared, provide maps of each site with sample locations or clearance boundaries clearly delineated and a scale provided.)

Utilities will be identified using all reasonably available as-built drawings, electronic locating devices, and any other means necessary to maintain the safety of drilling and sampling personnel and the protection of the base infrastructure. The location of utilities identified from as-built drawings or other maps must be verified in the field prior to marking.

Base utility drawings for the Site(s) (CHOOSE 1) can be found at <<insert specific department and address or phone number on the base>> and should be reviewed by the subcontractor and referenced as part of the utility locating. (OR), will be provided to the subcontractor by CH2M HILL upon the award of the subcontract. (OR), are not available. Utility drawings shall not be considered definitive and must be field verified.

Field verification will include detection using nonintrusive subsurface detection equipment (magnetometers, GPR, etc) as well as opening manhole covers to verify pipe directions. As part of the bid, the Subcontractor shall provide a list of the various subsurface investigation tools they propose to have available and use at the site and what the limitations are of each tool.

A CH2M HILL representative shall be present to coordinate utility clearance activities and identify points and features to be cleared.

Field Marking and Documentation

All utilities located within **(CHOOSE 1)** ***a 20-ft radius of the XX proposed soil boring locations*** **(OR)** ***within the boundary of the site(s)*** as identified on the attached figure(s) will be marked using **paint** ***(some Bases such as the WNY may have restrictions on the use of permanent paint)*** and/or pin flags color coded to indicate electricity, gas, water, steam, telephone, TV cable, fiber optic, sewer, etc. The color coding shall match the industry standard as described on the attached form. In addition, the ***Buried Utility Location Tracking Form*** (attached) will be completed by the Subcontractor based upon what is identified in the field during the utility locating and submitted back to CH2M HILL (field staff or project manager) within 24 hours of completing the utility locating activities.

(OPTIONAL) ***The subcontractor shall also provide a map (or hand sketch) of the identified utilities to the Engineer within XX days of field demobilization. The map shall include coordinates or ties from fixed surface features to each identified subsurface utility.***

Bid Sheet/Payment Units

The subcontractor will bid on a time and materials basis for time spent on site and researching utility maps. Mobilization (including daily travel to the site) should be bid as a lump sum, as well as the preparation of the AHA and any required mapping. The per diem line item should be used if the field crew will require overnight accommodations at the project site.

Health and Safety Requirements

The utility locating subcontractor is to provide and assume responsibility for an adequate corporate Health and Safety Plan for onsite personnel. Standard personal safety equipment including: hard hat, safety glasses, steel-toed boots, gloves are recommended for all project activities. Specific health and safety requirements will be established by the Subcontractor for each project. The health and safety requirements will be subject to the review of CH2M HILL.

The subcontractor shall also prepare and provide to the Engineer, at least 48 hours prior to mobilization, an acceptable Activity Hazard Analysis (AHA) using the attached AHA form or similar.

It is also required that all subcontractor personnel who will be on site attend the daily 15-minute health and safety tailgate meeting at the start of each day in the field.

Subcontractor personnel showing indications of being under the influence of alcohol or illegal drugs will be sent off the job site and their employers will be notified. Subcontractor personnel under the influence of prescription or over-the-counter medication that may impair their ability to operate equipment will not be permitted to do so. It is expected that the subcontractor will assign them other work and provide a capable replacement (if necessary) to operate the equipment to continue work.

Security

The work will be performed on US Navy property. CH2M HILL will identify the Subcontractor personnel who will perform the work to the appropriate Navy facility point-of-contact, and will identify the Navy point-of-contact to the Subcontractor crew. The Subcontractor bears final responsibility for coordinating access of his personnel onto Navy property to perform required work. This responsibility includes arranging logistics and providing to CH2M HILL, in advance or at time of entry as specified, any required identification information for the Subcontractor personnel. Specifically, the following information should be submitted with the bid package for all personnel that will perform the work in question (this information is required to obtain a base pass):

- Name
- Birth Place
- Birth Date
- Social Security Number
- Drivers License State and Number
- Citizenship

Please be advised that no weapons, alcohol, or drugs will be permitted on the Navy facility at any time. If any such items are found, they will be confiscated, and the Subcontractor will be dismissed.

Quality Assurance

The Subcontractor will be licensed and insured to operate in the State of <<state>> and will comply with all applicable federal, state, county and local laws and regulations. The subcontractor will maintain, calibrate, and operate all electronic locating instruments in accordance with the manufacturer's recommendations. Additionally, the Subcontractor shall make all reasonable efforts to review as-built engineering drawings maintained by Base personnel, and shall notify the CH2M HILL Project Manager in writing (email is acceptable) whenever such documentation was not available or could not be reviewed.

Subcontractor Standby Time

At certain periods during the utility locating activities, the Subcontractor's personnel may be asked to stop work and standby when work may normally occur. During such times, the Subcontractor will cease activities until directed by the CH2M HILL representative to resume operations. Subcontractor standby time also will include potential delays caused by the CH2M HILL representative not arriving at the site by the agreed-upon meeting time for start of the work day. Standby will be paid to the

Subcontractor at the hourly rate specified in the Subcontractor's Bid Form attached to these specifications.

Cumulative Subcontractor standby will be accrued in increments no shorter than 15 minutes (i.e., an individual standby episode of less than 15 minutes is not chargeable).

During periods for which standby time is paid, the surveying equipment will not be demobilized and the team will remain at the site. At the conclusion of each day, the daily logs for the Subcontractor and CH2M HILL representative will indicate the amount of standby time incurred by the Subcontractor, if any. Payment will be made only for standby time recorded on CH2M HILL's daily logs.

Down Time

Should equipment furnished by the Subcontractor malfunction, preventing the effective and efficient prosecution of the work, or inclement weather conditions prevent safe and effective work from occurring, down time will be indicated in the Subcontractor's and CH2M Hill representative's daily logs. No payment will be made for down time.

Schedule

It is anticipated that the subsurface utility locating activities will occur on <<insert date>>. It is estimated that the above scope will be completed within XXX days.

Attachment B - Services Available for Identifying and Marking Underground Utilities

The services that are available to us for identifying and marking underground utilities are:

- The Activity's PWC (or similar organization)
- The local public/private utility -run service such as Miss Utility
- Utility location subcontractors (hired by CH2M HILL)

Each are discussed below.

Navy Public Works Department

A Public Works Department (PWD) is usually present at each Activity. The PWD is responsible for maintaining the public works at the base including management of utilities. In many cases, the PWD has a written permit process in place to identify and mark-out the locations of Navy-owned utilities [Note: The PWD is usually NOT responsible for the locations/mark-outs of non-Navy owned, public utilities (e.g., Washington Gas, Virginia Power, municipal water and sewer, etc.). Therefore, it is likely that we will have to contact other organizations besides the PWD in order to identify non-Navy owned, public utilities].

At some Activities, there may not be a PWD, the PWD may not have a written permit process in place, or the PWD may not take responsibility for utility locating and mark-outs. In these cases, the PWD should still be contacted since it is likely that they will have the best understanding of the utility locations at the Activity (i.e., engineering drawings, institutional knowledge, etc.). Subsequently, the PWD should be brought into a cooperative arrangement (if possible) with the other services employed in utility locating and mark-out in order to have the most comprehensive assessment performed.

At all Activities we should have a contact (name and phone number), and preferably an established relationship, with PWD, either directly or through the NAVFAC Atlantic, Midlant, or Washington NTR or Activity Environmental Office that we can work with and contact in the event of problems.

Miss Utility or "One Call" Services for Public Utility Mark-outs

Miss Utility or "One Call" service centers are information exchange centers for excavators, contractors and property owners planning any kind of excavation or digging. The "One Call" center notifies participating public utilities of the upcoming excavation work so they can locate and mark their underground utilities in advance to prevent possible damage to underground utility lines, injury, property damage and service outages. In some instances, such with southeastern Virginia bases, the Navy has entered into agreement with Ms. Utilities and is part of the response process for Miss

Utilities. Generally, a minimum of 48 hours is required for the public utility mark-outs to be performed. The "One Call" services are free to the public. Note that the "One Call" centers only coordinate with participating public utilities. There may be some public utilities that do NOT participate in the "One Call" center which may need to be contacted separately. For example, in Washington, DC, the Miss Utility "One Call" center does not locate and mark public sewer and water lines. Therefore, the municipal water and sewer authority must be contacted separately to have the sewer and water lines marked out. The AM should contact the appropriate one-call center to determine their scope of services.

For the Mid-Atlantic region, the following "One Call" service centers are available.

Name	**Phone**	**Website**	**Comments**
Miss Utility of DELMARVA	800-257-7777	www.missutility.net	Public utility mark-outs in Delaware, Maryland, Washington, DC, and Northern Virginia
Miss Utility of Southern Virginia (One Call)	800-552-7001	not available	Public utility mark-outs in Southern Virginia
Miss Utility of Virginia	800-257-7777 800-552-7007	www.missutilityofvirginia.com	General information on public utility mark-outs in Virginia, with links to Miss Utility of DELMARVA and Miss Utility of Southern Virginia (One Call)
Miss Utility of West Virginia, Inc	800-245-4848	none	Call to determine what utilities they work with in West Virginia
North Carolina One Call Center	800-632-4949	www.ncocc.org/ncocc/default.htm	Public Utility Markouts in North Carolina

Private Subcontractors

1. Utility-locating support is required at some level for most all CH2M HILL field projects in "clearing" proposed subsurface boring locations on the project site. Utility location and sample clearance can include a comprehensive effort of GIS map interpretation, professional land surveying, field locating, and geophysical surveying. Since we can usually provide our own GIS-related services for projects and our professional land surveying services are normally procured separately, utility-locating subcontractors will normally only be required for some level of geophysical surveying support in the field. This level of geophysical surveying support can range widely from a simple electromagnetic (EM) survey over a known utility line, to a blind geophysical effort, including a ground-penetrating radar (GPR) survey and/or a comprehensive EM survey to delineate and characterize all unknown subsurface anomalies.

   The level of service required from the subcontractor will vary depending on the nature of the site. At sites where utility locations are well defined on the maps and recent construction is limited, CH2M HILL may be confident with a limited effort from a traditional utility-locating subcontractor providing a simple EM survey. At sites where utility locations are not well defined, where recent constructions may have altered utility locations, or the nature of the site makes utility location difficult, CH2M HILL will require the services of a comprehensive geophysical surveying subcontractor, with a wide range of GPR and EM services available for use on an "as-needed" basis. Typical costs for geophysical surveying subcontractors will range from approximately $200 per day for a simple EM effort (usually one crew member and one instrument) to approximately $1,500 per day for a comprehensive geophysical surveying effort (usually a two-person crew and multiple instruments). Comprehensive geophysical surveying efforts may also include field data interpretation (and subsequent report preparation) and non-destructive excavation to field-verify utility depths and locations.

The following table provides a list of recommended geophysical surveying support subcontractors that can be used for utility-locating services:

Company Name and Address	**Contact Name and Phone Number**	**Equipment[1]**					**Other Services[2]**		
		1	**2**	**3**	**4**	**5**	**A**	**B**	**C**
US Radar, Inc.* PO Box 319 Matawan, NJ 07747	Ron LaBarca 732-566-2035			4					
Utilities Search, Inc.*	Jim Davis 703-369-5758	4				4	4	4	4
So Deep, Inc.* 8397 Euclid Avenue Manassas Park, VA 20111	703-361-6005	4					4	4	4
Accurate Locating, Inc. 1327 Ashton Rd., Suite 101 Hanover, MD 21076	Ken Shipley 410-850-0280	4	4						
NAEVA Geophysics, Inc. P.O. Box 7325 Charlottesville, VA 22906	Alan Mazurowski 434-978-3187	4	4	4	4	4	4	4	4
Earth Resources Technology. Inc. 8106 Stayton Rd. Jessup, MD 20794	Peter Li 240-554-0161	4	4	4	4	4	4	4	
Geophex, Ltd 605 Mercury Street Raleigh, NC 27603	I. J. Won 919-839-8515	4	4	4	4	4	4	4	4

Notes:

*Companies denoted with an asterisk have demonstrated reluctance to assume responsibility for damage to underground utilities or an inability to accommodate the insurance requirements that CH2M HILL requests for this type of work at many Navy sites.

[1] Equipment types are:

1. Simple electromagnetic instruments, usually hand-held
2. Other, more innovative, electromagnetic instruments, including larger instruments for more area coverage
3. Ground-penetrating radar systems of all kinds
4. Audio-frequency detectors of all kinds
5. Radio-frequency detectors of all kinds

[2] Other services include:

A. Data interpretation and/or report preparation to provide a permanent record of the geophysical survey results and a professional interpretation of the findings, including expected accuracy and precision.

B. Non-destructive excavation to field-verify the depths, locations, and types of subsurface utilities.

C. Concrete/asphalt coring and pavement/surface restoration.

Attachment C – Equipment Used for Identifying Underground Utilities

This attachment provides a summary of the various types of equipment used for subsurface utility location. It describes the capabilities and limitations of each in order to help the AM and PM determine if the equipment being proposed by a subcontractor or Navy is adequate. A list of in-house experts that can be used to answer questions you may have is provided below.

CH2M HILL In-house Utility Location Experts

Tamir Klaff/WDC

Home Office Phone – 703-669-9611

Electromagnetic Induction (EMI) Methods

EMI instruments, in general, induce an electromagnetic field into the ground (the primary field) and then record the response (the secondary field), if any. Lateral changes in subsurface conductivity, such as caused by the presence of buried metal or by significant soil variations, cause changes in the secondary field recorded by the instrument and thus enable detection and mapping of the subsurface features. It should be noted that EMI only works for electrically conductive materials--plastic or PVC pipes are generally not detected with EMI. Water and gas lines are commonly plastic, although most new lines include a copper "locator" strip on the top of the PVC to allow for detection with EMI.

EMI technology encompasses a wide range of instruments, each with inherent strengths and weaknesses for particular applications. One major division of EMI is between "time-domain" and "frequency-domain" instruments that differ in the aspect of the secondary field they detect. Another difference in EMI instruments is the operating frequency they use to transmit the primary field. Audio- and radio-frequencies are often used for utility detection, although other frequencies are also used. Consideration of the type of utility expected, surface features that could interfere with detection, and the "congestion" of utilities in an area, should be made when choosing a particular EMI instrument for a particular site.

One common EMI tool used for utility location is a handheld unit that can be used to quickly scan an area for utilities and allows for marking locations in "real time". This method is most commonly used by "dig-safe" contractors marking out known utilities prior to excavation. It should be noted that this method works best when a signal (the primary field) can be placed directly onto the line (i.e., by clamping or otherwise connecting to the end of the line visible at the surface, or for larger utilities such as sewers, by running a transmitter through the utility). These types of tools also have a limited capability to scan an area for unknown utilities. Usually this requires having enough area to separate a hand held transmitter at least a hundred feet from the receiver. Whether hunting for unknown, or confirming known, utilities, this method will only detect continuous lengths of metallic conductors.

In addition to the handheld EMI units, larger, more powerful EMI tools are available that provide more comprehensive detection and mapping of subsurface features. Generally, data with these methods are collected on a regular grid in the investigation area, and are then analyzed to locate linear anomalies that can be interpreted as utilities. These methods will usually detect *all* subsurface metal (above a minimum size), including pieces of abandoned utilities. In addition, in some situations, backfill can be detected against native soils giving information on trenching and possible utility location. Drawbacks to these methods are that the secondary signals from utilities are often swamped (i.e., undetectable) close to buildings and other cultural features, and that the subsurface at heavily built-up sites may be too complicated to confidently interpret completely.

Hand-held metal detectors (treasure-finders) are usually based on EMI technology. They can be used to locate shallow buried metal associated with utilities (e.g., junctions, manholes, metallic locators). Advantages of these tools is the ease of use and real-time marking of anomalies. Drawbacks include limited depths of investigations and no data storage capacity.

Ground Penetrating Radar (GPR)

GPR systems transmit radio and microwave frequency (e.g., 80 megaHertz to 1,000 megaHertz) waves into the ground and then record reflections of those waves coming back to the surface. Reflections of the radar waves typically occur at lithologic changes, subsurface discontinuities, and subsurface structures. Plastic and PVC pipes can sometimes be detected in GPR data, especially if they are shallow, large, and full of a contrasting material such as air in a wet soil, or water in a dry soil. GPR data are usually collected in regular patterns over an area and then analyzed for linear anomalies that can be interpreted as utilities. GPR is usually very accurate in x-y location of utilities, and can be calibrated at a site to give very accurate depth information as well. A significant drawback to GPR is that depth of investigation is highly dependant on background soil conductivity, and it will not work on all sites. It is not uncommon to get only 1-2 feet of penetration with the signal in damp, clayey environments. Another drawback to GPR is that sites containing significant fill material (e.g., concrete rubble, scrap metal, garbage) will result in complicated anomalies that are difficult or impossible to interpret.

Magnetic Field Methods

Magnetic field methods rely on detecting changes to the earth's magnetic field caused by ferrous metal objects. This method is usually more sensitive to magnetic metal (i.e., deeper detection) than EMI methods. A drawback to this method is it is more susceptible to being swamped by surface features such as fences and cars. In addition, procedures must usually be implemented that account for natural variations in the earth's background field as it changes throughout the day. One common use of the method is to measure and analyze the gradient of the magnetic field, which eliminates most of the drawbacks to the method. It should be noted this method only detects ferrous metal, primarily iron and steel for utility location applications. Some utility detector combine magnetic and EMI methods into a single hand-held unit.

Optical Methods

Down the hole cameras may be useful in visually reviewing a pipe for empty conduits and/or vaults.

Attachment D – Utility Clearance Documentation Form

Attachment E – Utility Marking Color Codes

The following is the standard color code used by industry to mark various types of utilities and other features at a construction site.

White – Proposed excavations and borings

Pink – Temporary survey markings

Red – Electrical power lines, cables, conduits and lighting cables

Yellow – Gas, oil, steam, petroleum or gaseous materials

Orange – Communication, alarm or signal lines, cables, or conduits

Blue – Potable water

Purple – Reclaimed water, irrigation and slurry lines

Green – Sewer and storm drain lines

STANDARD OPERATING PROCEDURE

Equipment Blank and Field Blank Preparation

I. Purpose

To prepare blanks to determine whether decontamination procedures are adequate and whether any cross-contamination is occurring during sampling due to contaminated air and dust.

II. Scope

The general protocols for preparing the blanks are outlined. The actual equipment to be rinsed will depend on the requirements of the specific sampling procedure.

III. Equipment and Materials

- Blank liquid (use ASTM Type II or lab grade water)
- Sample bottles as appropriate
- Gloves
- Preservatives as appropriate

IV. Procedures and Guidelines

A. Decontaminate all sampling equipment that has come in contact with sample according to SOP *Decontamination of Personnel and Equipment.*

B. To collect an equipment blank for volatile analysis from the surfaces of sampling equipment other than pumps, pour blank water over one piece of equipment and into two or three (lab dependent) 40-ml vials until there is a positive meniscus, then seal the vials. Note the sample number and associated piece of equipment in the field notebook as well as the type and lot number of the water used.

For non-volatiles analyses, one aliquot is to be used for equipment. For example, if a pan and trowel are used, place trowel in pan and pour blank fluid in pan such that pan and trowel surfaces which contacted the sample are contacted by the blank fluid. Pour blank fluid from pan into appropriate sample bottles.

Do not let the blank fluid come in contact with any equipment that has not been decontaminated.

C. When collecting an equipment blank from a pump, run an extra gallon of deionized water through the pump while collecting the pump outflow into appropriate containers. Make sure the flow rate is low when sampling VOCs. If a submersible pump with disposable tubing is used, remove the disposable tubing after sampling but before decon. When decon is complete, put a 3- to 5-foot segment of new tubing onto the pump to collect the equipment blank.

D. To collect a field blank, slowly pour ASTM Type II or lab grade water directly into sample containers.

E. Document and ship samples in accordance with the procedures for other samples.

F. Collect next field sample.

V. Attachments

None.

VI. Key Checks and Items

- Wear gloves.
- Do not use any non-decontaminated equipment to prepare blank.
- Use ASTM-Type II or lab grade water.

STANDARD OPERATING PROCEDURE

Field Measurement of pH, Specific Conductance, Turbidity, Dissolved Oxygen, ORP, and Temperature Using a Water Quality Meter with Flow-Through Cell

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I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for using a water quality meter for field measurements of pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature of aqueous samples. The operator's manual should be consulted for detailed operating procedures.

II. Equipment and Materials

- Water Quality Monitoring System with flow-though cell (Horiba, YSI, In-Situ, Ion Science, etc)
- Calibration Standard Solution(s) (provided by rental company)
- Deionized water in spray bottle

III. Procedures and Guidelines

A. General Parameters and Specifications:

Note: the general parameters listed below may not be available for every type of meter used. Please refer to the specific meter's manual to determine meter's range of measurement and accuracy.

Parameter	Range of measurement	Accuracy
pH	0 to 14 pH units	+/- 0.1 pH units
Specific conductance	0 to 9.99 S/m	+/- 3 % full scale
Turbidity	0 to 800 NTU	+/- 5 % full scale
Dissolved oxygen	0 to 19.99 mg/l	+/- 0.2 mg/l
Temperature	0 to 55 ^{o}C	+/- 1.0 ^{o}C
ORP	-999 to +999 mV	+/- 15 mV
Salinity	0 to 4 %	+/- 0.3 %

B. Calibration:

Prior to each day's use, clean the probe and flow-through cell using deionized water and calibrate using the Standard Solution. Refer to the specific instrumentation manual for the proper calibration methods.

C. Sample Measurement:

The water quality probes are inserted into a flow-through cell, and the purged groundwater is directed through the cell by connecting the pump discharge tubing to the bottom port on the flow through cell, allowing measurements to be collected before the water contacts the atmosphere. The flow-through cell should be positioned out of direct sunlight to reduce solar heating, and wrapped in aluminum foil to minimize heat loss or gain.

As water passes through the flow-through the flow cell, press MEAS to obtain readings or the readings are displayed on the meter for each parameter (dependent on the type of meter used). Record the water quality parameter data in a field notebook.

Once the parameters have stabilized (see *Low-Flow Groundwater Sampling from Monitoring Wells – EPA Region I and III* or *Low-Flow Groundwater Sampling from Monitoring Wells – EPA Region IV* depending on project site location), remove the tubing from the bottom port of the flow-through cell.

Never collect a groundwater sample for laboratory analysis from the flow-through cell. Rinse the flow-through cell between wells to remove any sediment buildup within the cell.

IV. Key Checks and Preventive Maintenance

- Calibrate meter
- Clean probe with deionized water when done
- Refer to operations manual for recommended maintenance and troubleshooting
- Check batteries, and have a replacement set on hand
- Due to the importance of obtaining these parameters, the field team should have a spare unit readily available in case of an equipment malfunction.

STANDARD OPERATING PROCEDURE

Low-Flow Groundwater Sampling from Monitoring Wells – EPA Region I and III

I. Purpose and Scope

This SOP presents general guidelines for the collection of groundwater samples from monitoring wells using low-flow purging and sampling procedures.

II. Equipment and Materials

- Adjustable-rate positive-displacement pump, submersible pump, or peristaltic pump
- Horiba® U-22 or equivalent water quality meter to monitor pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature
- Air monitoring equipment
- Personal protective equipment
- Flow-through cell with inlet/outlet ports and watertight ports for each probe
- Generator or alternate power source depending on pump type
- Water-level indicator
- Disposable Teflon, Teflon-lined polyethylene tubing or polyethylene tubing for metals and other inorganics
- Plastic sheeting
- Well-construction information
- Calibrated container and stopwatch to determine flow rate
- Purged water containers
- Sample containers
- Waste container labels
- In-line disposable 0.45µm filters (QED® FF8100 or equivalent)
- Shipping supplies (labels, coolers, and ice)
- Aluminum foil
- Field book

III. Procedures and Guidelines

A. Setup and Purging

1. Obtain information on well location, diameter(s), depth, and screen interval(s), and the method for disposal of purged water.
2. Calibrate instruments according to manufacturer's instructions.

3. Record well number, site, date, and condition in the field logbook.

4. Place plastic sheeting on the ground surrounding well head. All decontaminated equipment to be used in sampling will be placed only on the plastic sheeting until after the sampling has been completed. Do not let any downhole equipment touch the ground.

5. Open the well and begin screening breathing zone with air monitoring device until sampling is complete, in accordance with the HASP.

6. All sampling equipment and any other equipment to be placed in the well must cleaned and decontaminated before sampling in accordance with SOP *Decontamination of Personnel and Equipment*.

7. Water level measurements are collected in accordance with the *Water Level Measurements* SOP. **Do not measure the depth to the bottom of the well at this time**; this reduces the possibility that any accumulated sediment in the well will be disturbed. Obtain depth to bottom information from well construction log.

7. Attach and secure the tubing to the pump. Lower the pump slowly into the well and set it at approximately the middle of the screen, or wetted screen interval, and at least two feet above the bottom of the well to avoid disturbance of sediment. Submersible pumps should be lowered by the suspension cable rather than the discharge tubing.

8. Insert the water quality measurement probes into the flow-through cell and place in a shaded area. The purged groundwater must enter the flow through the cell by the lower port and exit via the upper port. Wrap exposed tubing and the flow through cell in aluminum foil to minimize heat loss/gain due to environmental conditions.

9. Generators and fuel, if used, must be located at least 30 feet downwind from the well to avoid exhaust fumes contaminating the samples.

10. Begin purging the well at 0.2 to 0.5 liters per minute. Avoid surging. Purging rates for more transmissive formations could be started at 0.5-liter to 1 liter per minute. The initial field parameters of pH, specific conductance, dissolved oxygen, ORP, turbidity, and temperature of water are measured and recorded in the field logbook.

11. Contain purged water for placement in labeled 55-gallon drum or tank, as appropriate.

12. The water level should be monitored frequently during purging, and, ideally, the purge rate should equal the well recharge rate so that there is little or no drawdown in the well (i.e., less than 0.3-foot). The water level should stabilize for the specific purge rate. There should be at least 1 foot of water over the pump intake so there is no risk of the pump suction being broken, or entrainment of air in the sample. Record adjustments in the purge rate and changes in depth to water in the logbook. Purge rates should, if needed, be decreased to the minimum

capabilities of the pump (0.1- to 0.2-liter per minute) to minimize water level drawdown.

13. During purging, the field parameters must be measured frequently (every 5 minutes) until the parameters have stabilized. Field parameters are considered stable when measurements meet the following criteria:

    - pH: within 0.1 pH units
    - Specific conductance: within 3 percent
    - Dissolved oxygen: within 10 percent
    - Turbidity: within 10 percent for values greater than 5 NTU; if 3 turbidity values are less than 5 NTU, consider the values as stabilized
    - ORP: within 10 mV
    - Temperature: within 3 percent

B. Sample Collection

Once purging is complete the well is ready to sample. The pump should be allowed to operate at the same rate as the purge cycle until sampling begins, whereupon the discharge should be reduced to 0.1 L/m.

Samples will be placed in sample containers that have been cleaned to laboratory standards and are preserved in accordance with the analytical method. The containers are typically pre-preserved, if required.

VOC samples are normally collected first and directly into pre-preserved sample containers.

The steps to be followed for sample collection are as follows:

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.
2. The sample is slowly poured so that it runs down the inside of the sample bottle with a minimum of splashing. The pumping rate should be reduced to approximately 100 ml per minute when sampling VOCs.
3. Inorganics, including metals, may be collected and preserved in the filtered form as well as the unfiltered form. Disposable in-line filters (0.45 micron filter), connected to the end of the sample tubing, are typically used for field filtration. Samples are field filtered as the water is being placed into the sample container.
4. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to the top with a positive meniscus. VOC vials should be capped slowly to prevent introduction of air bubbles in the sample. Once capped, the VOC vial should be inverted and tapped to detect the presence of air bubbles.

5. Immediately upon collection, all samples for chemical analysis are to be labeled and placed on ice.

6. Re-usable equipment must be cleaned and decontaminated in accordance with the *Decontamination of Personnel and Equipment* SOP.

The following information, at a minimum, must be recorded in the log book:

1. Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; time and date; sampler's identity)
2. Sample source and source description
3. Field observations and measurements (appearance, field screening, field chemistry, sampling method), volume of water purged prior to sampling, and field parameter measurements
4. Sample disposition (preservative; laboratory name, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)

C. Additional remarks

1. If the well goes dry during purging, wait until it recovers sufficiently to remove the required volumes to sample all parameters. It may be necessary to return periodically to the well but a particular sample (e.g., large amber bottles for semivolatile analysis) should be filled at one time rather than over the course of two or more visits to the well.
2. Disposable tubing is disposed of with PPE and other site trash.

IV. Attachments

White paper on reasons and rationale for low-flow sampling.

V. Key Checks and Preventative Maintenance

- The drawdown in the well should be minimized as much as possible (preferably no more than 0.5-foot to 1 foot) so that natural groundwater-flow conditions are maintained as closely as possible.
- The highest purging rate should not exceed 1 liter per minute. This is to keep the drawdown minimized.
- Stirring up of sediment in the well should be avoided so that turbidity containing adsorbed chemicals is not suspended in the well and taken in by the pump.
- Overheating of the pump should be avoided to minimize the potential for losing VOCs through volatilization. Submersible pumps used in large diameter wells

should be equipped with a shroud to force water flow across the pump motor to dissipate heat build-up.

- Keep the working space clean with plastic sheeting and good housekeeping.
- Maintain field equipment in accordance with the manufacturer's recommendations. This will include, but is not limited to:
  - Inspect sampling pump regularly and replace as warranted
  - Inspect quick-connects regularly and replace as warranted
  - Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

Attachment to the SOP on Low-Flow Sampling Groundwater Sampling from Monitoring Wells

White Paper on Low-Flow Sampling

EPA recommends low-flow sampling as a means of collecting groundwater samples in a way that minimizes the disturbance to the natural groundwater flow system and minimizes the introduction of contamination into the samples from extraneous sources. The following are details about these issues.

When a pump removes groundwater from the well at the same rate that groundwater enters the well through the screen, the natural groundwater-flow system around the well experiences a minimum of disturbance. Some disturbance is bound to occur because you are causing groundwater to flow to the well in a radial fashion that otherwise would have flowed past it. However, the resulting low-flow sample provides the most-representative indication we can get of groundwater quality in the immediate vicinity of the well.

Normally, when a well is pumped at an excessive rate that drops the water level in the well below the water level in the aquifer, the water cascades down the inside of the well screen when it enters the well. The turbulence from this cascading causes gases such as oxygen and carbon dioxide to mix with the water in concentrations that are not representative of the native groundwater and are higher than expected. This causes geochemical changes in the nature of the water that can change the concentrations of some analytes, particularly metals, in the groundwater sample, not mention it's effect on the dissolved oxygen levels that then will be measured in the flow-through cell. Such turbulence also may cause lower-than-expected concentrations of volatile organic compounds due to volatilization.

For wells in which the water level is above the top of the screen, the water up in the riser is out of the natural circulation of the groundwater and, therefore, can become stagnant. This stagnant water is no longer representative of natural groundwater quality because its pH, dissolved-oxygen content, and other geochemical characteristics change as it contacts the air in the riser. If we minimize the drawdown in the well when we pump, then we minimize the amount of this stagnant water that is brought down into the well screen and potentially into the pump. As a result, a more-representative sample is obtained.

Typically, wells contain some sediment in the bottom of the well, either as a residue from development that has settled out of the water column or that has sifted through the sand pack and screen since the well was installed. This sediment commonly has adsorbed on it such analytes as metals, SVOCs, and dioxins that normally would not be dissolved in the groundwater. If these sediments are picked up in the groundwater when the well is disturbed by excessive pumping, they can:

- Make filtering the samples for metals analysis more difficult
- Add unreasonably to the measured concentration of SVOCs and other organic compounds

The SOP for low-flow sampling has been modified recently and should be consulted for additional information about low-flow sampling and ways of dealing with wells in which the water level cannot be maintained at a constant level.

STANDARD OPERATING PROCEDURE

Water-Level Measurements

I. Purpose and Scope

The purpose of this procedure is to provide a guideline for the measurement of the depth to groundwater in piezometers and monitoring wells, even where a second phase of floating liquid (e.g., gasoline) is encountered, and on staff gauges in surface-water bodies. This SOP includes guidelines for discrete measurements of static water levels and does not cover the use of continuously recording loggers (see SOP *Use of Data Loggers and Pressure Transducers)*.

II. Equipment and Materials

- Electronic water-level meter (Solinst® or equivalent) with a minimum 100-foot tape; the tape should have graduations in increments of 0.01 feet or less
- Interface probe (Solinst® Model 122 Interface Meter or equivalent)

III. Procedures and Guidelines

Verify that the unit is turned on and functioning properly. Slowly lower the probe on its cable into the piezometer or well until the probe just contacts the water surface; the unit will respond with a solid tone or light signal. Note the depth from a reference point indicated on the piezometer or well riser. Typically, this is the top of the PVC casing. If no reference is clearly visible, measure the depth to water from the northern edge of the PVC casing. If access to the top of the PVC casing is difficult, sight across the top of the locking casing adjacent to the measuring point, recording the position of the cable when the probe is at the water surface.

Measure the distance from this point to the closest interval marker on the tape and record the water level reading in the logbook. Water levels will be measured to the nearest 0.01-foot. Also, when specified in the project plans, measure and record the depth of the piezometer or well. The depth of the piezometer or well may be measured using the water-level probe with the instrument turned off.

Free product light or dense nonaqueous phase liquid may be present in the piezometer or well. If the presence of free product is suspected, the thickness of the product should be determined using appropriate equipment (e.g., Solinst® Model 122 Interface Meter). The depth to water also is determined with this equipment and the water-level meter should not be used in the piezometer or well as long as product is present. Typically, a constant sound is emitted from the device when free product is encountered and an alternating on/off beep sound is emitted when water is encountered.

The apparent elevation of the water level in the well or piezometer is determined by measuring both the apparent depth to water and the thickness of free product. The corrected water-level elevation is calculated by the following equation:

$WL_c = Wl_a + (\text{Free-product thickness} \times 0.80)$

Where WL_c = Corrected water-level elevation

Wl_a = Apparent water-level elevation

0.80 = Typical value for the density of petroleum hydrocarbon products.

If free product is detected on the surface of the water in the piezometer or well, the value of sampling should be reconsidered because of the potential for contaminating the sampling equipment.

Staff gauges may be installed in some surface-water bodies. These facilities typically are constructed by attaching a calibrated, marked staff gage to a wood or metal post, driving the post into the bottom of the surface-water body, and surveying the elevation of the top of the post to a resolution or 0.01-foot. The elevation of the water in the surface-water body then can be determined by reading off the distance the water level is from the top of the post. A shield or other protection may be needed to calm the fluctuations in water level if the gauge is installed at a location exposed to wind or wave.

IV. Attachments

None.

V. Key Checks

- Before each use, verify that the battery is charged by pressing the test button on the water-level meter.
- Verify that the unit is operating correctly by testing the probe in distilled or de-ionized water. Leave the unit turned off when not in use.

STANDARD OPERATING PROCEDURE

General Guidance for Monitoring Well Installation

I. Purpose

To provide site personnel with a review of the well installation procedures that will be performed. These procedures are to be considered general guidelines only and are in no way intended to supplement or replace the contractual specifications in the driller's subcontract.

II. Scope

Monitoring well installations are planned for shallow and/or deep unconsolidated aquifers and/or for bedrock aquifers. The SOPs *Installation of Shallow Monitoring Wells, Installation of Surface-Cased Monitoring Wells, Installation of Bedrock Monitoring Wells,* and *Installation of Monitoring Wells Using Sonic Drilling* provide more specifics.

III. Equipment and Materials

1. Drilling rig (hollow stem auger, sonic, air hammer, air rotary, or mud rotary)
2. Well-construction materials (i.e., surface casing, screens, riser, casing, caps, bottom plugs, centering guides, sand, bentonite, grout, and surface-finish materials)
3. Development equipment

IV. Procedures and Guidelines

1. Wells will be installed in accordance with standard EPA procedures. Note that USEPA Region III requires any well penetrating a confining layer to be double-cased.
2. The threaded connections will be water-tight.
3. Well screens generally will be constructed of 10-slot or 20-slot Schedule 40 PVC and will be 5 to 10 feet in length depending on saturated thickness of unconsolidated sediments. The exact slot size and length will be determined by the field team supervisor. Stainless-steel may be required under certain contaminant conditions.
4. Stick-up wells will be surrounded by four concrete-filled guard posts at least 2 inches in diameter.

5. A record of the finished well construction will be compiled.

6. All soils and liquids generated during well installations will be drummed for proper disposal.

Monitoring Well Installation

- 2″ monitoring wells in unconsolidated materials will be installed in at least 6-inch-diameter boreholes to accommodate well completion materials in designated locations.

- All monitoring wells penetrating a confining layer will be surface-cased from the ground surface to approximately 5 feet into the confining layer. Exceptions to this may be allowed under certain circumstances (e.g., evidence of significant natural gaps in the confining layer).

- Monitoring wells in unconsolidated materials will be constructed of 2-inch-diameter, factory manufactured, flush-jointed, Schedule 40 PVC (or stainless-steel) screen with threaded bottom plug and riser.

- Screens will be filter packed with a properly sized and graded, thoroughly washed, sound, durable, well-rounded basalt or siliceous sand. When using hollow-stem augers, the filter pack will be installed by slowly pouring the sand into the annular space while simultaneously raising the augers and using a weighted tape to sound for the sand surface. For rotary-drilled wells, the height of the sand pack also will be sounded with a weighted tape.

- The primary filter sand pack (typically Morie #00 or DSI #1 for a 10-slot screen) will extend from 1 to 2 feet below the base of the well to 2 feet above the top of the screen; filter pack will be allowed to settle before final measurement is taken. For wells deeper than 30 feet, the filter pack will be placed using a tremie pipe and flowing water.

Screen Size Opening (Inches)	Screen Size Slot Number	Typical Sand Pack Mesh Size (U.S. Standard Sieve Number)
0.005	5	100
0.010	10	20 to 40
0.020	20	10 to 20
0.030	30	10 to 20

- A secondary filter sand pack (typically a fine sand seal) 1-foot thick may be placed above the primary sand pack.

- Annular well seals will consist of 2 feet of pelletized, chip, or granular bentonite clay placed above the filter pack. If necessary, the pellets will be hydrated using potable water. For wells installed using hollow-stem augers, the bentonite will be poured into the annular space while slowly raising the augers and sounding for the top of the bentonite with a weighted tape. A high-solids bentonite slurry using powdered bentonite introduced with a side-discharging tremie pipe will be used for the bentonite seals in wells greater than 30 feet deep. For rotary-drilled wells, the height of the well seal also will be sounded with a weighted tape. High-solids slurries will have solids content of at least 20 percent.

- The top of the annular seal will be measured after the bentonite seal has been allowed to hydrate and before the grout is applied. The seal will be allowed to hydrate for at least 30 minutes before work in the well continues.
- The annular space above the bentonite seal will be filled to grade with a bentonite-cement slurry grout mixture.
- The grout mixture consists of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 6 pounds of bentonite added per bag of cement to reduce shrinkage. A grout density scale is recommended for determining the correct density. See attached grout volume and weights chart for calculation of grout volume.
- The grout mix will be carefully applied to avoid disturbing the bentonite seal; the method of grout placement must force grout from the top of the bentonite seal to ground surface.
- After allowing the grout to settle and set up overnight, additional grout will be added to maintain grade.
- A protective steel casing equipped with keyed alike locking caps will be grouted in place for each new well; the casing will extend at least 2 feet above grade and 3 feet below grade and will be painted a bright color.

Well Development

- New monitoring wells will be developed after the well has been completely installed and the grout has hardened (at least 24 hours)
- The well will be developed by surging and pumping.
- Equipment placed in the well will be decontaminated before use.
- If information is available, begin developing in the least-contaminated well first.
- Development will include surging the well by either abruptly stopping flow and allowing water in the well column to fall back into the well or through the use of a surge block that is slightly smaller in diameter than the well casing inner diameter.
- Pipes and pumps must not be fitted with foot valves or other devices that might inhibit the return flow of water to the well.
- Surging should continue throughout the development process.

