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FINAL SAMPLING AND ANALYSIS PLAN (FIELD SAMPLING PLAN AND QUALITY ASSURANCE PROJECT PLAN) REMEDIAL INVESTIGATION FOR PERFLUORINATED COMPOUNDS AND VAPOR INTRUSION EVALUATION FORMER NAWC WARMINSTER PA

10/01/2015

BATTELLE

SAP Worksheet #1 -- Title and Approval Page
(UFP-QAPP Manual Section 2.1)

Final
SAMPLING AND ANALYSIS PLAN
(Field Sampling Plan and Quality Assurance Project Plan)

October 2015

Remedial Investigation for Perfluorinated Compounds and Vapor Intrusion Evaluation, Former Naval Air Warfare Center Warminster, Pennsylvania

Prepared for:
NAVFAC BRAC Program Management Office, East
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Prepared under:
Contract No. N62583-11-D-0515
Task Order No. 0063

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Jeffrey Dale, NAVFAC RPM

Approval Signature: _____ Date: _____
Ken Bowers, NAVFAC Quality Assurance Officer

Approval Signature: Colin Wade Digitally signed by Colin Wade Date: _____
Colin Wade, Project Manager, PADEP

Approval Signature: _____ Date: 11/9/2015
Sarah Kloss, PM, EPA Region III

EXECUTIVE SUMMARY

The former Naval Air Warfare Center (NAWC) Warminster is an 824-acre facility located in Warminster Township, Northampton Township, and Ivyland Borough, Bucks County, PA. As a result of the Base Realignment and Closure (BRAC) Act, NAWC Warminster ceased operations on September 30, 1996 and the majority of the property has been transferred to the private sector and redeveloped. Chlorinated volatile organic compound (CVOC) plumes exist in groundwater as a result of historical operations at the site. Records of Decision (RODs) were signed for four groundwater operable units (OUs): OU-1A (Area A), OU-1B (Area B), OU-3 (Area C), and OU-4 (Area D). The OU-1A, OU-3, and OU-4 RODs include a component of groundwater extraction and treatment to maintain hydraulic control of source area groundwater in the vicinity of the extraction wells. The OU-1B ROD identified no further action.

Area A is comprised of three sites, Sites 1, 2, and 3, and lies within the northwest corner of the former Base, west of Jacksonville Road. Site 1 was historically operated as a burn pit, Site 2 consisted of two disposal trenches that received industrial wastewater sludges from the surface impoundments, and Site 3 also was reportedly used as a burn pit for solvents, paints, roofing materials, and other unspecified chemicals. Eight unlined lagoons used for storage of wastewater treatment plant sludges were formerly operated in the northern corner of Area A. An 85-ft diameter technical impractibility (TI) zone was established in Area A, focused around extraction wells EW-A6, EW-A7, EW-A9, and EW-A10, due to the potential presence of dense non-aqueous phase liquid (DNAPL).

Area B is located in the southeastern portion of the former NAWC Warminster, and was defined as encompassing Sites 5, 6, and 7 and adjacent areas where wastes were historically disposed. Site 5 reportedly consisted of up to eight trenches that were used for the disposal of demolition wastes, paints, solvents, scrap metal, aircraft paints, cans and asphalt. Sites 6 and 7 reportedly consisted of several pits that were used for disposal of waste paints, solvents, oil, flammable wastes, grease trap waste, and demolition debris. A former Navy housing area (Shenandoah Woods) currently occupies the location of Site 5, whereas Sites 6 and 7 are within an area of open space consisting of grass and woods.

Area C is located along Kirk Road and Newtown Road in the north-central portion of the former NAWC Warminster, and was defined as Sites 4 and 8 and nearby locations where hazardous substance releases may have resulted in groundwater contamination. Site 4 was a 7-acre area located north of the former main runway and south of Kirk Road. Several trenches were reportedly operated from 1966 to 1973 to dispose of non-industrial solid waste, paints, waste oils, waste metals, construction debris, solvents, and sewage sludge from the sewage treatment plant. Site 8 was located at the northeastern end of the old runway and was used as a fire-training area from 1961 to 1988. In addition, an area of the runway immediately south of the fire-training area (S-1) was used to test the resistance of aviation suits to fire.

Area D primarily includes the former main building complex at the former NAWC Warminster, and lies within the northwest corner of the former Base, just north of the intersection of Jacksonville Road and Street Road. The two main buildings in Area D housed several laboratories and shops that supported research and development activities and associated chemical and waste storage areas.

Groundwater samples collected from on- and off-site wells at the former NAWC Warminster between 2011 and 2014 contained elevated concentrations of perfluorinated compounds (PFCs), namely perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS). Maximum detected concentrations within Area C monitoring and extraction wells were 2.6 µg/L for PFOA and 16 µg/L for PFOS, both of which were detected in monitoring well OB-11 and are above the respective preliminary health advisory (PHA) values. In Area A, the highest concentrations of PFOA and PFOS were observed in EW-A5 (0.381 µg /L) and EW-A9 (0.707 µg /L), respectively. No Area A wells exceeded the PHA value for PFOA during baseline sampling, whereas 13 of the 15 wells exceeded the PHA value for PFOS.

In Area D, the highest concentrations of PFOA and PFOS were observed in EW-D4 (1.56 µg /L PFOA and 2.22 µg /L of PFOS). Seven of the eight Area D wells sampled during baseline sampling exceeded PHA values for PFOA and PFOA. In addition to the on-site groundwater monitoring and extraction wells, groundwater samples collected from Warminster Municipal Authority (WMA) production wells 10 (WMA-10), 13 (WMA-13), and 26 (WMA-26) showed elevated detections of PFOA and PFOS near or above PHA values. No PFC groundwater sampling was performed in Area B due to the absence of existing monitoring wells. Groundwater from private drinking water wells identified in the vicinity of the former NAWC Warminster was sampled for PFCs by Environmental Protection Agency (EPA) under an Interagency Agreement (IA) with the Navy.

As a result of these detections, the Navy initiated a preliminary assessment of potential sources of PFCs at the former NAWC Warminster (Tetra Tech, 2014). The report concluded that potential PFC sources in Area A and D, and Buildings 90 and 134 could have impacted WMA-10 and/or WMA-26. The report also concluded that Site 4 and/or Site 8 (including structure S-1) were the most likely potential sources of PFCs at Area C responsible for the elevated PFC levels observed in WMA-13.

The objective of this Sampling and Analysis Plan (SAP) is to document the approach for a remedial investigation (RI) designed to further identify the potential sources and the nature and extent of PFCs at the former NAWC Warminster. In addition to the PFC investigation, the SAP also will outline the approach for a vapor intrusion (VI) evaluation in several structures in the vicinity of the Area C dissolved CVOC plume that may pose a risk to human health.

The field activities documented in this plan include groundwater monitoring well installation and surface water sampling, groundwater sampling, sediment sampling, soil sampling, and private well sampling to investigate the PFC contamination at the former NAWC Warminster. The VI evaluation will include collection of ambient air, indoor air, and sub-slab vapor sampling at Area C. All of the field activities will be performed by Battelle for Naval Facilities Engineering Command (NAVFAC) BRAC Program Management Office (PMO) East Branch under Contract No. N62583-11-D-0515, Task Order No. 063. This work will be conducted with oversight from the EPA and Pennsylvania Department of Environmental Protection (PADEP).

The SAP also describes project management, assessment/oversight of quality assurance/quality control (QA/QC) issues, data validation, and QA/QC protocols necessary to achieve data quality objectives (DQOs).

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14-1: Field Audit Checklist
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27-2: Example Chain of Custody Record
27-3: Custody Seal

Attachment A: PFC Sampling Guidance
Attachment B: Well Drilling SOP
Attachment C: Soil Sampling SOP
Attachment D: Groundwater Sampling SOP
Attachment E: Surface Water Sampling SOP
Attachment F: Sediment Sampling SOP
Attachment G: Air Sampling SOP
Attachment H: Laboratory SOPs and Accreditations
Attachment I: Comment Response Forms

ACRONYMS

AFFF	aqueous film forming foam
AO	Administrative Order
BCDH	Department of Health of Bucks County, Pennsylvania
bgs	below ground surface
BRAC	Base Realignment and Closure
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CO/COR	Contracting Officer/Contracting Officer's Representative
COC	chain of custody
CSM	conceptual site model
CVOC	chlorinated volatile organic compound
DI	deionized
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DoD	Department of Defense
DQO	data quality objective
EDD	electronic data deliverable
ELAP	Environmental Laboratory Accreditation Program
EPA	United States Environmental Protection Agency
FS	Field Supervisor
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry
GWETS	groundwater extraction and treatment system
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSA	hollow stem auger
IA	Interagency Agreement
ID	identification
IDW	investigation-derived waste
J&E	Johnson & Ettinger
LCS	laboratory control sample
LDC	Laboratory Data Consultants
LGAC	liquid phase granular activated carbon
LIMS	laboratory information management system
LQAP	Laboratory Quality Assurance Plan
LTM	long-term monitoring
MCL	maximum contaminant level
MDL	method detection limit
MS/MSD	matrix spike/matrix spike duplicate

NAVFAC	Naval Facilities Engineering Command
NAWC	Naval Air Warfare Center
NEDD	Naval Electronic Data Deliverable
NIRIS	Naval Installation Restoration Information Solution
NJDEP	New Jersey Department of Environmental Protection
ORP	oxidation reduction potential
OSHA	Occupational Safety and Health Administration
OU	operable unit
PADEP	Pennsylvania Department of Environmental Protection
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCE	tetrachloroethene
PDB	passive diffusion bag
PFBS	perfluorobutanesulfonic acid
PFC	perfluorinated compound
PFHpA	perfluoroheptanoic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PHA	preliminary health advisory
PID	photoionization detector
PM	Project Manager
PMO	Program Management Office
PPE	personal protective equipment
QA/QC	quality assurance/quality control
QAO	Quality Assurance Officer
RI	remedial investigation
RL	reporting limit
ROD	Record of Decision
RPD	relative percent difference
RPM	Remedial Project Manager
SAP	Sampling and Analysis Plan
SL	screening level
SOP	standard operating procedure
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
TCE	trichloroethene
TI	technical impractibility
UCMR 3	Unregulated Contaminant Monitoring Rule 3
UFP-QAPP	Uniform Federal Policy for Quality Assurance Plans
USGS	United States Geological Survey
VI	vapor intrusion

VISL	Vapor Intrusion Screening Level
WMA	Warminster Municipal Authority

SAP Worksheet #2 -- SAP Identifying Information
(UFP-QAPP Manual Section 2.2.4)

Site Name/Number: Former NAWC Warminster
Operable Unit: OU-1A, OU-1B, OU-3, and OU-4
Contractor Name: Battelle Memorial Institute
Contract Number: N62583-11-D-0515
Contract Title: Environmental Services and Technologies
Task Order Number (optional): 063

1. This SAP was prepared in accordance with the requirements of the *Uniform Federal Policy for Quality Assurance Plans (UFP-QAPP)* (IDQTF, 2005) and *EPA Guidance for Quality Assurance Project Plans, EPA QA/G-5* (EPA, 2002)

2. Identify regulatory program: United States Navy BRAC

3. This SAP is a project-specific SAP.

4. List dates of scoping sessions that were held:

Scoping Session	Date
DQO development session	5/15/2014

5. List dates and titles of any SAP documents written for previous site work that are relevant to the current investigation.

Title	Date

6. List organizational partners (stakeholders) and connection with lead organization

United States Navy, NAVFAC BRAC PMO, East Branch: Responsible Federal Agency
United States Environmental Protection Agency, Region 3: Federal Regulatory Agency
Pennsylvania Department of Environmental Protection: State Regulatory Agency
Battelle Memorial Institute: Lead Contractor
H&S Environmental, Inc.: Subcontractor

7. Lead organization

United States Navy, NAVFAC BRAC PMO, East Branch

8. 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:

Worksheet #8 (Special Personnel Training Requirements Table) is not applicable to the project as there is no special training required.

UFP-QAPP Worksheet #	Required Information	Crosswalk to Related Information
A. Project Management		
Documentation		
1	Title and Approval Page	
2	Table of Contents SAP Identifying Information	
3	Distribution List	
4	Project Personnel Sign-Off Sheet	
Project Organization		
5	Project Organizational Chart	
6	Communication Pathways	
7	Personnel Responsibilities and Qualifications Table	
8	Special Personnel Training Requirements Table	This worksheet is not applicable. There is no specialized training required for this project.
Project Planning/ Problem Definition		
9	Project Planning Session Documentation (including Data Needs tables) Project Scoping Session Participants Sheet	
10	Problem Definition, Site History, and Background. Site Maps (historical and present)	
11	Site-Specific Project Quality Objectives	
12	Measurement Performance Criteria Table	
13	Sources of Secondary Data and Information Secondary Data Criteria and Limitations Table	
14	Summary of Project Tasks	
15	Reference Limits and Evaluation Table	
16	Project Schedule/Timeline Table	
B. Measurement Data Acquisition		
Sampling Tasks		
17	Sampling Design and Rationale	
18	Sampling Locations and Methods/SOP Requirements Table Sample Location Map(s)	
19	Analytical Methods/SOP Requirements Table	
20	Field Quality Control Sample Summary Table	
21	Project Sampling SOP References Table Sampling SOPs	
22	Field Equipment Calibration, Maintenance, Testing, and Inspection Table	
Analytical Tasks		
23	Analytical SOPs Analytical SOP References Table	
24	Analytical Instrument Calibration Table	
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	

UFP-QAPP Worksheet #	Required Information	Crosswalk to Related Information
Sample Collection		
26	Sample Handling System, Documentation Collection, Tracking, Archiving and Disposal Sample Handling Flow Diagram	
27	Sample Custody Requirements, Procedures/SOPs Sample Container Identification Example Chain-of-Custody Form and Seal	
Quality Control Samples		
28	QC Samples Table Screening/Confirmatory Analysis Decision Tree	
Data Management Tasks		
29	Project Documents and Records Table	
30	Analytical Services Table Analytical and Data Management SOPs	
C. Assessment Oversight		
31	Planned Project Assessments Table Audit Checklists	
32	Assessment Findings and Corrective Action Responses Table	
33	QA Management Reports Table	
D. Data Review		
34	Verification (Step I) Process Table	
35	Validation (Steps IIa and IIb) Process Table	
36	Validation (Steps IIa and IIb) Summary Table	
37	Usability Assessment	

SAP Worksheet #3 -- Distribution List
(UFP-QAPP Manual Section 2.3.1)

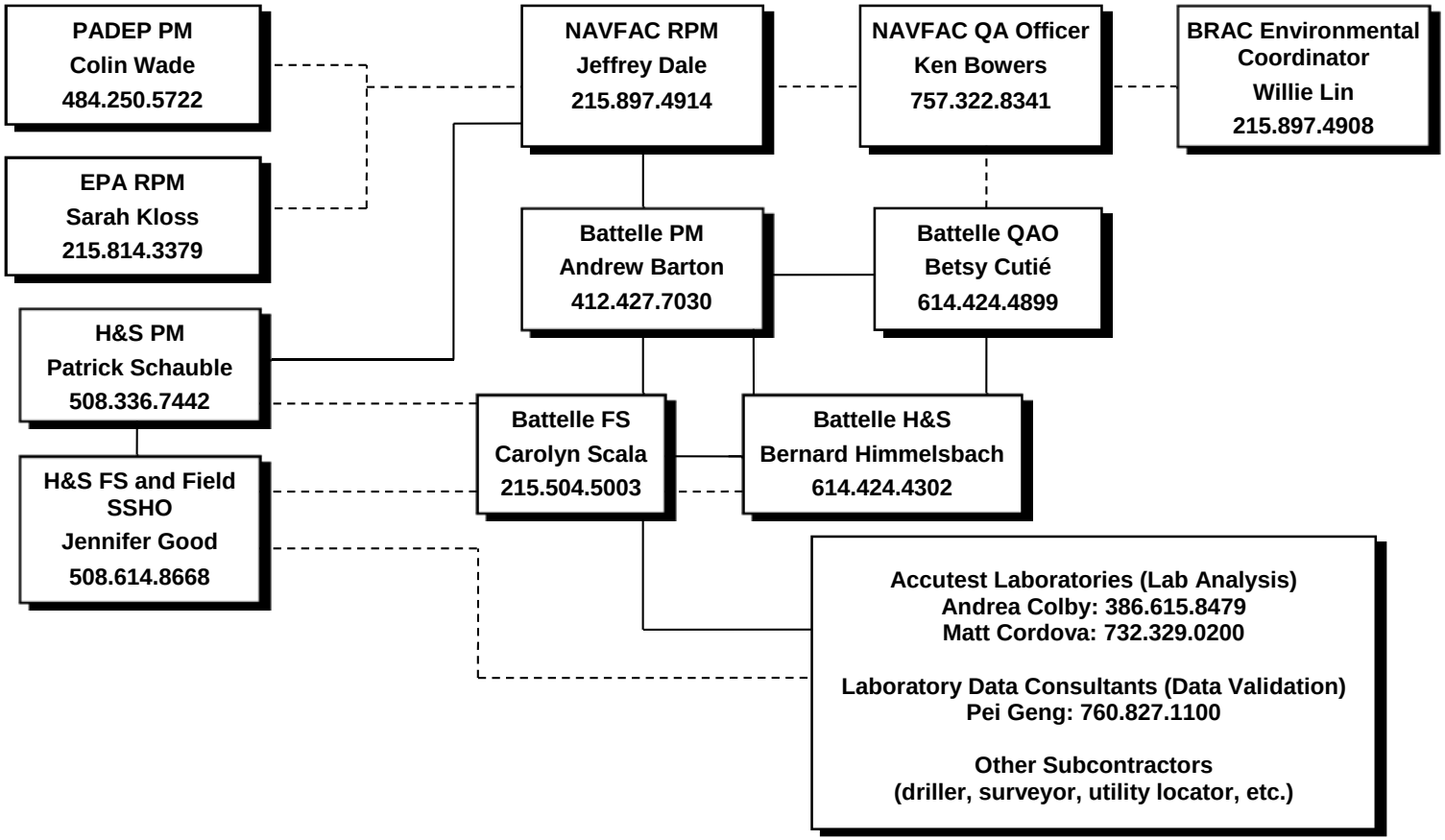
Name of SAP Recipients	Title/Role	Organization	Telephone Number (Optional)	E-mail Address or Mailing Address	Document Control Number (Optional)
Andrew Barton	Project Manager (PM)	Battelle	(412) 427-7030	bartona@battelle.org	
Carolyn Scala	Field Supervisor (FS)	Battelle	(215) 504-5003	scalac@battelle.org	
Betsy Cutié	QA Officer (QAO)	Battelle	(614) 424-4899	cutiee@battelle.org	
Jeffrey Dale	Remedial Project Manager (RPM)	NAVFAC BRAC PMO East	(215) 897-4914	jeffrey.m.dale@navy.mil	
Patrick Schauble	PM	H&S Environmental, Inc.	(508) 336-7442	pscchauble@hsenv.com	
Andrea Colby	PM	Accutest Laboratories - Orlando	(386) 615-8479	andreac@accutest.com	
Matt Cordova	PM	Accutest Laboratories – New Jersey	(732) 329-0200	mattc@accutest.com	
Pei Geng	PM	Laboratory Data Consultants (LDC)	(760) 827-1100	pgeng@lab-data.com	

SAP Worksheet #4 -- Project Personnel Sign-Off Sheet
(UFP-QAPP Manual Section 2.3.2)

Name	Organization/Title/Role	Telephone Number (optional)	Signature/E-mail Receipt	SAP Section Reviewed	Date SAP Read
Andrew Barton	Battelle/PM/Oversees project			All worksheets	
Carolyn Scala	Battelle/FS/Oversees fieldwork			All worksheets	
Betsy Cutié	QAO			All worksheets	
Jennifer Good	Site Safety and Health Officer (SSHO)/Oversees field activities for health and safety compliance			All worksheets	
Andrea Colby	Accutest Laboratories – Orlando /PM/Oversees analytical work			12, 15,19, 20, 22, 23, 24, 25, 26, 27, 28, 30, 34, 35, 36	
Matt Cordova	Accutest Laboratories – New Jersey /PM/Oversees analytical work			12, 15,19, 20, 22, 23, 24, 25, 26, 27, 28, 30, 34, 35, 36	
Pei Geng	Laboratory Data Consultants/PM/Oversees data validation			12, 15,19, 20, 22, 23, 24, 25, 26, 27, 28, 30, 34, 35, 36	

SAP Worksheet #5 -- Project Organizational Chart
(UFP-QAPP Manual Section 2.4.1)

Lines of Authority ——— ····· Lines of Communication



SAP Worksheet #6 -- Communication Pathways

(UFP-QAPP Manual Section 2.4.2)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or E-mail	Procedure (timing, pathway to & from, etc.)
Monthly briefing to NAVFAC RPM	Battelle PM	Andrew Barton	(412) 427-7030	Monthly phone call from the PM to the RPM.
Regular communication with NAVFAC RPM	Battelle PM	Andrew Barton	(412) 427-7030	Weekly communication at a minimum between the PM to the RPM during field effort either phone call or e-mail.
Regulatory Agency interface	Navy RPM	Jeffrey Dale	(215) 897-4914	Regulatory agencies will receive regular updates from the Navy RPM.
Coordination among field and laboratory contractors	Battelle FS	Carolyn Scala	(215) 504-5003	Daily updates from Battelle FS to PM.
Field progress reports	Battelle FS	Carolyn Scala	(215) 504-5003	Daily updates from Battelle FS to PM.
Field corrective actions	Battelle FS	Carolyn Scala	(215) 504-5003	Corrective action report for any activity requiring correction should be filled out and turned into the PM and Battelle QAO within 24 hours of noting activity in need of correction. Report will be reviewed, and if approved, forwarded to the RPM.
Field health and safety	Field SSHO	Jennifer Good	(508) 366-7422	Ensures that all activities performed follow the health and safety guidelines.
Sample collection	H&S Environmental	Jennifer Good	(508) 366-7422	Daily update to Battelle FS.
Sample receipt variances	Accutest Laboratories - Orlando	Andrea Colby	(386) 615-8479	Telephone call/e-mail on the day of sample receipt; chain of custody (COC) review from the Lab Representative to the PM.
Sample receipt variances	Accutest Laboratories – New Jersey	Matt Cordova	(732)329-0200	Telephone call/e-mail on the day of sample receipt; COC review from the Lab Representative to the PM.
SAP changes in the field Field corrective actions	Battelle PM	Andrew Barton	(412) 427-7030	A request detailing sampling locations and analytes will be sent via e-mail to the RPM. Concurrence of the changes will be obtained from the RPM and written approval of the changes will be obtained from the Navy QAO, prior to sampling activities.

SAP Worksheet #6 -- Communication Pathways (Continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or E-mail	Procedure (timing, pathway to & from, etc.)
Stop work due to safety issues	Battelle FS H&S Environmental Battelle QAO	Carolyn Scala Jennifer Good Betsy Cutié	(215) 504-5003 (508) 366-7422 (614) 424-4899	The Battelle FS can issue a stop work order via phone call or e-mail to the H&S PM for a situation that adversely affects integrity of the data or the safety of the staff. The H&S PM will notify the Battelle FS via phone call or e-mail when the stop work order is lifted.
Communication with NAVFAC QAO	Battelle QAO	Betsy Cutié	(614) 424-4899	E-mail to obtain written/formal approval of the planning documents (e.g., SAP) and communication via phone call and e-mail as necessary to discuss project issues. Any stop work orders will also be communicated to Navy QAO via phone calls and e-mail as necessary.
Reporting concerns involving laboratory	Battelle PM	Andrew Barton	(412) 427-7030	Battelle PM will provide bi-monthly updates of the status of sample analysis and any delays or problems to the RPM.
Notification of non-usable analytical data	Battelle PM	Andrew Barton	(412) 427-7030	If significant problems are identified by the laboratory or the project team that impact the usability of the data (i.e., the data are rejected or the DQOs are not met), the Battelle PM will notify the NAVFAC RPM and the Navy QAO within 24 hours or the next business day.
Data review and corrective action Regular communication with the analytical laboratories	Battelle QAO	Betsy Cutié	(614) 424-4899	Communication via phone calls and e-mail as necessary to discuss project status, any issues and to coordinate the validation of the analytical data.

SAP Worksheet #7 -- Personnel Responsibilities and Qualifications Table

(UFP-QAPP Manual Section 2.4.3)

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
Jeffrey Dale	Navy RPM	NAVFAC BRAC PMO East	• Project execution and coordination with Base representatives, regulatory agencies, and the NAVFAC BRAC PMO East management team • Final approval for conducting all field activities • Oversight of the overall task order • Execution of contracts • Approval of the release of reports	
Ken Bowers	Navy QAO	NAVFAC MIDLANT	• Provides government oversight of the QA program, including review and approval of SAPs, and all other QA/QC documents. The QAO has the authority to suspend affected projects or site activities if NAVFAC MIDLANT-approved quality requirements are not maintained. • Oversight of QA issues for entire program • Communication with Battelle QAO • Communication of issues to the Navy RPM	
Andrew Barton	Project Manager	Battelle	• Responsible for implementing all activities specified in the task order. Supervises preparation of the SAP by the Battelle team. Monitors field activities to ensure compliance with the SAP. • Assignment of personnel • Monitoring and control of cost, schedule, and QC • Compliance with regulations • Management of subcontractors • Liaison with Contracting Officer/Contracting Officer's Representative (CO/COR)	

SAP Worksheet #7 -- Personnel Responsibilities and Qualifications Table (Continued)

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
Carolyn Scala	Field Supervisor	Battelle	• Responsible for implementing all field activities in accordance with the SAP by the Battelle team • Monitors field activities to ensure compliance with the SAP • Manages on-site subcontractors	
Jennifer Good	SSHO	H&S Environmental	• Review of the project Site Safety and Health Plan (SSHP) • Ensuring that the field personnel have received appropriate health and safety training for project work • Monitor site health and safety according to the SSHP • Responsible for implementing the SSHP, determining appropriate site control measures, and identifying personal protection levels • Leads daily safety briefings for the Battelle Team, subcontractor personnel, and site visitors	
Betsy Cutié	QAO	Battelle	• Approval of SAP • Review of data • Coordination of data validation • Interaction with Navy QAO • Responsible for ensuring Battelle team's programmatic and project-specific compliance with QA policies and this SAP • Ensures SAP conforms to current NAVFAC MIDLANT and UFP-QAPP requirements • Ensures Battelle team maintains proper training, certification, and experience to execute project-specific tasks	

SAP Worksheet #7 -- Personnel Responsibilities and Qualifications Table (Continued)

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
Jennifer Good	Field Sampler	H&S Environmental	• Performance of all sampling in accordance with the approved SAP • Calibration and maintenance of field measurement equipment • Collection of samples	
Andrea Colby	PM and Point of Contact for Analytical Services	Accutest Laboratories - Orlando	• Sample preparation and analysis • Responsible for delivering analytical services that meet the requirements of this SAP • Works with the Battelle QAO to confirm sample delivery schedules • Reviews laboratory report deliverables	
Matt Cordova	PM and Point of Contact for Analytical Services	Accutest Laboratories – New Jersey	• Sample preparation and analysis • Responsible for delivering analytical services that meet the requirements of this SAP • Works with the Battelle QAO to confirm sample delivery schedules • Reviews laboratory report deliverables	
Pei Geng	PM and Point of Contact for Third-Party Data Validation Services	Laboratory Data Consultants	• Conducts independent third-party validation of analytical data received from laboratory • Ensures the data end user of known and documented data quality	

SAP Worksheet #8 -- Special Personnel Training Requirements Table

(UFP-QAPP Manual Section 2.4.4)

Project Function	Specialized Training By Title or Description of Course	Training Provider	Training Date	Personnel / Groups Receiving Training	Personnel Titles / Organizational Affiliation	Location of Training Records / Certificates

Worksheet #8 is not applicable to this project. There are no special training requirements.

SAP Worksheet #9 -- Project Scoping Session Participants Sheet
(UFP-QAPP Manual Section 2.5.1)

Project Name: PFC Sampling Projected Date(s) of Sampling: April 2015 Project Manager: Andrew Barton	Site Name: Former NAWC Warminster Site Location: Warminster, Pennsylvania

Date of Sessions: 05/14/2014 and 05/15/2014
Scoping Session Purpose: Discuss project scope, schedule, and DQOs

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Andrew Barton	PM	Battelle	(412) 427-7030	bartona@battelle.org	PM
Jeffrey Dale	RPM	NAVFAC BRAC PMO East	(215) 897-4914	jeffrey.m.dale@navy.mil	RPM
Russell Sirabian	Program Manager	Battelle	(914) 682-2179	sirabianr@battelle.org	Program Manager
Rosanna Buhl	QAO	Battelle	(781) 952-5309	buhlr@battelle.org	QA Officer
Carolyn Scala	Senior Research Scientist	Battelle	(215) 504-5003	scalac@battelle.org	FS
David Barclift	NA	NAVFAC LANT	(215) 897-4913	david.barclift@navy.mil	Stakeholder
Tavi Machini	Intern	PADEP	(267) 446-0163	omichini@pa.gov	Stakeholder
Margaret Pollich	NA	PADEP	(484) 250-5731	mpollich@pa.gov	Regulator
Kathy Davies	NA	EPA Region 3	(215) 814-3315	davies.kathy@epa.gov	Regulator
Sarah Kloss	NA	EPA Region 3	(215) 814-3379	kloss.sarah@epa.gov	Regulator
Willie Lin	NA	NAVFAC BRAC PMO East	(215) 897-4904	Willie.lin@navy.mil	Stakeholder
Jennifer Good	NA	H&S Environmental, Inc.	(508) 366-7442	jgood@hsenv.com	Stakeholder
Tim Cherry	NA	PADEP	(484) 250-5728	tcherry@pa.gov	Regulator

Comments/Decisions:

- PFC sampling procedures are very detailed and the potential for cross contamination is significant; detailed procedures are available and must be considered during sampling
- DQOs developed, including goals of the study and project boundaries
- Project schedule discussed
- Sub-slab sampling recommended for VI evaluation

Action Items:

- Obtain PFC sampling procedures from laboratory and Navy
- Evaluate VI guidance documents for sub-slab sampling procedures

Consensus Decisions:

- None

SAP Worksheet #10 -- Problem Definition
(UFP-QAPP Manual Section 2.5.2)

Introduction

The former NAWC Warminster is an 824-acre facility located in Warminster Township, Northampton Township, and Ivyland Borough, Bucks County, PA. As a result of the BRAC Act, NAWC Warminster ceased operations on September 30, 1996; the majority of the property has since been transferred to the private sector and redeveloped. Historic waste disposal locations were grouped within three general areas on the former NAWC property (see Figure 1): Area A (Sites 1, 2, and 3), Area B (Sites 5, 6, and 7), and Area C (Sites 4 and 8). A fourth general area (Area D) primarily includes the former main building complex at the former NAWC Warminster. CVOC plumes exist in groundwater as a result of historical operations at the site. RODs were signed for four groundwater OUs: OU-1A (Area A), OU-1B, (Area B), OU-3 (Area C), and OU-4 (Area D). The OU-1A, OU-3, and OU-4 RODs include a component of groundwater extraction and treatment to maintain hydraulic control of source area groundwater in the vicinity of the extraction wells. Treatment of the CVOCs is performed at a combined treatment system within Area A, which consists of air stripping and liquid phase granular activated carbon (LGAC). The OU-1B ROD recommended no further action. Each area is discussed in more detail below.

Area A. Area A is comprised of three sites, Sites 1, 2, and 3, and lies within the northwest corner of the former Base, west of Jacksonville Road (Figure 1). Site 1 was historically operated as a burn pit, Site 2 consisted of two disposal trenches that received industrial wastewater sludges from the surface impoundments, and Site 3 also was reportedly used as a burn pit for solvents, paints, roofing materials, and other unspecified chemicals. Eight unlined lagoons used for storage of wastewater treatment plant sludges were formerly operated in the northern corner of Area A. A TI evaluation performed in 2000 estimated that approximately 75 to 374 gallons of trichloroethene (TCE) was potentially present as DNAPL in Area A. As a result of the evaluation, an 85-ft diameter TI zone was established in Area A focused around extraction wells EW-A6, EW-A7, EW-A9, and EW-A10.

Historical investigations at Area A have shown that clayey residual soils overlie highly weathered bedrock that is located approximately 8 to 10 ft below ground surface (bgs). The weathered bedrock gradually transitions into competent bedrock of the Stockton Formation, which consists of alternating lithologic units of predominantly fine-grained sandstone siltstone/mudstone. Within Area A, bedrock strikes to the northeast and dips to the northwest. Area A has been divided into hydrogeologic units A, B, and C, representing sequential units with depth. Each hydrogeologic unit consists of one or more laterally extensive sandstone beds and adjacent mudstone units, which, based on hydrogeologic and water quality data, form an interconnected, discrete groundwater flow system. Hydrogeologic unit B is of most importance in terms of groundwater contaminant occurrence and migration from Area A, and is generally found at depths of 15 to 100 ft bgs. Groundwater flow in Area A is generally toward the north (Figures 2 through 4) and has been significantly affected by operation of the groundwater extraction system. An evaluation performed during Area A extraction and observation well installation identified fractures in the bedrock to depths of 86 ft bgs, with the majority of the fractures found in clusters between the depths of 22 to 30 ft bgs and 60 to 72 ft bgs. Recent well profiling activities in select Area A wells in the vicinity of the TI waiver zone area (Battelle, 2013) identified water-bearing fracture zones in the lower portion of hydrogeologic unit B, where an upward vertical flow component was observed in several profiled wells (EW-A6, EW-A9, and EW-A10). In addition, little to no vertical flow was measured in the central and upper portions of hydrogeologic unit B in the TI waiver zone during this investigation. Surface water at Area A drains northward to an unnamed tributary of Little Neshaminy Creek (see Figure 5).

Area B. Area B is located in the southeastern portion of the former NAWC Warminster (Figure 1), and was defined as encompassing Sites 5, 6, and 7 and adjacent areas where wastes were historically

disposed. Site 5 reportedly consisted of up to eight trenches that were used for the disposal of demolition wastes, paints, solvents, scrap metal, aircraft paints, cans and asphalt, and were operated from 1955 to 1970 (NFEC, 2000). Sites 6 and 7 reportedly consisted of several pits that were used for disposal of waste paints, solvents, oil, flammable wastes, grease trap waste, and demolition debris, and were in use from 1960 to 1980 (Tetra Tech NUS, 1998a). A former Navy housing area (Shenandoah Woods) currently occupies the location of Site 5, whereas Sites 6 and 7 are within an area of open space consisting of grass and woods (see Figure 1). The OU-1B ROD identified no further action.

Historical investigations at Area B have shown that residual soils (silt and clay with minor amounts of sand) overlie highly weathered bedrock that is located approximately 10 ft bgs. The weathered bedrock gradually transitions into competent bedrock of the Stockton Formation, as discussed above. Bedrock fractures were encountered at varying depths within Area B boreholes, with fractures in the sandstones typically yielding greater quantities of water (TetraTech NUS, 1998a). Groundwater at Area B flows toward the south (see Figures 2 through 4), consistent with surface topography. Surface runoff from Area B drains southward to an unnamed tributary to Southampton Creek (see Figure 5).

Area C. Area C is located along Kirk Road and Newtown Road in the north-central portion of the former NAWC Warminster (Figure 1), and was defined as Sites 4 and 8 and nearby locations where hazardous substance releases may have resulted in groundwater contamination. Site 4 was a 7-acre area located north of the former main runway and south of Kirk Road. Several trenches were reportedly operated from 1966 to 1973 to dispose of non-industrial solid waste, paints, waste oils, waste metals, construction debris, solvents, and sewage sludge from the sewage treatment plant. Other property in the vicinity of Site 4 is currently an open-space recreational park for Warminster Township. Site 8 was located at the northeastern end of the former runway and was used as a fire-training area from 1961 to 1988. In addition, an area of the runway immediately south of the fire-training area, a structure (S-1) was used to test the resistance of aviation suits to fire. The source of CVOCs within Area C was never definitively identified (Tetra Tech NUS, Inc., 2007). A portion of Area C west of Site 8 has been transferred and redeveloped for residential use (i.e., part of Ann's Choice Retirement Community and other residential development).

Historical investigations at Area C have shown that residual soils (mixtures of silt, clay, and sand) overlie highly weathered bedrock that is located approximately 5 to 15 ft bgs. The weathered bedrock gradually transitions into competent bedrock of the Stockton Formation, as described above. A geophysical investigation designed to provide information about water-bearing fractures within the bedrock beneath the site (U.S. Geological Survey [USGS], 2008) concluded that the majority of bedrock fractures at Area C were identified between the depths of 21 to 40 ft, with fractures becoming sparser with depth. Area C has been divided into shallow and deep hydrogeologic units. The shallow unit is comprised of sandstone and is the primary unit in which CVOC concentrations are observed. The deep hydrogeologic unit is defined as water-bearing bedrock beneath the shallow hydrogeologic unit, and typically exhibits artesian conditions. Shallow groundwater flow across Area C is to the north (see Figures 2 through 4) in the general direction of the slope of ground surface topography and has been affected by operation of the groundwater extraction system. Recent well profiling activities in select Area C wells (Battelle, 2013) identified a predominant upward vertical groundwater flow component in several wells and water-bearing fractures at depths ranging from 10 to 85 ft bgs. Surface drainage from Area C also is toward the north, toward an unnamed tributary of Little Neshaminy Creek (see Figure 5).

Area D. Area D primarily includes the former main building complex at the former NAWC Warminster, and lies within the northwest corner of the former Base, just north of the intersection of Jacksonville Road and Street Road (Figure 1). The two main buildings in Area D housed several laboratories and shops that supported research and development activities, including a metal plating laboratory (EA, 1995). Other historic operations in these buildings include an elastomer compounding and testing laboratory, electrical

laboratories, and operational and chemical polymer research laboratory, and a photography laboratory (Tetra Tech NUS, 1998b), and both buildings also had chemical and waste storage areas. Geologic and hydrogeologic conditions at Area D are similar to those at Area A, with the exception of a more westerly component of groundwater flow (see Figures 2 through 4). Surface drainage from Area D is toward the north and west toward unnamed tributaries of Little Neshaminy Creek and to a lesser degree Upper Pennypack Creek (see Figure 5).

Problem Definition

The two primary problems to be addressed at the former NAWC Warminster are as follows: (1) PFC contamination has been identified and needs to be evaluated via an RI, and (2) VI in several structures in the vicinity of the dissolved CVOC plume at Area C may be a risk to human health and needs to be evaluated. The following text further presents these problems.

PFC Remedial Investigation. PFCs are man-made compounds potentially used in a wide range of products related to historical activities at the former NAWC Warminster (e.g., metal plating, fire-resistant materials testing, and firefighting operations). PFCs break down very slowly in the environment, and are an emerging class of persistent environmental contaminants. PFCs are used to make a wide range of products including oil-, stain-, heat-, and water-resistant materials such as clothing, carpeting, furniture, food packaging, floors, non-stick cookware, stain/water resistant paint, and roofing materials. They are also used or were used as surfactants in metal plating baths, shampoos, moisturizers, shaving cream, oil well surfactants, aqueous film forming foam (AFFF), and semiconductor baths. Additional applications of PFCs include use in rust inhibitors, starting materials for polymers, herbicides/pesticides, acid mist suppressants, aviation hydraulic fluids, and adhesives. PFCs exist or were formerly present in 3M's Scotchgard™, GORE-TEX®, Stainmaster® and DuPont's Teflon® products. They also are found in solvents in products such as electronic etching baths and photographic film (Tetra Tech, 2014).

The six PFCs being investigated at the former NAWC Warminster are PFOA, PFOS, perfluorononanoic acid (PFNA), perfluorohexanesulfonic acid (PFHxS), perfluoroheptanoic acid (PFHpA) and perfluorobutanesulfonic acid (PFBS), in accordance with Department of Defense (DoD) Instruction 4715.18 regarding emerging contaminants and consistent with the six PFCs water authorities are required to monitor under the Unregulated Contaminant Monitoring Rule, Part 3 (DoD, 2011; internal Navy correspondence). Chemical concentration data for these six PFCs also will be used to support potential future remedial system design. PFOA and PFOS began to be produced by 3M in the late 1940s. It is not documented whether PFCs were specifically used at the former NAWC Warminster, but operations or activities commonly associated with PFCs did take place on site, such as metal plating, fire-resistant material testing, and firefighting. The products used in these activities included industrial paints, aircraft paints, metal plating materials, stain/surface protectors, and AFFF (commonly used to suppress jet fuel fires). In 2009, the EPA Office of Water developed PHA values for PFOA and PFOS to protect against potential risk from exposure to these chemicals through drinking water. The EPA PHA values are 0.4 µg/L for PFOA and 0.2 µg/L for PFOS. PHA values are not to be construed as legally enforceable federal standards and are subject to change as new information becomes available. There are no current PHA values for PFOS and PFOA in surface water, sediment, or soil, nor are there currently PHA values for the remaining four PFCs in any medium evaluated during this study.

PFOA and PFOS were detected in groundwater samples collected from initial PFC sampling from on- and off-site wells in the vicinity of Area C between 2011 and 2013 during the five year review (Tetra Tech, 2011) and as part of a research project led by Oregon State University. Maximum detected concentrations within Area C were 2.2 µg/L for PFOA (well EW-C19) and 1.7 µg/L for PFOS (well DG-14). These detections are above the respective PHA values, and the wells are located in the vicinity of Site 8 (Figure 6), in a general upgradient direction from WMA-13.

Based on the 2011 through 2013 results collected during the five-year review and research project, the Navy proposed that extraction wells EW-C16 and EW-C17 be activated to provide containment of groundwater near the former fire training area to protect well WMA-13 (Tetra Tech, 2013). Based on discussion during and following the 2013 Technical Review Committee meeting, the Navy agreed to sample nine wells prior to activation of the extraction wells to collect baseline data prior to conducting the RI. The two extraction wells were activated on January 13, 2014, after the baseline data were collected at Area C between January 6 and 9, 2014. Baseline data were subsequently collected at Areas A and D on May 21, 2014.

Figure 6 shows the most recent PFC contamination at Area C as detected during the preliminary investigation in January 2014, including recent detections in WMA-13 collected during Unregulated Contaminant Monitoring Rule 3 (UCMR 3) monitoring performed by WMA. Groundwater samples from six monitoring wells and two extraction wells in Area C and one from WMA-13 were collected as part of the preliminary investigation. All of the groundwater samples were analyzed for PFOA and PFOS. The highest concentrations of PFOA were observed in OB-11 (2.6 µg /L), OB-13 (2 µg /L), and EW-C16 (1.8 µg /L). The highest concentrations of PFOS were observed in OB-11 (16 J µg /L), OB-13 (6.5 µg /L), and EW-C16 (3.2 µg /L). The concentrations initially detected at WMA-13 for PFOA and PFOS were 0.093 µg /L and 0.21 µg /L, respectively (see Figure 6). Each of the eight sampled wells (EW-C16, EW-C17, HN-24S, HN-25S, HN-25I, OB-11, OB-13, and R-9) exceeded the PHA values for PFOA and PFOS. PFOS concentrations at WMA-13 (0.21 µg/L) exceeded the PHA value of 0.2 µg/L. Recent UCMR 3 monitoring in WMA-13 in June 2014 showed that PFOA (0.0796 µg/L) and PFOS (0.138 µg/L) concentrations were below their respective PHA values. It should be noted that this recently identified PFC contamination near Area C is distinct from the CVOC plume previously identified and documented at Area C.

Figure 7 shows the most recent PFC contamination at Areas A and D as detected during the May 2014 investigation, including recent detections in WMA-26 collected during UCMR 3 monitoring performed by WMA. Groundwater samples were collected from 15 Area A extraction wells and eight Area D extraction wells and analyzed for PFOA and PFOS. In Area A, the highest concentrations of PFOA and PFOS were observed in EW-A5 (0.381 µg /L) and EW-A9 (0.707 µg /L), respectively. No Area A wells exceeded the PHA value for PFOA, whereas 13 of the 15 wells exceeded the PHA value for PFOS. In Area D, the highest concentrations of PFOA and PFOS were observed in EW-D4 (1.56 µg /L PFOA and 2.22 µg /L of PFOS). Seven of the eight Area D wells exceeded PHA values for PFOA and PFOA, the exception being EW-D8, where PFOA and PFOA were detected below the reporting level. Recent UCMR 3 monitoring in WMA-26 in June 2014 showed a PFOA (0.349 µg/L) concentration slightly below the PHA value, and a PFOS (1.09 µg/L) concentration significantly above the PHA value of 0.2 µg/L. Although not shown on Figure 7, UCMR 3 monitoring in WMA-10 in June 2014 showed that PFOA (0.0822 µg/L) and PFOS (0.193 µg/L) concentrations were below their respective PHA values. It should be noted that this recently identified PFC contamination near Areas A and D is distinct from the CVOC plumes previously identified and documented at the site.

As a result of these detections, the Navy initiated a preliminary assessment of potential sources of PFCs at NAWC Warminster (Tetra Tech, 2014). Sites with potential PFC use at the former NAWC Warminster are shown on Figure 8 and are summarized as follows:

- ***Area A***. Wastes reportedly disposed of at Site 1 included inorganics, solvents, acids, bases, and firing range wastes (Tetra Tech, 2011). Site 3 was reportedly used as a burn pit for solvents, paints, roofing materials, and other specified chemicals (Haliburton NUS, 1993). PFCs potentially present in Site 1 and Site 3 historical wastes could be responsible for PFC detections in downgradient supply wells WMA-10 and WMA-26. An impoundment area located on the western side of Area A consisted of eight lagoons that held industrial wastewater sludge. PFCs

potentially could have originated from the liquids generated from the metal treatment baths from metal plating activities (Tetra Tech, 2011) and potentially migrated to WMA-10 and WMA-26.

- ***Area B.*** PFCs may have been present in paints and aircraft paints that were disposed of at Area B Sites 5, 6, and 7. Any PFCs at Area B would have migrated in a southerly direction, consistent with surface drainage and groundwater flow.
- ***Area C***. Area C Site 4 and/or Site 8 (including structure S-1) were the most likely sources of PFCs to WMA-13 due to their historical uses and position in a general upgradient direction from WMA-13. Site 4, the largest waste disposal location at NAWC Warminster, is located directly upgradient of WMA-13. A removal action consisting of excavation and off-site disposal at Site 4 was conducted in 1996. However, the site has not been discounted as a potential source at this time as PFCs were not sampled for in past groundwater monitoring of the site. Firefighting foam containing PFCs (AFFF products) was used at firefighting training activities that occurred at Site 8. Building 134, which is upgradient of Area C Site 8 (see Figure 8), served as the former fire station. A "water surfactant", possibly AFFF, was reportedly used in the building. Building 134 is still standing and serves as the Bucks County Emergency Response Facility. It is possible that spills in the vicinity of Building 134 may have led to a release of PFC-containing AFFF (Tetra Tech, 2014).
- ***Area D***. As discussed above, Buildings 1 and 2 housed several laboratories and shops that supported research and development activities and both buildings also had chemical and waste storage areas. PFC detections in WMA-10 and WMA-26 could be related to potential historic releases associated with activities at these buildings.
- ***Other Locations***. Building 90, which is located just east and upgradient of Area D, served as the former Crash House/Lab and was reportedly used for emergency response. Building 90 was reportedly used for storage of paints, lubricants, and degreasers (EA, 1995), and it is expected that some fire control equipment may have also be stored for a period of time. PFCs potentially released from Building 90 could serve as a source of PFCs to Areas A and D, and downgradient municipal supply wells. A 1973 plane crash in the northeastern portion of the site is a possible but unlikely source of PFCs at Areas A, B, C, or D, as it is cross gradient to the groundwater flow direction and is outside the projected capture zone for downgradient supply wells. Reportedly, the explosion that occurred after the plane crash consumed all of the fuel and there was no fire to extinguish; however, the use of AFFF as a precautionary measure cannot be ruled out (Tom Ames, personal communication, 2015). A historic drainage feature near the northeastern edge of the runway may have collected surface water and any excess AFFF discharged to the runway in this area (Tom Ames, personal communication, 2015). The discharge line from the former NAWC Warminster wastewater treatment plant serves as the discharge line for the currently operational groundwater extraction and treatment system (GWETS). If this line is compromised and leaking, it could potentially have resulted in releases of PFCs to shallow groundwater near the line, potentially impacting WMA-10 and WMA-26, and private wells. In addition, the outfall at the terminal end of the discharge line from the current Area A, C, and D GWETS may have historically served as a source of PFCs to the unnamed tributary of Little Neshaminy Creek (see Figure 5).

Also in response to the on-site PFC detections and the subsequent identification of potential on-site PFC sources, EPA issued an Administrative Order (AO) mandating the Navy perform private well sampling in the vicinity of the site. A total of 110 private wells were identified and prioritized into different zones based on proximity to potential on-site PFC sources. These wells were subsequently sampled by EPA through an IA with the Navy. Figure 9 shows the location and results of the private well sampling conducted by EPA within Zones 1 through 3, and shows PFOS or PFOA either met or exceeded the PHA value in 12 of 110 wells.

An RI will be performed to further identify the potential sources and the nature and extent of PFCs at Areas A, B, C, and D at the former NAWC Warminster.

VI Evaluation. During the well profiling evaluation at Area C (Battelle, 2013), historical site characterization data and groundwater well profiling were used to evaluate the potential for VI into structures that are adjacent to the Area C dissolved CVOC groundwater plume. Of primary concern was the building associated with Gilda's Club, which is located in between EW-C20 and EW-C21, roughly 50 ft from each well (see Figure 10). Historical investigations at Area C have shown that residual soils (identified as a silty loam) overlie highly weathered bedrock that is encountered at approximately 5 to 10 ft bgs in the vicinity of EW-C20 and EW-C21. To better evaluate shallow groundwater chemical concentrations in these wells, shallow groundwater samples were collected under non-pumping conditions using passive diffusion bag (PDB) samplers. All shallow (8.4 to 19 ft bgs) well profiling tetrachloroethene (PCE) concentrations were either non-detect or estimated below 1 µg/L. The maximum PCE concentration observed at any depth in the well profiling at EW-C20 and EW-C21 was 1.6 µg/L, which is below the maximum contaminant level (MCL) of 5 µg/L. The PCE concentrations in EW-C20 measured during the November 2013 and May 2014 long-term monitoring (LTM) events were 3.9 and 7.0 (estimated value) µg/L, respectively (the pump in EW-C20 is set at a depth of 46 ft bgs, which is significantly deeper than the shallow well profiling depths). The PCE concentrations in EW-C21 measured during the November 2013 and May 2014 LTM events were both below 1 µg/L. Borehole flow measurements made during the well profiling study indicated no vertical flow in EW-C20, and a slight downward flow component at the shallowest measurement point in EW-C21, below which no vertical flow was identified.

The potential for VI into a structure adjacent to EW-C20 and EW-C21 was subsequently evaluated by applying risk-based screening values for PCE in groundwater for comparison against existing groundwater concentrations of PCE at Area C. Two sets of generic risk-based screening values were estimated, one using the EPA Vapor Intrusion Screening Level (VISL) calculator and a second from the New Jersey Department of Environmental Protection (NJDEP). A third risk-based screening value was developed based on site-specific information using the EPA Johnson & Ettinger (J&E) model for groundwater. Current shallow PCE groundwater concentrations in monitoring wells and historical PCE concentrations in nearby private wells are below the screening values.

As a follow-up action to the Area C five-year review, the Navy is proposing to collect vapor samples (sub-slab, indoor air, and outside ambient background) for analysis of Area C target CVOCs unrelated to the aforementioned PFC contamination. The indoor air, sub-slab and ambient background samples will be collected from Gilda's Club and an associated outbuilding roughly 100 ft to the southwest of Gilda's Club (see Figure 10). The sample results will be used along with the well profiling and LTM results to perform a comprehensive VI evaluation to evaluate human health risk in these structures.

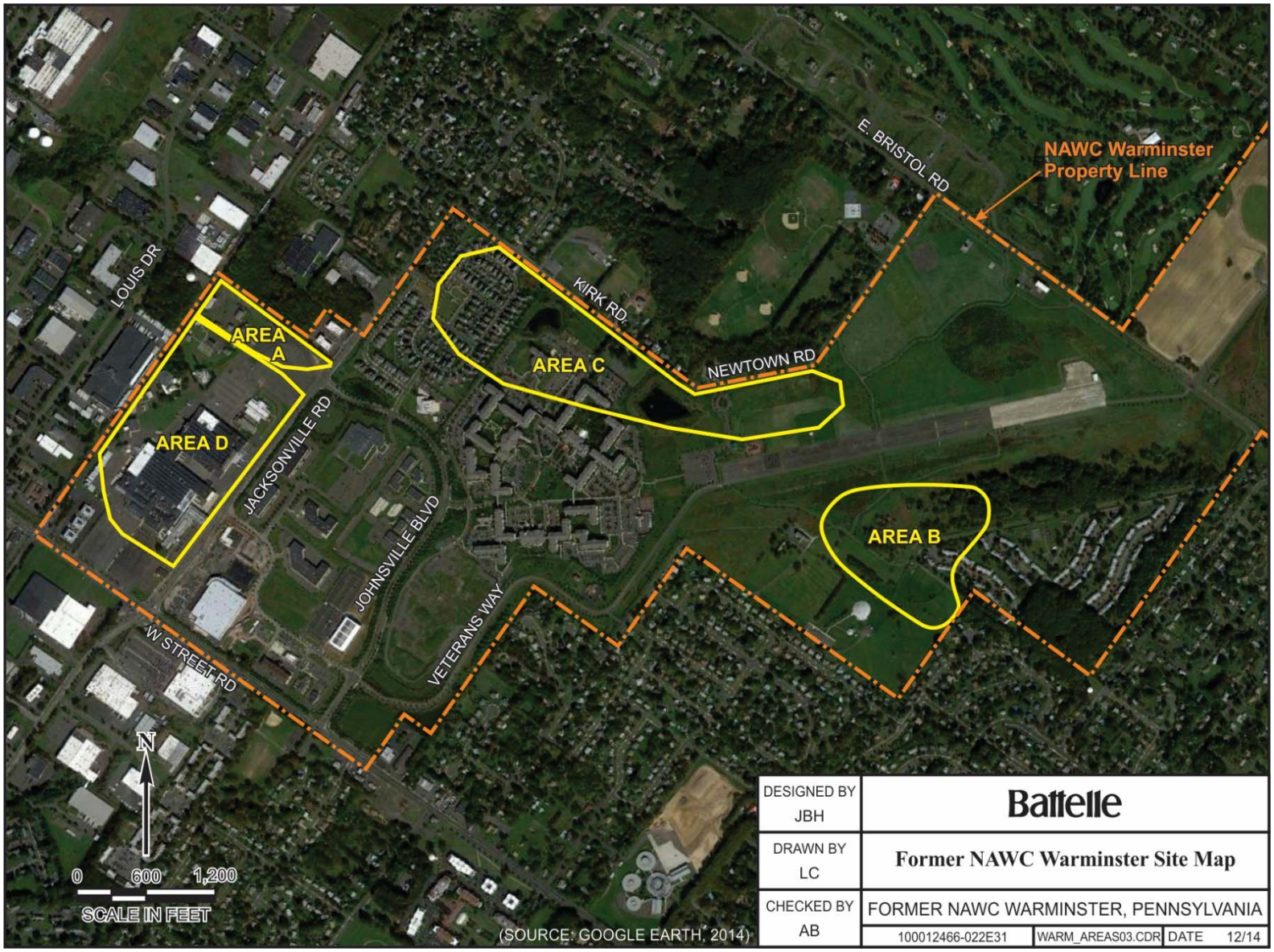


Figure 1. NAWC Warminster Site Map

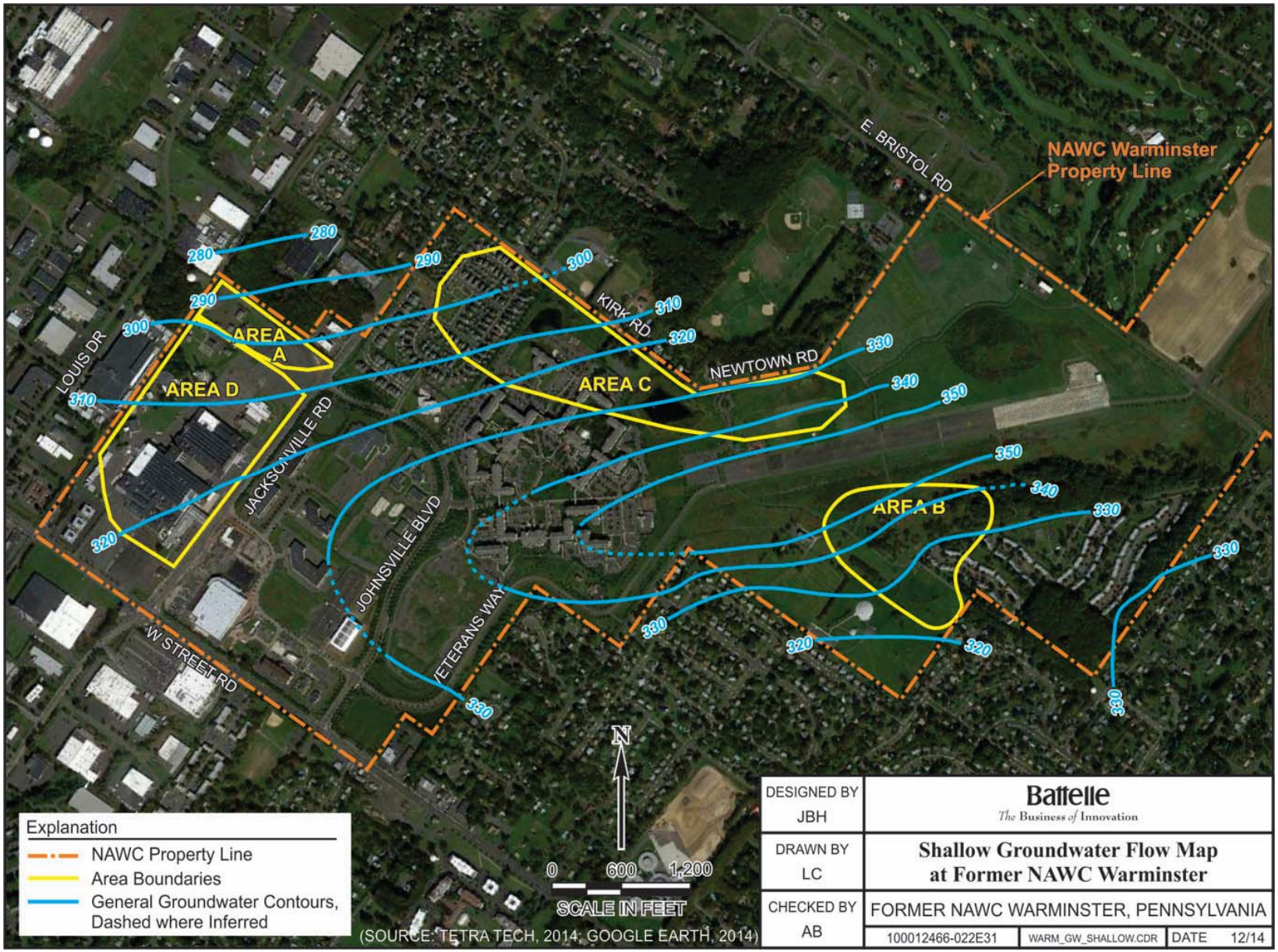


Figure 2. General Shallow Groundwater Flow Map at the Former NAWC Warminster

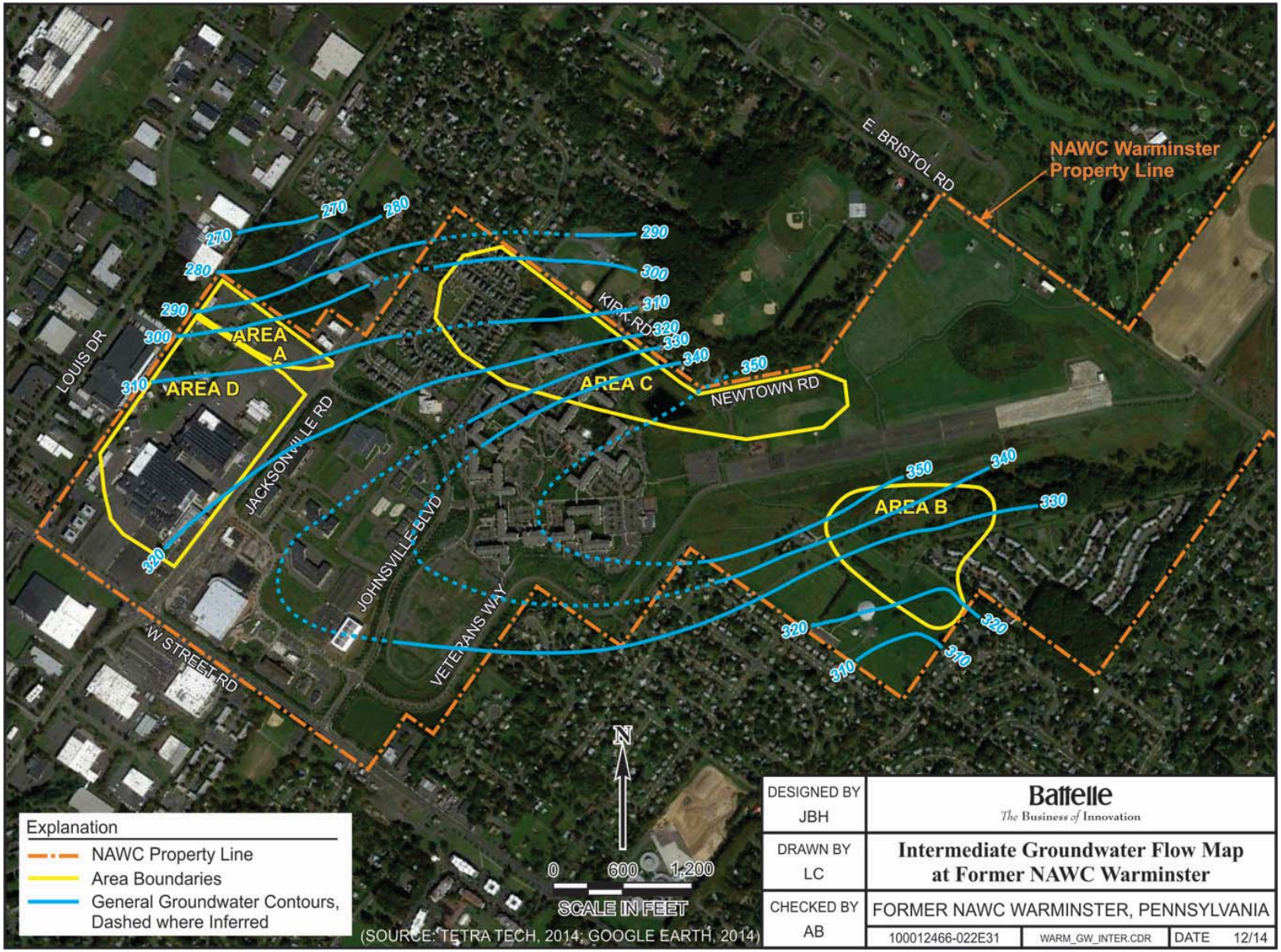


Figure 3. General Intermediate Groundwater Flow Map at the Former NAWC Warminster

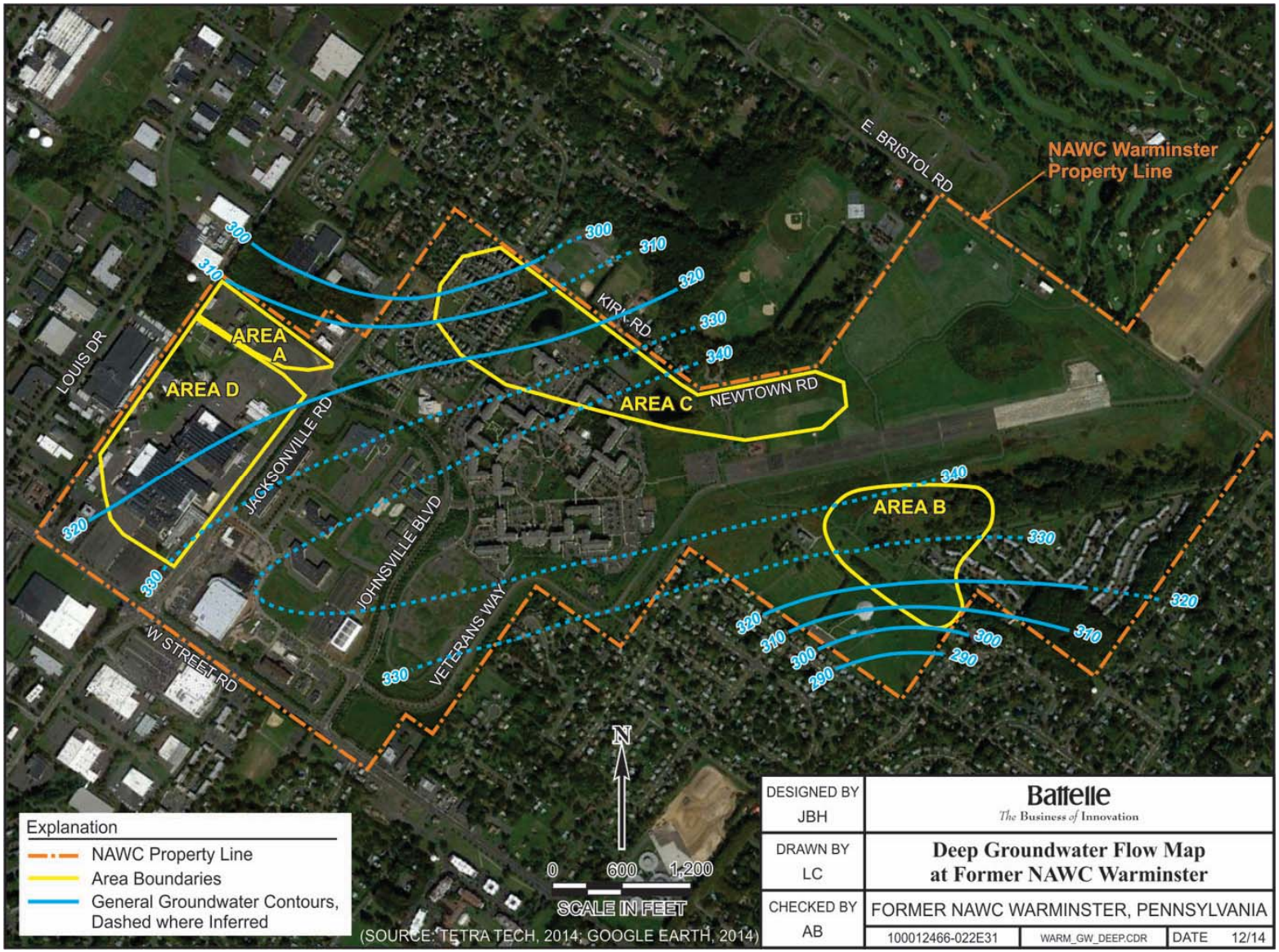


Figure 4. General Deep Groundwater Flow Map at the Former NAWC Warminster

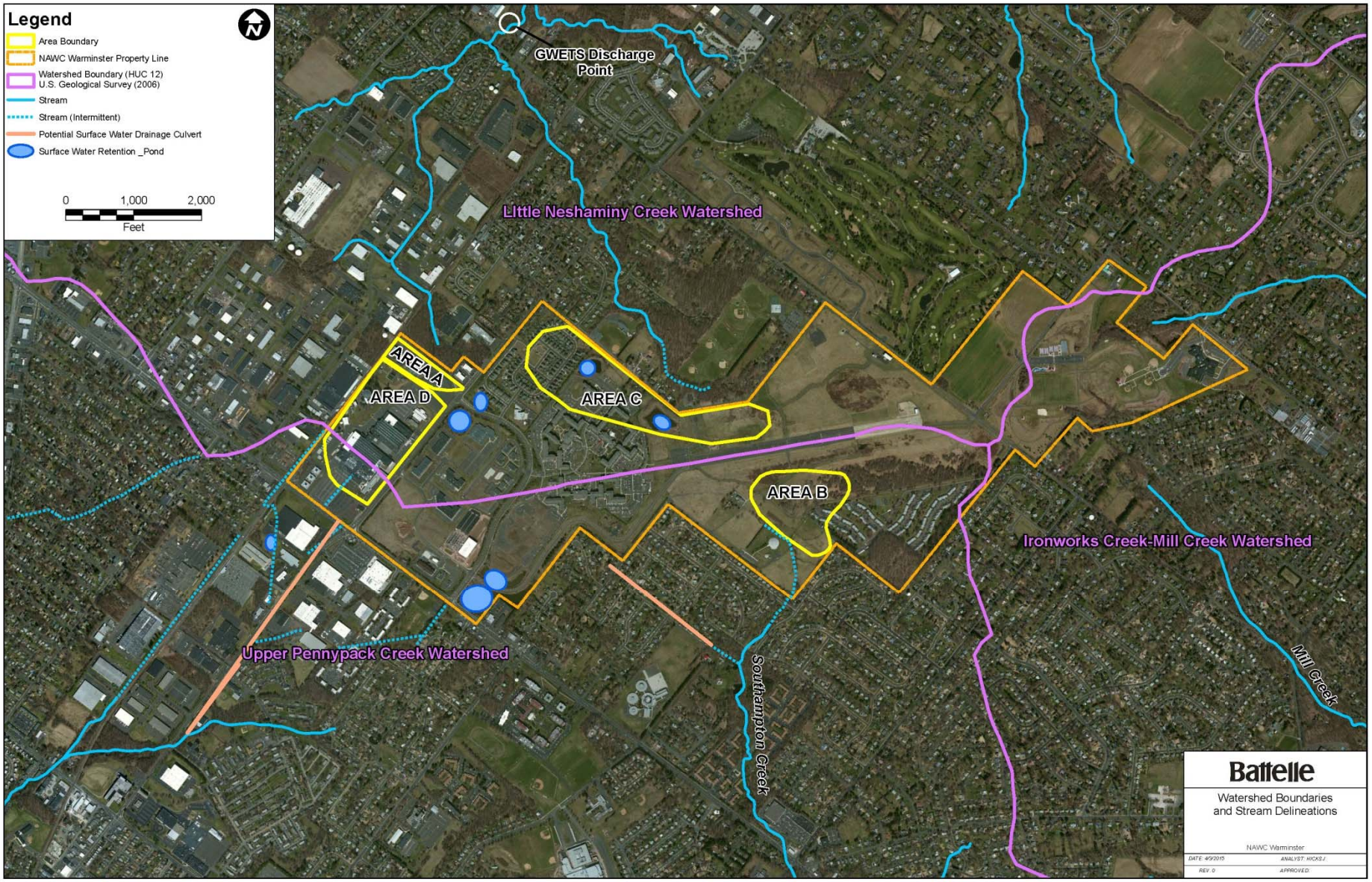


Figure 5. Watershed Boundaries and Surface Water Features at the Former NAWC Warminster

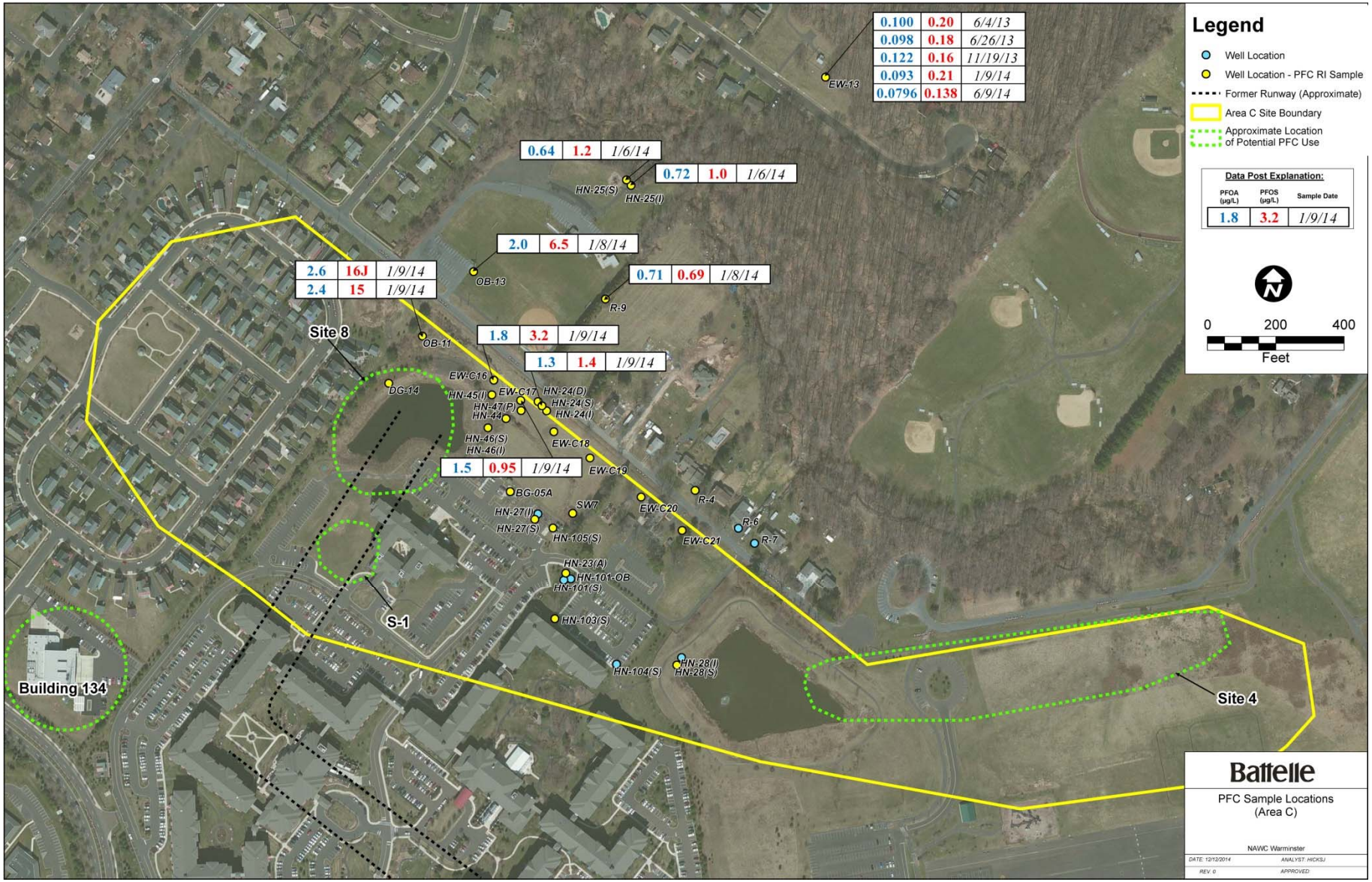


Figure 6. PFC Detections at Area C, Former NAWC Warminster

Figure 7. PFC Detections at Areas A and D, Former NAWC Warminster

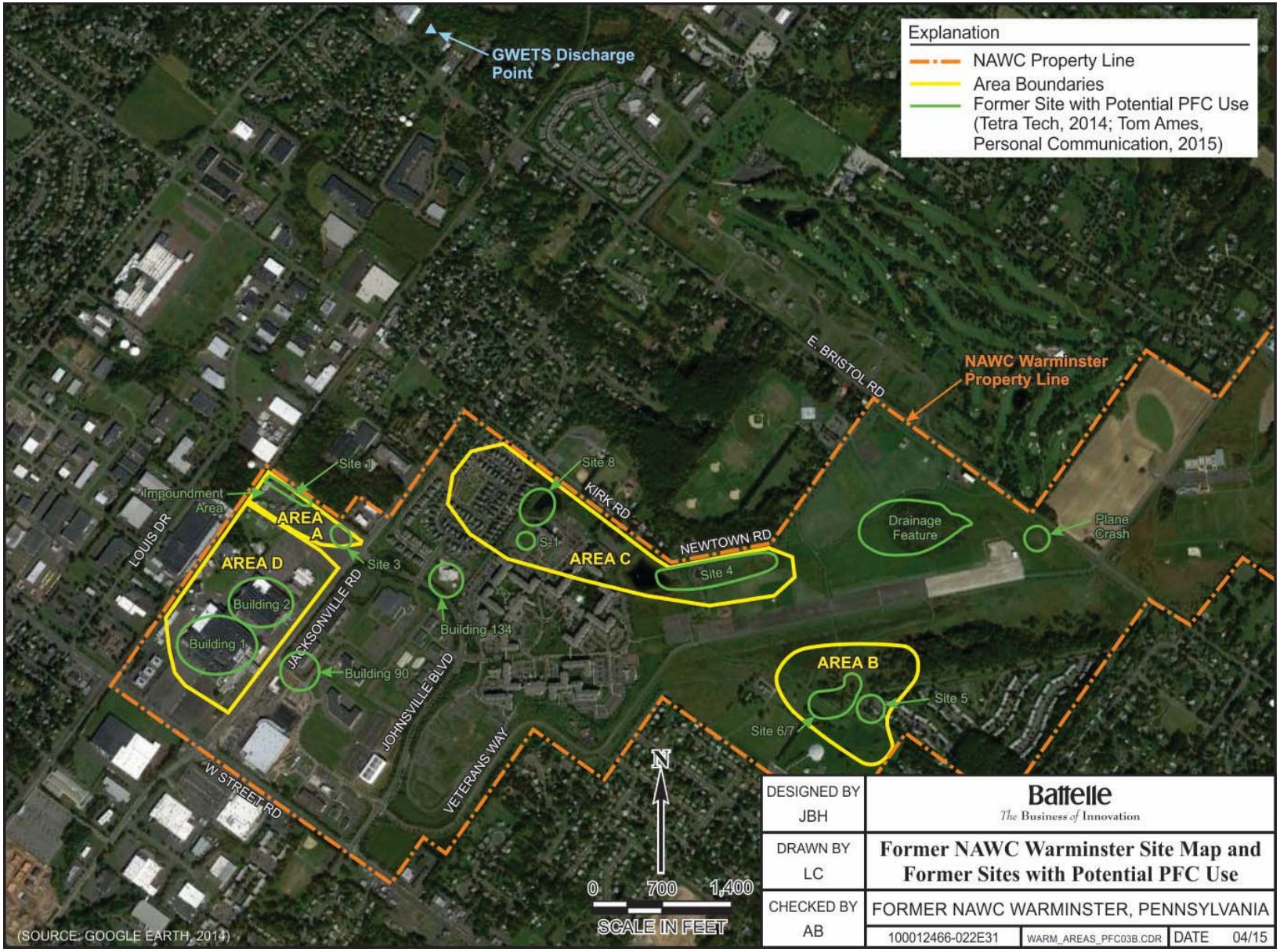


Figure 8. Former Sites with Potential PFC Use at the Former NAWC Warminster

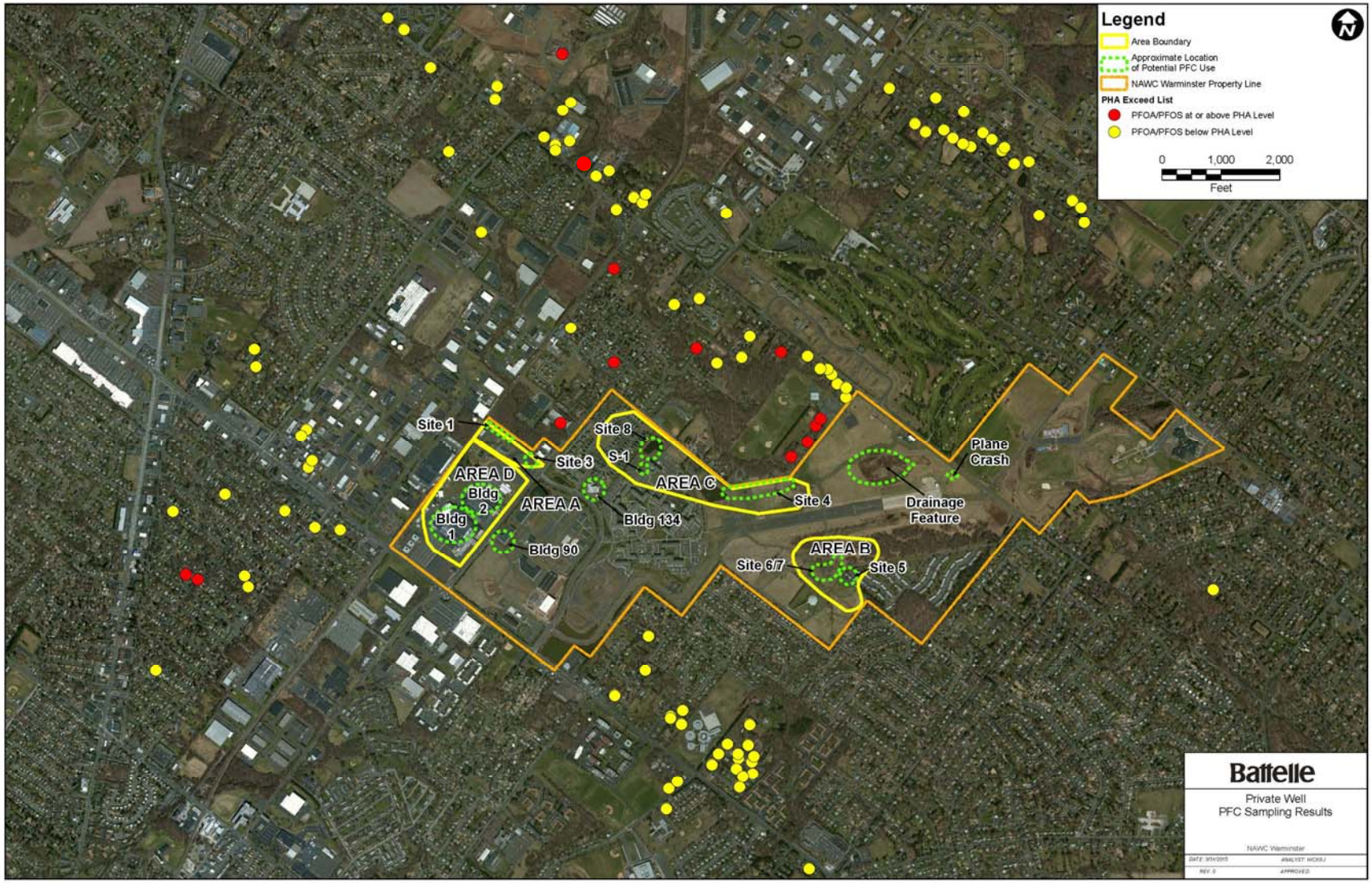


Figure 9. Private Water Well Sampling Locations and Results

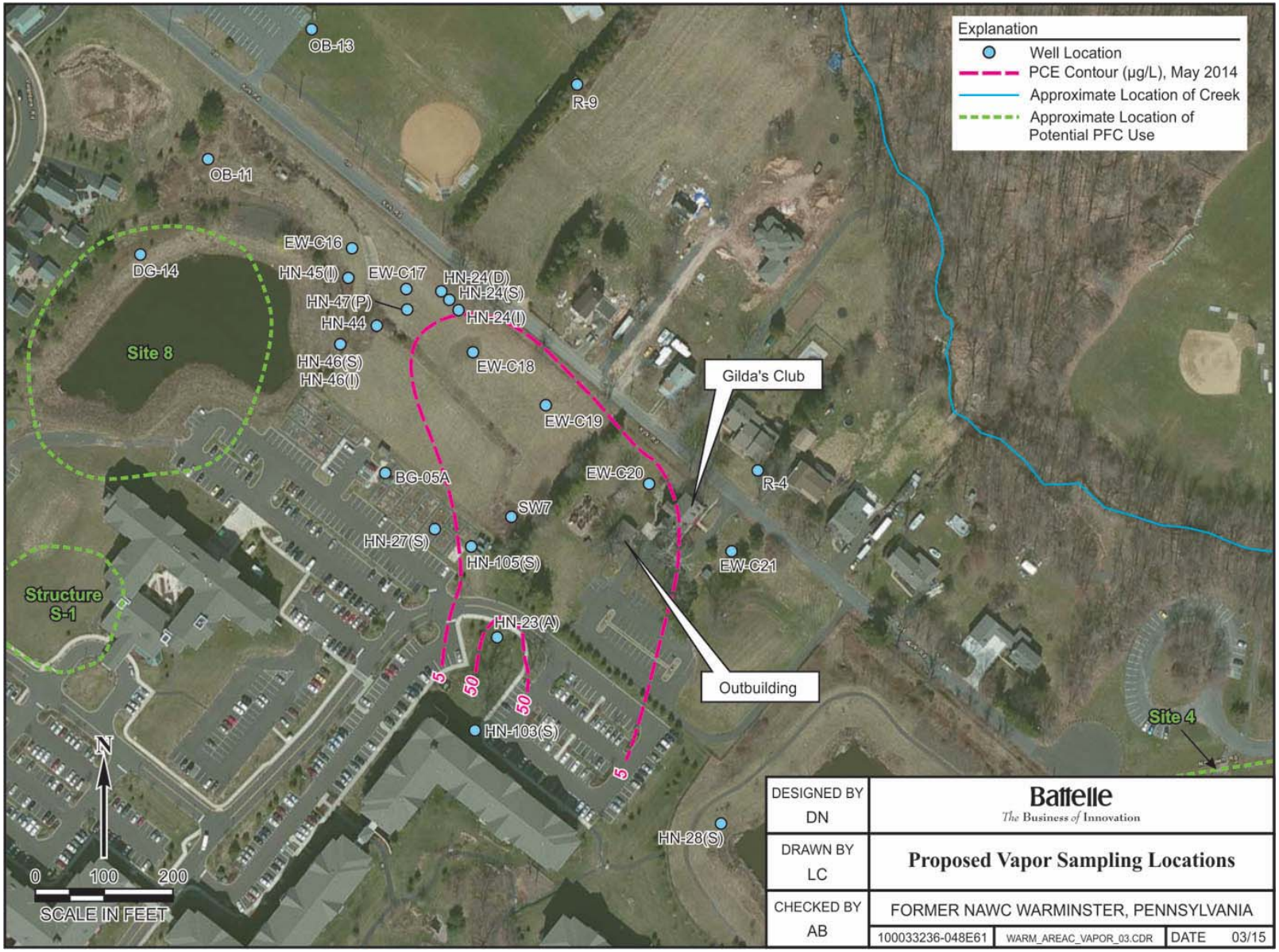


Figure 10. Former NAWC Warminster Area C Site Map Showing Location of PCE Plume and VI Sampling Locations

SAP Worksheet #11 -- Project Quality Objectives/Systematic Planning Process Statements (UFP-QAPP Manual Section 2.6.1)

1. STATE THE PROBLEM

Problem 1. PFOA and PFOS have been detected at concentrations at or above the EPA PHA values in monitoring wells in Areas A and D and in downgradient production wells WMA-10 and WMA-26 (see Figure 7), in Area C monitoring wells and in downgradient production well WMA-13 (see Figure 6), and in private groundwater wells.

The PFC source(s), direction and extent of the plume must be characterized through groundwater sampling at new and existing monitoring and extraction wells, soil sampling at new monitoring well locations, and surface water and sediment sampling near Areas A, B, C, and D at the former NAWC Warminster. Potential exposure routes must be identified to evaluate potential risk to receptors and to evaluate potential remedial alternatives.

In addition, private drinking water wells that may be downgradient of potential source areas must be identified and a subset of these wells will be sampled.

Problem 2. VI may pose a risk to receptors in several structures in the vicinity of the dissolved CVOC (PCE) plume at Area C.

VI at Area C will be evaluated through collection of ambient air, indoor air, and sub-slab samples from Gilda's Club and an associated outbuilding (see Figure 10). The sample results will be used in conjunction with the well profiling and LTM results to investigate the potential for VI from the dissolved CVOC plume to pose a risk to human health.

2. IDENTIFY THE GOAL OF THE STUDY (OR IDENTIFY THE DECISIONS)

Primary Goals

(1) Delineate source(s) and extent of PFCs at Areas A, B, C, and D (primarily PFOS and PFOA).
(2) Evaluate the human health risk from potential VI in structures adjacent to the dissolved CVOC plume at Area C.

Principle Study Questions:

(1) What is the nature and extent of PFC contamination at Areas A, B, C, and D?
(2) What is the human health risk associated with CVOC concentrations in indoor air and sub-slab vapor samples collected from Area C structures?

Study Question 1A. PFCs in Private Drinking Water Wells
What drinking water wells are downgradient of the possible source(s) and potentially affected by the PFC plume, and what are the PFC concentrations in these wells?

Study Question 1B. PFC Source and Plume Extent Characterization
Surface water, sediment, groundwater, and soil sampling will be performed to answer the following media-specific study questions.

Surface Water: Is the nature and extent of the PFCs in surface water resulting from groundwater discharge at Areas A, B, C, and D adequately characterized?

- *What is the extent of PFC concentrations in surface water?*

Sediment: Is the nature and extent of the PFCs in sediment at Areas A, B, C, and D adequately characterized?

- *What is the extent of PFC concentrations in sediment?*

Groundwater: Is the nature and extent of the PFCs in groundwater at Areas A, B, C, and D adequately characterized?

- *What are the concentrations of PFCs in groundwater?*
- *What and where are the source(s) of PFCs in groundwater?*
- *What is the extent of PFC concentrations in groundwater exceeding the EPA PHA values?*

Soil: Is the nature and extent of the PFCs in soil at Areas A, B, C, and D adequately characterized?

- *What are the concentrations of PFCs in the vicinity of the suspected source areas?*
- *What and where are the source(s) of PFCs in soil?*

Human health exposures are the focus of this investigation; ecological receptor impacts are not being considered as part of this investigation. Because the current EPA focus is on health effects of exposure to PFOA and PFOS in drinking water, there are no ecological risk-based values developed. Should the results of the soil, surface water, and sediment sampling indicate detected concentrations of PFCs (primarily PFOA and PFOS), the need to assess potential impacts to ecological receptors will be re-evaluated.

Study Question 2. VI Evaluation

Is there a human health risk associated with VI from the dissolved CVOC plume at Area C?

- *What are the CVOC concentrations in indoor air samples in structures adjacent to the dissolved CVOC plume?*
- *What are the CVOC concentrations in sub-slab vapor samples collected from structures adjacent to the dissolved CVOC plume?*
- *What are the CVOC concentrations in background ambient air samples?*
- *What is the human health risk associated with CVOC concentrations in sub-slab and indoor air samples collected from Area C structures?*

3. IDENTIFY INFORMATION INPUTS (OR IDENTIFY INPUTS TO THE DECISION)

The following information is needed to inform the principle study questions:

Study Question 1A. PFCs in Drinking Water Wells

- Locations of existing public water supply wells downgradient of Areas A, B, C, and D.
- Locations of private water supply wells downgradient of Areas A, B, C, and D.
- Concentrations of PFCs in samples collected by EPA from existing public supply and private drinking water wells.
- Concentrations of PFCs collected from a subset of private water supply wells used to define the extent of the PFC plume.
- EPA PHA values.
- Location of GWETS discharge point.

Study Question 1B. PFC Source and Plume Characterization

- Historical hydrogeological information, geotechnical information, and site use/operations documentation.

- Existing PFC concentration data in drinking water wells and in groundwater collected during previous investigations. Existing groundwater data will be validated as part of this site investigation.
- Concentrations of PFCs collected from newly installed and existing groundwater monitoring and extraction wells near the potential source(s) in Areas A, B, C, and D.
- Results of analysis of water from private water wells from Study Question 1A.
- Concentrations of PFCs in surface water, soil, and sediment locations near and downgradient of the potential source(s) in Areas A, B, C, and D.
- Standard field-collected depth to water and groundwater quality parameters.

Study Question 2. VI Evaluation

- Location of structures adjacent to the Area C CVOC plume where VI may be an issue.
- Concentrations of CVOCs collected from EW-C20 and EW-C21 during LTM and well profiling activities.
- Concentrations of CVOCs collected from wells/sumps located in structures adjacent to the Area C CVOC plume.
- Groundwater level and groundwater flow information collected from EW-C20 and EW-C21 during LTM and well profiling activities.
- Concentrations of CVOCs collected from ambient air, indoor air, and sub-slab samples from structures adjacent to the CVOC plume.
- Historical hydrogeological information, geotechnical information, and site use/operations documentation.

4. DEFINE THE BOUNDARIES OF THE STUDY

Study Question 1A. PFCs in Drinking Water Wells

Groundwater from private water wells identified upgradient and downgradient of the potential PFC source(s) were sampled for PFCs by EPA (see Figure 9) under an IA with the Navy. Samples will be collected from a subset of 25 of the 110 private water supply wells and analyzed for PFCs on a quarterly schedule for four quarters. The locations will be selected based on results from the EPA sampling, and used to further define the extent of the PFC plume.

Study Question 1B. PFC Source and Plume Characterization

The media-specific study boundaries for PFC source and plume characterization at Areas A, B, C, and D are presented below.

Surface Water. Surface water samples will be collected from up to 59 readily accessible surface water locations, as shown in Figure 11, and analyzed for PFCs. A summary of the surface water sample locations is as follows:

- Up to 10 surface water samples will be collected along the small, unnamed tributary of Little Neshaminy Creek located between Area C and WMA-13. It is assumed that up to three of these locations may instead be sumps within residential/commercial buildings in the vicinity of the Area C CVOC plume that would be analyzed for CVOCs in addition to PFCs.
- Up to five surface water samples will be collected from readily available locations along Southampton Creek downgradient of Area B.
- Up to 16 surface water samples will be collected from drainage ditches and readily available locations along the unnamed tributaries of Little Neshaminy Creek downgradient of Area A and

downstream of WMA-13. Several locations immediately downstream of the GWETS discharge point will be included.

- Up to 16 surface water samples will be collected from drainage ditches and readily available locations along the unnamed tributaries of Upper Pennypack Creek to the west, south and southwest of Area D.
- Up to 12 surface water samples will be collected from surface water retention ponds/catchment basins in the vicinity of the former NAWC Warminster.

It should be noted that the actual surface water sampling locations may be modified depending on the presence of surface water in the unnamed and named creeks and tributaries.

Sediment. Surface sediment samples will be collected from up to 30 readily accessible locations collocated with 30 of the surface water samples referenced above (see Figure 11) and analyzed for PFCs. Actual sediment sample locations will be based on field observations. It should be noted that no sediment samples will be collected from sumps in Area C buildings.

Groundwater. Initial groundwater sampling was performed at existing Area C extraction and monitoring wells during January 2014, and in extraction wells of Areas A and D in May 2014. These data will be validated and used to assist in defining the extent of PFC contamination at the site. In addition, groundwater samples collected from up to 58 existing monitoring and extraction wells will be analyzed for PFCs (see Figures 6, 7, and 12). Up to 40 new monitoring wells will be installed at 23 locations (including up to 17 nested wells) (see Figures 12, 12a, 12b, and 12c) in the vicinity and downgradient of the potential source area(s), the locations of which are based on the conceptual site model (CSM), the PFC source evaluation report (Tetra Tech, 2014), and the results of on-site groundwater and extraction well, municipal production well, and private well PFC sampling. The new monitoring wells will be installed to a depth of up to 100 ft bgs, with actual depths based on the CSM, field observations made during well installation, depths of adjacent monitoring/production wells, and the regional strike and dip of the interbedded sandstone and mudstone units. Monitoring well clusters may be installed to define and evaluate PFC contamination at varying depths in the aquifer.

Soil. Unsaturated shallow soil samples (up to 48) will be collected and analyzed for PFCs. Soil sample locations will focus primarily on potential PFC source areas (see Figure 13), with actual sample depths determined in the field during installation, and a maximum soil sample depth of 20 ft bgs.

Study Question 2 VI Evaluation
The boundaries of the VI evaluation are residential structures adjacent to the eastern edge of the dissolved CVOC plume at Area C, including Gilda's Club and an outbuilding located roughly 100 ft southwest of Gilda's Club (see Figure 10). A background ambient air sample will be collected on the property, upwind of the structures.

5. DEVELOP THE ANALYTICAL APPROACH (OR DEVELOP A DECISION RULE)

Study Question 1A. PFCs in Drinking Water Wells
Water samples were collected from private water wells for evaluation of PFCs by EPA as part of the IA. Additional samples will be collected from selected private water wells as part of this investigation. The analytical results of the PFC drinking water well samples will be an input into Study Question 1B.

Study Question 1B. PFC Source and Plume Characterization
The source area(s) will be identified as those areas in soil with elevated PFC (specifically PFOS and PFOA) concentrations. The extent of PFC contamination in surface water and sediment will be identified

by elevated PFC (specifically PFOS and PFOA) concentrations. The extent of PFC groundwater contamination will be defined by the spatial area with PFC concentrations above PHA values. If PFC concentrations in groundwater do not exceed PHA values, then no further action may be warranted. If PFOS and PFOA concentrations are measured in groundwater above the EPA PHA values, then the results will be combined with existing data and remedial options for source treatment and/or containment will be evaluated, and a human health risk assessment may be performed.

Study Question 2. VI Evaluation
Air samples will be collected from sub-slab, indoor air, and background ambient air locations for evaluation of select CVOC concentrations (primarily PCE, TCE, and carbon tetrachloride, and associated degradation products). If CVOC concentrations are not detected or if ambient air background CVOC concentrations are equal to or above indoor air concentrations, then no action will be taken. If CVOC concentrations in indoor air and/or sub-slab samples are measured above ambient background concentrations, a human health risk assessment may be performed. Water samples collected from the sump and the hand dug well in the sub-basement of Gilda's Club will be used in conjunction with groundwater LTM data to redefine the extent of the CVOC plume, and subsequently incorporated into the human health risk assessment if necessary.

6. SPECIFY PERFORMANCE OR ACCEPTANCE CRITERIA (OR SPECIFY TOLERABLE LIMITS OF DECISION ERRORS)

Data quality for this study will be ensured by the following criteria:

- Field equipment will be calibrated, tested, and decontaminated prior to use.
- Special precautions will be used in PFC sampling to avoid cross contamination, per laboratory and regulatory guidance.
- A field blank will be collected for each sampling trip to assess ambient air contamination.
- PFCs will be analyzed by a DoD Environmental Laboratory Accreditation Program (ELAP)-accredited laboratory using EPA Method 537.
- Air samples will be analyzed for CVOCs using EPA Method TO-15.
- Laboratory data will be validated by a third party.

Quality Control. The data quality indicators for screening and definitive data are defined in terms of the precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters. The assessment of the data quality indicators is necessary to determine data usability and involves the evaluation of the PARCC parameters. To ensure the quality and integrity of the project data, the precision and accuracy of the analysis, the representativeness of the results, the completeness of the data, and the comparability of the data to existing data will be evaluated. Data that meet the DQOs and fulfill project goals will be deemed acceptable. Data that do not meet objectives and goals will be reviewed on a case-by-case basis to ascertain its usefulness. To limit errors made based upon analytical data, the reporting limits (practical quantitation limits) for target analytes have been established at a level at least three times less than the action limit (the laboratory can achieve 10 times less than the PHA values) whenever technically feasible and the method detection limits (MDLs) must be less than the PHA values.

7. DEVELOP THE DETAILED PLAN FOR OBTAINING DATA

The sampling design incorporates a progressive assessment to ensure the extent of PFC contamination at the former NAWC Warminster and potential CVOC VI into structures adjacent to the Area C CVOC plume is adequately characterized. The design options, such as sample collection design, location, and frequency, will be evaluated based on study design criteria and ability to meet the project DQOs.

Worksheet #18 defines the type, frequency, and location of samples. Figure 11 shows the PFC surface water and sediment sampling locations, Figure 12 shows the PFC groundwater sampling locations, Figure 13 shows the PFC soil sampling locations, and Figure 10 shows the CVOC VI sampling locations.

Study Question 1A (PFCs in Drinking Water Wells) and 1B (PFC Source and Plume Characterization)

Private water well sampling locations will be identified based on results of the EPA private well sampling effort, with the goal of delineating the extent of the PFC plume. Municipal drinking water supply, groundwater, surface water, sediment, and soil sample locations have been identified based on previously identified potential PFC sources at the former NAWC Warminster and results from recent groundwater and private well sampling for PFCs. Locations were designed to provide spatial coverage within and hydraulically downgradient of the potential sources, as shown on Figures 6 and 7 (for existing groundwater wells) and Figures 11 through 13 (for new groundwater wells, soil, surface water, and sediment) and summarized in Worksheet #18. Additional sampling locations may be designated based on field observations and PFC (specifically PFOS and PFOA) concentrations measured during this initial investigation. These additional samples may be collected to delineate the extent of PFC contamination if perimeter well or boundary private water well samples are shown to have PFC concentrations above PHA values for PFOS and PFOA.

Study Question 2 (VI Evaluation)

Air and water samples will be collected and analyzed for select CVOCs (primarily PCE, TCE, and carbon tetrachloride and associated degradation products) to support a VI evaluation at Area C that satisfies the follow-up action from the five-year review. It is assumed that the air samples will be collected over an 8-hour period using 6-liter Summa® canisters that have been cleaned and certified by the analytical laboratory. Sampling will consist of up to two rounds (collected during the indoor heating season, separated by 1 to 3 months) of indoor air and sub-slab sampling at Gilda's Club and an associated outbuilding (see Figure 10). Ambient background air sampling also will be performed at an upwind location. It is estimated that a total of up to 30 air samples (including QA/QC samples) will be collected during the VI evaluation. Up to three water samples will be collected from the sump and the hand dug well in the sub-basement of Gilda's Club and analyzed for select CVOCs. Schematic drawings of Gilda's Club and the associated outbuilding are provided in Figures 14 through 16.