- The air-lift method may be used to pump materials out of the well. The air compressor will be fitted with filters to remove all oil and the air lift hose used will be made of inert materials.
- Well development will continue until the water produced is free of turbidity, sand, and silt. A Horiba-U22 meter, YSI meter with separate Hanna turbidity meter, or equivalent should be used to determine when the turbidity is low and parameters have stabilized.
- Development water will be considered hazardous and placed in sealed 55-gallon U.S. DOT approved steel drums. CH2M HILL will label and date the drums as pending analysis and transport the drums to a designated site for storage.

V. Attachments

Grout Volume and Weights Chart

VI. Key Check and Items

- Ensure that all equipment is properly decontaminated as needed.
- Only new, sealed materials (e.g., screens, risers, and sand) will be used in constructing the well.
- Care shall be taken when making downhole measurements to ensure that proper heights of sand, seal, and grout are achieved.

STANDARD OPERATING PROCEDURE

Installation of Monitoring Wells by Sonic Drilling

I. Purpose and Scope

The purpose of this guideline is to describe methods for drilling and installation of groundwater monitoring wells and piezometers in unconsolidated or poorly consolidated materials using sonic drilling techniques. Sonic drilling technology potentially eliminates telescoping monitoring wells, allowing the installation of aquifer penetrating, single-cased wells.

II. Equipment and Materials

Drilling

- Sonic drilling rig
- Override casings and core barrel

Well Riser/Screen

- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded riser; alternatively, stainless steel riser
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted screen; alternatively, stainless-steel screen.

Bottom Cap

- PVC, threaded to match the well screen; alternatively, stainless-steel
- Centering guides (if used)

Well Cap

- Above-grade well completion: PVC, threaded or push-on type, vented
- Flush-mount well completion: PVC, locking, leak-proof seal
- Stainless-steel to be used as appropriate

Sand

- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous material; primary (coarse – e.g., Morie #1) filter pack, and secondary (fine sand seal) filter pack. Grain size determined based on sediments observed during drilling.

Bentonite

- Pure, additive-free bentonite pellets
- Pure, additive-free powdered bentonite

- Coated bentonite pellets; coating must biodegrade within 7 days
- Cement-Bentonite Grout: proportion of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 pounds of bentonite added per bag of cement to reduce shrinkage

Protective Casing

- Above-grade well completion: 6-inch minimum ID black iron steel pipe with locking cover, diameter at least 2 inches greater than the well casing, painted with epoxy paint for rust protection; heavy duty lock; protective posts if appropriate
- Flush-mount well completion: 8-inch or 12-inch dia. manhole cover, or equivalent; rubber seal to prevent leakage

Well Development

- Surge block
- Well-development pump and associated equipment
- Calibrated meters to measure pH, temperature, specific conductance, and turbidity of development water
- Containers (e.g., 55-gallon drums) for water produced from well.

III. Procedures and Guidelines

A. Drilling Method

Drill rods and core barrel with a minimum 6-inch inside diameter (ID) will be used to drill monitoring well boreholes. Continuous core soil samples (4-inches outside diameter) will be collected for lithologic classification and intervals may be selected for chemical analysis. Soil sampling procedures are detailed in SOP *Shallow Soil Sampling.*

The use of water and additives to assist in sonic drilling for monitoring well installation will be minimized, unless required for such conditions as running sands or drilling bedrock formations.

Override casings, core barrels, and other downhole drilling tools will be decontaminated prior to the initiation of drilling activities and between each borehole location. Core barrels and other downhole soil sampling equipment will also be decontaminated before and after each use. SOP *Decontamination of Drilling Rigs and Equipment* details proper decontamination procedures.

Drill cuttings and decontamination fluids generated during well drilling activities will be contained according to the procedures detailed in the Sampling and Analysis Plan.

B. Monitoring Well Installation

Sonic drilling technology eliminates the necessity to install double or triple cased wells since the borehole will be fully cased during drilling activities. Monitoring wells will be constructed inside the override casing(s), once the borehole has been advanced to the desired depth. Following setting the well screen, riser, filter pack, and bentonite seal, the well will be grouted as the temporary casing is withdrawn, preventing cross contamination. If the borehole has been drilled to a depth greater than that at which the well is to be set, the borehole will be backfilled with bentonite pellets or a bentonite-cement slurry to a depth approximately 2 feet below the intended well depth. Approximately 2 feet of clean sand will be placed on top of the bentonite to return the borehole to the proper depth for well installation.

The appropriate lengths of well screen, nominally 10 feet (with bottom cap), and casing will be joined watertight and lowered inside the temporary casing to the bottom of the borehole. Centering guides, if used, will be placed at the bottom of the screen and above the interval in which the bentonite seal is placed.

A primary sand pack consisting of clean Morie No. 00 (or DSI No.1) silica sand for 0.010-inch slotted screen and Morie No. 01 (or DSI No.2) silica sand for 0.020-inch slotted screen will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. The inner-most override casing will be raised gradually during sand pack installation to avoid caving of the borehole wall; at no time will the innermost override casing be raised higher than the top of the sand pack during installation. During placement of the sand, the position of the top of the sand will be continuously sounded. The primary sand pack will extend from the bottom of the borehole to a minimum of 2 feet above the top of the well screen. A secondary, finer-grained sand pack may be installed for a minimum of 1 foot above the coarse sand pack. Heights of the coarse and fine sand packs and bentonite seal may be modified in the field to account for a shallow water table and small saturated thickness of the surficial aquifer.

A bentonite seal at least 2 feet thick will be placed above the sand pack. The seal will be placed into the borehole in a manner that will prevent bridging. The position of the top of the bentonite seal will be verified using a weighted tape measure. If all or a portion of the bentonite seal is above the water table, clean water will be added to hydrate the bentonite. A hydration period of at least 30 minutes will be required following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the bottom of the space to be grouted to the ground surface through a tremie pipe. The tremie pipe must be plugged at the bottom and have small openings along the sides of the bottom 1-foot length of pipe. This will allow the grout to discharge laterally into the borehole and not disturb the bentonite pellet seal.

C. Well Completion

For monitoring wells that will be completed above-grade, a locking steel protective casing set in a concrete pad will be installed. The steel protective casing will extend at least 2 feet into the ground and 3 feet above ground but should not penetrate the bentonite seal. The concrete pad will be square, approximately 2 feet per side (unless otherwise specified in the project plans) and poured into wooden forms. The concrete will be sloped away from the protective casing.

Guard posts may be installed in high-traffic areas for additional protection. Four steel guard posts will be installed around the protective casing, within the edges of the concrete pad. Guard posts will be concrete-filled, at least 2 inches in diameter, and will extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, Morrison 9-inch or 12-inch 519 manhole cover or equivalent, with a rubber gasket and drain will be installed. The top of the manhole cover will be positioned approximately 1 inch above grade. A square concrete pad, approximately 2 feet per side (unless otherwise specified in the project plans), will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic.

Concrete pads installed at all wells will be a minimum of 6 inches below grade. The concrete pad will be 12-inches thick at the center and taper to 6-inch thick at the edge. The surface of the pad should slope away from the protective casing to prevent water from pooling around the casing. Protective casing, guard posts, and flush mounts will be installed into this concrete.

Each well will be properly labeled on the exterior of the locking cap or protective casing with a metal stamp indicating the permanent well number.

C. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have stabilized and the turbidity of the discharge water is substantially reduced. Fine-grained materials in the surficial aquifer at the site may not allow low turbidity results to be achieved.

The surging apparatus will include a tight-fitting surge block. Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone. Following surging, the well will be pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, turbidity and specific conductance will be recorded.

Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is substantially reduced, and the pH, temperature, and specific conductance have stabilized at regional background levels, based on historical data. Development will continue for a minimum of one hour until the water removed from the well is as clear of turbidity as practicable.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in SOP *Decontamination of Personnel and Equipment*. Water generated during well development will be contained and managed as detailed in the SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan.

IV. Attachments

Schematic diagram of shallow monitoring well construction (MWSingleDiag.xls)

DRAFT FINAL STANDARD OPERATING PROCEDURE – NAVY CLEAN PROGRAM

Soil Sampling for Per- and Polyfluoroalkyl Substances

I. Purpose

This SOP provides guidelines for soil sample collection and handling for samples that will be analyzed for per- and polyfluoroalkyl substances (PFAS) via LC/MS/MS Compliant with QSM 5.1 Table B-15. Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Equipment and Materials

Equipment and Materials Required

- A hand auger or other device that can be used to remove the soil from the ground. Stainless steel tools, carbon steel tools, or steel DPT tooling with acetate sleeves are preferred for PFAS sampling. Avoid any sampling materials containing PFAS (such as Teflon, Viton, PTFE, or other fluorinated compounds). Any plastic sampling materials should be evaluated thoroughly before selection to ensure they are fluorine-free.
- A stainless steel spatula or fluorine-free disposable plastic scoop should be used to remove material from the sampling device.
- Unpainted wooden stakes or pin flags
- Fiberglass measuring tape (at least 200 feet in length)
- GPS Unit
- PFAS-free labels (if available[1]) shipping materials
- Loose leaf paper or a wire-bound notebook without waterproof coating
- Metal clipboard (if using loose-leaf paper)
- Pen (not Sharpie)
- Personal protection equipment (rubber or latex gloves, boots, etc.). Check with your SME prior to selecting PPE to ensure there are no fluorine-containing components.
- Sample jars (sample jars should be made of high density polyethylene (HDPE) as glass jars may sorb PFAS, please notify the project manager [PM] if glass jars are provided by the lab). Sample containers should not contain Teflon lids.
- Laboratory-prepared deionized, certified PFAS-free water for field blank collection

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[1] Efforts will be made to obtain PFAS-free labels; however, information on labels is scarce and labels are frequently mounted on PFAS-coated paper to allow for easy removal.

Equipment and Materials to Avoid During Sampling

Equipment and materials used to collect soil samples should not contain any fluorinated compounds including Teflon or synthetic rubber with fluoropolymer elastomers (e.g. Viton).

If a driller is supporting collection of soil samples in split spoons or acetate DPT sleeves, ensure the driller has not used and will not use drilling lube containing polytetrafluoroethylene (PTFE) or any other fluorine-containing substance. Biolube has been determined to be an acceptable substitute.

Specifically, the following material should be avoided during sampling:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistant clothing with fluorochemical treatment or anything advertised as water repellant.
- Weather-proof log books with fluorochemical coatings
- New clothing that has been washed fewer than six times

The sample collection area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers
- Aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

III. Procedures and Guidelines

Once the area has been determined to be free of materials potentially containing PFAS, these steps can be followed to collect the soil samples:

A. Wear protective gear, as specified in the Health and Safety Plan.

B. To locate samples, identify the correct location using the pin flags or stakes. Proceed to collect a sample from the undisturbed soil adjacent to the marker following steps C and D. If markers are not present, the following procedures will be used.

   1. For samples on a grid:

      a. Use measuring tape to locate each sampling point on the first grid line as prescribed in the sampling plan. As each point is located, drive a numbered stake in the ground and record its location on the site map and in the field notebook/clipboard.

      b. Proceed to sample the points on the grid line.

      c. Measure to location where next grid line is to start and stake first sample. For subsequent samples on the line take two orthogonal measurements: one to the previous grid line, and one to the previous sample on the same grid line.

d. Proceed to sample the points on the grid line as described in Section C below.

e. Make sure to stake location after sample collection in case professional surveying is to be completed.

f. Repeat 1c and 1e above until all samples are collected from the area.

g. Or, a GPS unit can be used to identify each location based on map coordinates, if available.

2. For non-grid samples:

   a. Use measuring tape to position sampling point at location described in the sampling plan by taking two measurements from fixed landmarks (e.g., corner of house and fence post).

   b. Note measurements, landmarks, and sampling point on a sketch in the field notebook, and on a site location map.

   c. Proceed to sample as described in Section C below.

   d. Make sure to stake location after sample collection in case professional surveying is to be completed.

   e. Repeat 2a through 2d above until all samples are collected from the area.

   f. Or, a GPS unit can be used to identify each location based on map coordinated, if available.

C. To the extent possible, differentiate between fill and natural soil. If both are encountered at a boring location, sample both as prescribed in the field sampling plan. Do not locate samples in debris, tree roots, or standing water. In residential areas, do not sample in areas where residents' activities may impact the sample (e.g., barbecue areas, beneath eaves of roofs, driveways, garbage areas). If an obstacle prevents sampling at a measured grid point, move as close as possible, but up to a distance of one half the grid spacing in any direction to locate an appropriate sample. If an appropriate location cannot be found, consult with the Field Team Leader (FTL). If the FTL concurs, the sampling point may be deleted from the program. The FTL will contact the CH2M HILL PM immediately. The PM and Navy Technical Representative (NTR) will discuss whether the point should be deleted from the program. If it is deleted, the PM will follow-up with the NTR in writing.

D. To collect samples using hand tools:

1. Use a decontaminated stainless steel scoop/trowel or disposable plastic scoop to scrape away surficial organic material (grass, leaves, etc.) adjacent to the stake. New disposable scoops or trowels may also be used to reduce the need for equipment blanks if the disposable scoops have been confirmed by your project PFAS subject matter expert (SME) to be PFAS free.

2. If sampling:

   a. Surface soil: Obtain soil sample by scooping soil using the augering scoop/trowel, starting from the surface and digging down to a depth of about 6 inches, or the depth specified in the workplan.

   b. Subsurface soil: Obtain the subsurface soil sample using an auger down to the depths prescribed in the field sampling plan.

3. Record lithologic description and any pertinent observations (such as discoloration) in the field notebook/clipboard.
4. Empty the contents of the scoop/trowel into a decontaminated stainless steel pan or dedicated sealable bag.
5. Repeat this procedure until sufficient soil is collected to meet volume requirements.
6. Homogenize cuttings in the pan using a decontaminated stainless steel utensil.
7. Transfer sample for analysis into appropriate containers with a decontaminated utensil. Affix labels after bottles have been closed; collect only one sample at a time to avoid mislabeling.
8. Immediately upon collection, all samples for chemical analysis are to be placed in a closed container on ice unless it is not possible to do so. Although unusual and uncommon, there may be instances where it is not possible to have containers with ice at the sample location. In these instances, the samples should be placed on ice as soon as practical and during the time between collection and placing the samples on ice, the samples should be kept as cool as possible.
9. Backfill the hole with soil removed from the borehole. To the extent possible, replace topsoil and grass and attempt to return appearance of sampling area to its pre-sampled condition. For samples in non-residential, unmowed areas, mark the sample number on the stake and leave stake in place. In mowed areas, remove stake.

E. To collect Samples Using DPT Methods

1. Decontaminate sampling tubes and other non-dedicated downhole equipment in accordance with SOP *Decontamination of Personnel and Equipment*. Ensure that decontamination water used is PFAS free (do not use water from fire hydrants on-base for steam cleaning unless the water has been demonstrated to be free of PFAS).
2. Drive sampling tube to the desired sampling depth using the truck-mounted hydraulic percussion hammer. If soil above the desired depth is not to be sampled, first drive the lead rod, without a sampling tube, to the top of the desired depth.
3. Remove the rods and sampling tube from the borehole and remove the sampling tube from the lead rod.
4. Cut open the acetate liner using a specific knife designed to slice the acetate liners (see below).

5. Fill all sample containers, using a decontaminated or dedicated sampling implement. Label the containers and immediately place samples on ice for shipment to the laboratory.
6. Decontaminate all non-dedicated downhole equipment (rods, sampling tubes, etc.) in accordance with SOP Decontamination of Personnel and Equipment and ensure decontamination water is from a PFAS-free water source.
7. Backfill borehole at each sampling location with grout or bentonite and repair the surface with like material (bentonite, asphalt patch, concrete, etc.), as required.

Equipment Decontamination

Whenever possible, use disposable equipment when collecting sediment samples. If reusable equipment must be used, the equipment must be cleaned/decontaminated between uses. Alconox and Liquinox soap are acceptable for cleaning/decontaminating reusable equipment at PFAS sites. Any water used for cleaning/decontamination must be certified PFAS-free by a laboratory. Consider triple-rinsing. Once decontaminated, wrap equipment in plastic bags (such as Ziploc), and store away from potential PFAS sources.

References

United States Environmental Protection Agency (USEPA), 2009. *Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)*. September.

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United States Navy, 2015. *Navy Drinking Water Sampling Policy for Perfluorochemicals: Perfluorooctane Sulfonate and Perfluorooctanoic acid.* September

DRAFT FINAL STANDARD OPERATING PROCEDURE – NAVY CLEAN PROGRAM

Surface Water Sampling for Per- and Polyfluoroalkyl Substances

I. Purpose and Scope

This SOP provides guidelines for surface water sample collection for samples that will be analyzed for per- and polyfluoroalklyl substances (PFAS) via LC/MS/MS Compliant with QSM 5.1 Table B-15. Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Materials and Equipment

Equipment and Materials Required

- Open tube sampler
- Dip sampler
- Weighted bottle sampler (no glass)
- Hand pump without Teflon components
- Van Dorn sampler (Kemmerer cannot be used as it has Teflon caps)
- Depth-integrating sampler
- Peristaltic pump and PFAS-free tubing
    - High density polyethylene tubing (unlined)
    - Masterflex tubing such as Cole Parmer C-Flex (06424 series) and Tygon E-3603 (06509 series) are suitable options
- Sample containers (high density polyethylene [HDPE] with HDPE screw cap [no Teflon caps])
- PFAS-free labels (if available[1]) and shipping materials
- Loose leaf paper or a wire-bound notebook without waterproof coating
- Metal clipboard
- Pen (not Sharpie)
- Nitrile or Latex gloves (Do not use Kleen Guard powder free nitrile gloves which were shown in research to contain fluorine)
- Meters for specific conductance, temperature, pH, and dissolved oxygen

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[1] Efforts will be made to obtain PFAS-free labels; however, information on labels is scarce and labels are frequently mounted on PFAS-coated paper to allow for easy removal.

Equipment and materials used to collect surface water samples should not contain any fluorinated compounds including Teflon or synthetic rubber with fluoropolymer elastomers (e.g. Viton). Neoprene and rubber waders should not be an issue, however, check with your PFAS subject matter expert (SME) during field preparation to ensure all equipment is free of fluorine-containing components.

Equipment and Materials to Avoid During Sampling

Equipment and materials used to collect groundwater samples should not contain any fluorinated compounds, Teflon, or synthetic rubber with fluoropolymer elastomers (e.g., Viton).

Specifically, the following material should be avoided during sampling:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistant clothing with fluorochemical treatment or anything advertised as water repellant.
- Weather-proof log books with fluorochemical coatings
- New clothing that has been washed fewer than six times

The sample collection area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers
- Aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

III. Procedures and Guidelines

Wash hands with dish detergent before sampling and don nitrile gloves. Do not use Kleen Guard powder free nitrile gloves which were shown in research to contain fluorine.

Before surface water samples are taken, all sampler assemblies and sample containers are cleaned and decontaminated as described in SOP *Decontamination of Personnel and Equipment* as well as this SOP (see below). Surface water samples collected from water bodies tidally influenced should be collected at low tide and under low flow conditions to minimize the dilution of potential contaminants. Once the area has been determined to be free of materials potentially containing PFAS, follow the methods for surface water sample collection described below.

Surface water samples are collected manually by submerging a clean stainless steel or polypropylene container into the water body. Samples may be collected at depth with a covered bottle that can be removed with a tripline provided the bottle or bottle cap does not contain Teflon. The most common sampler types are sealable bottles, pond samplers, peristaltic pumps, and weighted bottle samplers. Pond samplers have a fixed or telescoping pole attached to the sample container. Weighted bottle samplers are lowered below water surface, where the attached bottle is opened, allowed to fill, and pulled out of the water. When retrieved, the bottle is tightly capped and removed from the sampler assembly. A specific type of weighted bottle sampler is the Van Dorn and is acceptable in most instances. The Kemmerer weighted bottle sampler cannot be used for PFAS sampling due to the Teflon caps.

A sample is taken with the following specific steps:

1. The location and desired depth for water sampling are selected.
2. The sample site is approached from downstream in a manner that avoids disturbance of bottom sediments as much as possible. The sample bottle is gently submerged with the mouth pointed upstream and the bottle tilted slightly downstream. Bubbles and floating materials should be prevented from entering the bottle. If using a Peristaltic pump, lower the tubing into the water to the desired depth.
3. For weighted bottle samplers, the assembly is slowly lowered to the desired depth. The bottle stopper is unseated with a sharp tug and the bottle is allowed to fill until bubbles stop rising to the surface.
4. When the bottle is full, it is gently removed from the water. If sample transfer is required, it should be performed at this time. Fill all sample containers. Affix labels after sample containers are closed; collect only one sample at a time to avoid mislabeling.
5. Measure dissolved oxygen, specific conductance, temperature, and pH at the sampling location.

Equipment Decontamination

Whenever possible, use disposable equipment when collecting surface water samples. If reusable equipment must be used, the equipment must be cleaned/decontaminated between uses. Alconox and Liquinox soap are acceptable for cleaning/decontaminating reusable equipment at PFAS sites. Any water used for cleaning/decontamination must be certified PFAS-free by a laboratory. Consider triple-rinsing. Once decontaminated, wrap equipment in plastic bags (such as Ziploc), and store away from potential PFAS sources.

Use of Water Quality Equipment

Water quality meters typically do not contain PFAS.   However, consistent with general sampling SOPs, disconnect the water quality meter prior to sampling.

References

United States Environmental Protection Agency (USEPA), 2009. *Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)*. September.

United States Navy, 2015. *Navy Drinking Water Sampling Policy for Perfluorochemicals: Perfluorooctane Sulfonate and Perfluorooctanoic acid.* September.

DRAFT FINAL NAVY CLEAN STANDARD OPERATING PROCEDURE

Sediment Sampling for Per- and Polyfluoroalkyl Substances

I. Purpose and Scope

This SOP provides guidelines for sediment sample collection and handling for samples that will be analyzed for per- and polyfluoroalklyl substances (PFAS) via LC/MS/MS Compliant with QSM 5.1 Table B-15. Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Equipment and Materials

Equipment and Materials Required

- Sample collection device (hand corer, scoop, dredge, grab sampler, or other suitable device). Check with your PFAS subject matter expert (SME) during field preparation to ensure all equipment is free of fluorine-containing components.
- Stainless steel spoon or spatula or fluorine-free plastic disposable scoop for media transfer
- Measuring tape
- GPS Unit
- PFAS-free labels (if available[1]) shipping materials
- Loose leaf paper or a wire-bound notebook without waterproof coating
- Metal clipboard (if using loose-leaf paper)
- Pen (not Sharpie)
- Personal protection equipment (rubber or latex gloves, boots, hip waders, etc.). Check with your SME prior to selecting PPE to ensure there are no fluorine-containing components.
- Materials for classifying soils, particularly the percentage of fines
- Sample jars (high density polyethylene [HDPE] with HDPE screw cap [no Teflon caps])
- Laboratory prepared deionized, certified PFAS-free water for field blank collection

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[1] Efforts will be made to obtain PFAS-free labels; however, information on labels is scarce and labels are frequently mounted on PFAS-coated paper to allow for easy removal.

Equipment and Materials to Avoid During Sampling

Equipment and materials used to collect soil samples should not contain any fluorinated compounds including Teflon or synthetic rubber with fluoropolymer elastomers (e.g. Viton).

Specifically, the following material should be avoided during sampling:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistant clothing with fluorochemical treatment or anything advertised as water repellant.
- Weather-proof log books with fluorochemical coatings
- New clothing that has been washed fewer than six times

The sample collection area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers
- Aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

III. Procedures and Guidelines

Wash hands with dish detergent before sampling and don nitrile gloves. Do not use Kleen Guard powder free nitrile gloves which were shown in research to contain fluorine.

Once the area has been determined to be free of materials potentially containing PFAS, these steps can be followed to collect the sediment samples:

1. Field personnel will start downstream and work upstream to prevent contamination of unsampled areas. In surface water bodies that are tidally influenced, sampling will be performed at low tide and under low flow conditions to minimize the dilution of possible contaminants. Sediment sampling activities will not occur immediately after periods of heavy rainfall.
2. Make a sketch of the sample area that shows important nearby river features and permanent structures that can be used to locate the sample points on a map. Whenever possible, include measured distances from such identifying features.

Also include depth and width of waterway, rate of flow, type and consistency of sediment, and point and depth of sample removal (along shore, mid-channel, etc).

3. Note in the field book any possible outside sources of contamination; for example, the outlet to a drainage culvert in the water body near your sampling location.

4. Transfer sample into appropriate sample jars with a stainless steel utensil or plastic disposable scoop confirmed to be fluorine-free. Be especially careful to avoid the loss of the very fine clay/silt particles when collecting the sample. The fine particles have a higher adsorption capacity than larger particles. Minimize the amount of water that is collected within the sample matrix. Decant the water off the sample slowly and carefully to maximize retention of the very fine particles. The sampler's fingers should never touch the sediment. Classify the soil type of the sample using the Unified Soil Classification System, noting particularly the percentage of silt and clay. Affix the sample label to the container after the container has been closed; collect only one sample at a time to avoid mislabeling.

5. Rocks and other debris should be removed before placement in jars.

6. For channel sampling, be on the alert for submerged hazards (rocks, tree roots, drop-offs, loess silt and muck) which can make wading difficult.

7. Immediately upon collection, all samples are to be placed in a closed container on ice. Although unusual and uncommon, there may be instances where it is not possible to have containers with ice at the sample location. In these instances, the samples should be placed on ice as soon as practical and during the time between collection and placing the samples on ice, the samples should be kept as cool as possible.

Equipment Decontamination

Whenever possible, use disposable equipment when collecting sediment samples. If reusable equipment must be used, the equipment must be cleaned/decontaminated between uses. Alconox and Liquinox soap are acceptable for cleaning/decontaminating reusable equipment at PFAS sites. Any water used for cleaning/decontamination must be certified PFAS-free by a laboratory. Consider triple-rinsing. Once decontaminated, wrap equipment in plastic bags (such as Ziploc), and store away from potential PFAS sources.

References

United States Environmental Protection Agency (USEPA), 2009. *Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)*. September.

United States Navy, 2015. *Navy Drinking Water Sampling Policy for Perfluorochemicals: Perfluorooctane Sulfonate and Perfluorooctanoic acid.* September.

DRAFT FINAL STANDARD OPERATING PROCEDURE – Navy CLEAN PROGRAM

Groundwater Sampling for Per- and Polyfluoroalkyl Substances (PFAS)

I. Purpose and Scope

This SOP provides guidelines for groundwater sample collection for samples that will be analyzed for per- and polyfluoroalklyl substances (PFAS) via LC/MS/MS Compliant with QSM 5.1 Table B-15. This SOP should be used in conjunction with approved region-specific groundwater sampling SOPs which provide methods for general and low-flow groundwater sampling. In cases in which information in this SOP conflicts with region-specific groundwater sampling SOPs, this SOP will supersede the information in the general SOPs.

Standard techniques for collecting representative samples are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000. Materials, equipment, and procedures may vary; refer to the Sampling and Analysis Plan and operator's manuals for specific details.

II. Equipment and Materials

Equipment and Materials Required

- If installing wells, ensure driller does not use polytetrafluoroethylene (PFTE)-containing drill lube or other drilling lubes containing PFAS. Biolube has been determined to be an acceptable drilling lube for installing wells where PFAS may be of concern. Additionally, Waterra surge blocks have been confirmed to not contain PFAS and may be used for development.
- Groundwater sampling equipment
  - PFAS-free tubing (avoid Teflon, Viton, PTFE and other fluorinated compounds)
    - High density polyethylene tubing (unlined)
    - If Masterflex tubing is needed for peristaltic pumps, Cole Parmer C-Flex (06424 series) and Tygon E-3603 (06509 series) are suitable options
  - PFAS-free Bailer (if using a bailer[1])
  - PFAS-free Pump such as:
    - Geotech PFAS-free Portable Bladder Pump (note, most bladder pumps include a Teflon-lined bladder, but Geotech currently has one model which is Teflon-free).
    - Panacea P120 or P125. The P200 Stainless Steel Pump may also be used, but the standard model contains Teflon at the tube connection. If you are using this Panacea model, you must request one with the "PTFE-free thread sealant option."
    - Waterra stainless foot-valve
    - QED Sample Pro

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[1] Geotech and Waterra offer PFAS free bailer options

  - Monsoon or Mega Monsoon submersible pump
  - Grundfos Rediflo2 (this pump contains small Teflon components, but has not been shown to leach, it is less preferable than the other options)
  - Peristaltic pump (may be suitable for shallow locations)
- Groundwater sample containers (high density polyethylene [HDPE] bottle with HDPE screwcap), sample bottles should not be glass as glass may sorb PFAS. Sample bottle caps should not contain Teflon. Notify your project manager (PM) if bottles provided by the lab are glass or contain Teflon parts.
- Laboratory prepared deionized, certified PFAS-free water for field blank collection
- PFAS-free shipping supplies (labels [if available][2], coolers, and ice)
- Loose leaf paper without waterproof coating or a spiralbound notebook (not waterproof)
- Metal clip board (if using loose-leaf paper)
- Pen (not Sharpie)
- Nitrile or latex gloves

Equipment and Materials to Avoid During Sampling

Equipment and materials used to collect groundwater samples should not contain any fluorinated compounds, Teflon, or synthetic rubber with fluoropolymer elastomers (e.g., Viton).

Specifically, the following material should be avoided during sampling:

- Gore-Tex brand or similar high-performance outdoor clothing, clothing treated with ScotchGuard brand or similar water repellent, fluoropolymer-coated Tyvek, wrinkle-resistant fabrics, and fire-resistant clothing with fluorochemical treatment or anything advertised as water repellant.
- Weather-proof log books with fluorochemical coatings
- New clothing that has been washed fewer than six times

The sample collection area should be clear of the following items:

- Pre-packaged food wrappers (e.g., fast food sandwich wrappers, pizza boxes, etc.)
- Microwave popcorn bags
- Blue ice containers
- Aluminum foil
- Kim-Wipes
- Sunscreen, insect repellant and other personal hygiene products that may contain PFAS

Research which has not yet been published has allowed us to generate a list of sunscreens and insect repellents which do not contain fluorine. Check with Bill Diguiseppi or Laura Cook on recommendations (because the research is not ours, it cannot be released externally at this time).

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[2] Efforts will be made to obtain PFAS-free labels; however, information on labels is scarce and labels are frequently mounted on PFAS-coated paper to allow for easy removal.

III. Procedures and Guidelines

Wash hands with dish detergent before sampling and don nitrile gloves. Do not use Kleen Guard powder free nitrile gloves which were shown in research to contain fluorine

Follow Navy CLEAN SOPs for low-flow or conventional groundwater sample collection, depending on site requirements.

Sample Collection

Once water quality parameters have stabilized for low-flow purging, samples can be collected. For conventional purging, if water quality parameters do not stabilize, a minimum of 3 well volumes must be purged prior to sample collection.

The steps to be followed for sample collection are as follows:

1. Ensure that the end of the tubing does not touch the ground or equipment. Remove the cap from the sample bottle. Position the sample bottle under the end of the tubing.
2. Fill the bottle. Samples do not need to be collected headspace free.
3. Affix labels after bottles have been closed; collect only one sample at a time to avoid mislabeling. Pack the sample on ice immediately for shipment to the offsite laboratory. Avoid packing materials that may contain fluorine. Unpublished research has allowed us to generate a list of packing materials which do not contain fluorine. Please contact Bill Diguiseppi or Laura Cook for recommendations (because the research is not ours, it cannot be released externally at this time).

Equipment Decontamination

Whenever possible, use disposable equipment when collecting groundwater samples. If reusable equipment must be used, the equipment must be cleaned/decontaminated between uses. Alconox and Liquinox soap are acceptable for cleaning/decontaminating reusable equipment at PFAS sites. Any water used for cleaning/decontamination must be certified PFAS-free by a laboratory. Consider triple-rinsing. Once decontaminated, wrap equipment in plastic bags (such as Ziploc), and store away from potential PFAS sources.

Use of Water Quality Equipment and Water Level Indicators

Water quality meters typically do not contain PFAS. However, consistent with general sampling SOPs, disconnect the water quality meter prior to sampling. Some water level indicators do contain small polyvinylidene fluoride (a PFAS constituent for which we do not currently monitor) or less frequently, Teflon, components, but we have not noted cross contamination from water level indicators at any sites. The Durham Geoslope Water Level Indicators have been shown to be fluorine free.

V. References

United States Environmental Protection Agency (USEPA), 2009. *Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/ Tandem Mass Spectrometry (LC/MS/MS).* September.

United States Navy, 2017. *Interim Per- and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs).* September

United States Navy, 2015. *Navy Drinking Water Sampling Policy for Perfluorochemicals: Perfluorooctane Sulfonate and Perfluorooctanoic acid.* September.

STANDARD OPERATING PROCEDURE

Sampling Contents of Tanks and Drums

I. Scope and Application

This procedure provides an overview approach and guidelines for the routine sampling of drums and tanks. Its purpose is to describe standard procedures and precautions which are applied in sampling drums and tanks. Procedures for opening drums with the individual instruments are included in Attachment D.

The samples obtained may be used to obtain physical chemical or radiological data. The resulting data may be qualitative or quantitative in nature and are appropriate for use in preliminary surveys as well as confirmatory sampling.

II. Summary of Methods

Drums are generally sampled by means of sampling tubes such as glass sample tubes or COLIWASA samplers. In either case, the sampling tube is manually inserted into the waste material. A sample of the drum contents is withdrawn by the sampling device. Should a drum contain bottom sludge, a glass tube will be used to retrieve a sample of this as well.

Storage tank and tank trailers, because of their greater depths, require sampling devices that can be lowered from the top, filled at a particular depth, and then withdrawn. Such devices are a COLIWASA, a Kemmerer depth sampler, or a Bacon Bomb. Where samples of bottom sludge are desired, a gravity corer can be utilized. This heavy tube with a tapered nose piece will penetrate the sludge as it free falls through the tank.

III. Comments

The sampling of tanks, containers, and drums present unique problems not associated with environmental samples. Containers of this sort are generally closed except for small access ports, manways, or hatches on the larger vessels, or taps and bungs on smaller drums. The physical size, shape, construction material, and location of access limit the types of equipment and methods of collection that can be used.

When liquids are contained in sealed vessels, gas vapor pressure can build up, sludges can settle out, and density layerings (stratification) can develop. Bulging drums may be under pressure and extreme caution should be exercised. The potential exists for explosive reactions or the release of noxious gases when containers are opened. All vessels should be opened with extreme caution. Check the HSP for the level of personnel protection to be worn. A preliminary sampling of any headspace gases is warranted. As a minimum, a preliminary check with a Multi RAE or equivalent may be of aid in selecting a sampling method.

In most cases it is impossible to observe the contents of these sealed or partially sealed vessels. Since some layering or stratification is likely in any solution left undisturbed over time, a sample must be taken that represents the entire depth of the vessel.

IV. Required Equipment and Apparatus

A. **Health and safety equipment/materials**: As listed in the site safety plan.

B. **Sampling equipment**: COLIWASA, glass sample tubes, Kemmerer depth sampler, Bacon Bomb, gravity corer.

C. **Tools**: Rubber mallet, bung wrench, speed wrench with socket, etc., (all non-sparking), paint marker.

D. **Heavy equipment**: Backhoe equipped with explosion shield, drum grappler, and 3-foot copper-beryllium (non-sparking) spike with 6-inch collar (to puncture top of drums for sampling, if necessary).

E. **Sample Containers**: As specified in the field sampling plan.

V. Procedures

A. Drums

NOTE: DO NOT open more than one drum at a time. Each drum must be handled and sampled as a separate entity to reduce vapors in the sampling area.

1. Drums will be sampled on an area-by-area basis. Drums will be sampled after they have been placed in overpack drums but before they are transferred from the excavation to the onsite storage area.
2. Record, in logbook, all pertinent information from visual inspection of drum (e.g., physical condition, leaks, bulges, and labels). Label each drum with a unique identifying number.
3. If possible, stage drums for easy access.
4. If necessary, attach ground strap to drums and grounding point.
5. Remove any standing material (water, etc.) from container top.
6. Using non-sparking tools, carefully remove the bung or lid while monitoring air quality with appropriate instruments. If necessary (and as a last resort), the non-sparking spike affixed to the backhoe can also be used to puncture the drum for sampling. See Attachment D for method of drum opening. Record air-quality monitoring results.

7. When sampling a previously sealed vessel, a check should be made for the presence of bottom sludge. This is accomplished by measuring the depth to apparent bottom, then comparing it to the known interior depth.

8. Agitation to disrupt the layers and rehomogenize the sample is physically difficult and almost always undesirable. If the vessel is greater than 3 feet in depth (say, a 55-gallon drum), the appropriate sampling method is to slowly lower the sampling device (i.e., suction line of peristaltic pump, glass tube) in known increments of length. Discrete samples can be collected from various depths, then combined or analyzed separately. If the depth of the vessel is greater than the lift capacity of the pump, an at-depth water sampler, such as the Kemmerer or Bacon Bomb type, may be required.

9. Extract a representative sample from the drum using a glass rod, COLIWASA, Bacon Bomb, Kemmerer bottle, or gravity corer (See Attachments). Ensure that the entire depth of material is penetrated. Depending on the size of the opening of the drum, three to four takes should be collected from random locations across the drum surface, to ensure a representative sample. Any observed stratification must be recorded in logbook, including number and thickness of the layers and a conceptualized sketch.

10. Record a visual description of the sample (e.g., liquid, solid, color, viscosity, and percent layers).

11. When possible, sampling equipment (like glass tubes) should be expendable and be left inside the drum for disposal with drum contents, once sampling is completed.

12. Place lid, bung, cap, etc., back in place on drum. Tighten hand tight. If necessary, the sampling port can be sealed using a cork.

13. Wipe up spilled material with lab wipes. Wipe off sample containers.

14. Mark the drum with a unique sample identification number and date using a paint marker.

15. Samples will be handled as high hazard samples. Samples will be placed in containers defined according to the analytical needs, wiped clean, and then packed in paint cans for shipping. Packaging, labeling, and preparation for shipment procedures will follow procedures as specified in the field sampling plan.

B. Underground Storage Tanks

1. A sampling team of at least two people is required for sampling—one will collect samples, the other will relay required equipment and implements.

2. Sampling team will locate a sampling port on the tank. Personnel should be wearing appropriate protective clothing at this time and carrying sampling gear.
3. Do not attempt to climb down into tank. Sampling MUST BE accomplished from the top.
4. Collect a sample from the upper, middle, and lower section of the tank contents with one of the recommended sampling devices.
5. If compositing is necessary, ship samples to laboratory in separate containers for laboratory compositing.
6. Samples will be handled as hazardous. Samples will be placed in appropriate containers and packed with ice in a cooler. Packaging, labeling, and preparation for shipment will follow procedures specified in the field sampling plan.

C. Tank Trailers or Above-Ground Storage Tanks

1. A sampling team of two is required. One will collect samples, the other will relay required equipment and implements.
2. Samples will be collected through the manhole (hatch) on top of the tanker or the fill port. Do not open valves at the bottom. Before opening the hatch, check for a pressure gauge or release valve. Open the release valve slowly to bring the tank to atmospheric pressure.
3. If tank pressure is too great, or venting releases large amounts of toxic gas, discontinue venting and sampling immediately. Measure vented gas with organic vapor analyzer and explosimeter.
4. If no release valve exists, slowly loosen hatch cover bolts to relieve pressure in the tank. (Again, stop if pressure is too great.)
5. Once pressure in tank has been relieved, open the hatch and withdraw sample using one of the recommended sampling devices.
6. Sample each trailer compartment.
7. If compositing is necessary, ship samples to laboratory in separate containers for laboratory compositing.
8. Samples will be handled as hazardous. Samples will be placed in appropriate containers and packed with ice in a cooler. Packaging, labeling, and preparation for shipment will follow procedures specified in the field sampling plan.

D. Refer to Attachment B for procedures for sampling with appropriate devices as follows:

<u>Drum</u>

Glass tube – Procedure 1

COLIWASA — Procedure 2

Storage Tank and Tank Trailer

COLIWASA — Procedure 2
Bacon Bomb — Procedure 3
Gravity Corer — Procedure 4
(for bottom sludge)

VI. Contamination Control

Sampling tools, instruments, and equipment will be protected from sources of contamination prior to use and decontaminated after use as specified in SOP *Decontamination of Personnel and Equipment*. Liquids and materials from decontamination operations will be handled in accordance with the waste management plan. Sample containers will be protected from sources of contamination. Sampling personnel shall wear chemical resistant gloves when handling any samples. Gloves will be decontaminated or disposed of between samples.