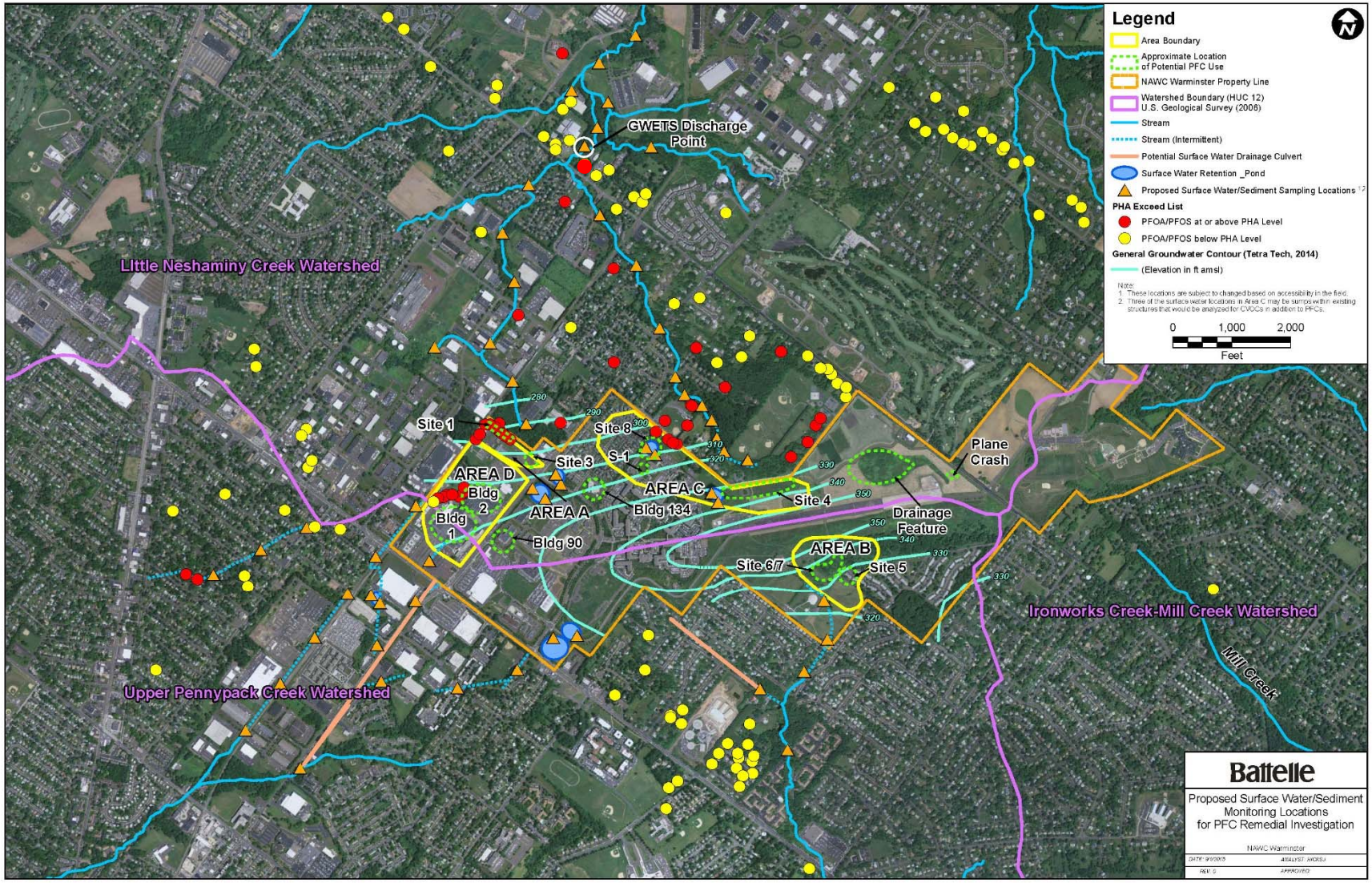


Figure 11. Proposed Surface Water Sampling Locations for PFCs

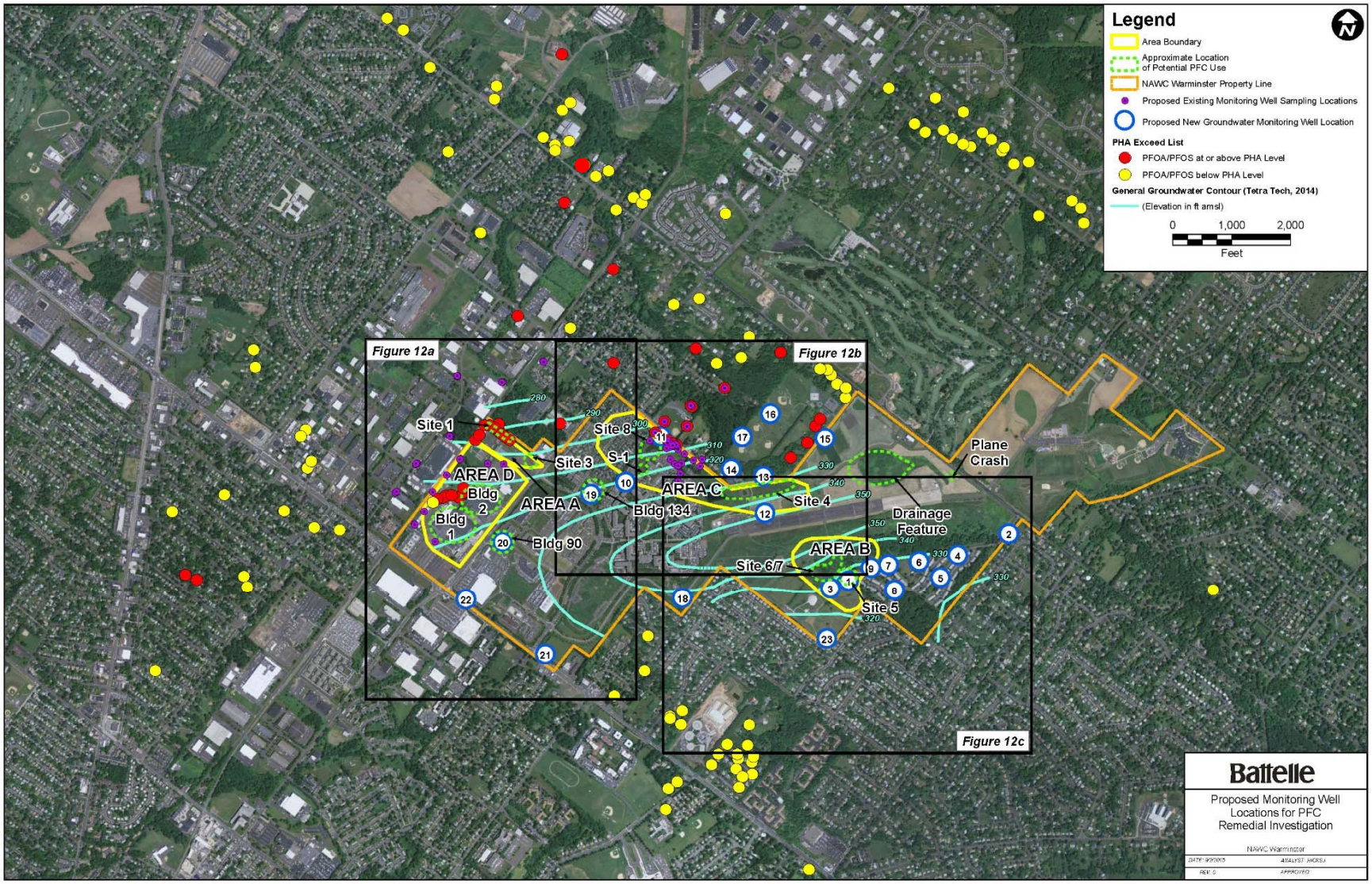


Figure 12. Proposed Monitoring Well Locations and Groundwater Sampling Locations for PFCs

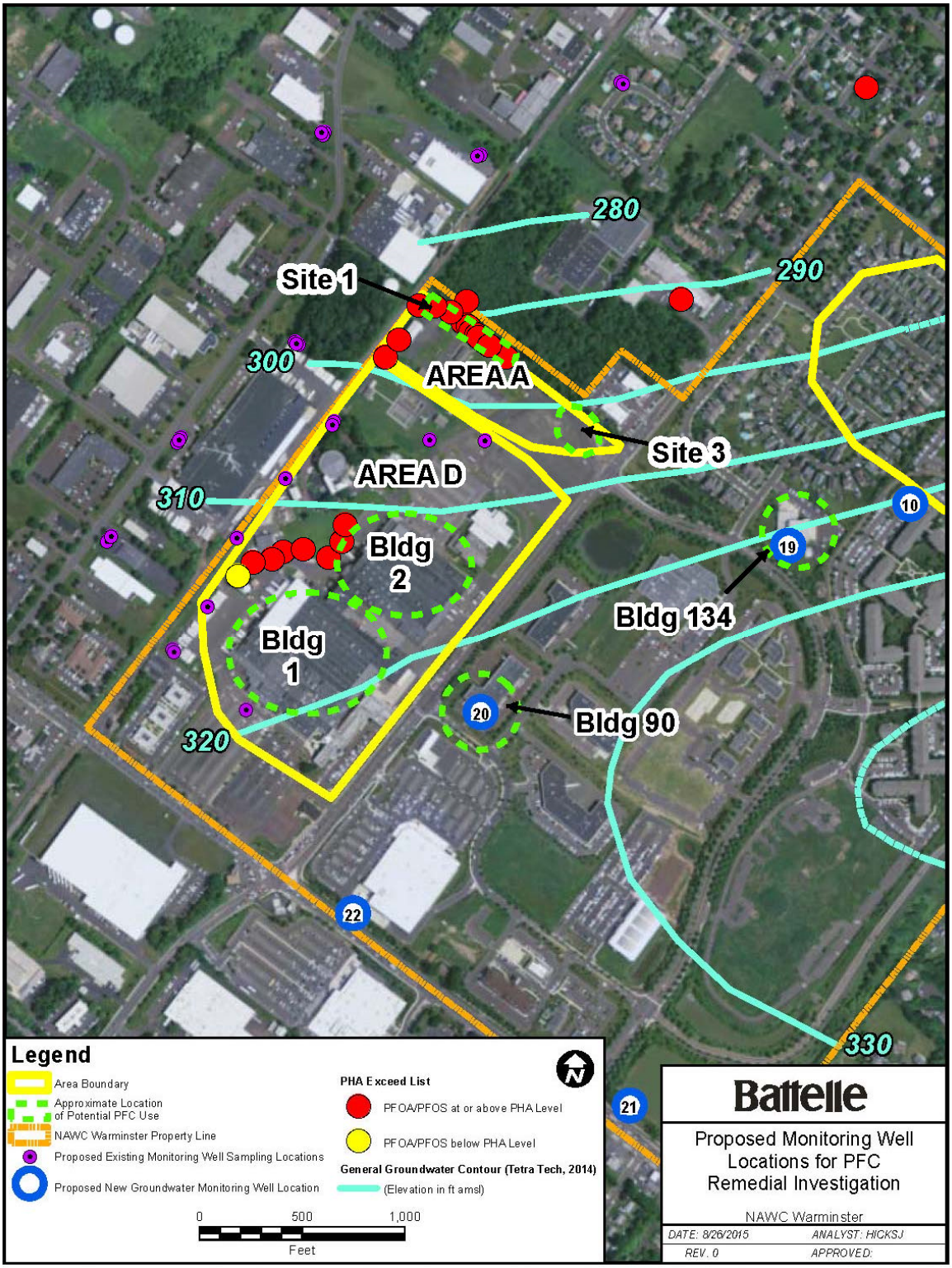


Figure 12a. Area A and D Proposed Monitoring Well Locations and Groundwater Sampling Locations for PFCs

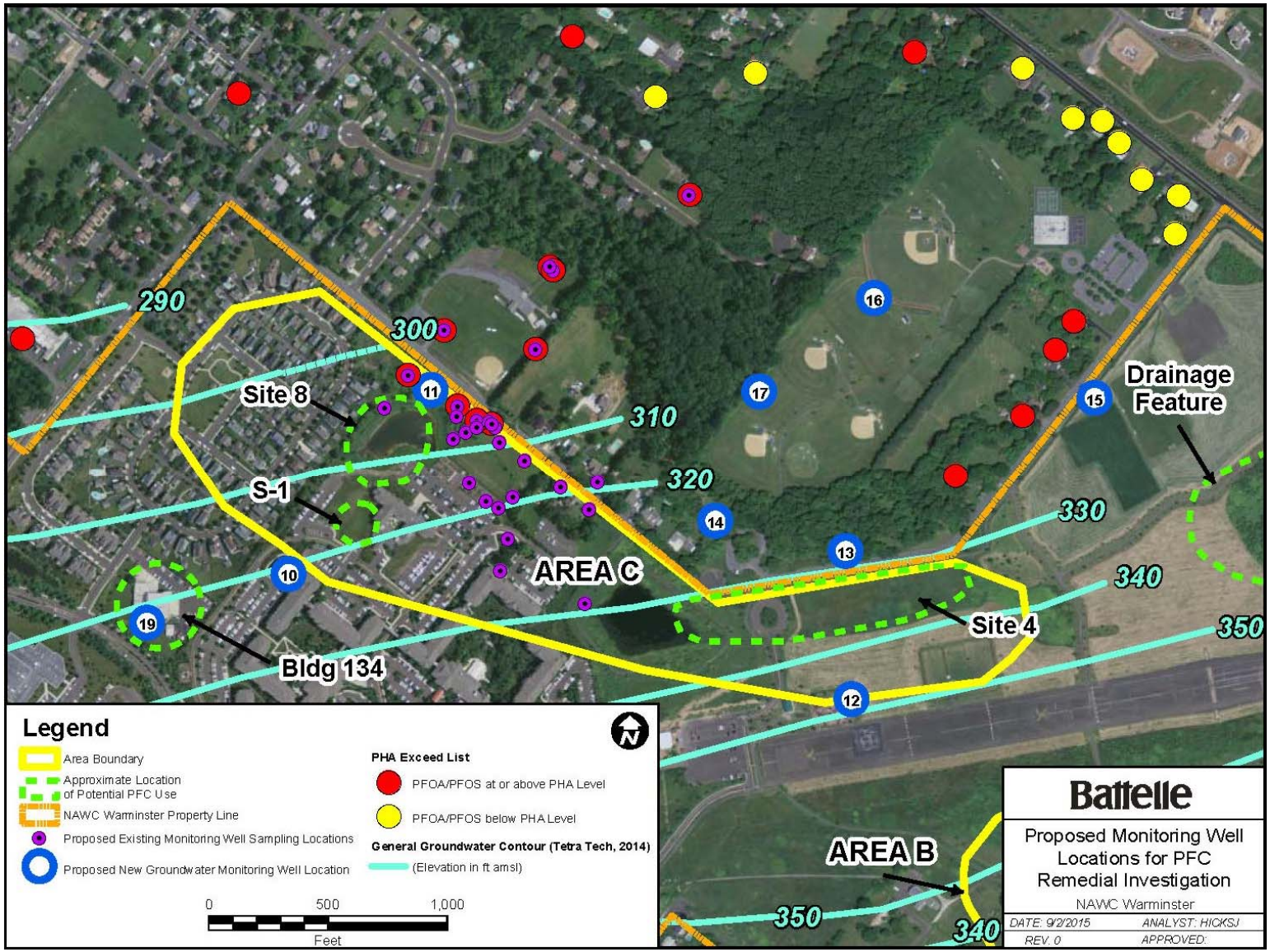


Figure 12b. Area C Proposed Monitoring Well Locations and Groundwater Sampling Locations for PFCs

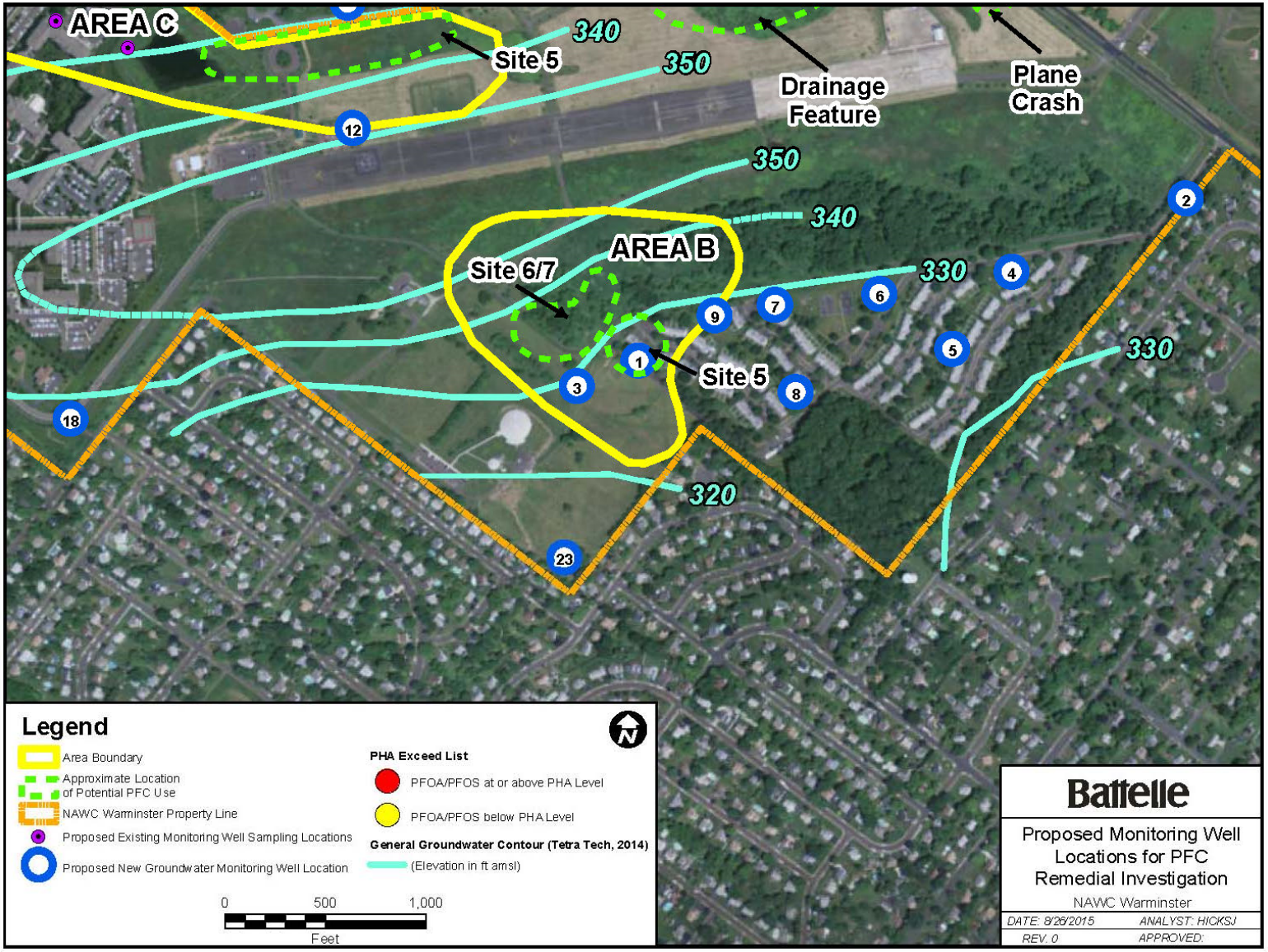


Figure 12c. Area B Proposed Monitoring Well Locations and Groundwater Sampling Locations for PFCs

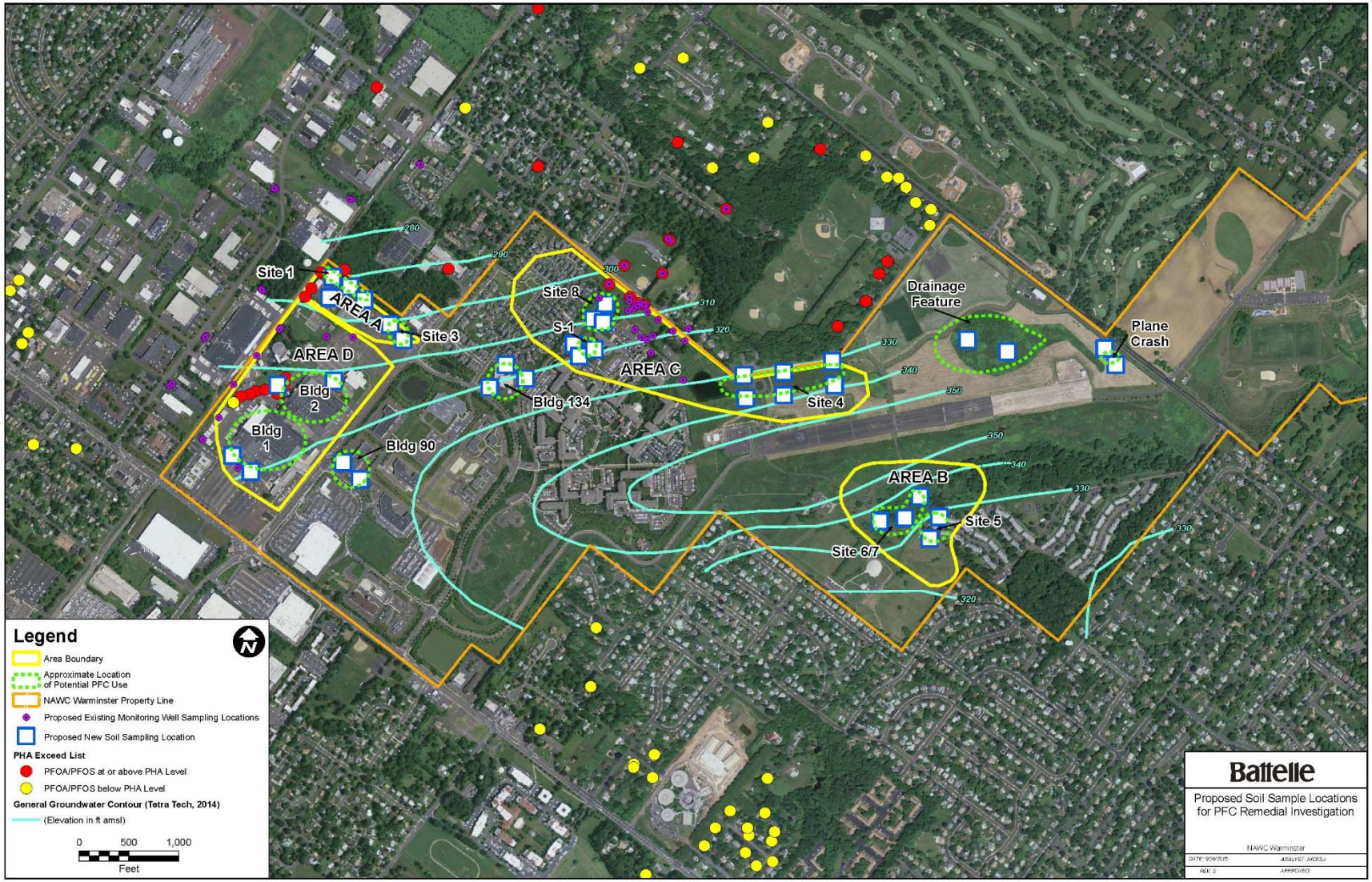


Figure 13. Proposed Soil Sampling Locations for PFCs

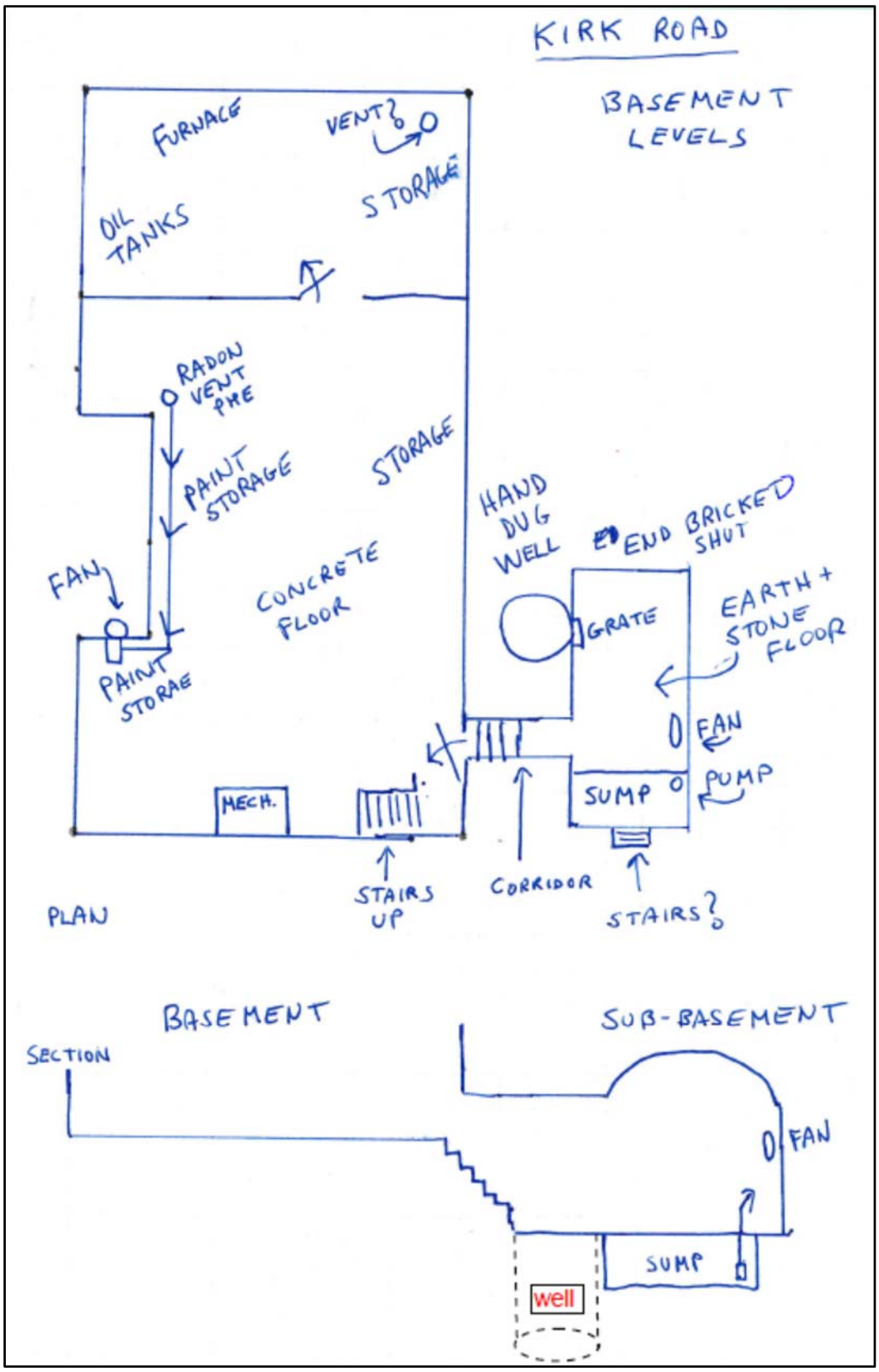


Figure 14. Schematic Drawing of Gilda's Club Basement and Sub-Basement Layout

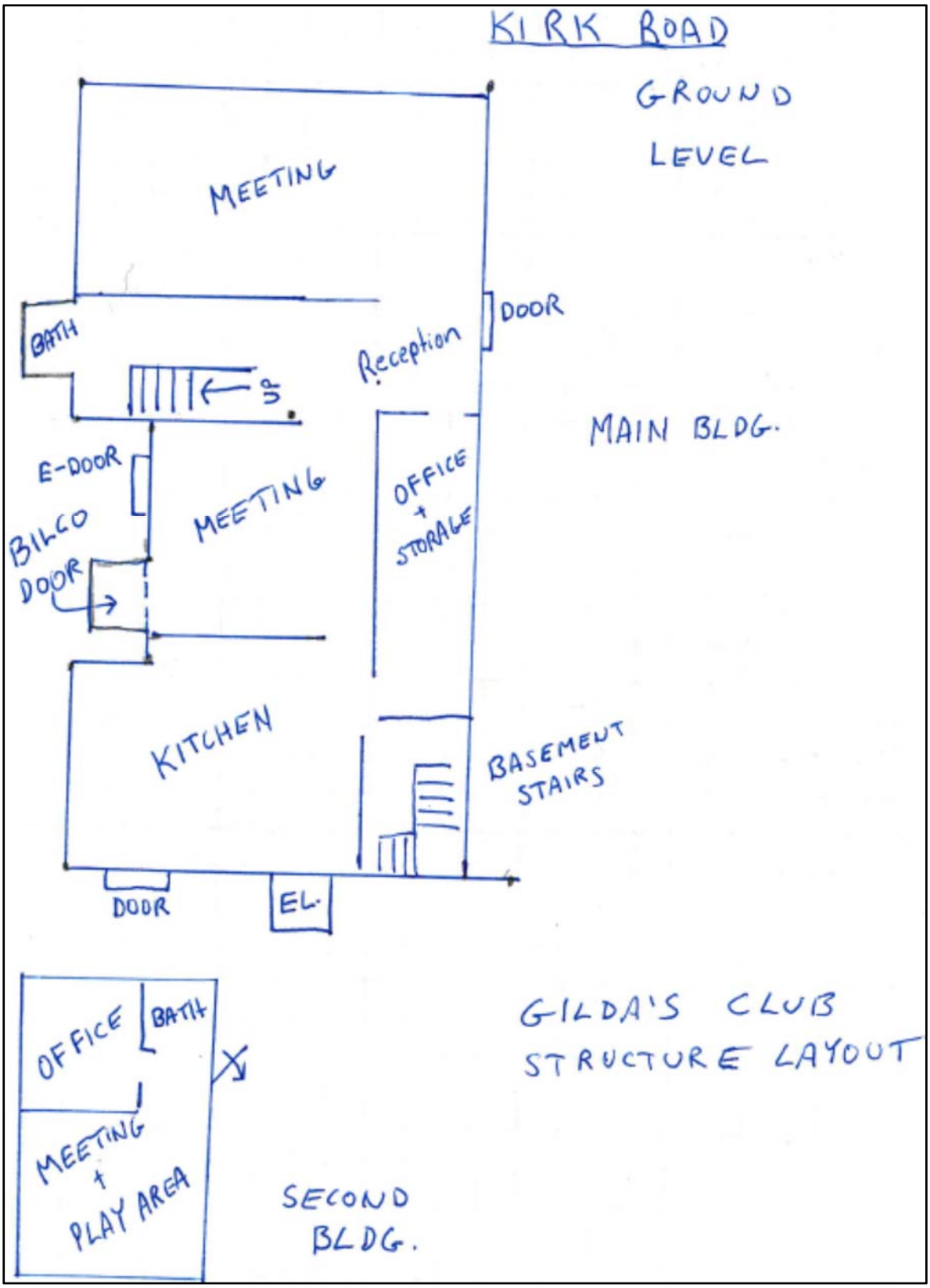


Figure 15. Schematic Drawing of First Floor of Gilda's Club and Associated Outbuilding

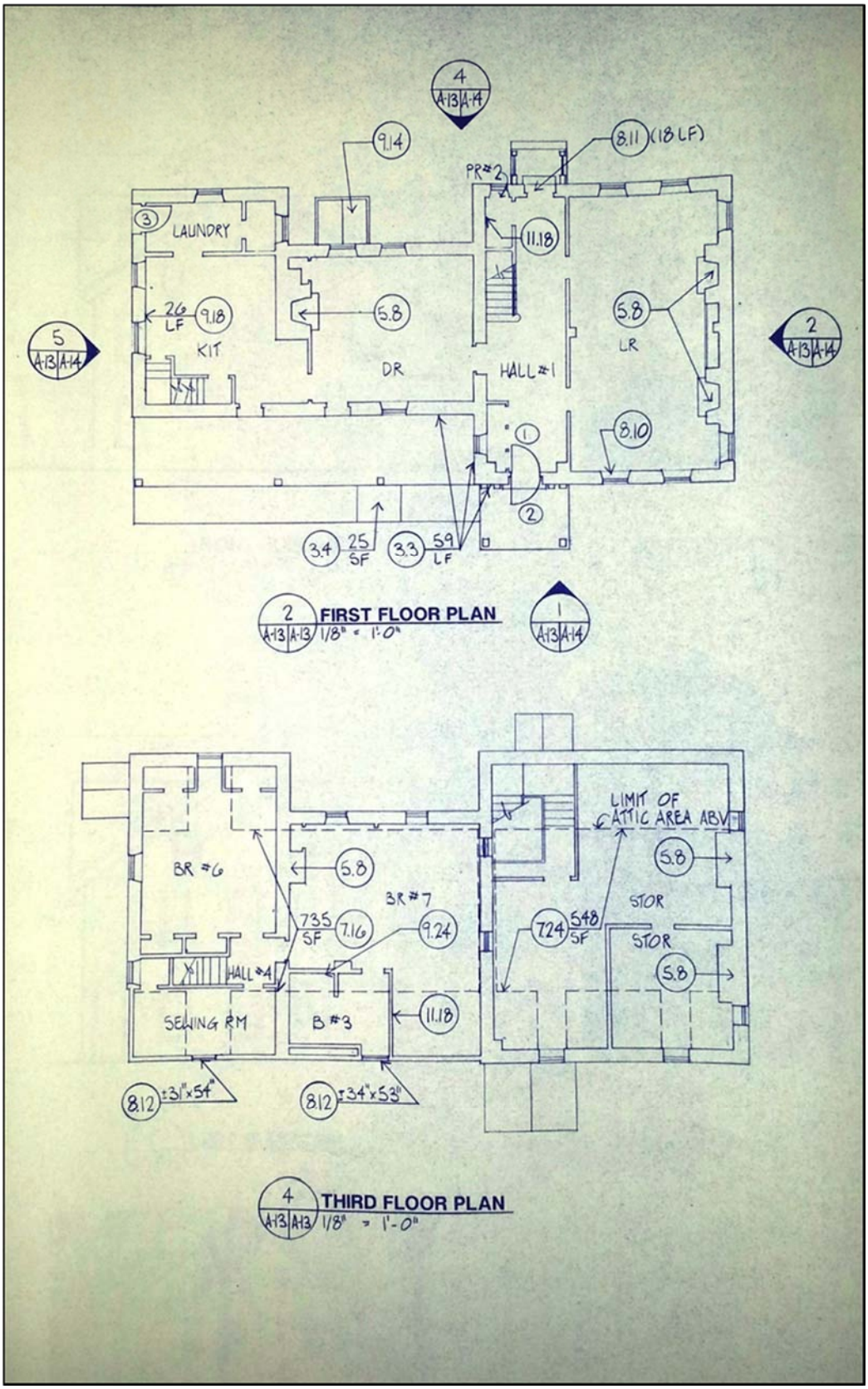


Figure 16. Layout of First Floor and Third Floor of Gilda's Club

SAP Worksheet #12-1 -- Measurement Performance Criteria Table – Soil Samples

(UFP-QAPP Manual Section 2.6.2)

QC Sample	Analytical Group	Frequency	Data Quality Indicators	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Field Duplicate	PFCs	10% of soil samples	Precision	RPD ≤ 30% when detects for both field duplicates	S&A
Matrix Spike and Matrix Spike Duplicates	PFCs	1 per batch of 20 samples	Precision/Accuracy	Measurement performance criteria are listed in Worksheet #28	A
Source Blank	PFCs	1 per source of decontamination water	Accuracy/Bias	No target compounds greater than the RL	S&A
Equipment Rinsate Blank	PFCs	1 per sampling day	Accuracy/Bias	No target compounds greater than the RL	S&A
Temperature Blank	Not Applicable	1 per cooler	Accuracy/Bias	4ºC ± 2ºC	S

RL = reporting limit
RPD = relative percent difference

SAP Worksheet #12-2 -- Measurement Performance Criteria Table – Sediment Samples

(UFP-QAPP Manual Section 2.6.2)

QC Sample	Analytical Group	Frequency	Data Quality Indicators	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Field Duplicate	PFCs	10% of sediment samples	Precision	RPD ≤ 30% when detects for both field duplicates	S&A
Matrix Spike and Matrix Spike Duplicates	PFCs	1 per batch of 20 samples	Precision/Accuracy	Measurement performance criteria are listed in Worksheet #28	A
Source Blank	PFCs	1 per source of decontamination water	Accuracy/Bias	No target compounds greater than the RL	S&A
Equipment Rinsate Blank	PFCs	1 per sampling day	Accuracy/Bias	No target compounds greater than the RL	S&A
Temperature Blank	Not Applicable	1 per cooler	Accuracy/Bias	4ºC ± 2ºC	S

SAP Worksheet #12-3 - Measurement Performance Criteria Table – Groundwater Samples

(UFP-QAPP Manual Section 2.6.2)

QC Sample	Analytical Group	Frequency	Data Quality Indicators	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Field Duplicate	PFCs	10% of groundwater samples	Precision	RPD ≤ 20% when detects for both field duplicates	S&A
Matrix Spike and Matrix Spike Duplicates	PFCs	1 per batch of 20 samples	Precision/Accuracy	Measurement performance criteria are listed in Worksheet #28	A
Equipment Rinsate Blank	PFCs	1 per sampling day	Accuracy/Bias	No target compounds greater than the RL	S&A
Source (Field) Blank	PFCs	1 per source of decontamination water per sampling event	Accuracy/Bias	No target compounds greater than the RL	S&A
Temperature Blank	Not Applicable	1 per cooler	Accuracy/Bias	4ºC ± 2ºC	S

SAP Worksheet #12-4 - Measurement Performance Criteria Table – Surface Water Samples

(UFP-QAPP Manual Section 2.6.2)

QC Sample	Analytical Group	Frequency	Data Quality Indicators	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Field Duplicate	PFCs, CVOCs	10% of surface water samples	Precision	RPD ≤ 20% when detects for both field duplicates	S&A
Matrix Spike and Matrix Spike Duplicates	PFCs, CVOCs	1 per batch of 20 samples	Precision/Accuracy	Measurement performance criteria are listed in Worksheet #28	A
Equipment Rinsate Blank	PFCs, CVOCs	1 per sampling day	Accuracy/Bias	No target compounds greater than the RL	S&A
Trip Blank	PFCs, CVOCs	1 per cooler of surface water samples	Accuracy/Bias	No target compounds greater than the RL	S&A
Source (Field) Blank	PFCs, CVOCs	1 per source of decontamination water per sampling event	Accuracy/Bias	No target compounds greater than the RL	S&A
Temperature Blank	Not Applicable	1 per cooler	Accuracy/Bias	4ºC ± 2ºC	S

SAP Worksheet #12-5 - Measurement Performance Criteria Table – Air Samples

(UFP-QAPP Manual Section 2.6.2)

QC Sample	Analytical Group	Frequency	Data Quality Indicators	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Field Duplicate	CVOCs	10% of air samples	Precision	RPD ≤ 30% when detects for both field duplicates	S&A

SAP Worksheet #13 -- Secondary Data Criteria and Limitations Table
(UFP-QAPP Manual Section 2.7)

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
Former NAWC Warminster PFC Source Investigation Report	NAVFAC BRAC PMO East and Tetra Tech, NUS, Evaluation of Potential Sources of Perfluorinated Compounds, Former Naval Air Warfare Center Warminster, Warminster, Pennsylvania, April 2014	Tetra Tech NUS, potential PFC source locations, groundwater flow maps, and PFC chemical concentration data collected in 2013 and 2014.	Identify PFC sources and select PFC sampling locations	None
Area A and C Well Profiling Report	NAVFAC BRAC PMO East and Battelle, Areas A and C Well Profiling Summary Report for Source Area Treatment Optimization at the Former NAWC Warminster, Pennsylvania, August 2013	Battelle, Area A and C CVOC groundwater concentration data, groundwater elevation data and flow direction, vertical groundwater flow direction, initial VI evaluation at Gilda's Club with calculated screening values.	Identify VI sampling locations at Area C	None
Area A, C, and D Monitoring Data	NAVFAC BRAC PMO East and H&S Environmental, Inc., Annual Monitoring Report for the Spring (May) 2014 Performance Monitoring Event for Long Term Environmental Monitoring at Operable Units 1A, 3, and 4 at the Former NAWC, Warminster, Pennsylvania	H&S Environmental, Inc., Area C CVOC groundwater concentration data; groundwater elevation data and flow direction.	Evaluate recent groundwater conditions	None

SAP Worksheet #14 -- Summary of Project Tasks

(UFP-QAPP Manual Section 2.8.1)

This worksheet summarizes the relevant tasks that will be performed as part of this investigation. A summary of tasks that will be performed are as follows and are provided in more detail below:

- Notifications and permitting
- Groundwater monitoring well installation and development
- Sampling and analysis of soil samples for PFCs
- Sampling and analysis of groundwater monitoring wells for PFCs
- Sampling and analysis of surface water samples for PFCs and select CVOCs
- Sampling and analysis of sediment samples for PFCs
- Sampling and analysis of air matrices for select CVOCs
- Sampling and analysis of private water wells for PFCs
- Post-sampling decontamination of equipment, waste characterization and disposal
- QC requirements
- Data management and review tasks
- Third-party data validation
- Data storage and archiving

14.1 Notifications and Permitting

All field work will be coordinated with the Navy RPM and the Department of Health of Bucks County, Pennsylvania (BCDH). All permits will be obtained by Battelle from the BCDH at least 5 days before any drilling. Access licenses for indoor air and sub-slab basement sampling also will be in place prior to sampling. Access licenses for the private water wells identified for PFC sampling will be coordinated by the Navy and EPA.

Prior to drilling at each of the selected monitoring well locations, Battelle will contact PA ONE CALL to perform an initial utility clearance at the selected area. PA ONE CALL will mark underground utility locations using paint of various colors keyed to the specific utility types. Each location will subsequently be cleared by a utility locating company.

All personnel at the site will have appropriate training and qualifications, as specified by the project health and safety plan officer. Each site worker will be required to have completed a 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) course and applicable annual 8-hour refresher as described under Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations (CFR) 1910.120(b)(4). All related documentation will be kept readily available in the project files on site.

14.2 PFC Sampling Requirements

Given the persistence of PFCs in commonly used household and industrial items, proper precautions are necessary when sampling for PFCs to minimize the potential for cross contamination. Sampling procedures consistent with PFC analysis will be used, including the use of polyethylene bailers, stainless steel equipment when possible, and personnel precautions. Dedicated equipment will be used when possible with proper decontamination between sample locations to minimize cross contamination.

Additional information on sampling guidance for PFCs are listed in Attachment A (PFC sampling guidance standard operating procedure [SOP]).

14.3 Groundwater Monitoring Well Installation and Development Procedures

Groundwater Monitoring Well Installation. Up to 40 groundwater monitoring wells will be installed in 23 locations (17 of which will be nested wells) (see Figures 12, 12a, 12b, and 12c) for subsequent sampling of PFCs in groundwater. All monitoring wells will be located within 0.5 mile of the former NAWC Warminster site boundary. The wells will be drilled using a hollow stem auger (HSA) from land surface through the unconsolidated soil to bedrock (see Attachment B – drilling and well development SOP). Once bedrock is reached, the drilling contractor will convert to air rotary drilling methods to complete the boring to the desired well depth (up to 100 ft bgs). It is assumed that a 6- or 8-inch roller bit will be used to drill the borings to accommodate installation of nested wells. For those borings completed in parks or open space areas, geophysical logging will be performed in the open borehole by USGS personnel prior to well installation. It should be noted that geophysical logging will not be performed for new borings completed on private property because of the extended period of time required for geophysical logging and the associated disruption to local residents.

Well screen intervals will be selected based on lithologic observations made during drilling, results of the geophysical logging (if applicable), and correlation of known water bearing fracture depths with the strike and dip of the formation, with the goal of monitoring fractured intervals in the desired aquifer zones. It is anticipated that in the 17 proposed nested well locations, a screen will be completed in the intermediate aquifer zone (between 50 to 90 ft bgs) and in the shallow aquifer zone (between the water table and 50 ft bgs). Wells will be constructed with a 2-inch polyvinyl chloride screen and riser and 2-inch threaded lockable cap with centralizers every 20 ft. A sand pack will be installed until approximately 2 ft above the screened interval, followed by 2 ft of bentonite pellets. The remaining annular space will be tremie grouted to 4 ft bgs. After well development (see below), monitoring wells will be constructed with flush-mounted road boxes with a 2-ft by 2-ft cement apron mounded at the ground surface to direct surface water runoff away from the well. The borehole of proposed well cluster 17 (see Figure 12b) will be logged and the intermediate interval will be screened within the same stratigraphic unit as the fire training area, although other sources of PFCs are likely present based on private well sampling results along Newtown Road.

A 5-ft stainless steel split-spoon sampler will be advanced in intervals from land surface down to the top of bedrock for soil sampling discussed below in Section 14.6. The split-spoon samples and drill cuttings will be screened using a photo-ionization detector (PID) to evaluate the presence of subsurface contamination. A Pennsylvania-licensed geologist will prepare daily field log sheets, lithologic boring logs, and monitoring well completion diagrams.

Groundwater monitoring wells installed will be surveyed for the spatial location (northing and easting coordinates) and elevation of the ground surface, the water-level measuring reference point (i.e., top of the polyvinyl chloride casings), and the top of the protective steel casing. All surveying will be measured to the nearest 0.01 ft using the benchmarks located on the Base. A reference point will be indicated on monitoring wells by a notch or a permanent mark on the casing. A qualified surveyor working under the supervision of a Pennsylvania-licensed professional surveyor will perform surveying according to North American Datum 83 in U.S. survey feet. Survey equipment will be calibrated in accordance with the manufacturer's recommendations.

Drill cuttings will be diverted directly into drums supplied by the driller, and the field team will continuously monitor the cuttings with a PID. The driller will transport the drums to the Area A groundwater treatment plant and stage them adjacent to the building in an area reserved by the treatment plant contractor. Waste generated during the field operations will be representatively sampled and analyzed to determine the hazard classification prior to transport offsite. Disposal of the cuttings will be performed by another contractor. The maximum distance from the monitoring wells to the Area A

treatment plant is roughly 2 miles. The driller will report the well construction information for each of the wells to BCDH and Battelle.

Groundwater Monitoring Well Development. The drilling contractor will clear the borehole and well of any fluids or substances that interfere with the free flow of groundwater through the well screen using approved development methods, including surging (2-inch surge block), pumping with a downhole submersible pump (Grundfos or similar), and/or by air lifting. Development will occur after any grout used during well installation has been allowed to dry for a minimum 24-hour period. Development water will be collected and transported by the subcontractor to tanks at the groundwater treatment system at Area A, located roughly 2 miles from the monitoring wells. Development water will be filtered to separate out any fines. All filtered development water can be disposed directly to the tanks at the treatment system. All fines separated by the filters will be containerized in 55-gallon drums and staged in the investigation-derived waste (IDW) staging area for disposal by others. Well development is anticipated to require 2 hours per well. Well development time includes setup/breakdown at each well, well purging, and transportation of water to the IDW staging area for disposal by others. Development and water transport shall be coordinated to minimize downtime. Attachment B presents the drilling and well development SOP.

14.4 Soil Sampling Procedures

During the field effort, up to 48 unsaturated soil samples will be collected for analysis of PFCs. Samples will be collected using procedures consistent with PFC analysis, including use of stainless steel spoons/trowels and personnel precautions as described in Attachments A (PFC sampling SOP) and C (soil sampling SOP). Dedicated equipment will be used when possible, and any non-dedicated equipment will be carefully decontaminated between sample locations to minimize the potential for cross contamination.

The soil sampling will occur in conjunction with advancement of the borings and sample locations will focus primarily on potential PFC source areas (see Figure 8), with actual sample depths determined in the field. As discussed earlier, one sample will be collected per 5 ft of unconsolidated soil, with up to four samples collected per location. After the soil samples have been collected, all soil cuttings shall be containerized in 55-gallon drums or a roll-off container to be provided by the driller, as described in Section 14.5.

For PFCs, the soil will be transferred from either a sleeve or auger into an EnCore® sampler (or similar airtight sampler) before being sent to the analytical laboratory for analysis. Detailed lithology from the samples will be recorded on borehole logs. Continuous core borehole logging will be conducted under supervision of a professional geologist licensed in the State of Pennsylvania. Soil core samples will be classified using the Unified Soil Classification System.

Worksheet #18 summarizes the soil sample identification (ID) numbers, analysis type, and frequency for each compound class required for soil samples at the site. Soil samples will be collected at the selected locations as indicated in Figure 13 and Worksheet #18.

Soil sampling will be conducted as follows:

(1) After reaching the desired depth, the continuous core sampling sleeve will be retrieved from the borehole so that the soil recovered in the sleeve rests in the remaining half of the barrel.

(2) To isolate the soil samples for PFC analysis, the sleeve will be cut down the center and EnCore® samplers (or similar airtight sampler) will be used to collect the samples from the sleeve.

(3) All soil samples collected in EnCore® (or similar) samplers will be sealed in a plastic bag and placed in an ice chest or a refrigerator, where they will be maintained at approximately 4 ±2°C until shipment for laboratory analyses.

(4) Soil cuttings from the same depth as the soil samples will be placed in separate plastic bags and sealed. After the bagged soil cuttings have warmed up to the ambient temperature, headspace measurements for the resulting vapors will be collected using a PID.

Samples will be shipped to accommodate hold times as documented in Worksheet #19 for PFC analysis (via EPA Method 537). The samples will be preserved in accordance with the procedures presented in this SAP. All samples will be shipped to the designated laboratory under appropriate COC documentation.

14.5 Groundwater Sampling Procedures

Groundwater-Level Measurement. Groundwater-level measurements will be taken from each monitoring well at the site before purging is initiated. Once the cap is removed, the groundwater will be allowed to equilibrate with atmospheric conditions for approximately 5 minutes before taking a groundwater-level measurement. The depth to groundwater will be measured using a Solinst interface meter (or equivalent) in 0.01-ft increments, relative to a permanently marked survey point located at the top of the well casing.

Groundwater Sample Collection from Monitoring Wells. The groundwater monitoring well sampling techniques described below were adapted from the current SAP for LTM at NAWC Warminster (H&S, 2011). Groundwater samples will be collected from the monitoring/observation wells using the standard sampling techniques (e.g., three-purge volume) outlined in the LTM SAP. For screened monitoring/ observation wells, a submersible pump will be lowered to a depth of 3 to 5 feet above the bottom of the well screen. For open bedrock monitoring/observation wells, the submersible pump will be lowered halfway down the open borehole interval of each well. The well will be purged for a minimum of three and a maximum of five well volumes, while collecting field measurements of pH, oxidation-reduction potential (ORP), dissolved oxygen (DO), specific conductance, temperature, and turbidity at 5- to 10-minute intervals. Stabilization of these field parameters within ±10% will be the criterion for termination of purging operations prior to reaching five well volumes. If stabilization is not reached within 2 hours of purging, the samples may be collected at the 2-hour mark. The pumping rate for well purging should be low enough that the groundwater elevation in the well is not drawn down more than one-third of the total water column in the well, if possible. If the monitoring/observation well is not capable of at least 1 gallon per minute sustained yield, the well should be pumped dry and sampled after the well recovers to at least 75% of the initial groundwater level.

Upon stabilization of water quality parameters, groundwater samples will be collected directly from the sample tubing into bottleware provided by the certified laboratory. Procedures documented in Attachments A and D will be followed to minimize the potential interferences of PFCs that could occur during sampling. Polyethylene tubing will be used for both submersible and bladder pumps. Submersible pumps will be carefully decontaminated between wells to avoid cross contamination. Bladder pumps also will be carefully decontaminated between wells to avoid cross contamination. In addition, disposable polyethylene bladders will be used and changed out between wells to minimize cross contamination. In general and if possible, wells will be sampled in an order such that wells with the least contamination are sampled first and wells where higher contaminant concentrations are suspected are sampled last.

After sample collection, the containers will be labeled, prepared for shipment, and placed in an insulated cooler with ice (double-bagged in re-sealable plastic bags). Groundwater samples will be shipped for analysis of PFCs based on the procedures outlined in EPA Method 537. All samples will be shipped to

the designated laboratory under appropriate COC documentation. Additional details on monitoring/ observation well sampling procedures for PFCs are listed in Attachments D (groundwater sampling SOP) and A (PFC sampling guidance SOP).

For newly installed monitoring wells (see Section 14.3), groundwater samples will be collected a minimum of two weeks after well development, consistent with the procedures described above.

Groundwater Sample Collection from Extraction Wells. The groundwater extraction well sampling techniques described below were adapted from the current SAP for LTM at NAWC Warminster (H&S, 2011). The extraction wells that are in operation will be sampled directly from the sampling port installed on the discharge line from each well (direct fill). Because each well is to be in continuous operation, purging and field parameter stabilization will not be used as criteria for sampling. For those wells not in operation at the time of sampling, the sampling techniques for monitoring/observation wells will be used to collect a groundwater sample.

After sample collection, the containers will be labeled, prepared for shipment, and placed in an insulated cooler with ice (double-bagged in re-sealable plastic bags). Groundwater samples will be shipped for analysis of PFCs based on the procedures outlined in EPA Method 537. All samples will be shipped to the designated laboratory under appropriate COC documentation. Additional details on extraction well sampling procedures for PFCs are listed in Attachments D (groundwater sampling SOP) and A (PFC sampling guidance SOP).

14.6 Surface Water Sampling Procedures

A maximum of 59 surface water samples will be collected at the former NAWC Warminster. The sampling locations will be from drainage ditches, retention ponds, and other readily accessible surface water locations along unnamed tributaries of Little Neshaminy Creek, Southampton Creek, and Upper Pennypack Creek (see Figure 11). The locations will be initially flagged for later surveying for northing and easting coordinates and sample elevation using a licensed surveyor. Surface water will be field measured for pH, ORP, DO, specific conductance, temperature, and turbidity. After collection, samples will be visually inspected and any observations will be noted in the field logbook. Up to three of the surface water sampling locations may be sumps within residential buildings in Area C that would be sampled with a bailer and analyzed for CVOCs in addition to PFCs.

Additional details on surface water sampling procedures for PFCs are listed in Attachments E (surface water sampling SOP) and A (PFC sampling guidance SOP).

Surface water samples will be shipped to accommodate hold times as documented in Worksheet #19 for analysis of PFCs (via EPA Method 537) and CVOCs (via EPA Method 8260B). The samples will be preserved in accordance with the procedures presented in this SAP. All samples will be shipped to the designated laboratory under appropriate COC documentation.

14.7 Sediment Sampling Procedures

A maximum of 30 sediment samples will be collected at Area C, collocated with selected surface water locations (see Figure 11). The locations will be initially flagged for later surveying for northing and easting coordinates and ground surface elevation using a licensed surveyor. To minimize the potential for cross contamination, stainless steel trowels will be used for the collection of PFC samples. Dedicated equipment when possible will be used and decontamination of any non-dedicated equipment between sample locations will be performed to minimize cross contamination. After collection, samples will be visually inspected and any observations will be noted in the field logbook.

More details on the sediment sampling procedures are listed in Attachments F (sediment sampling SOP) and A (PFC sampling SOP).

Samples will be shipped to accommodate hold times as documented in Worksheet #19 for analysis of PFCs (via EPA Method 537). The samples will be preserved in accordance with the procedures presented in this SAP. All samples will be shipped to the designated laboratory under appropriate COC documentation.

14.8 Air Sampling Procedures

Up to 30 air samples will be collected for analysis as part of a VI evaluation. Sampling will consist of two rounds of up to 15 samples each separated by one to three months, attempting to collect both rounds during the indoor heating season. Air samples will be collected from sub-slab, indoor, and ambient background locations for evaluation of select CVOC concentrations. Air samples will be collected over an 8-hour period using 6-L Summa® canisters that will be provided by the analytical laboratory according to the procedures outlined in Attachment G. Associated QA/QC samples also will be collected and submitted for analysis. All access licenses for indoor basement sampling will be in place prior to sampling.

Samples will be shipped to accommodate hold times as documented in Worksheet #19 for CVOC analysis (via EPA TO-15). All samples will be shipped to the designated laboratory under appropriate COC documentation.

14.9 Private Well Sampling Procedures

Up to 25 private water well sampling locations will be sampled and analyzed for PFCs on a quarterly basis for four quarters. Sample locations will be based on results of the EPA sampling effort, with the goal of delineating and monitoring the extent of the PFC plume. Samples will be collected prior to treatment from a tap or spigot within the structure supplied by the private well according to procedures outlined in Attachment D and those established by EPA during initial private well sampling efforts. Samples will be shipped to accommodate hold times as documented in Worksheet #19 for PFC analysis (via EPA Method 537). The samples will be preserved in accordance with the procedures presented in this SAP. All samples will be shipped to the designated laboratory under appropriate COC documentation. Private well groundwater sampling procedures are documented in Attachments A and D.

14.10 Post-Sampling Decontamination of Equipment, Waste Characterization and Disposal

Equipment Decontamination. Dedicated and disposable sampling equipment will be used to the extent possible to avoid the potential for cross contamination of samples due to inadequate decontamination processes. The dedicated/disposable sampling equipment will include disposable polyethylene tubing, disposable gloves, and laboratory supplied sample bottles. Non-disposable or non-dedicated sampling equipment (e.g., submersible pumps, water level indicators, water quality meters, etc.) will be decontaminated prior to sampling and between samples. Cleaning of equipment is performed to prevent cross contamination between samples and to maintain a clean working environment for all personnel. Decontamination will generally consist of a water rinse station to remove gross contamination (if needed), followed by a nonphosphate detergent (e.g., Alconox®) water rinse, and a rinse with PFC-free deionized (DI) water. If recycled paper towels are used, then the groundwater-level measurements will be conducted after completion of groundwater sampling to avoid potential contamination from materials containing PFCs.

The following general sequence will be used to clean equipment and sampling devices prior to and between each use:

(1) Disassemble the equipment (if possible) and scrub the equipment with a stiff-bristle brush using laboratory grade detergent, such as Alconox®, and rinse with PFC-free DI water. The equipment will be scrubbed and rinsed in separate 5-gallon buckets.

(2) Reassemble the equipment and place it on a clean surface and air dry on PFC-free polyethylene plastic sheeting.

(3) Equipment rinsates will be collected from decontaminated equipment daily to provide a QC check on the decontamination procedure above. At least one field blank (source water used in the decontamination procedure) will be collected in the beginning of the investigation and analyzed for all target compounds.

Investigation Derived Waste Management. IDW will be produced during the site investigation. The soil boring, well installation, and sampling efforts will produce various types of IDW including soil cuttings, used personal protective equipment (PPE), purge water, and decontamination water. State and federal regulations require waste generators to determine if a waste is hazardous. Soil cuttings, purge water, and development water generated during drilling operations may potentially be classified as hazardous waste.

Waste generated during the field operations will be representatively sampled and analyzed to determine the hazard classification prior to transport offsite. The waste profiling (waste classification determination) will be based on the results of the soil or water sample analyses as appropriate.

Several waste streams may result from the pre-design site characterization field effort, performance monitoring well installations, and groundwater sampling activities such as:

- *Solid Waste.* The drilling effort will produce soil cuttings, which will be stored temporarily in an appropriate container. Used PPE also will be contained in drums. The soil analytical results from samples will be used to characterize the waste prior to disposal.
- *Liquid Waste.* The decontamination, groundwater sampling, and well development activities will produce wastewater, which will be stored temporarily in an appropriate container. The wastewater will be sampled and analyzed prior to disposal.
- *Sampling Materials and PPE.* Used disposable sampling materials (e.g., tubing, bladders, string, bailers, etc.) and PPE during groundwater sampling activities.
- Inert or non-hazardous solid waste (refuse).

All IDW will be removed from the site and disposed of properly. Original copies of any manifests and disposal notification forms will be provided to the transporter for shipment. Copies of waste manifests and receipts for the disposal of wastes will be retained.

14.11 Quality Control Requirements

Media-specific field QC samples including matrix spike/matrix spike duplicates (MS/MSDs) will be used to measure total process performance. QA is an integrated system of activities in the area of quality planning, assessment, and improvement to provide the project with a measurable assurance that the established standards of quality are met. QC checks, including both field and laboratory, are specific operational techniques and activities used to fulfill the QA requirements. Worksheets #12 and #28 summarize the collection frequencies for the various field and laboratory QC samples, respectively. QC tasks that will be completed for this project are as follows:

Field Quality Control. The field QC samples will be assigned unique sample numbers and will be submitted to the analytical laboratory. If abnormalities are detected in field QC samples, the data associated with the QC samples will be flagged and appropriate actions will be taken to rectify issues.

Field Duplicate Samples. Field duplicate/replicate samples will be collected at a rate of 10% of the total number of samples. If fewer than 10 samples are collected, one duplicate sample will be collected. For all water samples, duplicate samples will be collected by retaining consecutive samples from the sampling device.

Equipment Rinsate Blanks. Equipment rinsate blanks will be collected daily during sampling to ensure that non-dedicated sampling devices have been decontaminated effectively. Equipment rinsate blanks will consist of the same DI water used in the final step of the sampling equipment decontamination procedure. Rinsate samples will be collected at a frequency of one per day during sampling events.

Trip Blanks. Trip blanks are hydrochloric acid-preserved organic-free water prepared by the fixed-base laboratory in 40-mL volatile organic analysis vials that will be carried into the field, stored with the samples, and returned to the laboratory for CVOC analysis. Trip blanks will be used to determine whether samples have been cross contaminated with CVOCs during sample collection and transportation. Because trip blanks pertain only to VOCs, the vial must be free of any headspace. Trip blanks will be provided in each cooler and analyzed for VOCs for each shipment of samples sent to the fixed-base laboratory.

Source Blanks. Source blanks are collected to ensure that water used during decontamination is not a source of contamination. Source blank samples will be collected at a frequency of one for each source of water used for equipment rinsate blanks (for the duration of the sampling). If the source for decontamination water changes, additional source blank samples will be collected. To prepare source blanks, the sample containers will be filled with source water at the same time that it is used for decontamination.

Temperature Blanks. Temperature blank samples will accompany each cooler that contains samples with a temperature preservative requirement. The temperature blank will be prepared either by the analytical laboratory or the field sampling crew by filling volatile organic analysis vials with DI water. The temperature of the samples will be verified upon arrival at the analytical laboratory using the temperature blank.

Laboratory Quality Control. Laboratory QC is addressed through the analysis of laboratory QC samples, documented internal and external laboratory QC practices, and laboratory audits. The types of laboratory QC samples will be project/chemical specific, but may include laboratory control samples (LCSs), laboratory duplicates, MSs, surrogate standards, internal standards, method blanks, and instrument blanks. MSs, MSDs, and LCSs are analyzed for every batch of up to 20 samples and serve as a measure of analytical accuracy. Surrogate standards are added to all samples, blanks, MSs, MSDs, and LCSs which are analyzed for organic compounds to evaluate the method's accuracy and to help determine matrix interferences. Definitions of each type of laboratory QC sample are listed in the following subsections. For laboratory measurements, if any of the QC checks are outside the acceptance criteria, corrective actions will be taken based on procedures in the Laboratory Quality Assurance Plan (LQAP).

Laboratory Control Samples. LCSs include blank spikes and blank spike duplicates. Blank spike samples are designed to check the accuracy of the laboratory analytical procedures by measuring a known concentration of an analyte in the blank spike samples. Blank spike duplicate samples are designed to check laboratory accuracy and precision of the analytical procedures by measuring a known concentration

of an analyte in the blank spike duplicate sample. Blank spike and blank spike duplicate samples are prepared by the laboratory using clean laboratory matrices spiked with the same spiking compounds used for matrix spikes at levels approximately 10 times greater than the MDL. LCSs will be processed with each analytical batch consisting of 20 samples or less.

Laboratory Duplicates. Laboratory duplicates are two aliquots of a sample taken from the same sample container under laboratory conditions and analyzed independently. The analysis of laboratory duplicates allows the laboratory to measure the precision associated with laboratory procedures. Laboratory duplicate samples will be processed with each analytical batch consisting of 20 samples or less.

Matrix Spikes. MS and MSD samples are designed to check the precision and accuracy of the analytical methods through the analysis of a field sample with a known amount of analyte added. Additional sample volume for MS and MSD samples is collected in the field in the same manner as field duplicate samples. In the laboratory, two portions of the sample are spiked with a standard solution of target analytes. MS and MSD samples are analyzed for the same parameters as the field samples, and analytical results will be evaluated for precision and accuracy of the laboratory process and effects of the sample matrix. A minimum of one MS/MSD will be analyzed each day that field samples are analyzed at a rate of one per 20 field samples or one per batch, whichever is more frequent.

Surrogate Standards. Surrogates are chemical compounds with properties that mimic analytes of interest, but that are unlikely to be found in environmental samples. Surrogates will be added to all field and QC samples analyzed for volatiles, analyzed by gas chromatography (GC) or GC/mass spectroscopy (GC/MS) to assess the recovery of the laboratory process, and to detect QC problems. The concentration and type of the surrogates used will be based on the LQAP.

Internal Standards. Like the surrogate standard, an internal standard is a chemical compound, unlikely to be found in environmental samples, that is added as a reference compound for sample quantification. Internal standard procedures are used for the analysis of volatile organics and extractable organics using GC/MS and also can be used for other GC and high-performance liquid chromatography analytical methods. The concentration and type of the internal standards used will be based on the LQAP.

Method Blanks. Method blanks are designed to detect contamination of field samples that may occur in the laboratory. Method blanks verify that method interference caused by contaminants in solvents, reagents, glassware, and other sample processing hardware are known and minimized. A minimum of one method blank will be analyzed each day that field samples are analyzed at the rate of 1 per 20 field samples. A method blank must be analyzed daily. The concentration of the target compounds in the method blank sample must be less than five times the MDL. If the blank is not under the specified limit, the source contamination is to be identified and corrective actions taken.

14.12 Data Management and Review Tasks

Field Documentation. All field observations and laboratory results will be linked to a unique sample location through the use of the sample ID system. Field observations and measurement data will be recorded on the field forms and in a field logbook to provide a permanent record of field activities. All data that are hand entered will be subjected to a review by a second person to minimize data entry errors. A check for completeness of field records (logbooks, field forms, databases, and electronic spreadsheets) will ensure that all requirements for field activities have been fulfilled, complete records exist for each activity, and the procedures specified in this SAP have been implemented. Field documentation will ensure sample integrity and provide sufficient technical information to recreate each field event.

Complete and accurate documentation is essential to demonstrate that field sampling procedures were carried out as described in this SAP. Field activities will be documented using standard forms including, but not limited to, sample labels, COC forms and sampling forms.

A project-specific field logbook will be used to provide daily records of significant events, observations, and measurements during field investigations. The field logbook also will be used to document all sampling activities. All logbook entries will be made with indelible ink to provide a permanent record. Logbooks will be kept in the possession of the field supervisor during the on-site work and all members of the field team will have access to the notebook. These notebooks will be maintained as permanent records. Any errors found in the logbook will be verified, crossed through, and initialed by the person discovering the error.

The field logbooks are intended to provide sufficient data and observations to reconstruct events that occurred during field activities. Field logbooks should be permanently bound and pre-paginated; the use of designated forms should be used whenever possible to ensure that field records are complete. The following items are examples of information that may be included in a field logbook:

- Name, date, and time of entry
- Names and responsibilities of field crew members
- Name and titles of any site visitors
- Descriptions of field procedures, and problems encountered
- Number and amount of samples taken at each location
- Details of sampling location, including sampling coordinates
- Sample identification numbers of all samples collected
- Date and time of collection
- Sample collector
- Sample collection method
- Decontamination procedures
- Field instrument calibration and maintenance
- Field measurements (e.g., CVOCs by PID) and general observations.

Analytical Data Documentation. Analytical data generated by the fixed-base laboratory will be reviewed by the laboratory using three levels of document review and reporting. Review processes will be documented using appropriate checklists, forms or logbooks that will be signed and dated by the reviewer. Electronic copies of the analytical data will be stored at Battelle as described below.

Data Transfer. Data will be incorporated into tables, graphs or other visuals. These data will be incorporated into Draft and Final Summary Reports. For samples collected and analyzed as part of the project, analytical results are required to be delivered in Adobe® pdf and electronic data deliverable (EDD) formats. An automated laboratory information management system (LIMS) must be used to produce the electronic copy. The laboratory will verify the electronic data files before they are issued. Data will be delivered in a format compatible with Naval Electronic Data Deliverable (NEDD).

Assessment/Audit Tasks. During project activities, ongoing assessments will include peer review, QC reviews, audits of field operations using the Field Audit Checklist (Attachment 14-1), checks to see that project personnel have read appropriate planning documents and are following documented procedures, and reviews to ensure that clearance activities and preliminary work have been satisfactorily completed.

Data Review Tasks: All analytical data generated in support of this project will be reviewed internally by the laboratory prior to reporting, to ensure the validity of reported data. This internal laboratory process will consist of data reduction and three levels of document review. As the analytical data are received at Battelle, the project manager will compare the generated data with the project goals and objectives to ensure that project DQOs can be met by the data. Data review and validation will also be performed by a third-party data validation company. As previously mentioned, the data will be validated at 90% EPA Level III and 10% EPA Level IV.

Data Storage and Transmittal to NIRIS: The data will be submitted electronically to the Naval Installation Restoration Information Solution (NIRIS) database via NEDD. Battelle will maintain electronic copies of all sampling forms, COC forms, analytical data and NEDD.

All field and analytical data in electronic format will be stored at Battelle in project file directories, which are backed up daily on magnetic tape for long-term storage for at least 10 years. Field documentation will be stored at the field site while in use. At the conclusion of the project, paper and electronic records will be transferred to Battelle's Records Management Office for secure storage. The archival period for project-related records in the Records Management Office is 10 years after record accession.

All relevant raw data and documentation including, but not limited to, logbooks, data sheets, electronic files and final reports will be maintained by the laboratory for at least 10 years.

14.13 Third-Party Data Validation

Data Validation. Data generated for this project will be reviewed and verified by the Battelle QAO and validated by an independent outside reviewer. Only fixed-base laboratory samples will be validated. Data verification involves the process of generating qualitative and quantitative sample information through observations, field procedures, analytical measurements, and calculations. The data verification and reporting process for the field data involves ensuring that blank samples and field duplicates defined in this SAP are within the acceptance criteria. The verification process for the laboratory data involves ensuring that the holding times, precision, accuracy, laboratory blanks, and detection limits are within the acceptance criteria outlined in this SAP.

The field and laboratory personnel will provide the Battelle QAO with all the data. The Battelle QAO will be responsible for the overall review of the data verification results for compliance with the specified DQOs. Data verification tasks include confirmation that laboratory sample receipt forms match COC documentation and logbook entries. The sampling data will be validated by an independent third-party. For this project, a 10% EPA Level IV and 90% EPA Level III data validation strategy will be implemented.

Level III Validation. EPA Level III begins the process of data validation and includes assessment of all the results reported in the standard data package. Qualifiers are issued at Level III and above. For Level III data validation, the data values for routine and QC samples are generally assumed to be correctly reported by the laboratory. Data quality will be assessed by comparing the QC parameters to the appropriate criteria (or limits) as specified in this SAP, by Contract Laboratory Program (CLP) requirements, or by method-specific requirements (e.g., CLP, SW-846). If calculations for quantitation are verified, it is done on a limited basis and may require raw data in addition to the standard data forms normally present in a data package.

Level IV Validation. Level IV data validation constitutes the most extensive review and includes re-quantification of reported QC and field sample values using the raw data files. Level IV data validation follows the EPA protocols and CLP criteria set forth in the functional guidelines for evaluating organic

analyses (EPA, 2008). These guidelines apply to analytical data packages that include the raw data (e.g., spectra and chromatograms) and backup documentation for calibration standards, analysis run logs, LCS, dilution factors, and other types of information. This additional information is utilized in the Level IV data validation process for checking calculations of quantified analytical data. Calculations are checked for lab QC samples (e.g., MS/MSD and LCS data) and routine field samples (including field duplicates, field and equipment rinsate blanks, and VOC trip blanks). To ensure that detection limit and data values are accurate and appropriate, an evaluation is made of instrument performance, calibration methods, and the original data for calibration standards.

Data Qualifiers. Analytical data may be qualified based on data validation reviews. Qualifiers will be consistent with the applicable EPA functional guidelines and will be used to provide data users with an estimate of the level of uncertainty associated with the result "flagged." Data validation results will be evaluated with respect to the attached qualifiers to determine data usability issues, if any. The following qualifiers may be assigned during the validation process:

- J – estimated concentration
- R – rejected value (unusable)
- U – not detected (e.g., not present based on blank contamination)
- UJ – sample detection limit is estimated.

For any instances where the validation qualifiers impact the overall data interpretation and project recommendations, the data quality assessment will present the issue and the necessary corrective action.

14.14 Data Storage and Archiving

All field and analytical data in electronic format will be stored at Battelle in project file directories, which are backed up daily on magnetic tape for long-term storage for at least 10 years. At the conclusion of the project, paper and electronic records will be transferred to Battelle's Records Management Office for secure storage. The archival period for project-related records in the Records Management Office is 10 years after record accession.

All relevant raw data and documentation including, but not limited to, logbooks, data sheets, electronic files and final reports will be maintained by the analytical laboratory for at least 10 years. The laboratory will obtain approval from the Navy for the destruction of records at the end of the storage period.

Attachment 14-1: Field Audit Checklist

Site Name: Former NAWC Warminster Date:_____

Checklist Completed by: _____ Reviewed by: _____
signature date initials date

Samples in proper container/bottle?	Yes ☐	No ☐
Sample containers intact?	Yes ☐	No ☐
Sufficient sample volume?	Yes ☐	No ☐
Was a matrix spike/matrix spike duplicate (MS/MSD) collected today?	Yes ☐	No ☐
COC agrees with sample labels?	Yes ☐	No ☐
Placed bagged ice in cooler?	Yes ☐	No ☐
Temperature blank in cooler?	Yes ☐	No ☐
COC signed when received and relinquished?	Yes ☐	No ☐
COC taped to the inside of cooler lid?	Yes ☐	No ☐
Checked that drain plug is taped over and taped up cooler?	Yes ☐	No ☐
Filled out FedEx Form and attached to cooler? (Retain copy for records and tracking)	Yes ☐	No ☐
Notified Lab of # of coolers and # samples and tracking #?	Yes ☐	No ☐

Number of samples collected today:_____

Number of QC samples collected today: _____

Document any modifications to sampling procedures or problems that occurred:
_____
_____

POC:	Role:	Phone Number:
Andrew Barton	Battelle PM	412-427-7030
Carolyn Scala	Battelle FS	215-504-5003
Jennifer Good	H&S Environmental FS	508-614-8668

SAP Worksheet #15-1 -- Reference Limits and Evaluation Table
(UFP-QAPP Manual Section 2.8.1)

Matrix: Soil
Analytical Group: PFCs

Analyte	CAS Number	Project Action Limit (µg/kg)	Project Action Limit Reference	Project Quantitation Limit Goal (µg/kg)	Laboratory-Specific		
					LOQ (µg/kg)	LOD (µg/kg)	DL (µg/kg)
Perfluorooctanoic acid (PFOA)	335-67-1	67,000	SL	13	13	10	5
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	27,000	SL	13	13	10	5
Perfluorononanoic acid (PFNA)	375-95-1	NE	NE	13	13	10	5.8
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	NE	NE	13	13	10	5
Perfluoroheptanoic acid (PFHpA)	375-85-9	NE	NE	13	13	10	5
Perfluorobutanesulfonic acid (PFBS)	375-73-5	NE	NE	13	13	10	5

SL: Child recreator screening level values calculated by the Navy and Marine Corps Public Health Center.
NE: Not established
LOQ = limit of quantitation
LOD = limit of detection
DL = detection limit

SAP Worksheet #15-2 -- Reference Limits and Evaluation Table
(UFP-QAPP Manual Section 2.8.1)

Matrix: Sediment
Analytical Group: PFCs

Analyte	CAS Number	Project Action Limit (µg/kg)	Project Action Limit Reference	Project Quantitation Limit Goal (µg/kg)	Laboratory-Specific		
					LOQ (µg/kg)	LOD (µg/kg)	DL (µg/kg)
Perfluorooctanoic acid (PFOA)	335-67-1	67,000	SL	13	13	10	5
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	27,000	SL	13	13	10	5
Perfluorononanoic acid (PFNA)	375-95-1	NE	NE	13	13	10	5.8
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	NE	NE	13	13	10	5
Perfluoroheptanoic acid (PFHpA)	375-85-9	NE	NE	13	13	10	5
Perfluorobutanesulfonic acid (PFBS)	375-73-5	NE	NE	13	13	10	5

SL: Child recreator screening level values calculated by the Navy and Marine Corps Public Health Center.
NE: Not established

SAP Worksheet #15-3 -- Reference Limits and Evaluation Table
(UFP-QAPP Manual Section 2.8.1)

Matrix: Groundwater (including water from private wells)
Analytical Group: PFCs

Analyte	CAS Number	Project Action Limit (µg/L)	Project Action Limit Reference	Project Quantitation Limit Goal (µg/L)	Laboratory-Specific		
					LOQ (µg/L)	LOD (µg/L)	DL (µg/L)
Perfluorooctanoic acid (PFOA)	335-67-1	0.4	PHA value	0.04	0.020	0.016	0.008
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	0.2	PHA value	0.02	0.020	0.016	0.008
Perfluorononanoic acid (PFNA)	375-95-1	NE	NE	0.020	0.020	0.016	0.008
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	NE	NE	0.020	0.020	0.016	0.008
Perfluoroheptanoic acid (PFHpA)	375-85-9	NE	NE	0.020	0.020	0.016	0.008
Perfluorobutanesulfonic acid (PFBS)	375-73-5	NE	NE	0.020	0.020	0.016	0.008

PHA value: EPA Office of Water developed PHA values for PFOA and PFOS to protect against potential risk from exposure to these chemicals through drinking water (EPA, 2009).
NE: Not established

SAP Worksheet #15-4 -- Reference Limits and Evaluation Table
(UFP-QAPP Manual Section 2.8.1)

Matrix: Surface Water
Analytical Group: PFCs

Analyte	CAS Number	Project Action Limit (µg/L)	Project Action Limit Reference	Project Quantitation Limit Goal (µg/L)	Laboratory-Specific		
					LOQ (µg/L)	LOD (µg/L)	DL (µg/L)
Perfluorooctanoic acid (PFOA)	335-67-1	526	SL	0.04	0.020	0.016	0.008
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	730	SL	0.02	0.020	0.016	0.008
Perfluorononanoic acid (PFNA)	375-95-1	NE	NE	0.020	0.020	0.016	0.008
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	NE	NE	0.020	0.020	0.016	0.008
Perfluoroheptanoic acid (PFHpA)	375-85-9	NE	NE	0.020	0.020	0.016	0.008
Perfluorobutanesulfonic acid (PFBS)	375-73-5	NE	NE	0.020	0.020	0.016	0.008

SL: Child recreator screening level values calculated by the Navy and Marine Corps Public Health Center.
NE: Not established

SAP Worksheet #15-5 -- Reference Limits and Evaluation Table
(UFP-QAPP Manual Section 2.8.1)

Matrix: Surface Water (from sumps)
Analytical Group: CVOCs

Analyte	CAS Number	Project Action Limit (µg/L)	Project Action Limit Reference	Project Quantitation Limit Goal (µg/L)	Laboratory-Specific		
					LOQ (µg/L)	LOD (µg/L)	DL (µg/L)
Carbon tetrachloride	56-23-5	5	MCL	0.05	1	0.5	0.4
Tetrachloroethene (PCE)	127-18-4	5	MCL	0.05	1	0.5	0.26
Trichloroethene (TCE)	79-01-6	5	MCL	0.05	1	0.5	0.3
cis-1,2-Dichloroethene	156-59-2	70	MCL	0.7	1	0.5	0.22
trans-1,2-Dichloroethene	156-60-5	100	MCL	1	1	0.5	0.21
Vinyl chloride	75-01-4	2	MCL	0.02	1	0.5	0.25

MCL: available at http://water.epa.gov/drink/contaminants/index.cfm

SAP Worksheet #15-6 -- Reference Limits and Evaluation Table
(UFP-QAPP Manual Section 2.8.1)

Matrix: Air
Analytical Group: CVOCs

Analyte	CAS Number	Project Action Limit (µg/m^3)[1]	Project Action Limit Reference	Project Quantitation Limit Goal (µg/m^3)	Laboratory-Specific		
					LOQ (µg/m^3)	LOD (µg/m^3)	DL (µg/m^3)
Carbon tetrachloride	56-23-5	0.47[2]/4.7	VISL	0.47	1.3	0.25	0.16
Tetrachloroethene (PCE)	127-18-4	11/110	VISL	11	0.27	0.27	0.25
Trichloroethene (TCE)	79-01-6	0.48/4.8	VISL	0.48	0.21	0.21	0.16
cis-1,2-Dichloroethene	156-59-2	NE	NE	0.81	0.81	0.16	0.10
trans-1,2-Dichloroethene	156-60-5	NE	NE	0.81	0.81	0.16	0.10
Vinyl chloride	75-01-4	0.17[2]/1.7	VISL	0.17	0.52	0.10	0.08

NE: Not established
[1] Project action limits for indoor air samples/ambient background and sub-slab air samples.
[2] Project action limit is the LOQ because that is the lowest achievable limit for the analyte.
VISL: EPA Vapor Intrusion Screening Level (VISL) using VISL Calculator Version 3.3.1; May 2014, available at http://www.epa.gov/oswer/vaporintrusion/guidance.html

SAP Worksheet #16 -- Project Schedule/Timeline Table
(UFP-QAPP Manual Section 2.8.2)

Activities	Organization	Dates		Deliverable	Deliverable Due Date
		Anticipated Date(s) of Initiation	Anticipated Date of Completion		
Monitoring well installation and well development	H&S, Battelle	November 2015	June 2016	RI Report	September 2016
Soil Sampling	H&S, Battelle	November 2015	June 2016	RI Report	September 2016
Surface water sampling	H&S, Battelle	November 2015	June 2016	RI Report	September 2016
Sediment sampling	H&S, Battelle	November 2015	June 2016	RI Report	September 2016
Groundwater sampling	H&S, Battelle	November 2015	June 2016	RI Report	September 2016
Vapor sampling	H&S, Battelle	June 2015	January 2016	RI Report	September 2016
Private well sampling	H&S, Battelle	November 2016	December 2016	RI Report; Semiannual LTM Reports	September 2016; December 2016

SAP Worksheet #17 -- Sampling Design and Rationale

(UFP-QAPP Manual Section 3.1.1)

The primary objective of sample collection for this project is to:

(1) Delineate source(s) and extent of PFCs (primarily PFOS and PFOA).
(2) Evaluate the human health risk from VI in structures adjacent to the dissolved CVOC plume using samples from ambient background air, indoor air, and sub-slab locations.

The sampling design is described below and is based on the two primary objectives stated above.

PFCs in Private Wells

Up to 25 private drinking water well locations will be selected for additional sampling based on results of the EPA sampling effort within Zones 1 through 3 and the results of the initial PFC sampling in Areas A and D (see Figure 9), with the goal of delineating the extent of the PFC plume. These wells will be sampled quarterly for one year to evaluate trends in PFC concentrations over time.

PFC Source and Extent Delineation

Figure 11 shows the proposed sampling locations for surface water and sediment, Figure 12 shows the proposed groundwater sampling locations, and Figure 13 shows the proposed soil sampling locations. The groundwater, surface water, soil, and sediment samples collected will be analyzed for PFCs. Surface water locations inside Area C buildings may be sampled for select CVOCs in addition to PFCs. Field measurements of physical and geochemical parameters also will be conducted. The data from sampling will help identify PFC source(s) and the extent of the plume at the former NAWC Warminster.

- ***Soil.*** Unsaturated shallow soil samples (up to 48) will be collected and analyzed for PFCs (via EPA Method 537). Soil samples will be collected from potential PFC source areas (see Figure 13), with actual sample depths determined in the field during installation, with a maximum soil sample depth of 20 ft bgs. A minimum of one soil sample will be collected from each 5-ft depth interval, with a maximum of four soil samples collected from each location.
- ***Surface Water.*** Surface water samples will be collected from up to 59 readily accessible surface water locations, including intermittent/permanent streams, catchment basins and surface water retention ponds, areas where overland runoff has been observed, areas of observed/ suspected groundwater discharge, and from wastewater and treatment system discharge locations, as shown in Figure 11 and described in Worksheet 14. These samples will be analyzed for PFCs (via EPA Method 537). Up to three additional locations may instead be sumps within the structures evaluated for VI that would be analyzed for select CVOCs (via EPA Method 8260B) in addition to PFCs. Several surface water samples will be collected immediately downstream of the GWETS discharge line.
- ***Sediment.*** Sediment samples will be collected from up to 30 readily accessible locations collocated with 30 of the surface water sampling locations (see Figure 11) referenced above. These samples will be analyzed for PFCs (via EPA Method 537). A sediment sample collocated with the surface water sample collected immediately downstream of the GWETS discharge line will be collected.
- ***Groundwater.*** Up to 40 new monitoring wells will be installed at the former NAWC Warminster in 23 locations (17 nested wells) upgradient and downgradient of the potential PFC source areas, with actual locations based on the CSM, the source evaluation report, and recent PFC data collected from on-site monitoring wells and nearby private supply wells (see Figure 12). Groundwater samples will be collected from these new monitoring wells and sampled for PFCs. In addition, groundwater samples collected from up to 58 existing monitoring and extraction wells will be analyzed for PFCs (using EPA Method 537) (see Figures 6, 7, and 12), with the goal

of delineating the PFC plume. A description of the location and purpose of the proposed new monitoring wells is provided in the following table:

Fig ID[1]	Well ID	Location	Purpose
1	HN-107S/I	Area B	Downgradient of Sites 5, 6, and 7
2	HN-108S/I	Area B	Delineate PFCs on east edge of former NAWC Warminster
3	HN-109S/I	Area B	Downgradient of Sites 5, 6, and 7
4	HN-110	Area B	Downgradient of Sites 5, 6, and 7
5	HN-111	Area B	Downgradient of Sites 5, 6, and 7
6	HN-112	Area B	Downgradient of Sites 5, 6, and 7
7	HN-113	Area B	Downgradient of Sites 5, 6, and 7
8	HN-114	Area B	Downgradient of Sites 5, 6, and 7
9	HN-115	Area B	Downgradient of Sites 5, 6, and 7
10	HN-116S/I	Area C	Upgradient of Site 8 and former structure S-1
11	HN-117S/I	Area C	Downgradient of Site 8
12	HN-118S/I	Area C	Upgradient of Site 4
13	HN-119S/I	Area C	Downgradient of Site 4; located between elevated PFC detections in private water supply wells
14	HN-120S/I	Area C	Downgradient of Site 4
15	HN-121S/I	Area C	Downgradient of Site 4 and former runway; upgradient of elevated PFC detections in private water supply wells.
16	HN-122S/I	Area C	Downgradient of potential PFC sources
17	HN-123S/I	Area C	Downgradient of potential PFC sources
18	HN-124S/I	Perimeter	Delineate PFCs in south central portion of former NAWC Warminster
19	HN-125S/I	Bldg 134	Delineate potential PFC source
20	HN-126S/I	Bldg 90	Delineate potential PFC source
21	HN-127S/I	Perimeter	Delineate PFCs in southwestern portion of former NAWC Warminster
22	HN-128S/I	Perimeter	Delineate PFCs in southwestern portion of former NAWC Warminster south of Area D
23	HN-129S/I	Area B	Downgradient of Sites 5, 6, and 7

1. See Figures 12, 12a, 12b, and 12c for well location IDs.
S = Shallow depth well to be screened at a water-bearing fracture between the water table and 50 ft bgs.
I = Intermediate depth well to be screened at a water-bearing fracture between 50 and 90 ft bgs.

It should be noted that the actual location of these wells is subject to change based on site conditions and is contingent upon obtaining access agreements with property owners.

Evaluation of Vapor Intrusion

Air samples from sub-slab, indoor, and ambient background locations will be collected and analyzed for evaluation of select CVOCs to support a VI evaluation at Area C that satisfies the follow-up action from the five-year review. Figure 10 shows the proposed structures that were identified for vapor sampling. Air samples will be collected over an 8-hour period using 6-L Summa canisters that have been cleaned and certified by the analytical laboratory. Up to two rounds of sampling will be performed during the indoor heating season with target dates established in consultation with EPA and PADEP. The proposed sampling locations are as follows:

- Gilda's Club – 10 locations
  - 1 indoor air sample from sub-basement
  - 2 indoor air samples from basement; one sample from each room

  - 3 indoor air samples from first floor; one sample each from the two meeting rooms and the office
  - 1 indoor air sample from second floor
  - 1 indoor air sample from third floor
  - 2 sub-slab air samples from the basement; one sample each from the radon vent pipe and a second vent pipe in the basement storage room
- Outbuilding – 3 locations
  - 1 indoor air sample from first floor
  - 2 sub-slab samples from beneath the first floor; one sample each from the office and meeting rooms
- Ambient Air – 1 location
  - 1 ambient air sample from upwind location within perimeter of Gilda's Club property

Indoor air samplers will be placed on the floor in the center of the room where the occupants spend the majority of their time (i.e., the room where potential VI would pose the greatest risk). Schematic drawings of Gilda's Club and the associated outbuilding are provided in Figures 14 through 16.

SAP Worksheet #18 -- Sampling Locations and Methods/SOP Requirements Table
(UFP-QAPP Manual Section 3.1.1)

Sampling Location / ID Number	Matrix	Monitored Interval (ft bgs)	Analytical Group	Number of Samples	Sampling SOP Reference
WMA-13	Groundwater	NA	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-25(S)	Groundwater	26-49	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-25(I)	Groundwater	69-82	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
OB-13	Groundwater	20-175	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
R-9	Groundwater	30-40	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
OB-11	Groundwater	20-156	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
EW-C16	Groundwater	18-143	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-45(I)	Groundwater	55-75	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
EW-C17	Groundwater	22-127	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-24(D)	Groundwater	0-117	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-24(S)	Groundwater	45-65	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-24(I)	Groundwater	95-115	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-47(P)	Groundwater	47-122	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-44	Groundwater	37-122	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-46(S)	Groundwater	29-38	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-46(I)	Groundwater	64-81	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
DG-14	Groundwater	18-46	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
EW-C18	Groundwater	25-115	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
EW-C19	Groundwater	25-100	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
EW-C20	Groundwater	18-83	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
EW-C21	Groundwater	25-70	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
R-4	Groundwater	25-40	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
SW-7	Groundwater	NA	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
BG-05A	Groundwater	20-75	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-27(S)	Groundwater	18-52	PFCs	1	NAWC-SOP-03, NAWC-SOP-01

SAP Worksheet #18 -- Sampling Locations and Methods/SOP Requirements Table (Continued)

Sampling Location / ID Number	Matrix	Monitored Interval (ft bgs)	Analytical Group	Number of Samples	Sampling SOP Reference
HN-105(S)	Groundwater	18-75	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-23A	Groundwater	40-60	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-103(S)	Groundwater	22-51	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-28(S)	Groundwater	53-68	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-20(S)	Groundwater	76-96	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-42(S)	Groundwater	52-65	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-42(I)	Groundwater	81-111	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-53(S)	Groundwater	40-60	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-53(I)	Groundwater	69-83	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-53(D)	Groundwater	189-206	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-54(S)	Groundwater	55.5-71	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-54(I)	Groundwater	107-124	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-73(S)	Groundwater	42-52	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-73(I)	Groundwater	58-72	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-73(D)	Groundwater	115-130	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-74(S)	Groundwater	54-71	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-74(I)	Groundwater	79-103	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
OW-D10	Groundwater	15-92	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-82S	Groundwater	40-56	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
MW-04	Groundwater	22-60	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-17(S)	Groundwater	84-102	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-17(I)	Groundwater	185-202	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-19(S)	Groundwater	30-44	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-19(I1)	Groundwater	138-155	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-19(I2)	Groundwater	87-110	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-52(S)	Groundwater	73-87	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-52(I)	Groundwater	115-132	PFCs	1	NAWC-SOP-03, NAWC-SOP-01

SAP Worksheet #18 -- Sampling Locations and Methods/SOP Requirements Table (Continued)

Sampling Location / ID Number	Matrix	Monitored Interval (ft bgs)	Analytical Group	Number of Samples	Sampling SOP Reference
HN-52(D)	Groundwater	178-194	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-16(S)	Groundwater	51-65	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-16(I)	Groundwater	101-120	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-50(S)	Groundwater	67-83	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-50(I)	Groundwater	105-122	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-50(D)	Groundwater	160-174	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
SED1 through SED30	Sediment	0-2	PFCs	30	NAWC-SOP-05, NAWC-SOP-01
SW1 through SW59	Surface water	NA	PFCs, CVOCs[1]	59	NAWC-SOP-04, NAWC-SOP-01
HN-107S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-107I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-108S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-108I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-109S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-109I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-110[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-111[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-112[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-113[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-114[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-115[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-116S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-116I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-117S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-117I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-118S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-118I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-119S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-119I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01

SAP Worksheet #18 -- Sampling Locations and Methods/SOP Requirements Table (Continued)

Sampling Location / ID Number	Matrix	Monitored Interval (ft bgs)	Analytical Group	Number of Samples	Sampling SOP Reference
HN-120S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-120I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-121S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-121I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-122S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-122I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-123S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-123I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-124S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-124I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-125S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-125I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-126S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-126I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-127S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-127I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-128S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-128I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-129S[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
HN-129I[2]	Groundwater	TBD	PFCs	1	NAWC-SOP-03, NAWC-SOP-01
PW-1 through PW-25	Groundwater	TBD	PFCs	100	NAWC-SOP-03, NAWC-SOP-01
S1 through S48	Soil	TBD	PFCs	48	5-362-01, NAWC-SOP-01
AIR-AB1	Air	NA	CVOCs	1	NAWC-SOP-06
AIR-GIL-INDOOR1 through AIR-GIL-INDOOR8	Air	NA	CVOCs	8	NAWC-SOP-06
AIR-GIL-SUBSLAB1 through AIR-GIL-SUBSLAB2	Air	NA	CVOCs	2	NAWC-SOP-06

SAP Worksheet #18 -- Sampling Locations and Methods/SOP Requirements Table (Continued)

Sampling Location / ID Number	Matrix	Monitored Interval (ft bgs)	Analytical Group	Number of Samples	Sampling SOP Reference
AIR-OUT-INDOOR1	Air	NA	CVOCs	1	NAWC-SOP-06
AIR-OUT-SUBSLAB1 through AIR-OUT-SUBSLAB2	Air	NA	CVOCs	2	NAWC-SOP-06

NA: not applicable
TBD: to be determined
[1] It is assumed that up to three of these locations may instead be sumps within residential/commercial buildings that would be analyzed for CVOCs in addition to PFCs.
[2] HN-107 through HN-129 are designated as proposed Well 1 through 23, respectively, in Worksheet 17 and on Figure 12.

SAP Worksheet #19 -- Analytical SOP Requirements Table

(UFP-QAPP Manual Section 3.1.1)

Matrix	Analytical Group	Analytical and Preparation Method/ SOP Reference	Containers (number, size, and type)	Sample Volume	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/ analysis)
Groundwater	PFCs	U.S. EPA Method 537MOD/ SOP# OP058/MS014	2, 125 mL, Polyethylene	125 ml	chilled to ≤ 10ºC for shipping, stored at ≤ 6ºC	14 days to extract, 28 days to analyze
Soil	PFCs	U.S. EPA Method 537MOD/ SOP# MS014	2, 125 mL, Polyethylene Wide Mouth	4 oz	chilled to ≤ 10ºC for shipping, stored at ≤ 6ºC	14 days to extract, 28 days to analyze
Surface water	PFCs	U.S. EPA Method 537MOD/ SOP# OP058/MS014	2, 125 mL, Polyethylene	125 ml	chilled to ≤ 10ºC for shipping, stored at ≤ 6ºC	14 days to extract, 28 days to analyze
Sediment	PFCs	U.S. EPA Method 537MOD/ MS014	2, 125 mL, Polyethylene Wide Mouth	4 oz	chilled to ≤ 10ºC for shipping, stored at ≤ 6ºC	14 days to extract, 28 days to analyze
Indoor/ Ambient Air	CVOCs	U.S.EPA Method TO-15/ SOP# EAT001(TO-15)	6 L Summa Canister	6L	keep at ambient	Analyze within 30 days
Sub-slab Air	CVOCs	U.S.EPA Method TO-15/ SOP# EAT001(TO-15)	6 L Summa Canister	6L	keep at ambient	Analyze within 30 days
Surface Water	CVOCs	U.S. EPA Method 8260B/ SOP#OP021/MS005	3x VOC vials	40 ml	pH <2 with HCl, cool to <6ºC	14 days to analysis

SAP Worksheet #20 -- Field Quality Control Sample Summary Table
(UFP-QAPP Manual Section 3.1.1)

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates (10%)	No. of MS/MSDs (5%)	No. of Field Blanks (1 per source)	No. of Equip. Blanks (1 per day)	No. of VOA Trip Blanks (1 per cooler)	Total No. of Samples to Lab
Groundwater	PFCs	110	11	5	2	16	6	150
Soil	PFCs	48	5	3	1	10	2	69
Surface water	PFCs	59	6	3	1	3	2	74
Sediment	PFCs	30	3	2	1	3	2	41
Drinking water	PFCs	25[1]	3	2	1	3	2	36
Indoor air	CVOCs	9[1]	1	0	0	0	0	10
Sub-slab air	CVOCs	4[2]	0	0	0	0	0	4
Ambient air	CVOCs	1[2]	0	0	0	0	0	1
Surface water	CVOCs	3	1	1	1	1	1	8

[1] Number of sampling locations per quarterly sampling event.
[2] Number of sampling locations per sampling event.

SAP Worksheet #21 -- Project Sampling SOP References Table

(UFP-QAPP Manual Section 3.1.2)

Reference Number	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
NAWC-SOP-01	Attachment A-Sampling Guidance for PFCs	Battelle	NA	Y	Project-specific
NAWC-SOP-02	Attachment B-Standard Operating Procedure for drilling and well development	Battelle, RAAB drilling	Hollow stem auger, rotating drill pipe, surge block	Y	Project-specific SOPs Attachment B1 – RAAB drilling Attachment B2 – HSA Drilling Attachment B3 – Air Rotary Drilling Attachment B4 – Well Development
5-362-01	Attachment C-Standard Operating Procedure for general soil sampling	Battelle	Encore® sampling device or similar	N	
NAWC-SOP-03	Attachment D-Standard Operating Procedure for groundwater sampling	Battelle	Submersible pump, bladder pump	Y	Project-specific
NAWC-SOP-04	Attachment E-Standard Operating Procedure for surface water sampling	Battelle	Polyethylene bailers	Y	Project-specific
NAWC-SOP-05	Attachment F-Standard Operating Procedure for sediment sampling	Battelle	Stainless steel scoop, corers	Y	Project-specific
NAWC-SOP-06	Attachment G-Standard Operating Procedure for Indoor air/sub slab Vapor Sampling	NJDEP EPA OSWER	Summa canister	Y	In accordance with NJDEP *Vapor Intrusion Guidance* and 2013 EPA OSWER vapor intrusion guidance document

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

(UFP-QAPP Manual Section 3.1.2.4)

Field Equipment	Activity	Frequency	Acceptance Criteria	Corrective Action	Resp. Person	SOP Reference	Comments
Solinst Interface Meter (for groundwater levels)	Maintenance	As needed. Decontaminate after each use.	Operational. Depress the battery test button to test the battery and circuitry.	In house repair or return to manufacturer	Battelle FS or Sampling Technician	Operator Manual and NAWC-SOP-03	Replace batteries as needed.
YSI Meter (for DO, pH, specific conductance, temperature, and ORP field readings)	Maintenance	Check daily. Rate of deposit build-up for anodes, cathodes, and surface of sensors. Check electrolyte solution and membrane cap every 30 days.	Reports criteria per calibration ranges.	In house repair or return to manufacturer	Battelle FS or Sampling Technician	Operator Manual and NAWC-SOP-03	Replace batteries as needed. Store sonde in calibration cup filled with pH 4.0 solution and sealed to prevent evaporation when not in use.
YSI Meter (for DO, pH, specific conductance, temperature, and ORP field readings)	Calibration	At the start of each sampling day and as needed throughout the day if needed. Factory calibration as specified by manufacturer.	Per manufacturer instrument specifications. Calibration ranges vary per parameter (DO, pH, specific conductivity, temperature, and ORP).	Recalibrate until within the acceptable range or return to manufacture for repair.	Battelle FS or Sampling Technician	Operator Manual and NAWC-SOP-03	Replace batteries as needed.

SAP Worksheet #22 -- Field Equipment Calibration, Maintenance, Testing, and Inspection Table (Continued)

Field Equipment	Activity	Frequency	Acceptance Criteria	Corrective Action	Resp. Person	SOP Reference	Comments
QED Micro Purge Control and Power Pack (for groundwater sampling)	Maintenance	Check various components (valves, regulators, gauges, and controller) daily per sampling event.	Pumping at required flow pressure and rate for sample recovery.	In house repair or return to manufacturer	Battelle FS or Sampling Technician	Operator Manual and NAWC-SOP-03	Replace batteries as needed.
QED Sample Pro Portable Purge Pump (for groundwater sampling)	Maintenance	Check bladders and gaskets daily and decontaminate after each use.	Pumping at required flow pressure and rate for sample recovery.	In house repair or return to manufacturer	Battelle FS or Sampling Technician	Operator Manual and NAWC-SOP-03	Various connecting parts and gaskets must fit and be in good working order. Inspect polyethylene tubing and bladders for leaks or wear. Decontaminate after each well sampled.
LaMotte 2020 Turbidity Meter (for turbidity)	Maintenance	As needed	Per manufacturer specifications	In house repair or return to manufacturer	Battelle FS or Sampling Technician	Operator Manual and NAWC-SOP-03	Replace batteries as needed.
LaMotte 2020 Turbidity Meter (for turbidity)	Calibration	At the start of each sampling day during calibration check. Factory calibration as specified by manufacturer.	Per manufacturer instrument specifications calibration ranges.	In house repair or return to manufacturer	Battelle FS or Sampling Technician	Operator Manual and NAWC-SOP-03	Replace batteries as needed.

SAP Worksheet #22 -- Field Equipment Calibration, Maintenance, Testing, and Inspection Table (Continued)

Field Equipment	Activity	Frequency	Acceptance Criteria	Corrective Action	Resp. Person	SOP Reference	Comments
Photovac MicroFID and MultiRAE Plus PID or equivalent (for measuring organic vapors during soil sampling)	Maintenance	Daily	Per manufacturer specifications. Instrument is clean of dust, dirt, and grease.	In house repair or return to manufacturer	Battelle FS or Sampling Technician	Operator Manual	Replace batteries as needed.
Photovac MicroFID and MultiRAE Plus PID or equivalent (for measuring organic vapors during soil sampling)	Calibration	At the start of each sampling day during calibration check. Factory calibration as specified by manufacturer.	Per manufacturer instrument specifications calibration ranges. ± 10% of standard gasses	In house repair or return to manufacturer	Battelle FS or Sampling Technician	Operator Manual	Replace batteries as needed.
MGD2002 or equivalent (for measuring helium during VI sampling leak detection)	Maintenance	Daily	Per manufacturer specifications. Instrument is clean of dust, dirt, and grease.	In house repair or return to manufacturer	Battelle FS or Sampling Technician	Operator Manual	Replace batteries as needed.
MGD2002 or equivalent (for measuring helium during VI sampling leak detection)	Calibration	At the start of each sampling day during calibration check. Factory calibration as specified by manufacturer.	Per manufacturer instrument specifications calibration ranges. ± 10% of standard gasses	In house repair or return to manufacturer	Battelle FS or Sampling Technician	Operator Manual	Replace batteries as needed.

SAP Worksheet #23 -- Analytical SOP References Table

(UFP-QAPP Manual Section 3.2.1)

Lab SOP Number	Title, Revision Date, and / or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
OP058	SOP for the Extraction of Perfluorinated Alkyl Acids from Water Samples for LC/MS/MS, May 2014	Definitive	PFCs/Groundwater, Surface Water	None	Accutest - Orlando	No
MS014	Analysis of Perfluorinated Alkyl Acids by LC/MS/MS, May 2014	Definitive	PFCs/Groundwater, Surface Water, Soil, Sediment	LC/MS/MS	Accutest - Orlando	No
OP021	Preparation of aqueous samples for VOCs analysis by 8260B, June 2014	Definitive	CVOCs/Surface Water	None	Accutest - Orlando	No
MS005	SOP for analysis of VOCs by 8260B, June 2014	Definitive	CVOCs/Surface Water	GC/MS	Accutest - Orlando	No
EAT001-22	SOP for analysis of VOCs by TO-15, Dec. 2013	Definitive	CVOCs/Air	GC/MS	Accutest – New Jersey	No

Note: Laboratory SOPs are provided in Attachment H.

SAP Worksheet #24 -- Analytical Instrument Calibration Table

(UFP-QAPP Manual Section 3.2.2)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
Agilent HPLC/MS/MS (Electrospray detector)	Perfluorinated compounds, EPA 537MOD, 6 points minimum	Major maintenance (per method) or second consecutive failure of opening CCV warrants recalibration	Correlation coefficient R $\geq$ 0.995 and each calibration point %D <25 %. Low standard %D<30% CCV and ICV %D <25% ISTD %RPD < 20% between high and low points	Instrument maintenance, standard inspection, recalibration	Laboratory Analyst	MS014
HP5890/5970, HP5890/5973, HP6890/5975	VOC, SW-846 8260B, 5 points minimum	Major maintenance (per method) or second consecutive failure of opening CCV warrants recalibration	ICAL %RSD <15%, or Correlation coefficient R $\geq$ 0.995 ICV, CCV %D < 20%	Instrument maintenance and leak check, standard inspection, retuning and recalibration	Laboratory Analyst	MS005
Agilent 6890/5973 Agilent 6890/5975	TO-15, 5-points minimum	Major maintenance (per method) or second consecutive failure of opening CCV warrants recalibration	ICAL %RSD < 30%, two compounds may be up to 40% ICV, CCV %D < 30%	Instrument maintenance, leak check, standard inspection, recalibration	Laboratory Analyst	EAT001-22

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

(UFP-QAPP Manual Section 3.2.3)

Instrument/ Equipment	Maintenance Activity/ Testing Activity/Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Agilent HPLC/MS/MS	Spray chamber, clean capillary, check tune, leak checks, pressure check, mobile phase filters, needle inspection	Need for maintenance determined by passing calibration– see MS014 and WS #24	Passing calibration	Check LC column Run Autotune Check calculations Re-run affected samples	Laboratory Analyst	MS014
HP5890/5970, HP5890/5973, HP6890/5975	Leak check, gas pressure check, detector cleaning, septa replacement, Tune check pass control before every analytical shift, then daily CCV passes method-defined criteria	Daily	Passing calibration	Instrument maintenance and leak check, standard inspection, retuning and recalibration	Laboratory Analyst	MS005
Agilent 6890/5973 Agilent 6890/5975	Injector port, column maintenance Leak test, column and injector port inspection	As needed	Passing bromo-fluorobenzene tune, passing CCV	Column clipping, seals and liners replacement, recalibrate and reanalyze affected samples	Laboratory Analyst	EAT001-22

SAP Worksheet #26 -- Sample Handling System
(UFP-QAPP Manual Appendix A)

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): FS/Battelle
Sample Packaging (Personnel/Organization): FS/Battelle
Coordination of Shipment (Personnel/Organization): FS/Battelle
Type of Shipment/Carrier: FedEx
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Coordinator/Accutest
Sample Custody and Storage (Personnel/Organization): Sample Coordinator/Accutest
Sample Preparation (Personnel/Organization): Lab Analyst/Accutest
Sample Determinative Analysis (Personnel/Organization): Lab Analyst/Accutest
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): Field samples will be archived for 60 days after sample analysis results have been reported.
Sample Extract/Digestate Storage (No. of days from extraction/digestion): Sample extracts will be archived for 60 days after extraction.
Biological Sample Storage (No. of days from sample collection): NA
SAMPLE DISPOSAL
Personnel/Organization: Sample Coordinator/Accutest
Number of Days after Analysis: Samples will be held for 60 days after sample analysis results have been reported.