VIII. Attachments

A. Collection of Liquid-Containerized Wastes Using Glass Tubes

B. Sampling Containerized Wastes Using the Composite Liquid Waste Sample (COLIWASA)

C. Sampling Containerized Wastes Using the Bacon Bomb Sampler

D. Gravity Corer for sampling Sludges in Large Containers

E. Construction of a Typical COLIWASA

F. Drum Opening Techniques and Equipment

IX. References

A Compendium of Superfund Field Operations Methods, EPA/540/P-87/001, U.S. Environmental Protection Agency, Washington, D.C., 1987.

Data Quality Objectives for Remedial Activities - Development Process, EPA/540/G-87/003, U.S. Environmental Protection Agency, Washington, D.C., 1987.

Annual Book of ASTM Standards, *Standard Recommended Practices for Sampling Industrial Chemicals*, ASTM-E-300, 1986.

Test Method for Evaluating Solid Waste, SW-846, Volume II, Field Methods, Second Edition, U.S. Environmental Protection Agency, Washington, D.C., 1982.

U.S. Environmental Protection Agency, *Characterization of Hazardous Waste Sites – A Method Manual: Volume II, Available Sampling Methods*, USEPA Environmental Monitoring Systems Laboratory, Las Vegas, EPA-600/4-84-076, December, 1984.

Environmental Surveillance Procedures, Quality Control Program, Martin Marietta Energy Systems, ESH/Sub/87-21706/1, Oak Ridge, TN, September 1988.

X. Field Checklist

_______ Sampling Instruments
_______ Tools
_______ Rubber Mallet
_______ Logbook
_______ Safety Glasses or Monogoggles
_______ Safety Shoes
_______ Ice/Cooler, as required
_______ Custody Seals, as required
_______ Chain-of-Custody Forms
_______ Drum Labels, as required
_______ Paint Marker, if drum sampling
_______ Black Indelible Pen
_______ Monitoring Instruments

_____ Labels
_____ Sampling and Analysis Plan
_____ Health and Safety Plan
_____ Decontamination Equipment
_____ Lab Wipes
_____ Lab Spatulas or Stainless Steel Spoons
_____ Chemical Preservatives, as required
_____ Appropriate Containers for Waste and Equipment
_____ Duct Tape
_____ Plastic Sheeting

Attachment A Collection of Liquid-Containerized Wastes Using Glass Tubes

Discussion

Liquid samples from opened containers (i.e., 55-gallon drums) are collected using lengths of glass tubing. The glass tubes are normally 122 centimeters long and 6 to 16 millimeters inside diameter. Larger diameter tubes may be used for more viscous fluids if sampling with the small diameter tube is not adequate. The tubing is broken and discarded in the container after the sample has been collected, eliminating difficult cleanup and disposal problems. This method should not be attempted with less than a two-person sampling team.

Uses

This method provides for a quick, relatively inexpensive means of collecting concentrated containerized wastes. The major disadvantage is from potential sample loss that is especially prevalent when sampling low-viscosity fluids. Splashing can also be a problem and proper protective clothing should always be worn.

Note: A flexible tube with an aspirator attached is an alternative method to the glass tube and allows various levels to be sampled discretely.

Procedures for Use

1. Remove cover from sample container.
2. Insert glass tubing almost to the bottom of the container. Tubing should be of sufficient length so that at least 30 centimeters extend above the top of the container.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Cap the top of the tube with a safety-gloved thumb or a stopper.
5. Carefully remove the capped tube from the drum. If the tube has passed through more than one layer, the boundary should be apparent in the glass tube.
6. Insert the bottom, uncapped end into the sample container.
7. Partially release the thumb or stopper on the top of the tube and allow the sample to slowly flow into the sample container. If separation of phases is desired, cap off tube before the bottom phase has completely emptied. It may be advisable to have an extra container for “waste,” so that the fluid on either side of the phase boundary can be directed into a separate container, allowing collection of pure phase liquids in the sample containers. The liquid remaining after the boundary fluid is removed is collected in yet a third container. NOTE: It is not necessary to put phases in separate containers if analysis of separate phases is not desired.
8. Repeat steps 2 through 6 if more volume is needed to fill the sample container.
9. Remove the tube from the sample container and replace the tube in the drum, breaking it, if necessary, in order to dispose of it in the drum.

Optional Method (if sample of bottom sludge is desired)

1. Remove the cover from the container opening.
2. Insert glass tubing slowly almost to the bottom of the container. Tubing should be of sufficient length so that at least 30 cm extends above the top of the container.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Gently push the tube towards the bottom of the drum into the sludge layer. Do not force it.
5. Cap the top of the tube with a safety-gloved thumb or stopper.
6. Carefully remove the capped tube from the drum and insert the uncapped end into the sample container.
7. Release the thumb or stopper on the top of the tube and allow the sample container to fill to approximately 90 percent of its capacity. If necessary, the sludge plug in the bottom of the tube can be dislodged with the aid of the stainless-steel laboratory spatula.
8. Repeat if more volume is needed to fill sample container and recap the tube.

Note:

1. If a reaction is observed when the glass tube is inserted (violent agitation, smoke, light, etc.), the investigators should leave the area immediately.
2. If the glass tube becomes cloudy or smoky after insertion into the drum, the presence of hydrofluoric acid maybe indicated, and a comparable length of rigid plastic tubing should be used to collect the sample.
3. When a solid is encountered in a drum (either layer or bottom sludge) the optional method described above may be used to collect a core of the material, or the material may be collected with a disposable scoop attached to a length of wooden or plastic rod.

Attachment B: Sampling Containerized Wastes using the Composite Liquid Waste Sampler (COLIWASA)

Discussion

The COLIWASA is a much-cited sampler designed to permit representative sampling of multiphase wastes from drums and other containerized wastes. The sampler is commercially available or can be easily fabricated from a variety of materials, including PVC, glass, or Teflon. In its usual configuration it consists of a 152 cm by 4 cm (inside diameter) section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper. See Attachment E: Construction of a COLIWASA.

Uses

The COLIWASA is primarily used to sample containerized liquids. The PVC COLIWASA is reported to be able to sample most containerized liquid wastes except for those containing ketones, nitrobenzene, dimethylforamide, mesityloxide, and tetrahydrofuran. A glass COLIWASA is able to handle all wastes unable to be sampled with the plastic unit except strong alkali and hydrofluoric acid solutions. Due to the unknown nature of many containerized wastes, it would therefore be advisable to eliminate the use of PVC materials and use samplers composed of glass or Teflon.

The major drawback associated with using a COLIWASA is concern for decontamination and costs. The sampler is difficult, if not impossible, to decontaminate in the field, and its high cost in relation to alternative procedures (glass tubes) makes it an impractical throwaway item. It still has applications, however, especially in instances where a true representation of a multiphase waste is absolutely necessary.

Procedures for Use

1. Check to make sure the sampler is functioning properly. Adjust the locking mechanism, if present, to make sure the neoprene rubber stopper provides a tight closure.

2. Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler’s locking block.

3. Slowly lower the sampler into the liquid waste. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a non-representative sample.

4. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.

5. Slowly withdraw the sampler from the waste container with one hand while wiping the sampler tube with a laboratory wipe with the other hand. A phase boundary, if present, can be observed through the tube.

6. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.

7. Unscrew the T-handle of the sampler and disengage the locking block.

Attachment C: Sampling Containerized Wastes using the Bacon Bomb Sampler

Discussion

The Bacon Bomb is designed for the withdrawal of samples from various levels within a storage tank. It consists of a cylindrical body with an internal tapered plunger that acts as a valve to admit the sample. A line attached to the top of the plunger is used to open and close the valve. A removable cover provides a point of attachment for the sample line and has a locking mechanism to keep the plunger closed after sampling. The Bacon Bomb is usually constructed of chrome-plated brass and bronze with a rubber O-ring acting as the plunger-sealing surface. Stainless steel versions are also available. The volumemetric capacity is 8, 16, or 32 oz (237, 473, or 946 ml).

Uses

The Bacon Bomb is a heavy sampler suited best for viscous materials held in large storage tanks or in lagoons. If a more non-reactive sampler is needed, the stainless steel version would be used, or any of the samplers could be coated with Teflon.

Procedures for Use

1. Attach the sample line and the plunger line to the sampler.
2. Measure and then mark the sampling line at the desired depth.
3. Gradually lower the sampler by the sample line until the desired level is reached.
4. When the desired level is reached, pull up on the plunger line and allow the sampler to fill for a sufficient length of time before releasing the plunger line to seal off the sampler.
5. Retrieve the sampler by the sample line, being careful not to pull up on the plunger line, thereby accidentally opening the bottom valve.
6. Wipe off the exterior of the sampler body.
7. Position the sampler over the sample container and release its contents by pulling up on the plunger line.

Attachment D: Gravity Corer for Sampling Sludges in Large Containers

Discussion

A gravity corer is a metal tube with a replaceable tapered nosepiece on the bottom and a ball or other type of check valve on the top. The check valve allows water to pass through the corer on descent but prevents a washout during recovery. The tapered nosepiece facilitates cutting and reduces core disturbance during penetration. Most corers are constructed of brass or steel and many can accept plastic liners and additional weights.

Uses

Corers are capable of collecting samples of most sludges and sediments. They collect essentially undisturbed samples that represent the strata profile that may develop in sediments and sludges during variations in the deposition process. Depending on the density of the substrate and the weight of the corer, penetration to depths of 75 cm (30 in.) can be attained. Exercise care when using gravity corers in vessels or lagoons that have liners because penetration depths could exceed those of the substrate; this could result in damage to the liner material.

Procedures for Use

1. Attach a precleaned corer to the required length of sample line. Solid braided 5-mm (3/16-in.) nylon line is sufficient; however, 20-mm (3/4-in.) nylon is easier to grasp during hand hoisting. An additional weight can be attached to the outside of the corer if necessary.
2. Secure the free end of the line to a fixed support to prevent accidental loss of the corer.
3. Allow corer to free fall through the liquid to the bottom.
4. Retrieve corer with a smooth, continuous, up-lifting motion. Do not bump corer because this may result in some sample loss.
5. Remove nosepiece from corer and slide sample out of corer into stainless steel or Teflon pan (preferred).
6. Transfer sample into appropriate sample bottle with a stainless steel lab spoon or laboratory spatula.

Attachment E: Construction of a Typical COLIWASA

The sampling tube consists of a 1.52-m (5-ft) by 4.13-cm (1-5/8 in) I.D. translucent plastic pipe, usually polyvinyl chloride (PVC) or borosilicate glass plumbing tube. The closure-locking mechanism consists of a short-length, channeled aluminum bar attached to the sampler's stopper rod by an adjustable swivel. The aluminum bar serves both as a T-handle and lock for the samplers' closure system. When the sampler is in the open position, the handle is placed in the T-position and pushed down against the locking block. This manipulation pushes out the neoprene stopper and opens at the sampling tube. In the closed position, the handle is rotated until one leg of the T is squarely perpendicular against the locking block. This tightly seats the neoprene stopper against the bottom opening of he sampling tube and positively locks the sampler in the closed position. The closure tension can be adjusted by shortening or lengthening the stopper rod by screwing it in or out of the T-handle swivel. The closure system of the sampler consists of a sharply tapered neoprene stopper attached to a 0.95-cm (3/8-in) O.D. rod, usually PVC. The upper end of the stopper rod is connected to the swivel of the aluminum T-handle. The sharply tapered neoprene stopper can be fabricated according to specifications by plastic-products manufacturers at an extremely high price, or it can be made in-house by grinding down the inexpensive stopper with a shop grinder.

COLIWASA samplers are typically made out of plastic or glass. The plastic type consists of translucent plastic (usually PVC) sampling tube. The glass COLIWASA uses borosilicate glass plumbing pipe as the sampling tube and a Teflon plastic stopper rod. For purpose of multiphase sampling, clear plastic or glass is desirable in order to observe the profile of the multiphase liquid.

The sampler is assembled as follows:

a. Attach the swivel to the T-handle with the 3.18-cm (1-1/4 in) long bolt and secure with the 0.48-cm (3/16-in) National Coarse (NC) washer and lock nut.

b. Attach the PFTE stopper to one end of the stopper rod and secure with the 0.95-cm (3/8-in) washer and lock nut.

c. Install the stopper and stopper rod assembly in the sampling tube.

d. Secure the locking block sleeve on the block with glue or screw. This block can also be fashioned by shaping a solid plastic rod on a lathe to the required dimension.

e. Position the locking block on top of the sampling tube such that the sleeveless portion of the block fits inside the tube, the sleeve sits against the top end of the tube, and the upper end of the stopper rod slips though the center hole of the block.

f. Attach the upper end of the stopper rod to the swivel of the T-handle.

g. Place the sampler in the close position and adjust the tension on the stopper by screwing the T-handle in or out.

Attachment F: Drum Opening Techniques and Equipment [1]

I. Introduction

The opening of closed drums prior to sampling entails considerable risk if not done with the proper techniques, tools, and safety equipment. The potential for vapor exposure, skin exposure due to splash or spraying, or even explosion resulting from sparks produced by friction of the tools against the drum, necessitate caution when opening any closed container. Both manual drum opening and remote drum opening will be discussed in the following paragraphs. When drums are opened manually risks are greater than when opened remotely; for this reason, the remote opening of drums is advised whenever possible.

Prior to sampling, the drums should be staged to allow easy access. Also, any standing water or other material should be removed from the container top so that the representative nature of the sample is not compromised when the container is opened. There is also the possibility of encountering a water-reactive substance.

II. Manual Drum Opening

A. Bung Wrench

A common method for opening drums manually is using a universal bung wrench. These wrenches have fittings made to remove nearly all commonly encountered bungs. They are usually constructed of cast iron, brass, or a bronze-beryllium (a non-sparking alloy formulated to reduce the likelihood of sparks). The use of bung wrenches marked “NON SPARKING” is encouraged. However, the use of a “NON SPARKING” wrench does not completely eliminate the possibility of spark being produced. Such a wrench only prevents a spark caused by wrench-to-bung friction, but it cannot prevent sparking between the threads on the drum and the bung.

A simple tool to use, the fitting on the bung wrench matching the bung to be removed is inserted into the bung and the tool is turned counterclockwise to remove the bung. Since the contents of some drums may be under pressure (especially, when the ambient temperature is high), the bung should be turned very slowly. If any hissing is heard, the person opening the drum should back off and wait for the hissing to stop. Since drums under pressure can spray out liquids when opened, the wearing of appropriate eye and skin protection in addition to respiratory protection is critical.

B. Drum Deheader

One means by which a drum can be opened manually when a bung is not removable with a bung wrench is by using a drum deheader. This tool is constructed of forged steel with an alloy steel blade and is designed to cut the lid of a drum off or part way

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[1] Taken from EPA Training Course: “Sampling for Hazardous Materials,” U.S. Environmental Protection Agency, Office of Emergency and Remedial Response Support Division, March 24, 1987.

off by means of a scissors-like cutting action. A limitation of this device is that it can be attached only to closed head drums (i.e., DOT Specification 17E and 17F drums); drums with removable heads must be opened by other means.

Drums are opened with a drum deheader by first positioning the cutting edge just inside the top chime and then tightening the adjustment screw so that the deheader is held against the side of the drum. Moving the handle of the deheader up and down while sliding the deheader along the chime will enable the entire top to be rapidly cut off if so desired. If the top chime of a drum has been damaged or badly dented it may not be possible to cut the entire top off. Since there is always the possibility that a drum may be under pressure, the initial cut should be made very slowly to allow for the gradual release of any built-up pressure. A safer technique would be to employ a remote pressure release method prior to using the deheader.

C. Hand Pick or Spike

When a drum must be opened and neither a bung wrench nor a drum deheader is suitable, then it can be opened for sampling by using a hand pick, pickaxe, or spike. These tools are usually constructed of brass or a non-sparking alloy with a sharpened point that can penetrate the drum lid or head when the tool is swung. The hand picks or pickaxes that are most commonly used are commercially available, whereas the spikes are generally uniquely fabricated 4- foot long poles with a pointed end. Often the drum lid or head must be hit with a great deal of force in order to penetrate it. Because of this, the potential for splash or spraying is greater than with other opening methods and therefore this method of drum opening is not recommended, particularly when opening drums containing liquids. Some spikes used for drum opening have been modified by the addition of a circular splash plate near the penetrating end. This plate acts as a shield and reduces the amount of splash in the direction of the person using the spike. Even with this shield, good splash gear is essential.

Since drums, some of which may be under pressure, cannot be opened slowly with these tools, “sprayers” may result and appropriate safety measures must be taken. The pick or spike should be decontaminated after each drum is opened to avoid cross contamination and/or adverse chemical reaction from incompatible materials.

III. Remote Opening

A. Backhoe Spike

The most common means used to open drums remotely for sampling is the use of a metal spike attached or welded to a backhoe bucket. In addition to being very efficient, this method can greatly reduce the likelihood of personnel exposure.

Drums should be “staged,” or placed in rows with adequate aisle space to allow ease in backhoe maneuvering. Once staged, the drums can be quickly opened by punching a hole in the drum head or lid with the spike.

The spike should be decontaminated after each drum is opened to prevent cross contamination. Even though some splash or spray may occur when this method is used, the operator of the backhoe can be protected by mounting a large shatter-resistant shield in front of the operator's cage. This, combined with the normal sampling safety gear, should be sufficient to protect the operator. Additional respiratory protection can be afforded by providing the operator with an on-board airline system. The hole in the drum can be sealed with a cork.

B. Hydraulic Devices

Recently, remotely operated hydraulic devices have been fabricated to open drums remotely. One such device is discussed here. This device uses hydraulic pressure to pierce through the wall of a drum. It consists of a manually operated pump that pressurizes oil through a length of hydraulic line. A piercing device with a metal point is attached to the end of this line and is pushed into the drum by the hydraulic pressure. The piercing device can be attached so that a hole for sampling can be made in either the side or the head/lid of the drum. Some of the metal piercers are hollow or tube-like so that they can be left in place, if desired, and serve as a permanent tap or sampling port. The piercer is designed to establish a tight seal after penetrating the container.

C. Pneumatic Devices

Pneumatically-operated devices utilizing compressed air have been designed to remove drum bungs remotely. A pneumatic bung remover consists of a compressed air supply (usually SCBA cylinders) that is controlled by a heavy-duty, 2-stage regulator. A high pressure air line of desired length delivers compressed air to a pneumatic drill that is adapted to turn a bung fitting (preferably, a bronze-beryllium alloy) selected to fit the bung to be removed. An adjustable bracketing system has been designed to position and align the pneumatic drill over the bung. This bracketing system must be attached to the drum before the drill can be operated. Once the bung has been loosened, the bracketing system must be removed before the drum can be sampled. This attachment and removal procedure is time- consuming and is the major drawback of this device. This remote bung opener does not permit the slow venting of the container, and therefore appropriate precautions must be taken. It also requires the container to be upright and relatively level. Bungs that are rusted shut cannot be removed with this device.

IV. Summary

The opening of closed containers is one of the most hazardous site activities. Maximum efforts would be made to ensure the safety of the sampling team. Proper protective equipment and a general wariness of the possible dangers will minimize the risk inherent to sampling operations. Employing proper drum opening techniques and equipment will also safeguard personnel. The use of remote sampling equipment whenever feasible is highly recommended.

STANDARD OPERATING PROCEDURE – Navy CLEAN PROGRAM

Management of Liquid Waste Containing Per- and Polyfluoroalkyl Substances (PFAS)

I. Purpose and Scope

This SOP provides guidelines for managing waste containing per- and polyfluoalklyl substances (PFAS) in accordance with the *Interim Per- and Polyfluoralkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)/September 2017 Update* (guidance). This SOP should be used in conjunction with an Environmental and/or Waste Management Plan (EMP and/or WMP) approved by your Environmental Manager (EM). If you do not have a site-specific EMP, please contact your EM.

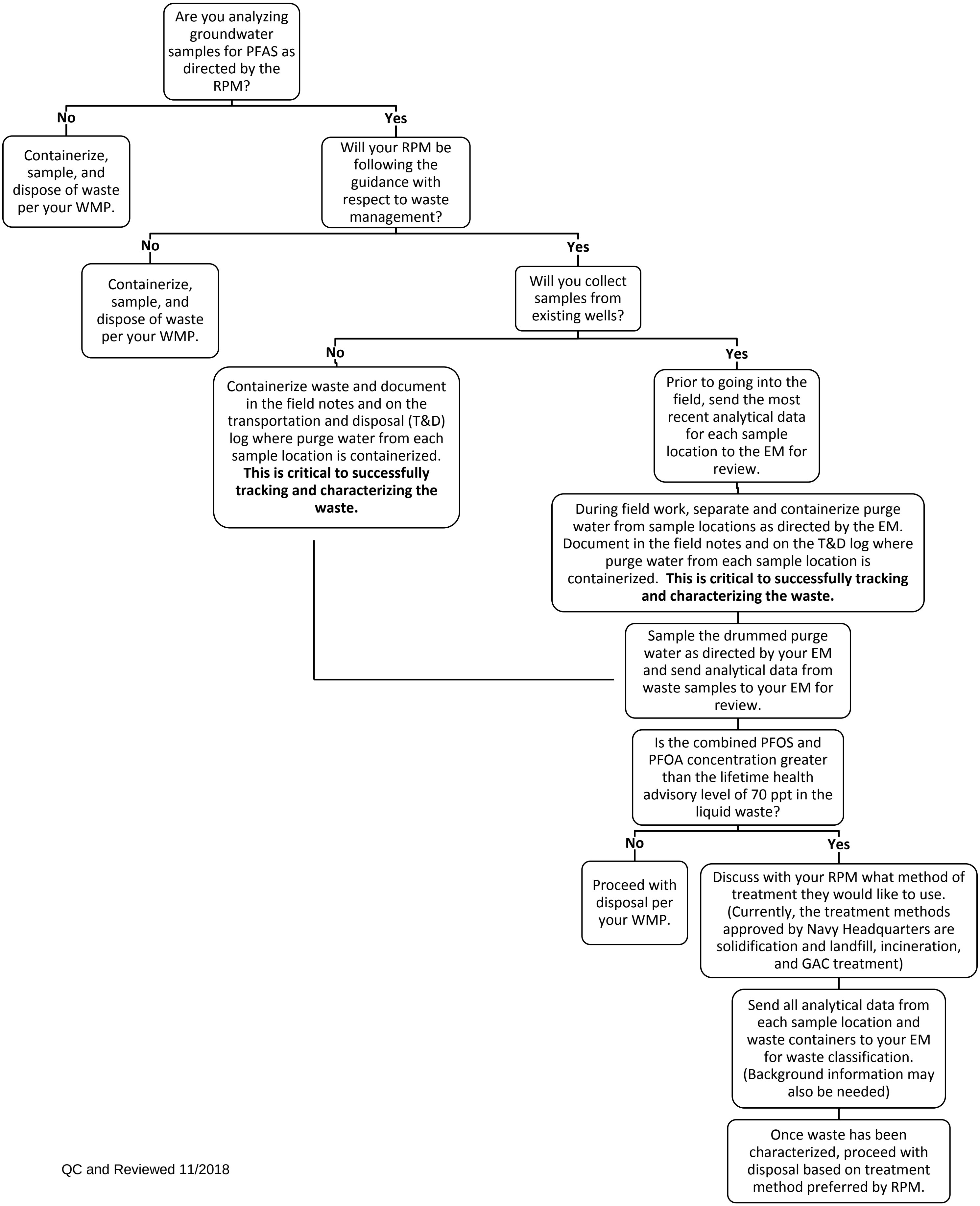
Standard procedures for managing liquid waste during PFAS investigation are summarized. These procedures are specific to the Navy Comprehensive Long-term Environmental Action Navy (CLEAN) Program under Contract N62470-16-D-9000.

Currently, PFAS are not regulated as a hazardous waste in US EPA regulations (state and territory rules may vary). Treatment of liquid waste containing PFAS, as recommended by the guidance, is a client directed action. When and how it is implemented will be left to the discretion of the individual RPMs. These project specific actions will be communicated with the Project Manager (PM) and/or Activity Manager (AM).

II. Procedures and Guidelines

The following flowchart outlines the procedures required to manage liquid waste during PFAS investigations. Any deviations from this procedure must be approved by the EM.

ch2m



Are you analyzing groundwater samples for PFAS as directed by the RPM?

No

Containerize, sample, and dispose of waste per your WMP.

Yes

Will your RPM be following the guidance with respect to waste management?

No

Containerize, sample, and dispose of waste per your WMP.

Yes

Will you collect samples from existing wells?

No

Containerize waste and document in the field notes and on the transportation and disposal (T&D) log where purge water from each sample location is containerized. **This is critical to successfully tracking and characterizing the waste.**

Yes

Prior to going into the field, send the most recent analytical data for each sample location to the EM for review.

During field work, separate and containerize purge water from sample locations as directed by the EM. Document in the field notes and on the T&D log where purge water from each sample location is containerized. **This is critical to successfully tracking and characterizing the waste.**

Sample the drummed purge water as directed by your EM and send analytical data from waste samples to your EM for review.

Is the combined PFOS and PFOA concentration greater than the lifetime health advisory level of 70 ppt in the liquid waste?

No

Proceed with disposal per your WMP.

Yes

Discuss with your RPM what method of treatment they would like to use. (Currently, the treatment methods approved by Navy Headquarters are solidification and landfill, incineration, and GAC treatment)

Send all analytical data from each sample location and waste containers to your EM for waste classification. (Background information may also be needed)

Once waste has been characterized, proceed with disposal based on treatment method preferred by RPM.

QC and Reviewed 11/2018

STANDARD OPERATING PROCEDURE

Aquifer Slug Testing

I. Purpose and Scope

The purpose of this procedure is to outline the equipment and methods that will be used to perform variable-head tests ("slug" tests) on piezometers and monitoring wells. The guidance covers use of both air and solid displacement methods.

II. Equipment and Materials

- In-Situ data loggers or equivalent
- Well-testing assembly
  - packer
  - fittings for pressure transducers
  - fittings for air supply
  - release valve
- Compressed air
- Computer and associated equipment
- Solid displacement device with rope

III. Procedures and Guidelines

The tests to be performed are rising head tests. The tests are accomplished by lowering the head of water in the well and monitoring the recovery of the water level to the static water level. The water level will be lowered by one of two methods. One method is the use of an air displacement device. Alternatively, a solid displacement device removed from the well will be used.

The air displacement apparatus consists of a packer assembly, fittings to accommodate transducers and air pressurization, and a pressure-release valve. The packer is lowered into the upper portion of the monitoring well, secured in place and inflated, providing a seal between the apparatus and the inside of the well. Two fittings are provided for pressure transducers: one transducer is fed through the inside of the device and positioned below the water surface and the other is inserted to measure the air pressure inside the assembly. A third fitting is connected to the pressurized air supply, a compressed air tank.

The datalogger will be programmed to display the air pressure in units of head, the head measured by the submerged transducer, and the difference between the two. The difference between the two pressure transducers is the height of the water column on the submerged transducer. The readings are recorded in a field notebook, and then the assembly is pressurized. The air pressure applied will be equivalent to 3 to 7 feet of head. The pressures are allowed to stabilize. The pressure of the air should not lower the water level to below the base of the bentonite seal installed in the well.

Each test is started by releasing the air pressure inside the assembly and allowing the water level to rise to the static water level. When the datalogger perceives a change in water level in the well above a preset trigger amount, it automatically begins to record the water levels and elapsed time. Alternatively, the datalogger can be started manually just prior to injection of air. Each test will be terminated when the water level has recovered to at least 90 percent of the original equilibrium level before pressurization. Note that the test method cannot be used if the well is screened across or near the water table.

An alternate method of lowering the water level is to use a solid displacement device. A single transducer will be installed in the well below the water table. A weighted solid displacement device is added to the well and the water level allowed to stabilize at the original static water level. The test is started by rapidly removing the displacement device, which causes a drop in the water level. The data logger begins recording the water level and elapsed time when the preset trigger amount is reached. Readings are taken as above, and the test stopped when the well has recovered to 90 percent of the original level.

At least two valid tests will be performed in each well. Additional tests will be required if there is some evidence that any of the tests were unacceptable.

At the end of each test, the test results will be transferred to a laptop and the data downloaded and checked for preliminary completeness.

IV. Attachments

None.

V. Key Checks and Preventive Maintenance

- Check that the packer assembly is in good condition and not leaking. Provide a repair kit including tape and clamps. Take additional packer assembly and other spare parts.
- Check the batteries for the datalogger and computer. Check that the computer disks containing the programs for the datalogger are packed.
- Check the datalogger calculation of the well hydraulic conductivity at the end of each test to determine if these are consistent with expectations.

Appendix B
Laboratory DoD ELAP Accreditation Letter

PERRY JOHNSON LABORATORY ACCREDITATION, INC.

Certificate of Accreditation

Perry Johnson Laboratory Accreditation, Inc. has assessed the Laboratory of:

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061

(Hereinafter called the Organization) and hereby declares that Organization has met the requirements of ISO/IEC 17025:2005 "General Requirements for the competence of Testing and Calibration Laboratories" and the DoD Quality Systems Manual for Environmental Laboratories Version 5.1.1 February 2018 and is accredited is accordance with the:

United States Department of Defense Environmental Laboratory Accreditation Program (DoD-ELAP)

This accreditation demonstrates technical competence for the defined scope:

Environmental Testing

(As detailed in the supplement)

Accreditation claims for such testing and/or calibration services shall only be made from addresses referenced within this certificate. This Accreditation is granted subject to the system rules governing the Accreditation referred to above, and the Organization hereby covenants with the Accreditation body's duty to observe and comply with the said rules.

For PJLA:

Tracy Szerszen

Tracy Szerszen
President/Operations Manager

Initial Accreditation Date:	*Issue Date:*	*Expiration Date:*
November 17, 2016	December 20, 2018	February 28, 2021
Revision Date:	*Accreditation No.:*	*Certificate No.:*
January 22, 2019	91667	L18-588-R1

Perry Johnson Laboratory
Accreditation, Inc. (PJLA)
755 W. Big Beaver, Suite 1325
Troy, Michigan 48084

The validity of this certificate is maintained through ongoing assessments based on a continuous accreditation cycle. The validity of this certificate should be confirmed through the PJLA website: www.pjlabs.com

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Drinking Water	EPA 537.1	LC/MS/MS	4,8-dioxa-3H-perfluorononanoic acid (ADONA)
Drinking Water	EPA 537.1	LC/MS/MS	9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)
Drinking Water	EPA 537.1	LC/MS/MS	11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)
Drinking Water	EPA 537.1	LC/MS/MS	Hexafluoropropylene oxide dimer acid (HFPO-DA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-hexanoic acid (PFHxA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-heptanoic Acid (PFHpA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-octanoic Acid (PFOA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluorononanoic acid (PFNA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-decanoic Acid (PFDA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-undecanoic acid (PFUnA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-dodecanoic acid (PFDoA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-tridecanoic acid (PFTrDA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-n-tetradecanoic acid (PFTeDA)
Drinking Water	EPA 537.1	LC/MS/MS	N-methylperfluoro-1-octanesulfonamidoacetic acid (NMeFOSAA)
Drinking Water	EPA 537.1	LC/MS/MS	N-ethylperfluoro-octanesulfonamidoacetic acid (NEtFOSAA)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-1-butanesulfonic Acid (PFBS)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-1-hexanesulfonic Acid (PFHxS)
Drinking Water	EPA 537.1	LC/MS/MS	Perfluoro-1-octanesulphonic Acid (PFOS)
Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-1-octanesulfonamide (PFOSA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Sodium perfluoro-1-pentanesulfonate (PFPeS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-1-nonanesulfonate (PFNS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-1-heptanesulfonate (PFHpS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	N-ethylperfluoro-octanesulfonamidoacetic acid (NEtFOSAA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	1H,1H,2H,2H-Perfluorohexane sulfonate (4:2FTS)

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	1H,1H,2H,2H-Perfluorooctane sulfonate (6:2FTS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	1H,1H,2H,2H-Perfluorodecane sulfonate (8:2FTS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-butanoic Acid (PFBA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-pentanoic acid (PFPeA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-hexanoic acid (PFHxA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-heptanoic Acid (PFHpA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-octanoic Acid (PFOA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluorononanoic acid (PFNA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-decanoic Acid (PFDA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-undecanoic acid (PFUnA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-dodecanoic acid (PFDoA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-tridecanoic acid (PFTrDA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-n-tetradecanoic acid (PFTeDA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	N-methylperfluoro-1-octanesulfonamidoacetic acid (NMeFOSAA)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-1-butanesulfonic Acid (PFBS)

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-1-hexanesulfonic Acid (PFHxS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-1-octanesulphonic Acid (PFOS)
Aqueous/Solids/Tissues	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoro-1-decanesulfonate (PFDS)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,3',4,4'-Hexachlorobiphenyl (BZ 128)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,3',4,5-Hexachlorobiphenyl (BZ 129)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,4',5,5'-Heptachlorobiphenyl (BZ 180)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,4',5',6-Heptachlorobiphenyl (BZ 183)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,4',5'-Hexachlorobiphenyl (BZ 138)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,4',6,6'-Heptachlorobiphen yl (BZ 184)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4',5,5',6-Heptachlorobiphenyl (BZ 187)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,4,5'-Pentachlorobiphenyl (BZ 87)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',3,5'-Tetrachlorobiphenyl (BZ 44)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',4,4',5,5'-Hexachlorobiphenyl (BZ 153)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',4,5,5'-Pentachlorobiphenyl (BZ 101)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',4,5'-Tetrachlorobiphenyl (BZ 49)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',5,5'-Tetrachlorobiphenyl (BZ 52)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,2',5-Trichlorobiphenyl (BZ 18)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,3,3',4,4'-Pentachlorobiphenyl (BZ 105)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,3,3',4',6-Pentachlorobiphenyl (BZ 110)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,3',4,4',5-Pentachlorobiphenyl (BZ 118)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,3',4,4'-Tetrachlorobiphenyl (BZ 66)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4,4'-Trichlorobiphenyl (BZ 28)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4'-DDD
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4'-DDE
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4'-DDT
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	2,4'-Dichlorobiphenyl (BZ 8)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	3,3',4,4',5,5'-Hexachlorobiphenyl (BZ 169)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	3,3',4,4',5-Pentachlorobiphenyl (BZ 126)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	3,3',4,4'-Tetrachlorobiphenyl (BZ 77)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	4,4'-DDD
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	4,4'-DDE
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	4,4'-DDT

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Aldrin
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	alpha-BHC (alpha-Hexachlorocyclohexane)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	alpha-Chlordane
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	beta-BHC (beta-Hexachlorocyclohexane)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Chlorpyrifos
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	cis-Nonachlor
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Decachlorobiphenyl (BZ 209)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	delta-BHC
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Dieldrin
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endosulfan II
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endosulfan I
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endosulfan sulfate
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endrin
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endrin aldehyde
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Endrin ketone
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	gamma-BHC (Lindane, gamma-Hexachlorocyclohexane)
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	gamma-Chlordane
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Heptachlor
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Heptachlor epoxide
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Hexachlorobenzene
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Methoxychlor
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Mirex
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	Oxychlordane
Aqueous/Solid/Tissue	EPA 8081 MOD	GC-ECD	trans-Nonachlor
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	1,4-Dichlorobenzene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	1-Methylnaphthalene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	1-Methylphenanthrene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (BZ 206)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,4',5,5'-Octachlorobiphenyl (BZ 194)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,4',5,6,6'-Nonachlorobiphenyl (BZ 207)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,4',5,6-Octachlorobiphenyl (BZ 195)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,4',5-Heptachlorobiphenyl (BZ 170)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,4',6,6'-Octachlorobiphenyl (BZ 197)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,4',6-Heptachlorobiphenyl (BZ 171)

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,4'-Hexachlorobiphenyl (BZ 128)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl (BZ 208)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5,5',6-Octachlorobiphenyl (BZ 198)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5,5',6'-Octachlorobiphenyl (BZ 199)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5,5'-Heptachlorobiphenyl (BZ 172)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5,6,6'-Octachlorobiphenyl (BZ 200)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5',6,6'-Octachlorobiphenyl (BZ 201)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5,6-Heptachlorobiphenyl (BZ 173)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5,6'-Heptachlorobiphenyl (BZ 174)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5',6-Heptachlorobiphenyl (BZ 175)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5',6'-Heptachlorobiphenyl (BZ 177)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,5'-Hexachlorobiphenyl (BZ 130)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,6,6'-Heptachlorobiphenyl (BZ 176)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4,6-Hexachlorobiphenyl (BZ 131)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',4-Pentachlorobiphenyl (BZ 82)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',5,5',6,6'-Octachlorobiphenyl (BZ 202)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',5,5',6-Heptachlorobiphenyl (BZ 178)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',5,6,6'-Heptachlorobiphenyl (BZ 179)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',5,6-Hexachlorobiphenyl (BZ 134)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',5,6'-Hexachlorobiphenyl (BZ 135)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',5-Pentachlorobiphenyl (BZ 83)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',6,6'-Hexachlorobiphenyl (BZ 136)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3',6-Pentachlorobiphenyl (BZ 84)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,3'-Tetrachlorobiphenyl (BZ 40)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4',5,5',6-Octachlorobiphenyl (BZ 203)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4',5,5'-Heptachlorobiphenyl (BZ 180)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4',5',6-Heptachlorobiphenyl (BZ 183)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4',5-Hexachlorobiphenyl (BZ 137)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4',5'-Hexachlorobiphenyl (BZ 138)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4',6,6'-Heptachlorobiphenyl (BZ 184)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4',6-Hexachlorobiphenyl (BZ 139)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4',6'-Hexachlorobiphenyl (BZ 140)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,4'-Pentachlorobiphenyl (BZ 85)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,5,5',6-Heptachlorobiphenyl (BZ 185)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4',5,5',6-Heptachlorobiphenyl (BZ 187)

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ISO/IEC 17025:2005 and DoD-ELAP

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,5,5'-Hexachlorobiphenyl (BZ 141)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4',5,5'-Hexachlorobiphenyl (BZ 146)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4',5,6,6'-Heptachlorobiphenyl (BZ 188)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4',5',6-Hexachlorobiphenyl (BZ 149)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,5',6-Hexachlorobiphenyl (BZ 144)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4,5'-Pentachlorobiphenyl (BZ 87)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4',5'-Pentachlorobiphenyl (BZ 97)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4',6-Pentachlorobiphenyl (BZ 91)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4-Tetrachlorobiphenyl (BZ 41)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,4'-Tetrachlorobiphenyl (BZ 42)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,5,5',6-Hexachlorobiphenyl (BZ 151)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,5,5'-Pentachlorobiphenyl (BZ 92)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,5',6-Pentachlorobiphenyl (BZ 95)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,5-Tetrachlorobiphenyl (BZ 43)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,5'-Tetrachlorobiphenyl (BZ 44)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,6'-Tetrachlorobiphenyl (BZ 46)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3,6-Tetrachlorobiphenyl (BZ 45)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',3-Trichlorobiphenyl (BZ 16)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,4',5,5'-Hexachlorobiphenyl (BZ 153)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,4',5,6'-Hexachlorobiphenyl (BZ 154)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,4',5-Pentachlorobiphenyl (BZ 99)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,4',6,6'-Hexachlorobiphenyl (BZ 155)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,4',6-Pentachlorobiphenyl (BZ 100)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,4'-Tetrachlorobiphenyl (BZ 47)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,5,5'-Pentachlorobiphenyl (BZ 101)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,5-Tetrachlorobiphenyl (BZ 48)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,5'-Tetrachlorobiphenyl (BZ 49)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,6,6'-Pentachlorobiphenyl (BZ 104)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,6'-Tetrachlorobiphenyl (BZ 51)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4,6-Tetrachlorobiphenyl (BZ 50)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',4-Trichlorobiphenyl (BZ 17)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',5,5'-Tetrachlorobiphenyl (BZ 52)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',5,6'-Tetrachlorobiphenyl (BZ 53)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',5-Trichlorobiphenyl (BZ 18)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',6,6'-Tetrachlorobiphenyl (BZ 54)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2',6-Trichlorobiphenyl (BZ 19)

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,2'-Dichlorobiphenyl (BZ 4)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4,4',5,5',6-Octachlorobiphenyl (BZ 205)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4,4',5,5'-Heptachlorobiphenyl (BZ 189)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4,4',5,6-Heptachlorobiphenyl (BZ 190)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4,4',5',6-Heptachlorobiphenyl (BZ 191)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4,4',5-Hexachlorobiphenyl (BZ 156)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4,4',5'-Hexachlorobiphenyl (BZ 157)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4,4',6-Hexachlorobiphenyl (BZ 158)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4,4'-Pentachlorobiphenyl (BZ 105)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4',5,5',6-Heptachlorobiphenyl (BZ 193)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4',5,6-Hexachlorobiphenyl (BZ 163)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4',5',6-Hexachlorobiphenyl (BZ 164)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4',6-Pentachlorobiphenyl (BZ 110)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,3',4'-Tetrachlorobiphenyl (BZ 56)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4,4',5,5'-Hexachlorobiphenyl (BZ 167)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,4,4',5,6-Hexachlorobiphenyl (BZ 166)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,4,4',5-Pentachlorobiphenyl (BZ 114)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4,4',5-Pentachlorobiphenyl (BZ 118)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4,4',5'-Pentachlorobiphenyl (BZ 123)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,4,4',6-Pentachlorobiphenyl (BZ 115)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,4,4'-Tetrachlorobiphenyl (BZ 60)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4,4'-Tetrachlorobiphenyl (BZ 66)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4',5,5'-Pentachlorobiphenyl (BZ 124)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4',5',6-Pentachlorobiphenyl (BZ 125)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,4',5-Tetrachlorobiphenyl (BZ 63)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4,5-Tetrachlorobiphenyl (BZ 67)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4',5-Tetrachlorobiphenyl (BZ 70)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,4',6-Tetrachlorobiphenyl (BZ 64)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4',6-Tetrachlorobiphenyl (BZ 71)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,4'-Trichlorobiphenyl (BZ 22)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4-Trichlorobiphenyl (BZ 25)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',4'-Trichlorobiphenyl (BZ 33)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',5-Trichlorobiphenyl (BZ 26)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,5-Trimethylnaphthalene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3,6-Trichlorobiphenyl (BZ 24)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3',6-Trichlorobiphenyl (BZ 27)

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3-Dichlorobiphenyl (BZ 5)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,3'-Dichlorobiphenyl (BZ 6)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4,4',5-Tetrachlorobiphenyl (BZ 74)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4,4',6-Tetrachlorobiphenyl (BZ 75)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4,4'-Trichlorobiphenyl (BZ 28)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4,5-Trichlorobiphenyl (BZ 29)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4',5-Trichlorobiphenyl (BZ 31)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4,6-Trichlorobiphenyl (BZ 30)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4',6-Trichlorobiphenyl (BZ 32)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4'-DDD
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4'-DDE
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4'-DDT
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4-Dichlorobiphenyl (BZ 7)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,4'-Dichlorobiphenyl (BZ 8)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,5-Dichlorobiphenyl (BZ 9)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2,6-Dimethylnaphthalene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2-Chlorobiphenyl (BZ 1)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2-Chloronaphthalene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2-Methylnaphthalene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	2-Methylphenanthrene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,3',4,4',5,5'-Hexachlorobiphenyl (BZ 169)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,3',4,4',5-Pentachlorobiphenyl (BZ 126)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,3',4,4'-Tetrachlorobiphenyl (BZ 77)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,3',4,5,5'-Pentachlorobiphenyl (BZ 127)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,3',5,5'-Tetrachlorobiphenyl (BZ 80)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,3'-Dichlorobiphenyl (BZ 11)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,4,4',5-Tetrachlorobiphenyl (BZ 81)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,4,4'-Trichlorobiphenyl (BZ 37)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,4-Dichlorobiphenyl (BZ 12)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,4'-Dichlorobiphenyl (BZ 13)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	3,6-Dimethylphenanthrene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	4,4'-Dichlorobiphenyl (BZ 15)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	4-Chlorobiphenyl (BZ 3)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Acenaphthene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Acenaphthylene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Anthracene

Certificate of Accreditation: Supplement

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Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Benzo(a)anthracene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Benzo(a)pyrene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Benzo(b)fluoranthene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Benzo(b)thiophene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Benzo(e)pyrene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Benzo(g,h,i)perylene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Benzo(k)fluoranthene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Biphenyl
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Chrysene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	cis-Decalin
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Decachlorobiphenyl (BZ 209)
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Dibenz(a,h)anthracene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Dibenzofuran
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Dibenzothiophene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Fluoranthene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Fluorene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	lndeno(l,2,3-cd)pyrene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Naphthalene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Perylene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Phenanthrene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	Pyrene
Aqueous/Solid/Tissue	EPA 8270D MOD	GC-MS	trans-Decalin

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Battelle

141 Longwater Drive, Suite 202, Norwell, MA 02061
Contact Name: Jonathan Thorn Phone: 781-681-5565

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 3510 C	Separatory Funnel	Prep
Aqueous	EPA 3640A MOD	Gel-permeation chromatography (GPC)	Cleanup
Aqueous	EPA 3660B MOD	Sulfur Cleanup	Cleanup
Solid	EPA 3640A MOD	Gel-permeation chromatography (GPC)	Cleanup
Solid	EPA 3660B MOD	Sulfur Cleanup	Cleanup
Solid	NOAA NOS ORCA 71	Orbital Shaker	Prep
Tissue	EPA 3640A MOD	Gel-permeation chromatography (GPC)	Cleanup
Tissue	EPA 3660B MOD	Sulfur Cleanup	Cleanup
Tissue	NOAA NOS ORCA 71	Tissuemizer	Prep

PERRY JOHNSON LABORATORY ACCREDITATION, INC.