NA: not applicable

SAP Worksheet #27 – Sample Custody Requirements Table

(UFP-QAPP Manual Section 3.3.3)

Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory): Sample cooler(s) will be prepared with the appropriate number and type of sample bottles. All sample bottles will be new and will contain the appropriate preservatives as indicated in Worksheet #19. Each sample collected will be assigned a unique sample ID. The sample ID is project specific and a record of all sample IDs will be kept with the field records and recorded on the COC form. Each sample bottle will be affixed with a pre-printed, waterproof label consisting of the sample ID, sample location, sample matrix, analysis required, preservative and spaces to record the date and time of sample collection, and the collector's initials in permanent ink. See Attachment 27-1 for an example label. Samples will be collected according to procedures detailed in Worksheet #14. The samples will be sealed in individual PFC-free polyethylene bags to minimize the potential for cross contamination, wrapped in bubble wrap to prevent breakage, placed in a cooler, and packed in ice. A COC form will be completed for each cooler and placed inside an airtight, re-sealable plastic bag and taped to the inside lid of the cooler. See Attachment 27-2 for a sample COC form. Each cooler will be sealed with shipping tape and labeled for ID. Custody seals will be placed over the cooler lid, signed and dated. See Attachment 27-3 for a sample custody seal. Custody seals (if broken) would indicate the samples may have been tampered with during transport. The coolers will be shipped priority overnight via FedEx to Accutest for analysis.
Laboratory Sample Custody Procedures (receipt of samples, archiving, and disposal): Upon receipt of the samples by Accutest, laboratory personnel will inspect the cooler(s) for signs of tampering. The samples will be logged into the facility and the temperature of the cooler will be recorded by measuring the temperature of the water in the temperature blank bottle using a calibrated thermometer. The samples will be held in a temperature controlled storage area until 60 days after the results have been reported. After 60 days, the samples will be disposed of by the laboratory unless notified otherwise by Battelle personnel.

SAP Worksheet #27 – Sample Custody Requirements Table (Continued)

Sample Identification Procedures: Each sample collected will be given a unique sample ID. The sample ID is project specific and a record of all sample IDs will be kept with the field records and recorded on a COC form.

The soil and sediment sample ID numbers will include the sampling location code, the sample depth and the sampling date.

- For example, ID number "S1-5-09-30-2014"/"S1-5-09-30-2014DUP", represents the soil sample from soil boring 1 and its duplicate, sampling depth of 5 feet bgs, collected on September 30, 2014.
- For example, ID number "SED1-1.5-09-30-2014"/ "SED1-1.5-09-30-2014DUP", represents sediment location 1 and its duplicate, sampling depth of 1.5 feet bgs, collected on September 30, 2014.

The groundwater, surface water, and air sample ID numbers will include the sampling location code, and the sampling date.

- For example, ID number "EW-C16-09-30-2014/"EW-C16-09-30-2014DUP"", represents groundwater location EW-C16, and its duplicate collected on September 30, 2014.
- For example, ID number "SW1-09-30-2014"/SW1-09-03-2014DUP", represents surface water location 1 and its duplicate, collected on September 30, 2014.
- For example, ID number "AIR-INDOOR1-09-30-2014"/"AIR-INDOOR1-09-30-2014DUP", represents indoor air location 1 and its duplicate, collected on September 30, 2014.

Field QC samples will be identified with a two letter designation, field blank (FB), equipment blank (EB), source blank (SB) or trip blank (TB), and the date of collection.

- For example, ID number "EB-09-30-2014", represents equipment blank collected on September 30, 2014.

Chain-of-Custody Procedures: The sample ID, matrix, sample collector's name, collection date and time, number of containers, QC sample designation, along with the laboratory analyses required for the sample will be recorded on the COC in the field. Just before the samples are shipped, the sample relinquishment time and date will be documented on the COC by the field supervisor (or designee). The COC will then be signed, placed in an airtight, re-sealable plastic bag, taped to the top lid of the cooler, and sealed in the sample cooler. Upon receipt of the sample cooler(s) by Accutest, the laboratory personnel will record the cooler(s) temperature on the COC, inspect the samples for completeness, and document the receipt time and date of the samples on the COC.

ATTACHMENT 27-1

Sample Label

Date: [DATE] ***Time:*** [TIME]
Collector's Initials:
Sample ID:
Sample Location:
Matrix: *Soil*
Analyses Required: *PFCs*
Preservative: *Ice*

ATTACHMENT 27-2

Example Chain of Custody Record

Project: _____Site:_____

Point of Contact Name & Address: _____Phone:_____

Collector's Signature: _____ Date: _____Samples being shipped to: _____

					Analyses Requested					
	Sample ID	**Date**	**Time**	**Description / Preservative**						
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Relinquished by: _____Date:_____Received by:_____Date:_____

Relinquished by: _____Date:_____Received by:_____Date:_____

ATTACHMENT 27-3

CUSTODY SEAL

Signature: _____

Date: _____

SAP Worksheet #28-1 -- Laboratory QC Samples Table

(UFP-QAPP Manual Section 3.4)

Matrix	Soil, Sediment, Groundwater, Surface Water, Drinking Water
Analytical Group	PFCs
Analytical Method/ SOP Reference	EPA Method 537MOD/ SOP #MS 014

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action (CA)	Person(s) Responsible for CA	Data Quality Indicator	Measurement Performance Criteria
Method Blank	1 per batch of 20 samples	No analytes detected > ½ RL, 1/10 the amount measured in any sample, or 1/10 the regulatory limit, whichever is greater.	Identify source of contamination, then reanalyze affected batch samples or qualify data	Accutest Lab Analyst	Accuracy/Bias	Method Blank < 1/2 Reporting Limit
Lab Blank Spike	One per preparatory batch of up to 20 samples.	QC acceptance criteria +/- 30%.	Correct problem, re-prep and reanalyze LCS and all samples in associated batch for failed analytes. If problem persists, call PM.	Accutest Lab Analyst	Accuracy/Bias	Lab Blank < 1/2 Reporting Limit
Matrix Spike	One per preparatory batch of up to 20 samples.	Within control limits listed in Tables 28-1 and 28-2 (surface water)	Examine project-specific requirements and evaluate matrix effect	Accutest Lab Analyst	Precision	Within control limits listed in Tables 28-1 and 28-2 (surface water)

SAP Worksheet #28-1 -- Laboratory QC Samples Table (Continued)

Matrix	Soil, Sediment, Groundwater, Surface Water, Drinking Water
Analytical Group	PFCs
Analytical Method/ SOP Reference	EPA Method 537MOD/ SOP #MS 014

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action (CA)	Person(s) Responsible for CA	Data Quality Indicator	Measurement Performance Criteria
Matrix Spike Duplicate	One per preparatory batch of up to 20 samples.	Within control limits listed in Tables 28-1 and 28-2 (surface water)	Examine project-specific requirements and evaluate matrix effect, Evaluate source of poor reproducibility.	Accutest Lab Analyst	Precision	Within control limits listed in Tables 28-1 and 28-2 (surface water)
Surrogate Spike	Every field and QC sample	Surrogate acceptance criteria: +/- 30%.	Field samples may be considered affected by matrix. Failed QC sample – correct analytical problem and reanalyze all failed samples.	Accutest Lab Analyst	Accuracy/Bias	Within laboratory control limits
Internal Standards	Every standard and sample	For samples - +/- 50% of average areas measured during ICAL. For ICAL Standards - %RPD between high and low points <20%	If only field samples are affected, samples may be considered suffering from matrix effect. Failed QC samples must be reanalyzed with all associated failed field samples	Accutest Lab Analyst	Instrument stability	Within SOP control limits

SAP Worksheet #28-1 -- Laboratory QC Samples Table (Continued)

Matrix	Surface Water
Analytical Group	CVOCs
Analytical Method/ SOP Reference	EPA Method 8260B/ SOP #MS005

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action (CA)	Person(s) Responsible for CA	Data Quality Indicator	Measurement Performance Criteria
Method Blank	1 per batch of 20 samples	< ½ the reporting limit of each analyte	Identify source of contamination, then reanalyze affected batch samples or qualify data	Accutest Lab Analyst	Accuracy/Bias	Method Blank < 1/2 Reporting Limit
Lab Blank Spike	1 per batch of 20 samples	Within control limits listed in Table 28-2	Identify source of contamination, then reanalyze affected batch samples or qualify data	Accutest Lab Analyst	Accuracy/Bias	Within control limits listed in Table 28-2
Matrix Spike	1 per batch of 20 samples	Within control limits listed in Table 28-2	If MS/MSD is outside control limits, reanalyze affected samples or qualify data	Accutest Lab Analyst	Precision	Within control limits listed in Table 28-2
Matrix Spike Duplicate	1 per batch of 20 samples	Within control limits listed in Table 28-2	If MS/MSD is outside control limits, reanalyze affected samples or qualify data	Accutest Lab Analyst	Precision	Within control limits listed in Table 28-2
Surrogate Spike	Each sample	Within laboratory control limits	If surrogate is outside control limits, reanalyze affected samples or qualify data	Accutest Lab Analyst	Accuracy/Bias	Within laboratory control limits

SAP Worksheet #28-1 -- Laboratory QC Samples Table (Continued)

Matrix	Surface Water
Analytical Group	CVOCs
Analytical Method/ SOP Reference	EPA Method 8260B/ SOP #MS005

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action (CA)	Person(s) Responsible for CA	Data Quality Indicator	Measurement Performance Criteria
Internal standards	Every field and QC sample	Internal standard area = -50% to +100% of CCV	If failure is due to instrument performance issues, the problem must be identified, corrected, and the sample must be re-analyzed. If no instrument problem is found the sample must be re-analyzed. If upon re-analysis the responses are still not within limits, the problem may be considered sample matrix interference.	Analyst	Instrument sensitivity control	Detector stability

SAP Worksheet #28-1 -- Laboratory QC Samples Table (Continued)

Matrix	Air
Analytical Group	CVOCs
Analytical Method/ SOP Reference	EPA Method TO-15/ SOP #EAT001-22

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action (CA)	Person(s) Responsible for CA	Data Quality Indicator	Measurement Performance Criteria
Method Blank	Every 24 hours	<MDL	Identify source of contamination, then reanalyze affected batch samples or qualify data	Accutest Lab Analyst	Absence of interference/ contamination	< MDL
LCS/Laboratory Control Sample Duplicate	1 per 20 samples	70-130% (Table 28-3)	Source of poor recovery is investigated and eliminated. A new LCS is run if second failure, then recalibrate	Accutest Lab Analyst	Laboratory Accuracy& Precision /Method bias in ideal matrix	70-130% (Table 28-3)
Matrix Duplicates	1 per 20 samples	25% RSD (Table 28-3)	If other QC passes, matrix interference is suspected, no further action required.	Accutest Lab Analyst	Precision in field samples	25% RSD (Table 28-3)
Surrogate Spikes	Every sample and standard	50-129%	Check for errors, reanalyze samples	Accutest Lab Analyst	Individual sample preparation efficiency control	50-129%
Internal Standard	Every sample and standard	60-140% of daily calibration standard	Check for errors, reanalyze samples	Accutest Lab Analyst	Individual sample preparation efficiency control	60-140%

Table 28-1. Precision and Accuracy for Soil, Sediment, and Groundwater Samples

Analyte	Precision (%RPD)	Accuracy MS/MSD (% recovery)	Accuracy LCS/LCSD (% recovery)
PFCs			
Perfluorooctanoic acid (PFOA)	30	70-130	70-130
Perfluorooctanesulfonic acid (PFOS)	30	70-130	70-130
Perfluorononanoic acid (PFNA)	30	70-130	70-130
Perfluorohexanesulfonic acid (PFHxS)	30	70-130	70-130
Perfluoroheptanoic acid (PFHpA)	30	70-130	70-130
Perfluorobutanesulfonic acid (PFBS)	30	70-130	70-130

Table 28-2. Precision and Accuracy for Surface Water Samples

Analyte	Precision (%RPD)	Accuracy MS/MSD (% recovery)	Accuracy LCS/LCSD (% recovery)
PFCs			
Perfluorooctanoic acid (PFOA)	30	70-130	70-130
Perfluorooctanesulfonic acid (PFOS)	30	70-130	70-130
Perfluorononanoic acid (PFNA)	30	70-130	70-130
Perfluorohexanesulfonic acid (PFHxS)	30	70-130	70-130
Perfluoroheptanoic acid (PFHpA)	30	70-130	70-130
Perfluorobutanesulfonic acid (PFBS)	30	70-130	70-130
CVOCs			
Carbon tetrachloride	23	76-136	76-136
Tetrachloroethene (PCE)	16	76-135	76-135
Trichloroethene (TCE)	15	81-126	81-126
cis-1,2-Dichloroethene	15	78-120	78-120
trans-1,2-Dichloroethene	17	76-127	76-127
Vinyl chloride	18	69-159	69-159

Table 28-3. Precision and Accuracy for Air Samples

Analyte	Matrix Duplicate Precision (%RPD)	Accuracy MS/MSD (% recovery)	Accuracy LCS/LCSD (% recovery)
CVOCs			
Carbon tetrachloride	30	NA	70-130
Tetrachloroethene (PCE)	30	NA	70-130
Trichloroethene (TCE)	30	NA	70-130
cis-1,2-Dichloroethene	30	NA	70-130
trans-1,2-Dichloroethene	30	NA	70-130
Vinyl chloride	30	NA	70-130

NA: not applicable

SAP Worksheet #29 – Project Documents and Records Table

Document	Where Maintained
Sampling and Analysis Plan	Battelle
Health and Safety Plan	Battelle
Field Data Collection Sheets	Battelle
Field Logbook	Battelle
Field COC Records	Battelle, Accutest
Air Bills	Battelle
Communication Logs	Battelle
Field Corrective Action Reports	Battelle
Documentation of Deviation From Field Methods	Battelle
Laboratory QA Plan	Accutest
MDL Study Information	Accutest
DoD ELAP Accreditation	Accutest
Sample Receipt and Tracking Records	Battelle, Accutest, LDC
Laboratory Chain-of-Custody Records	Battelle, Accutest, LDC
Equipment Calibration Logs	Accutest
Sample Prep Logs	Accutest
Laboratory Corrective Action Reports	Accutest
Electronic copy of the analytical data reports	Battelle, Accutest
Data Summary and Instrument raw data for Field Samples, Standards, QC Checks, and QC Samples	Accutest
Laboratory Internal Data Package Completeness Checklist	Accutest
Case Narrative	Battelle, Accutest
Definition of Laboratory Qualifiers	Battelle, Accutest, LDC
Documentation of Laboratory Method Deviations	Accutest
Laboratory Sample Identification Numbers	Battelle, Accutest, LDC
Signatures for Laboratory Sign-Off	Battelle, Accutest, LDC
Standards Traceability Records	Accutest
Electronic Data Deliverables	Battelle, Accutest
Analytical Audit Checklists	Accutest, LDC
Field Sampling Audit Checklists	Battelle
Data Assessment Reports	Battelle, LDC
Assessment Corrective Action Reports	Battelle, LDC
Data Validation Reports	Battelle, LDC

SAP Worksheet #30 -- Analytical Services Table
(UFP-QAPP Manual Section 3.5.2.3)

Matrix	Analytical Group	Sample Locations/ ID Numbers	Analytical Method/ SOP Reference	Data Package Turnaround Time	Laboratory (Name and Address, Contact Person and Telephone Number)	Backup Laboratory (Name and Address, Contact Person and Telephone Number
Soil	PFCs	S1 through S48	EPA Method 537/ SOP #MS 014	10 business days	Accutest Southeast 4405 Vineland Road, Suite C-15 Orlando, FL 32811 Andrea Colby (386) 615-8479	TBD
Ground-water	PFCs	WMA-13, HN-25(S), HN-25(I), OB-13, R-9, OB-11, EW-C16, HN-45(I), EW-C17, HN-24(D), HN-24(S), HN-24(I), HN-47(P), HN-44, HN-46(S), HN-46(I), DG-14, EW-C18, EW-C19, EW-C20, EW-C21, R-4, SW-7, BG-05A, HN-27(S), HN-105(S), HN-23(A), HN-103(S), HN-28(S), HN-20(S), HN-42(S), HN-42(I), HN-53(S), HN-53(I), HN-53(D), HN-54(S), HN-54(I), HN-73(S), HN-73(I), HN-73(D), HN-74(S), HN-74(I), OW-D10, HN-82(S), MW-04, HN-17(S), HN-17(I), HN-19(S), HN-19(I1), HN-19(I2), HN-52(S), HN-52(I), HN-52(D), HN-16(S), HN-16(I), HN-50(S), HN-50(I), HN-50(D), HN-107 through HN-129, PW1 through PW-25 (sampled quarterly)	EPA Method 537/ SOP #MS 014	10 business days	Accutest Southeast 4405 Vineland Road, Suite C-15 Orlando, FL 32811 Andrea Colby (386) 615-8479	TBD

SAP Worksheet #30 -- Analytical Services Table (Continued)

Matrix	Analytical Group	Sample Locations/ ID Numbers	Analytical Method/ SOP Reference	Data Package Turnaround Time	Laboratory (Name and Address, Contact Person and Telephone Number)	Backup Laboratory (Name and Address, Contact Person and Telephone Number
Sediment	PFCs	SED1 through SED30	EPA Method 537/ SOP #MS 014	10 business days	Accutest Southeast 4405 Vineland Road, Suite C-15 Orlando, FL 32811 Andrea Colby (386) 615-8479	TBD
Surface water	PFCs	SW1 through SW59, SUMP1 through SUMP3	EPA Method 537/ SOP #MS 014	10 business days	Accutest Southeast 4405 Vineland Road, Suite C-15 Orlando, FL 32811 Andrea Colby (386) 615-8479	TBD
Surface water	CVOCs	SUMP1 through SUMP3	EPA Method 8260B/ SOP #MS005	10 business days	Accutest Southeast 4405 Vineland Road, Suite C-15 Orlando, FL 32811 Andrea Colby (386) 615-8479	TBD
Air	CVOCs	AIR-AB1, AIR-GIL-INDOOR1 through AIR-GIL-INDOOR8, AIR-GIL-SUBSLAB1 through AIR-GIL-SUBSLAB2, AIR-OUT-INDOOR1, AIR-OUT-SUBSLAB1 through AIR-OUT-SUBSLAB2	EPA Method TO-15/ SOP #EAT001-22	10 business days	Accutest 2235 US Highway 130 Dayton, NJ 08810 Matt Cordova (732)329-0200	TBD

TBD: to be determined

SAP Worksheet #31 -- Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (Title and Org.)	Person(s) Responsible for Responding to Assessment Findings (Title and Org.)	Person(s) Responsible for Identifying and Implementing Corrective Actions (CA) (Title and Org.)	Person(s) Responsible for Monitoring Effectiveness of CA (Title and Org.)
Internal Laboratory Assessment	Once per project	Internal	Accutest Laboratories	QAO at Accutest	Laboratory Manager, Accutest	Laboratory Manager, Accutest	QAO at Accutest
Field Sampling Technical Systems Audit	Once at start of sampling	Internal	Battelle	FS, Battelle	PM, Battelle	PM, Battelle	FS, Battelle
Field Documentation Review	Once at the end of sampling	Internal	Battelle	FS, Battelle	PM, Battelle	PM, Battelle	FS, Battelle

SAP Worksheet #32 -- Assessment Finding and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (Name, Title, Org.)	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response (Name, Title, Org.)	Timeframe for Response
Internal Laboratory Assessment	Lab report to detail project deviations	Laboratory Manager at Accutest	Within 5 days of sample analysis	Documented in the lab report	QAO at Accutest	2 weeks
Field Sampling Audit	Checklist to detail deviations from SAP	Andrew Barton, PM, Battelle	Once at start of sampling	Written documentation in the project file	Carolyn Scala, FS Battelle	3 days

SAP Worksheet #33 -- QA Management Reports Table

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (Title and Organizational Affiliation)	Report Recipient(s) (Title and Organizational Affiliation)
Field Sampling Technical Systems Audit	Once at start of sampling	February 2015	Field Team Sampler, Battelle	Andrew Barton, PM, Battelle
Data Review Report	Once after all data are reported and validated	July 2016	QAO, Battelle	Andrew Barton, PM, Battelle
Draft and Final Summary Reports	Once after all QA management and data usability completed	September 2016	PM, Battelle	Jeffrey Dale, RPM, NAVFAC BRAC PMO, East

SAP Worksheet #34 -- Verification (Step I) Process Table

Verification Input	Description	Internal/ External	Responsible for Verification (Name, Org.)
Field and sampling documents	FS or a designee will maintain a field logbook to document day-to-day sampling activities (site information, samples collected and locations, monitoring well information, etc.). Person responsible for groundwater sampling will maintain document water parameters, well depth and location and other relevant information. Battelle PM will review field documentation to verify completeness of the documents listed. A Pennsylvania-licensed geologist will review all boring and monitoring well construction logs. The person responsible for sampling activities will maintain sample COC forms. The FS or designee will verify: completion and accuracy of the COC against sample bottle labels, signatures, dates and times, and verify that shipping coolers have adequate ice to maintain cooler temperature at 2 to 6 °C. Upon relinquishing sample coolers to the courier from the laboratory, the courier will sign the COC for the receipt of the cooler(s) with time and date of receiving the coolers. Shipping air-way bills will be filed if sample coolers are delivered to the laboratory by a shipping agency such as FedEx.	Int.	PM, Battelle FS, Battelle

SAP Worksheet #34 -- Verification (Step I) Process Table (Continued)

Verification Input	Description	Internal/ External	Responsible for Verification (Name, Org.)
Analytical Data Packages	All data will be subjected to a tiered review process before it is released from the laboratory.		
	The **first step** is when the analysts review the quality of their work based on established guidelines. This includes reviewing and performing the following activities: (1) ensuring that calibrations, tunes, blanks, and any other instrument QC criteria were met during the analysis reported; (2) ensuring that calculations of individual analytes and detection limits were met; (3) verifying that holding times or extraction times were met; and, (4) making notes or footnotes on the report if abnormalities occurred during the analysis or any other QA/QC problems associated with the sample occurred.	Int.	Laboratory Analyst and Laboratory QA Manager, Accutest Labs
	The **second step** is performed by a supervisor or data review specialist whose function is to provide an independent review of data packages. This person will verify that all dates, sample IDs, detection limits, reported analyte values, concentration units, header information, and footnotes or comments were transcribed accurately. This person also will check to ensure that data that do not meet project objectives will be flagged with the appropriate data qualifiers. All information in final report that can be verified against the COC will be checked for errors and completeness.	Ext.	Laboratory Supervisor, Accutest Labs, LDC
	The **third step** is done by the Laboratory Director or his designee who will sign the final reports. This person spot-checks activities associated with the log-in, tracking, extraction, sample analysis, and final reporting for technical and scientific soundness. The Laboratory QA Manager then will review 10% of all data packages to ensure that all QA requirements have been met. This person will ensure that the data package is consistent and complies with project requirements.		

SAP Worksheet #35 -- Validation (Steps IIa and IIb) Process Table

Steps IIa/IIb	Validation input	Description	Responsible for Validation (name, org.)
IIa	Analytes	Ensure that the required analytes were reported as specified in methods, procedures or contracts.	Lab Manager, Accutest Data Validator, LDC
IIa	Chain-of Custody	Examine traceability of the data from time of collection through reporting. Examine COC records against methods, procedures or contracts.	Lab Manager, Accutest Data Validator, LDC
IIa	Sampling Methods and Procedures	Ensure that sampling methods were followed and any deviations were documented.	Field Supervisor, Battelle
IIa	Sample Handling	Ensure that sample handling, receipt and storage procedures were followed and any deviations were documented.	Field Supervisor, Battelle Lab Manager, Accutest Data Validator, LDC
IIa	Analytical Methods and Procedures	Ensure that the required analytical methods were used and any deviations were noted.	Lab Manager, Accutest Data Validator, LDC
IIa	Data Qualifiers	Determine that laboratory data qualifiers were defined and applied as specified in methods, procedures or contracts.	Lab Manager, Accutest Data Validator, LDC
IIa	Standards	Determine that standards were traceable and met the method requirements.	Lab Manager, Accutest Data Validator, LDC
IIa	Step IIA Validation Report	Summarize deviations from methods, procedures or contracts. Include qualified data and explanation of all data qualifiers.	Lab Manager, Accutest Data Validator, LDC
IIb	Sampling Plan	Determine whether the SAP was executed as specified (e.g., the number, location and type of field samples were collected and analyzed as specified in the SAP).	QAO, Battelle
IIb	Sampling Procedures	Evaluate whether sampling procedures were followed with respect to equipment and sample handling (e.g., techniques, equipment, temperature, preservatives, etc.)	FS, Battelle
IIb	Holding Times	Ensure that samples were analyzed within holding times specified in methods, procedures or contracts and any deviations were documented.	QAO, Battelle Data Validator, LDC
IIb	Field Duplicates	Compare results of field duplicates with criteria in the SAP and document any deviations.	QAO, Battelle
IIb	Project Quantitation Limits	Determine that quantitation limits were achieved as outlined in the SAP.	QAO, Battelle

SAP Worksheet #35 -- Validation (Steps IIa and IIb) Process Table (Continued)

Steps IIa/IIb	Validation input	Description	Responsible for Validation (name, org.)
IIb	Performance Criteria	Evaluate QC data against project-specific performance criteria (e.g., precisions, accuracy, representativeness, comparability, completeness and sensitivity).	QAO, Battelle
IIb	Step IIb Validation Report	Summarize outcome of comparison of the data to method performance criteria in the SAP.	QAO, Battelle

SAP Worksheet #36 -- Analytical Data Validation (Steps IIa and IIb) Summary Table

Step IIa/IIb	Matrix	Analytical Group	Validation Criteria	Data Validator (title and organizational affiliation)
IIa	Soil, Sediment, Groundwater, Surface Water	PFCs	EPA National Functional Guidelines, U.S. EPA Methods SW-846, DoD QSM and this SAP	QAO, Battelle Data Validator, LDC
IIa	Surface Water, Air	CVOCs	EPA National Functional Guidelines, U.S. EPA Methods SW-846, DoD QSM and this SAP	QAO, Battelle Data Validator, LDC
IIb	Soil, Sediment, Groundwater, Surface Water	PFCs	EPA National Functional Guidelines, U.S. EPA Methods SW-846, DoD QSM and this SAP	QAO, Battelle Data Validator, LDC
IIb	Surface Water, Air	CVOCs	EPA National Functional Guidelines, U.S. EPA Methods SW-846, DoD QSM and this SAP	QAO, Battelle Data Validator, LDC

DoD QSM = Department of Defense Quality System Manual Version 4.2.
Note: Data validation will be conducted in accordance with the Navy's Environmental Work Instruction #1 and the validation strategy of 90% Level III and 10% Level IV.

SAP Worksheet #37 – Usability Assessment

This section describes the QA/QC activities that occur after the data collection phase of the project has been completed. These activities ensure that data conform to the specified criteria and thus are useful for their intended purpose.

Usability Assessment Objectives. The data quality is a function of the sampling plan rationale and the procedures used to collect the samples, as well as the analytical methods and instrumentation used. As discussed in the following sections, data collected during this investigation will be evaluated for usability with respect to precision, accuracy, representativeness, completeness, comparability and sensitivity to determine whether the project DQOs have been met. All validated data collected for this investigation will be identified and included in a data usability assessment. The data usability assessment will be completed by Battelle personnel under the oversight of Russell Sirabian, Battelle Program Manager. The Battelle PM, Andrew Barton, will be responsible for the coordination and performance of the usability assessment.

The data quality assessment team will perform the following steps, using guidance contained in EPA (2002) and IDQTF (2005).

1. Review the project objectives and sampling design defined during systematic planning to ensure they are still applicable and that assumptions were valid.
2. Review QA reports and conduct preliminary review of the data set.
3. Reconvene the project team to discuss the quality of the data and if the data set meets the project needs.

Precision. Precision quantifies the repeatability of a given measurement. Given the limited number of field and QC samples for this project, precision will be measured by the analyses of both field and laboratory duplicate samples, including MS/MSD. The laboratory will review the QC samples to ensure that internal QC data lies within the limits of acceptability. Any suspect trends will be investigated and corrective actions taken. The findings of the usability of the data relative to precision will be included in the report, including any limitations on the data set and/or individual analytical results. Precision quantifies the repeatability of a given measurement. Precision is estimated by calculating the RPD of laboratory duplicates, as shown in the following equation:

$$\text{RPD (\%)} = \frac{|\text{Result - Duplicate Result}|}{(\text{Result + Duplicate Result})/2} \times 100\%$$

Accuracy. Accuracy refers to the percentage of a known amount of analyte recovered from a given matrix. It measures the bias in a measurement system. A measurement is accurate when the value reported does not differ (by a specified amount) from the true value, or from the known concentration of a MS or standard. The accuracy of the analytical determinations will be evaluated based on the analyses of LCS, MS/MSD, and surrogate spikes (where applicable). The findings of the usability of the data relative to accuracy will be included in the report, including any limitations on the data set and/or individual analytical results. Percent recoveries are estimated using the following equation:

$$\begin{array}{c}\text{Recovery Laboratory Control Standard (LCS)}\\ \text{and Surrogate Internal Standard (SIS) (\%)}\end{array} = \frac{\text{Amount Spike Recovered}}{\text{Amount Spike Added}} \times 100$$

The laboratory will review the QC samples to ensure that internal QC data lie within the limits of acceptability. Any suspect trends will be investigated and corrective actions taken.

***Representativeness*.** Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter that is most concerned with the proper design of the sampling program. Sample representativeness will be assessed in terms of adherence to established sample collection procedures, required preservation, storage, and holding times. Over the course of this project, samples will be collected in a manner such that they are representative of both the chemical composition and the physical state of the sample at the time of sampling. The findings of the usability of the data relative to representativeness will be included in the report, including any limitations on the data set and/or individual analytical results.

***Comparability*.** Comparability expresses the confidence with which one data set is compared with another. This evaluation criterion is critical for use in analyzing temporal trends in constituent variations within the sampling domain. To ensure comparability, samples will be collected at specified intervals and in a similar manner, and will be analyzed within the required holding times by accepted and comparable methods. Comparability will be achieved by using standard methods for sampling and analyses, presenting data in standard units, normalizing results to standard conditions, and using standard and comprehensive reporting formats. The findings of the usability of the data relative to comparability will be included in the report, including any limitations on the data set and/or individual analytical results. All data and units used in reporting for this project will be consistent with accepted conventions for environmental matrix analyses. This approach will ensure direct comparability between the results from this project and the results from other projects using the methods presented in this SAP.

Representativeness and comparability will be accomplished by comparing the COC and field notes with the data for the sample. If the reported concentration of a field sample from a specific location is an anomaly, then efforts will be made to determine if the sample was compromised during collection, preservation, shipping, or analysis. QA/QC requirements that bracket questionable data will be reviewed to confirm the performance of instrumentation during the time when questionable data was generated. Any deviation will be documented, and corrective actions will be taken to determine if the data meet project goals. If the data do not meet project goals, then the need for additional sampling and analysis will be determined.

Sensitivity. Sensitivity is the capability of a test method or instrument to discriminate between measurement responses representing different levels (e.g., concentrations) of an analyte of interest. Sensitivity has been addressed primarily through the selection of appropriate analytical methods, equipment, and instrumentation. It will be monitored through the achievement of the established method detection limits, instrument calibration and procedural blanks. The findings of the usability of the data relative to sensitivity will be included in the report, including any limitations on the data set and/or individual analytical results.

***Completeness*.** Completeness is a measure of the amount of valid data obtained from a measurement system compared with the amount expected to be obtained under normal conditions. Completeness is determined based on the number of valid points (data not rejected) relative to the total number of validated data. In addition to validated results, broken, spilled samples, and any other problems that may compromise sample representativeness are included in the assessment of completeness. Completeness is calculated as shown in the following equation. The target completeness goal for all compounds is 90%. The goal for holding times will be 100%.

$$\text{Completeness (\%)} = \frac{\text{Number of Measurements Judged Valid}}{\text{Total Number of Measurements}} \times 100$$

The laboratory that generates the analytical data (i.e., Accutest Labs) has the primary responsibility for the correctness and completeness of the data. Before releasing any analytical data, the laboratory will review and verify that the data has met all of the method criteria and is scientifically correct. Data reviews include the evaluation of information, as presented by an analyst or staff member, for accurate representation of the samples submitted. The findings of the usability of the data relative to completeness will be included in the report, including any limitations on the data set and/or individual analytical results. The usability of the data will be discussed in the QC summary of the final report.

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ATTACHMENT A

PFC SAMPLING GUIDANCE

SOP-01

SAMPLING GUIDANCE FOR PERFLUORINATED COMPOUNDS

1. PURPOSE

The purpose of this document is to provide guidance for sampling of PFCs.

2. SCOPE

This procedure is applicable to all projects where sampling for PFCs will be performed.

3. BACKGROUND

Perfluorinated compounds (PFCs) are emerging contaminants that are extremely persistent in the environment and resistant to typical environmental degradation processes. They are used in a wide variety of industrial products such as textiles, paints, metal plating, leather products, pesticides etc (EPA, 2014).

PFCs are man-made compounds with chemical properties similar to fluorocarbons. Due to the strength of multiple carbon-fluorine bonds, PFCs breakdown very slowly.

PFOS and PFOA are two perfluorinated chemicals that have been produced in the largest amounts within the United States. PFOS is a perfluoralkyl sulfonate that is commonly used as a simple salt (such as potassium, sodium or ammonium) or is incorporated into larger polymers. PFOA is a perfluoralkyl carboxylate that is produced synthetically as a salt. Ammonium salt is the most widely produced form (EPA, 2014).

EPA has developed Provisional Health Advisory values for PFOA and PFOS to protect against potential risk from exposure to these chemicals through drinking water. The PHA values are 0.4 μg/L for PFOA and 0.2 μg/L for PFOS. Provisional Health Advisories are not to be construed as legally enforceable federal standards and are subject to change as new information becomes available.

EPA Method 537, is used to analyze selected perfluorinated alkyl acids in drinking water. This method requires plastic sample bottles because PFCs are known to adhere to glass (EPA 2014).

4. PFC-SPECIFIC SAMPLING

Dedicated and disposable sampling equipment should be used to the extent possible to avoid the potential for cross contamination of samples due to inadequate decontamination processes. The dedicated or disposal sampling equipment will include disposable polyethylene tubing, disposable gloves, and laboratory supplied sample bottles. In addition, to the extent practicable, the following measures will be taken during the sampling process to avoid sample contamination during PFC sample collection:

- Use dedicated stainless steel or polyethylene equipment for sampling.
- Avoid contact with glass containers since PFCs can potentially adsorb to glass surfaces.
- Avoid contact with methanol, aluminum foil, bottle caps to be free from PFC interferences.
- Glass bottles with Teflon lined caps can NOT be used.

- Sample personnel should not use Post-it Notes at any time during sample handling, or mobilization/demobilization.
- Sample personnel should wear only old, well laundered (at least 6 washings since purchase) clothing.
- Sample personnel should not wear water resistant clothing prior or during sample collection.
- Tyvek suits must not be worn during sample handling.
- Nitrile glove must be worn at all times while collecting and handling samples.
- Many food and snack products are packaged in wrappers treated with PFCs. Therefore, hands will be thoroughly washed after handling fast food, carryout food, or snacks.
- Prewrapped food or snacks (like candy bars, microwave popcorn, etc.) must not be in the possession of the sampling personnel during sampling.
- Blue ice must not be used to cool samples or be used in sample coolers.
- Products containing Teflon® will not be used during sample handling, or mobilization/demobilization.

6. PFC- SPECIFIC DECONTAMINATON

Non-disposable or non-dedicated sampling equipment (e.g., peristaltic pumps, water level indicators, water quality meters, etc.) will be decontaminated prior to sampling and between samples. Cleaning of equipment is performed to prevent cross-contamination between samples and to maintain a clean working environment for all personnel.

Decontamination will generally consist of a water rinse station to remove gross contamination (if needed), followed by a nonphosphate detergent (e.g., Alconox®) water rinse, and a rinse with de-ionized water. Once the equipment has been cleaned, do NOT wrap it in aluminum foil for storage. There is a coating on some foils that contains PFCs. If recycled paper towels are used then the water level measurements will be conducted after completion of groundwater sampling to avoid potential contamination from materials containing PFCs.

ATTACHMENT B

WELL DRILLING SOP

Attachment B1

SOP-02

Standard Operating Procedure for RAAB Drilling

Raab Well Drilling

METHODOLOGY

Drilling and Containment System :

Scope and Application :

Split spoon samples and hollow stem augers will be advanced to refusal by a Ingersoll Rand T3 drill rig, after completion of the auger hole surface 8" casing will be installed in bore hole then air rotary drilling will be used to advance a 8" bore hole to preset depth.

A diverter system capable of high volumes of water will be attached to the temporary casing. Diverter is discharged into containment Roll off where water will be separated from drillings and pumped to a 4000gal mobile tanker and spoils will be collected in the container. The discharge water will be pumped to tanker for transport to groundwater treatment plant. Please see attached pictures of containment operation.

Upon the completion of drilling 2" screen and riser will be installed to desired depth, sand pack will be placed around screen until approximately two feet above screen interval followed by two feet of bentonite pellets. Tremie grout the remaining annular space to four feet below land surface and surface casing.

Well development will take place after screen placement is finished and grout has been in place for a minimum 24-hour period, and will consist of the use of a 2" surge block and air lifting until fines are removed

Equipment:

Ingersoll Rand T3 Drill Rig
Kenworth Rig Tender/1500 gallon clean water tank
Large Capacity Diverter
6" Discharge Pipes
4000 gallon drill water transport truck
Full Containment Roll off
3" Honda trash pump
3" Discharge Hose
Duplex filter bag system
Hot water pressure washer for decon
60,000 pound Roll Off Truck
hollow stem augers

Attachment B2
Standard Operating Procedure for
Hollow Stem Auger Drilling

Standard Operating Procedure
for
Hollow Stem Auger Drilling

1. PURPOSE

This procedure provides the standard practice for hollow stem auger drilling. This procedure includes the minimum required steps and quality checks that employees and subcontractors are to follow when performing the subject task.

This procedure may also contain guidance for recommended or suggested practice that is based upon collective professional experience. Recommended practice goes beyond the minimum requirements of the procedure, and should be implemented when appropriate.

2. SCOPE

The Standard Operating Procedure (SOP) describes standards for hollow stem auger drilling, and discusses how such drilling activities will be conducted. The SOP addresses technical requirements and required documentation. Responsibilities of individuals performing the work are also detailed.

3. DEFINITIONS

The following definitions are applicable to hollow stem auger drilling and this SOP.

Cleanout depth—The depth to which the end (bit or core barrel cutting end) of the drill string has reached after an interval of cutting. The cleanout depth (or drilled depth as it is referred to after clean-out of any sloughed material in the bottom of the borehole) is usually recorded to the nearest 0.1 feet (0.03 m).

Drawworks—A power-driven winch, or several winches, usually equipped with a clutch and brake system(s) for hoisting or lowering a drill string or sampling device.

Drill hole, Boring, or Borehole—A cylindrical hole advanced into the subsurface by mechanical means (e.g., drilling).

Drill string—The complete hollow stem auger assembly under rotation including augers, bit, sample barrel or core barrel, and/or removable center plug. The total length of the auger assembly is used to determine drilling depth by referencing the position of the top of the auger assembly to a fixed datum near the ground surface.

Hoisting line or Drilling line—Wire rope used on the drawworks to hoist and lower loose augers, the removable center plug, sampling rods and sample barrel, or the downhole sampling hammer assembly.

Hollow Stem Auger Drilling—A drilling method using rotating auger flights (typically in 5-foot joints) with a bit on the bottom of the lead flight (sometimes called the "lead auger"). The flights consist of a hollow pipe and an outer spiral plate, which when rotated, forces soil cuttings upward along the borehole wall to the surface. The auger string is advanced by rotation, with downward pressure exerted by the rig, forcing the bit to cut the soil at the bottom and direct cuttings to the augers. Hollow stem augers typically range from 6 to 14 inches in diameter.

A retractable plug with a pilot bit is placed at the bottom of the auger string to prevent cuttings from entering the hollow stem. When the plug is retracted, a sampler may be sent through the hollow center to sample soil at the bottom of the borehole without requiring the augers to be removed. A wireline sampler may also be attached to the inside of the lead auger for coring as the borehole is advanced.

The hollow stem auger method is commonly used for drilling and sampling of soil borings, collection of soil gas and screening-level water samples, and installation of some smaller diameter wells for environmental projects. The well casing string may be placed through the hollow stem.

This drilling method has advantages over other drilling techniques in certain circumstances, and disadvantages in others. This method is highly suitable for unconsolidated and consolidated fine-grained soils. Hollow-stem auger drilling can achieve the most rapid rates of penetration in soft, sticky, clay-dominated soils. However, coarse and consolidated gravels and hard bedrock may be too dense for adequate drill penetration. Soil cuttings are typically disaggregated and remolded, making bedding, fabric, and soil property determination difficult.

Although hollow stem auger methods allow for the collection of driven soil samples and soil cores, these types of soil samples may be more efficiently collected using direct push methods. Hollow stem auger soil sampling methods are typically utilized when soil borings and monitoring wells are required at the same location, or when the depth or soil types limit the effectiveness or practicality of direct push methods.

The most reliable method for logging of soils during hollow stem auger drilling is to collect relatively intact samples through the hollow stem. An advantage of the hollow stem auger method is that soil samples can be readily obtained from the bottom of the hole without requiring the removal of the auger string (unlike with air or mud rotary methods).

The hollow stem auger method may be used to install monitoring wells (limited by diameter), as it allows good depth control and the auger can be progressively pulled as well construction materials are added to the borehole. The methodology may also be used to drill out monitoring wells for abandonment.

Another advantage of the hollow stem auger method is that air or mud are not required as circulating media. Therefore, there is limited to no potential for flushing of soil samples collected for chemical analyses, and a reduction in volumes of investigation-derived wastes requiring costly handling and management procedures. Auger-type rigs can be significantly smaller than other types of rigs, making them suitable for some jobs with significant space constraints, including overhead clearance.

One limitation of the hollow stem auger method is a typical maximum drilling depth of 100 to 200 feet (may be less depending on soil conditions). Another limitation is that the method tends to smear clays along the borehole wall, creating a “skin” that has to be removed through well development.

Mast—A load-bearing structure on a drilling rig used for supporting the rotation head, pulldown hydraulics, hoisting lines, and so forth. It must be constructed to safely carry the expected loads encountered in drilling and completion of wells of the diameter and depth for which the rig manufacturer specifies the equipment. To allow for contingencies, it is recommended that the rated capacity of the mast should be at least twice the anticipated weight load or normal pulling load.

4. RESPONSIBILITIES

4.1. Procedure Responsibility

The Technical Lead is responsible for the development, maintenance, and revision of this procedure. Any questions, comments, or suggestions regarding this technical SOP should be sent to the Technical Lead.

4.2. Project Responsibility

Employees planning or supervising hollow stem auger drilling are responsible for meeting the requirements of this procedure. Employees conducting technical review or oversight of hollow stem auger drilling activities are also responsible for following appropriate portions of this SOP.

For those projects where hollow stem auger drilling methods are conducted, the Project Manager, or designee, is responsible for ensuring that the drilling activities are conducted in accordance with this and other applicable procedures. Project participants are responsible for recording information in sufficient detail to provide objective documentation (i.e. field notes, logs, forms, reports, etc.) that the requirements of this SOP have been met. Such documentation should be retained as project records.

5. PROCEDURES

This section contains basic requirements and procedures for hollow stem auger drilling. As stated above, the hollow stem auger method is commonly used for soil sampling and monitoring well installation on environmental projects.
The selection and implementation of hollow stem auger drilling techniques must incorporate site-specific conditions and requirements. Consequently, the project-specific work plans should identify the following:

- The purpose of each borehole (e.g., to install a monitoring well, to collect soil samples, to conduct soil vapor sampling, etc.)
- Specific methodology for drilling, including equipment to be utilized and cuttings/fluid containment requirements
- Specific locations, depths, and diameters of boreholes
- Type of sampling and/or logging of boreholes to be conducted
- Details of mobilization/demobilization and decontamination of equipment
- Appropriate health and safety guidelines and personnel protective equipment requirements
- Additional procedures or requirements beyond those covered in this SOP

5.1. Basic Equipment Requirements and Considerations

Basic equipment requirements and considerations are as follows:

- Rigs should be of sufficient horsepower, torque, and hoisting capacity to drill boreholes of anticipated diameter to anticipated maximum depths, as specified in the project work plans. Each rig should be equipped with a pump capable of injecting water and/or grout.
- Drill rigs should preferably be self-propelled or capable of accessing anticipated site field conditions.
- Rigs used for hollow stem auger drilling should have a sampling drive hammer system attached to the mast assembly. Mechanical or automatic hammer systems are preferable; however, downhole hammers and free-falling hammers controlled with a heavy hemp rope and a “Cat-Head” are acceptable and also used. The use of retrofitted drilling rigs with anything but a manufacturer-supplied sampling drive hammer assembly should not be allowed. A rig that requires personnel to climb onto the mast to attach or detach the hammer is unacceptable for safety reasons.
- Monitoring, extraction, or injection wells may be constructed through the interior portion of the hollow stem augers. A minimum clearance of 2 inches between the outer wall of the well casing and the borehole wall is preferred (greater annular clearance usually results in fewer well construction difficulties).
- Only Teflon™-based thread compound may be used to lubricate auger bolts or threaded portions of the drill string assembly. No other compound may be used unless otherwise directed in the project work plans. Such directed use in the project work plans should take into account applicable regulatory agency requirements and/or approval.
- Drill bit teeth and associated hard facing on the auger flights should be in good or “near new” condition. Proper types of bits, augers, and sampling string apparatus are to be available at the sizes and lengths needed to properly drill the desired diameters in the formation(s) to be encountered.

During drilling, no additives (except water) may be added to the borehole and interior portion of the auger string without appropriate regulatory approval and/or concurrence with project-specific requirements. Only

"clean" water may be added to the borehole and interior portion of the auger string, and only after discussion with and approval by the rig geologist. The rig geologist is responsible for ensuring that drilling and sampling activities are conducted in a manner that is consistent with applicable regulatory agency requirements, and project-specific requirements/procedures.

5.2. Health and Safety Requirements

Prior to initiating drilling activities, applicable project-specific safety requirements must be reviewed by Battelle/H&S site personnel and subcontractors. This review is conducted to familiarize these individuals with specific hazards associated with the site and drilling activities, as well as with health and safety procedures associated with the operation and maintenance of drilling equipment. Such information may be found in the project health and safety plan. Additional health and safety requirements are presented in the following text.

Tailgate Safety Meetings should be held in the manner and frequency stated in the project health and safety plan. All personnel at the site should have appropriate training and qualifications, as specified by the project health and safety plan. Documentation should be kept readily available in the project files on site.

During drilling, all personnel within the exclusion zone should pay close attention to all rig operations. Rotating drilling tools can catch or snag loose clothing causing serious injury. Sampling hammers can often create pinch points and/or crush hazards. Improper handling of augers can also create potential pinch points (hands and feet), crush hazards, and back strain.

Clear communication signals must be established with the drilling crew, since verbal communication may not be heard during the drilling process. Hearing protection is usually mandatory around drill rigs.

The entire crew should be aware of the need to inform the rig geologist when any unforeseen hazard arises or when anyone is approaching the exclusion zone.

5.3. Drilling Site Mobilization

Basic site preparation and mobilization requirements and procedures are as follows:

- All drilling and sampling equipment should be decontaminated before drilling.
- The driller and the rig geologist should inspect the drilling equipment for proper maintenance and appropriate decontamination. All clutches, brakes, winches, and drive heads should be in proper working order. All cables and hydraulic hoses should be in good condition. All auger connections, associated auger bolts, sampling rod joints, and plug rod joints should be in good condition with no significantly worn threads, cracked or worn joint connections, or other signs of excessive wear.
- Any excessive leakage of fluids from the rig should be immediately repaired and appropriate portions of the rig decontaminated again before it is allowed to remobilize to the site.
- The logistics of drilling, logging, sampling, cuttings/fluid containment, and/or well construction should be determined before mobilizing. The site should be prepared in accordance with the project work plans.
- Before mobilization, the Site Superintendent and the rig geologist should assess the drilling site. This assessment should identify potential hazards (e.g., slip/trip/fall, overhead, soft or sloping ground, etc.) and determine how drilling operations may impact the environment (e.g., dust, debris, noise). Potential hazards should be evaluated and corrected, or the borehole location changed or shifted in accordance with the project work plans.
- The Site Superintendent, or designee, should ensure that all identifiable underground and overhead utilities around the drilling location have been marked and properly noted. The borehole location should be properly cleared as per the project work plans. At a minimum, copies of the site clearance documents should be kept on-site in a common accessible location.

- Overhead obstructions such as trees, tall shrubs, and building overhangs should be evaluated and avoided for safety reasons, as they can impair the proper function of drill mast components. .
- Once site preparation is completed, the rig is mobilized to the site and positioned over the identified borehole location. The rig should then be leveled with a set of hydraulic pads at the front and rear of the equipment. Once the rig is leveled, the mast should be raised slowly and carefully to prevent tipping or damaging the rig and to avoid hitting any obstructions or hazards.
- Appropriate barriers and markers should be in place prior to drilling, as per the project health and safety plan. Visqueen (plastic) may be required beneath the rig and around the auger area. When plastic is placed in the general vicinity of the rotating augers, extra precaution may be necessary to make sure that the plastic does not pose a safety hazard or unwarranted distraction or nuisance to the drill crew.
- Appropriate containment for cuttings and other investigation-derived waste should be set up on site prior to the commencement of drilling.

5.4 Basic Drilling Requirements and Procedures

Basic hollow stem auger drilling requirements and procedures are as follows:

Immediately prior to drilling, all safety sampling and monitoring equipment will be calibrated as per manufacturer's specifications. The rig geologist should inform the driller of the appropriate equipment (e.g., cookie cutter, etc.) to be used for penetrating the specific surface cover (e.g., asphalt, concrete, cement, etc.) at the drilling location.

In the event of breaking ground where a shallow subsurface hazard may exist (e.g., unidentifiable utility, trapped vapors, etc.), the driller should be informed of the potential hazard. Drilling of the surface hole should commence slowly to allow continuous visual inspection and, if necessary, probing. The shallow portion of the hole may be hand excavated, or hand augered, to the anticipated maximum depth of any suspected obstructions. Specific requirements for such subsurface hazard clearance should be contained in the project work plans.

Once the surface cover is removed, and the subsurface hazard clearance completed (if required), hollow stem auger drilling of the borehole may commence.

During hollow stem auger drilling operations, as the borehole is advanced, the rig geologist will generally do the following:

- Observe and monitor rig operations
- Conduct all health and safety monitoring and sampling, and supervise health and safety compliance
- Prepare a boring log from cuttings or soil samples as per applicable project-specific requirements
- Document drilling progress and other appropriate observations on appropriate forms
- Supervise the collection and preparation of any soil, soil vapor, or groundwater samples The rig geologist should not leave the drill site whenever drilling operations are conducted and the borehole is being advanced. A Battelle/H&S employee should be present at all times when subcontract personnel are on the project site.

As drilling progresses, the rig geologist should observe and be in frequent communication with the driller regarding drilling operations. Conditions noted should include relative rates of penetration (as indicated by fast or slow drilling), rotation speeds, chattering and bucking of the rig, hard or sticky drilling, drilling refusal, etc. These conditions, including penetration rates, should be recorded on the appropriate logs and

forms as per applicable project work plans. Drilling should not be allowed to progress faster than the rig geologist can adequately observe conditions, compile logs, and supervise safety and sampling activities.

The rig geologist should also observe the fitting and placement of auger connections, as well as the make-up and tightening of drill rods for the center plug, and/or sampling string. Any observed drilling problems and causes, including significant down time, should be recorded on the appropriate forms.

Cutting and fluid containment during drilling should be observed and supervised by the rig geologist as per the project work plans.

The rig geologist should continue to oversee or conduct appropriate health and safety sampling and monitoring during drilling. If any potentially unsafe conditions are evident from drilling observations or health and safety monitoring, the rig geologist may suspend drilling operations at any time and take appropriate actions, in accordance with the project health and safety plan. In the event of a suspension of drilling activities, the following actions are required:

− The Site Superintendent must be informed of the situation

  − Appropriate corrective action must be implemented before drilling may continue

  − The observed problem, suspension, and corrective action must be entered on the appropriate forms

During drilling, the rig geologist will compile a boring log in accordance with applicable SOPs. The boring log should include the following:

− Borehole location

  − Name of the drilling company and driller

  − Dates and times of drilling events, including when drilling began, the total depth and when it was reached, intermediate milestones, and any changes in equipment (e.g., over ream auger sizes, etc.)

  − Relative drilling rate(s) and presence of drill chatter (these parameters may aid in confirming lithologic boundaries)

  − Lithologic data and descriptions from cuttings or soil samples including depths, frequency, and quality

  − Sampling depths and recovery of soil samples

  − Premature total depth due to refusal and the cause of refusal (if known)

  − Any other observed drilling conditions such as observed groundwater levels, zones of hard or soft drilling, flowing sands etc.

    • The rig geologist will also enter pertinent information on the appropriate forms (in addition to the boring log), as required in the project work plans. This information includes but is not limited to the following:

      − The dates and times of drilling events including when drilling began, the total depth and when it was reached, intermediate milestones, and any changes in equipment (e.g., over ream auger sizes, etc.)

      − The dates, times, and causes of any significant down time

      − Premature total depth due to refusal and the cause of refusal

Subsurface soil sampling with a drive sampler can be done at discrete intervals while drilling with hollow stem auger methods. Though sample breaks are commonly made at five foot intervals (when new flights

are added to the auger string), drive sampling can be conducted at any depth interval. The sampling depths or intervals should be specified in the project work plans. Driven samples typically require the removal of the drive head and extraction of the center plug to allow the insertion of a sampling string. The sampler is advanced (driven or pushed) beyond the bit to obtain a relatively undisturbed sample. Drive sampling conducted during hollow stem auger drilling should follow requirements in appropriate project work plans.

If the borehole is to be abandoned once drilling is completed, the abandonment should follow procedures outlined in applicable project work plans. The abandonment will be supervised by the rig geologist.

Hollow stem auger boreholes may be used for monitoring, extraction, or injection well installation. If a monitoring, extraction, or injection well is to be installed in the borehole, installation should follow appropriate project-specific requirements/procedures. The well installation will be supervised by the rig geologist. In the process of constructing a well, the auger string should be extracted from the borehole using the rig's hydraulics, or hoisting line; providing a vertical lift with as little rotation of the auger string as possible. Rotation of the auger string while constructing wells should be minimized in order to avoid damaging or lifting the well casing.

5.5. Demobilization

After drilling, sampling, and well installation or borehole abandonment is completed, the augers and rods are laid down, the mast is lowered, and the rig is moved off of the location. Demobilization/site restoration will be supervised by the rig geologist or appropriate designee. Additional demobilization requirements/procedures are as follows:

- All debris generated by the drilling operation should be removed and appropriately disposed of.
- The site should be cleaned, the ground washed as necessary, and the site conditions restored as specified by the project work plans.
- All abandoned borings should be topped off and completed as specified in the project work plans. All wells should also have their surface completions finished in accordance with the project work plans.
- Any hazards remaining as a result of drilling activities should be identified, and appropriate barriers and markers should be put in place, in accordance with the project health and safety plan.
- All soil cuttings, drilling fluids, and decontamination fluids should be properly contained, clearly labeled, and maintained, in compliance with the project work plans and/or other applicable local, state, and federal requirements and regulations.

5.6. Technical Review

All hollow stem auger drilling specifications, procedures, and results (e.g., reports, forms, etc.) should undergo technical review. It is recommended that the technical reviewer also provide review/oversight of the actual field implementation of the hollow stem auger drilling activities. This should include aiding in troubleshooting drilling problems. The technical reviewer should be an experienced senior geologist or hydrogeologist. At a minimum, the technical reviewer should be a person capable of planning and supervising hollow stem auger drilling and associated sampling and well installation programs. Individuals needing assistance in finding qualified technical reviewers may consult internal technical listings for experts in drilling or hollow stem auger drilling.

Any issues raised during the technical review shall be resolved between the reviewer and the staff planning, conducting, or preparing results of hollow stem auger drilling activities as follows:

- Comments/issues raised relative to planning and developing detailed procedures for hollow stem auger drilling should be resolved before mobilization and drilling commences

- Comments/issues raised relative to results of drilling activities should be resolved before external use or submission of the results.

- The technical review comments and issues, and corresponding resolution, shall be documented and filed with the project records. The records should be maintained until project close-out.

Attachment B3
Standard Operating Procedure for
Air Rotary Drilling

STANDARD OPERATING PROCEDURE
For
Air Rotary Drilling

1. PURPOSE

This procedure provides the standard practice for air rotary drilling. This procedure includes the minimum required steps and quality checks that employees and subcontractors are to follow when performing the subject task.

This procedure may also contain guidance for recommended or suggested practice that is based upon collective professional experience. Recommended practice goes beyond the minimum requirements of the procedure, and should be implemented when appropriate.

2. SCOPE

This Standard Operating Procedure (SOP) describes standards for air rotary drilling, and discusses how such drilling activities will be conducted. The SOP addresses technical requirements and required documentation. Responsibilities of individuals performing the work are also detailed.

3. DEFINITIONS

The following definitions are applicable to air rotary drilling and this SOP.

Air Rotary Drilling—Any method of drilling that employs a rotating drill pipe and bit to advance the borehole and uses air as a circulating medium. Air is forced down through the center of the drill pipe, out through the bit at the bottom of the borehole, and then upward in the annular space between the borehole wall and drill pipe. The upward return stream removes cuttings from the bottom of the borehole.

Air rotary drilling is generally limited in environmental projects to drilling in hard consolidated rock for coring and installing wells. It may at times be used to drill consolidated sediment or soil. Air rotary drilling achieves some of the fastest penetration rates, compared to other drilling methods, in hard rock formations.

Air rotary drilling commonly has problems in drilling loose unconsolidated coarse sediment or soil. The air does not provide sufficient density or viscosity to keep the borehole open while drilling through these deposits and the borehole collapses, binding the bit in the hole. In addition the air circulation is lost through invasion into coarse permeable beds.

Foam additives have been developed to combat these problems but are generally not allowed by regulatory agencies for use on environmental projects. The air rotary casing hammer drilling method was developed to address these problems and is covered below.

A variety of drilling bits may be used to penetrate various formations encountered. Cone-type bits and down-hole hammers with button bits are typically used to drill through consolidated rock and granular soils. Drag (fishtail)-type bits are commonly used to progress through clayey and silty soils.

Cuttings produced by this method are typically disaggregated, making bedding and fabric determination difficult at best. Soil samples can be obtained from the bottom of the hole; however, this typically requires removing ("tripping") the entire drill string.

Additional considerations in using air rotary drilling techniques include the potential for pushing vapor phase contaminants into the surrounding soil/rock matrix and for flushing samples with air, and introduces the possibility of vapors exiting the borehole.

Air Rotary Casing Hammer Drilling—This drilling method is similar to the air rotary method in that it uses an air rotary drill string (drill pipe and bit) contained inside a slightly larger diameter drive casing. The drive casing is a heavy-walled, threaded pipe that allows for pass-through of the rotary drill bit inside the center of the casing. The drive casing is used to maintain borehole stability, to temporarily isolate multiple contaminated zones, and to reduce lost circulation of the subsurface air stream.

During drilling, the hole is deepened with the air rotary drill string. The drive casing is advanced simultaneously with the air rotary bit, using a rig-mounted hydraulic or air hammer. The drive casing is not rotated.

Air is forced down through the center drill pipe to the bit, and then upward through the space between the drive casing and the drill pipe. The upward return stream removes cuttings from the bottom of the borehole.

This method is highly useful in drilling coarse unconsolidated sediment and soils. Consequently, it is used more commonly in environmental projects than the air rotary method above. The method is also commonly used to install monitoring wells, as it provides good depth control, and the drive casing can be progressively pulled as well construction materials are placed in the borehole.

The air rotary casing hammer method is also used to drill through consolidated rock and large boulder beds. For these types of formations, an eccentric underreaming bit assembly (such as the ODEX™ or STRATEX™ systems) is attached to the inner rotary drill string. The eccentric underreamer drills a slightly larger diameter borehole than the drive casing. This allows the casing to be advanced while drilling through boulders and bedrock.

Cuttings produced by this method are typically disaggregated, like with the air rotary method above. Soil samples can be obtained from the bottom of the hole; however, this typically requires removing the entire inner rotary drill string for each sample run.

Cleanout depth—The depth to which the end of the drill string (bit or core barrel cutting end) has reached after an interval of cutting. The cleanout depth (or drilled depth as it is referred to after clean-out of any sloughed material in the bottom of the borehole) is usually recorded to the nearest 0.1 feet (0.03 m).

Drawworks—A power-driven winch, or several winches, usually equipped with a clutch and brake system(s) for hoisting or lowering a drill string.

Drill hole, Boring, or Borehole—A cylindrical hole advanced into the subsurface by mechanical means (e.g., drilling).

Drill string—The complete direct air-rotary drilling assembly under rotation including bit, sampler/core barrel, drill pipe, collars, stabilizers, and connector assemblies (subs). The total length of this assembly is used to determine drilling depth by referencing the position of the top of the string to a datum near the ground surface.

Hoisting line or Drilling line—Wire rope used on the drawworks to hoist and lower the drill string.

Mast—A load-bearing structure on a drilling rig used for supporting the crown block, top drive, pulldown chains, hoisting lines, and so forth. It must be constructed to safely carry the expected loads encountered in drilling and completion of wells of the diameter and depth for which the rig manufacturer specifies the equipment. To allow for contingencies, it is recommended that the rated capacity of the mast should be at least twice the anticipated weight load or normal pulling load.

4. RESPONSIBILITIES

4.1. Procedure Responsibility

The Technical Lead is responsible for the development, maintenance, and revision of this procedure. Any questions, comments, or suggestions regarding this technical SOP should be sent to the discipline Lead.

4.2. Project Responsibility

Employees planning or supervising air rotary drilling activities are responsible for meeting the requirements of this procedure. Employees conducting technical review of air rotary drilling activities are also responsible for following appropriate portions of this SOP.

For those projects where air rotary drilling methods are conducted, the Project Manager, or designee, is responsible for ensuring that the drilling activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for recording information in sufficient detail to provide objective documentation (i.e. field notes, logs, forms, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

5. PROCEDURES

This section contains basic requirements and procedures for air rotary casing hammer drilling. As stated above, the air rotary casing hammer method is more commonly used for environmental projects than air rotary alone. Consequently, the remainder of this document covers air rotary casing hammer drilling. The procedures and requirements for air rotary drilling would essentially be similar to those outlined for the air rotary casing hammer technique.

The selection and implementation of air rotary casing hammer drilling techniques must incorporate knowledge of site-specific conditions and requirements. Consequently, the project-specific work plans should identify the following:

- The purpose of each borehole (e.g., to install a monitoring well, to collect soil samples, to conduct soil vapor sampling, etc.)
- The specific methodology for drilling, including equipment to be utilized and cuttings/fluid containment requirements
- Specific locations, depths, and diameters of boreholes
- The type of sampling and/or logging of boreholes to be conducted
- Details of mobilization/demobilization and decontamination of equipment
- Appropriate health and safety guidelines and personal protective equipment requirements
- Additional procedures or requirements beyond those covered in this SOP

5.1. Basic Equipment Requirements and Considerations

Basic equipment requirements and considerations include the following:

- Drill rigs should be of sufficient horsepower, torque, and hoisting capacity to drill boreholes of the anticipated diameter to anticipated maximum depths, as specified in the project work plans. Each rig should be equipped with a water injection pump.
- Drill rigs should preferably be self-propelled or capable of accessing anticipated site field conditions.
- Rigs used for air rotary casing hammer drilling should have the hammer handling system integrally built into the mast assembly. The use of retrofitted drilling rigs without a swing-out, independently-operated drive hammer should not be allowed. A rig which requires personnel to climb onto the mast to attach or detach the hammer is unacceptable for safety reasons.

- The casing hammer should be a drill-through, pneumatic type (suggested minimum rated energy force of 7,200 foot pounds). The casing hammer should have a rotary drilling rod packing assembly to pressurize the system for an air- and water-tight seal, ensuring that all cuttings, water, and air are discharged through the hammer exit spout to an attached removable discharge hose and cyclone.
- The removable discharge hose should be of sufficient size and length to reach the cyclone when the hammer is raised to the top of the mast. The hose shall be properly anchored and attached to a cyclone that effectively decelerates cuttings from the air stream. The cyclone must be positioned such that the rig geologist or other site personnel can easily collect samples of cuttings as they drop out of the bottom.
- Hydraulic and/or other fluid (air) lines and hoses that can move or whip rapidly in an unsafe manner, when under pressure or variations in pressure, should be restrained with appropriate safety lines or cables (e.g., whip checks).
- An air compressor or combination of compressors must be made available and should meet minimum discharge requirements at specified pressures. An example discharge/pressure combination for 300 foot borings through interbedded cobble and silt strata is 750 cfm at 250 psi. In-line filters must be installed in the air stream from the compressor(s) for reducing oil content. The filters will be inspected and changed on a regular basis to prevent the passage of oil into the subsurface.
- Drive casings should have a required minimum tensile strength (e.g., 100,000 psi) and have external and internal flush threads on each pin and box for connecting. The use of rope thread drive casing with dissimilar metal threaded end pieces attached to mild steel casing bodies should not be allowed. The drive casing shall have uniform wall thickness, tensile strength, and treaded ends machined directly to the casing. A hardened drive shoe with the same internal and external dimensions as the drive casing will be threaded to the bottom of the first joint of the drive casing.
- Drive casings of various lengths should be provided by the subcontractor to facilitate emplacement of sand pack, bentonite seal, and grout. One 3-foot, two 5-foot, and two 10-foot lengths, in addition to a sufficient number of standard length drive casing joints, are recommended for each rig.
- A hydraulic casing extractor must be used to remove the drive casing from the borehole. Extraction of the casing by “hammering-up” with the casing hammer must not be allowed. The hydraulic casing extractor should have a required minimum pulling capacity (e.g., 250 tons) and be constructed as a single unit with hydraulic cylinders, pulling arms, base plate, valves, hoses, slips and spiders, safety bypass valves, back-up wrench, and break-out tongs. The slips and spiders should be of sufficient size to grip the outside of the drive casing and withstand the lifting force (i.e., the pulling capacity of the casing extractor).
- Only Teflon™-based thread compound may be used to lubricate drill pipe threads. No other compound may be used unless otherwise directed in the project work plans. Such directed use in the project work plans should take into account applicable regulatory agency requirements and/or approval.
- Drill bit bearings, cones, rollers, and teeth should be in top operating condition. Proper types of bits, slips, collars, and subs are to be available at sizes needed to drill the desired diameters in the formation(s) to be encountered.
- During drilling, no foam or other drilling additives (except water) may be added to the circulating air (fluid) stream without securing appropriate regulatory approval and/or meeting project-specific requirements.

5.2. Health and Safety Requirements

Prior to initiating drilling activities, applicable project-specific safety requirements must be reviewed by Battelle site personnel and subcontractors. This review is conducted to familiarize these individuals with specific hazards associated with the site and drilling activities, as well as with health and safety procedures associated with the operation and maintenance of drilling equipment. Additional health and safety requirements include the following:

- Tailgate Safety Meetings should be held in the manner and frequency stated in the project health and safety plan. All personnel at the site should have appropriate training and qualifications as specified by the project health and safety plan. Documentation should be kept readily available in the project files on site.

- During drilling, all personnel within the exclusion zone should pay close attention to all rig operations. Rapidly rotating drill tools can catch or snag loose clothing, causing serious injury.

- Clear communication signals must be established with the drilling crew since verbal communication may not be heard during the drilling process.

- The entire crew should be made aware to inform the rig geologist when any unforeseen hazard arises or when anyone is approaching the exclusion zone.

5.3. Drilling Site Mobilization

Basic site preparation and mobilization requirements and procedures are as follows:

- All drilling and sampling equipment should be decontaminated before drilling in accordance with applicable project-specific requirements/procedures.
- The driller and the rig geologist should inspect the drilling equipment for proper maintenance and appropriate decontamination. All clutches, brakes, rotary tables, swivels, kellys, and drive heads should be in proper working order. All cables and hydraulic hoses should be in good condition. All pipe joints and bits should be in good condition with no worn threads, cracked tool joint connections, or excessive wear, etc.
- Any excessive leakage of fluids from the rig or fluid circulation system (e.g., portable mud pits, mud pumps, hoses, etc.) should be immediately repaired and the rig or circulation equipment decontaminated again before it is allowed to mobilize to the site.
- The logistics of drilling, logging, sampling, cuttings/fluid containment, and/or well construction should be determined before mobilizing. The site should be prepared as specified by the project work plans.
- Before mobilization, the Site Superintendent and the rig geologist should assess the drilling site. This assessment should identify potential hazards (e.g., slip/trip/fall, overhead, etc.), and determine how drilling operations may impact the environment (e.g., dust, debris, noise). Potential hazards should be evaluated and corrected, or the borehole location changed or shifted, in accordance with the project work plans.
- The Site Superintendent, or designee, should ensure that all identifiable underground utilities around the drilling location have been marked and the borehole location cleared in accordance with the project work plans. At a minimum, copies of the site clearance documents should be kept on site in a common accessible location.
- Once site preparation is completed, the rig is mobilized to the site and positioned over the identified borehole location. The rig should then be leveled with a set of hydraulic pads at the front and rear of

the equipment. Once the rig is leveled, the mast should be raised slowly and carefully to prevent tipping or damaging the rig and to avoid hitting any obstructions or hazards.

- Appropriate barriers and markers should be in place prior to drilling, in accordance with the project health and safety plan. Visqueen (plastic) may be required beneath the rig and mud circulation system.
- Appropriate fluids, cuttings, and other investigation-derived waste containment should be set up on site prior to drilling.

5.4. Basic Drilling Requirements and Procedures

Basic air rotary and air rotary casing hammer drilling requirements and procedures are as follows:

- Immediately prior to drilling, all safety sampling and monitoring equipment will be calibrated according to manufacturer's specifications. The rig geologist should inform the driller of the appropriate equipment (e.g., cookie cutter, etc.) to be used for penetrating the specific surface cover (e.g., asphalt, concrete cement, etc.) at the drilling location.
- The upper or "surface hole" portion (first 5 to 20 feet below ground surface) of an air rotary borehole may be drilled with auger or air rotary drilling methods in order to set a temporary conductor casing. The conductor casing is used to keep the upper portion of the hole open and to prevent drilling fluids from channeling to the surface through shallow unconsolidated soils. The length of the conductor casing depends, in part, on the consolidation and permeability of the shallow subsurface soils. If geophysical logging is planned, the conductor pipe should only be as long as is necessary to keep the upper part of the hole open.
- In the event of breaking ground where a shallow subsurface hazard may exist (e.g., unidentifiable utility, trapped vapors, etc.), the driller should be informed of the potential hazard. Drilling of the surface hole should commence slowly to allow continuous visual inspection and, if necessary, probing. The shallow portion of the hole may be hand excavated to the anticipated maximum depth of any suspected obstructions. Specific requirements for such subsurface hazard clearance should be contained in the project work plans.
- Once the surface hole is drilled to the necessary depth, and the conductor casing set in the borehole, the air rotary or air rotary casing hammer drilling of the borehole may commence.
- During air rotary or air rotary casing hammer drilling operations, as the borehole is advanced beyond the conductor casing, the rig geologist will generally do the following:

  - Observe and monitor rig operations
  - Conduct all health and safety monitoring and sampling, and supervise health and safety compliance
  - Prepare a boring log from cuttings, core, or soil samples.
  - Document drilling progress and other appropriate observations on appropriate forms
  - Supervise the collection and preparation of any soil, soil vapor, or groundwater samples
  - Supervise any borehole geophysical logging conducted in the borehole

The field geologist should not leave the drill site while drilling operations are conducted and the borehole is being advanced.

As drilling progresses, the rig geologist should observe and be in frequent communication with the driller regarding drilling operations. Conditions noted should include relative rates of penetration (as indicated

by fast or slow drilling), rotation speeds, chattering and bucking of the rig, lost returns, lost circulation zones, hard or sticky drilling, drilling refusal, etc. These conditions, including penetration rates, should be recorded on the appropriate logs and forms as per applicable project work plans. Drilling should not be allowed to progress faster than the rig geologist can adequately observe conditions, compile logs, and supervise safety and sampling activities.

The rig geologist should also observe the make-up and tightening of connections as additional pipe joints are added to the drill string. Any observed drilling problems and causes, including significant down time, should be recorded on the appropriate forms.

Cutting and fluid containment during drilling should be observed and supervised by the rig geologist in accordance with the project work plans. The air/water circulation system should be inspected periodically for leaks.

The rig geologist should continue to oversee or conduct appropriate health and safety sampling and monitoring during drilling. If any potentially unsafe conditions are evident from drilling observations or health and safety monitoring, the rig geologist may suspend drilling operations at any time and take appropriate actions in accordance with the project health and safety plan. In the event of a suspension of drilling activities, the following actions shall be taken:

- The Site Superintendent must be informed of the situation.
    - Appropriate corrective action must be implemented before drilling may continue.
    - The observed problem, suspension, and corrective action must be entered on the appropriate forms

During drilling, the rig geologist will compile a boring log as per applicable. The boring log should include the following information:

- Borehole location
    - Name of the drilling company and driller
    - Dates and times of drilling events, including when drilling began, the total depth and when it was reached, intermediate milestones (additional casing, geophysical logs etc.), and any changes in equipment (bits, drill pipe, tools etc.)
    - Relative drilling rate(s) and presence of drill chatter (these parameters may aid in confirming lithologic boundaries)
    - Lithologic data and descriptions from cuttings, core, or soil samples including depths, frequency, and quality
    - Sampling depths and recovery for core or soil samples
    - Premature total depth due to refusal and the cause of refusal (if known)
    - Any other observed drilling conditions such as lost circulation zones, zones of hard or soft drilling, etc.

The rig geologist will also enter pertinent information on the appropriate forms (in addition to the boring log) in accordance with the project work plans. The information to be recorded includes but is not limited to the following:

- The dates and times of drilling events including when drilling began, the total depth and when it was reached, intermediate milestones (additional casing, geophysical logs etc.), and any changes in equipment (e.g., bits, drill pipe, tools, etc.)

− The dates, times, and causes of any significant down time

− Premature total depth due to refusal and the cause of refusal

Subsurface soil sampling with a drive sampler can be conducted at discrete intervals while drilling with air rotary or air rotary casing hammer methods. However, driven samples typically require the removal of the drill pipe to advance the sampler beyond the bit. Drive sampling conducted during air rotary or air rotary casing hammer drilling should follow requirements in appropriate project work plans.

Borehole geophysical logs may be run at various depths or prior to completing a well. The geophysical logging should be conducted as per applicable project work plans. The rig geologist should note the type(s) of logs run, logging conditions, distribution of log copies and originals, and any observed problems on the appropriate forms.

If the borehole is to be abandoned once drilling is completed, the abandonment should follow procedures outlined in applicable project work plans. The abandonment will be supervised by the rig geologist.

Air rotary or air rotary casing hammer boreholes may be used for monitoring, extraction, or injection well installation. If a monitoring, extraction, or injection well is to be installed in the borehole, installation should follow appropriate project-specific requirements/procedures. The well installation will be supervised by the rig geologist.

5.5. Demobilization

After drilling, sampling, and well installation or borehole abandonment is completed, the drill pipe and tools are laid down, the mast is lowered and the rig is moved off of the location. Demobilization/site restoration will be supervised by the rig geologist or appropriate designee. Additional demobilization requirements/procedures are as follows:

- All debris generated by the drilling operation should be removed and appropriately disposed of.
- The site should be cleaned, the ground washed as necessary, and the site conditions restored as per the project work plans.
- All abandoned borings should be topped off and completed as per the project work plans. All wells should also have their surface completions finished as per the project work plans.
- Any hazards remaining as a result of drilling activities should be identified, and appropriate barriers and markers should be put in place, as per the project health and safety plan.
- All soil cuttings and fluids should be properly contained, clearly labeled, and maintained in compliance with the project work plans and/or other applicable requirements.

5.6. Technical Review

All air rotary drilling specifications, procedures, and results (e.g., reports, forms, etc.) should undergo technical review. It is recommended that the technical reviewer also provide review/oversight of the actual field implementation of the air rotary drilling activities. This may include aiding in troubleshooting drilling problems. The technical reviewer should be an experienced senior geologist or hydrogeologist. At a minimum, the technical reviewer should be a person capable of planning and supervising air rotary drilling and associated sampling and well installation programs. Individuals needing assistance in finding qualified technical reviewers may consult internal technical listings for experts in drilling or air rotary drilling.

Any issues raised during the technical review shall be resolved between the reviewer and the staff planning, conducting, or preparing results of air rotary drilling activities, as follows:

- Comments/issues raised relative to planning and developing detailed procedures for air rotary drilling should be resolved before mobilization and drilling commences
- Comments/issues raised relative to results of drilling activities should be resolved before external use or submission of the results.
- The technical review comments and issues, and corresponding resolution, shall be documented and filed with the project records. Such records should be maintained until project closeout.

Attachment B4
Standard Operating Procedure for
Well Development

STANDARD OPERATING PROCEDURE
for
Well Development

1. PURPOSE

This procedure provides the standard practice for development of monitoring wells. The procedure includes the minimum required steps and quality checks that all employees and subcontractors are to follow when performing the subject task.

This procedure may also contain guidance for recommended or suggested practice that is based upon collective professional experience. Recommended practice goes beyond the minimum requirements of the procedure, and should be implemented when appropriate.

2. SCOPE

This Standard Operating Procedure describes standards for well development, and how such development activities will be conducted for projects executed by Battelle. The SOP addresses technical requirements and required documentation. Responsibilities of individuals performing the work are also detailed.

3. DEFINITIONS

The following definitions are applicable to well development and this SOP.

Airlift Pumping—A method of well development for groundwater production wells. It utilizes an airlift pump consisting of two pipes, with one (the air line) inside the other (the eductor pipe) used to withdraw water from a well. The lower ends of the pipes are submerged, and compressed air is delivered through the inner pipe to form a mixture of air and water. This mixture rises in the outer (eductor) pipe to the surface because the specific gravity of this mixture is less than that of the water column. This method of pumping is not usually recommended by regulatory agencies for development of monitoring wells due to the fact that volatile organics may be stripped from the groundwater, or the introduction of air can change formation and groundwater chemistry.

Backwashing—The reversal of water flow (due to the addition of water to a well) that causes water to move through the well screen, sand pack and into the formation to loosen bridges and facilitate the removal of fine grained materials. Only formation water and a pump without a check valve are used for this process. Water is first discharged from the well and then the pump is shut down. The corresponding water column in the eductor line then flows back down through the pump and into the well causing the flow reversal.

Bailer—A cylindrical steel, stainless steel, Schedule 40 Polyvinyl Chloride (PVC) or Teflon container with a valve at the bottom, and sometimes open at the top, for admission of fluid and sediment. The bailer is attached to a wire line or string and used in recovering and removing water, cuttings, mud, sand or debris from the bottom of a well.

Bailing—A technique whereby a bailer is lowered to the bottom of a well and then raised to recover and remove water, cuttings, mud, sand or debris from the well.

Eductor Pipe—The pipe used to transport water discharged to the surface from a pump (during pumping or air lifting).

Hydraulic Jetting—A well development method that employs a jetting tool with nozzles and a high-pressure pump to force water outwardly through the well screen, the filter pack and into the adjacent formation to dislodge fine sediment and sand bridges, and rehabilitate formation damage from drilling.

Overpumping—Pumping at rates generally greater than those used during sampling, well purging, or general groundwater extraction. Commonly combined with backwashing or surging of the well as part of development.

Suction Bailer (Also referred to as a Double Bailer or Moran Bailer or Sand Pump)—A suction bailer is a specially built bailer that can remove sediment or other foreign objects from the bottom of a monitoring or extraction well. The upward and downward movement of the bailer may also help to surge the well. A suction bailer is one of the tools used by a well development subcontractor.
Surge Block—A plunger like tool consisting of leather or rubber discs sandwiched between steel or wooden discs that may be solid or valved (vented surge block) that is used in well development. (See "Surging" below.)
Surging—A well development technique using a number of different types of equipment or methods to create a strong inward and outward movement of water through the well screen, sand pack, and into the formation.
Turbidity—The state, condition, or quality of opaqueness or reduced clarity of a fluid due to the presence of suspended matter. Also, a measure of the ability of suspended material to disturb or diminish the penetration of light through a fluid; commonly measured as nephelometric turbidity units (NTUs).
Washing—The addition of water to a well to conduct development. This is usually done for wells with the water level in the middle of the well screen interval. That is, part of the sand pack and formation is not saturated. The water is added to develop the unsaturated portion of the well screen, sand pack and adjoining formation. Potable water from a domestic water supply is commonly used; however, most regulatory agencies do not like the use of this technique for monitoring wells. Any water added to the well must be of known and acceptable chemistry. The effects of the wash water to the formation groundwater chemistry must also be ascertained. Well water may also be used to wash the well cap and inside of the casing (above the static water level) of sediment from the development process. This application of washing is usually acceptable to the regulatory community.
Well Development—The use of any number of mechanical techniques to remove fine grained materials, drilling fluids, and sand bridges from the well screen, sand pack and adjacent formation to provide sediment-free representative groundwater samples, enhance well yields and help restore natural hydraulic conditions in the formation.

4. RESPONSIBILITIES

4.1. Procedure Responsibility

The Technical Lead is responsible for the development, maintenance, and revision of this procedure. Any questions, comments or suggestions regarding this technical SOP should be sent to the technical lead.

4.2. Project Responsibility

Employees conducting well development are responsible for meeting the requirements of this procedure. Employees conducting field technical review of well development activities are also responsible for the following appropriate portions of this SOP.

For those projects where well development methods are conducted, the Project Manager, or designee, is responsible for ensuring that well development activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for recording information in sufficient detail to provide objective documentation (i.e., field notes, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

5. PROCEDURES

This section presents information on basic considerations and methods, planning and preparation, basic procedures and requirements, and technical review requirements for well development.

5.1. Basic Considerations and Methods

Well development is conducted to help restore natural hydraulic conditions in the formation, enhance well

yields and provide sediment-free water samples from the wells that are representative of groundwater in the formation. The development process involves use of one or a combination of mechanical methods to 1) recover fluids introduced into the formation and sand pack during drilling; 2) remove fine grained materials and sand bridges from the sand pack and adjacent formation; 3) remove the "skin" from the borehole wall; and 4) help repair damage to the formation from drilling.

Well development should be conducted on all newly installed wells, after a specified period of time (e.g., a minimum of 48 hours and not more than seven days after sealing the annular space of the well). State or local regulatory agencies may specify the time period and individuals planning well development activities should be aware of such requirements relative to their specific site(s). Monitoring wells may also be redeveloped after they have not been used for a period of time, show evidence of sediment buildup in the bottom of the well, or start yielding turbid water samples. The remainder of this text will focus upon development of newly installed wells or redevelopment of wells that have not undergone rehabilitation efforts.

Many well development methods are currently in use within the industry. These include surging, bailing, pumping, overpumping, airlifting, washing, backwashing, and jetting. Some combination of methods are specifically planned and implemented for development of wells relative to specific construction parameters and subsurface conditions at a particular site. For instance, monitoring wells can be developed by: surging and pumping; surging and bailing; bailing, pumping and backwashing, etc. The focus of developing monitoring wells is towards providing representative groundwater samples, though some monitoring wells are used for slug and specify capacity testing. The combination of development methods selected reflects the main objective.

The specific combination used should include a method that imparts a surge or flow of water from the well out thorough the sand pack, into the formation and back through the sand pack into the well. This surge or flow is necessary to remove fines and drilling fluids, and break up sand bridges in the sand pack and formation.

The exact combination of development methods to be used for wells at a site depends on a variety of project- or site-specific factors that include, but are not limited to, the following:

- Development objectives
- Intended use and type of the well
- Well construction parameters
- Drilling methods used, including type of drilling fluids and volume of fluid loss
- Regulatory requirements
- Type(s) of contaminants present, or potentially present, including non-aqueous phase liquids(NAPL)
- Type and composition of formation at the well completion interval
- Water level position inside the well
- Other previous well development issues or problems occurring at the site
- Types and relative costs of methods available by local subcontractors

Certain special well construction and site conditions may require additional evaluation and consideration for the planning and implementation of well development activities. Individuals planning and selecting appropriate development methods/combinations for their particular wells should consider and evaluate the above information. They should look at methods and techniques used for previous similar wells (completed in the same formations) on site or near the site area. They may also

seek the aid of an experienced senior geologist or hydrogeologist.

5.2. Planning and Preparation

- Planning and preparation for well development activities involves the following:
- Identifying specific well development objectives and development methods to be used (including possible limitations to the development methodologies)
- Determining specific well(s) to be developed, locations of the wells, specific identification numbers and securing construction details on the wells
- Securing construction details and information on the expected condition of each of the wells to be developed
- Listing known or assumed hydrogeologic conditions for each well, e.g., high yield, low yield, potential for presence of non-aqueous phase liquid (NAPL)
- Identifying and listing exact equipment to be used (simple or complex)
- Determining type, duration and frequency of field parameter measurements to be made during development
- Identifying and listing exact criteria to be used to determine when a well has been sufficiently developed
- Describing the estimated duration(s) of the development effort per well
- Specifying water and sediment handling and disposal requirements
- Identifying site access and restrictions on equipment layout
- Determining and listing expected hardcopy and electronic work products to be generated from the development activities
- Listing all pertinent Health and Safety issues and requirements, including those contained in the project-specific Health and Safety Plan(s), relative to work activities
- Identifying applicable requirements of this and other applicable SOPs and pertinent project-specific requirements for the well development effort
- Determining and describing detailed project-specific procedures for the well development effort
- Identifying all main subcontractor requirements for well development to be compiled into subsequent Statement of Work to procure subcontractor services
- Procuring the appropriate well development subcontractor

The above information is necessary for effective implementation of the well development effort and should be presented in the project work plans, especially the detailed project-specific development procedures.

Prior to initiating well development activities in the field, site personnel and subcontractors should be briefed on the above information in the work plans and project or corporate health and safety requirements. This is done to familiarize personnel with specific objectives, requirements procedures and hazards associated with the site as well as health and safety procedures associated with the field operation. The project manager, or designee, is responsible for ensuring that the briefing is conducted.

5.3. Basic Procedures and Requirements

This text describes the basic method or process for conducting well development. It is not possible to write

a single specific procedure for well development applicable to the wide range of sites encountered methods available. Attachment 1 provides an example of general procedures for monitoring well development.

The basic process for monitoring well development is as follows.

Decontaminate the development rig and all development equipment, including pumps, bailers, riser pipes, etc. in accordance with appropriate project-specific requirements/procedures.

Calibrate all field measuring and testing equipment (e.g. pH, temperature, conductivity, turbidity, dissolved oxygen meters, etc.) according to the instrument manufacturer's specifications, and appropriate project-specific requirements.

Access the wellhead according to the project work plans; visually inspect the well to ensure that it is undamaged, properly labeled, and secured. Any observed problems with the well head should be noted on the appropriate forms and reported to the Site Superintendent.

Unlock the well and obtain a depth to water level measurement according applicable to project-specific procedures/requirements. Sound the total well depth and compare that value with that shown on the well completion diagram or form. In addition, observe and record any unusual conditions such as possible obstructions or tight-spots as the well tape is lowered or removed from the well. (Do not insert bailers, pumps or surge blocks into the well if obstructions, parting of the casing or other damage to the well are suspected. Instead, report the conditions to the Site Superintendent and Project Manager and obtain approval to continue or cease well development activities, as appropriate.)

Calculate the volume of water in the well (well volume).

Collect an initial sample of the well water and measure and record field parameters on the appropriate forms according to the project work plans.
Compare the measured total well depth to the well construction diagram. If sand or sediment is present inside the well, it should be first removed. This is usually done by bailing. (Note: during the initial lowering of the bailer into the well, direct the subcontractor to lower the bailer slowly, and not drop the bailer to the bottom of the well. Failure to do this may cause the bailer to break or dislodge the well bottom cap or sump, resulting in costly repair/replacement of the well).

Periodically measure the depth to water and check to see that the well recovers sufficiently during and immediately after sediment removal.

Begin developing by applying the development method or combination of methods as specified in the project work plans. Begin gently at first and then progress as appropriate and specified.

While development progresses, take periodic water level measurements (as specified in the project work plans) (at least one every 5 to 10 minutes) to determine if drawdown is occurring and record the measurements on the appropriate forms.

While development progresses, measure the water discharge and calculate the rate at which water is being removed from the well. Record the volume, time and rate on the appropriate forms. Record any observations made regarding general well yield and/or recovery.

While developing, periodically collect water directly from the pump, eductor pipe or bailer discharge and measure for specified parameters. The time intervals for collection and measurement (e.g., every 15 minutes, etc.) should be listed in the project work plans. The parameters measured usually include: temperature, pH, conductivity, and turbidity. Dissolved oxygen (DO) and oxidation/reduction potential (ORP) are optional parameters that may also be measured. All measurements and associated times should be recorded on the appropriate form(s).

Development should continue until a predetermined set of conditions are met. The exact conditions and criteria should be specified in the project work plans. These can include the following:

- The well water appears clear and sediment free to the unaided eye

- The sediment thickness remaining in the well is less than 1 percent of the screen length
- A predetermined number of well volumes (previously calculated) of water, usually from three to five, have been removed from the well
- The final turbidity goal (usually 5 or 10 NTUs) has been attained
- The measured indicator parameters have stabilized. Stabilization is defined where three or more readings are within tolerances specified in the project work plans. Example tolerances and indicator parameters include: 0.1 units for pH; 1 degree F or less for temperature; and, 10 percent or less for conductivity.
- Review of measured parameters may also be conducted to determine if drilling fluids have been sufficiently removed from the formation.
- Sand production during pumping is less than or equal to a specified value (e.g., 3 parts per million [ppm])

Termination of development prior to the required water removal and stabilized parameters will require the concurrence with the Project Geologist/Hydrogeologist. The Project Geologist/Hydrogeologist is responsible for ensuring that development activities are appropriately planned and implemented. The individual selected as the Project Geologist/Hydorgeologist should be a senior professional with experience in planning, implementing, and evaluating well development programs.

Once development is considered complete, obtain a final water level and turbidity measurement and record on the appropriate form(s). Collect a 1-pint sample of the well water for storage and photographing.

Remove all equipment form the well and decontaminate appropriately for storage or development of another well according to the project work plans.

Complete documentation of the well development event on the appropriate form(s). At a minimum, the following information should be recorded:

- Project name/client name
- Project number
- Well I.D. number
- Location
- Start and end dates
- Developer/subcontractor
- Well diameter
- Total depth of well as installed and at time of development
- Top and bottom depth of screen/sand pack
- Static water level
- Development method(s)
- Equipment used; decontamination method and calibration method
- Record of water levels, volumes removed, measured parameters, measurement times and any observations.

Collect and appropriately transport and dispose of water removed from the well in accordance with the project work plans and regulatory requirements.

Allow the well to recover for a time period specified in the project work plans (generally 24 to 48 hours - check for local and/or regulatory requirements) prior to sampling.

5.4. Technical Review

All well development procedures, data analysis, and results (e.g., reports, etc.) should undergo technical review. It is recommended that the technical reviewer also provide review/oversight of the actual field implementation of well development activities. The technical reviewer should be an experienced senior geologist or hydrogeologist. At a minimum, the technical reviewer should be a person capable of planning, conducting, and evaluating well development activities and results. Individuals needing assistance in finding qualified technical reviewers may consult internal experts in well development.

Any issues raised during the technical review should be resolved between the reviewer and staff conducting the well development activities before external use or submission of the results. The technical review comments and issues, and corresponding resolution, shall be documented and filed with the project records. Such records should be maintained until project closeout.

6. ATTACHMENTS

Attachment 1- Example Monitoring Well Development Procedure

ATTACHMENT 1 Example Monitoring Well Development Procedure

This text provides an example monitoring well development procedure by bailing, pumping and back-washing. Other projects and sites may have different conditions and requirements, and use different development methods. This example procedure may therefore be modified or customized, as appropriate, to address specific site conditions, requirements and methods.

The example procedure is as follows:

1. Development will be performed no less than 2 days and not more than 7 days after well installation is complete.

2. Decontaminate the development rig and all downhole equipment (e.g., pumps, bailers, surge blocks, pumps, riser pipes, etc.) in accordance with the project work plans. This includes steam cleaning with unchlorinated water from an approved source followed by thorough rinsing with 100PPM unchlorinated, organic-free water.

3. Inspect the equipment to ensure that it is in good working order. Repair or replace damaged or malfunctioning equipment and decontaminate appropriately.

4. Calibrate and test all measuring and testing equipment prior to use according to manufacturer's specifications.

5. Access the well head according to the project work plans; visually inspect the well to ensure that it is undamaged, properly labeled, and secured. Any observed problems with the well head should be noted on the appropriate forms and reported to the Site Superintendent.

6. Unlock the well and obtain a depth to water level measurement. Then sound the total well depth and record the measurements on the appropriate forms specified in the project work plans. In addition, observe and record any unusual conditions such as possible obstructions or tight-spots as the well tape is lowered or removed from the well. (Do not insert bailers, pumps, or surge blocks into the well if obstructions, parting of the casing or other damage to the well are suspected. Instead, report the conditions to the Site Superintendent and obtain approval to continue or cease well development activities, as appropriate.)

7. Calculate the volume of water in the well (well volume).

8. Slowly lower a bailer into the well to mid-screen and collect a water sample. Empty the sample into a vessel and measure and record field parameters on the appropriate forms according to the project work plans and as discussed below.

9. Compare the measured total well depth to the well construction diagram. If sand or sediment is present inside the well, they should be first removed by bailing. After the bailer is initially placed on the bottom of the well, check to make sure that the subcontractor marks the wire line as to the total depth of the well. Bail the sediment from the bottom of the well.

10. Periodically measure the depth to water and check to see that the well recovers sufficiently during and immediately after sediment removal via bailing.

11. Once sediment removal is complete, measure the water level. Allow sufficient equalization of the water level to commence pumping.

12. Lower a decontaminated electric-powered submersible pump (without check valve) into the well and pump the well.

13. Periodically during pumping, the well will be backwashed by turning the power of the pump off and allowing the water in the pump pipe to flow back into the well. (This creates a surging action of water into the screen, sandpack and formation.) Additionally, the pump will be periodically lifted up and down inside the well screen while the pump is operating. Water will not be added to the well to aid in development, nor will any type of airlift techniques be used.

14. While developing, periodically collect water directly from the pump eductor pipe or bailer discharge every 15 minutes and measure for the following parameters: temperature, pH, conductivity, turbidity, dissolved oxygen (DO) and oxidation/reduction potential (ORP). Record all measurements and associated times on the appropriate form(s).

15. Rinse the cap and all internal components of the well casing above the water table with well water to remove all traces of soil/sediment/cuttings. Washing will be conducted before and/or during development.

16. Development will proceed until the following conditions are met:
    - The well water is clear to the unaided eye.
    - The measured turbidity is $\leq$ 5 NTU.
    - The sediment thickness remaining in the well is less than 1 percent of the screen length (the depth to the water/sediment interface will be measured with a weighted tape and the percentage of sediment height to screen length will be calculated).
    - At least three well volumes (including the saturated filter material in the annulus), plus the volume of water/drilling fluid lost during the drilling process has been removed form the well.
    - The pH, temperature and conductivity of the development water have stabilized. Stabilization is defined as successive readings in which the pH has changed $\leq$ 0.1 pH units, temperature has changed $\leq$ 1 degree F or less, and conductivity has changed by less than 10%.

17. Once development is considered complete, obtain a final water level and turbidity measurement and record on the appropriate form(s). Collect a 1-pint sample of the well water; label the jar with the well number and development date. Agitate the sample and immediately photograph with a 35-millimeter camera in a backlit setting so that the clarity of the water is visible. Prepare the sample for storage according to the project work plans.

18. Remove all equipment from the well; if the equipment is to be stored, decontaminate appropriately according to the project work plans.

19. Cap and secure the wellhead.

20. Complete documentation of the well development event on the appropriate form(s). At a minimum the following information should be recorded:
    - Project name/client name
    - Project number
    - Well I.D. number
    - Location
    - Date of well installation.
    - Start and end dates of development
    - Developer/subcontractor
    - Well diameter
    - Height of well casing above ground surface
    - Quantity of water lost during drilling
    - Total depth of well as installed and at time of development
    - Top and bottom depth of screen/sand pack

- Static water Level
- Development method(s); description of pumping technique
- Type and size/capacity of pump used.
- Equipment used, decontamination method and calibration method
- Record of water levels, volumes removed, measured parameters and measurement times
- Any observations including physical character of removed water and changes in clarity, color, particulates, and odor during development.

21. Collect and appropriately transport and dispose of water removed from the well in accordance with the project work plans and regulatory requirements.

22. Allow the well to recover at least 48 hours prior to sampling.

ATTACHMENT C

SOIL SAMPLING SOP

Battelle

STANDARD OPERATING PROCEDURE
FOR
SOIL SAMPLING

APPROVALS

Originator	Date: 4/6/2015
Technical Reviewer	Date: 4/6/2015
QA Officer	Date: 4/6/2015
Resource Manager	Date: 4/6/2015

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1.0 SCOPE

The purpose of this standard operating procedure (SOP) is to describe the procedures for the collection of representative soil samples. Sampling locations and depths are assumed to be those that can be reached with the use of hand held equipment, drill rig, or other mechanized equipment (i.e. backhoe).

The following are standard (i.e., typically applicable) operating procedures which may be adjusted due to site conditions, equipment limitations, and/or limitations imposed by a site-specific procedure. In all instances, the actual procedures used should be documented and described in the site field summary documentation.

2.0 OBJECTIVE

The objective of this SOP is to describe procedures for collecting soil samples at the surface and in the subsurface. The procedures describe sampling at discrete depths to ensure the samples are representative of current site conditions such that the samples are neither altered nor contaminated by sampling and handling techniques.

Soil samples may be collected using a variety of methods and equipment depending on the depth of the desired sample, the type of sample required (disturbed vs. undisturbed), and the soil type. Near surface soils may be easily sampled using a spade, trowel, or shovel. Sampling at greater depths may be performed using a hand auger (more shallow depths), several drilling methods (direct push, hollow stem auger, sonic, etc.) for deep sample collection, a split-spoon sampler (in combination with drilling), or, if required, a backhoe.

3.0 REFERENCES

ASTM D1586-98, "Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils".

NAVFAC Northwest SOP I-B-01, *Soil Sampling*

EPA. 1996. Test Methods for Evaluating Solid Waste, Physical Chemical Methods. (SW-846), Third edition. December.

4.0 DEFINITIONS

None

5.0 RESPONSIBILITIES

It is the responsibility of the Battelle Resource Group Manager's to ensure that all staff performing the procedures described in this SOP are properly trained. Individuals are responsible for performing soil sampling according to this SOP.

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6.0 INTERFERENCES AND POTENTIAL PROBLEMS

Two of the more prominent problems associated with soil sampling include cross contamination of samples and improper sample collection. Cross contamination problems may be eliminated or minimized through the use of dedicated sampling equipment and proper decontamination after each sample is collected. Improper sample collection can involve using contaminated equipment, disturbance of the matrix, and inadequate homogenization of the samples, when required, resulting in non-representative results.

7.0 RESPONSIBILITIES

It is the responsibility of Battelle Resource Manager's to ensure that all staff performing the procedures described in this SOP are properly trained, and this training is up to date and current. Individuals collecting soil samples are responsible for performing sampling according to this SOP, unless otherwise instructed by the Project Manager and/or the site specific sampling SOP. The sampler should also reference the site specific Work Plan (WP) and Sampling and Analysis Plan (SAP) to ensure all applied procedures are appropriate. If a different procedure is outlined within the approved site documentation, contact the Project Manager for clarification on the procedure prior to field work.

Review the site specific Health and Safety Plan and ensure that all safety precautions including appropriate monitoring equipment are installed as required. These safety measures and monitoring devices include but are not limited to the following:

- Health and Safety first aid kit.
- Blow horn.
- Eye wash station.
- Delineators.
- Traffic control signage (if necessary).
- Fire extinguishers (when applicable).
- Photoionization detector (e.g. MiniRae) of flame ionization detector.
- Decibel sensors (if applicable).
- Ear plugs or similar sound reducing device.

8.0 EQUIPMENT AND SUPPLIES

The sampling equipment is dependent upon the method of sampling described in the project WP or SAP and the depth of sampling. Generally, surface soil samples are collected up to 6 inches in depth. Samples collected at greater than six inches in depth are considered to be subsurface soil samples. The following lists are general and may be added to depending on site specific requirements.

General Soil Sampling Equipment (surface and subsurface) –

- Maps/plot plan
- Safety equipment, as specified in the site-specific Health and Safety Plan
- Survey equipment or global positioning system (GPS) to locate sampling points. If not available, accurate measuring, usually triangulating locations, may be used to identify sample points
- Tape measure

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- Survey stakes or flags
- Camera for documenting site conditions
- Stainless steel, plastic, or other appropriate homogenization bucket, bowl or pan
- Appropriate sample containers. These are usually provided by the lab contracted to analyze the samples.
- Cooler(s)
- Ice
- Ziploc plastic bags
- Site specific field logbook
- Sample labels
- Chain of Custody records and custody seals
- Field data sheets
- Decontamination supplies/equipment (e.g., liquinox, distilled water, 5 gallon buckets or equivalent water tight container)
- Canvas or plastic sheet for covering surface where samples will be processed and containerized.
- 55-gallon department of transportation rated drums (or similar)

Surface Soil Sampling Equipment

- Spade or shovel
- Stainless steel bowl
- Spatula
- Plastic or stainless steel spoons
- Trowel(s)

Subsurface Soil Sampling Equipment

- Appropriate drill rig (dependent on subsurface conditions, depth required, etc.) necessary for subsurface soil sample collection. The available drilling rigs include but are not limited to hollow stem auger (HAS), direct push (DPT), sonic, mud rotary, etc.
- Posthole auger, if subsurface sample is near surface.
- T-handle and extension rods (for hand augering only).
- Appropriate subsurface sampling device (hand auger, split spoon, thin wall tube sampler, Shelby tube, macrocore, etc….).
- Backhoe; only applicable when project requires an excavation.

9.0 PROCEDURES

9.1 PREPARATION

1. Determine the nature and scope of the sampling effort, the sampling methods to be employed, and the appropriate soil sampling equipment.
2. Prepare schedules and coordinate with staff, client, and regulatory agencies.
3. Obtain sampling and monitoring equipment.
4. Decontaminate/pre-clean equipment, and ensure that it is in working order.
5. Perform a general site survey prior to site entry in accordance with the site specific Health and Safety Plan. This may also be done same day if time allows.
6. Use stakes, flagging, or equivalent to identify and mark all sampling locations.

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7. Specific site factors, including extent and nature of contaminant, need to be considered when selecting sample locations. If required, the proposed locations may be adjusted based on site access, property boundaries, surface obstructions, and observations in the field. Document this information and relay to PMs prior to sampling.
8. All staked locations should be utility-cleared prior to soil sampling; and utility clearance should always be confirmed before beginning work.
9. Obtain any site specific permits if required (e.g., city or OSHA permits).

9.2 SAMPLE COLLECTION

9.2.1 Surface Soil Sampling

Collection of samples from near-surface soil can be accomplished with tools such as spades, shovels, trowels, and scoops. Surface material is removed to the required depth and the appropriate sampling tool is used to collect the sample. This method can be used in most soil types but is limited to sampling at or near the ground surface. A flat, pointed mason trowel to cut a block of the desired soil is helpful when undisturbed profiles are required. Tools plated with chrome or other materials should not be used. Plating is particularly common with garden implements such as potting trowels.