Certificate of Accreditation

Perry Johnson Laboratory Accreditation, Inc. has assessed the Laboratory of:

Gulf Coast Analytical Laboratories, LLC

7979 Innovation Park Drive, Baton Rouge, LA 70820

(Hereinafter called the Organization) and hereby declares that Organization has met the requirements of ISO/IEC 17025:2005 "General Requirements for the competence of Testing and Calibration Laboratories" and the DoD Quality Systems Manual for Environmental Laboratories Version 5.1.1 February 2018 and is accredited is accordance with the:

United States Department of Defense Environmental Laboratory Accreditation Program (DoD-ELAP)

This accreditation demonstrates technical competence for the defined scope:

Environmental Testing

(As detailed in the supplement)

Accreditation claims for such testing and/or calibration services shall only be made from addresses referenced within this certificate. This Accreditation is granted subject to the system rules governing the Accreditation referred to above, and the Organization hereby covenants with the Accreditation body's duty to observe and comply with the said rules.

For PJLA:

Initial Accreditation Date:	*Issue Date:*	*Expiration Date:*
October 2, 2013	December 27, 2018	December 27, 2020

Accreditation No.:	*Certificate No.:*
74960	L18-597

Tracy Szerszen
President/Operations Manager

Perry Johnson Laboratory
Accreditation, Inc. (PJLA)
755 W. Big Beaver, Suite 1325
Troy, Michigan 48084

The validity of this certificate is maintained through ongoing assessments based on a continuous accreditation cycle. The validity of this certificate should be confirmed through the PJLA website: www.pjlabs.com

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Gulf Coast Analytical Laboratories, LLC

7979 Innovation Park Drive, Baton Rouge, LA 70820
Contact Name: Randy Whittington Phone: 225-769-4900

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 1664A	Gravimetric	Oil & Grease
Aqueous	EPA 200.8	ICP-MS	Aluminum
Aqueous	EPA 200.8	ICP-MS	Antimony
Aqueous	EPA 200.8	ICP-MS	Arsenic
Aqueous	EPA 200.8	ICP-MS	Barium
Aqueous	EPA 200.8	ICP-MS	Beryllium
Aqueous	EPA 200.8	ICP-MS	Cadmium
Aqueous	EPA 200.8	ICP-MS	Calcium
Aqueous	EPA 200.8	ICP-MS	Chromium
Aqueous	EPA 200.8	ICP-MS	Cobalt
Aqueous	EPA 200.8	ICP-MS	Copper
Aqueous	EPA 200.8	ICP-MS	Iron
Aqueous	EPA 200.8	ICP-MS	Lead
Aqueous	EPA 200.8	ICP-MS	Magnesium
Aqueous	EPA 200.8	ICP-MS	Manganese
Aqueous	EPA 200.8	ICP-MS	Molybdenum
Aqueous	EPA 200.8	ICP-MS	Nickel
Aqueous	EPA 200.8	ICP-MS	Potassium
Aqueous	EPA 200.8	ICP-MS	Selenium
Aqueous	EPA 200.8	ICP-MS	Silver
Aqueous	EPA 200.8	ICP-MS	Sodium
Aqueous	EPA 200.8	ICP-MS	Strontium
Aqueous	EPA 200.8	ICP-MS	Thallium
Aqueous	EPA 200.8	ICP-MS	Tin
Aqueous	EPA 200.8	ICP-MS	Titanium
Aqueous	EPA 200.8	ICP-MS	Total Hardness (as CaCO3)
Aqueous	EPA 200.8	ICP-MS	Vanadium
Aqueous	EPA 200.8	ICP-MS	Zinc
Aqueous	EPA 200.8	ICP-MS	Zirconium
Aqueous	EPA 245.2	CVAA	Mercury
Aqueous	EPA 300.0	IC	Bromide
Aqueous	EPA 300.0	IC	Chloride
Aqueous	EPA 300.0	IC	Fluoride
Aqueous	EPA 300.0	IC	Nitrate and Nitrite as N
Aqueous	EPA 300.0	IC	Nitrate as N
Aqueous	EPA 300.0	IC	Nitrite as N

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 300.0	IC	Sulfate
Aqueous	EPA 420.4	FIA	Total Phenolics (4AAP)
Aqueous	EPA 624	GC-MS	1,1,1,2-Tetrachloroethane
Aqueous	EPA 624	GC-MS	1,1,1-Trichloroethane
Aqueous	EPA 624	GC-MS	1,1,2,2-Tetrachloroethane
Aqueous	EPA 624	GC-MS	1,1,2-Trichloroethane
Aqueous	EPA 624	GC-MS	1,1-Dichloroethane
Aqueous	EPA 624	GC-MS	1,1-Dichloroethene
Aqueous	EPA 624	GC-MS	1,1-Dichloropropene
Aqueous	EPA 624	GC-MS	1,2 Dichlorobenzene
Aqueous	EPA 624	GC-MS	1,2 Dichloroethane
Aqueous	EPA 624	GC-MS	1,2,3-Trichlorobenzene
Aqueous	EPA 624	GC-MS	1,2,3-Trichloropropane
Aqueous	EPA 624	GC-MS	1,2,4-Trichlorobenzene
Aqueous	EPA 624	GC-MS	1,2,4-Trimethylbenzene
Aqueous	EPA 624	GC-MS	1,2-Dibromo-3-chloropropane (DBCP)
Aqueous	EPA 624	GC-MS	1,2-Dibromoethane (EDB)
Aqueous	EPA 624	GC-MS	1,2-Dichloropropane
Aqueous	EPA 624	GC-MS	1,3 Dichlorobenzene
Aqueous	EPA 624	GC-MS	1,3,5-Trimethylbenzene
Aqueous	EPA 624	GC-MS	1,3-Dichloropropane
Aqueous	EPA 624	GC-MS	1,4 Dichlorobenzene
Aqueous	EPA 624	GC-MS	2,2-Dichloropropane
Aqueous	EPA 624	GC-MS	2-Butanone (MEK)
Aqueous	EPA 624	GC-MS	2-Chloroethylvinylether
Aqueous	EPA 624	GC-MS	2-Chlorotoluene
Aqueous	EPA 624	GC-MS	2-Hexanone
Aqueous	EPA 624	GC-MS	4-Chlorotoluene
Aqueous	EPA 624	GC-MS	4-Methyl-2-pentanone (MIBK)
Aqueous	EPA 624	GC-MS	Acetone
Aqueous	EPA 624	GC-MS	Acetonitrile
Aqueous	EPA 624	GC-MS	Acrolein
Aqueous	EPA 624	GC-MS	Acrylonitrile
Aqueous	EPA 624	GC-MS	Benzene
Aqueous	EPA 624	GC-MS	Bromochloromethane
Aqueous	EPA 624	GC-MS	Bromodichloromethane

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Gulf Coast Analytical Laboratories, LLC

7979 Innovation Park Drive, Baton Rouge, LA 70820
Contact Name: Randy Whittington   Phone: 225-769-4900

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 624	GC-MS	Bromoform
Aqueous	EPA 624	GC-MS	Bromomethane
Aqueous	EPA 624	GC-MS	Carbon disulfide
Aqueous	EPA 624	GC-MS	Carbon tetrachloride
Aqueous	EPA 624	GC-MS	Chlorobenzene
Aqueous	EPA 624	GC-MS	Chloroethane
Aqueous	EPA 624	GC-MS	Chloroform
Aqueous	EPA 624	GC-MS	Chloromethane
Aqueous	EPA 624	GC-MS	cis-1,2-Dichloroethene
Aqueous	EPA 624	GC-MS	cis-1,3-Dichloropropylene
Aqueous	EPA 624	GC-MS	Dibromochloromethane
Aqueous	EPA 624	GC-MS	Dibromomethane
Aqueous	EPA 624	GC-MS	Dichlorodifluoromethane
Aqueous	EPA 624	GC-MS	Ethylbenzene
Aqueous	EPA 624	GC-MS	Hexachlorobutadiene
Aqueous	EPA 624	GC-MS	Isopropylbenzene
Aqueous	EPA 624	GC-MS	m+p-Xylene
Aqueous	EPA 624	GC-MS	Methyl tert-butyl ether (MTBE)
Aqueous	EPA 624	GC-MS	Methylene Chloride
Aqueous	EPA 624	GC-MS	Naphthalene
Aqueous	EPA 624	GC-MS	n-Butylbenzene
Aqueous	EPA 624	GC-MS	n-Propylbenzene
Aqueous	EPA 624	GC-MS	o-Xylene
Aqueous	EPA 624	GC-MS	p-Isopropyltoluene
Aqueous	EPA 624	GC-MS	sec-Butylbenzene
Aqueous	EPA 624	GC-MS	Styrene
Aqueous	EPA 624	GC-MS	tert-Butylbenzene
Aqueous	EPA 624	GC-MS	Tetrachloroethene
Aqueous	EPA 624	GC-MS	Toluene
Aqueous	EPA 624	GC-MS	trans-1,2-Dichloroethene
Aqueous	EPA 624	GC-MS	trans-1,3-Dichloropropene
Aqueous	EPA 624	GC-MS	Trichloroethene
Aqueous	EPA 624	GC-MS	Trichlorofluoromethane
Aqueous	EPA 624	GC-MS	Vinyl acetate
Aqueous	EPA 624	GC-MS	Vinyl chloride
Aqueous	EPA 624	GC-MS	Xylenes, total

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 625	GC-MS	1,2,4,5-Tetrachlorobenzene
Aqueous	EPA 625	GC-MS	1,2,4-Trichlorobenzene
Aqueous	EPA 625	GC-MS	1-Methylnaphthalene
Aqueous	EPA 625	GC-MS	2,3,4,6-Tetrachlorophenol
Aqueous	EPA 625	GC-MS	2,4,5-Trichlorophenol
Aqueous	EPA 625	GC-MS	2,4,6-Trichlorophenol
Aqueous	EPA 625	GC-MS	2,4-Dichlorophenol
Aqueous	EPA 625	GC-MS	2,4-Dimethylphenol
Aqueous	EPA 625	GC-MS	2,4-Dinitrophenol
Aqueous	EPA 625	GC-MS	2,4-Dinitrotoluene
Aqueous	EPA 625	GC-MS	2,6-Dichlorophenol
Aqueous	EPA 625	GC-MS	2,6-Dinitrotoluene
Aqueous	EPA 625	GC-MS	2-Chloronaphthalene
Aqueous	EPA 625	GC-MS	2-Chlorophenol
Aqueous	EPA 625	GC-MS	2-Methyl-4,6-Dinitrophenol
Aqueous	EPA 625	GC-MS	2-Methylnaphthalene
Aqueous	EPA 625	GC-MS	2-Methylphenol
Aqueous	EPA 625	GC-MS	2-Nitroaniline
Aqueous	EPA 625	GC-MS	2-Nitrophenol
Aqueous	EPA 625	GC-MS	3,3'-Dichlorobenzidine
Aqueous	EPA 625	GC-MS	3-Nitroaniline
Aqueous	EPA 625	GC-MS	4-Bromophenyl-phenylether
Aqueous	EPA 625	GC-MS	4-Chloro-3-methylphenol
Aqueous	EPA 625	GC-MS	4-Chloroaniline
Aqueous	EPA 625	GC-MS	4-Chlorophenyl-phenylether
Aqueous	EPA 625	GC-MS	4-Methylphenol (and/or 3-Methylphenol)
Aqueous	EPA 625	GC-MS	4-Nitroaniline
Aqueous	EPA 625	GC-MS	4-Nitrophenol
Aqueous	EPA 625	GC-MS	Acenaphthene
Aqueous	EPA 625	GC-MS	Acenaphthylene
Aqueous	EPA 625	GC-MS	Aniline
Aqueous	EPA 625	GC-MS	Anthracene
Aqueous	EPA 625	GC-MS	Benzidine
Aqueous	EPA 625	GC-MS	Benzo(a)anthracene
Aqueous	EPA 625	GC-MS	Benzo(a)pyrene
Aqueous	EPA 625	GC-MS	Benzo(b)fluoranthene

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Gulf Coast Analytical Laboratories, LLC

7979 Innovation Park Drive, Baton Rouge, LA 70820
Contact Name: Randy Whittington   Phone: 225-769-4900

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 625	GC-MS	Benzo(g,h,i)perylene
Aqueous	EPA 625	GC-MS	Benzo(k)fluoranthene
Aqueous	EPA 625	GC-MS	Benzoic acid
Aqueous	EPA 625	GC-MS	Benzyl alcohol
Aqueous	EPA 625	GC-MS	bis(2-Chloroethoxy)methane
Aqueous	EPA 625	GC-MS	bis(2-Chloroethyl)ether
Aqueous	EPA 625	GC-MS	bis(2-Chloroiospropyl) ether
Aqueous	EPA 625	GC-MS	bis(2-ethylhexyl) phthalate
Aqueous	EPA 625	GC-MS	Butyl benzyl phthalate
Aqueous	EPA 625	GC-MS	Carbazole
Aqueous	EPA 625	GC-MS	Chrysene
Aqueous	EPA 625	GC-MS	Dibenzo(a,h)anthracene
Aqueous	EPA 625	GC-MS	Dibenzofuran
Aqueous	EPA 625	GC-MS	Diethyl phthalate
Aqueous	EPA 625	GC-MS	Dimethyl phthalate
Aqueous	EPA 625	GC-MS	Di-n-butylphthalate
Aqueous	EPA 625	GC-MS	Di-n-octylphthalate
Aqueous	EPA 625	GC-MS	Fluoranthene
Aqueous	EPA 625	GC-MS	Fluorene
Aqueous	EPA 625	GC-MS	Hexachlorobenzene
Aqueous	EPA 625	GC-MS	Hexachlorocyclopentadiene
Aqueous	EPA 625	GC-MS	Indeno(1,2,3, cd)pyrene
Aqueous	EPA 625	GC-MS	Isophorone
Aqueous	EPA 625	GC-MS	Naphthalene
Aqueous	EPA 625	GC-MS	Nitrobenzene
Aqueous	EPA 625	GC-MS	N-Nitrosodiethylamine
Aqueous	EPA 625	GC-MS	N-Nitrosodimethylamine
Aqueous	EPA 625	GC-MS	N-Nitroso-di-n-propylamine
Aqueous	EPA 625	GC-MS	N-Nitrosodiphenylamine
Aqueous	EPA 625	GC-MS	o-Toluidine
Aqueous	EPA 625	GC-MS	Pentachlorobenzene
Aqueous	EPA 625	GC-MS	Pentachlorophenol
Aqueous	EPA 625	GC-MS	Phenanthrene
Aqueous	EPA 625	GC-MS	Phenol
Aqueous	EPA 625	GC-MS	Pyrene
Aqueous	EPA 625	GC-MS	Pyridine

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Gulf Coast Analytical Laboratories, LLC

7979 Innovation Park Drive, Baton Rouge, LA 70820
Contact Name: Randy Whittington Phone: 225-769-4900

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 7470A	CVAA	Mercury
Aqueous	EPA 8011	GC-ECD	1,2-Dibromo-3-chloropropane (DBCP)
Aqueous	EPA 8011	GC-ECD	1,2-Dibromoethane (EDB)
Aqueous	EPA 8081B	GC-ECD	Diallate
Aqueous	EPA 9040C	pH Meter	Corrosivity (pH)
Aqueous	HACH 8000	Spectrophotometer	COD
Aqueous	RSK175	GC-FID	Acetylene
Aqueous	RSK175	GC-FID	Butane
Aqueous	RSK175	GC-TCD	Carbon Dioxide
Aqueous	RSK175	GC-FID	Ethane
Aqueous	RSK175	GC-FID	Ethene
Aqueous	RSK175	GC-FID	Methane
Aqueous	RSK175	GC-FID	Propane
Aqueous	SM 2130B	Turbidimetric	Turbidity
Aqueous	HACH 10242	Spectrophotometer	Total Kieldahl Nitrogen
Aqueous	SM 2310B	Titration	Acidity(as CaCO3)
Aqueous	SM 2320B	Titration	Total Alkalinity(as CaCO3)
Aqueous	SM 2340 B	ICP-MS	Total Hardness (as CaCO3)
Aqueous	SM 2540B	Gravimetric	Total Solid
Aqueous	SM 2540C	Gravimetric	Total Dissolved Solid (TDS)
Aqueous	SM 2540D	Gravimetric	Non-Filterable Residue (TSS)
Aqueous	SM 3500-Fe B	Spectrophotometer	Ferrous Iron
Aqueous	SM 4500-Cl E	Autotitrator	Chloride
Aqueous	SM 4500-H+ B	pH Meter	Corrosivity (pH)
Aqueous	SM 4500-H+ B	pH Meter	pH
Aqueous	SM 4500-PE	Spectrophotometer	Orthophosphate as P
Aqueous	SM 4500-S2 D	Spectrophotometer	Sulfide
Aqueous	SM 4500-S2 F	Titration	Sulfide
Aqueous	SM 4500-SiO2 C	Spectrophotometer	Silica
Aqueous	SM 4500-SO4 E	IC	Sulfate
Aqueous	SM 5310B	TOC Analyzer	TOC
Aqueous	EPA 9020B	TOX Analyzer	Total Organic Halides
Drinking Water	EPA 537	LC/MS/MS	NMeFOSAA
Drinking Water	EPA 537	LC/MS/MS	NEtFOSAA
Drinking Water	EPA 537	LC/MS/MS	PFBS
Drinking Water	EPA 537	LC/MS/MS	PFDA

Matrix	Standard/Method	Technology	Analyte
Drinking Water	EPA 537	LC/MS/MS	PFDoA
Drinking Water	EPA 537	LC/MS/MS	PFHpA
Drinking Water	EPA 537	LC/MS/MS	PFHxS
Drinking Water	EPA 537	LC/MS/MS	PFHxA
Drinking Water	EPA 537	LC/MS/MS	PFNA
Drinking Water	EPA 537	LC/MS/MS	PFOS
Drinking Water	EPA 537	LC/MS/MS	PFOA
Drinking Water	EPA 537	LC/MS/MS	PFTA
Drinking Water	EPA 537	LC/MS/MS	PFTrDA
Drinking Water	EPA 537	LC/MS/MS	PFUnA
Solid	EPA 1030	N/A	Ignitability
Solid	EPA 3060A	N/A	Hexavalent Chromium Preparation
Solid	EPA 7471B	CVAA	Mercury
Solid	EPA 9045D	pH Meter	Corrosivity (pH)
Solid	EPA 9095B	N/A	Paint Filter Test
Solid	SM 2540G	Gravimetric	Percent Moisture
Solid	SM 2540G	Gravimetric	Total Solid
Aqueous/Solid	EPA 1010A	Automated FP Analyzer	Ignitability
Aqueous/Solid	EPA 353.2	FIA	Nitrate and Nitrite as N
Aqueous/Solid	EPA 353.2	FIA	Nitrate as N
Aqueous/Solid	EPA 353.2	FIA	Nitrite as N
Aqueous/Solid	EPA 365.1	FIA	Total Phosphorous
Aqueous/Solid	EPA 6020A	ICP-MS	Aluminum
Aqueous/Solid	EPA 6020A	ICP-MS	Antimony
Aqueous/Solid	EPA 6020A	ICP-MS	Arsenic
Aqueous/Solid	EPA 6020A	ICP-MS	Barium
Aqueous/Solid	EPA 6020A	ICP-MS	Beryllium
Aqueous/Solid	EPA 6020A	ICP-MS	Cadmium
Aqueous/Solid	EPA 6020A	ICP-MS	Calcium
Aqueous/Solid	EPA 6020A	ICP-MS	Chromium
Aqueous/Solid	EPA 6020A	ICP-MS	Cobalt
Aqueous/Solid	EPA 6020A	ICP-MS	Copper
Aqueous/Solid	EPA 6020A	ICP-MS	Iron
Aqueous/Solid	EPA 6020A	ICP-MS	Lead
Aqueous/Solid	EPA 6020A	ICP-MS	Magnesium
Aqueous/Solid	EPA 6020A	ICP-MS	Manganese

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 6020A	ICP-MS	Molybdenum
Aqueous/Solid	EPA 6020A	ICP-MS	Nickel
Aqueous/Solid	EPA 6020A	ICP-MS	Potassium
Aqueous/Solid	EPA 6020A	ICP-MS	Selenium
Aqueous/Solid	EPA 6020A	ICP-MS	Silver
Aqueous/Solid	EPA 6020A	ICP-MS	Sodium
Aqueous/Solid	EPA 6020A	ICP-MS	Strontium
Aqueous/Solid	EPA 6020A	ICP-MS	Thallium
Aqueous/Solid	EPA 6020A	ICP-MS	Tin
Aqueous/Solid	EPA 6020A	ICP-MS	Titanium
Aqueous/Solid	EPA 6020A	ICP-MS	Vanadium
Aqueous/Solid	EPA 6020A	ICP-MS	Zinc
Aqueous/Solid	EPA 6020A	ICP-MS	Zirconium
Aqueous/Solid	EPA 6020B	ICP-MS	Aluminum
Aqueous/Solid	EPA 6020B	ICP-MS	Antimony
Aqueous/Solid	EPA 6020B	ICP-MS	Arsenic
Aqueous/Solid	EPA 6020B	ICP-MS	Barium
Aqueous/Solid	EPA 6020B	ICP-MS	Beryllium
Aqueous/Solid	EPA 6020B	ICP-MS	Cadmium
Aqueous/Solid	EPA 6020B	ICP-MS	Calcium
Aqueous/Solid	EPA 6020B	ICP-MS	Chromium
Aqueous/Solid	EPA 6020B	ICP-MS	Cobalt
Aqueous/Solid	EPA 6020B	ICP-MS	Copper
Aqueous/Solid	EPA 6020B	ICP-MS	Iron
Aqueous/Solid	EPA 6020B	ICP-MS	Lead
Aqueous/Solid	EPA 6020B	ICP-MS	Magnesium
Aqueous/Solid	EPA 6020B	ICP-MS	Manganese
Aqueous/Solid	EPA 6020B	ICP-MS	Molybdenum
Aqueous/Solid	EPA 6020B	ICP-MS	Nickel
Aqueous/Solid	EPA 6020B	ICP-MS	Potassium
Aqueous/Solid	EPA 6020B	ICP-MS	Selenium
Aqueous/Solid	EPA 6020B	ICP-MS	Silver
Aqueous/Solid	EPA 6020B	ICP-MS	Sodium
Aqueous/Solid	EPA 6020B	ICP-MS	Strontium
Aqueous/Solid	EPA 6020B	ICP-MS	Thallium
Aqueous/Solid	EPA 6020B	ICP-MS	Tin

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 6020B	ICP-MS	Titanium
Aqueous/Solid	EPA 6020B	ICP-MS	Vanadium
Aqueous/Solid	EPA 6020B	ICP-MS	Zinc
Aqueous/Solid	EPA 6020B	ICP-MS	Zirconium
Aqueous/Solid	EPA 7196A	Spectrophotometer	Chromium VI
Aqueous/Solid	EPA 8015C	GC-FID	Diesel
Aqueous/Solid	EPA 8015C	GC-FID	Diesel range organics (DRO)
Aqueous/Solid	EPA 8015C	GC-FID	Gasoline range organics (GRO)
Aqueous/Solid	EPA 8015C	GC-FID	Oil Range Organics (ORO)
Aqueous/Solid	EPA 8081B	GC-ECD	Aldrin
Aqueous/Solid	EPA 8081B	GC-ECD	alpha-BHC
Aqueous/Solid	EPA 8081B	GC-ECD	alpha-Chlordane
Aqueous/Solid	EPA 8081B	GC-ECD	beta-BHC
Aqueous/Solid	EPA 8081B	GC-ECD	Chlordane
Aqueous/Solid	EPA 8081B	GC-ECD	Chlordane (total)
Aqueous/Solid	EPA 8081B	GC-ECD	DDD (4,4’)
Aqueous/Solid	EPA 8081B	GC-ECD	DDE (4,4’)
Aqueous/Solid	EPA 8081B	GC-ECD	DDT (4,4’)
Aqueous/Solid	EPA 8081B	GC-ECD	delta-BHC
Aqueous/Solid	EPA 8081B	GC-ECD	Dieldrin
Aqueous/Solid	EPA 8081B	GC-ECD	Endosulfan I
Aqueous/Solid	EPA 8081B	GC-ECD	Endosulfan II
Aqueous/Solid	EPA 8081B	GC-ECD	Endosulfan sulfate
Aqueous/Solid	EPA 8081B	GC-ECD	Endrin
Aqueous/Solid	EPA 8081B	GC-ECD	Endrin aldehyde
Aqueous/Solid	EPA 8081B	GC-ECD	Endrin ketone
Aqueous/Solid	EPA 8081B	GC-ECD	gamma-BHC (Lindane)
Aqueous/Solid	EPA 8081B	GC-ECD	gamma-Chlordane
Aqueous/Solid	EPA 8081B	GC-ECD	Heptachlor
Aqueous/Solid	EPA 8081B	GC-ECD	Heptachlor Epoxide (beta)
Aqueous/Solid	EPA 8081B	GC-ECD	Methoxychlor
Aqueous/Solid	EPA 8081B	GC-ECD	Toxaphene
Aqueous/Solid	EPA 8081B	GC-ECD	Toxaphene (total)
Aqueous/Solid	EPA 8082A	GC-ECD	Aroclor 1016
Aqueous/Solid	EPA 8082A	GC-ECD	Aroclor 1221
Aqueous/Solid	EPA 8082A	GC-ECD	Aroclor 1232

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Gulf Coast Analytical Laboratories, LLC

7979 Innovation Park Drive, Baton Rouge, LA 70820
Contact Name: Randy Whittington   Phone: 225-769-4900

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8082A	GC-ECD	Aroclor 1242
Aqueous/Solid	EPA 8082A	GC-ECD	Aroclor 1248
Aqueous/Solid	EPA 8082A	GC-ECD	Aroclor 1254
Aqueous/Solid	EPA 8082A	GC-ECD	Aroclor 1260
Aqueous/Solid	EPA 8082A	GC-ECD	Aroclor 1262
Aqueous/Solid	EPA 8082A	GC-ECD	Aroclor 1268
Aqueous/Solid	EPA 8141B	GC-NPD	Azinphos-methyl (Guthion)
Aqueous/Solid	EPA 8141B	GC-NPD	Diazinon
Aqueous/Solid	EPA 8141B	GC-NPD	Disulfoton
Aqueous/Solid	EPA 8141B	GC-NPD	Malathion
Aqueous/Solid	EPA 8141B	GC-NPD	Parathion, ethyl
Aqueous/Solid	EPA 8141B	GC-NPD	Parathion, methyl
Aqueous/Solid	EPA 8141B	GC-NPD	Phorate
Aqueous/Solid	EPA 8141B	GC-NPD	Ronnel
Aqueous/Solid	EPA 8141B	GC-NPD	Stirophos
Aqueous/Solid	EPA 8151A	GC-ECD	2, 4, DB
Aqueous/Solid	EPA 8151A	GC-ECD	2, 4-D
Aqueous/Solid	EPA 8151A	GC-ECD	2,4,5-T
Aqueous/Solid	EPA 8151A	GC-ECD	2,4,5-TP (Silvex)
Aqueous/Solid	EPA 8151A	GC-ECD	2,4-DP (Dichlorprop)
Aqueous/Solid	EPA 8151A	GC-ECD	3,5-Dichlorobenzoic acid
Aqueous/Solid	EPA 8151A	GC-ECD	4-Nitrophenol
Aqueous/Solid	EPA 8151A	GC-ECD	Acifluorfen
Aqueous/Solid	EPA 8151A	GC-ECD	Bentazon
Aqueous/Solid	EPA 8151A	GC-ECD	Chloramben
Aqueous/Solid	EPA 8151A	GC-ECD	Dacthal (DCPA)
Aqueous/Solid	EPA 8151A	GC-ECD	Dalapon
Aqueous/Solid	EPA 8151A	GC-ECD	Dicamba
Aqueous/Solid	EPA 8151A	GC-ECD	Dinoseb
Aqueous/Solid	EPA 8151A	GC-ECD	MCPA
Aqueous/Solid	EPA 8151A	GC-ECD	MCPP
Aqueous/Solid	EPA 8151A	GC-ECD	Pentachlorophenol
Aqueous/Solid	EPA 8260B	GC-MS	1,1,1,2-Tetrachloroethane
Aqueous/Solid	EPA 8260B	GC-MS	1,1,1-Trichloroethane
Aqueous/Solid	EPA 8260B	GC-MS	1,1,2,2-Tetrachloroethane
Aqueous/Solid	EPA 8260B	GC-MS	1,1,2-trichloro-1,2,2-trifluoroethane

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Gulf Coast Analytical Laboratories, LLC

7979 Innovation Park Drive, Baton Rouge, LA 70820
Contact Name: Randy Whittington Phone: 225-769-4900

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8260B	GC-MS	1,1,2-Trichloroethane
Aqueous/Solid	EPA 8260B	GC-MS	1,1-Dichloroethane
Aqueous/Solid	EPA 8260B	GC-MS	1,1-Dichloroethene
Aqueous/Solid	EPA 8260B	GC-MS	1,1-Dichloropropene
Aqueous/Solid	EPA 8260B	GC-MS	1,2 Dichlorobenzene
Aqueous/Solid	EPA 8260B	GC-MS	1,2 Dichloroethane
Aqueous/Solid	EPA 8260B	GC-MS	1,2,3-Trichlorobenzene
Aqueous/Solid	EPA 8260B	GC-MS	1,2,3-Trichloropropane
Aqueous/Solid	EPA 8260B	GC-MS	1,2,4,5-Tetrachlorobenzene
Aqueous/Solid	EPA 8260B	GC-MS	1,2,4-Trichlorobenzene
Aqueous/Solid	EPA 8260B	GC-MS	1,2,4-Trimethylbenzene
Aqueous/Solid	EPA 8260B	GC-MS	1,2-Dibromo-3-chloropropane (DBCP)
Aqueous/Solid	EPA 8260B	GC-MS	1,2-Dibromoethane (EDB)
Aqueous/Solid	EPA 8260B	GC-MS	1,2-Dichloropropane
Aqueous/Solid	EPA 8260B	GC-MS	1,3 Dichlorobenzene
Aqueous/Solid	EPA 8260B	GC-MS	1,3,5-Trimethylbenzene
Aqueous/Solid	EPA 8260B	GC-MS	1,3-Dichloropropane
Aqueous/Solid	EPA 8260B	GC-MS	1,4 Dichlorobenzene
Aqueous/Solid	EPA 8260B	GC-MS	1-Chlorohexane
Aqueous/Solid	EPA 8260B	GC-MS	2,2-Dichloropropane
Aqueous/Solid	EPA 8260B	GC-MS	2-Butanone (MEK)
Aqueous/Solid	EPA 8260B	GC-MS	2-Chloroethylvinylether
Aqueous/Solid	EPA 8260B	GC-MS	2-Chlorotoluene
Aqueous/Solid	EPA 8260B	GC-MS	2-Hexanone
Aqueous/Solid	EPA 8260B	GC-MS	4-Chlorotoluene
Aqueous/Solid	EPA 8260B	GC-MS	4-Methyl-2-pentanone (MIBK)
Aqueous/Solid	EPA 8260B	GC-MS	Acetone
Aqueous/Solid	EPA 8260B	GC-MS	Acetonitrile
Aqueous/Solid	EPA 8260B	GC-MS	Acrolein
Aqueous/Solid	EPA 8260B	GC-MS	Acrylonitrile
Aqueous/Solid	EPA 8260B	GC-MS	Benzene
Aqueous/Solid	EPA 8260B	GC-MS	Bromobenzene
Aqueous/Solid	EPA 8260B	GC-MS	Bromochloromethane
Aqueous/Solid	EPA 8260B	GC-MS	Bromodichloromethane
Aqueous/Solid	EPA 8260B	GC-MS	Bromoform
Aqueous/Solid	EPA 8260B	GC-MS	Bromomethane

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Gulf Coast Analytical Laboratories, LLC

7979 Innovation Park Drive, Baton Rouge, LA 70820
Contact Name: Randy Whittington   Phone: 225-769-4900

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8260B	GC-MS	Carbon disulfide
Aqueous/Solid	EPA 8260B	GC-MS	Carbon tetrachloride
Aqueous/Solid	EPA 8260B	GC-MS	Chlorobenzene
Aqueous/Solid	EPA 8260B	GC-MS	Chloroethane
Aqueous/Solid	EPA 8260B	GC-MS	Chloroform
Aqueous/Solid	EPA 8260B	GC-MS	Chloromethane
Aqueous/Solid	EPA 8260B	GC-MS	cis-1,2-Dichloroethene
Aqueous/Solid	EPA 8260B	GC-MS	cis-1,3-Dichloropropylene
Aqueous/Solid	EPA 8260B	GC-MS	Dibromochloromethane
Aqueous/Solid	EPA 8260B	GC-MS	Dibromomethane
Aqueous/Solid	EPA 8260B	GC-MS	Dichlorodifluoromethane
Aqueous/Solid	EPA 8260B	GC-MS	DIPE
Aqueous/Solid	EPA 8260B	GC-MS	ETBE
Aqueous/Solid	EPA 8260B	GC-MS	Ethylbenzene
Aqueous/Solid	EPA 8260B	GC-MS	Hexachlorobutadiene
Aqueous/Solid	EPA 8260B	GC-MS	Isopropylbenzene
Aqueous/Solid	EPA 8260B	GC-MS	m+p-Xylene
Aqueous/Solid	EPA 8260B	GC-MS	Methyl tert-butyl ether (MTBE)
Aqueous/Solid	EPA 8260B	GC-MS	Methylcyclohexane
Aqueous/Solid	EPA 8260B	GC-MS	Methylene Chloride
Aqueous/Solid	EPA 8260B	GC-MS	Methyl Acetate
Aqueous/Solid	EPA 8260B	GC-MS	MTBE
Aqueous/Solid	EPA 8260B	GC-MS	Naphthalene
Aqueous/Solid	EPA 8260B	GC-MS	n-Butylbenzene
Aqueous/Solid	EPA 8260B	GC-MS	n-Propylbenzene
Aqueous/Solid	EPA 8260B	GC-MS	o-Xylene
Aqueous/Solid	EPA 8260B	GC-MS	p-Isopropyltoluene
Aqueous/Solid	EPA 8260B	GC-MS	sec-Butylbenzene
Aqueous/Solid	EPA 8260B	GC-MS	Styrene
Aqueous/Solid	EPA 8260B	GC-MS	TAME
Aqueous/Solid	EPA 8260B	GC-MS	tert-Butyl alcohol
Aqueous/Solid	EPA 8260B	GC-MS	tert-Butylbenzene
Aqueous/Solid	EPA 8260B	GC-MS	Tetrachloroethene
Aqueous/Solid	EPA 8260B	GC-MS	Toluene
Aqueous/Solid	EPA 8260B	GC-MS	trans-1,2-Dichloroethene
Aqueous/Solid	EPA 8260B	GC-MS	trans-1,3-Dichloropropene

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8260B	GC-MS	Trichloroethene
Aqueous/Solid	EPA 8260B	GC-MS	Trichlorofluoromethane
Aqueous/Solid	EPA 8260B	GC-MS	Vinyl acetate
Aqueous/Solid	EPA 8260B	GC-MS	Vinyl chloride
Aqueous/Solid	EPA 8260B	GC-MS	Xylenes, total
Aqueous/Solid	EPA 8260B	GC-MS VOC	Cyclohexane
Aqueous/Solid	EPA 8260B	GC-MS VOC	Ethyl Acetate
Aqueous/Solid	EPA 8260B	GC-MS VOC	n-Butanol
Aqueous/Solid	EPA 8260C	GC-MS	1,1,1,2-Tetrachloroethane
Aqueous/Solid	EPA 8260C	GC-MS	1,1,1-Trichloroethane
Aqueous/Solid	EPA 8260C	GC-MS	1,1,2,2-Tetrachloroethane
Aqueous/Solid	EPA 8260C	GC-MS	1,1,2-trichloro-1,2,2-trifluoroethane
Aqueous/Solid	EPA 8260C	GC-MS	1,1,2-Trichloroethane
Aqueous/Solid	EPA 8260C	GC-MS	1,1-Dichloroethane
Aqueous/Solid	EPA 8260C	GC-MS	1,1-Dichloroethene
Aqueous/Solid	EPA 8260C	GC-MS	1,1-Dichloropropene
Aqueous/Solid	EPA 8260C	GC-MS	1,2 Dichlorobenzene
Aqueous/Solid	EPA 8260C	GC-MS	1,2 Dichloroethane
Aqueous/Solid	EPA 8260C	GC-MS	1,2,3-Trichlorobenzene
Aqueous/Solid	EPA 8260C	GC-MS	1,2,3-Trichloropropane
Aqueous/Solid	EPA 8260C	GC-MS	1,2,4,5-Tetrachlorobenzene
Aqueous/Solid	EPA 8260C	GC-MS	1,2,4-Trichlorobenzene
Aqueous/Solid	EPA 8260C	GC-MS	1,2,4-Trimethylbenzene
Aqueous/Solid	EPA 8260C	GC-MS	1,2-Dibromo-3-chloropropane (DBCP)
Aqueous/Solid	EPA 8260C	GC-MS	1,2-Dibromoethane (EDB)
Aqueous/Solid	EPA 8260C	GC-MS	1,2-Dichloropropane
Aqueous/Solid	EPA 8260C	GC-MS	1,3 Dichlorobenzene
Aqueous/Solid	EPA 8260C	GC-MS	1,3,5-Trimethylbenzene
Aqueous/Solid	EPA 8260C	GC-MS	1,3-Dichloropropane
Aqueous/Solid	EPA 8260C	GC-MS	1,4 Dichlorobenzene
Aqueous/Solid	EPA 8260C	GC-MS	1-Chlorohexane
Aqueous/Solid	EPA 8260C	GC-MS	2,2-Dichloropropane
Aqueous/Solid	EPA 8260C	GC-MS	2-Butanone (MEK)
Aqueous/Solid	EPA 8260C	GC-MS	2-Chloroethylvinylether
Aqueous/Solid	EPA 8260C	GC-MS	2-Chlorotoluene
Aqueous/Solid	EPA 8260C	GC-MS	2-Hexanone

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8260C	GC-MS	4-Chlorotoluene
Aqueous/Solid	EPA 8260C	GC-MS	4-Methyl-2-pentanone (MIBK)
Aqueous/Solid	EPA 8260C	GC-MS	Acetone
Aqueous/Solid	EPA 8260C	GC-MS	Acetonitrile
Aqueous/Solid	EPA 8260C	GC-MS	Acrolein
Aqueous/Solid	EPA 8260C	GC-MS	Acrylonitrile
Aqueous/Solid	EPA 8260C	GC-MS	Benzene
Aqueous/Solid	EPA 8260C	GC-MS	Bromobenzene
Aqueous/Solid	EPA 8260C	GC-MS	Bromochloromethane
Aqueous/Solid	EPA 8260C	GC-MS	Bromodichloromethane
Aqueous/Solid	EPA 8260C	GC-MS	Bromoform
Aqueous/Solid	EPA 8260C	GC-MS	Bromomethane
Aqueous/Solid	EPA 8260C	GC-MS	Carbon disulfide
Aqueous/Solid	EPA 8260C	GC-MS	Carbon tetrachloride
Aqueous/Solid	EPA 8260C	GC-MS	Chlorobenzene
Aqueous/Solid	EPA 8260C	GC-MS	Chloroethane
Aqueous/Solid	EPA 8260C	GC-MS	Chloroform
Aqueous/Solid	EPA 8260C	GC-MS	Chloromethane
Aqueous/Solid	EPA 8260C	GC-MS	cis-1,2-Dichloroethene
Aqueous/Solid	EPA 8260C	GC-MS	cis-1,3-Dichloropropylene
Aqueous/Solid	EPA 8260C	GC-MS	Dibromochloromethane
Aqueous/Solid	EPA 8260C	GC-MS	Dibromomethane
Aqueous/Solid	EPA 8260C	GC-MS	Dichlorodifluoromethane
Aqueous/Solid	EPA 8260C	GC-MS	DIPE
Aqueous/Solid	EPA 8260C	GC-MS	ETBE
Aqueous/Solid	EPA 8260C	GC-MS	Ethylbenzene
Aqueous/Solid	EPA 8260C	GC-MS	Hexachlorobutadiene
Aqueous/Solid	EPA 8260C	GC-MS	Isopropylbenzene
Aqueous/Solid	EPA 8260C	GC-MS	m+p-Xylene
Aqueous/Solid	EPA 8260C	GC-MS	Methyl tert-butyl ether (MTBE)
Aqueous/Solid	EPA 8260C	GC-MS	Methylcyclohexane
Aqueous/Solid	EPA 8260C	GC-MS	Methylene Chloride
Aqueous/Solid	EPA 8260C	GC-MS	Methyl Acetate
Aqueous/Solid	EPA 8260C	GC-MS	MTBE
Aqueous/Solid	EPA 8260C	GC-MS	Naphthalene
Aqueous/Solid	EPA 8260C	GC-MS	n-Butylbenzene

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Gulf Coast Analytical Laboratories, LLC

7979 Innovation Park Drive, Baton Rouge, LA 70820
Contact Name: Randy Whittington   Phone: 225-769-4900

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8260C	GC-MS	n-Propylbenzene
Aqueous/Solid	EPA 8260C	GC-MS	o-Xylene
Aqueous/Solid	EPA 8260C	GC-MS	p-Isopropyltoluene
Aqueous/Solid	EPA 8260C	GC-MS	sec-Butylbenzene
Aqueous/Solid	EPA 8260C	GC-MS	Styrene
Aqueous/Solid	EPA 8260C	GC-MS	TAME
Aqueous/Solid	EPA 8260C	GC-MS	tert-Butyl alcohol
Aqueous/Solid	EPA 8260C	GC-MS	tert-Butylbenzene
Aqueous/Solid	EPA 8260C	GC-MS	Tetrachloroethene
Aqueous/Solid	EPA 8260C	GC-MS	Toluene
Aqueous/Solid	EPA 8260C	GC-MS	trans-1,2-Dichloroethene
Aqueous/Solid	EPA 8260C	GC-MS	trans-1,3-Dichloropropene
Aqueous/Solid	EPA 8260C	GC-MS	Trichloroethene
Aqueous/Solid	EPA 8260C	GC-MS	Trichlorofluoromethane
Aqueous/Solid	EPA 8260C	GC-MS	Vinyl acetate
Aqueous/Solid	EPA 8260C	GC-MS	Vinyl chloride
Aqueous/Solid	EPA 8260C	GC-MS	Xylenes, total
Aqueous/Solid	EPA 8260C	GC-MS VOC	Cyclohexane
Aqueous/Solid	EPA 8260C	GC-MS VOC	Ethyl Acetate
Aqueous/Solid	EPA 8260C	GC-MS VOC	n-Butanol
Aqueous/Solid	EPA 8270C	GC-MS	1,2 Dichlorobenzene
Aqueous/Solid	EPA 8270C	GC-MS	1,2,4,5-Tetrachlorobenzene
Aqueous/Solid	EPA 8270C	GC-MS	1,2,4-Trichlorobenzene
Aqueous/Solid	EPA 8270C	GC-MS	1,2-Diphenylhydrazine
Aqueous/Solid	EPA 8270C	GC-MS	1,3 Dichlorobenzene
Aqueous/Solid	EPA 8270C	GC-MS	1,4 Dichlorobenzene
Aqueous/Solid	EPA 8270C	GC-MS	1-Methylnaphthalene
Aqueous/Solid	EPA 8270C	GC-MS	2,3,4,6-Tetrachlorophenol
Aqueous/Solid	EPA 8270C	GC-MS	2,4,5-Trichlorophenol
Aqueous/Solid	EPA 8270C	GC-MS	2,4,6-Trichlorophenol
Aqueous/Solid	EPA 8270C	GC-MS	2,4-Dichlorophenol
Aqueous/Solid	EPA 8270C	GC-MS	2,4-Dimethylphenol
Aqueous/Solid	EPA 8270C	GC-MS	2,4-Dinitrophenol
Aqueous/Solid	EPA 8270C	GC-MS	2,4-Dinitrotoluene
Aqueous/Solid	EPA 8270C	GC-MS	2,6-Dichlorophenol
Aqueous/Solid	EPA 8270C	GC-MS	2,6-Dinitrotoluene

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8270C	GC-MS	2-Chloronaphthalene
Aqueous/Solid	EPA 8270C	GC-MS	2-Chlorophenol
Aqueous/Solid	EPA 8270C	GC-MS	2-Methyl-4,6-Dinitrophenol
Aqueous/Solid	EPA 8270C	GC-MS	2-Methylnaphthalene
Aqueous/Solid	EPA 8270C	GC-MS	2-Methylphenol
Aqueous/Solid	EPA 8270C	GC-MS	2-Nitroaniline
Aqueous/Solid	EPA 8270C	GC-MS	2-Nitrophenol
Aqueous/Solid	EPA 8270C	GC-MS	3,3'-Dichlorobenzidine
Aqueous/Solid	EPA 8270C	GC-MS	3-Nitroaniline
Aqueous/Solid	EPA 8270C	GC-MS	4-Bromophenyl-phenylether
Aqueous/Solid	EPA 8270C	GC-MS	4-Chloro-3-methylphenol
Aqueous/Solid	EPA 8270C	GC-MS	4-Chloroaniline
Aqueous/Solid	EPA 8270C	GC-MS	4-Chlorophenyl-phenylether
Aqueous/Solid	EPA 8270C	GC-MS	4-Methylphenol (and/or 3-Methylphenol)
Aqueous/Solid	EPA 8270C	GC-MS	4-Nitroaniline
Aqueous/Solid	EPA 8270C	GC-MS	4-Nitrophenol
Aqueous/Solid	EPA 8270C	GC-MS	Acenaphthene
Aqueous/Solid	EPA 8270C	GC-MS	Acenaphthylene
Aqueous/Solid	EPA 8270C	GC-MS	Acetophenone
Aqueous/Solid	EPA 8270C	GC-MS	Aniline
Aqueous/Solid	EPA 8270C	GC-MS	Anthracene
Aqueous/Solid	EPA 8270C	GC-MS	Atrazine
Aqueous/Solid	EPA 8270C	GC-MS	Benzaldehyde
Aqueous/Solid	EPA 8270C	GC-MS	Benzidine
Aqueous/Solid	EPA 8270C	GC-MS	Benzo(a)anthracene
Aqueous/Solid	EPA 8270C	GC-MS	Benzo(a)pyrene
Aqueous/Solid	EPA 8270C	GC-MS	Benzo(b)fluoranthene
Aqueous/Solid	EPA 8270C	GC-MS	Benzo(g,h,i)perylene
Aqueous/Solid	EPA 8270C	GC-MS	Benzo(k)fluoranthene
Aqueous/Solid	EPA 8270C	GC-MS	Benzoic acid
Aqueous/Solid	EPA 8270C	GC-MS	Benzyl alcohol
Aqueous/Solid	EPA 8270C	GC-MS	Biphenyl
Aqueous/Solid	EPA 8270C	GC-MS	bis(2-Chloroethoxy)methane
Aqueous/Solid	EPA 8270C	GC-MS	bis(2-Chloroethyl)ether
Aqueous/Solid	EPA 8270C	GC-MS	bis(2-Chloroiospropyl) ether
Aqueous/Solid	EPA 8270C	GC-MS	bis(2-ethylhexyl) phthalate

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Gulf Coast Analytical Laboratories, LLC

7979 Innovation Park Drive, Baton Rouge, LA 70820
Contact Name: Randy Whittington Phone: 225-769-4900

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8270C	GC-MS	bis(2-ethylhexyl) phthalate
Aqueous/Solid	EPA 8270C	GC-MS	Butyl benzyl phthalate
Aqueous/Solid	EPA 8270C	GC-MS	Butyl benzyl phthalate
Aqueous/Solid	EPA 8270C	GC-MS	Caprolactom
Aqueous/Solid	EPA 8270C	GC-MS	Carbazole
Aqueous/Solid	EPA 8270C	GC-MS	Carbazole
Aqueous/Solid	EPA 8270C	GC-MS	Chrysene
Aqueous/Solid	EPA 8270C	GC-MS	Chrysene
Aqueous/Solid	EPA 8270C	GC-MS	Dibenzo(a,h)anthracene
Aqueous/Solid	EPA 8270C	GC-MS	Dibenzo(a,h)anthracene
Aqueous/Solid	EPA 8270C	GC-MS	Dibenzofuran
Aqueous/Solid	EPA 8270C	GC-MS	Dibenzofuran
Aqueous/Solid	EPA 8270C	GC-MS	Diethyl phthalate
Aqueous/Solid	EPA 8270C	GC-MS	Diethyl phthalate
Aqueous/Solid	EPA 8270C	GC-MS	Dimethyl phthalate
Aqueous/Solid	EPA 8270C	GC-MS	Dimethyl phthalate
Aqueous/Solid	EPA 8270C	GC-MS	Di-n-butylphthalate
Aqueous/Solid	EPA 8270C	GC-MS	Di-n-butylphthalate
Aqueous/Solid	EPA 8270C	GC-MS	Di-n-octylphthalate
Aqueous/Solid	EPA 8270C	GC-MS	Di-n-octylphthalate
Aqueous/Solid	EPA 8270C	GC-MS	Fluoranthene
Aqueous/Solid	EPA 8270C	GC-MS	Fluoranthene
Aqueous/Solid	EPA 8270C	GC-MS	Fluorene
Aqueous/Solid	EPA 8270C	GC-MS	Fluorene
Aqueous/Solid	EPA 8270C	GC-MS	Hexachlorobenzene
Aqueous/Solid	EPA 8270C	GC-MS	Hexachlorobenzene
Aqueous/Solid	EPA 8270C	GC-MS	Hexachlorobutadiene
Aqueous/Solid	EPA 8270C	GC-MS	Hexachlorobutadiene
Aqueous/Solid	EPA 8270C	GC-MS	Hexachlorocyclopentadiene
Aqueous/Solid	EPA 8270C	GC-MS	Hexachloroethane
Aqueous/Solid	EPA 8270C	GC-MS	Indeno(1,2,3, cd)pyrene
Aqueous/Solid	EPA 8270C	GC-MS	Isophorone
Aqueous/Solid	EPA 8270C	GC-MS	Naphthalene
Aqueous/Solid	EPA 8270C	GC-MS	Nitrobenzene
Aqueous/Solid	EPA 8270C	GC-MS	N-Nitrosodiethylamine
Aqueous/Solid	EPA 8270C	GC-MS	N-Nitrosodimethylamine

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8270C	GC-MS	N-Nitroso-di-n-propylamine
Aqueous/Solid	EPA 8270C	GC-MS	N-Nitrosodiphenylamine
Aqueous/Solid	EPA 8270C	GC-MS	o-Toluidine
Aqueous/Solid	EPA 8270C	GC-MS	p-Dioxane
Aqueous/Solid	EPA 8270C	GC-MS	Pentachlorobenzene
Aqueous/Solid	EPA 8270C	GC-MS	Pentachlorophenol
Aqueous/Solid	EPA 8270C	GC-MS	Phenanthrene
Aqueous/Solid	EPA 8270C	GC-MS	Phenol
Aqueous/Solid	EPA 8270C	GC-MS	Pyrene
Aqueous/Solid	EPA 8270C	GC-MS	Pyridine
Aqueous/Solid	EPA 8270C SIM	GC-MS	1-Methylnaphthalene
Aqueous/Solid	EPA 8270C SIM	GC-MS	2-Methylnaphthalene
Aqueous/Solid	EPA 8270C SIM	GC-MS	Acenaphthene
Aqueous/Solid	EPA 8270C SIM	GC-MS	Acenaphthylene
Aqueous/Solid	EPA 8270C SIM	GC-MS	Anthracene
Aqueous/Solid	EPA 8270C SIM	GC-MS	Benzo(a)anthracene
Aqueous/Solid	EPA 8270C SIM	GC-MS	Benzo(a)pyrene
Aqueous/Solid	EPA 8270C SIM	GC-MS	Benzo(b)fluoranthene
Aqueous/Solid	EPA 8270C SIM	GC-MS	Benzo(g,h,i)perylene
Aqueous/Solid	EPA 8270C SIM	GC-MS	Benzo(k)fluoranthene
Aqueous/Solid	EPA 8270C SIM	GC-MS	Chrysene
Aqueous/Solid	EPA 8270C SIM	GC-MS	Dibenz(a,h) anthracene
Aqueous/Solid	EPA 8270C SIM	GC-MS	Fluoranthene
Aqueous/Solid	EPA 8270C SIM	GC-MS	Fluorene
Aqueous/Solid	EPA 8270C SIM	GC-MS	Indeno(1,2,3-cd) pyrene
Aqueous/Solid	EPA 8270C SIM	GC-MS	Naphthalene
Aqueous/Solid	EPA 8270C SIM	GC-MS	Phenanthrene
Aqueous/Solid	EPA 8270C SIM	GC-MS	Pyrene
Aqueous/Solid	EPA 8270D	GC-MS	1,2 Dichlorobenzene
Aqueous/Solid	EPA 8270D	GC-MS	1,2,4,5-Tetrachlorobenzene
Aqueous/Solid	EPA 8270D	GC-MS	1,2,4-Trichlorobenzene
Aqueous/Solid	EPA 8270D	GC-MS	1,2-Diphenylhydrazine
Aqueous/Solid	EPA 8270D	GC-MS	1,3 Dichlorobenzene
Aqueous/Solid	EPA 8270D	GC-MS	1,4 Dichlorobenzene
Aqueous/Solid	EPA 8270D	GC-MS	1-Methylnaphthalene
Aqueous/Solid	EPA 8270D	GC-MS	2,3,4,6-Tetrachlorophenol

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8270D	GC-MS	2,4,5-Trichlorophenol
Aqueous/Solid	EPA 8270D	GC-MS	2,4,6-Trichlorophenol
Aqueous/Solid	EPA 8270D	GC-MS	2,4-Dichlorophenol
Aqueous/Solid	EPA 8270D	GC-MS	2,4-Dimethylphenol
Aqueous/Solid	EPA 8270D	GC-MS	2,4-Dinitrophenol
Aqueous/Solid	EPA 8270D	GC-MS	2,4-Dinitrotoluene
Aqueous/Solid	EPA 8270D	GC-MS	2,6-Dichlorophenol
Aqueous/Solid	EPA 8270D	GC-MS	2,6-Dinitrotoluene
Aqueous/Solid	EPA 8270D	GC-MS	2-Chloronaphthalene
Aqueous/Solid	EPA 8270D	GC-MS	2-Chlorophenol
Aqueous/Solid	EPA 8270D	GC-MS	2-Methyl-4,6-Dinitrophenol
Aqueous/Solid	EPA 8270D	GC-MS	2-Methylnaphthalene
Aqueous/Solid	EPA 8270D	GC-MS	2-Methylphenol
Aqueous/Solid	EPA 8270D	GC-MS	2-Nitroaniline
Aqueous/Solid	EPA 8270D	GC-MS	2-Nitrophenol
Aqueous/Solid	EPA 8270D	GC-MS	3,3'-Dichlorobenzidine
Aqueous/Solid	EPA 8270D	GC-MS	3-Nitroaniline
Aqueous/Solid	EPA 8270D	GC-MS	4-Bromophenyl-phenylether
Aqueous/Solid	EPA 8270D	GC-MS	4-Chloro-3-methylphenol
Aqueous/Solid	EPA 8270D	GC-MS	4-Chloroaniline
Aqueous/Solid	EPA 8270D	GC-MS	4-Chlorophenyl-phenylether
Aqueous/Solid	EPA 8270D	GC-MS	4-Methylphenol (and/or 3-Methylphenol)
Aqueous/Solid	EPA 8270D	GC-MS	4-Nitroaniline
Aqueous/Solid	EPA 8270D	GC-MS	4-Nitrophenol
Aqueous/Solid	EPA 8270D	GC-MS	Acenaphthene
Aqueous/Solid	EPA 8270D	GC-MS	Acenaphthylene
Aqueous/Solid	EPA 8270D	GC-MS	Aniline
Aqueous/Solid	EPA 8270D	GC-MS	Anthracene
Aqueous/Solid	EPA 8270D	GC-MS	Atrazine
Aqueous/Solid	EPA 8270D	GC-MS	Benzidine
Aqueous/Solid	EPA 8270D	GC-MS	Benzo(a)anthracene
Aqueous/Solid	EPA 8270D	GC-MS	Benzo(a)pyrene
Aqueous/Solid	EPA 8270D	GC-MS	Benzo(b)fluoranthene
Aqueous/Solid	EPA 8270D	GC-MS	Benzo(g,h,i)perylene
Aqueous/Solid	EPA 8270D	GC-MS	Benzo(k)fluoranthene
Aqueous/Solid	EPA 8270D	GC-MS	Benzoic acid

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8270D	GC-MS	Benzyl alcohol
Aqueous/Solid	EPA 8270D	GC-MS	bis(2-Chloroethoxy)methane
Aqueous/Solid	EPA 8270D	GC-MS	bis(2-Chloroethyl)ether
Aqueous/Solid	EPA 8270D	GC-MS	bis(2-Chloroiospropyl) ether
Aqueous/Solid	EPA 8270D	GC-MS	bis(2-ethylhexyl) phthalate
Aqueous/Solid	EPA 8270D	GC-MS	Butyl benzyl phthalate
Aqueous/Solid	EPA 8270D	GC-MS	Caprolactom
Aqueous/Solid	EPA 8270D	GC-MS	Carbazole
Aqueous/Solid	EPA 8270D	GC-MS	Chrysene
Aqueous/Solid	EPA 8270D	GC-MS	Dibenzo(a,h)anthracene
Aqueous/Solid	EPA 8270D	GC-MS	Dibenzofuran
Aqueous/Solid	EPA 8270D	GC-MS	Diethyl phthalate
Aqueous/Solid	EPA 8270D	GC-MS	Dimethyl phthalate
Aqueous/Solid	EPA 8270D	GC-MS	Di-n-butylphthalate
Aqueous/Solid	EPA 8270D	GC-MS	Di-n-octylphthalate
Aqueous/Solid	EPA 8270D	GC-MS	Fluoranthene
Aqueous/Solid	EPA 8270D	GC-MS	Fluorene
Aqueous/Solid	EPA 8270D	GC-MS	Hexachlorobenzene
Aqueous/Solid	EPA 8270D	GC-MS	Hexachlorobutadiene
Aqueous/Solid	EPA 8270D	GC-MS	Hexachlorocyclopentadiene
Aqueous/Solid	EPA 8270D	GC-MS	Hexachloroethane
Aqueous/Solid	EPA 8270D	GC-MS	Indeno(1,2,3, cd)pyrene
Aqueous/Solid	EPA 8270D	GC-MS	Isophorone
Aqueous/Solid	EPA 8270D	GC-MS	Naphthalene
Aqueous/Solid	EPA 8270D	GC-MS	Nitrobenzene
Aqueous/Solid	EPA 8270D	GC-MS	N-Nitrosodiethylamine
Aqueous/Solid	EPA 8270D	GC-MS	N-Nitrosodimethylamine
Aqueous/Solid	EPA 8270D	GC-MS	N-Nitroso-di-n-propylamine
Aqueous/Solid	EPA 8270D	GC-MS	N-Nitrosodiphenylamine
Aqueous/Solid	EPA 8270D	GC-MS	o-Toluidine
Aqueous/Solid	EPA 8270D	GC-MS	Pentachlorobenzene
Aqueous/Solid	EPA 8270D	GC-MS	Pentachlorophenol
Aqueous/Solid	EPA 8270D	GC-MS	Phenanthrene
Aqueous/Solid	EPA 8270D	GC-MS	Phenol
Aqueous/Solid	EPA 8270D	GC-MS	Pyrene
Aqueous/Solid	EPA 8270D	GC-MS	Pyridine

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Gulf Coast Analytical Laboratories, LLC

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Contact Name: Randy Whittington   Phone: 225-769-4900

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8270D SIM	GC-MS	1-Methylnaphthalene
Aqueous/Solid	EPA 8270D SIM	GC-MS	2-Methylnaphthalene
Aqueous/Solid	EPA 8270D SIM	GC-MS	Acenaphthene
Aqueous/Solid	EPA 8270D SIM	GC-MS	Acenaphthylene
Aqueous/Solid	EPA 8270D SIM	GC-MS	Anthracene
Aqueous/Solid	EPA 8270D SIM	GC-MS	Benzo(a)anthracene
Aqueous/Solid	EPA 8270D SIM	GC-MS	Benzo(a)pyrene
Aqueous/Solid	EPA 8270D SIM	GC-MS	Benzo(b)fluoranthene
Aqueous/Solid	EPA 8270D SIM	GC-MS	Benzo(g,h,i)perylene
Aqueous/Solid	EPA 8270D SIM	GC-MS	Benzo(k)fluoranthene
Aqueous/Solid	EPA 8270D SIM	GC-MS	Chrysene
Aqueous/Solid	EPA 8270D SIM	GC-MS	Dibenz(a,h) anthracene
Aqueous/Solid	EPA 8270D SIM	GC-MS	Fluoranthene
Aqueous/Solid	EPA 8270D SIM	GC-MS	Fluorene
Aqueous/Solid	EPA 8270D SIM	GC-MS	Indeno(1,2,3-cd) pyrene
Aqueous/Solid	EPA 8270D SIM	GC-MS	Naphthalene
Aqueous/Solid	EPA 8270D SIM	GC-MS	Phenanthrene
Aqueous/Solid	EPA 8270D SIM	GC-MS	Pyrene
Aqueous/Solid	EPA 8330A	HPLC	1,3,5-Trinitrobenzene
Aqueous/Solid	EPA 8330A	HPLC	1,3-Dinitrobenzene
Aqueous/Solid	EPA 8330A	HPLC	2,4,6-Trinitrotoluene
Aqueous/Solid	EPA 8330A	HPLC	2,4-Dinitrotoluene
Aqueous/Solid	EPA 8330A	HPLC	2,6-Dinitrotoluene
Aqueous/Solid	EPA 8330A	HPLC	2-Amino-4,6-dinitrotoluene
Aqueous/Solid	EPA 8330A	HPLC	2-Nitrotoluene
Aqueous/Solid	EPA 8330A	HPLC	3,5-Dinitroaniline
Aqueous/Solid	EPA 8330A	HPLC	3-Nitrotoluene
Aqueous/Solid	EPA 8330A	HPLC	4-Amino-2,6-dinitrotoluene
Aqueous/Solid	EPA 8330A	HPLC	4-Nitrotoluene
Aqueous/Solid	EPA 8330A	HPLC	HMX (Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)
Aqueous/Solid	EPA 8330A	HPLC	Nitrobenzene
Aqueous/Solid	EPA 8330A	HPLC	Nitroglycerin
Aqueous/Solid	EPA 8330A	HPLC	Pentaerythritoltetranitrate
Aqueous/Solid	EPA 8330A	HPLC	RDX (Hexahydro-1,3,5-trinitro-1,3,5-triazine)

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	EPA 8330A	HPLC	Tetryl (Methyl-2,4,6-trinitrophenylnitramine)
Aqueous/Solid	EPA 8330B	HPLC	1,3,5-Trinitrobenzene
Aqueous/Solid	EPA 8330B	HPLC	1,3-Dinitrobenzene
Aqueous/Solid	EPA 8330B	HPLC	2,4,6-Trinitrotoluene
Aqueous/Solid	EPA 8330B	HPLC	2,4-Dinitrotoluene
Aqueous/Solid	EPA 8330B	HPLC	2,6-Dinitrotoluene
Aqueous/Solid	EPA 8330B	HPLC	2-amino-4,6-dinitrotoluene
Aqueous/Solid	EPA 8330B	HPLC	2-Nitrotoluene
Aqueous/Solid	EPA 8330B	HPLC	3,5-Dinitroaniline
Aqueous/Solid	EPA 8330B	HPLC	3-Nitrotoluene
Aqueous/Solid	EPA 8330B	HPLC	4-amino-2,6-dinitrotoluene
Aqueous/Solid	EPA 8330B	HPLC	4-Nitrotoluene
Aqueous/Solid	EPA 8330B	HPLC	HMX (Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)
Aqueous/Solid	EPA 8330B	HPLC	Nitrobenzene
Aqueous/Solid	EPA 8330B	HPLC	Nitroglycerin
Aqueous/Solid	EPA 8330B	HPLC	Pentaerythritoltetranitrate
Aqueous/Solid	EPA 8330B	HPLC	RDX (Hexahydro-1,3,5-trinitro-1,3,5-triazine)
Aqueous/Solid	EPA 8330B	HPLC	Tetryl (Methyl-2,4,6-trinitrophenylnitramine)
Aqueous/Solid	EPA 9012B	FIA	Total Cyanide
Aqueous/Solid	EPA 9038	Spectrophotometer	Sulfate
Aqueous/Solid	EPA 9056A	IC	Bromide
Aqueous/Solid	EPA 9056A	IC	Chloride
Aqueous/Solid	EPA 9056A	IC	Fluoride
Aqueous/Solid	EPA 9056A	IC	Nitrate and Nitrite as N
Aqueous/Solid	EPA 9056A	IC	Nitrate as N
Aqueous/Solid	EPA 9056A	IC	Nitrite as N
Aqueous/Solid	EPA 9056A	IC	Sulfate
Aqueous/Solid	EPA 9060A	TOC Analyzer	TOC
Aqueous/Solid	EPA 9066	FIA	Total Phenolics (4AAP)
Aqueous/Solid	EPA 9251	FIA	Chloride
Aqueous/Solid	FL-PRO	GC-FID	Petroleum Hydrocarbons
Aqueous/Solid	GCAL SOP WL-070	IC	Acetic Acid
Aqueous/Solid	GCAL SOP WL-070	IC	Butyric Acid
Aqueous/Solid	GCAL SOP WL-070	IC	Formic Acid

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Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solid	GCAL SOP WL-070	IC	Lactic Acid
Aqueous/Solid	GCAL SOP WL-070	IC	Propionic Acid
Aqueous/Solid	MADEP EPH	GC-FID	C11-C22 Aromatic Hydrocarbons
Aqueous/Solid	MADEP EPH	GC-FID	C19-C36 Aliphatic Hydrocarbons
Aqueous/Solid	MADEP EPH	GC-FID	C9-C18 Aliphatic Hydrocarbons
Aqueous/Solid	MADEP VPH	GC-FID	C5-C8 Aliphatic Hydrocarbons
Aqueous/Solid	MADEP VPH	GC-FID	C9-C10 Aromatic Hydrocarbons
Aqueous/Solid	MADEP VPH	GC-FID	C9-C12 Aliphatic Hydrocarbons
Aqueous/Solid	SM5210 B	Assay	BODs
Aqueous/Solid	SM4500-NH3 B & D	ISE	Ammonia as N
Aqueous/Solid	SW846 Sec 7.3	FIA	Reactive Cyanide
Aqueous/Solid	SW846 Sec 7.3	Titration	Reactive sulfide
Aqueous/Solid	TCEQ 1005	GC-FID	Total Petroleum Hydrocarbon
Aqueous/Solid	TNRCC 1006	GC-FID	DRO-aplhatic
Aqueous/Solid	TNRCC 1006	GC-FID	DRO-aromatic
Aqueous/Solid	TNRCC 1006	GC-FID	DRO-Total
Aqueous/Solid	TNRCC 1006	GC-FID	GRO-aliphatic
Aqueous/Solid	TNRCC 1006	GC-FID	GRO-aromatic
Aqueous/Solid	TNRCC 1006	GC-FID	GRO-Total
Aqueous/Solid	TNRCC 1006	GC-FID	ORO-aliphatic
Aqueous/Solid	TNRCC 1006	GC-FID	ORO-aromatic
Aqueous/Solid	TNRCC 1006	GC-FID	ORO-Total
Aqueous/Solid	TNRCC 1006	GC-FID	Total Petroleum Hydrocarbon
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Fluorotelomer sulfonate 8:2 (8:2 FTS)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Fluorotelomer sulfonate 4:2 (4:2 FTS)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Fluorotelomer sulfonate 6:2 (6:2 FTS)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)

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Contact Name: Randy Whittington   Phone: 225-769-4900

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluorobutanesulfonate (PFBS)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluorobutanoic acid (PFBA)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluorodecanesulfonate (PFDS)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluorodecanoic acid (PFDA)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluorododecanoic acid (PFDoA)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoroheptanesulfonate (PFHpS)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoroheptanoic acid (PFHpA)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluorohexanesulfonate (PFHxS)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluorohexanoic acid (PFHxA)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluorononanesulfonate (PFNS)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluorononanoic acid (PFNA)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluorooctane sulfonamide (FOSA)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluorooctanesulfonate (PFOS)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluorooctanoic acid (PFOA)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoropentanoic acid (PFPeA)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoropentansulfonate (PFPeS)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluorotetradecanoic acid (PFTeDA)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluorotridecanoic acid (PFTrDA)
AFFF/Aqueous/Solid	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	LC/MS/MS	Perfluoroundecanoic acid (PFUdA)

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Contact Name: Randy Whittington   Phone: 225-769-4900

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 3010A	Acid Digestion - Metals	Prep Method
Aqueous	EPA 3510C	Separatory Funnel	Prep Method
Aqueous	EPA 3520C	Continuous Liquid/Liquid Extraction	Prep Method
Aqueous	EPA 3535A	Solid Phase Extraction	Prep Method
Aqueous	EPA 5030B	Purge and Trap	Prep Method
Solid	EPA 1311	SPLC	Prep Method
Solid	EPA 1311	TCLP	Prep Method
Solid	EPA 3050B	Acid Digestion	Prep Method
Solid	EPA 3535A	Incremental Sampling Method	Prep Method
Solid	EPA 3550C	Extraction - Sonication	Prep Method
Solid	EPA 3540C	Extraction - Soxhlet	Prep Method
Solid	EPA 3546	Extraction - Microwave	Prep Method
Solid	EPA 5035	Purge and Trap	Prep Method

Appendix C
July 2018 Scoping Session Presentation

Expanded SI Scoping

Path Forward

- Source Area Assessment will be completed in FY 2019 to identify any additional PFAS source areas and complete interviews with Base personnel.
- ESI UFP-SAP is expected to be submitted to the Team in November 2018.

Expanded SI Objectives

- Further define the lateral and vertical extent of PFAS contamination
- Refine understanding of the hydraulic characteristics of the site
- Determine if PFAS contamination is present in soil at additional source areas not evaluated in the SI
- Determine if PFAS contamination is present in surface water, and/or sediment
- Conduct supplemental Ecological and Human Health Risk Screenings

Ecological Screening Values - Soil

Chemical	ESV (ug/kg)	Type/ Receptor	Reference	Comments
PFOS	4,600	Plant	Beach et al. 2006	Ryegrass, 21-day NOEC (shoot height); converted to dry weight based on a reported value of 85% solids
	10,000	Invertebrate	NPCA 2008	Earthworm NOEC (note: UF of 100 was applied to this NOEC by NPCA to derive a PNEC value of 100 µg/kg but this was considered very conservative even for use as a screening value and the UF was not applied to derive the ESV)
PFOA	16,000	Invertebrate	NPCA 2008	Earthworm NOEC (note: UF of 100 was applied to this NOEC by NPCA to derive a PNEC value of 160 µg/kg but this was considered very conservative even for use as a screening value and the UF was not applied to derive the ESV)

Beach, S.A., J.L. Newsted, K. Coady, and J.P. Giesy. 2006. Ecotoxicological Evaluation of Perfluorooctanesulfonate (PFOS). Reviews of Environmental Contamination and Toxicology. 186:133-174.

Norwegian Pollution Control Authority (NPCA). 2008. Screening of Polyfluorinated Organic Compounds at Four Fire Training Facilities in Norway. TA-2444/2008. December.

Ecological Screening Values – Fresh Surface Water

Chemical	ESV (ug/L)	Type	Comments
PFOS	5.10	Final chronic value	Acute-to-chronic ratio applied to Final Acute Value (protective of 95% of test species)
PFOA	2,900	Secondary chronic value	
PFBS	24,000	Secondary chronic value	

Giesy J.P., J.E. Naile, J.S. Khim, P.D. Jones, and J.L. Newsted. 2010. Aquatic toxicology of perfluorinated chemicals. Reviews of Environmental Contamination and Toxicology. 202:1–52.

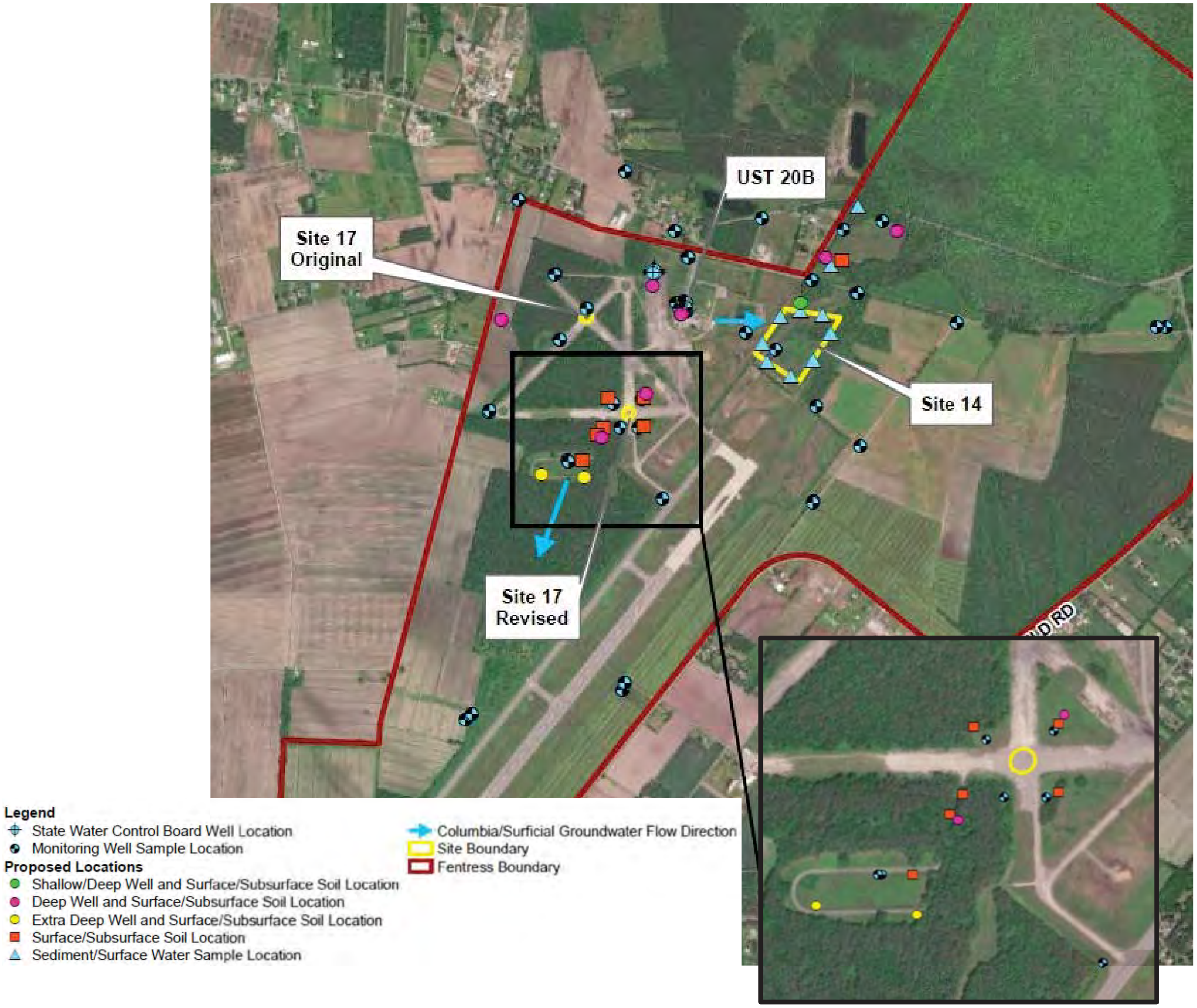
Ecological Screening Values – Fresh Sediment

Chemical	ESV (ug/kg)	Type	Comments
PFOS	220	Chronic NOEC	Threshold for chronic toxic effects

Norwegian Pollution Control Authority (NPCA). 2008. Screening of Polyfluorinated Organic Compounds at Four Fire Training Facilities in Norway. TA-2444/2008. December.