The following procedure should be used when collecting surface/near surface soil samples:

1. Using a pre-cleaned/decontaminated stainless steel scoop, spade, shovel, or trowel, carefully remove the top layer of soil (~6") or debris to the desired sample depth, unless samples are required from the top layer. If top layer is desired, use the above mentioned sampling devices for collection of soil,
2. Remove and discard the layer of soil from the area that came in contact with the spade.
3. **If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent, and secure the cap tightly before transferring soil for analysis of other parameters.** Place the remainder of the sample into a stainless steel, plastic, or other appropriate container, and mix thoroughly. This becomes your homogenous sample representative of the entire sampling interval. If a discrete depth is required, do not homogenize soil. Sample from specified depth only. Place the collected sample into appropriate, labeled, and pre-cleaned sample containers provided by the lab, and secure the caps tightly.

9.2.2 Subsurface Soil Sampling

9.2.2.1 Sampling at Shallow Depths with Hand Augers and Thin Wall Tube Samplers

This procedure's equipment consists of a hand auger, a thin-wall tube sampler, a series of extensions, and a "T" handle. The auger is used to bore a hole to a desired sampling depth, and is then withdrawn. The sample may be collected directly from the auger. If a core sample is to be collected, the auger tip is then replaced with a thin wall tube sampler. The thin wall tube sampler (or equivalent) is then lowered down the borehole, and driven into the soil to the

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completion depth. The sampler is withdrawn and the core is collected from the thin wall tube sampler.

The following procedure is used for collecting soil samples with a hand auger:

1. Clear the area to be sampled of any surface debris (e.g., twigs, grass, rocks, litter). It is recommended to remove the first three to six inches of surface soil for an area around the location to be augered. This will help initially guide the auger straight downhole.
2. Attach the auger bit to a drill rod extension, and attach the "T" handle to the drill rod.
3. Begin augering, periodically removing and depositing accumulated soils into a drum/bucket, or equivalent, adjacent to the hole. This prevents accidental brushing of loose material back downhole when removing the auger or adding drill rods. It also facilitates refilling the hole (if allowed within the site specific SOP), and avoids possible contamination of the surrounding area.
4. After reaching the desired depth, slowly and carefully remove the auger from the hole. If sampling directly from the auger, collect the sample after the auger is removed from the hole and proceed to Step 10.
5. Remove the auger cutting shoe from the extension rods and replace with a pre-cleaned thin wall tube sampler, or equivalent.
6. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the soil by carefully twisting and forcing it downward. Do not scrape the borehole sides. Avoid hammering the rods as the vibrations may cause the boring walls to collapse.
7. Remove the tube sampler, and unscrew the drill rods.
8. Remove the cutting tip and the core from the device.
9. Discard the top of the core (approximately 1 inch), as this possibly represents material that may have fallen from the boring wall during auger retraction. Place the remaining core into the appropriate labeled sample container. Sample homogenization only if required.
10. **If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent, and secure the cap tightly before transferring soil for analysis of other parameters.** Place the remainder of the sample into a stainless steel, plastic, or other appropriate container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. If a discrete depth is required, do not homogenize soil. Sample from specified depth only. Then place the sample into appropriate, labeled and clean sample containers provided by the lab, and secure the caps tightly.
11. If another sample is to be collected in the same hole, but at a greater depth, reattach the auger bit to the drill and assembly, and follow steps 3 through 10, making sure to decontaminate the auger and tube sampler between samples. If the field technician is able to place the sampler into the hole already created by the previous sample (after verifying the walls have not caved), place the sampler back downhole and follow steps 6 through 10.
12. If no well is to be set, abandon boring according to applicable state regulations.
13. If a well is to be set once total depth is reached and all samples have been taken, containerize all waste for waste classification and disposal and proceed with setting the well.

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9.2.2.2 Sampling at Depth with a Split Spoon (Barrel) Sampler or Equivalent

Split spoon sampling is generally used to collect undisturbed soil cores of 18 or 24 inches in length utilizing a drill rig to reach desired sample interval. Other similar sampling devices include Macrocore samplers, Shelby Tubes, etc. Each has their own specific use, but all will follow this general procedure for collecting samples.

Drill rigs chosen for each sampling event are directly dependent on the site specific subsurface conditions and lithology. Rigs include but are not limited to HSA, solid/continuous auger flights, air rotary, sonic, direct push, mud rotary, etc. A series of consecutive cores may be extracted with a split spoon sampler (or equivalent) to give a complete soil column profile. The split spoon is driven to the specified sampling interval once desired depth is verified.

When soil sampling is performed to gain geologic information, all work should be performed in accordance with ASTM D1586-98, "Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils".

The following general procedure is used for collecting soil samples with a split spoon:

1. Assemble the sampler. Normally performed by the drilling subcontractor.
2. Place the sampler in a vertical position over the desired sample material.
3. Using a slide hammer attached to the rig (140 lbs. hammer is most common), drive the sampler into the subsurface. Do not drive past the bottom of the head piece or compression of the sample will result.
4. Record in the site logbook or on field data sheets the length of the tube used to penetrate the material being sampled, and the number of blows required to obtain this depth. Blows are defined as the number of times the hammer is dropped to collect each 6" sample interval. The information is used to estimate the formation's resistance/hardness.
5. Withdraw the sampler, and open by unscrewing the bit and head and splitting the barrel. This is normally performed by the drilling subcontractor.
6. The amount of recovery and soil type should be recorded on the boring log field sheet. If a split sample is desired, a clean, stainless steel knife should be used to divide the tube contents in half, longitudinally. This sampler is typically available in 2 and 3 1/2 inch diameters. A larger barrel may be necessary to obtain the required sample volume, or an additional boring could be drilled.
7. Without disturbing the core, transfer it to appropriate labeled sample container(s) and seal tightly.
    a. **If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent, and secure the cap tightly before transferring soil for analysis of other parameters.** Place the remainder of the sample into a stainless steel, plastic, or other appropriate container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. If a discrete depth is required, do not homogenize soil. Sample from specified depth only. Then place the sample into

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appropriate, labeled and clean sample containers provided by the lab, and secure the caps tightly.

9.2.2.3 Test Pit/Trench Excavation

A backhoe can be used to remove sections of soil, when detailed examination of soil characteristics is required. This is probably the most expensive sampling method because of the relatively high cost of backhoe operation and large volume of waste created relative to other subsurface sampling techniques.

The following procedures are used for collecting soil samples from test pits or trenches:

1. Prior to any excavation with a backhoe, ensure all sampling locations are clear of overhead and buried utilities.
2. Using the backhoe, excavate the specified location marked during site preparation. Place excavated soils on plastic sheets, within roll off bins, or equivalent staging area as to prevent contaminated sediments from impacting the surrounding areas. Trenches greater than five feet deep must be sloped or protected by a shoring system, as required by Federal OSHA. **If work is being performed in California, trenches greater than 4 feet deep must be sloped or protected by a shoring system according to Cal/OSHA.**
3. A pre-cleaned/decontaminated shovel (or equivalent) is used to remove a one to two inch layer of soil from the vertical face or base of the excavation, where sampling is to be conducted.
4. Samples are taken using a trowel, scoop, or coring device at the desired intervals. Be sure to scrape the vertical face at the sample point to remove any soil that may have fallen from above, and to expose fresh soil for sampling. In some instances, samples can be collected directly from the backhoe bucket, in which case the bucket needs to be fully decontaminated prior to collecting samples.
5. **If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly before transferring soil for analysis of other parameters.** Place the remainder of the sample into a stainless steel, plastic, or other appropriate container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.
6. Abandon the pit or excavation according to applicable state regulations and according the site specific approved work plan.

9.3 SAMPLE PRESERVATION

Chemical preservation of solids is not generally required, with the exception of volatile organics. A 10 gram soil sample (collected via a lab supplied T handle Terra Core device) is collected and preserved in a 40ml VOA containing 10ml of Methanol (MeOH). Only one VOA is required per individual sample. All samples are to be cooled and protected from sunlight to minimize any potential reaction. A cooler with ice

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is recommended. Always request and follow laboratory instructions for proper sample collection, preservation (if applicable), and storage.

9.4 QA/QC

Quality assurance/quality control (QA/QC) samples are designed to help identify potential sources of sample contamination. Different types of QA/QC samples include field blanks, rinse blanks, trip blanks, and duplicate samples. Due to the inherent variability of the soil matrix, some SAPs will not require duplicate samples. The frequency of collection and types of QA/QC samples required are indicated in the site-specific SAP. All QA/QC samples are labeled with QA/QC identification and sent to the laboratory with the other samples for analysis.

10.0 TRAINING

Environmental Resource Group staff responsible for collecting samples described herein are required to read and understand this SOP and document training in Battelle University. At minimum, staff collecting samples will have the following training certificates:

1. 40-hour OSHA HAZWOPER certification
    a. Most recent 8-hour refresher certification if applicable (required once a year).
2. Bloodborne pathogens training (taken internally through Battelle University, updated once a year).
3. CPR/First Aid training certificate (updated every 2 years).

11.0 ATTACHMENTS/FORMS

None

12.0 REVISION HISTORY

Version	Summary of Changes
01	None. This is the first version of this SOP.

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ATTACHMENT D

GROUNDWATER SAMPLING SOP

STANDARD OPERATING PROCEDURE

Subject: Groundwater Sampling for PFCs

1. PURPOSE

The purpose of this document is to provide methods, procedures, and guidance for sampling of groundwater for PFC analysis.

2. SCOPE

This procedure is applicable where groundwater sampling for PFCs will be performed and where no project/program plan or procedure is in place to direct those activities.

3. RESPONSIBILITIES

3.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be directed to the Field Sampling Discipline Lead.

3.2 Project Responsibility

Personnel performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e., calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

4. PROCEDURE

This set of procedures outlines the general steps for collection of groundwater samples consistent with the approach for conventional groundwater sample collection developed for NAWC Warminster, as documented in the existing Sampling and Analysis Plan prepared by H&S Environmental, Inc., in 2011.

Groundwater Sampling Procedures from Monitoring/Observation Wells

Groundwater samples are to be collected from the monitoring/observation wells using standard techniques. These techniques are summarized below:

- For screened monitoring/observation wells, lower a submersible pump to a depth 3 to 5 feet above the bottom of the well screen. For open bedrock monitoring/observation wells, the submersible pump will be lowered half-way down the open borehole interval of each well. For wells 6-inch in diameter or larger, two 2-inch submersible pumps may be used to maximize the purge rate, assuming suggested drawdown in the well as indicated below is not exceeded. Generally, one pump may be operated at a lower flowrate than the other in order to facilitate collection of in-line field measurements from the lower flowrate pump.
- Purge the well for a minimum of three and a maximum of five well volumes, while collecting field measurements of pH, oxidation-reduction potential (ORP), dissolved oxygen (DO), specific conductance, temperature, and turbidity at 5- to 10-minute intervals. Stabilization of these field

parameters within ±10% will be the criterion for termination of purging operations prior to reaching five well volumes. If stabilization is not reached within 2 hours of purging the samples may be collected at the 2 hour mark.

- The pumping rate for well purging should be low enough that the groundwater elevation in the well is not drawn down more than one-third of the total water column in the well, if possible. If the monitoring/observation well is not capable of at least 1 gpm sustained yield, the well should be pumped dry and sampled after the well recovers to at least 75% of the initial groundwater level.
- Once purging has been completed (both a minimum of three well volumes and stabilization has been reached), a sample will be collected directly from the polyethylene discharge hose.
- Preserve the samples according to the analytical method (or collect the sample directly into pre-preserved bottles) and store the samples at 4°C (+/- 2°C) prior to shipping in accordance with standard sampling protocol.
- The following precautions must be taken by sample personnel to avoid field contamination during PFC sample collection:
    - Sample personnel should not use Post-it Notes® at any time during sample handling, or mobilization/demobilization.
    - Sample personnel should wear only old, well laundered (at least six washings since purchase) clothing.
    - Sample personnel should not wear water resistant clothing prior to or during sample collection. Tyvek suits must not be worn during sample handling.
    - Nitrile glove must be worn at all times while collecting and handling samples.
    - Many food and snack products are packaged in wrappers treated with perfluorochemicals. Therefore, hands will be thoroughly washed after handling fast food, carryout food, or snacks.
    - Pre-wrapped food or snacks (such as candy bars, microwave popcorn, etc.) must not be in the possession of the sampling personnel during sampling.
    - Blue ice must not be used to cool samples or be used in sample coolers.

Groundwater Sampling Procedures for Extraction Wells

The extraction wells that are in operation within Areas A, C, and D will be sampled directly from the sampling port installed on the discharge line from each well (direct fill). Because each well is to be in continuous operation, purging and field parameter stabilization will not be used as criteria for sampling. For those wells not in operation at the time of sampling, the sampling techniques described above for observation/monitoring wells will be used to collect a groundwater sample.

For collection of samples to be analyzed for PFCs, the following additional sampling procedures will be taken into consideration in addition to those outlined above in the monitoring/observation well sampling procedure:

- Samples will be collected directly from the dedicated sample port within the extraction well vault. If tubing is used to go from the sample port to the bottle, the tubing will be polyethylene with no Teflon® lining. Samples will be collected into the specified bottleware required for the PFC analytical method. The required bottleware is generally a non-preserved, non-Teflon® containing plastic container obtained from the laboratory.

Groundwater Sampling Procedures for Private Wells

Prior to sampling private wells, the Navy will obtain an access agreement with the respective well owner. Because each private well is assumed to be in semi-continuous operation, purging and field parameter stabilization will not be used as criteria for sampling. Private wells will be sampled

directly from a spigot or sample port within the building or residence. If possible all samples will be collected from a spigot/sample port prior to disinfection/treatment. For collection of samples to be analyzed for PFCs, the following additional sampling procedures will be taken into consideration in addition to those outlined above in the monitoring/observation well sampling procedure:

- Samples will be collected directly from the dedicated spigot/sample port. If tubing is used to go from the sample port to the bottle, the tubing will be polyethylene with no Teflon® lining. Samples will be collected into the specified bottleware required for the PFC analytical method. The required bottleware is generally a non-preserved, non-Teflon® containing plastic container obtained from the laboratory.

ATTACHMENT E

SURFACE WATER SAMPLING SOP

SOP-04

STANDARD OPERATING PROCEDURE

Subject: Surface Water Sampling for Perfluorinated Compounds (PFCs)

1. PURPOSE

The purpose of this document is to provide methods, procedures, and guidance for sampling of surface waters or liquids in lakes, streams, pits, sumps, lagoons, and similar reservoirs for Perfluorinated compounds (PFC) analysis.

2. SCOPE

This procedure is applicable to all projects where surface water sampling for PFCs will be performed and where no project/program plan or procedure is in place to direct those activities. The procedure presents two methods of sampling: direct grab sampling containers and use of a double check valve bailer.

3. RESPONSIBILITIES

3.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be directed to the Field Sampling Discipline Lead.

3.2 Project Responsibility

Personnel performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

4. PROCEDURE

Safety Note: Surface water sampling can sometimes require the use of boats or access into or across bodies of water. Observe all boating safety considerations including donning of proper life jackets. Do not wade into a water body unless the depth is well known, currents are flowing at a safe speed, appropriate personnel have determined it is safe, and a spotter is available.

Surface water samples will be collected in a manner that minimizes the potential for sample cross-contamination during collection activities. When feasible, samples will be collected by dipping pre-cleaned sample containers directly into the source water, using either a gloved hand or by attaching the containers to a clean extension pole. During collection, the mouth of the container should be directed upstream, into the current. Samples will be collected from the active portion of the stream on the side nearest the source of contamination or suspected plume.

4.1 Direct Grab

The following procedure shall be used for direct grab sampling:

- Don a pair of clean nitrile gloves.
- Obtain the required 125 ml polyethylene sample container(s)
- If entering the water body, always do so with as little bottom disturbance as possible and wait for the water around the planned sampling area to return to its undisturbed state (clarity) before samplng.
- Collect each liquid sample by slowly submerging the sample container with minimal surface disturbance. If sampling in a stream or current, make sure the open end of the sample container is pointed upstream.
- Retrieve the container from the liquid with minimal disturbance; cap and wipe the outside of the container with a towel or cloth.
- Complete all required documentation, and place the sample containers into a cooler or other specified container.
- Marking the location where the surface water is collected with a flagged stake at the stream bank or GPS coordinates.

4.2 Double Check-Valve Bailers

Collect samples using **polyethylene** double check-valve bailers for PFCs if the data requirements do not necessitate a sample from a strictly discrete interval of the water column. Bailers with an upper and lower check-valve can be lowered through the water column and water will continually be displaced through the bailer until the desired depth is reached, at which point the bailer is retrieved.

- As the bailer is dropped through the water column, water is displaced through the body of the bailer. The degree of displacement depends upon the check-valve ball movement to allow water to flow freely through the bailer body.
- Slowly lower the bailer to the appropriate depth. Upon retrieval, the two check-valves seat, preventing water from escaping or entering the bailer.
- Rinse the sampling device with ample amounts of site water prior to collecting the first sample.
- Fill the individual sample bottles via the discharge tube.
- Complete all required documentation, and place the sample containers into a cooler or other specified container.
- Marking the location where the surface water is collected with a flagged stake at the stream bank or GPS coordinates.

4.3 Sample Recording

- Measuring and recording pH, temperature, specific conductance, and DO at each surface water sampling point;
- Recording the location on a project map
- Date and time of sample collection
- Location with respect to the nearest landmark
- Distance out from the stream bank
- Method of sample collection
- Surface water conditions (e.g., sheen or debris)
- Streambed conditions (e.g., soil, mud, gravel, debris)
- Presence or absence of bank vegetation; and,
- Location of any nearby discharge pipes, sewers, or tributaries, both to and from streams.

5. PFC- SPECIFIC REQUIREMENTS

- Use dedicated equipment when possible.

- Decontaminate equipment using PFC-free deionized water between sample locations to minimize cross contamination.
- Obtain water samples prior to performing other activities at a sampling station (such as obtaining sediment samples, wading to measure field parameters).
- Sample at the furthest possible downstream point and proceed upstream.
- Avoid the use of water resistant clothing or Tyvek suits prior to and during sample collection.
- Avoid the use of Teflon-based products during sample collection.
- Wear well-laundered clothing (at least six washes since purchase).
- Avoid having packaged food or snack products in the vicinity of sample collection locations.
- Wear nitrile gloves at all times while collecting and handling samples.
- Avoid contact with glass containers since PFCs can potentially adsorb to glass surfaces.
- Avoid contact with Teflon products, methanol. Aluminum foil, bottle caps to be free from PFC interferences.
- Samples collected in 125 ml polyethylene bottles fitter with a polyethylene screw cap. Alternate size polyethylene bottles may be used depending on project requirements. **Glass bottles with Teflon lined caps can NOT be used**.
- The samples must be chilled to ≤10ºC from the time of collection until arrival at the laboratory. Samples must not exceed 10ºC during the first 48 hours after collection. The samples must be refrigerated at < 6ºC from the time of receipt until extraction.
- Deviations from these SOPs concerning preservation and holding times relating to remote and long term deployments due to site specific considerations must be agreed upon by project management.

ATTACHMENT F

SEDIMENT SAMPLING SOP

SOP-05

STANDARD OPERATING PROCEDURE

Subject: Sediment Sampling for PFCs

1. PURPOSE

The purpose of this document is to provide methods, procedures, and guidance for sampling of sediment for PFC analysis.

2. SCOPE

This procedure is applicable to all projects where sediment sampling for PFCs will be performed and where no project/program plan or procedure is in place to direct those activities. The procedure presents three methods of sampling: scoop sampling, corers, and dredges or grab samplers.

3. RESPONSIBILITIES

3.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be directed to the Field Sampling Discipline Lead.

3.2 Project Responsibility

Personnel performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

4. PROCEDURE

Safety Note: Sediment sampling can sometimes require the use of boats or access into or across bodies of water. Observe all boating safety considerations including donning of proper life jackets. Do not wade into a water body unless the depth is well known, currents are flowing at a safe speed, appropriate personnel have determined it is safe, and a spotter is available.

Sediment samples will be collected in a manner that minimizes the potential for sample cross-contamination during collection activities. Samples will be collected as an adjunct to surface water samples. Sediment will be sampled using one of three different types of equipment: scoops, corers and dredges or grab samplers. Use dredges for hard or rocky substrates. They are heavy enough to use in high velocity streams. Use coring devices in quiescent waters, unless water depth precludes effective sample collection.

4.1 Scoop or similar equipment. Scooping is generally most useful around the margin or shore of the water body or by wading in shallow waters. A stainless steel scoop must be used for sampling PFCs.

- Stand facing the direction of flow and approach the location from the downstream direction.
- Take precautions not to disturb the bottom prior to scooping.
- Scoop the sample in the upstream direction of flow.
- For obtaining samples several feet from shore or from a boat, attach the scoop to an extendible pole.
- Transfer sample to the appropriate sample container(s), using a clean non-reactive utensil.
- Label, preserve to 4°C with wet ice and complete field notes.
- Marking the location where the sediment water is collected with a flagged stake at the stream bank or GPS coordinates.

4.2 Corers

- Stainless Steel coring devices must be used for sampling PFCs.
- Some corers are simple "push tubes," whereas other more sophisticated models may be finned, gravity driven devices.
- A core may be useful for preserving the historical layering of sediments.
- Upon descent, water displacement is minimal with core samplers, which minimizes the shock wave produced by other equipment such as dredges.
- The corer is an acceptable choice for sampling fine sediments in static waters, especially those containing trace organics and metals.
- Corer diameter, grain size and sample consistency will determine if the sample will remain in the corer upon withdrawal.
- Sample washout can be a problem and there are several ways to reduce or prevent it.
    - Fit the leading edge of the corer with a nosepiece or core catcher that physically keeps the sample from slipping back out of the corer. The core catcher material must also be compatible with the analytes of interest.
    - A second option is fit the top or back end with a check valve which creates negative pressure on the back of the sample as it is being pulled from the substrate and prevents surface water from washing out the top portion of the sample.
- Rotate the corer, if needed, as it is pushed into the sediment.
    - Rotate be around its axis (do not rock the coring device back and forth).
    - Rotation improves penetration and prevents compaction of the sample as it is pushed to the full length of the corer.
- Upon withdrawal from the water surface, place a cap on the bottom to prevent the sample from sliding out.
- Corers can also be fitted with liners. This is advantageous if a complete core is desired that has not been in contact with the atmosphere. It is also advantageous if the coring device is not constructed of the proper material (e.g., PVC) and one of the analytes requires a sampler of inert construction (glass, stainless steel or Teflon).
- As the core is extruded, carefully remove the sample with a clean, non-reactive utensil and transfer into the appropriate sample container(s).
- Label, preserve to 4°C with wet ice and complete field notes.
- Marking the location where the sediment water is collected with a flagged stake at the stream bank or GPS coordinates.

4.3 Dredges or Grab Samplers

- The three main types of devices used in freshwater are the Ekman, Peterson and Ponar. Heavier oceanographic dredges are used in marine and estuarine waters.
    - The Peterson and Ponar are virtually the same, except that the Ponar has been adapted with a top screen and side plates to prevent sample loss upon ascent. For this reason,

the Ponar is the dredge of choice for rocky substrates. These dredges are heavy enough to use in streams with fast currents.
    - Open the jaws and place the cross bar into the proper notch.
    - Lower the dredge to the bottom, making sure it settles flat.
    - When tension is removed from the line, the cross bar will drop, enabling the dredge to close as the line is pulled upward during retrieval.
    - Pull the sampler to the surface. Check to make sure the jaws are fully closed and that no sample was lost while lifting the dredge.
    - Carefully open the jaws, remove the sample with a clean, non-reactive utensil and transfer the sample into the appropriate sample container(s), label, preserve to 4°C with wet ice and complete field notes.
- The Ekman is designed for sampling soft substrates (e.g., sand, silt or mud) in areas with little current.
    - Open the spring-loaded jaws and attach the chains to the pegs at the top of the sampler.
    - Lower the dredge to the bottom, making sure it settles flat.
    - Holding the line taut, send down the messenger to close the jaws of the dredge.
    - Pull the sampler to the surface. Check to make sure the jaws are fully closed and that no sample was lost while lifting the dredge.
    - Carefully open the jaws, remove the sample with a clean, non-reactive utensil and transfer the sample into the appropriate sample container(s).
    - Label, preserve to 4°C with wet ice and complete field notes.
    - Marking the location where the sediment water is collected with a flagged stake at the stream bank or GPS coordinates.

4.4 Sample Recording

Sediment samples collected underwater using a grab sampler must meet acceptability criteria that include minimal winnowing of the sample, the desired penetration depth, and the presence of overlying water. The gross characteristics of the sample will be recorded. The following records should be maintained during sediment sampling:

- Date and time of sample collection
- Location with respect to the nearest landmark
- Distance out from the stream bank
- Method of sample collection
- Depth of the sample
- Estimate of width, depth, and flow rate (feet per minute) for streams
- Surface water conditions (e.g., sheens or debris)
- Streambed conditions (e.g., dry or wet; soil, mud, gravel, debris)
- Sediment description including: texture, color, odor, biological structures, debris; and,
- Location of any nearby discharge pipes, sewers, or tributaries, both to and from streams.

5. PFC- SPECIFIC REQUIREMENTS

- Use dedicated stainless steel equipment for sampling. Steel collection equipment, ponar grab, spoon, augur, etc.
- Decontaminate equipment using PFC-free deionized water between sample locations to minimize cross contamination.
- Obtain water samples prior to performing other activities at a sampling station (such as obtaining sediment samples, wading to measure field parameters).
- Sample at the furthest possible downstream point and proceed upstream.
- Avoid the use of water resistant clothing or Tyvek suits prior to and during sample collection.

- Avoid the use of Teflon-based products during sample collection.
- Wear well-laundered clothing (at least six washes since purchase).
- Avoid having packaged food or snack products in the vicinity of sample collection locations.
- Wear nitrile gloves at all times while collecting and handling samples.
- Avoid contact with glass containers since PFCs can potentially adsorb to glass surfaces.
- Avoid contact with Teflon products, methanol, aluminum foil, bottle caps to be free from PFC interferences.
- **Glass bottles with Teflon lined caps can NOT be used**.

ATTACHMENT G

AIR SAMPLING SOP

SOP-06

STANDARD OPERATING PROCEDURE

Subject: Ambient, Indoor, and Sub-Slab Vapor Sample Collection

This set of procedures outlines the general steps for collection of indoor air, ambient air, and sub-slab vapor samples into evacuated stainless steel canisters consistent with the EPA OSWER *Draft Final Guidance for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Sources to Indoor Air* and the New Jersey Department of Environmental Protection (NJDEP) *Vapor Intrusion Guidance* (VIG).

Prior to all sampling activities, the following general procedures are to be followed:

- Sampling personnel should avoid activities immediately before and during the sampling that may contaminate the sample (e.g., using markers, fueling vehicles, etc.).

- Every effort shall be made to remove likely background sources of indoor air contamination from the building several days prior to the indoor air sampling.

- Record weather information (temperature, barometric pressure, relative humidity, wind speed, and wind direction) and indoor temperature and humidity at the beginning of the sampling event. Record substantial changes to these conditions that may have occurred over the past 24 to 48 hours and that do occur during the course of sampling. The information may be measured with onsite equipment or obtained from a reliable source of local measurements (e.g., a local airport).

- Analyze the indoor air, sub-slab, and ambient air samples from the stainless steel sampling containers using USEPA Method TO-15

Indoor Air and Ambient (Outdoor) Air Sampling Procedures

- For the indoor air samples, identify the sampling location(s) on a floor plan that also identifies locations of HVAC equipment, chemical storage areas, garages, doorways, stairways, sumps, drains, utility perforations, north direction, and separate footing sections. For the ambient air sample, select a location upwind or near the HVAC air intake for the building being sampled.
- Use an evacuated 6-Liter Summa® passivated (or equivalent) stainless-steel canister to collect each sample. The canisters will typically be provided by the analysis laboratory, along with flow controllers equipped with an in-line particulate filter and canister vacuum gauge. Each flow controller, canister and gauge will be certified clean, and flow controllers will be pre-calibrated by the laboratory for the predetermined and desired flow rate or duration of sample collection (8 hours). The average sampling flow rate should be approximately 12.5 milliliters per minute.
- Place the canisters at the sampling locations on a stable surface. Measures should also be taken to avoid impact by weather events.
- Remove the protective brass plug from each canister. Connect the pre-calibrated flow controller to each canister.
- Record the identification numbers for the canisters and flow controllers. Record the initial canister pressures on the canister vacuum gauge (check equipment-specific instructions for taking this measurement). Canisters with a significantly different (> 2 psia) pressure than originally recorded by the testing laboratory should not be used for sampling. Record these numbers and values on the chain-of-custody form for each sample.
- Completely open the valve on each canister. Record the date and time that each valve was opened (beginning of sampling) and the pressure on the vacuum gauge on the flow controller).
- Photograph each canister and the area surrounding the canisters. Additionally, for the ambient air sample, document on a field form an outdoor plot sketch that indicates the building being sampled, streets, sampling location, location of potential outdoor air sources, north direction and paved areas, and prevailing wind direction. Also record pertinent observations such as, odors, readings from field instrumentation, and significant activities in the vicinity that result in air emissions.
- Stop sample collection after the scheduled duration of sample collection (8 hours), but make sure that the canister still has a minimum amount of vacuum remaining. Check with the laboratory supplying the canister and flow controller for the ideal final vacuum pressure. Typically, the minimum vacuum is between 2 and 5 inches of mercury, but not zero. If there is no vacuum remaining, the sample will be rejected and should be collected again in a new canister.
- Record the final canister pressure and close the canister valves. Record the date and time that sample collection was stopped.
- Remove the flow controller from each canister and replace the protective brass plugs.
- Attach labels/tags (sample name, time/date of sampling, unique canister study identification number etc.) to the canisters as directed by the laboratory.
- Place the canisters and other laboratory-supplied equipment in the packaging provided by the analysis laboratory.
- Enter the information required for each sample on the chain-of-custody form, making sure to

include the identification numbers for each canister and flow controller, and the initial and final canister pressures on the vacuum gauges.

- Include the required copies of the chain-of-custody form in the shipping packaging, as directed by the laboratory. The field crew should retain a copy of the chain-of-custody for the project file.
- Deliver or ship the samples to the analysis laboratory within one business day of sample collection and via overnight delivery (when shipping). If pressure reading of canister is "zero" when logged in by the laboratory the sample shall not be analyzed and will be recollected.

Sub-Slab Soil Vapor Sample Port Installation Procedure

Temporary sub-slab sampling probes will be installed using the following procedures:

- Identify sampling location(s) on a floor plan that also identifies any slab breeches (e.g., utility penetrations, sumps, drains, and cracks) and locations of HVAC equipment.

- Insert a section of new (inert) 1/4-inch Teflon® or nylon tubing (no Tygon®) through an approximate 1/2-inch hole drilled through the slab. The drill bit should be advanced 2 to 3 inches into the sub-slab material to create an open cavity, and filled with approximately one inch of 20/40 mesh sand. Use the bit to measure the slab thickness.

- Install the tubing inlet to the specified sampling depth into the sand at the bottom of the drill hole.

- Seal the annular space between the hole and tubing using modeling clay or another inert, non-shrinking sealing compound.

Sub-Slab Vent Pipe Vapor Sample Port Installation Procedure

Vent pipes will be fitted with temporary sub-slab sampling probes using the following procedures:

- For open vent pipes, cap vent pipe with a PVC cap using a threaded cap (if applicable) or a fitted cap sealed with modeling clay or another inert, non-shrinking sealing compound.

- For vent pipes vented outdoors or to a fan, cut out a section of vent pipe near the floor and cap the vent pipe with a PVC cap using a threaded cap (if applicable) or a fitted cap sealed with modeling clay or another inert, non-shrinking sealing compound. After sampling is complete, subsequently reconnect the ends of the vent pipes using a stopcock that can isolate pipe flow for potential future sampling activities.

- Insert a section of new (inert) 1/4-inch Teflon® or nylon tubing (no Tygon®) through an approximate 1/2-inch hole drilled through the pipe below the vent cap.

- Install the tubing inlet to a length equal to the radius of the vent pipe.

- Seal the annular space between the hole and tubing using modeling clay or another inert, non-shrinking sealing compound.

Sub-Slab and Vent Pipe Soil Vapor Leak Testing Procedure

Leak tests will be performed on the sub-slab and sub-slab vent pipe vapor sampling ports prior to collecting a soil vapor sample to verify the integrity of the seals. The leak test serves as a quality control measure to evaluate the potential for dilution of a sample from indoor air. Leak testing procedures for the sub-slab soil vapor ports are as follows:

- An air-tight shroud with two access ports is placed over the sub-slab soil vapor sampling port.
- Release an inert tracer vapor (helium) into the shroud with a target concentration of 10-20% through one of the shroud access ports.
- Collect a soil vapor sample with a syringe from the sub-slab soil vapor sample port using a Tedlar® bag from the second shroud access port.
- A leak is occurring when the helium concentration in the Tedlar® bag sample (measured using a hand-held thermal helium detector or similar) is greater than 10% of the concentration within the shroud. In this case, the leak must be fixed and the leak check repeated. Multiple test failures may require the sub-slab sample port to be abandoned and a replacement sub-slab sample port be installed.

Sub-Slab Soil Vapor Sampling Procedures

- Allow for a minimum of 24 hours of equilibration between sample port installation and leak testing, and sample collection.
- Purge the tubing using a vacuum pump or vapor-tight syringe (~60 cc). Calculate the volume of air (volume = $\pi r^2 h$) in the tubing and purge three tubing volumes prior to sample collection at a rate no greater than 0.2 liter per minute (lpm). For sampling from vent pipes, purge the volume of the tubing plus the volume of the vent pipe above grade.
- Use an evacuated 6-Liter Summa® passivated (or equivalent) stainless-steel canister to collect each sample. The canisters will typically be provided by the analysis laboratory, along with flow controllers equipped with an in-line particulate filter and canister vacuum gauge. Each flow controller, canister and gauge will be certified clean, and flow controllers will be pre-calibrated by the laboratory for the predetermined and desired flow rate or duration of sample collection (8 hours). The average sampling flow rate should be approximately 12.5 milliliters per minute
- Remove the protective brass plug from canister. Connect the pre-calibrated flow controller to the canister.
- Record the identification numbers for the canister and flow controller. Record the initial canister pressure on the vacuum gauge (check equipment-specific instructions for taking this measurement). Canisters with a significantly different (> 2 psia) pressure than originally recorded by the testing laboratory should not be used for sampling. Record these numbers and values on the chain-of-custody form for each sample.
- Connect the tubing from the sub-slab vapor sampling probe to the flow controller.
- Completely open the valve on the canister. Record the date and time that the valve is opened (beginning of sampling) and the canister pressure on the vacuum gauge.
- Photograph the canister and the area surrounding the canister.
- Stop sample collection after the scheduled duration of sample collected, but when the canister still has a minimum amount of vacuum remaining. Check with the laboratory supplying the canister and flow controller for the ideal final vacuum pressure. Typically, the minimum vacuum is between 2 and 5 inches of mercury, but not zero. If there is no vacuum remaining, the sample will be rejected and should be collected again in a new canister.
- Record the final vacuum pressure and close the canister valve. Record the date and time that sample collection was stopped.
- Remove the flow controller from the canister and replace the protective brass plug.
- Attach labels/tags (sample name, time/date of sampling, etc.) to the canister as directed by the laboratory.
- Place the canister and other laboratory-supplied equipment in the packaging provided by the laboratory.
- Enter the information required for each sample on the chain-of-custody form, making sure to include the identification numbers for the canister and flow controller, and the initial and final canister pressures on the vacuum gauges.
- Include the required copies of the chain-of-custody form in the shipping packaging, as directed by the laboratory. The field crew should retain a copy of the chain-of-custody for

the project file.

- Deliver or ship the samples to the laboratory within one business day of sample collection and via overnight delivery (when shipping).
- For temporary probes, remove the probe and seal the slab or vent pipe hole with cement or similar compound. Repair flooring, if needed.

ATTACHMENT H

LABORATORY SOPs AND ACCREDITATIONS

STANDARD OPERATING PROCEDURE FOR THE EXTRACTION OF PERFLUORINATED ALKYL ACIDS FROM WATER SAMPLES FOR LC/MS/MS ANALYSIS

Prepared by: Norm Farmer Date: 05/19/14

Approved by: Mike Eger Date: 05/23/14

Annual Review

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TEST NAME: **STANDARD OPERATING PROCEDURE FOR THE EXTRACTION OF PERFLUORINATED ALKYL ACIDS FROM WATER SAMPLES FOR LC/MS/MS ANALYSIS**

Method: SW846 3535A / LC/MS/MS

Dept: OP

Revised Sections: 2.0, 3.1.1, 3.1.3, 3.1.4, 5.4, 6.10, 7.5, 7.7, 7.11, 7.18-7.20 and 10.0

1.0 Summary, Scope and Application

1.1 Summary

Aqueous samples are extracted using solid-phase extraction cartridges, eluted with methanol, and stored in polyethylene screw cap vials.

1.2 Scope and Application

This procedure is applicable to low level aqueous samples submitted for Perfluorinated alkyl acids (PFAA) analysis by LC/MS/MS. For samples that require direct injection only, see SOP MS014.

2.0 Discussion and Comments

This method is adapted from EPA 537 and modified for the analysis of environmental water samples per DoD QSM 5.0. This SOP is not designed to be used to analyze drinking water by EPA 537. Samples expected to contain high levels of PFAA compounds should be screened using the direct injection technique.

The analytes in this method can also be found in many common laboratory supplies and equipment, such as PTFE (polytetrafluoroethylene) or Teflon products, HPLC solvent lines, methanol, aluminum foil, SPE transfer lines, bottle caps, etc. All of the materials used for this method must be demonstrated to be free from interferences.

Contact with glass containers, pipettes, or syringes should be minimized since the PFAA compounds can potentially adsorb (stick) to glass surfaces.

SPE cartridges can be a source of interferences. The analysis of method and field blanks can provide important information regarding the presence or absence of such interferences. Brands and lots of SPE devices should be tested to ensure that contamination does not preclude analyte identification and quantitation.

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3.0 Preservation and Holding Times

3.1 Preservation

3.1.1 Samples shall be collected in 125ml polyethylene bottles fitted with a polyethylene screw cap. Alternate size polyethylene bottles may be used depending on project requirements. **Glass bottles with Teflon lined caps can NOT be used.**

3.1.2 The samples must be chilled to ≤10°C from the time of collection until arrival at the laboratory. Samples must not exceed 10°C during the first 48 hours after collection. The samples must be refrigerated at ≤ 6°C from the time of receipt until extraction.

3.1.3 Chlorinated finish waters or samples expected to have extreme pH's may be treated with 5.0 g/L of Trizma®.

3.1.4 The extracts should be stored at ≤6°C to minimize the potential for methanol evaporation but must be allowed to come to room temperature prior to analysis.

3.2 Holding Time

3.2.1 Aqueous samples must be extracted within 14 days of collection. The Date/Time that the extraction is started and completed must be recorded on the prep sheet.

3.2.2 Extracts must be analyzed within 28 days of extraction.

4.0 Definitions

4.1 Batch: A group of samples which are similar with respect to matrix and the testing procedures being employed and which are processed as a unit. A sample batch is limited to a maximum of 20 samples or 12 hours which ever comes first.

4.2 Blank Spike (BS): An analyte-free matrix spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. Blank Spike Recoveries are used to document laboratory performance for a given method. This may also be called a Laboratory Control Sample (LCS).

4.3 Holding Time: The maximum times that samples may be held prior to preparation and/or analysis and are still considered valid.

4.4 Matrix Spike (MS): A sample aliquot spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical

procedure. The matrix spike recoveries are used to document the bias of a method in a given sample matrix.

4.5 Matrix Spike Duplicate (MSD): A replicate sample aliquot spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. The matrix spike duplicate recoveries are used to document the precision and bias of a method in a given sample matrix.

4.6 Method Blank (MB): An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank is processed simultaneously with the samples through all the steps of the analytical procedure. The method blank is used to document contamination resulting from the analytical process.

4.7 Sample Duplicate (DUP): A replicate sample which is used to document the precision of a method in a given sample matrix.

4.8 Preservation: Refrigeration and/or reagents added at the time of sample collection (or later) to maintain the chemical integrity of the sample.

4.9 Surrogate: An organic compound which is similar to the target analyte(s) in chemical composition and behavior, but which is not normally found in environmental samples. Surrogates are used to measure the extraction efficiency.

5.0 Reagents

5.1 Methanol – HPLC grade or equivalent

5.2 SPE Cartridges – Strata SDB or equivalent

5.3 Reagent water – HPLC grade or equivalent - free of interferences

5.4 Trizma® - A premixed blend of Tris [Tris(hydroxymethyl)aminomethane] and Tris HCL [Tris(hydroxymethyl)aminomethane hydrochloride] – Sigma cat# T-7193 or equivalent.

5.5 PFAA Surrogate Solution – prepared in methanol at a concentration specified by the LC/MS/MS analyst. All surrogate solutions must be logged in the Spike and Surrogate Logbook and each solution must be verified prior to use.

5.6 PFAA Spike Solution – prepared in methanol at a concentration specified by the LC/MS/MS analyst. All spike solutions must be logged in the Spike and Surrogate Logbook and each solution must be verified prior to use.

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6.0 Glassware and Apparatus

6.1 Solid-phase cartridge extraction system – suitable for use with extraction cartridges

6.2 Vacuum pump

6.3 2000ml Vacuum Flasks

6.4 70-100ml SPE reservoirs

6.5 15ml Polyethylene Centrifuge tubes with caps

6.6 10ml, 25ml, 250ml, and 1000ml Polyethylene graduated cylinder

6.7 25ul, 50ul, and 500ul syringes

6.8 Volumetric Pipettors and tips

6.9 Disposable polyethylene transfer pipettes

6.10 10ml, 25ml, and 100ml Polyethylene or Polypropylene volumetric flasks

6.11 2.0ml or 4.0ml polyethylene screw cap vials

6.12 Polyethylene Wash Bottles

6.13 Nitrogen evaporator

7.0 Procedure

7.1 The extraction of all samples must be documented on a “prep sheet”. The prep sheet will include such items as: batch number, sample ID, bottle number, initial amount, final volume, solvent lot numbers, spike and surrogate lot numbers, batch numbers, extraction dates and times, and extraction technician.

The extraction technician is responsible for filling out all the required information on the prep sheet. A copy of the prep sheet will be submitted to the LC/MS/MS analyst with the extracts. The Batch number, extraction technician, and extraction start Date and Time are entered into LIMS.

7.2 Assemble the solid-phase extraction system. Label the side of each cartridge with the sample ID.

7.3 Wash each cartridge with 15ml of methanol (approximately 3 cartridge volumes). Use gravity flow if possible or a 1 to 2 ml/min flow rate. Do not allow the cartridge to go dry.

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7.4 When only a small layer of methanol remains above the sorbent bed, add 20ml of reagent water (approximately 4 cartridge volumes). Do not allow the cartridge to go dry. Stop the flow just before the cartridge goes dry.

7.5 Fill each cartridge with about 5ml of reagent water (approximately 1 cartridge volume). Attach a labeled sample reservoir and adapter to each cartridge.

7.6 Mark the level of the sample (upper edge) on the bottle with a marker.

7.7 Use 125ml polyethylene bottles for the method blank (MB) and blank spike (BS). Fill each of these bottles with 125ml of reagent water.

7.8 Use a separate bottle for the matrix spike (MS) and the matrix spike duplicate (MSD). If there is only one bottle for the MS/MSD, it can be split into two aliquots. This should be noted on the prep sheet. Record the sample ID, bottle number, and volume on the prep sheet.

7.9 Check the pH of each sample by dipping a disposable transfer pipette into the sample and touching it to the pH paper. Record the pH on the prep sheet. Samples for PFAA analysis should be extracted at the pH at which they were received.

7.10 Using the dedicated surrogate syringe or volumetric pipettor add **20ul** of surrogate solution to each of the samples including the QC samples. Record the surrogate lot number on the prep sheet.

7.11 Using the dedicated spike syringe or volumetric pipettor add **10ul** of spike solution to the BS, MS, and MSD. Record the spike lot number on the prep sheet.

7.12 Transfer an aliquot of each sample including the QC samples to the appropriate sample reservoirs.

7.13 Turn on the vacuum and draw the sample through the cartridge at a rate of about 10 ml/min. Add additional sample aliquots to the sample reservoirs until the entire sample has passed through the cartridge. As particulate clogs the cartridge, increase the vacuum to maintain a reasonable flow rate.

7.14 Once the entire sample has been pulled through the cartridge, shut off the vacuum. Rinse each sample bottle and reservoir with two ~10ml aliquots of reagent water. Turn on the vacuum. Draw the reagent water through the cartridge. Shut off the vacuum once the water has passed through the cartridge.

7.15 Place an appropriately labeled 15.0ml centrifuge tube under each cartridge.

7.16 Rinse each sample bottle and reservoir with two ~4ml aliquots of methanol. Allow it to pass through the cartridge under gravity flow. A slight vacuum may need to be applied if the cartridge media is clogged.

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7.17 Fill each sample bottle to the sample mark with tap water. Transfer the water to a 250ml graduated cylinder and record the sample volume. Discard the tap water.

7.18 Remove each of the centrifuge tubes from the SPE apparatus and place them in the rack for the nitrogen evaporator. Use a steady stream of nitrogen to concentrate the extract to ~0.5ml.

7.19 Adjust the volume to 1.0ml with methanol and mix thoroughly. Extracts may be stored in the 15ml centrifuge tubes or they may be transferred to appropriately labeled 2.0ml or 4.0ml screw cap vials.

7.20 Polyethylene vials and caps may still allow some methanol to evaporate, so the extracts may be stored at ≤6°C until they are needed for analysis.

8.0 Quality Assurance and Quality Control

8.1 An extraction batch is defined as samples of a similar matrix that are prepared for a particular parameter. The batch size is limited to 20 samples. A batch may be held open for up to 12 hours; however, samples should not be added after the QC set has been completed. **NOTE:** Some project plans may require different batch definitions.

8.2 A method blank (MB), blank spike (BS), matrix spike (MS), and matrix spike duplicate (MSD) must be extracted with each new batch of samples.

9.0 Safety and Waste Disposal

9.1 Safety

9.1.1 Safety glasses, gloves and lab coats should be worn when handling samples, standards or solvents.

9.1.2 Material Safety Data Sheets (MSDS) or Safety Data Sheets (SDS) are available for all reagents and solvents used in the lab. Technicians should review the MSDS or SDS prior to using any new reagents or solvents.

9.1.3 Methanol is an inhalation hazard. Use in well ventilated area.

9.2 Waste Disposal

9.2.1 Waste methanol is placed in the “non-chlorinated waste” container.

9.2.2 Spent solid-phase extraction cartridges may be disposed of in the trash.

9.2.3 Extracted water samples are rinsed down the drain with large amounts of water.

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9.2.4 Samples are archived and stored for 30 days after analysis. After the storage time has elapsed, the remaining aqueous samples are transferred to the appropriate drums for disposal.

10.0 References

SW-846 Method 3500C, Rev. 3, 02/07

SW-846 Method 3535A, Rev. 1, 11/00

EPA Method 537 Revision 1.1, September 2009

DOD QSM 5.0, July 2013

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ANALYSIS OF PERFLUORINATED ALKYL ACIDS BY LC/MS/MS

Prepared by: Norm Farmer Date: 05/14/14

Approved by: Mike Eger Date: 05/21/14

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TEST NAME: ANALYSIS OF PERFLUORINATED ALKYL ACIDS BY LC/MS/MS

METHOD REFERENCE: LC/MS/MS

DEPT: HPLC

Revised Sections: 1.1.2, 1.1.7, 1.2.1, 1.2.3, 2.1.1, 2.1.3, 3.6, 5.5, 6.2, 6.4, 6.9-6.12, 7.1, 7.2.1, 7.2.2, 7.3.1.4, 7.3.2, 7.3.3.4-7.3.3.9, 7.4.2.1, 7.5.4.3, 9.1.1, 9.2.2.3, 9.4.2.3, and 12.0.

1.0 SCOPE AND APPLICATION, SUMMARY

1.1 Scope and Application

1.1.1 This method is used to determine the concentrations of select Perfluorinated Alkyl Acids (PFAA) in water and solid matrices utilizing an HPLC equipped with a tandem mass spectrometer (MS/MS).

1.1.2 The following compound can be reported by this method:

TARGET	Synonym
Perfluorobutanoic acid*	PFBA*
Perfluoropentanoic acid*	PFPeA*
Perfluorohexanoic acid	PFHxA
Perfluoroheptanoic acid	PFHpA
Perfluorooctanoic acid	PFOA
Perfluorononanoic acid	PFNA
Perfluorodecanoic acid	PFDA
Perfluoroundecanoic acid	PFUnDA
Perfluorododecanoic acid	PFDoDA
Perfluorotridecanoic acid	PFTrDA
Perfluorotetradecanoic acid	PFTeDA
Perfluorohexadecanoic acid	PFHxDA
Perfluorooctadecanoic acid	PFODA
Perfluorobutanesulfonic acid	PFBS
Perfluorohexanesulfonic acid	PFHxS
Perfluoroheptanesulfonic acid	PFHpS
Perfluorooctanesulfonic acid	PFOS
Perfluorodecanesulfonic acid	PFDS

1.1.3 The reporting limits (RL) are based on the extraction procedure and the lowest calibration standard. Reporting limits may vary depending on matrix complications and volumes. Reporting limits for this method are 2-5ug/l for direct inject aqueous samples, 10-25ng/l for SPE extracted aqueous samples and 10-25ug/kg for solid samples.

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1.1.4 Acceptable recoveries for **PFBA** and **PFPeA** can not be attained by SPE and should not be reported by that technique.

1.1.5 The Method Detection Limit (MDL) for each analyte is evaluated on an annual basis for each matrix and instrument. MDLs are pooled for each matrix, and the final pooled MDLs are verified. The verified MDLs are stored in the LIMS and should be at least 2 to 3 times lower than the RL. Exceptions may be made on a case by case basis; however, at no point shall the MDL be higher than the reported RL.

1.1.6 Compounds detected at concentrations between the RL and MDL are quantitated and qualified as estimated values and reported with either a "J" or "I" qualifier. Some program or project specifications may require that no values below the RL be reported.

1.1.7 For DOD projects refer to QSM 5.0, Table 15 for additional method requirements and data qualifying guidance.

1.2 Summary

1.2.1 This method is adapted from EPA 537 and modified for the analysis of environmental water and soil samples per DoD QSM 5.0. This SOP is not designed to be used to analyze drinking water by EPA 537. For the purpose of the AFCEE ERPIMS EDD, this method is referred to as MS014.0.

1.2.2 Samples are received, stored, and extracted within the appropriate holding times.

1.2.3 Water samples are filtered and analyzed directly by LC/MS/MS. Soils are extracted with methanol, centrifuged and then analyzed by LC/MS/MS. Sample preparation is discussed within this SOP.

1.2.4 Low level waters are extracted by SPE in accordance to SOP OP058.

1.2.5 Perfluorinated compounds are separated, detected and quantitated using an LC/MS/MS. After HPLC separation and ionization, the specific Perfluorinated compound is isolated in the first mass spectrometer and transferred to a collision cell for fragmentation. The resulting fragments are introduced into the second mass spectrometer where they are detected and quantified.

1.2.6 Manual integrations are performed in accordance with SOP QA029.

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2.0 PRESERVATION AND HOLDING TIME

2.1 Preservation

2.1.1 Samples shall be collected in 125mL polyethylene bottles. A 125mL polyethylene wide mouth bottle is recommended for solid samples. Caps must not have Teflon liners.

2.1.2 The samples must be chilled to ≤10°C from the time of collection until arrival at the laboratory. Samples must not exceed 10°C during the first 48 hours after collection. The samples must be refrigerated at ≤ 6°C from the time of receipt until extraction.

2.1.3 The extracts should be stored at ≤6°C to minimize the potential for methanol evaporation but must be allowed to come to room temperature prior to analysis.

2.2 Holding Time

2.2.1 Aqueous samples must be extracted within 14 days of collection. Direct injection samples should be analyzed within 14 days of collection.

2.2.2 Solid and waste samples must be extracted within 14 days of collection.

2.2.3 Extracts must be analyzed within 28 days of extraction.

3.0 INTERFERENCES

3.1 Data from all blanks, samples, and spikes must be evaluated for interferences. Method interferences may be caused by contaminants in solvents, reagents, or glassware. The analytes in this method can also be found in many common laboratory supplies and equipment, such as PTFE (polytetrafluoroethylene) or Teflon products, HPLC solvent lines, methanol, aluminum foil, SPE transfer lines, bottle caps, etc. All of these materials must be demonstrated to be free from interferences.