Proposed Sampling Strategy

- Install 1 shallow monitoring well and 10 deep monitoring wells, including 2 at a deeper interval than previously installed
- Complete a groundwater level survey of all new and existing monitoring wells
- Sample all previously monitored monitoring wells and all newly installed monitoring wells Collect approximately 15 co-located surface (0 to 6” bgs) and subsurface (6 to 24” bgs) soil samples and collect co-located surface and subsurface soil samples at all new monitoring well locations
- Collect approximately 10 co-located sediment and surface water samples
- All samples will be analyzed for 14 PFAS


UST 20B
Site 17 Original
Site 14
Site 17 Revised
ND RD
Legend
State Water Control Board Well Location
Monitoring Well Sample Location
Proposed Locations
Shallow/Deep Well and Surface/Subsurface Soil Location
Deep Well and Surface/Subsurface Soil Location
Extra Deep Well and Surface/Subsurface Soil Location
Surface/Subsurface Soil Location
Sediment/Surface Water Sample Location
Columbia/Surficial Groundwater Flow Direction
Site Boundary
Fentress Boundary

Appendix D

PFAS Laboratory Standard Operating Procedures

Battelle
Standard Operating Procedure

for

ANALYSIS OF POLY AND PERFLUOROALKYL SUBSTANCES IN ENVIRONMENTAL SAMPLES BY LIQUID CHROMATOGRAPHY AND TANDEM MASS SPECTROMETRY (LC-MS/MS)

Summary of changes in this version: Secondary transition for PFHpS updated. Updated internal standard area criteria to use level 5 of the calibration curve. Updated section 5.3 to define calibration points for the CCV and ISC samples.

1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes the identification and quantification of perfluoroalkyl substances (PFASs) in environmental samples by liquid chromatography and tandem mass spectrometry (LC-MS/MS). This method was developed with consideration given to ASTM method 7968 (ASTM, 2014), EPA Method 537 (Shoemaker, Grimmett, & Boutin, 2009), and Sciex application notes for PFAS extraction and analysis (Simon, et al., 2016).

2.0 METHOD SUMMARY

PFAS compounds are extracted and prepared for analysis utilizing the appropriate technique dependent on matrix (SOP 5-370). The extracts are analyzed by LC-MS/MS monitoring the primary transition for each target analyte, when available, a secondary transition is monitored for confirmation. The analytes are identified by the primary transition and retention time. The identified analytes are quantified using an isotopic dilution approach (where an isotopically labelled compound was not available for a target analyte, the labelled analog with the closet retention time (RT) is used for quantification). A data system interfaced to the LC-MS/MS is used to control acquisition and to store, retrieve, and manipulate LC-MS/MS data. This method provides specific procedures for the identification and measurement of the PFAS listed in **Attachment 1**. Individual projects may analyze all or a subset of the target analytes presented in this attachment.

3.0 EQUIPMENT AND SUPPLIES

The following equipment is required to perform the analytical method. Equivalent apparatus and materials may be substituted if approved by the laboratory and project managers.

- HPLC (Shimadzu LC20ADXR, Agilent 1260 SL, or equivalent)
- Tandem Mass Spectrometer (Sciex 6500, Sciex 5500, or equivalent)
- Analytical column (Phenomenex Gemini® C18 3 µm; 50 x 2 mm, part No. 00B-4439-B0, or equivalent)
- Delay Column (Phenomenex Luna® C18(2) 5 µm; 30 x 2 mm, part No. 00A-4252-B0, or equivalent)

4.0 REAGENTS AND STANDARDS

4.1 Reagents and Consumable Materials

The following Battelle SOPs outline reagent login, labeling, and storage that are applicable to this method:

5-015 (Solvent/Reagent Inventory and Contaminant Residue Checks)
5-027 (Analytical Standards in the Organics Laboratory)
5-217 (Labeling of Chemical Materials in the Laboratory)

4.1.1 Solvents and Reagents

- Methanol (HPLC grade, or equivalent)
- Ammonium Acetate (reagent grade, or equivalent)
- Reagent water (Millipore or equivalent)

4.1.2 Consumables

- Polypropylene vials (Environmental Express part No. SC475, or equivalent)
- 1 mL Polypropylene LC extract vials (Thermo Fisher part No. 22-294325, or equivalent)
- Snap caps (Thermo Fisher part No. 03-345-24G, or equivalent)

4.2 Standards and Solutions

Standard preparation procedures for all calibration solutions are detailed in SOP 5-027. All prepared standards must be stored refrigerated and can be kept in screw-cap polypropylene vials. Standards are stored separately from samples. All stock solutions are prepared in 96% methanol in reagent water

4.2.1 Calibration Standards

Calibration standards should contain all individual target compounds. Primary stock solutions that contain the target analytes are purchased and used to prepare the Initial Calibration (ICAL), Continuing Calibration Verification (CCV), and Independent Calibration Check (ICC) standards. Most standards used for this method are purchased from standard providers (e.g., Sigma Aldrich and Wellington) in neat or solution form. Equivalent standards may be substituted if approved by the laboratory and project manager. All final calibration standards for this method are made in 80% methanol in reagent water. The ICC must be independent of the ICAL standards and thus should be made using either a standard from a different vendor or a standard from the same vendor with a lot number different from the ICAL standard. When commercially available, the calibration curve will contain both branched and linear isomers. Technical grade standards cannot be used for quantitative analysis.

The recommended calibration levels for the ICAL standards are presented in **Table 1** below. The concentration of the IS does not vary with each level. The lowest point of the calibration curve will be at or below the LOQ for all target analytes. The remaining concentration levels should not exceed the working range of the LC-MS/MS system. If concentrations of samples are above the calibration range, the extract will be diluted and re-analyzed.

***Table 1**: Nominal Calibration Concentrations (ng/L)*

	L1	L2	L3	L4	L5	L6	L7	L8	L9
Targets	25	50	100	250	500	1,000	2,500	10,000	20,000
Labeled Analogues	100	100	100	100	100	100	100	100	100
Internal Standard	100	100	100	100	100	100	100	100	100

4.2.2 ICC Spiking Solution

The ICC spiking solution should include all target compounds proposed for analysis from a source independent from the initial calibration (if commercially available). The concentration should be at or near the midpoint of the initial calibration.

5.0 PROCEDURES

5.1 Sample Analysis

The extracts were analyzed under the conditions presented in **Table 2**.

***Table 2**: Analytical Parameters*

Column:	Phenomenex Gemini® C18 – 3 µm; 50 x 2 mm (analytical) Phenomenex Lina® C18(2) – 5 µm; 30 x 2 mm (delay)		
Column Temperature:	40 °C (analytical), delay column installed between the pump mixing chamber and the column, outside of the column oven		
Injection Volume:	10 µL		
Flow Rate:	600 µL/min		
Mobile Phase A:	Millipore water with 20 mM ammonium acetate		
Mobile Phase B:	Methanol		
Analytical Run Time (end)	7.00 minutes		
	Time – minutes	% A	% B
	0.00	90	10
	0.10	45	55
	4.50	1	99
	4.95	1	99
	7.00	90	10
Ion Source:	Turbo Ion Spray		
Polarity:	Negative		
Ion Spray Voltage (IS):	-4500 v		
Collision Gas (CAD):	Medium		
Temperature (TEM):	450 °C		
Curtain Gas (CUR):	35 PSI		
Ion Source Gas 1 (GS1):	50 PSI		
Ion Source Gas 2 (GS2):	50 PSI		
Entrance Potential (EP):	10		

Multiple Reaction Monitoring (MRM) transitions are monitored for each analyte, labeled analogue, and internal standard using the scheduled MRM™ algorithm in the data acquisition software. The MRM transitions are collected inside of a 60 second window around the expected retention time to maximize the spectra scans collected.

The following quality control checks are required for analysis.

5.1.1 Mass Calibration

Prior to initial use and after performing major maintenance, calibrate the mass scale of the MS with calibration compounds as described by the instrument manufacturer. The entire mass range must be calibrated. This is performed during the scheduled 6-month preventative maintenance (PM) by an outside vendor.

5.1.2 Tune Check

When the masses fall outside of the +/- 0.5 amu of the true values (as determined by the product ion formulas) the instrument must be retuned and verified. Sample analysis shall not proceed until the masses are within +/- 0.5 amu of the true values. This is performed after instrument re-tuning and during the scheduled 6-month PM by an outside vendor.

5.2 Calibration

Demonstration and documentation of acceptable initial calibration is required before any samples are analyzed. The ICAL must be verified by analysis of an ICC immediately following the ICAL. A CCV is required at the beginning of each sample analysis sequence and after ten injections during the sample analysis sequence.

5.2.1 Initial Calibration

Analyze a minimum of five calibration standards that will represent the expected concentration range of the samples. Suggested standard concentrations are outlined in **Table 1** above.

For each level of calibration, calculate the correlation coefficient (r) with a weighting of 1/x for each analyte of interest in the calibration standard using the software supplied with the LC-MS/MS data system. The formula is provided in Section 7.0.

ICAL acceptance criteria

The ICAL criteria are:

- $r^2 > 0.99$ for each analyte
- Minimum of 5 points for a linear curve fitting
- Minimum of 6 points for a quadratic curve fitting
- Each target compound must be within 70% – 130% of their true value
- Labeled analyte concentrations must be within 70% – 130% of their true value
- Internal standard area must be within +/- 50% of the L5 of the calibration curve

If these requirements are not met for the ICAL, corrective action is performed and the calibration is repeated.

5.2.2 Independent Calibration Check

Verify the ICAL with an ICC immediately after the ICAL is completed. The ICC is analyzed under the same analytical conditions used in the ICAL and for the analysis of samples.

ICC Target Analyte Performance Criteria

The ICC criteria are:

- Individual %DIFF ≤ 30%
- Labeled analyte concentrations must be within 70% – 130% of their true value
- Internal standard area must be within +/- 50% of the L5 of the calibration curve

If ICC meets the above criteria, then the ICAL is assumed to be valid. If the criteria are not met, reanalyze the ICC. If the second ICC fails, a new ICAL must be performed or justification for continuing must be documented.

5.2.3 Continuing Calibration Verification

The ICAL is verified at least at the beginning and end of each 12-h period during which analyses are to be performed. The CCV is analyzed under the same analytical conditions used for the ICAL and ICC. The appropriate CCV solution is analyzed, quantified, and assessed as described below.

CCV Target Analyte Performance Criteria

The CCV criteria are:

- Frequency: beginning of each sample analysis sequence (if not preceded by and ICC) and after 10 injections during sample analysis sequence
- Individual % DIFF ≤ 30%
- Labeled analyte concentrations must be within 50% of their true value

If CCV meets the above criteria, then the ICAL is assumed to be verified. Proceed with the analysis of samples. When a CCV fails to meet any of the above criteria, two additional CCV's are analyzed consecutively. If both additional CCV's pass criteria, the samples can be reported. If either of the two additional CCV's fail criteria or cannot be analyzed all samples that were analyzed after the prior acceptable CCV must be re-analyzed. If a CCV fails because a target analyte exceeded the acceptance limit defined above (over response only) and that analyte was not detected in any samples, then the samples do not need to be reanalyzed. In all other cases, the sample must be reanalyzed after an acceptable CCV has been established or justification for continuing is approved by the project manager and documented.

For successive continuing calibrations, vary the CCV standard concentration.

5.2.4 Instrument Blank (IB)

An instrument blank must be analyzed immediately following the highest calibration standard analyzed and daily prior to sample analysis. Any concentration that can be determined for each analyte must be ≤ ½ of the LOQ. If acceptance criteria are not met, additional IB samples will be analyzed until acceptance is met.

5.2.5 Post Spike and Matrix Duplicate Samples

Post spike and Matrix Duplicate (MD) sample analysis will not be performed as this analytical method does not allow for direct injection of aqueous samples. If direct injection analysis is required for high level samples (i.e. AFFF formulations, the post spike and MD samples will be addressed in the Project Plan.

5.2.6 Branched Isomer Verification

A standard containing commercially available branched isomers is run after the ICAL to verify that potential branched ion transitions are collected during analysis. Branched isomers will be quantified vs. the linear isomer unless the calibration contains branched isomers. Examples of branched isomers can be found in **Attachment 4**.

5.2.7 Instrument Sensitivity Check (ISC)

An instrument sensitivity check at a concentration no greater than the LOQ value is analyzed to verify instrument sensitivity. The analyte concentrations must be within 30% of their true values. An ISC must be analyzed prior to sample analysis and at least every twelve hours during sample analysis. No samples can be analyzed until the ISC has met criteria. The ISC can be used as a CCV during analysis.

5.2.8 Labeled Analogues (Extracted Internal Standards)

The labeled analogues used for quantification must me added prior to extraction (extractions detailed in SOP 5-370). Recoveries must be between 50% – 150% of their true value. If the recoveries are acceptable in QC samples but not field samples, the field samples must be repreped and reanalyzed as a greater dilution may be needed. If recoveries of the QC samples are not acceptable, the problem must be corrected and all associated samples must be reanalyzed. The data will be qualified and discussed in the case narrative only if the reanalysis confirms the failures.

5.2.9 Internal Standard Area (Injection Internal Standards)

The internal standard area for all injections must be within +/- 50% of the internal standard area of the L5 of the ICAL. When the calibration is not performed on the same day as the analysis, the area must be within +/- 50% of the area of the daily initial CCV. If the area of a sample extract fails criteria, corrective action must be taken. Corrective action includes analyzing a second aliquot of sample, if available, or reanalysis of the original extract. If the second analysis passes criteria, the second analysis will be reported. If the IS are fails after additional analysis, either value can be reported with the appropriate data qualifier and discussed in the case narrative.

5.2.10 Retention Time Windows

A default RT window for an analyte is +/- 10 s. The ICC and CCV analytes must fall within the established RT window. If the RT of these compounds does not fall within the window, evaluation for acceptable identification by an experienced analyst shall be considered or corrective action can be taken to restore the system.

Because of the variable patterns of target compounds in many samples, pattern recognition and analyst experience should weigh heavily in the interpretation of chromatograms. A narrative must accompany any target analyte selected that falls outside its RT window.

DoD Projects:
A retention time study will be performed prior to the start of a DoD project and will be valid until a major change in the analysis system occurs (e.g., column changed).

5.3 Sequence of Analysis

An analysis sequence is initiated with an acceptable ICAL and ICC (if necessary) or an acceptable CCV followed by the appropriate number of samples to be analyzed and ending with a CCV. The sequence may be continued with another group or groups of samples and CCVs provided the CCV results remain within the acceptance criteria (reference Section 5.2.3). All QC and authentic samples must be bracketed by acceptable CCVs or ICAL.

The order of calibration and analysis is as follows (if a new ICAL is needed):

a. Methanol
b. ICAL
c. IB
d. ICC
e. Branched Standard
f. Methanol
g. Sample analysis sequence
h. CCV or ISC (ISC required every 12 hours, otherwise CCV is varied from L2 –L7 of calibration curve; ISC is any standard between L2 and L5 of the calibration curve)
i. Methanol

Repeat g, h, and i for continued analysis of QC and authentic samples if g and h continue to pass criteria.

When a new ICAL is not needed, analysis must start with an ISC and IB sample.

5.4 Sample Analysis

Samples are run under the same conditions as the ICAL. Start the analysis of samples with quality control samples.

5.4.1 Qualitative Identification of Individual Target Compounds

Sample peaks are identified visually using the MultiQuant™ display program. Sample peaks should fall within the established retention time window. A narrative must accompany any target analyte selected that falls outside its retention time window. For peak identification, the experience of the analysts should weigh heavily in the interpretation of data.

Identify the target compounds (**Attachment 2**) based on retention time established during the calibration and the transitions presented in **Attachment 3**. Comparison of both retention times and transitions to reference standard is also useful in compound identification.

5.4.2 Mass Spectral Acquisition Rate

A minimum of 10 spectra scans are acquired for each peak.

5.4.3 Ion Transitions

With the exception of PFBA and PFPeA, two transitions and the ion transition ratio will be monitored for each target analyte and reported. Transitions are defined in **Attachment 3**. Two transitions are not required for labeled analogues and internal standards.

5.4.4 Signal to Noise Ratio

A minimum signal to noise ratio of 10:1 is required for all ion transitions used for quantification. Analytes that have a health advisory (HA) level or other action level, must have a signal to noise ratio of at least 3:1 for the confirmatory transition.

5.4.5 Quantification of Analytes

Identify target analyte peaks that match retention times and other criteria above. Confirm the auto-baseline on the quantification ions or redraw the baselines, as necessary. Quantify each peak following procedures presented in the instrument manufacturer user's manual and Battelle SOP 4-038.

Quantification of analytes identified in samples will be performed by the isotopic dilution method, using the appropriate curve fitting from the ICAL. See Section 7.0 for additional information regarding calculations used for the determination of target analyte concentrations in samples. Upon selection of the appropriate calibration option and the identification of a peak, the MultiQuant™ software calculates the compound amounts from the peak areas, as described in Section 7.0. Review the results against calibration standards and other project samples for reasonableness.

5.4.6 Manual Integrations

Using the MultiQuant™ software, identify target analyte peaks that match retention time and other criteria above. Confirm acceptance of the MultiQuant™ auto-baseline for the peak or redraw the baseline, as necessary. Manual integrations will be used to separate near co-eluted peaks, remove negative peaks, and compensate for other peak shape or baseline anomalies that often occur in environmental samples. Guidance for manual integrations is provided in SOP 4-038.

DoD projects:
The rationale for manual integrations must be documented in the data package; samples and analytes which required manual integrations must be identified in the case narrative.

5.4.7 Reporting Units

Reporting units are ng/L for water and ng/g for soil, sediments, and tissues unless the QAPP specifies otherwise. Soils and sediments are typically reported on a dry weight basis while tissues are reported on a wet weight basis.

6.0 QUALITY CONTROL

LC Facility operations are documented according to SOP 6-025. Electronic files of all calibrations and sample data are kept in project specific network folders (SOP 6-032). Analysis of quality control samples including Procedural Blank (PB), Laboratory Control Sample (LCS), laboratory Control Sample Duplicate (LCSD), Matrix Spike (MS), Matrix Spike Duplicate (MSD), Duplicate (DUP), and Triplicate (TRP) are specified in the QAPP. The quality control acceptance criteria will follow the criteria outlined in SOP 7-029 unless modified in the QAPP. Key elements of the quality control program include:

1. There must be an initial calibration of the instrument as specified in 5.

2. Each day that analysis is performed, the calibration verification standard should be evaluated to determine if the chromatographic system is operating properly.

3. It is recommended each day that analysis is performed, an instrument blank should be evaluated to determine if the chromatographic system is free of contamination.

4. Peak shape should be evaluated for proper peak shape and symmetry.

5. The instrumental response should be comparable to previous calibrations.

6. The system must be recalibrated at method setup and after major maintenance.

DoD projects:
The analysis, frequency, and acceptance criteria of quality control samples will be determined in the latest revision of the Quality Systems Manual.

7.0 DATA ANALYSIS AND CALCULATIONS

7.1 Initial Calibration

Correlation Co-efficient

$$r = \left(\sum w \sum wyy_c - \sum wy \sum wy_c\right) / \sqrt{\left(D_y D_{yc}\right)}$$

where:

$$D_y = \sum w \sum wy^2 - \left(\sum wy\right)^2$$

y_c = calculated y-value using the equation below:

$$D_{yc} = \sum w \sum wy_c^2 - \left(\sum wy_c\right)^2$$

Linear Regression Method

- Y = mX + b

  which is equivalent to: $A_A/A_{IS} = [[m\ H\ (C_A/C_{IS})] + b]$

- $C_A = [(A_A/A_{IS})\ b]\ H\ (C_{IS}/m)$

The slope and intercept are calculated as:

$$m = \left(\sum w \sum wxy - \sum wx \sum wy\right) / D_x$$

$$b = \left(\sum wx^2 \sum wy - \sum wx \sum wxy\right) / D_x$$

Where:

$$D_x = \sum w \sum wx^2 - \left(\sum wx\right)^2$$

Weighting Type	Weight (w)
1 / x	If $|x| < 10^{-5}$, then $w = 10^5$. Otherwise, $w = 1 / |x|$.

7.2 Calibration Verification

Calculate the percent difference (%DIFF) between the calculated amount ("found" amount) and the true amount using the equation below:

$$\%DIFF = \frac{(A_C - A_I)}{A_I} * 100\%$$

Where:
A_I = "true" analyte amount
A_C = "found" analyte amount

7.3 Quantification of Samples

Samples are quantified as detailed in Section 5. The concentration of target analytes is determined using the following equation:

$$x = (y - b) / m$$

8.0 TRAINING

The trainee must read and fully understand the policies and procedures outlined in this SOP and have documented training in Battelle SOPs 4-038 and 6-025. Training for these SOPs should be documented according to procedures outlined in the Quality Assurance Manual. The trainee will then be given a demonstration of all aspects of this SOP.

Analysts may work independently once they have satisfactorily performed the following training:

- Demonstrate ability to set up the instrument and perform routine maintenance
- Analyze an acceptable initial calibration
- Analyze at least four LCS samples concurrently or over a period of days that meet the criteria outlined in SOP 7-029.

When training is completed, the trainee will be issued a Demonstration of Capability (DOC) Certificate (SOP 2-011). The original completed training certificate and all supporting documentation will be stored in the Chemistry files.

Analysts must also demonstrate annual proficiency in the method. SOP 2-011 (Staff Training) outlines the acceptable performance procedures. When annual training is completed, the analyst will be issued a DOC Certificate.

9.0 SAFETY

All LC-MS/MS operators must be experienced with the operation and maintenance of the LC-MS/MS system.

- Protective clothing should be worn when appropriate.
- Proper care must be exercised when using syringes.
- Certain areas of the LC-MS/MS system are heated zones and bodily contact with these zones should be avoided.

- High voltages exist in certain marked areas of the LC-MS/MS system and bodily contact with these areas is to be avoided.
- Care should be taken when using solvents in and around the LC system.

10.0 POLLUTION PREVENTION

Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. Staff should make every effort to use the minimum amount of sample and reagent for this analytical procedure. All samples and reagents are contained and disposed of in an appropriate manner (Section 12).

11.0 CORRECTIVE ACTION

Battelle maintains a corrective action program that is detailed in SOP 4-035. The Laboratory Manager must approve all corrective actions initiated within the laboratory. The effectiveness of corrective actions is verified by the Quality Assurance Unit.

12.0 WASTE MANAGEMENT

All waste streams generated within the laboratory are collected and stored in an appropriate container and disposed according to SOP 5-114 or when appropriate, by other approved waste management procedures.

13.0 INTERFERENCES

Method inferences may be caused by contaminants in solvents, reagents, glassware, and other sample processing apparatus that lead to discrete artifacts or elevated baselines in chromatograms. All solvent/reagents must be analyzed initially to demonstrate they are free from interferences (SOP 5-015). Glassware must be scrupulously cleaned following the procedures outlined in SOP 5-216. The use of high purity reagents and solvents helps to minimize these interference problems. Significant effort must be taken to ensure no PTFE or other surface containing PFAS comes in contact with the materials or equipment in the sample pathway from preparation to analysis.

Matrix interferences may be caused by contaminants that are co-extracted from the sample. The extent of matrix interferences will vary considerably from source to source, depending on the nature and diversity of the sample. Specific to PFOS analysis in tissues, the transition 499 → 80 from taurodeoxycholic acid (TDCA) may interfere with quantification. The transition 499 → 107 will be monitored for the presence of TDCA, if present, the quantification of PFOS will be performed using the confirmation transition of 499 → 99.

Cross-contamination can occur whenever high-level and low-level samples are analyzed sequentially. Whenever an unusually concentrated sample is analyzed, the samples following it may need re-analysis if cross-contamination is suspected. The LC system may require maintenance if it has been exposed to high level samples.

14.0 DEFINITIONS

Battelle's methodology terms are consistent with the The NELAC Institute (TNI) Glossary of Terms outlined in the TNI Constitutions, Bylaws and Standards Manual. The TNI Glossary of Terms currently being utilized by Battelle is outlined in Attachment B of Battelle's Quality Assurance Manual. Battelle's method detection terminology is defined in SOP 5-291 and quality control terminology in SOP 7-029.

15.0 METHOD DETECTION LIMITS

Battelle maintains a program for determining and verifying method detection limits (MDL), LOD, LOQ, and reporting limit (RL) values. The policies and procedures are defined in SOP 5-291 and Battelle's Quality Assurance Manual. All MDL, LOD, and LOQ study results are accessible within the laboratory network files. All reporting limits are based on the low standard of the calibration curve, sample dilutions and sample size.

16.0 METHOD PERFORMANCE

Battelle maintains a program for determining method performance. The policies and procedures are outlined in SOP 5-295 and Battelle's Quality Assurance Manual. The Laboratory Manager must approve all new methodologies before use.

17.0 DATA ASSESSMENT AND ACCEPTANCE CRITERIA

Battelle maintains a program for assessing data and determining acceptance criteria for quality control measures. These policies and procedures are outlined in SOP 7-029 and in Battelle's Quality Assurance Manual. Battelle also maintains a program for handling out-of-control or unacceptable data. These policies and contingencies are outlined in SOP 4-035, SOP 7-029, and Battelle's Quality Assurance Manual.

18.0 REFERENCES

ASTM. (2014). *D7968: Standard Test Method for Determination of Perfluorinated Compounds in Soil by Liquid Chromatography Tandem Mass Sectrometry (LC/MS/MS).* West Conshohocken: ASTM.

Shoemaker, J. A., Grimmett, P. E., & Boutin, B. K. (2009). *Method 537 Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS).* Cincinnati: EPA.

Simon, R., KC, H., Craig, B., Scott, K., Eric, R., & Christopher, B. (2016). *Quantitation of PFASs in Water Samples Using LC/MS/MS: Large-Volume Direct Injection and Solid Phase Extraction.* Framingham: Sciex.

ATTACHMENTS

Attachment 1	Revision History
Attachment 2	PFAS Target Analyte List
Attachment 3	Acquisition Parameters and Transitions
Attachment 4	Example Chromatograms for Branched Isomers

APPROVALS:

Author		Digitally signed by Jonathan Thorn Date: 2018.04.25 18:29:36 -04'00'
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Quality Systems Manager	Zachary Willenberg	Digitally signed by Zachary Willenberg Date: 2018.04.26 16:21:56 -04'00'
Laboratory Manager		Digitally signed by Jonathan Thorn Date: 2018.04.26 16:29:29 -04'00'
	Name	Date

ATTACHMENT 1

Revision History

Version	Summary of Changes
02	Removed sample preparation methods from SOP (moved to SOP 5-370). Updated analytical method. This method is not equivalent to the previous analytical method, new Demonstrations of Capability (DOC) will be needed for this version of the SOP. Revision history added as **Attachment 1**.
03	Updated the analyte list and corrected an error in the labeling of the branched isomer examples This method is equivalent to the previous version, a new Demonstration of capability (DOC) will not be needed for this version.
04	Added three target analytes to the analyte list, expanded the list of labeled analogs and internal standards used. Clarified section on post spike samples and Matrix Duplicate samples. This revision requires a new Demonstration of capability (DOC) for the additional analytes.
05	Primary transition for PFHpS updated. The storage of prepared standards updated.

ATTACHMENT 2

PFAS Target Analyte List

Analyte	Code	CAS No.
Perfluoro-n-butanoic acid	PFBA	375-22-4
Perfluoro-n-pentanoic acid	PFPeA	2706-90-3
Perfluororhexanoic acid	PFHxA	307-24-4
Perfluoroheptanoic acid	PFHpA	374-85-9
Perfluorooctanoic acid	PFOA	335-67-1
Perfluorononanoic acid	PFNA	375-95-1
Perfluorodecanoic acid	PFDA	335-76-2
Perfluoroundecanoic acid	PFUnA	2058-94-8
Perfluorododecanoic acid	PFDoA	307-55-1
Perfluorotridecanoic acid	PFTrA	72629-94-8
Perfluorotetradecanoic acid	PFTeDA	376-06-7
N-methylperfluoro-1-octanesulfonamidoacetic acid	NMeFOSAA	2355-31-9
N-ethylperfluoro-1-octanesulfonamidoacetic acid	NEtFOSAA	2991-50-6
Perfluoro-1-octanesulfonamide	PFOSA	754-91-6
Perflurorbutanesulfonic acid	PFBS	375-73-5
perfluoro-1-pentanesulfonate	PFPeS	BDO-2114
perfluoro-1-hexanesulfonate	PFHxS	3781-99-6
Perfluoro-1-heptanesulfonate	PFHpS	375-99-6
Perfluorooctanesulfonic acid	PFOS	1763-23-1
Perfluoro-1-nonanesulfonate	PFNS	98789-57-2
Perfluoro-1-decanesulfonate	PFDS	2806-15-7
1H,1H,2H,2H-Perfluorohexane sulfonate	4:2FTS	NA
1H,1H,2H,2H-Perfluorooctane sulfonate	6:2FTS	27619-97-2
1H,1H,2H,2H-Perfluorodecane sulfonate	8:2FTS	39108-34-4
Labeled Analogues		
Perfluoro-n-[1,2,3,4-13C4]butanoic acid	13C4-PFBA	BDO-2105
Perfluoro-n-[13C5]pentanoic acid	13C5-PFPeA	BDO-2216
Perfluoro-n-[1,2,3,4,6-13C5]hexanoic acid	13C5-PFHxA	BDO-2217
Perfluoro-n-[1,2,3,4-13C4]hepetanoic acid	13C4-PFHpA	BDO-2218
Perfluoro-n-[13C8]octanoic acid	13C8-PFOA	BDO-2219
Perfluoro-n-[13C9]nonanoic acid	13C9-PFNA	BDO-2221
Perfluoro-n-[1,2,3,4,5,6-13C6]decanoic acid	13C6-PFDA	BDO-2222
Perfluoro-n-[1,2,3,4,5,6,7-13C7]undecanoic acid	13C7-PFUnA	BDO-2223
Perfluoro-n-[1,2-13C2]dodecanoic acid	13C2-PFDoA	BDO-2112
Perfluoro-n-[1,2-13C2]tetradecanoic acid	13C2-PFTeDA	BDO-2224
N-methyl-d3-perfluoro-1-octanesulfonamidoacetic acid	d3-MeFOSAA	BDO-2125

Analyte	**Code**	**CAS No.**
N-ethyl-d5-perfluoro-1-octanesulfonamidoacetic acid	d5-EtFOSAA	BDO-2126
Perfluoro-1-[13C8]octanesulfonamide	13C8-FOSA	BDO-2225
perfluoro-1-[2,3,4-13C3]butanesulfonate	13C3-PFBS	BDO-2226
perfluoro-1-[1,2,3-13C3]hexanesulfonate	13C3-PFHxS	BDO-2227
perfluoro-1-[13C8]octanesulfonate	13C8-PFOS	BDO-2228
1H,1H,2H,2H-perfluoro-1-[1,2-13C2]hexanesulfonate	13C2-4:2FTS	BDO-2229
1H,1H,2H,2H-perfluoro-1-[1,2-13C2]octanesulfonate	13C2-6:2FTS	BDO-2230
1H,1H,2H,2H-perfluoro-1-[1,2-13C2]decanesulfonate	13C2-8:2FTS	BDO-2220
Internal Standards		
Perfluoro-n-[2,3,4-13C3]butanoic Acid	13C3-PFBA	BDO-2231
Perfluoro-n-[1,2-13C2]octanoic acid	13C2-PFOA	BDO-2107
Perfluoro-n-[1,2-13C2]decanoic acid	13C2-PFDA	BDO-2110
Perfluoro-1-]1,2,3,4-13C4]octanesulfonate	13C4-PFOS	BDO-2121
Potential Interferences		
Taurodeoxycholic acid	TDCA	1180-95-6

ATTACHMENT 3

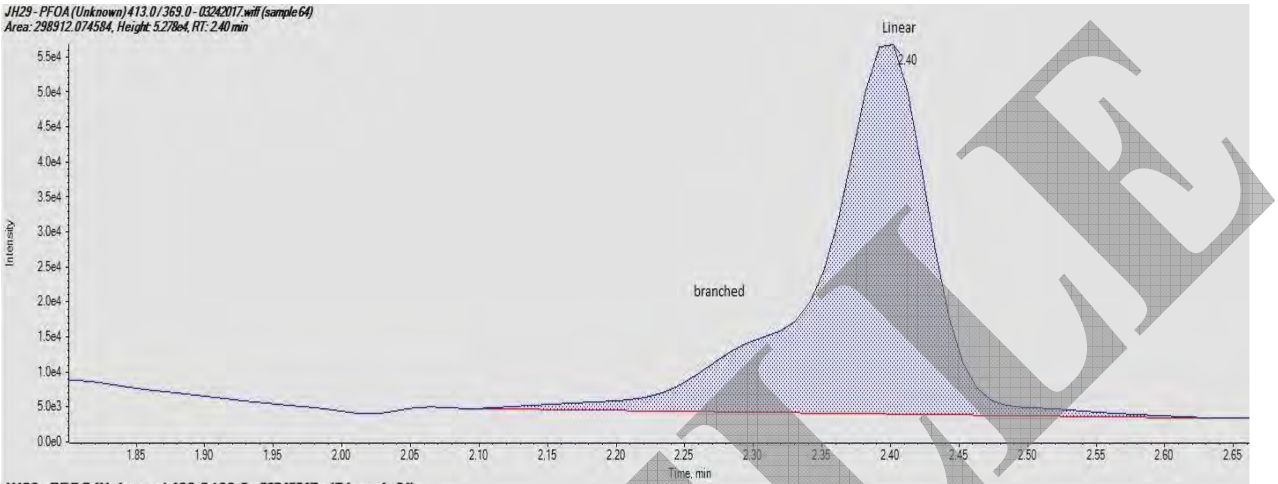
Acquisition Parameters and Transitions

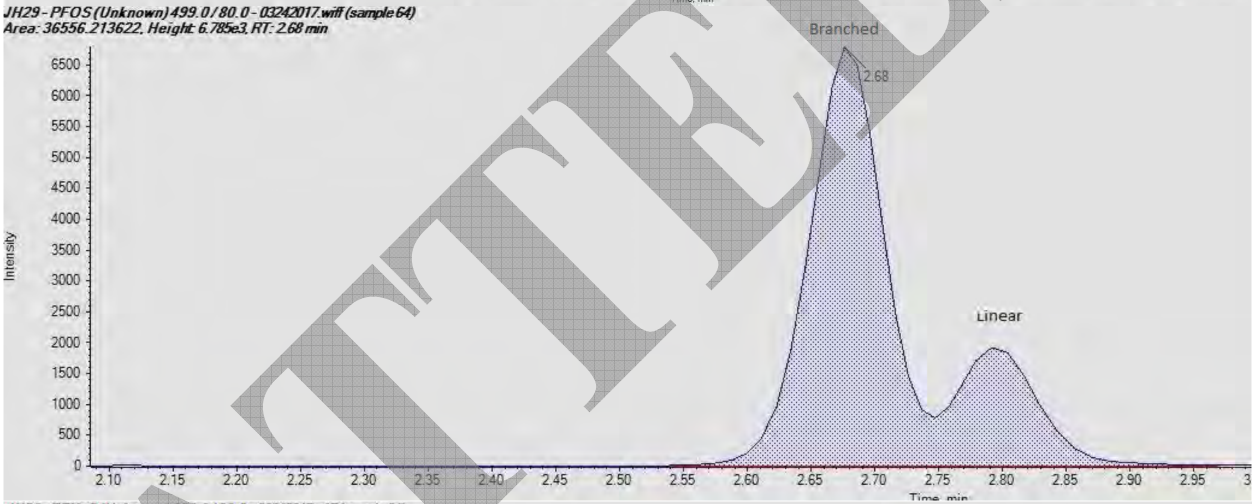
	Primary Transition		**Confirmation Transition**			
Analyte Code	Q1	Q3	Q1	Q3	**DP**	**CE**
PFBA	213	169	NA	NA	-25	-12
PFPeA	263	219	NA	NA	-20	-12
PFHxA	313	269	313	119	-25	-12
PFHpA	363	319	363	169	-25	-12
PFOA	413	369	413	169	-25	-14
PFNA	463	419	463	219	-25	-14
PFDA	513	469	513	219	-25	-16
PFUnA	563	519	563	269	-25	-18
PFDoA	613	569	613	319	-25	-18
PFTrA	663	619	663	169	-25	-20
PFTeDA	713	669	713	169	-25	-22
NMeFOSAA	570	419	570	512	-40	-36
NEtFOSAA	584	419	584	483	-50	-36
PFOSA	498	78	498	83	-60	-85
PFBS	299	80	299	99	-35	-48
PFPeS	349	99	349	80	-35	-48
PFHxS	399	80	399	99	-60	-74
PFHpS	449	80	449	99	-65	-88
PFOS	499	80	499	99	-65	-108
PFNS	549	99	549	80	-50	-120
PFDS	599	80	599	99	-85	-118
4:2FTS	327	307	327	80	-50	-32
6:2FTS	427	407	427	81	-50	-32
8:2FTS	527	507	527	487	-50	-40
13C4-PFBA	217	172	NA	NA	-15	-10
13C5-PFPeA	268	223	NA	NA	-20	-15
13C5-PFHxA	318	273	NA	NA	-20	-15
13C4-PFHpA	367	322	NA	NA	-20	-15
13C8-PFOA	421	376	NA	NA	-20	-15
13C9-PFNA	472	427	NA	NA	-20	-15
13C6-PFDA	519	474	NA	NA	-20	-15
13C7-PFUnA	570	525	NA	NA	-20	-15
13C2-PFDoA	615	570	NA	NA	-25	-18
13C2-PFTeDA	715	670	NA	NA	-20	-15
d3-MeFOSAA	573	419	NA	NA	-40	-36
d5-EtFOSAA	589	419	NA	NA	-40	-36
13C8-FOSA	506	78	NA	NA	-65	-108
13C3-PFBS	302	99	NA	NA	-45	-65
13C3-PFHxS	402	99	NA	NA	-50	-75
13C8-PFOS	507	99	NA	NA	-65	-108
13C2-4:2FTS	329	81	NA	NA	-50	-75
13C2-6:2FTS	429	81	NA	NA	-50	-75

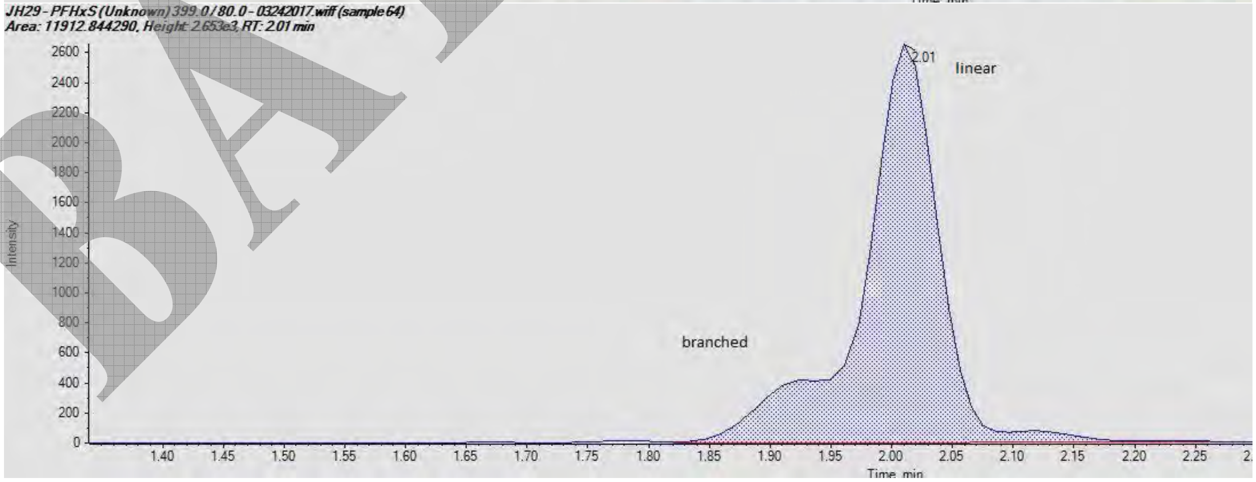
Analyte Code	Primary Transition		Confirmation Transition		DP	CE
	Q1	Q3	Q1	Q3		
13C2-8:2FTS	529	81	NA	NA	-50	-75
13C3-PFBA	216	172	NA	NA	-40	-20
13C2-PFOA	415	370	NA	NA	-25	-14
13C2-PFDA	515	470	NA	NA	-25	-16
13C4-PFOS	503	99	NA	NA	-75	-100
TCDA	NA	NA	499	107	TBD	TBD

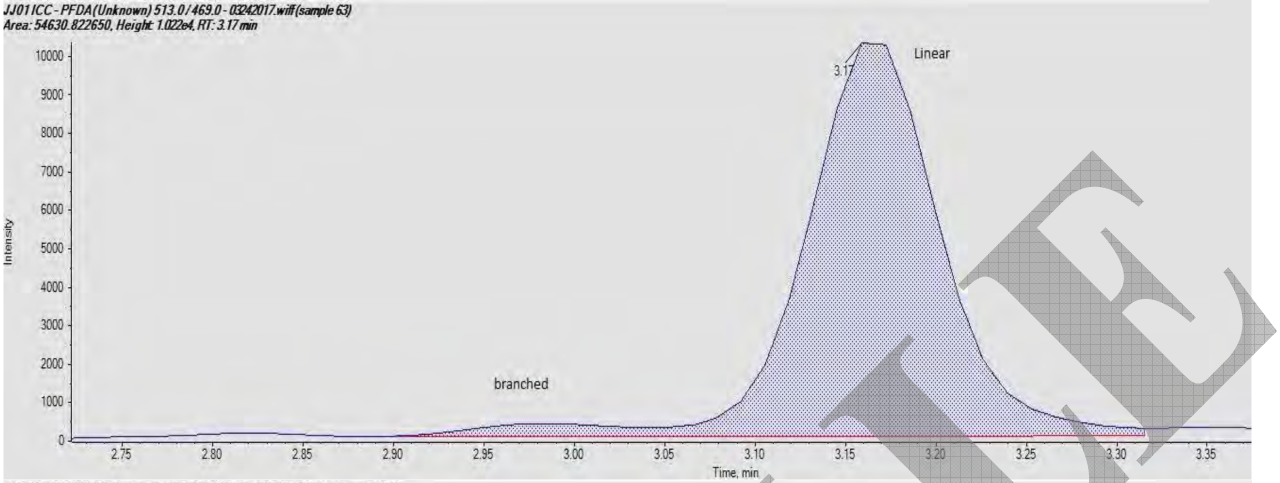
Attachment 4

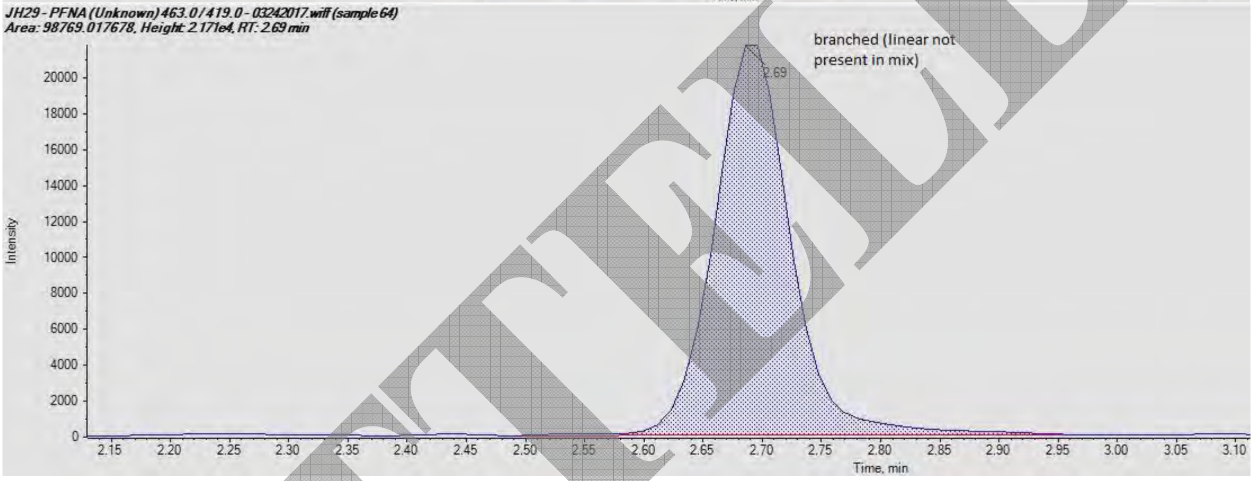
Example Chromatograms for Branched Isomers








JJ01ICC - PFDA(Unknown) 513.0 / 469.0 - 03242017.wiff (sample 63)
Area: 54630.822650, Height: 1.022e4, RT: 3.17 min
Intensity
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
3.17
Linear
branched
2.75
2.80
2.85
2.90
2.95
3.00
3.05
3.10
3.15
3.20
3.25
3.30
3.35
Time, min


JH29 - PFNA (Unknown) 463.0 / 419.0 - 03242017.wiff (sample 64)
Area: 98769.017678, Height: 2.171e4, RT: 2.69 min
Intensity
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
2.69
branched (linear not present in mix)
2.15
2.20
2.25
2.30
2.35
2.40
2.45
2.50
2.55
2.60
2.65
2.70
2.75
2.80
2.85
2.90
2.95
3.00
3.05
3.10
Time, min

Battelle
Standard Operating Procedures

for

EXTRACTION OF POLY AND PERFLUOROALKYL SUBSTANCES FROM ENVIRONMENTAL MATRICES

Summary of changes in this version: Updated final extract preparation procedures to change final split and pre-injection volume. Added procedure for prescreening samples. Added procedure for direct injection analysis of highly contaminated non-potable water samples. This method is equivalent to the previous version, new Demonstrations of Capability (DOC) will not be required under this version of the SOP.

1.0 OBJECTIVE

The objective of this document is to define standard procedures for extracting poly and perfluoroalkyl substances (PFAS) from environmental matrices, including, but not limited to, surface water, ground water, soil, sediment, and tissue. Extraction methods are based on EPA Method 537 (Shoemaker, Grimmett, & Boutin, 2009) and ASTM Method D7968 (ASTM, 2014). All extracts are analyzed via Liquid Chromatography/Tandem Mass Spectrometry (LC-MS/MS) following Battelle SOP 5-369.

Note 1: The mixing and sub-sampling procedures presented in this SOP are appropriate for relatively homogeneous soil and sub-aqueous sediment samples. The mixing and sub-sampling presented in section 3 do not apply to solid samples originating at hazardous waste sites or other sites where potential inherent heterogeneity affects representativeness or comparability. For heterogeneous samples, specific mixing and sub-sampling procedures will be presented in the project- specific Project Plan. Project managers should refer to ASTM D 6323, laboratory Sub-sampling of Media Related to Waste Management Activities for guidance.

2.0 METHOD SUMMARY

PFAS compounds are extracted and purified for water samples, using solid phase extraction (SPE) methods. Soil, sediment, and tissue samples are extracted using a Geno/Grinder® followed by extract cleanup. All samples are fortified with labeled surrogate internal standards (SIS) prior to extraction. All extracts are fortified with an internal standard (IS) after cleanup, just prior to analysis. A flow chart for both aqueous and solid sample extractions is presented in **Attachment 2**.

3.0 PREPARATION

3.1 APPARATUS AND MATERIALS

Apparatus
- Top-loading balance capable of weighing to 0.01 g (SOP No. 3-160)
- Aluminum weighing pans
- Stainless steel spatula (or equivalent)
- Drying oven maintained at 115 ± 15ºC
- Centrifuge
- Spex Geno/Grinder® 2010 (or equivalent)

- Teflon free SPE extraction block (Waters part No. WAT200609, or equivalent)
- SPE manifold vacuum trap (Sigma part No. 57120-U, or equivalent)
- Vacuum pump (Vaccubrand diaphragm pump ME 1, or equivalent)
- Large volume SPE reservoir (Sigma part No. 54258-U, or equivalent)
- High density polyethylene (HDPE) sample bottles, 250 mL (Thermo Fisher part No. 2104-0008, or equivalent), for waters
- HDPE jars (Quality Environmental Containers (QEC) part No. 2214-0008, or equivalent), for solids and tissues
- Falcon 15 mL centrifuge tubes (Thermo Fisher part No. 339650, or equivalent)
- Falcon 50 mL centrifuge tubes (Thermo Fisher part No. 14-432-22, or equivalent)
-
- 11 mm Polypropylene LC extract vials (Thermo Fisher part No. 22-045618, or equivalent)
- Snap caps (Thermo Fisher part No. 03-345-24G, or equivalent)
- Nitrogen evaporation apparatus, N-Evap or equivalent, with water bath
- Class A volumetrics, various sizes
- Class A graduated cylinders, various sizes
- Calibrated pipettes (SOP 3-181)

3.2 SOLVENTS AND REAGENTS

- Methanol (HPLC grade, or equivalent)
- 7 N NH_3 solution in methanol (Sigma part No. 499145, or equivalent)
- 0.4% NH_3 solution in methanol (W/V) = using the 7 N solution, dilute 3.5 mL to 100 mL in methanol. This solution must be prepared fresh on the day of use.
- Supelclean ENVI-Carb 6 mL / 500 mg SPE cartridge (Supelco part No. 57094-U, or equivalent)
- Oasis Weak Anion Exchange (WAX) 500 mg / 6 mL SPE cartridge (Waters part No. 186004647, or equivalent)
- Millipore water
- Ottawa Sand (Applied Separations part No. 10548, or equivalent)
- Tilapia (locally sourced and verified prior to use)
- Surrogate Internal Standards (SIS) solutions
- Internal Standards (IS) solutions
- Target analyte (LCS/MS) spiking solutions

3.3 LABWARE PREPARATION

All glassware and labware must be cleaned according to laboratory protocols defined in SOP 5-216, glassware is then rinsed with methanol and air dried prior to contact with samples. Glassware pre-cleaned by manufacturer may be used as purchased. Teflon material should be avoided for this method.

3.4 RECORD KEEPING

Samples are assigned unique identification numbers and logged into the Laboratory Information Management System (LIMS) according to laboratory protocols (SOP 6-007). All sample data are managed using the LIMS from sample receipt to data reporting.

Data will be recorded in the sample preparation module in the LIMS (refer to the *LIMS Sample Preparation Training Manual* for examples of reports and instructions on entering data). Information to be recorded includes wet and dry weight information, dates of extraction/processing procedures, initials of laboratory personnel performing the procedures, types and volume of internal standards added to samples, and, if necessary, comments regarding individual samples.

Record information regarding sample integrity that might have bearing on the results; for example, amount of overlying water, sulfurous or oil odors, unusual color, or other unusual attributes. If debris or rocks or stones are removed, document the type and amount.

4.0 PROCEDURES

4.1 GENERAL

Samples are processed and extracted in batches of 20 or fewer authentic field samples. Quality control (QC) samples accompanying each batch may include a procedural blank (PB), laboratory control sample (LCS), matrix spike (MS), reference material (SRM) and/or field sample replicates (DUP and/or TRP). For the PB and LCS samples use Millipore water for aqueous samples, Ottawa Sand for soil and sediment samples, and clean fish tissue (e.g. tilapia) for tissue samples. Record the actual weight in LIMS (based on the target weight listed in the project plans). The moisture for sand is automatically entered as 100% dry weight. (See Section 5.0 for more detail).

Sample processing is performed in a vented area free of contamination. For soil and sediment samples, prior to sub-sampling for percent moisture and extraction, decant over-lying water and remove foreign objects, such as leaves, sticks and rocks. Stir the entire sample in its original container with a spatula for 2 to 3 minutes, until the sample appears uniform. Remove subsamples for analysis and percent moisture only after a uniform consistency and color is observed. In each subsample, use material from the top, middle, and bottom of the homogenized sample in case settling or separation of phases has occurred. Tissue samples will be homogenized using Teflon free homogenization equipment.

4.2 SAMPLE PRE-SCREENING

To avoid potential contamination of the laboratory and instruments, all non-potable water and solid samples will be pre-screened to determine if individual analytes are present in the samples above 10x sample equivalent concentrations of the high level of the calibration for each matrix.

Non-potable water – a small volume of water will be removed from each sample container and pre-screened to determine if concentration levels above 1,000 ng/L are present. All non-potable waters, with the exception of field blanks and equipment blanks will be processed using the following procedure:

- Shake sample bottle well, centrifuge if sample bottle has high levels of particulate matter
- Remove 250 µL of sample
- Add SIS to achieve concentrations of 250 ng/L at a PIV of 1 mL (25 µL of SIS if concentration is 0.005 ng/µL and final volume is 1 mL)
- Add 225 µL of methanol
- Cap, vortex, and transfer to analysis

Solids – all soil and sediment samples will be pre-screened to determine if concentration levels above 1,000 ng/g are present. All solid samples will be processed using the following procedure:

- Mix the solid sample following the procedure in section 4.1.
- Weigh 1 g of well mixed solid into a 50 mL Falcon tube
- Add 5 mL of Methanol
- Extract using Geno/Grinder® (1,200 RPM for 30 minutes)
- Centrifuge for 5 minutes at 2,500 RPM

- Remove 50 µL of extract and place into an Eppendorf tube containing:
  - 25 µL of SIS (0.005 ng/L)
  - 100 µL of Millipore water
  - 325 µL of Methanol
- Cap, vortex, and transfer to analysis

Any samples that have concentrations for individual PFAS compounds above 1,000 ng/L or 1,000 ng/g will need to be processed in a manner to avoid the potential of cross-contaminating the laboratory or the instrument. The client will be consulted if direct injection analysis is required for non-potable water samples.

4.3 AQUEOUS SAMPLE EXTRACTION AND CLEANUP

Water samples should be collected in 250 mL HDPE sample bottles, with the entire sample being extracted. All water samples are extracted using SPE techniques.

- Prior to spiking samples, draw a line on each sample container equivalent to the top of the water line (samples should be approximately 250 mL) – this will be used to refill the bottles after extraction to record the sample volumes (sample size may be changed in the Project Plan)
- Fortify samples will the appropriate SIS solutions, per the Project Plan, cap and mix
  - LCS, MS, and MSD samples should be fortified with the appropriate targets
- Condition the OASIS WAX cartridges as follows (***if cartridges go dry during the conditioning step, the process must be restarted***):
  - Rinse cartridges with 2 x 5 mL of methanol (collect to waste)
  - Rinse cartridges with 2 x 5 mL of 0.4% NH_3 in methanol (collect to waste)
  - Rinse cartridges with 2 x 5 mL of Millipore water (collect to waste)
  - Add 1- 2 mL of Millipore water to each cartridge and close the stopcock to stop the flow through the SPE cartridge
- Attach a reservoir to each SPE cartridge using the adaptor
- Load samples onto the cartridges
- Elute at approximately 5 mL/minute (collect to waste)
  - Record the start and stop times in LIMS to verify proper flow rate
- Rinse The sample bottle onto the cartridge with 2 x 7.5 mL washes of Millipore water, ensuring a good rinse of the sample bottle and the reservoir used for extraction (collect to waste)

  - Immediately rinse the sample bottle with 1-mL of methanol, adding the rinsate to the SPE reservoir.
- Once the entire sample has passed through the SPE cartridge, dry columns under vacuum for a minimum of 10 minutes
- Discard waste and replace with clean 15 mL centrifuge tubes
- To ensure that no PFAS compounds have been retained in the original sample container, the following rinses should be added to the original sample bottle prior to eluting the columns
- Under vacuum, elute the SPE cartridge as follows:
  - Elute cartridges with 2 x 5 mL of 0.4% NH_3 in methanol
- Remove the centrifuge tubes from the extraction manifold
- Concentrate the entire extract to dryness under nitrogen in a water bath (temperature set to approximately 35-45 °C)
- Reconstitute extract with 80/20 methanol/water (V/V) and fortify with IS and vortex
  - The volume of methanol used should be equal to the pre-injection volume (PIV) in the Project Plan minus the volume of IS fortified (typical PIV is 1,000 µL)
- Aliquot approximately 300 µL into a polypropylene snap cap vial (no Teflon septa) using a pipettor, the remaining extract can be stored in the 15 mL centrifuge tube, at room temperature.

- Transfer the extract for analysis via LC-MS/MS (SOP 5-369)

4.4 PERCENT MOISTURE DETERMINATION (SOIL / SEDIMENT AND TISSUE SAMPLES)

- Record the weight of an aluminum drying pan
- Place approximately 5 grams of homogenized sample on the drying pan and record the weight
- Place pan in drying oven overnight
- Record the weight of the pan and dried sample

4.5 SOIL / SEDIMENT AND TISSUE EXTRACTION AND CLEANUP

The default extraction solvent is 0.4% NH_3 in methanol, however, other solvents may be substituted if specified in the Project Plan.

4.4.2 Soil/Sediment Sample Extraction

- Accurately weigh 2.0 g (± 0.2 g) of homogenized sample into a 15 mL centrifuge tube (sample size may be changed in the Project Plan)
- Fortify samples will the appropriate SIS solutions, per the Project Plan
    - LCS, MS, and MSD samples should be fortified with the appropriate targets
- Add 5 mL of 0.4% NH_3 in methanol and extract using Geno/Grinder® (1,200 RPM for 15 minutes)
- Centrifuge for 5 minutes at 2,500 RPM
- Decant supernatant into clean 15 mL centrifuge tube
- Add a fresh 5 mL of 0.4% NH_3 in methanol and extract using Geno/Grinder® (1,200 RPM for 15 minutes)
- Centrifuge for 5 minutes at 2,500 RPM
- Decant supernatant combining with the extract from the first extraction and mix the combined extract well (initial volume for split is 10 mL)
- Remove 1 mL for extract cleanup

4.4.3 Tissue Sample Extraction

- Accurately weigh 2.0 g (± 0.2 g) of homogenized sample into a 50 mL centrifuge tube (sample size may be changed in the Project Plan)
- Fortify samples with the appropriate SIS solutions, per the Project Plan
    - LCS, MS, and MSD samples should be fortified with the appropriate targets
- Add 10 mL of 0.4% NH_3 in methanol and extract using Geno/Grinder® (1,200 RPM for 15 minutes)
- Centrifuge for 5 minutes at 2,500 RPM
- Decant supernatant into clean 50 mL centrifuge tube
- Add a fresh 10 mL of 0.4% NH_3 in methanol and extract using Geno/Grinder® (1,200 RPM for 15 minutes)
- Centrifuge for 5 minutes at 2,500 RPM
- Decant supernatant combining with the extract from the first extraction and mix the combined extract well (initial volume for split is 20 mL)
- Remove 2 mL for extract cleanup (starting volume for dilution is 20 mL, dilution factor is 20 mL / 2 mL for a dilution factor of 10)

4.4.4 Extract cleanup

- Place Supelclean ENVI-Carb cartridges on the manifold
- Rinse the Supelclean ENVI-Carb cartridge as follows (***these can go dry between rinses***):
    - Rinse cartridges with 3 x 2 mL of 0.4% NH_3 in methanol
    - Discard waste and replace with clean 15 mL centrifuge tubes
- Load the 1 mL sample from the extraction step above onto the SPE cartridge
- Elute the SPE cartridges as follows:
    - Elute cartridges with 2 x 5 mL of 0.4% NH_3 in methanol
- Remove the centrifuge tubes from the extraction manifold and proceed to final extract processing

4.4.5 Final Extract Processing

- Remove the centrifuge tubes from the extraction manifold, concentrate the entire extract to dryness under nitrogen in a water bath (temperature set to approximately 35-45 °C)
- Reconstitute extract with 80/20 methanol/water (V/V) and fortify with IS and vortex
    - The volume of methanol used should be equal to the PIV in the Project Plan minus the volume of IS fortified (typical PIV is 1,000 µL)
- Aliquot approximately 300 µL into a polypropylene snap cap vial (no Teflon septa) using a pipettor, the remaining extract can be stored in the 15 mL centrifuge tube, at room temperature. Extracts must be analyzed within 28 days of extraction.
- Transfer the extract for analysis via LC-MS/MS (SOP 5-369)

5.0 CALCULATIONS

Calculate percent dry weight with the following equation:

$$\%\, dry\ weight\ = \frac{aliquot\ dry\ wt^{a}}{aliquot\ wet\ wt^{a}} \times 100$$

[a] corrected for pan weight

Calculate percent moisture with the following equation:

$$\%\ moisture\ = 100 - \%\ dry\ weight$$

Calculate sample dry weight with the following equation:

$$Sample\ dry\ weight\ (g)\ =\ \%\ dry\ wt.\ *\ sample\ wet\ wt.\ (g)$$

6.0 QUALITY CONTROL

Samples must be extracted in batches of 20 or fewer authentic field samples. QC samples accompanying each batch may include a procedural blank, laboratory control sample, matrix spike, standard reference material and/or field sample replicates.

The QC program for each project is defined in the project plan, which will define the type and amount of internal standards/spiking solutions to be added to the samples, the specific QC samples to be processed, any modifications to the standard QC acceptance criteria, and the corrective action required if QC results do not meet those acceptance criteria.

7.0 TRAINING

The trainee must read and fully understand the policies and procedures outlined in this SOP. The trainee will then be given a demonstration of all aspects of this SOP.

SOP 2-011 defines the training procedures and required documentation for sample preparation and analytical SOPs. These apply to both technicians processing samples and the analysts. The acceptance criteria for the Demonstration of Capability (DOC) are the same as for routine QC samples as defined in SOP 7-029.

When training is completed, the trainee will be issued an IDC Certificate (SOP 2-011). The laboratory Quality Assurance Manual and SOP 2-011 define the locations of training records.

8.0 SAFETY

As part of the above training program, the analyst will be made aware of the particular safety concerns of this procedure, including:

- Use of protective eyewear and clothing
- Proper use of fume hoods
- Location and use of laboratory safety devices; eyewashes, emergency showers, fire extinguishers, fire blankets, and first aid kits, as well as SDS sheets.

References

ASTM. (2014). *D7968: Standard Test Method for Determination of Perfluorinated Compounds in Soil by Liquid Chromatography Tandem Mass Sectrometry (LC/MS/MS).* West Conshohocken: ASTM.

Shoemaker, J. A., Grimmett, P. E., & Boutin, B. K. (2009). *Method 537 Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS).* Cincinnati: EPA.

ATTACHMENTS

Attachment 1	Revision History
Attachment 2	Sample processing flow chart

APPROVALS

Author Jonathan Thorn		Digitally signed by Jonathan Thorn Date: 2018.10.01 10:15:22 -04'00'
Technical Reviewer Denise Schumitz	Denise Schumitz	schumitzd@battelle.org 2018.10.02 16:56:19 -04'00'
Quality Systems Manager Zachary Willenberg	Zachary Willenberg	Digitally signed by Zachary Willenberg Date: 2018.10.02 17:07:46 -04'00'
Laboratory Director Jonathan Thorn		Digitally signed by Jonathan Thorn Date: 2018.10.02 17:14:22 -04'00'
	Name	Date

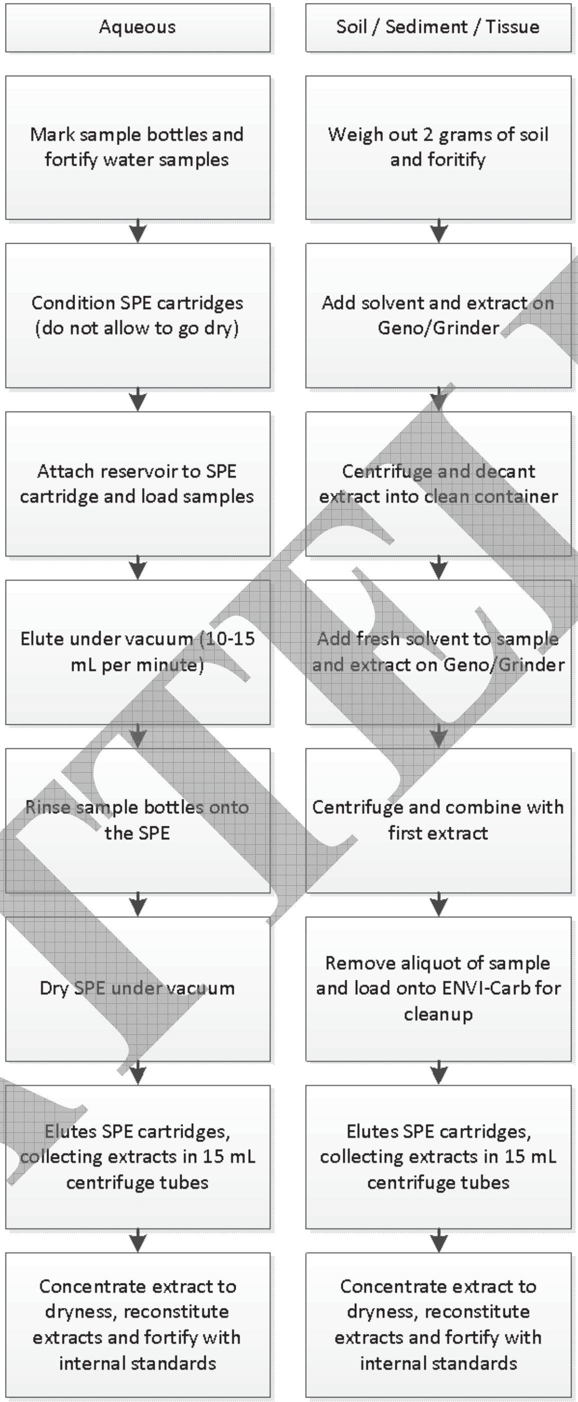
ATTACHMENT 1

Revision History

Version	Summary of Changes
02	Modified extraction procedures for tissues and updated the SPE cartridge for aqueous samples. This method is equivalent to the previous sample preparation method for water and soil/sediment, new Demonstrations of Capability (DOC) will only be needed for tissue under this version of the SOP. Revision history added as **Attachment 1**.
03	Updated section 4.2 to require recording the start and stop times for loading the samples onto the solid phase extraction cartridges. Updated section 4.4.2 for tissue extraction procedures. Updated section 4.4.3 for elution of cleanup cartridge. This method is equivalent to the previous version, new Demonstrations of Capability (DOC) will not be required under this version of the SOP.
04	Updated initial extraction volume for non-potable water samples. Updated extraction section for solids and tissues (serial extraction). This method is equivalent to the previous version, new Demonstrations of Capability (DOC) will not be required under this version of the SOP.
05	Updated initial extraction volume for non-potable water samples. Updated extraction section for solids and tissues (serial extraction). This method is equivalent to the previous version, new Demonstrations of Capability (DOC) will not be required under this version of the SOP.
06	Updated extraction solvent to be prepared day of use. Reduced blow-down temperatures for final extract concentration. This method is equivalent to the previous version, new Demonstrations of Capability (DOC) will not be required under this version of the SOP.

ATTACHMENT 2

Sample Processing Flow Chart



Battelle
Standard Operating Procedure

for

ANALYSIS OF POLY AND PERFLUOROALKYL SUBSTANCES IN DRINKING WATER SAMPLES BY LIQUID CHROMATOGRAPHY AND TANDEM MASS SPECTROMETRY (LC-MS/MS) FOLLOWING EPA METHOD 537.1 Version 1.0

Summary of changes in this version: Updated method reference to Method 537.1 to include new analytes. A new Demonstration of Capability (DOC) for the new analytes will be required, however, the DOC for the original analytes is still valid.

1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes the identification and quantification of perfluoroalkyl substances (PFASs) in drinking water sample by liquid chromatography and tandem mass spectrometry (LC-MS/MS). This SOP defines the laboratories procedures for EPA Method 537.1 Version 1.0 (Shoemaker, Grimmett, Boutin, & Tettenhorst, 2018).

2.0 METHOD SUMMARY

PFAS compounds are extracted and prepared for analysis utilizing Solid Phase Extraction (SPE) techniques. The extracts are analyzed by LC-MS/MS monitoring the primary transition for each target analyte, when available, a secondary transition is monitored for confirmation. The analytes are identified by the primary transition and retention time. The identified analytes are quantified using an internal standard method. A data system interfaced to the LC-MS/MS is used to control acquisition and to store, retrieve, and manipulate LC-MS/MS data. This method provides specific procedures for the identification and measurement of the PFAS listed in **Attachment 1**.

This method follows all of the requirements defined in EPA Method 537 Version 1.1, section 1.6, for method flexibility.

3.0 EQUIPMENT AND SUPPLIES

The following equipment is required to perform the extraction and analytical method. Equivalent apparatus and materials may be substituted, in some cases, if approved by the laboratory and project managers. The sample extraction cartridge bed material cannot be changed from the material listed below.

3.1 APPARATUS AND MATERIALS

- Teflon free SPE extraction block (Waters part No. WAT200609, or equivalent)
- SPE manifold vacuum trap (Sigma part No. 57120-U, or equivalent)
- Vacuum pump (Vaccubrand diaphragm pump ME 1, or equivalent)
- Large volume SPE reservoir (Sigma part No. 54258-U, or equivalent)
- Polyethylene Disposable Pipettes (Fisher Scientific Part No. 13-711-7, or equivalent)
- Polypropylene sample bottles, 250 mL (Fisher Scientific part No. 02-896D, or equivalent)

- Falcon 15 mL centrifuge tubes (Thermo Fisher part No. 339650, or equivalent)
- 1 mL Polypropylene LC extract vials (Thermo Fisher part No. 22-294325, or equivalent)
- Snap caps (Thermo Fisher part No. 03-375-24G, or equivalent)
- Nitrogen evaporation apparatus, N-Evap or equivalent, with water bath
- Class A volumetrics, various sizes
- Class A graduated cylinders, various sizes
- Calibrated pipettes (SOP 3-181) with disposable polypropylene tips
- HPLC (Shimadzu LC20ADXR, Agilent 1260 SL, or equivalent)
- Tandem Mass Spectrometer (Sciex 6500, Sciex 5500, or equivalent)
- Analytical column (Phenomenex Gemini® C18 3 µm; 50 x 2 mm, part No. 00B-4439-B0, or equivalent)
- Delay Column (Phenomenex Luna® C18(2) 5 µm; 30 x 2 mm, part No. 00A-4252-B0, or equivalent)

3.2 LABWARE PREPARATION

All glassware and labware must be cleaned according to laboratory protocols defined in SOP 5-216, glassware is then rinsed with methanol and air dried prior to contact with samples. Glassware pre-cleaned by manufacturer may be used as purchased. Teflon material should be avoided for this method. If re-usable glassware is used for PFAS analysis, foil should not be used to cap the glassware after cleaning

4.0 REAGENTS AND STANDARDS

4.1 Reagents and Solvents

The following Battelle SOPs outline reagent login, labeling, and storage that are applicable to this method:

5-015 (Solvent/Reagent Inventory and Contaminant Residue Checks)
5-027 (Analytical Standards in the Organics Laboratory)
5-217 (Labeling of Chemical Materials in the Laboratory)

- Methanol (HPLC grade, or equivalent)
- Strata SDBL 100 µm Styrene divinylbenzene 500 mg / 6 mL SPE cartridge (Phenomenex part No. 8B-S014-HCH, or equivalent)
- Millipore water
- Surrogate Internal Standards (SIS) solutions
- Internal Standards (IS) solutions
- Target analyte (LCS/MS) spiking solutions
- Nitrogen
- Trizma® Pre-set crystals (Sigma-Aldrich part No. T7193, or equivalent)
- Ammonium Acetate (reagent grade, or equivalent)
- 20 mM Ammonium Acetate in Millipore water (mobile phase) – bring 1,540 mg of ammonium acetate to a final volume of 1 L with Millipore water. Due to potential volatility losses, this solution expires one week after preparation.

4.2 Standards and Solutions

Standard preparation procedures for all calibration solutions are detailed in SOP 5-027. All standards, except for solutions purchased in glass ampules, must be stored in screw-cap polypropylene vials. Stock solutions will be stored ≤ 6 °C but above freezing. Primary dilution standards and fortification standards are stored at room temperature. If purchased as salts, all analytes must be corrected and reported as the acid equivalent. Standards are stored separately from samples.

4.2.1 Calibration Standards

Calibration standards should contain all individual target compounds. Primary stock solutions that contain the target analytes are purchased and used to prepare the Initial Calibration (ICAL), Continuing Calibration Verification (CCV), and Independent Calibration Check (ICC) standards. Most standards used for this method are purchased from standard providers (e.g., Sigma Aldrich and Wellington) in neat or solution form. Equivalent standards may be substituted if approved by the laboratory and project manager. All final calibration standards for this method are made in 96% methanol in reagent water. The ICC must be independent of the ICAL standards and thus should be made using either a standard from a different vendor or a standard from the same vendor with a lot number different from the ICAL standard. When commercially available, the calibration curve will contain both branched and linear isomers.

The recommended calibration levels for the ICAL standards are presented in **Table 1** below. The concentration of the surrogates (SIS) and internal standards (IS) does not vary with each level. The lowest point of the calibration curve will be at or below the LOQ for all target analytes. The remaining concentration levels should not exceed the working range of the LC-MS/MS system. If concentrations of samples are above the calibration range, the extract will be diluted and re-analyzed. Diluted extracts will have additional IS added to maintain a concentration equivalent to that in the calibration curve.

***Table 1**: Nominal Calibration Concentrations (ng/L)*

	L1	L2	L3	L4	L5	L6	L7	L8	L9
Targets	25	50	100	250	500	1,000	2,500	5,000	10,000
Surrogates	100/400	100/400	100/400	100/400	100/400	100/400	100/400	100/400	100/400
Internal Standards	100-400	100-400	100-400	100-400	100-400	100-400	100-400	100-400	100-400

4.2.2 ICC Spiking Solution

The ICC spiking solution should include all target compounds proposed for analysis from a source independent from the initial calibration (if commercially available). The concentration should be at or near the midpoint of the initial calibration.

4.2.3 Internal Standard (IS) Solutions

This method utilized three isotopically labelled IS standards. Intermediate stock solutions and final fortification stocks are made in 96:4% (vol/vol) methanol:water. Final IS target concentrations are 100 ng/L for $^{13}C_2$-PFOS, 287 ng/L for $^{13}C_4$-PFOA, and 400 ng/L for d3-MeFOSAA in a 1 mL extract.

4.2.4 Surrogate Internal Standard (SIS) Solutions

This method utilized three isotopically labelled SIS standards. Intermediate stock solutions and final fortification stocks are made in 96:4% (vol/vol) methanol:water. SIS target concentrations are 100 ng/L for $^{13}C_2$-PFHxA, $^{13}C_2$-PFDA, and $^{13}C_3$-HFPO-DA and 400 ng/L for d5-EtFOSAA in a 250 mL sample prior to extraction.

5.0 PROCEDURES

The following section details the sample collection, preservation, extraction, and analysis of drinking water samples for PFAS. Deviations from the sample collection and preservation (section 5.2) and sample extraction (section 5.3) are not allowed under EPA Method 537 Version 1.1. These sections follow the EPA method as written. The sample analysis (section 5.4) is modified based on allowable modifications listed in section 1.6 (method flexibility) of EPA Method 537 Version 1.1.

5.1 Method Validation – Initial Demonstration of Capability (IDC)

Prior to performing analysis on client samples, the following IDC procedures must be completed, refer to **Attachment 4** for a summary of these requirements. All samples below must also contain the preservative, Trizma, at concentrations equivalent to field samples.

- Initial Demonstration of Low System Background – any time a new lot of SPE cartridges, solvents, centrifuge tubes, disposable pipets, and autosampler vials are used, it must be demonstrated that a Procedural Blank (PB) is reasonably free of contamination and meets the criteria in attachment 4.

- Initial Demonstration of Precision (IDP) – prepare, extract, and analyze four to seven replicate Laboratory Control Samples (LCS) near the midrange of the calibration curve. The relative standard deviation (RSD) of the results of the replicate analyses must be less than 20%.

- Initial Demonstration of Accuracy (IDA) – the calculated average recovery for the samples used to generate the IDP must be within +/- 30% of the true value.

- Initial Demonstration of Peak Asymmetry Factor – peak asymmetry factors must be calculated using the equation in Section 7 for the first two eluting peaks in a mid-level calibration curve. The peak asymmetry factor must be between 0.8 and 1.5.

- Minimum Reporting Level (MRL) Confirmation – MRL may be established by the laboratory or set by a regulatory agency. The lowest calibration point in the ICAL must be at or below the concentration of the MRL. Verify the MRL using the following procedure:

    - Fortify, extract, and analyze seven replicate LCS samples fortified at the proposed MRL concentrations. Calculate the mean concentration and standard deviation for the replicates. Determine the Half Range for the prediction interval of results (HR_{PIR}) using the equation in Section 7.

    - Confirm that the upper and lower limits for the Prediction Interval of Results (PIR = mean +/- HR_{PIR}) meet the upper and lower recovery limits following the equations presented in Section 7

    - The MRL is validated if both the upper and lower PIR limits meet the criteria presented with the calculations. If the criteria are not met, the MRL has been set too low and must be determined again at a higher concentration.

- Calibration Confirmation – the calibration must be confirmed using an independent calibration verification as described in section 5.5.2.

- Detection Limit (DL) Determination (*optional per EPA 537.1 Version 1.0*) – replicate analysis should be completed over at least three days (i.e. new replicates should be extracted and analyzed over a minimum of three days). Prepare at least seven replicate samples fortified at a concentration estimated to be near the DL. Calculate the DL as described in SOP 5-291.

5.2 Sample Collection and Preservation

All samples must be collected and preserved under the following conditions (available as **Attachment 3** to send with sample kits):

- Samples must be collected in a 250 mL polypropylene bottle with a polypropylene screw cap.

- Bottles shipped to the field must be preserved by adding Trizma® as a solid to each bottle prior to shipping to the field. The final concentration of Trizma® should be approximately 5.0 g/L (1.25 g +/- 0.2 g per sample bottle).

- Sample collector should wash hands prior to sampling and wear nitrile gloves during collection.

- Turn on tap water and allow the system to equilibrate / flush until the water temperature has stabilized (approximately 3 to 5 minutes).

- Collect the sample from the flowing system – fill the collection bottle, taking care not to flush the preservative from the collection bottle. Sample does not have to be free of headspace.

- Cap the container and shake to dissolve the preservative.

- The container must be kept sealed from this point until samples are ready for extraction.

- A field reagent blank (FRB) must be handled with each set of samples collected. Prior to shipment of bottles to the field, a sample bottle is filled with Millipore water and preservative. This sample, and a clean, empty bottle (no preservative) are shipped to the field. At the sampling site, the sampler must open the FRB and pour the contents into the empty sample bottle shipped with the FRB. The bottle is then sealed and labelled as the FRB and shipped to the laboratory with the samples collected. This sample is to ensure that PFAS are not introduced during sample handling.

- The same batch of preservative must be used for the FRB and all samples collected during one collection run.

- The reagent water used for the FRB must be initially analyzed for the method analytes and must meet all method criteria prior to use.

- Samples must be chilled during shipment and must not exceed 10 °C during the first 48 hours after collection. Samples should be chilled prior to shipment and shipped on ice to the laboratory. Temperatures will be confirmed upon arrival at the laboratory.

- Samples must be extracted within 14 days of collection and analyzed within 28 days after extraction. Sample extracts must be stored at room temperature.

5.3 Sample Extraction

The following Quality Control (QC) samples are required with each preparation batch, a summary of these requirements can be found in **Attachment 4**.

- Laboratory Reagent Blank (LRB) – sample to confirm that potential background contaminants are not interfering with the identification or quantitation of target analytes. If the LRB produces a peak within the retention time window of any analytes that would prevent the determination of that analyte, the source of contamination must be determined and eliminated before processing samples. Background contaminants that interfere with the measurement of method analytes must be below 1/3 of the MRL, if values exceed this limit, all data for the impacted analyte(s) must be considered invalid for all samples in the extraction batch. The LRB is equivalent to Battelle's Procedural Blank (PB) sample.

- Laboratory Fortified Blank (LFB) – a fortified sample created using Millipore water is required with each extraction batch. The LFB is fortified at low, medium, and high concentrations and are varied from batch to batch. Low level sample recoveries must be between 50-150% of the true value, all other fortification must be between 70-130% of the true value. If the LFB does not meet criteria, then all data for the problem analyte(s) must be considered invalid for all samples in the extraction batch. The LFB is equivalent to Battelle's Laboratory Control Sample (LCS).

- Internal Standards (IS) – the IS response area in each sample must be within 70-140% of the corresponding IS in the most recent Continuing Calibration Verification (CCV) sample and must not deviate by more than 50% from the average area measured in the initial calibration curve. If the IS area in a sample does not meet criteria, a second aliquot of the sample must be prepared in a fresh autosampler vial for analysis. If the reanalysis passes criteria, report the second analysis. If the reanalysis does not pass, verify that the calibration is acceptable by reanalyzing the most recently acceptable ICAL standard, if the ICAL standard fails criteria (see Section 5) recalibrate and reanalyze the impacted samples. If the ICAL standard is acceptable, extraction of the sample may need to be repeated provided that additional sample is within holding time. Otherwise, report the results obtained from the reinjected analysis but annotate the results as suspect.

- Surrogate Recovery – all field and QC samples are fortified with surrogates. The surrogate recovery is used to assess method performance from extraction to analysis. The calculated recovery must be between 70-130% of the true value. If SIS recoveries fail criteria check the calculations to locate possible errors, standard solutions for degradation or contamination, and check for instrument performance issues. If a problem is found, correct the issue and reanalyze the extract. If the reanalysis meets criteria, report only the data from the reanalysis. If the reanalysis does not meet criteria, verify the calibration by re-injecting the last CCV, if the CCV is acceptable, the sample should be reextracted provided the sample is still within holding time. If the reextracted sample also fails recovery criteria, report all the data for the impacted sample as suspect/SIS recovery.

- Laboratory Fortified Sample matrix (LFSM) – extraction and analysis of a LFSM is required in each batch and is used to determine that the sample matrix does not adversely affect method accuracy. A field sample is fortified with target analytes prior to sample extraction. Spiking concentrations should be greater than or equal to background concentrations, if known. Low, mid, and high-level concentrations should be used based on historical data, if available. Samples fortified at or above their native concentration must be between 70-130% of the true value, except for low level fortifications, near the MRL, which must be between 50-150% of the true value. If the recoveries fall outside the acceptable range and the CCV samples are in control, the recovery is judged to be matrix biased. Results in the unfortified sample for the impacted target(s) is labeled suspect/matrix. The LFSM sample is equivalent to Battelle's Matrix Spike (MS) sample.

- Field Duplicate or Laboratory Fortified Sample Matrix Duplicate (FD or LFSMD) – a minimum of one FD or LFSMD sample is extracted with each batch of samples. Duplicate samples are used to check the precision associated with sample collection, preservation, storage, and laboratory procedures. If target analytes are not routinely observed in field samples, a LFSMD sample should be prepared instead of a FD sample. The calculated relative percent difference (RPD) between calculated concentrations (FD), or calculated recoveries (LFSMD) should be ≤30%. For FD samples with a factor of 2 of the MRL, greater variability may be observed. At these concentrations, FD should have RPDs ≤50%. If the RPD falls outside the range and the CCV samples are in control, the values are judged to be matrix biased. Results in the unfortified sample for the impacted target(s) is labeled suspect/matrix. The LFSMD sample is equivalent to Battelle's Matrix Spike Duplicate (MSD) sample.

- Field Reagent Blank (FRB) – the FRB sample is used to ensure that the PFAS measured in field samples were not inadvertently introduced into the samples during collection/handling. The FRB is extracted and analyzed in the same manner as field samples. If the target analytes found in the field sample are present in the FRB at concentrations greater than 1/3 the MRL, all samples collected with that FRB are invalid and must be recollected and reanalyzed.

Samples are collected and preserved as described in section 5.1. All field and QC samples must contain the preservative (dechlorinating agent).

- Initial sample volume is determined by marking the level of the sample on the bottle prior to fortification and extraction. Post extraction, fill the bottle to the level marked prior to extraction and measure the volume of water necessary to reach this level. Record the volume of water to the nearest 10 mL using a graduated cylinder.

- Fortify samples with the appropriate amount of SIS to each sample, cap and invert to mix.

- Fortify laboratory spiked samples (LCS, MS, MSD) with target analytes, cap and invert to mix.

SPE cartridge cleanup and conditioning:

- Do not allow cartridge bed material to go dry during any of the conditions steps. If the cartridge goes dry during the condition phase, the conditioning must be restarted.

- Attach cartridges to the SPE extraction manifold.

- Rinse each cartridge with 15 mL of methanol.

- Rinse each cartridge with 18 mL of Millipore water, do not allow water to fall below the top of the bed material.

- Add 4-5 mL of Millipore water to each cartridge and attach a reservoir to the top of each cartridge using an adaptor.

Sample extraction:

- Add sample into the reservoir and start the vacuum. Adjust the vacuum so that the approximate flow rate is 10-15 mL/min.
    - Record the start and stop times in LIMS to verify proper flow rate has been achieved.
- Do not allow the cartridge to go dry before the entire sample has been passed through the column.
- After the entire sample has passed through the column, rinse the sample bottle with two (2) 7.5 mL aliquots of Millipore water ensuring that each rinse also passes through the reservoir.
- Draw air through the cartridge for 5 minutes at high vacuum (10-15 in. Hg)

Sample bottle and cartridge elution:

- Turn off and release the vacuum. Insert rack and collection vials into the manifold for sample extract collection.
- Rinse the collection bottle with 4 mL of methanol and transfer the rinse to the reservoir. All rinses must go through the reservoir tube.
- Use a low vacuum pressure to allow for elution from SPE cartridge in a dropwise fashion.
- Repeat sample bottle rinse with a second 4 mL aliquot of methanol.

Extract concentration:

- Concentrate the extracts to dryness under a gentle stream of nitrogen in a heated water bath (60-65 °C).
- Add 96:4% (v/v) methanol:water solution and IS solution for a final pre-injection volume (PIV) of 1 mL and vortex
- Transfer a small aliquot of extract to a polypropylene autosampler vial using a plastic pipette.
- Submit the extract for analysis.

5.4 Sample Analysis

The extracts are analyzed under the conditions presented in **Table 2**.

***Table 2**: Analytical Parameters*

Column:	Phenomenex Gemini® C18 – 3 µm; 50 x 2 mm (analytical) Phenomenex Luna® C18(2) – 5 µm; 30 x 2 mm (delay)		
Column Temperature:	40 ºC (analytical), delay column installed between the pump mixing chamber and the column, outside of the column oven		
Injection Volume:	10 µL		
Flow Rate:	600 µL/min		
Mobile Phase A:	Millipore water with 20 mM ammonium acetate		
Mobile Phase B:	Methanol		
Analytical Run Time (end)	7.00 minutes		
	Time – minutes	% A	% B
	0.00	90	10
	0.10	45	55
	4.50	1	99
	4.95	1	99
	7.00	90	10
Ion Source:	Turbo Ion Spray		
Polarity:	Negative		
Ion Spray Voltage (IS):	-4500 v		
Collision Gas (CAD):	Medium		
Temperature (TEM):	450 °C		
Curtain Gas (CUR):	35 PSI		
Ion Source Gas 1 (GS1):	50 PSI		
Ion Source Gas 2 (GS2):	50 PSI		
Entrance Potential (EP):	10		

Multiple Reaction Monitoring (MRM) transitions are monitored for each analyte, labeled analogue, and internal standard using the scheduled MRM™ algorithm in the data acquisition software. The MRM transitions are collected inside of a 60 second window around the expected retention time to maximize the spectra scans collected.

The following quality control checks are required for analysis.

5.4.1 Peak Asymmetry Factor

Peak asymmetry factors must be calculated using the equation in Section 7 for the first two eluting peaks in a mid-level calibration curve. This factor must be calculated each time a new ICAL is performed. The peak asymmetry factor must be between 0.8 and 1.5. If the criteria are not met, change the initial mobile phase conditions to a higher aqueous content until the asymmetry ration for each peak is between 0.8 and 1.5.

5.5 Calibration

Demonstration and documentation of acceptable initial calibration is required before any samples are analyzed. The ICAL must be verified by analysis of an ICC immediately following the ICAL. A CCV is required at the frequency defined in Section 5.5.3.

5.5.1 Initial Calibration

Analyze a minimum of five calibration standards that will represent the expected concentration range of the samples. Suggested standard concentrations are outlined in **Table 1** above. The calibration is calculated using internal standard methods and all analytes MUST be forced through zero.

For each level of calibration, calculate the correlation coefficient (r) with a weighting of 1/x for each analyte of interest in the calibration standard using the software supplied with the LC-MS/MS data system. The formula is provided in Section 7.0.

ICAL acceptance criteria

The ICAL criteria are:

- $r^2 > 0.99$ for each analyte
- Minimum of 5 points for a linear curve fitting
- Each target compound must be within 70-130% of the true value, except for the lowest point of the curve which must be within 50-150% of the true value
- Surrogate concentrations must be within 70-130% of the true value
- The internal standard area of the highest calibration point must be compared to the area in the lowest point. The RPD between the two standards must be ≤20%, if this value is exceeded, the instrument must be recalibrated using lower concentrations for the high standard until the value meets criteria, indicating that suppression of the IS at high concentrations is in control

If these requirements are not met for the ICAL, corrective action is performed and the calibration is repeated.

5.5.2 Independent Calibration Check

Verify the ICAL with an ICC immediately after the ICAL is completed. The ICC is analyzed under the same analytical conditions used in the ICAL and for the analysis of samples.

ICC Target Analyte Performance Criteria

The ICC criteria are:

- Individual target concentrations within 70-130% of the true value
- Surrogate concentrations must be within 70-130% of the true value
- IS area within 50-150% of the average area in the ICAL

If ICC meets the above criteria, then the ICAL is assumed to be valid. If the criteria are not met, reanalyze the ICC. If the second ICC fails, a new ICAL must be performed.

5.5.3 Continuing Calibration Verification

The ICAL is verified at the beginning of each batch, after every 10 field samples, and at the end of each batch, in the context of this SOP, the QC samples described in Section 5.3 are not considered field samples. The CCV is analyzed under the same analytical conditions used for the ICAL and ICC. The initial CCV must be at or below the MRL to verify instrument sensitivity prior to sample analysis, subsequent CCV samples should vary between mid and high level concentrations.

CCV Target Analyte Performance Criteria

The CCV criteria are:

- Frequency: beginning of each sample analysis sequence (if not preceded by an ICC), after 10 field samples, and at the end of each batch
- Initial CCV must be at or below the MRL

- IS area within 70-140% of the area of the last CCV
- IS area within 50-150% of the average area in the ICAL
- Individual recoveries for target analytes must be between 70-130% of the true value, except for the lowest calibration point which must be between 50-150% of the true value
- Individual recoveries for surrogates must be between 70-130% of the true value

If CCV meets the above criteria, then the ICAL is assumed to be verified. Proceed with the analysis of samples. When a CCV fails to meet any of the above criteria, corrective action must be taken, up to and including recalibration of the instrument. If a CCV fails because a target analyte exceeded the acceptance limit defined above (over response only) and that analyte was not detected in any samples, then the samples do not need to be reanalyzed. In all other cases, the sample must be reanalyzed after appropriate corrective action has been taken and the instrument is again in control.

5.6 Sequence of Analysis

An analysis sequence is initiated with an acceptable ICAL and ICC (if necessary) or an acceptable CCV followed by the appropriate number of samples to be analyzed and ending with a CCV. The sequence may be continued with another group or groups of samples and CCVs provided the CCV results remain within the acceptance criteria (reference Section 5.5.3). All QC and authentic samples must be bracketed by acceptable CCVs or ICAL.

The order of calibration and analysis is as follows (if a new ICAL is needed):

a. Methanol
b. ICAL
c. ICC
d. Sample analysis sequence
e. CCV
f. Methanol

Repeat d, e, and f for continued analysis of QC and authentic samples if e continues to pass criteria.

When a new ICAL is not needed, analysis must start with a low level CCV sample.

5.7 Sample Analysis

Samples are run under the same conditions as the ICAL. Start the analysis of samples with quality control samples.

5.7.1 Qualitative Identification of Individual Target Compounds

Sample peaks are identified visually using the MultiQuant™ display program. For peak identification, the experience of the analysts should weigh heavily in the interpretation of data.

Identify the target compounds (**Attachment 1**) based on retention time established during the calibration and the transitions presented in **Attachment 2**. Comparison of both retention times and transitions to reference standard is also useful in compound identification.

5.7.2 Mass Spectral Acquisition Rate

A minimum of 10 spectra scans are acquired for each peak.

5.7.3 Ion Transitions

Two transitions and the ion transition ratio will be monitored for each target analyte. Transitions are defined in **Attachment 2**. Two transitions are not required for surrogates and internal standards.

5.7.4 Signal to Noise Ratio

A minimum signal to noise ratio of 3:1 is required for all ion transitions used for quantification. Analytes that have a health advisory (HA) level or other action level, must have a signal to noise ratio of at least 3:1 for the confirmatory transition.

5.7.5 Quantification of Analytes

Identify target analyte peaks that match retention times and other criteria above. Confirm the auto-baseline on the quantification ions or redraw the baselines, as necessary. Quantify each peak following procedures presented in the instrument manufacturer user’s manual and Battelle SOP 4-038.

Quantification of analytes identified in samples will be performed by the internal standard method, using the appropriate curve fitting from the ICAL. See Section 7.0 for additional information regarding calculations used for the determination of target analyte concentrations in samples. Upon selection of the appropriate calibration option and the identification of a peak, the MultiQuant™ software calculates the compound amounts from the peak areas, as described in Section 7.0. Review the results against calibration standards and other project samples for reasonableness.

5.7.6 Manual Integrations

Using the MultiQuant™ software, identify target analyte peaks that match retention time and other criteria above. Confirm acceptance of the MultiQuant™ auto-baseline for the peak or redraw the baseline, as necessary. Manual integrations will be used to separate near co-eluted peaks, remove negative peaks, and compensate for other peak shape or baseline anomalies that often occur in environmental samples. Guidance for manual integrations is provided in SOP 4-038.

DoD projects:
The rationale for manual integrations must be documented in the data package; samples and analytes which required manual integrations must be identified in the case narrative.

5.7.7 Reporting Units

Reporting units are typically µg/L unless the QAPP specifies otherwise. Data is not reported as surrogate corrected.

6.0 QUALITY CONTROL

LC Facility operations are documented according to SOP 6-025. Electronic files of all calibrations and sample data are kept in project specific network folders (SOP 6-032). Analysis of quality control samples including Procedural Blank (PB), Laboratory Control Sample (LCS), laboratory Control Sample Duplicate (LCSD), Matrix Spike (MS), Matrix Spike Duplicate (MSD), Duplicate (DUP), and Triplicate (TRP) are specified in the QAPP. The quality control acceptance criteria will follow the criteria outlined in SOP 7-029 unless modified in the QAPP. Key elements of the quality control program include:

1. There must be an initial calibration of the instrument as specified in Section 5.

2. Each day that analysis is performed, the calibration verification standard should be evaluated to determine if the chromatographic system is operating properly.

3. The system must be recalibrated at method setup and after major maintenance.

4. All QC samples and criteria defined in Sections 5.1, 5.3, 5.4, 5.5 and Attachment 4.

7.0 DATA ANALYSIS AND CALCULATIONS

Common laboratory calculations are defined in SOP 7-029.

7.1 Initial Calibration

Correlation Co-efficient

$$r = \left(\sum w \sum w y y_c - \sum w y \sum w y_c\right) / \sqrt{\left(D_y D_{yc}\right)}$$

where:

$$D_y = \sum w \sum w y^2 - \left(\sum w y\right)^2$$

y_c = calculated y-value using the equation below:

$$D_{yc} = \sum w \sum w y_c^2 - \left(\sum w y_c\right)^2$$

Linear Regression Method

- Y = mX + b

  which is equivalent to: $A_A/A_{IS} = [[m \text{ H } (C_A/C_{IS})] + b]$

- $C_A = [(A_A/A_{IS})\ b] \text{ H } (C_{IS}/m)$

The slope and intercept are calculated as:

$$m = \left(\sum w \sum wxy - \sum wx \sum wy\right) / D_x$$

$$b = \left(\sum wx^2 \sum wy - \sum wx \sum wxy\right) / D_x$$

Where:

$$D_x = \sum w \sum wx^2 - \left(\sum wx\right)^2$$

Weighting Type	Weight (w)
1 / x	If $|x| < 10^{-5}$, then $w = 10^5$. Otherwise, $w = 1 / |x|$.

7.2 Quantification of Samples

Samples are quantified as detailed in Section 5. The concentration of target analytes is determined using the following equation:

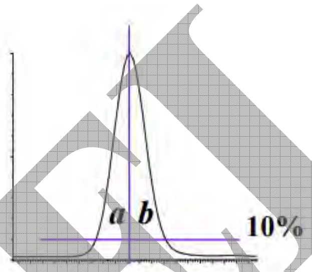
$$x = (y - b) / m$$

Where:
x = concentration
y = area
b = intercept (in this case, 0 as this method is always forced through zero)
m = slope

7.3 Peak Asymmetry

Peak asymmetry is calculated using:

$$A_s = \frac{b}{a}$$



where:
A_s = peak asymmetry factor
B = width of the back half of the peak measured (at 10% peak height) from the trailing edge of the peak to a line dropped perpendicularly from the peak apex
a = the width of the front half of the peak measured (at 10% peak height) from the leading edge of the peak to a line dropped perpendicularly from the apex.

7.4 Prediction Interval of Result

The Half Range for the Prediction Interval of Result as well as the upper and lower limits are calculated as follows (Winslow, et al., 2006):

$$HR_{PIR} = 3.963s$$

where
s = the standard deviation
3.963 = a constant value for seven replicates.

The Upper PIR Limit must be ≤150% recovery.

$$\frac{Mean + HR_{PIR}}{FortifiedConcentration} \times 100\% \leq 150\%$$

The Lower PIR Limit must be ≥ 50% recovery.

$$\frac{Mean - HR_{PIR}}{FortifiedConcentration} \times 100\% \geq 50\%$$

7.5 Calculation of Detection Limit

Calculate the detection limit as follows:

$$DL = s\ x\ t_{(n-1,1-\alpha=0.99)}$$

Where:

s = standard deviation of replicate analysis
t(n-1,1-α=0.99) = Student's t value for the 99% confidence level with n-1 degrees of freedom
n = number of replicates

8.0 TRAINING

The trainee must read and fully understand the policies and procedures outlined in this SOP. The trainee will then be given a demonstration of all aspects of this SOP.

SOP 2-011 defines the training procedures and required documentation for sample preparation and analytical SOPs. These apply to both technicians processing samples and the analysts. The acceptance criteria for the Demonstration of Capability (DOC) are the same as for routine QC samples as defined in SOP 7-029.

When training is completed, the trainee will be issued an IDC Certificate (SOP 2-011). The laboratory Quality Assurance Manual and SOP 2-011 define the locations of training records.

LC-MS/MS analysts must also have documented training in Battelle SOPs 4-038 and 6-025. Training for these SOPs should be documented accourding to procedures outlined in the Qaulity Assurance Manual.

9.0 SAFETY

As part of the above training program, the analyst will be made aware of the particular safety concerns of this procedure, including:

- Protective eyewear and clothing should be worn when appropriate.
- Proper use of fume hoods.
- Proper care must be exercised when using syringes.
- Location and use of laboratory safety devices; eyewashes, emergency showers, fire extinguishers, fire blankets, and first aid kits, as well as SDS sheets.
- Certain areas of the LC-MS/MS system are heated zones and bodily contact with these zones should be avoided.
- High voltages exist in certain marked areas of the LC-MS/MS system and bodily contact with these areas is to be avoided.
- Care should be taken when using solvents in and around the LC system.

10.0 POLLUTION PREVENTION

Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. Staff should make every effort to use the minimum amount of sample and reagent for this analytical procedure. All samples and reagents are contained and disposed of in an appropriate manner (Section 12).

11.0 CORRECTIVE ACTION

Battelle maintains a corrective action program that is detailed in SOP 4-035. The Laboratory Manager must approve all corrective actions initiated within the laboratory. The effectiveness of corrective actions is verified by the Quality Assurance Unit.

12.0 WASTE MANAGEMENT

All waste streams generated within the laboratory are collected and stored in an appropriate container and disposed according to SOP 5-114 or when appropriate, by other approved waste management procedures.

13.0 INTERFERENCES

Method inferences may be caused by contaminants in solvents, reagents, glassware, and other sample processing apparatus that lead to discrete artifacts or elevated baselines in chromatograms. All solvent/reagents must be analyzed initially to demonstrate they are free from interferences (SOP 5-015). Glassware must be scrupulously cleaned following the procedures outlined in SOP 5-216. The use of high purity reagents and solvents helps to minimize these interference problems. Significant effort must be taken to ensure no PTFE or other surface containing PFAS comes in contact with the materials or equipment in the sample pathway from preparation to analysis.

Matrix interferences may be caused by contaminants that are co-extracted from the sample. The extent of matrix interferences will vary considerably from source to source, depending on the nature and diversity of the sample.

Cross-contamination can occur whenever high-level and low-level samples are analyzed sequentially. Whenever an unusually concentrated sample is analyzed, the samples following it may need re-analysis if cross-contamination is suspected. The LC system may require maintenance if it has been exposed to high level samples.

14.0 DEFINITIONS

Battelle's methodology terms are consistent with the The NELAC Institute (TNI) Glossary of Terms outlined in the TNI Constitutions, Bylaws and Standards Manual. The TNI Glossary of Terms currently being utilized by Battelle is outlined in Attachment B of Battelle's Quality Assurance Manual. Battelle's method detection terminology is defined in SOP 5-291 and quality control terminology in SOP 7-029.

15.0 METHOD DETECTION LIMITS

Battelle maintains a program for determining and verifying method detection limits (MDL), LOD, LOQ, and reporting limit (RL) values. The policies and procedures are defined in SOP 5-291 and Battelle's Quality Assurance Manual. All MDL, LOD, and LOQ study results are accessible within the laboratory network files. All reporting limits are based on the low standard of the calibration curve, sample dilutions and sample size.

16.0 METHOD PERFORMANCE

Battelle maintains a program for determining method performance. The policies and procedures are outlined in SOP 5-295 and Battelle's Quality Assurance Manual. The Laboratory Manager must approve all new methodologies before use.

17.0 DATA ASSESSMENT AND ACCEPTANCE CRITERIA

Battelle maintains a program for assessing data and determining acceptance criteria for quality control measures. These policies and procedures are outlined in SOP 7-029 and in Battelle's Quality Assurance Manual. Battelle also maintains a program for handling out-of-control or unacceptable data. These policies and contingencies are outlined in SOP 4-035, SOP 7-029, and Battelle's Quality Assurance Manual. When criteria exist in both this SOP and SOP 7-029, the criteria defined in this SOP override criteria in SOP 7-029.

18.0 REFERENCES

Shoemaker, J. A., Grimmett, P. E., Boutin, B. K., & Tettenhorst, D. R. (2018). *Method 537.1 Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS).* Cincinnati: EPA.

Winslow, S. D., Pepich, B. V., Martin, J. J., Hallberg, G. R., Munch, D. J., Frebis, C. P., . . . Krop, R. A. (2006). Statistical Proceduers for Determination and Verification of Minimum Reporting Levels for Drinking Water Methods. *Environmental Science and Technology*, 281-288.

ATTACHMENTS

Attachment 1	PFAS Target Analyte List
Attachment 2	Acquisition Parameters and Transitions
Attachment 3	Sampling Instructions
Attachment 4	QC Sample Requirements
Attachment 5	Example Chromatograms for Branched Isomers
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APPROVALS:

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	Name	Date

ATTACHMENT 1

PFAS Target Analyte List

Analyte	Code	CAS No.	IS Reference
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	$^{13}C_2$-PFOA
Perfluororhexanoic acid	PFHxA	307-24-4	$^{13}C_2$-PFOA
Perfluoroheptanoic acid	PFHpA	375-85-9	$^{13}C_2$-PFOA
Perfluorooctanoic acid	PFOA	335-67-1	$^{13}C_2$-PFOA
Perfluorononanoic acid	PFNA	375-95-1	$^{13}C_2$-PFOA
Perfluorodecanoic acid	PFDA	335-76-2	$^{13}C_2$-PFOA
Perfluoroundecanoic acid	PFUnA	2058-94-8	$^{13}C_2$-PFOA
Perfluorododecanoic acid	PFDoA	307-55-1	$^{13}C_2$-PFOA
Perfluorotridecanoic acid	PFTrA	72629-94-8	$^{13}C_2$-PFOA
Perfluorotetradecanoic acid	PFTeDA	376-06-7	$^{13}C_2$-PFOA
N-methylperfluoro-1-octanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	d3-MeFOSAA
N-ethylperfluoro-1-octanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	d3-MeFOSAA
Perflurorbutanesulfonic acid	PFBS	375-73-5	$^{13}C_4$-PFOS
(Na) perfluoro-1-hexanesulfonate	PFHxS	3871-99-6	$^{13}C_4$-PFOS
Perfluorooctanesulfonic acid	PFOS	1763-23-1	$^{13}C_4$-PFOS
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9	$^{13}C_4$-PFOS
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid	9Cl-PF3ONS	756426-58-1	$^{13}C_4$-PFOS
4,8-dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	$^{13}C_2$-PFOA
Surrogates			
Perfluoro-n-[1,2-13C2] hexanoic acid	$^{13}C_2$-PFHxA	NA	$^{13}C_2$-PFOA
Perfluoro-n-[1,2-13C2] decanoic acid	$^{13}C_2$-PFDA	NA	$^{13}C_2$-PFOA
N-ethyl-d5-perfluoro-1-octanesulfonamidoacetic acid	d5-EtFOSAA	NA	d3-MeFOSAA
Tetrafluoro-2-heptafluoropropoxy-13C3-propanoic acid	$^{13}C_3$-HFPO-DA	NA	$^{13}C_2$-PFOA
Internal Standards			
Perfluoro-n-[1,2-13C2] octanoic acid	$^{13}C_2$-PFOA	NA	NA
Perfluoro-1-[1,2,3,4-13C4] octanesulfonate	$^{13}C_4$-PFOS	NA	NA
N-methyl-d3-perfluoro-1-octanesulfonamidoacetic acid	d3-MeFOSAA	NA	NA

ATTACHMENT 2

Acquisition Parameters and Transitions

	Primary Transition		**Confirmation Transition**			
Analyte Code	Q1	Q3	Q1	Q3	**DP**	**CE**
HFPO-DA	285	169	285	118	12	8
PFHxA	313	269	313	119	25	12
PFHpA	363	319	363	169	25	12
PFOA	413	369	413	169	25	14
PFNA	463	419	463	219	25	14
PFDA	513	469	513	219	25	16
PFUnA	563	519	563	269	25	18
PFDoA	613	569	613	319	25	18
PFTrA	663	619	663	169	25	20
PFTeDA	713	669	713	169	25	22
NMeFOSAA	570	419	570	512	40	36
NEtFOSAA	584	419	584	483	50	36
PFBS	298.9	80	298.9	99	55	58
PFHxS	399	80	399	99	60	74
PFOS	499	80	499	99	65	108
11Cl-PF3OUdS	631	451	631	83	40	24
9Cl-PF3ONS	531	351	531	83	40	24
ADONA	377	251	377	85	14	12
$^{13}C_2$-PFHxA	315	270	NA	NA	25	12
$^{13}C_2$-PFDA	515	470	NA	NA	25	16
d5-EtFOSAA	589	419	NA	NA	50	36
$^{13}C_3$-HFPO-DA	287	169	NA	NA	10	6
$^{13}C_2$-PFOA	415	270	NA	NA	25	14
$^{13}C_4$-PFOS	503	80	NA	NA	65	108
d3-MeFOSAA	573	419	NA	NA	40	36

ATTACHMENT 3

Sampling Instructions

All samples must be collected and preserved under the following conditions:

- Samples must be collected in a 250 mL polypropylene bottle with a polypropylene screw cap.
- Bottles shipped to the field must be preserved by adding Trizma® as a solid to each bottle prior to shipping to the field. The final concentration of Trizma® should be approximately 5.0 g/L (1.25 g +/1 0.2 g per sample bottle).
- Sample collector should wash hands prior to sampling and wear nitrile gloves during collection.
- Turn on tap water and allow the system to equilibrate / flush until the water temperature has stabilized (approximately 3 to 5 minutes).
- Collect the sample from the flowing system – fill the collection bottle, taking care not to flush the preservative from the collection bottle. Sample does not have to be free of headspace.
- Cap the container and shake to dissolve the preservative.
- The container must be kept sealed from this point until samples are ready for extraction.
- A field reagent blank (FRB) must be handled with each set of samples collected. Prior to shipment of bottles to the field, a sample bottle is filled with Millipore water and preservative. This sample, and a clean, empty bottle (no preservative) are shipped to the field. At the sampling site, the sampler must open the FRB and pour the contents into the empty sample bottle shipped with the FRB. The bottle is then sealed and labelled as the FRB and shipped to the laboratory with the samples collected. This sample is to ensure that PFAS are not introduced during sample handling.
- The same batch of preservative must be used for the FRB and all samples collected during one collection run.
- The reagent water used for the FRB must be initially analyzed for the method analytes and must meet all method criteria prior to use.
- Samples must be chilled during shipment and must not exceed 10 °C during the first 48 hours after collection. Samples should be chilled prior to shipment and shipped on ice to the laboratory. Temperatures will be confirmed upon arrival at the laboratory.
- Samples must be extracted within 14 days of collection and analyzed within 28 days after extraction.

ATTACHMENT 4

QC Sample Requirements

Initial Demonstration of Capability Quality Control Requirements

Reference	Requirement	Specification and Frequency	Acceptance Criteria
EPA 537 Version 1.1 Section 9.2.1	Initial Demonstration of Low System Background	Analyze LRB (PB) prior to any other IDC step	Demonstrate that all method analytes are below 1/3 the MRL and that possible interferences from extraction media do not prevent the identification and quantification of method analytes
EPA 537 Version 1.1 Section 9.2.2	Initial Demonstration of Precision (IDP)	Analyze four to seven replicate LFB (LCS) fortified near the midrange calibration concentration.	% RSD must be <20%
EPA 537 Version 1.1 Section 9.2.3	Initial Demonstration of Accuracy (IDA)	Calculate average recovery for the replicates used in the IDP	Mean recovery +/- 30% of true value
EPA 537 Version 1.1 Section 9.2.4	Initial Demonstration of Peak Asymmetry Factor	Calculate the peak asymmetry factor using the equation in Section 7.3 for the first two eluting chromatographic peaks in a mid-level ICAL standard	Peak asymmetry factor of 0.8 – 1.5
EPA 537 Version 1.1 Section 9.2.5	Minimum Reporting Limit (MRL) confirmation	Fortify, extract, and analyze seven replicate LFB (LCS) at the proposed MRL concentration. Calculate the Mean and the Half Range (HR). Confirm that the upper and lower limits for the Prediction Interval of Result (Upper PIR, Lower PIR, Section 7.4) meet the recovery criteria.	Upper PIR ≤ 150% Lower PIR ≥ 50%
NA	Fortified samples	All fortified samples must be spiked using a second source solution as compared to the calibration curve.	Second source samples must meet the criteria defined in this table (see ICC, LCS, MS, MSD, etc.)

Reference	Requirement	Specification and Frequency	Acceptance Criteria
EPA 537 Version 1.1 Section 9.2.7	Detection Limit (DL) Determination (optional)	Over a period of three days, prepare a minimum of seven replicate LFB/LCS fortified at a concentration estimated to be near the DL. Analyze the replicates through all steps of the analysis. Calculate the DL using the equation in Section 7.5.	Data from the DL replicates are <u>not</u> required to meet method precision and accuracy criteria. If the DL replicates are fortified at a low enough concentration, it is likely that they will not meet precision and accuracy criteria.

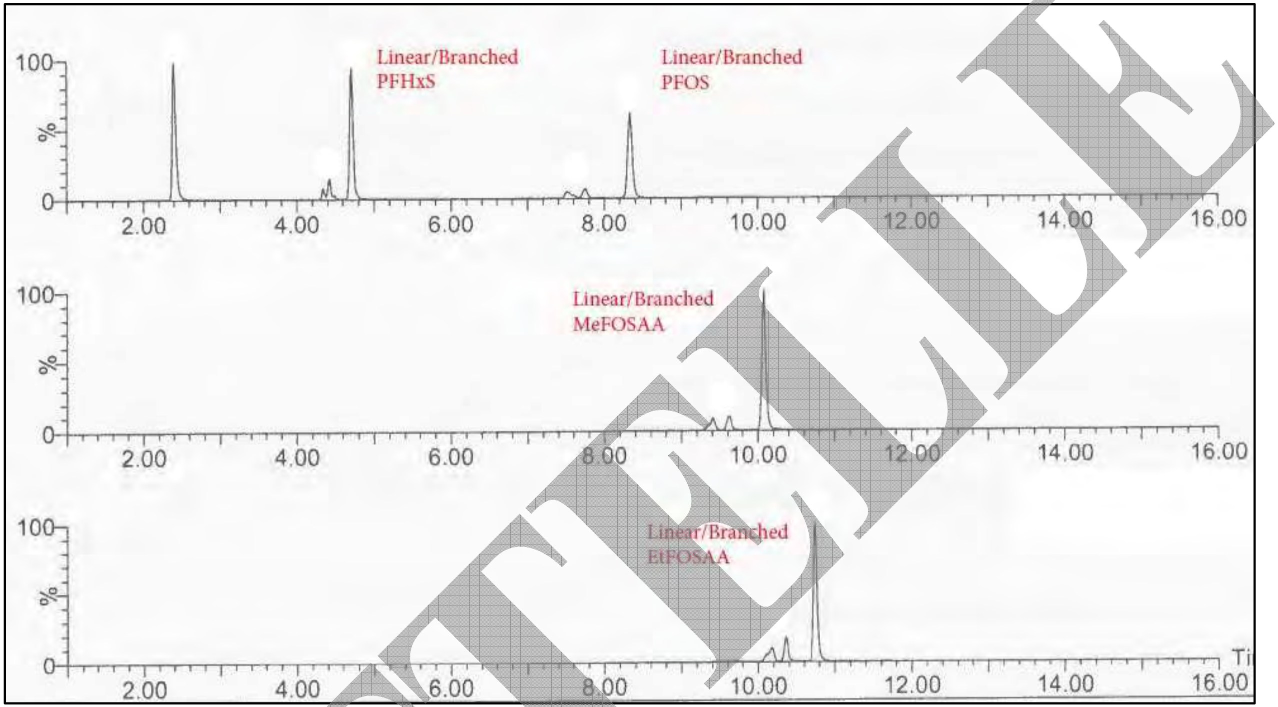
Ongoing Quality Control Requirements

Reference	Requirement	Specification and Frequency	Acceptance Criteria
EPA 537 Version 1.1 Section 8.5	Sample Holding Time	14 days with appropriate preservation and storage as described in Section 5.2	Sample results are valid only if samples are extracted within the sample hold time.
EPA 537 Version 1.1 Section 8.5	Extract Holding Time	28 days when stored at room temperature in polypropylene centrifuge tubes	Extract results are valid only if extracts are analyzed within the extract hold time.
EPA 537 Version 1.1 Section 9.3.1	Laboratory Reagent Blank (LRB) / Procedural Blank (PB)	Daily, or with each extraction batch of up to 20 samples, whichever is more frequent.	Demonstrate that all method analytes are below 1/3 the MRL, and confirm that all possible interferences do not prevent quantification of method analytes.
EPA 537 Version 1.1 Section 9.3.3	Laboratory Fortified Blank (LFB) / Laboratory Control Sample (LCS)	Analyze at least one LFB / LCS daily or one for each extraction batch up to 20 Field Samples. Rotate the fortified concentrations between low, medium, and high amounts.	Results of the LFB /LCS must be 70-130% of the true value for each method analyte for all fortified concentrations except the lowest CAL point. Results corresponding to the lowest CAL point for each method analyte must be 50-150% of the true value.
EPA 537 Version 1.1 Section 9.3.4	Internal Standard (IS)	Internal standards are added to all calibration standards and extracts, including QC samples. Compare IS areas to the average IS area in the initial calibration and to the most recent CCV.	Peak area counts for all IS in all injections must be within +/- 50% of the average peak area calculated during the ICAL and 70-140% from the most recent CCV. If ISs do not meet this criterion, corresponding target results are invalid.
EPA 537 Version 1.1 Section 9.3.5	Surrogate Standards (SUR) / Surrogate Internal Standards (SIS)	Surrogate standards are added to all calibration standards and samples, including QC samples. Calculate SUR/SIS recoveries.	SUR/SIS recoveries must be 70-130% of the true value. If a SUR/SIS fails this criterion, report all results for sample as suspect / SIS recovery.
EPA 537 Version 1.1 Section 9.3.6	Laboratory Fortified Sample Matrix (LFSM) / Matrix Spike (MS)	Analyze one LFSM/MS per extraction batch (20 samples or less) fortified with method analytes at a concentration close to but greater than the native concentration, if known. Calculate LFSM/MS recoveries	Recoveries at mid an high levels should be within 70-130% and within 50-150% at the low-level fortified amount (near the MRL). If these criteria are not met, results are labeled suspect due to matrix effects.

Reference	Requirement	Specification and Frequency	Acceptance Criteria
EPA 537 Version 1.1 Section 9.3.7	Laboratory Fortified Sample Matrix Duplicate (LFSMD) / Matrix Spike Duplicate (MSD) or Field Duplicate (FD)	Extract and analyze at least one MSD or FD with each extraction batch (20 samples or less). A MSD may be substituted for a FD when frequency of detects are low. Calculate RPDs.	Method analyte PRDs for the MSD or FD should be ≤ 30% at the mid and high levels of fortification and ≤ 50% near the MRL. If these criteria are not met, results are labeled suspect due to matrix effects.
EPA 537 Version 1.1 Section 9.3.8	Field Reagent Blank (FRB)	Analysis of the FRB is required only if a field sample contains a method analyte or analytes at or above the MRL. The FRB is processed, extracted, and analyzed in exactly the same manner as a Field Sample.	If the method analytes(s) found in the Field Sample is present in the FRB at a concentration greater than 1/3 the MRL, then all samples collected with that FRB are invalid and must be recollected and reanalyzed.
EPA 537 Version 1.1 Section 9.3.9	Peak Asymmetry Factor	Calculate the peak asymmetry factor for the first two eluting chromatographic peaks in a mid-level ICAL standard every time a calibration curve is generated.	Peak asymmetry factor of 0.8 – 1.5
EPA 537 Version 1.1 Section 10.2	Initial Calibration (ICAL)	Use IS calibration technique to generate a first or second order calibration curve forced through zero. Use at least five standard concentrations. Check the calibration curve as described in Section 7.1.	When each standard is calculated as an unknown using the calibration curve, the analyte results should be 70-130% of the true value for all except the lowest standard, which should be 50-150% of the true value. Recalibration is recommended if these criteria are not met.
NA	Initial Calibration Check (ICC)	Analyze after each new ICAL. ICC is made from second source material as compared to the ICAL.	Recoveries for each analyte and surrogate must be within 70-130% of the true value. Recalibration is required if criteria is not met.
EPA 537 Version 1.1 Section 10.3	Continuing Calibration Check (CCC) / Continuing Calibration Verification (CCV)	Verify initial calibration by analyzing a low level (at the MRL or below) CCV prior to analyzing samples. CCV are then injected after every 10 samples and after the last sample, rotating concentrations to cover the calibration range of the instrument.	Recoveries for each analyte and surrogate must be within 70-130% of the true value for all but the lowest level of the calibration. Recovery for each analyte in the lowest level must be within 50-150% of the true value and the surrogates within 70-130% of the true value.

Attachment 5

Example Chromatograms for Branched Isomers (from certificates of analysis)



Attachment 6

Revision History

Version	Summary of Changes
02	Updated section 5.3 to require recording the start and stop times for loading the samples onto the solid phase extraction cartidges. Updated calibration curve levels in Table 1. This method is equivalent to the previous version, new Demonstrations of Capability (DOC) will not be required under this version of the SOP.
03	Updated method reference to Method 537 Version 1.1 from Method 537.1. Updated concentrations of internal standards and surrogates used in calibration and extractions.