3.2 All reagent solutions and samples (including QC samples) should be filtered through 0.45um nominal pore size or smaller (0.2um) membrane syringe filter to remove particulates and prevent damage to the instrument, columns and flow systems. Filters specifically designed for HPLC applications should be used. Filter membranes should be PVDF or similar, Teflon membranes can not be used.

3.3 Contact with glass containers, pipettes, or syringes should be minimized since the Perfluorinated compounds can potentially adsorb to glass surfaces.

3.4 Matrix interferences may be caused by contaminants that are co-extracted from the sample. The extent of matrix interferences will vary considerably from source

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to source, depending upon the nature of the water. Humic and/or fulvic material can be co-extracted during SPE and high levels can cause enhancement and/or suppression in the electrospray ionization source or low recoveries on the SPE sorbent. Total organic carbon (TOC) is a good indicator of the humic content of the sample.

3.5 SPE cartridges can be a source of interferences. The analysis of field and method blanks can provide important information regarding the presence or absence of such interferences. Brands and lots of SPE devices should be tested to ensure that contamination does not preclude analyte identification and quantitation.

3.6 Water and containers used for equipment blanks or field blanks should be tested prior to use. For smaller sampling events DI water will be provided in the same type of bottle used for sample collection. For larger sampling events four liter collapsible LDPE containers should be used. Containers should be filled with DI water and allowed to sit for several hours before testing. If the bottles are from the same lot and filled with DI on the same day, then one analysis per 10 containers should suffice. The DI water and container blanks must be free of any analytes of interest or interferences at ½ the required reporting level to be acceptable.

4.0 DEFINITIONS

4.1 Batch: A group of samples which are similar with respect to matrix and the testing procedures being employed and which are processed as a unit. A sample batch is limited to a maximum of 20 samples.

4.2 Blank Spike (BS): An analyte-free matrix spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. Blank Spike Recoveries are used to document laboratory performance for a given method. This may also be called a Laboratory Control Sample (LCS).

4.3 Continuing Calibration Verification (CCV): A check standard used to verify instrument calibration throughout an analytical run. For all GC and HPLC methods, a CCV must be analyzed at the beginning of the analytical run, after every 10 samples, and at the end of the run.

4.4 Holding Time: The maximum times that samples may be held prior to preparation and/or analysis and still considered valid.

4.5 Internal Standards (ISTD): A compound which is similar to the target analyte(s) in chemical composition and behavior, but which is not normally found in environmental samples.

4.6 Initial Calibration (ICAL): A series of standards used to establish the working range of a particular instrument and detector. The low point should be at a level equal to or below the reporting level.

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4.7 Initial Calibration Verification (ICV): A standard from a source different than that used for the initial calibration. A different vendor should be used whenever possible. The ICV is used to verify the validity of an Initial Calibration. This may also be called a QC check standard.

4.8 Matrix Spike (MS): A sample aliquot spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. The matrix spike recoveries are used to document the bias of a method in a given sample matrix.

4.9 Matrix Spike Duplicate (MSD): A replicate sample aliquot spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. The matrix spike duplicate recoveries are used to document the precision and bias of a method in a given sample matrix.

4.10 Method Blank (MB): An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank is processed simultaneously with the samples through all the steps of the analytical procedure. The method blank is used to document contamination resulting from the analytical process.

4.11 Sample Duplicate (DUP): A replicate sample which is used to document the precision of a method in a given sample matrix.

4.12 Preservation: Refrigeration and/or reagents added at the time of sample collection (or later) to maintain the chemical integrity of the sample.

5.0 REAGENTS

5.1 Water – HPLC grade or equivalent

5.2 Methanol – HPLC grade or equivalent

5.3 Acetonitrile – HPLC grade or equivalent

5.4 Perfluorinated Alkyl Acids stock standards – Traceable to Certificate of Analysis.

5.5 Mass labeled – Internal Standards

Perfluoro-[1,2-13C2]octanoic acid (13C2-PFOA)
Perfluoro-1-[1,2,3,4-13C4]octanesulfonic acid (13C4-PFOS)
Perfluoro-n-[1,2-13C2]hexadecanoic acid (13C2-PFHxDA)

5.6 Mass labeled – Surrogates

Perfluoro-n-[1,2-13C2]hexanoic acid (13C2-PFHxA)
Perfluoro-n-[1,2-13C2]decanoic acid (13C2-PFDA)

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6.0 APPARATUS

6.1 HPLC – Agilent Technologies 1260

Suitable HPLC equipped with an autosampler, pump, and column compartment. System should have a membrane degasser.

6.2 MS/MS – Agilent Technologies 6460A

LC/MS/MS must be capable of negative ion electrospray ionization near the required flow rate of the HPLC Column. The system must be capable of performing MS/MS to produce unique precursor and product ions for the PFAA method analytes within the specified retention time segments. A minimum of 10 scans across each peak is required to ensure adequate precision.

6.3 Data System – Agilent Technologies MassHunter B.04.0x and B.05.0x.

6.3.1 A computer system interfaced to the HPLC/MS/MS that allows for the continuous acquisition and storage of all data obtained throughout the duration of the chromatographic program.

6.3.2 The software should allow for the viewing of the specific MS/MS Spectra acquired over the analytical run. Comparisons can then be made between spectra from standards and samples.

6.3.3 Data is archived to a backup server for long term storage.

6.4 Column – Poroshell 120 EC C18 2.7um, 100 x 4.6 mm ID or equivalent

6.5 Vortexer

6.6 Ultrasonic Bath

6.7 Centrifuge – Adequate for clarifying soils extracts prior to filtration.

6.8 15ml Centrifuge tubes

6.9 Polyethylene screw cap and autosampler vials

6.10 Volumetric Pipettors and volumetric “plasticware” for dilutions of standards and extracts.

6.11 4 liter collapsible LDPE containers – For Field and Equipment Blanks, shown to be PFC free - Fisher 11-375-115B or equivalent

6.12 Top loading balance – capable of weighing samples to +/- 0.01 grams

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7.0 PROCEDURE

7.1 Standards Preparation

Standards are prepared from commercially available certified neat or reference standards. All standards must be logged in the HPLC Standards Logbook. All standards shall be traceable to their original source. The standards should be stored at ≤ 6°C, or as recommended by the manufacturer. Calibration levels, spike and surrogate concentrations, preparation information, and vendor part numbers can be found in the MS STD Summary in the Active SOP directory.

7.1.1 Stock Standard Solutions

Stock standards are available from some commercial vendors. All vendors must supply a "Certificate of Analysis" with the standard. The certificate will be retained by the lab. Hold time for unopened stock standards is until the vendor's expiration date. Once opened, the hold time is reduced to one year or the vendor's expiration date (whichever is shorter).

7.1.2 Intermediate Standard Solutions

Intermediate standards are prepared by quantitative dilution of the stock standard with methanol. The hold time for intermediate standards is six months or the vendor's expiration date (whichever is shorter). Intermediate standards may need to be remade if comparisons to other standards indicate analyte degradation or concentration changes. Intermediate standards should be stored in polyethylene vials.

7.1.3 Calibration Standards

Calibration standards for Perfluorinated analytes are prepared at a minimum of five concentration levels through quantitative dilutions of the intermediate standard. Calibration standards are prepared in methanol. The low standard is at a concentration at or below the RL and the remaining standards defines the working range of the detector. Calibration standards should be stored in polyethylene vials.

Calibration standard concentrations are verified by the analysis of an initial calibration verification (ICV) standard.

7.2 HPLC/MS/MS Conditions

7.2.1 HPLC Conditions

5ul autosampler injection

Column temperature – 50.0 °C Flow – 1.0 ml/min

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Gradient Table

Time (min)	Water (5% ACN)	MeOH (0.1% acetic acid)
0-0.0	65%	35%
0-6.0	0%	100%
6.0-12.0	0%	100%
12.0-18.0	65%	35%

7.2.2 MS/MS Conditions

Parameter	Value	Parameter	Value
Gas Temp C	325	Sheath Gas Flow (l/min)	10
Gas Flow (l/min)	10	Capillary (V)	4500
Nebulizer (psi)	55	V Charging	600
Sheath Gas Heater	300	Ionization Mode	Neg ESI

Fragmentation Table

Compound	ISTD/SURR	Precursor Ion	Product Ion	Frag (V)	CE (V)	Polarity
PFBA		213	169	60	0	Negative
PFPeA		263	219	47	7	Negative
PFBS		299	99	133	29	Negative
PFBS		299	80	133	45	Negative
PFHxA		313	269	40	0	Negative
13C2-PFHxA	SURR	315	270	40	2	Negative
PFHpA		363	319	50	8	Negative
PFHxS		399	99	105	45	Negative
PFHxS		399	80	95	45	Negative
PFOA		413	369	60	3	Negative
PFOA		413	169	60	15	Negative
13C2-PFOA	ISTD	415	370	60	3	Negative
PFHpS		449	80	100	45	Negative
PFNA		463	419	40	10	Negative
PFOS		499	99	180	51	Negative
PFOS		499	80	180	70	Negative
13C4-PFOS	ISTD	503	80	180	70	Negative
PFDA		513	469	42	9	Negative
13C2-PFDA	SURR	515	470	42	9	Negative
PFUnDA		563	519	45	9	Negative
PFDS		599	80	95	45	Negative
PFDoDA		613	569	48	10	Negative
PFTrDA		663	619	40	10	Negative
PFTeDA		713	669	20	11	Negative
PFHxDA		813	769	45	10	Negative
13C2-PFHxDA	ISTD	815	771	45	10	Negative
PFODA		913	869	45	10	Negative

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LC/MS/MS conditions are optimized for each instrument. Actual conditions may vary slightly from those listed above.

7.3 Sample Preparation

7.3.1 Aqueous Samples

7.3.1.1 Remove samples to be analyzed from the storage cooler and allow them to warm to ambient temperature. Transfer 1.0ml of sample to a 4ml screw top vial.

7.3.1.2 Use 1.0ml of reagent water for the method blank (MB) and blank spike (BS). Use additional 1.0ml aliquots for the matrix spike (MS) and matrix spike duplicate (MSD).

7.3.1.3 Add 20ul of spike mix to the BS, MS, and MSD.

7.3.1.4 Add 40ul of surrogate solution to each of the samples including the QC samples. Cap and invert several times.

7.3.1.5 Add 1.0ml methanol to the screw top vial. Cap and shake for about 1 minute. Store until ready for analysis.

7.3.2 Low Level Aqueous Samples

A 125ml aliquot of sample is extracted utilizing a solid phase extraction cartridge. The cartridge is eluted with methanol. The extract is concentrated and the final volume is adjusted to 1.0ml. Refer to SOP OP058.

7.3.3 Solid Samples

7.3.3.1 Remove samples to be analyzed from the storage cooler. Transfer 1.0g of sample to a clean 15ml centrifuge tube. Record the weight to 0.01g on the prep sheet.

7.3.3.2 Use 1.0g of blank sand for the method blank (MB) and blank spike (BS). Use additional 1.0g aliquots for the matrix spike (MS) and matrix spike duplicate (MSD).

7.3.3.3 Add 50ul of spike mix to the BS, MS, and MSD.

7.3.3.4 Add 100ul of surrogate solution to each of the samples including the QC samples.

7.3.3.5 Add 5ml methanol to the centrifuge tube. Cap and shake for about 1 minute.

7.3.3.6 Vortex each sample to thoroughly mix the contents.

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7.3.3.7 Place the centrifuge tubes in an ultrasonic bath for 30 minutes.

7.3.3.8 Remove the samples from the ultrasonic bath and centrifuge the samples for 5 minutes to separate the solids from the extract (methanol).

7.3.3.9 Transfer ~2ml of extract to a labeled 4ml screw top vial. Store the extracts at ≤6°C to minimize the potential for methanol evaporation. Allow the extracts to come to room temperature prior to analysis.

7.4 HPLC/MS/MS Analysis

Instrument calibration consists of three major sections:

Mass Tuning and Calibration
Initial Calibration Procedures
Continuing Calibration Verification

7.4.1 Mass Tuning and Calibration

Before samples can be run, the LC/MS/MS system must be mass tuned and calibrated.

The instrument should be hardware tuned per manufacturer's instructions after any maintenance is performed and prior to analyzing a new calibration curve.

The instrument must have a valid mass calibration prior to any sample analysis. The mass calibration should be updated as needed. (i.e. QC failures, ion masses showing large deviations from know masses, or major instrument maintenance is performed).

Verify the instrument tune and mass calibration by analyzing a mid-point Perfluorinated compound standard. This may be done using the daily CCV. The ions should be within ± 0.5 *m/z* of the expected mass.

7.4.2 Initial Calibration Procedures

Before samples can be run, the LC/MS/MS system must be calibrated.

7.4.2.1 Internal Standard Calibration

A minimum 5-point calibration curve is created for the Perfluorinated compounds and surrogates using an internal standard technique. Accutest Laboratories routinely performs a 6-point calibration to maximize the calibration range.

Use the LC/MS/MS data system to generate a linear regression or quadratic calibration curve for each of the

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analytes. This curve **must** be forced through zero and may be concentration weighted. Forcing zero allows for a better estimate of the background levels of method analytes.

The correlation coefficient (r) should be ≥0.995 (r^2 ≥0.990. Additionally, each calibration point for each analyte must be recalculated against the current initial calibration. The recovery of each analyte must be within 75%-125%, except for the low calibration point which must be within 50%-150% (70%-130% for DoD QSM) of the expected value.

- The mass labeled ISTDs in this method may undergo suppression in the ESI source if the concentration of the co-eluting unlabeled method analyte(s) is too high. The analyte concentration at which suppression may occur can vary depending on the instrument, LC conditions, ESI conditions, ISTD concentration, etc. To evaluate whether suppression is occurring during calibration, calculate the relative percent difference (RPD) between the high standard (H) and low standard (L) areas for each ISTDs using the following equation:

$$RPD = [(H-L) / \{(H+L)/2\}] \times 100$$

- The RPD calculated above must be < 20% for each ISTD during calibration. If the calculated RPD is > 20% for any ISTD, the analyst must recalibrate at lower analyte concentrations until the ISTD RPDs are < 20%.

7.4.2.2 Initial Calibration Verification (ICV)

The validity of the initial calibration curve must be verified through the analysis of an initial calibration verification (ICV) standard. The ICV should be prepared from a second source at a mid-range concentration.

The %D for the compound of interest should be ≤ 25%. If the ICV does not meet these criteria, a second standard should be prepared. If the ICV still does not meet criteria, analyze an ICV prepared from a third source (if available). If this ICV meets criteria, proceed with sample analysis. If the ICV still does not meet criteria, determine which two standards agree. Make fresh calibration standards and an ICV from the two sources that agree. Recalibrate the instrument.

NOTE: Second source standards may not be available for all of the Perfluorinated analytes.

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7.4.2.3 Retention Time Windows

Retention time windows must be established whenever a new column is installed in an instrument or whenever a major change has been made to an instrument.

Retention time windows are crucial to the identification of target compounds. Absolute retention times are used for compound identification in all GC and HPLC methods that do not employ internal standard calibration. Generally internal calibration methods utilize relative retentions times. Retention time windows are established to compensate for minor shifts in absolute retention times that result from normal chromatographic variability. The width of the retention time window should be carefully established to minimize the occurrence of both false positive and false negative results.

Retention time windows are established by injecting all standard mixes three times over the course of 72 hours. The width of the retention time window for each analyte, surrogate, and major constituent in multi-component analytes is defined as ± 3 times the standard deviation of the mean absolute retention time or 0.03 minutes, whichever is greater.

Establish the center of the retention time window for each analyte and surrogate by using the absolute retention time for each analyte and surrogate from the calibration verification standard at the beginning of the analytical shift. For samples run during the same shift as an initial calibration, use the retention time of the mid-point standard of the initial calibration.

Peak identification is based on the retention time of a peak falling within the retention time window for a given analyte. Time reference peaks internal standards and surrogates are used to correct for run-to-run variations in retention times due to temperature, flow, or injector fluctuations. HPLC retention times tend to shift more than GC retention times.

The retention time windows should be used as a guide for identifying compounds; however, the experience of the analyst should weigh heavily in the interpretation of the chromatograms. The analyst should monitor the retention times of known peaks (internal standards and surrogates) throughout an instrument run as an indication of instrument performance.

Because calculated retention time windows are generally very tight (less than ± 0.03 minutes), the retention time windows for the data processing method are generally set wider than the

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calculated window. This is done to ensure that the software does not miss any potential "hits". The analyst will then review these "hits" and determine if the retention times are close enough to the retention time of the target analyte to positively identify the peak or to require confirmation.

7.5.3 Continuing Calibration Verification (CCV)

Continuing calibration verification standards for the Perfluorinated compounds are prepared at a mid-range concentration.

The CCV must be analyzed at the beginning and end of each run to verify that the initial calibration is still valid. Additionally the mid-point CCV must be analyzed after every 10 samples.

The percent difference (%D) for each analyte of interest will be monitored. The |%D| should be ≤ 25% for the analyte in the mid-point CCV.

If the first continuing calibration verification does not meet criteria, a second standard may be injected. If the second standard does not meet criteria, the system must be recalibrated.

If the |%D| is outside the control limits, then documented corrective action is necessary. This may include recalibrating the instrument and reanalyzing the samples, performing instrument maintenance to correct the problem and reanalyzing the samples, or qualifying the data. Under certain circumstances, the data may be reported, i.e. The CCV failed high, the associated QC passed, and the samples were ND.

NOTE: Any target analytes that are detected in the samples must be bracketed by an acceptable initial calibration curve and acceptable CCV standards; otherwise, the samples must be reanalyzed or the data must be qualified.

7.5.4 Sample Extract Analysis

7.5.4.1 Samples are analyzed in a set referred to as an analysis sequence or batch. A batch consists of the following:

Initial Calibration Standards (or Initial CCV)
QC Extracts
Sample Extracts
CCV Standards

7.5.4.2 Two microliters of internal standard solution is added to every 100ul of extract in the autosampler vial. Generally, 500ul of extract are transferred to the autosampler vial with a gas tight syringe.

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7.5.4.3 Five microliters (same amount as standards) of extract is injected into the HPLC by the autosampler. The data system then records the resultant peak responses and retention times.

7.5.4.4 Tentative identification of an analyte occurs when the peak from the sample extract fall within the retention time window of the target compound.

7.5.4.5 Positive identification is confirmed by comparing the mass spectra in the sample to the mass spectra of the standards.

7.5.4.6 Some of the PFAAs may have multiple chromatographic peaks due to the presence of linear and branched isomers. This is prevalent in PFHxS and PFOS. The areas of all the linear and branched isomers peaks must be included and the concentrations reported as a total for each of these analytes.

7.5.4.7 If the compound identification does not confirm, then the result should be reported as ND or “U”.

7.5.4.8 If the analyte response exceeds the linear range of the system, the extract must be diluted and reanalyzed. It is recommended that extracts be diluted so that the response falls into the middle of the calibration curve.

7.5.4.9 If peak identification is prevented by the presence of interferences, further cleanup may be required or the extract must be diluted so that the interference does not mask any analytes.

7.6 Maintenance and Trouble Shooting

7.6.1 Refer to SOP GC001 for routine instrument maintenance and trouble shooting.

7.6.2 All instrument maintenance must be documented in the appropriate “Instrument Repair and Maintenance” log. The log will include such items as problem, action taken, correction verification, date, and analyst.

7.6.3 Repairs performed by outside vendors must also be documented in the log. The analyst or Department Supervisor responsible for the instrument must complete the log if the repair technician does not.

7.6.4 PC and software changes must be documented in the “Instrument Repair and Maintenance” log. Software changes may require additional validation.

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8.0 METHOD PERFORMANCE

Method performance is monitored through the routine analysis of negative and positive control samples. These control samples include method blanks (MB), blank spikes (BS), matrix spikes (MS), and matrix spike duplicates (MSD). The MB and BS are used to monitor overall method performance, while the MS and MSD are used to evaluate the method performance in a specific sample matrix.

Blank spike, blank spike duplicate, matrix spike, and matrix spike duplicate samples are compared to **DoD QSM defined** control limits. Control limits are stored in the LIMS. Additionally, blank spike accuracy is regularly evaluated for statistical trends that may be indicative of systematic analytical errors.

9.0 QUALITY ASSURANCE / QUALITY CONTROL

Accuracy and matrix bias are monitored by the use of surrogates and by the analysis of a QC set that is prepared with each batch (maximum of 20 samples) of samples. The QC set consists of a method blank (MB), blank spike (BS), matrix spike (MS), and matrix spike duplicate (MSD). All control limits are updated annually and are listed in the LIMS.

9.1 Internal Standards

9.1.1 Perfluoro-[1,2-13C2]octanoic acid (13C2-PFOA) and Perfluoro-1-[1,2,3,4-13C4]octanesulfonic acid (13C4-PFOS) are used as internal standards for this method. Additional analytes such as Perfluoro-n-[1,2-13C2]hexadecanoic acid (13C2-PFHxDA) may be used for internal standards when reporting additional analytes. The response of the internal standard in all subsequent runs should be ±50% of the internal standard average response from the initial calibration.

9.1.2 If the internal standard responses are not within limits, the following are required.

9.1.2.1 Check to be sure that there are no errors in calculations, integrations, or internal standards solutions. If errors are found, recalculate the data accordingly.

9.1.2.2 Check instrument performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample. If the recovery is high due to interfering peaks, it may be possible to get a more accurate recovery by analyzing the sample on a different column type.

9.1.2.3 If no problem is found, prepare a second aliquot of extract and reanalyze the sample.

9.1.2.4 If upon reanalysis, the responses are still not within limits, the problem is considered matrix interference.

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9.1.2.5 The sample may need to be reported from the dilution or the results qualified.

9.2 Surrogates

9.2.1 Perfluoro-n-[1,2-13C2]hexanoic acid (13C2-PFHxA) and Perfluoro-n-[1,2-13C2]decanoic acid (13C2-PFDA) are used as the surrogate standards to monitor the efficiency of the extraction.

A known amount of surrogate standard is added to each sample including the QC set prior to extraction. The percent recovery for each surrogate is calculated as follows:

% Recovery = (Sample Amount / Amount Spiked) X 100

The percent recovery for each surrogate must fall within 70-130% of true value for the results to be acceptable.

9.2.2 If any surrogate recovery is not within the established control limits, the following are required.

9.2.2.1 Check to be sure that there are no errors in calculations, dilutions, integrations, surrogate solutions or internal standard solutions. If errors are found, recalculate the data accordingly. If errors are suspected, re-vial and re-inject the extract to verify.

9.2.2.2 Check instrument performance. It may be necessary to re-vial and re-inject the extract in order to verify performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample.

9.2.2.3 If no problem is found, re-extract and reanalyze the sample. **NOTE:** If the recoveries are high and the sample is non-detect, then re-extraction may not be necessary. For any DoD QSM projects the resulting data must be qualified accordingly. If there is insufficient sample for re-extraction, reanalyze the sample and footnote this on the report.

9.2.2.4 If upon reanalysis, the recovery is still not within control limits, the problem is considered matrix interference. Surrogates from both sets of analysis should be reported on the final report.

9.2 Method Blank

9.3.1 The method blank is either HPLC water or cleaned sand (depending upon sample matrix). The method blank is then taken through all procedures along with the other samples to determine any contamination from reagents, glassware, or high level samples. The method blank must be

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free of any analytes of interest or interferences at ½ the required reporting level to be acceptable. If the method blank is not acceptable, corrective action must be taken to determine the source of the contamination. Samples associated with a contaminated method blank shall be evaluated as to the best corrective action for each particular sample. This may include reanalyzing the samples, re-extracting and reanalyzing the samples or qualifying the results with a "B" or "V" qualifier.

9.3.2 If the MB is contaminated but the samples are non-detect, then the source of contamination should be investigated and documented. The sample results can be reported without qualification.

9.3.3 If the MB is contaminated but the samples results are > 10 times the contamination level, the source of the contamination should be investigated and documented. The samples results may be reported with the appropriate "B" or "V" qualifier. This must be approved by the department supervisor.

9.3.4 If the MB is contaminated but the samples results are < 10 times the contamination level, the source of the contamination should be investigated and documented. The samples should be re-extracted and reanalyzed for confirmation. If there is insufficient sample to re-extract, or if the sample is re-extracted beyond hold time, the appropriate footnote and qualifiers should be added to the results. This must be approved by the department supervisor.

9.4 Blank Spike

9.4.1 The blank spike is either HPLC water or cleaned sand (depending upon sample matrix) to which the spike standard has been added. The blank spike is then taken through all procedures along with the other samples to monitor the efficiency of the extraction procedure. The percent recovery for each analyte is calculated as follows:

% Recovery = (Blank Spike Amount / Amount Spiked) X 100

The percent recovery for each analyte of interest must fall within 70-130% of true value for the results to be acceptable.

9.4.2 If the blank spike recoveries are not within the established control limits, the following are required.

9.4.2.1 Check to be sure that there are no errors in calculations, dilutions, integrations, or spike solutions. If errors are found, recalculate the data accordingly. If errors are suspected, re-vial and re-inject the extract to verify.

9.4.2.2 Check instrument performance. It may be necessary to re-vial and re-inject the extract in order to verify performance. If an

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instrument performance problem is identified, correct the problem and reanalyze the sample.

9.4.2.3 If the recovery of an analyte in the BS is high and the associated sample is non-detect, the data may be reportable. For any DoD QSM projects the resulting data must be qualified accordingly.

9.4.2.4 If no problem is found, the department supervisor shall review the data and determine what further corrective action is best for each particular sample. That may include reanalyzing the samples, re-extracting and reanalyzing the samples, or qualifying the results as estimated.

9.4.2.5 If there is insufficient sample to re-extract, or if the sample is re-extracted beyond hold time, the appropriate footnote and qualifiers should be added to the results. This must be approved by the department supervisor.

9.5 Matrix Spike and Matrix Spike Duplicate

9.5.1 Matrix spike and spike duplicates are replicate sample aliquots to which the spike standard has been added. The matrix spike and spike duplicate are then taken through all procedures along with the other samples to monitor the precision and accuracy of the procedure. The percent recovery for each analyte is calculated as follows:

% Recovery = [(Spike Amount – Sample Amount) / Amount Spiked] X 100

The percent recovery for each analyte of interest must fall within 70-130% of true value for the results to be acceptable.

9.5.2 If the matrix spike recoveries are not within the established control limits, the following are required.

9.5.2.1 Check to be sure that there are no errors in calculations, dilutions, integrations, or spike solutions. If errors are found, recalculate the data accordingly. If errors are suspected, re-vial and re-inject the extract to verify.

9.5.2.2 Check instrument performance. It may be necessary to re-vial and re-inject the extract in order to verify performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample.

9.5.2.3 If no problem is found, compare the recoveries to those of the blank spike. If the blank spike recoveries indicate that the problem is sample related, document this on the run narrative. Matrix spike recovery failures are not grounds for re-extract but are indications of the sample matrix effects.

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9.5.3 Precision

Matrix spike and spike duplicate recoveries for each analyte are used to calculate the relative percent difference (RPD) for each compound.

RPD = [| MS Result – MSD Result | / Average Result] X 100

The RPD for each Perfluorinated compound should be less than 30%. If the RPDs fall outside of the established control limits, the MS and MSD should be reanalyzed to ensure that there was no injection problem. If upon reanalysis the RPDs are still outside of the control limits, the department supervisor shall review the data and determine if any further action is necessary. RPD failures are generally not grounds for re-extraction.

10.0 CALCULATIONS

The concentration of each Perfluorinated compound in the original sample is calculated as follows:

Water (ug/l) = ($CONC_{inst}$) X (V_F / V_I) X DF

Soil (ug/kg) = [($CONC_{inst}$) X (V_F / W_I) X DF] / %solids

$CONC_{inst}$	=	Instrument concentration calculated from the initial Calibration using mean CF, linear curve, or Quadratic curve
DF	=	Dilution Factor
V_F	=	Volume of final extract (ml)
V_I	=	Volume of sample extracted (ml)
W_I	=	Weight of sample extracted (g)
%solids	=	Dry weight determination in decimal form

11.0 SAFETY AND POLLUTION PREVENTION

11.1 Safety

The analyst should follow normal safety procedures as outlined in the Accutest Health and Safety Plan and Personal Protection Policy, which includes the use of safety glasses, gloves, and lab coats.

The toxicity of each reagent and target analyte has not been precisely defined; however, each reagent and sample should be treated as a potential health hazard. Material Safety Data Sheets (MSDS) or Safety Data Sheets (SDS) are available for all reagents and many of the target analytes. Exposure must be reduced to the lowest possible level. Personal protective equipment should be used by all analysts.

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11.2 Pollution Prevention

Wastewater and methanol from the instrument are collected in waste storage bottles and are eventually transferred to the non-chlorinated waste drum.

Sample Extracts are archived and stored for 30 days after analysis. Old extracts and standards are disposed of in the waste vial drum.

12.0 REFERENCES

SW846 Method 8000C Revision 3, March 2003

EPA Method 537 Revision 1.1, September 2009

DOD QSM 5.0, July 2013

SOP for the Extraction of and Quantitation of Perfluorinated Compounds from Surface Soils, Mark Strynar, October 2008

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Compound List Report

Product: LC537PFC Perfluorinated Compounds
Matrix: SO Solid

Feb 26, 2014 05:52 pm

Method List:	LC537MOD SO	**Method Ref:**	EPA 537 MOD	LF21781
Report List:	LC537PFC ALL		Perfluorinated Carboxylic Acids and Sulfonates	LF21493
RL/MDL Factor:	5			

						Limits (%) Rev: 11/11/13		
Compound	**CAS No.**	**LOQ**	**LOD**	**MDL**	**Units**	**MS/MSD**	**RPD**	**BS**
Perfluorohexanoic acid	307-24-4	13	10	5.0	ug/kg	70-130	30	70-130
Perfluoroheptanoic acid	375-85-9	13	10	5.0	ug/kg	70-130	30	70-130
Perfluorooctanoic acid	335-67-1	13	10	5.0	ug/kg	70-130	30	70-130
Perfluorononanoic acid	375-95-1	13	10	5.8	ug/kg	70-130	30	70-130
Perfluorodecanoic acid	335-76-2	13	10	6.4	ug/kg	70-130	30	70-130
Perfluoroundecanoic acid	2058-94-8	13	10	7.7	ug/kg	70-130	30	70-130
Perfluorododecanoic acid	307-55-1	13	10	5.0	ug/kg	70-130	30	70-130
Perfluorotridecanoic acid	72629-94-8	13	10	6.4	ug/kg	70-130	30	70-130
Perfluorotetradecanoic acid	376-06-7	13	10	5.0	ug/kg	70-130	30	70-130
Perfluorobutanesulfonic acid	375-73-5	13	10	5.0	ug/kg	70-130	30	70-130
Perfluorohexanesulfonic acid	355-46-4	13	10	5.0	ug/kg	70-130	30	70-130
Perfluoroheptanesulfonic acid		13	10	5.0	ug/kg	70-130	30	70-130
Perfluorooctanesulfonic acid	1763-23-1	13	10	5.0	ug/kg	70-130	30	70-130
Perfluorodecanesulfonic acid		13	10	5.0	ug/kg	70-130	30	70-130
13C2-PFHxA		13	10	5.0		Surrogate Limits:		70-130
13C2-PFDA		13	10	5.0		Surrogate Limits:		70-130

14 compounds and 2 surrogates reported in list LC537PFC

Compound List Report

Product: LC537PFC Perfluorinated Compounds
Matrix: AQ Aqueous

Feb 24, 2014 01:44 pm

Method List:	LC537MOD AQ	**Method Ref:**	EPA 537 MOD	LF21780
Report List:	LC537PFC ALL		Perfluorinated Carboxylic Acids and Sulfonates	LF21493
RL/MDL Factor:	0.008			

						Limits (%) Rev: 11/11/13		
Compound	**CAS No.**	**LOQ**	**LOD**	**MDL**	**Units**	**MS/MSD**	**RPD**	**BS**
Perfluorohexanoic acid	307-24-4	0.020	0.016	0.0080	ug/l	70-130	30	70-130
Perfluoroheptanoic acid	375-85-9	0.020	0.016	0.0080	ug/l	70-130	30	70-130
Perfluorooctanoic acid	335-67-1	0.020	0.016	0.0080	ug/l	70-130	30	70-130
Perfluorononanoic acid	375-95-1	0.020	0.016	0.0080	ug/l	70-130	30	70-130
Perfluorodecanoic acid	335-76-2	0.020	0.016	0.0080	ug/l	70-130	30	70-130
Perfluoroundecanoic acid	2058-94-8	0.020	0.016	0.0080	ug/l	70-130	30	70-130
Perfluorododecanoic acid	307-55-1	0.020	0.016	0.0080	ug/l	70-130	30	70-130
Perfluorotridecanoic acid	72629-94-8	0.020	0.016	0.0080	ug/l	70-130	30	70-130
Perfluorotetradecanoic acid	376-06-7	0.020	0.016	0.0080	ug/l	70-130	30	70-130
Perfluorobutanesulfonic acid	375-73-5	0.020	0.016	0.0080	ug/l	70-130	30	70-130
Perfluorohexanesulfonic acid	355-46-4	0.020	0.016	0.0080	ug/l	70-130	30	70-130
Perfluoroheptanesulfonic acid		0.020	0.016	0.0080	ug/l	70-130	30	70-130
Perfluorooctanesulfonic acid	1763-23-1	0.020	0.016	0.0080	ug/l	70-130	30	70-130
Perfluorodecanesulfonic acid		0.020	0.016	0.0080	ug/l	70-130	30	70-130
13C2-PFHxA		0.020	0.016	0.0080		Surrogate Limits:		70-130
13C2-PFDA		0.020	0.016	0.0080		Surrogate Limits:		70-130

14 compounds and 2 surrogates reported in list LC537PFC

ANALYSIS OF VOLATILE ORGANICS BY GC/MS

Prepared by: Norm Farmer Date: 05/14/14

Approved by: Mark Erstling Date: 05/21/14

Annual Review

Reviewed by: _____ Date: _____

Reviewed by: _____ Date: _____

Reviewed by: _____ Date: _____

Document Control

Issued to: QA Department Date: 05/28/14

Issued to: MS Volatile Department Date: 05/28/14*

Issued to: MS Volatile Soil Lab Date: _____

Issued to: _____ Date: _____

Issued to: _____ Date: _____

Issued to: _____ Date: _____

Effective 7 days after "*" date

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TEST NAME: ANALYSIS OF VOLATILE ORGANICS BY GC/MS

METHOD REFERENCE: SW846 8260B

DEPT: MS

Revised Sections: 1.1.5, 7.1, 7.5.2.6, 7.5.1.3, 7.5.2.2, 7.5.2.5-7.5.2.7, 7.5.3.4, 7.5.3.5, 9.2.2.3, 9.4.1 and 9.4.2.4

1.0 SCOPE AND APPLICATION, SUMMARY

1.1 Scope and Application

1.1.1 This method is used to determine the concentrations of various volatile organic compounds in water and solid matrices utilizing a gas chromatograph equipped with a mass spectrometer detector. Routine compounds can be found in Table 1.

1.1.2 Reporting limits (RL) are based on the sample amount and the lowest calibration standard. Reporting limits may vary depending on matrix complications and sample volumes. Reporting limits for this method are in the range of 1.0 ug/l for aqueous samples and 5 ug/kg for solid samples. Solid matrices are reported on a dry weight basis.

1.1.3 The Method Detection Limit (MDL) for each analyte is evaluated on an annual basis for each matrix and instrument. MDLs are pooled for each matrix, and the final pooled MDLs are verified. The verified MDLs are stored in the LIMS and should be at least 2 to 3 times lower than the RL. Exceptions may be made on a case by case basis; however, at no point shall the MDL be higher than the reported RL.

1.1.4 Compounds detected at concentrations between the RL and MDL are quantitated and qualified as estimated values and reported with either a “J” or “I” qualifier. Some program or project specifications may require that no values below the RL be reported.

1.1.5 For DOD projects refer to QSM 4.2, Table F4 or QSM 5.0, Table 4 for additional method requirements and data qualifying guidance.

1.2 Summary

1.2.1 This method is adapted from SW846 method 8260B.

1.2.2 Samples are received, stored and analyzed within the appropriate holding times.

1.2.3 Sample preparation is performed in accordance with Accutest SOP OP020 and OP021.

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1.2.4 The samples are analyzed on a gas chromatograph equipped with mass spectrometer detector.

1.2.5 The peaks detected are identified by comparison to characteristic ions and retention times specific to the known target list of compounds.

1.2.6 Additional unknown peaks with a response > 10% of the closest internal standard may be processed through a library search with comparison to a database of approximately 98,000 spectra. An estimated concentration is quantitated by assuming a response factor of 1.

1.2.7 Manual integrations are performed in accordance with SOP QA029.

2.0 PRESERVATION AND HOLDING TIME

2.1 Preservation

Aqueous Samples:

2.1.1 Samples shall be collected in standard 40ml vials with Teflon lined silicone septa. HCl is used to adjust the pH of the sample to <2.

2.1.2 The samples must be stored in capped vials, with minimum headspace, at ≤ 6 °C in an area free of solvent fumes. The size of any bubble caused by degassing upon cooling should not exceed 5-6mm.

Solid Samples:

2.1.3 Special 40ml vials for purge-and-trap of solid samples, as well as the collection and preservation options are described in OP020.

2.1.4 Low level soil samples are preserved by storing them in sealed VOA vials at temperatures between –10 °C to –20 °C. High level soil samples are preserved by storing them in methanol at a ratio of 1 gram of soil to 1ml of methanol.

2.2 Holding Time

2.2.1 Aqueous samples are to be analyzed within 14 days of collection, unless otherwise specified by the contract. Samples that are not preserved should be analyzed within 7 days of collection; however, the preservation deficiency must be noted in the report.

2.2.2 Solid and waste samples must be analyzed within 14 days of collection.

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3.0 INTERFERENCES

3.1 Data from all blanks, samples, and spikes must be evaluated for interferences.

3.2 Impurities in the purge gas, organic compounds out-gassing from the plumbing ahead of the trap, and solvent vapors in the laboratory account for the majority of contamination problems. The analytical system must be demonstrated to be free from contamination under the conditions of the analysis by running laboratory blanks. The use of non-TFE tubing, non-TFE thread sealants, or flow controllers with rubber components in the purging device should be avoided.

3.3 Samples can be contaminated by diffusion of volatile organics (particularly methylene chloride and fluorocarbons) through the septum seal into the sample during shipment and storage. A trip blank can serve as a check on such contamination.

3.4 Contamination by carry-over can occur whenever high level and low-level samples are sequentially analyzed. Whenever an unusually concentrated sample is encountered, it should be followed by an analysis of reagent water to check for carry-over.

4.0 DEFINITIONS

4.1 Batch: A group of samples which are similar with respect to matrix and the testing procedures being employed and which are processed as a unit. A sample batch is limited to a maximum of 20 samples or samples loaded on an instrument within the same 12-hour shift, which ever comes first.

4.2 Blank Spike (BS): An analyte-free matrix spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. Blank Spike Recoveries are used to document laboratory performance for a given method. This may also be called a Laboratory Control Sample (LCS).

4.3 Continuing Calibration Verification (CCV): A check standard used to verify instrument calibration throughout an analytical run. For all MS methods, a CCV must be analyzed at the beginning of each analytical run.

4.4 Holding Time: The maximum times that samples may be held prior to preparation and/or analysis and still be considered valid.

4.5 Internal Standards: An organic compound which is similar to the target analyte(s) in chemical composition and behavior, but which is not normally found in environmental samples. Internal standards for Mass Spec methods are often deuterated forms of target analytes. Internal standards are used to compensate for retention time and response shifts during an analytical run.

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4.6 Initial Calibration (ICAL): A series of standards used to establish the working range of a particular instrument and detector. The low point should be at a level equal to or below the reporting level.

4.7 Initial Calibration Verification (ICV): A standard from a source different than that used for the initial calibration. A different vendor should be used whenever possible. The ICV is used to verify the validity of an Initial Calibration. This may also be called a QC check standard.

4.8 Matrix Spike (MS): A sample aliquot spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. The matrix spike recoveries are used to document the bias of a method in a given sample matrix.

4.9 Matrix Spike Duplicate (MSD): A replicate sample aliquot spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. The matrix spike duplicate recoveries are used to document the precision and bias of a method in a given sample matrix.

4.10 Method Blank (MB): An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank is processed simultaneously with the samples through all the steps of the analytical procedure. The method blank is used to document contamination resulting from the analytical process.

4.11 Sample Duplicate (DUP): A replicate sample which is used to document the precision of a method in a given sample matrix.

4.12 Preservation: Refrigeration and/or reagents added at the time of sample collection (or later) to maintain the chemical integrity of the sample.

4.13 Surrogate: An organic compound which is similar to the target analyte(s) in chemical composition and behavior, but which is not normally found in environmental samples. Surrogates are used to measure the purge efficiency.

4.14 Trip Blank: A sample of analyte-free matrix taken from the laboratory to the sampling site and returned to the laboratory unopened. A trip blank is used to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organic samples.

5.0 REAGENTS

5.1 Methanol – purge-and-trap grade or equivalent

5.2 Volatile stock standards – Various mixes, traceable to Certificate of Analysis

5.3 4-Bromofluorobenzene (BFB) – instrument tuning mix

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5.4 Surrogate standards –

Dibromofluoromethane
1,2-Dichloroethane-d4
Toluene-d8
4-Bromofluorobenzene

5.5 Internal standards –

Fluorobenzene
Chlorobenzene-d5
1,4-Dichlorobenzene-d4
tert-Butyl alcohol-d10

6.0 APPARATUS

6.1 Gas Chromatograph – HP 5890 or Agilent Technologies 6890 or 7890

6.1.1 Gas Chromatograph

The analytical system that is complete with a temperature programmable gas chromatograph and all required accessories, analytical columns, and gases.

6.1.2 The injection port is designed for split-splitless injection with capillary columns. The injection port must have an appropriate interface for sample introduction.

6.2 Mass Spectrometer– HP 5970 or Agilent Technologies 5973 or 5975

The mass spectrometer must be capable of scanning from 35-300 amu every second or less utilizing 70-volt (nominal) electron energy in the electron impact ionization mode. It must also be capable of producing a mass spectrum that meets all the criteria in section 7.5.1.1 when injecting 50 ng of Bromofluorobenzene (BFB).

6.3 Purge and Trap – OI Analytical 4560 or 4660 with OI Analytical 4552 or 4551

6.3.1 The following autosampler models are used for purging, trapping and desorbing the sample onto GC column.

- O.I. Model 4560 sample concentrator with 4552 Water/Soil multisampler
- O.I. Model 4660 sample concentrator with 4552 Water/Soil multisampler
- O.I. Model 4660 sample concentrator with 4551 Water multisampler

6.3.2 The sample purge vessel must be designed to accept 5 ml samples with a water column at least 3 cm deep.

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6.3.3 The multisampler is equipped with a heater capable of maintaining the purge chamber at 40 °C to improve purging efficiency. The heater is to be used for soil and sediment analysis.

6.3.4 The desorber should be capable of rapidly heating the trap to the manufacturer recommended desorb temperature.

6.4 Data System – Agilent Technologies MS Chemstation rev. AA 03.02, DA 00.01, DA 02.0x, DA 03.0x or EA02.0x.

6.4.1 A computer system interfaced to the mass spectrometer that allows for the continuous acquisition and storage of all mass spectral data obtained throughout the duration of the chromatographic program.

6.4.2 The computer utilizes software that allows searching any GC/MS data file for ions of a specific mass and that can plot such ion abundances versus time or scan number. This type of plot is defined as an Extracted Ion Current Profile (EICP).

6.4.3 The software should allow for integrating the abundances in any EICP between specific time or scan number limits. Characteristic ions for each analyte are listed in Table 2.

6.4.4 The most recent version of the EPA/NIST mass spectral library should be available.

6.4.5 Data is archived to a backup server for long term storage.

6.5 Trap – OI #10 or equivalent: Tenax, Silica Gel, and Carbon Molecular Sieve. The trap should be conditioned according to the manufacturer‘s recommendations.

6.6 Columns – RTX-624 or equivalent: 60m X 0.25mm 1.4um.
- RTX-VMS or equivalent: 60m X 0.25mm 1.4um
- RTX-VMS or equivalent: 40m X 0.18mm 1.0um

6.7 Gas-tight syringes and class “A” volumetric glassware for dilutions of standards and samples.

7.0 PROCEDURE

7.1 Standards Preparation

Standards are prepared from commercially available certified reference standards. All standards must be logged in the Volatile Standards Logbook. All standards shall be traceable to their original source. The standards should be stored at temperatures between –10 °C and –20 °C, or as recommended by the manufacturer. Calibration levels, spike and surrogate concentrations,

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preparation information, and vendor part numbers can be found in the MSVOA STD Summary in the Active SOP directory.

7.1.1 Stock Standard Solutions

Stock standards are available from several commercial vendors. All vendors must supply a "Certificate of Analysis" with the standard. The certificate will be retained by the lab. Hold time for unopened stock standards is until the vendor's expiration date. Once opened, the hold time is reduced to six months (one month for gases) or the vendor's expiration date (whichever is shorter).

7.1.2 Intermediate Standard Solutions

Intermediate standards are prepared by quantitative dilution of the stock standard with methanol. The hold time for intermediate standards is one month (one week for gases) or the vendor's expiration date (whichever is shorter). Intermediate standards may need to be remade if comparison to other standards indicates analyte degradation or concentration changes.

7.1.3 Calibration Standards

Calibration standards for the volatile organics are prepared at a minimum of five concentration levels through quantitative dilutions of the intermediate standard. The low standard is at a concentration at or below the RL and the remaining standards define the working range of the detector.

Calibration standard concentrations are verified by the analysis of an initial calibration verification (ICV) standard.

7.2 Instrument Conditions

<u>Gas Chromatograph/ Mass Spectrometer</u>

Carrier gas flow	1.0 ml/min
Transfer line temperature	220 - 280 °C
Analyzer temperature	150 °C

Oven program – 45 °C for 2.0 minutes (RTX-624)
10 °C/min to 80 °C for 0 minutes
14 °C/min to 210 °C for 0 minutes
16 °C/min to 240 °C for 4.2 minutes

Oven program – 45 °C for 2.5 minutes (RTX-VMS 40m)
10 °C/min to 80 °C for 0 minutes
15 °C/min to 185 °C for 0 minutes
30 °C/min to 240 °C for 2.5 minutes

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Oven program – 45 °C for 5.0 minutes (RTX-VMS 60m)
10 °C/min to 180 °C for 0 minutes
15 °C/min to 240 °C for 2.33 minutes

GC conditions are optimized for each instrument. Actual conditions may vary slightly from those listed above.

7.3 Purge and Trap Device conditions

Purge Gas:	Helium at 30 ml/min
Sample Temp:	Aqueous (Ambient)
	Soils (40°C)
Trap Temp:	<25°C
Purge Time:	11 min
Desorb:	2 min. at 190°C
Bake:	5 min. at 210°C

7.4 Sample Preparation

7.4.1 Water Samples

A 5ml aliquot of sample is loaded onto the purge-and-trap device and purged for 11 minutes. Detailed procedures are described in SOP OP021.

7.4.2 Solid Samples

A 5-gram aliquot of sample is loaded onto the purge-and-trap device. 5mls of reagent water is added along with internal standards and surrogates. The sample is then purged for 11 minutes while heated to 40°C and mechanically agitated. Detailed procedures are described in SOP OP020.

Alternatively methanol aliquot from the sample is loaded onto the purge-and-trap device. 5mls of reagent water is added along with internal standards and surrogates. The sample is then purged for 11 minutes. Detailed procedures are described in SOP OP020.

7.5 Gas Chromatographic Analysis

Instrument calibration consists of two major sections:

Initial Calibration Procedures
Continuing Calibration Verification

7.5.1 Initial Calibration Procedures

Before samples can be run, the GC/MS system must be tuned, the injection port inertness must be verified, and the instrument must be calibrated.

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7.5.1.1 Tune Verification (BFB)

The instrument should be hardware tuned per manufacturer's instructions. Verify the instrument tune by injecting 2ul (50ng) of BFB solution onto the instrument. The BFB standard may also be purged. The resulting BFB spectra should meet the criteria in the following table.

BFB KEY IONS AND ION ABUNDANCE CRITERIA

Mass	Ion Abundance Criteria
50	15-40% of mass 95
75	30-60% of mass 95
95	Base peak, 100% relative abundance
96	5-9% of mass 95
173	<2% of mass 174
174	>50% of mass 95
175	5-9 % of mass 174
176	>95% and <101% of mass 174
177	5-9% of mass 176

Evaluate the tune spectrum using three mass scans from the chromatographic peak and a subtraction of instrument background. This procedure is performed automatically by the MS Chemstation software by running "autofind" on the BFB peak.

Select the scans at the peak apex and one to each side of the apex. Calculate an average of the mass abundances from the three scans.

Background subtraction is required. Select a single scan in the chromatogram that is absent of any interfering compound peak and no more than 20 scans prior to the elution of BFB. The background subtraction should be designed only to eliminate column bleed or instrument background ions. Do not subtract part of the tuning compound peak.

Alternatively, the average spectra over the entire peak may be used. **All subsequent tune evaluations must use the same procedure that was used for the Initial Calibration.**

If the criteria are not achieved, the analyst must retune the mass spectrometer and repeat the test until all criteria are met.

Analysis must not begin until the tuning criteria are met. The injection time of the acceptable tune analysis is considered the start of the 12-hour clock. The same mass spec settings must

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be used for the calibration standards and samples that were used for the tune evaluation standard.

7.5.1.2 Internal Standard Calibration

A minimum 5-point calibration curve is created for the volatile organic compounds and surrogates using an internal standard technique. Accutest Laboratories routinely performs a 6-point calibration to maximize the calibration range.

The low point may be omitted from the calibration table for any compound with an RL set at the level two standard. Additionally the high point may be omitted for any compound that exhibits poor linearity at the upper end of the calibration range.

Response factors (RF) for each analyte are determined as follows:

$$RF = (A_{anayte} \mathbf{X} C_{istd})/(A_{istd} \mathbf{X} C_{analyte})$$

A_{anayte} = area of the analyte
A_{istd} = area of the internal standard
$C_{analyte}$ = concentration of the analyte
C_{istd} = concentration of the internal standard.

The mean RF and standard deviation of the RF are determined for each analyte. The percent relative standard deviation (%RSD) of the response factors is calculated for each analyte as follows:

%RSD = (Standard Deviation of RF X 100) / Mean RF

If the %RSD ≤ 15%, linearity through the origin can be assumed and the mean RF can be used to quantitate target analytes in the samples. Alternatively if the %RSD > 15% a calibration curve of response vs. amount can be plotted. If the correlation coefficient (r) is ≥0.995 (r^2 ≥0.990) then the curve can be used to quantitate target analytes in the samples.

The method also employs a series of Calibration Check Compounds (CCC) and System Performance Check Compounds (SPCC). The %RSD for any CCC must be ≤ 30 % and the average relative response factor for any SPCC must be at least 0.10 or 0.30 (See tables below). If the %RSD for any CCC is ≤ 30% but > 15% the compound should be evaluated by curve fit.

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Calibration Check Compounds (CCC)

Vinyl chloride	1,1-Dichloroethene
Chloroform	1,2-Dichloropropane
Toluene	Ethylbenzene

System Performance Check Compounds (SPCC)

Compound	**Minimum RF**
Chloromethane	0.1
1,1-Dichloroethane	0.1
Bromoform	0.1
1,1,2,2-Tetrachloroethane	0.3
Chlorobenzene	0.3

7.5.1.3 Initial Calibration Verification (ICV)

The validity of the initial calibration curve must be verified through the analysis of an initial calibration verification (ICV) standard. The ICV should be prepared from a second source at a mid-range concentration.

The %D for all normal analytes of interest should be ≤ 20%, the %D for all poor performing (PP) analytes of interest should be ≤ 40%. (These analytes are identified in Table 1) If the %D > 20% (>40% for PP), the analysis of samples may still proceed if the analyte failed high and the analyte is not expected to be present in the samples. However, if a reportable analyte is detected in a sample and the %D for that analyte was greater than 20% (>40% for PP) in the ICV, the sample will need to be reanalyzed on a system with a passing ICV for that analyte.

For any DoD QSM project, the %D for all target compounds should be ≤ 20%. If samples must be analyzed with an analyte of interest having a %D > 20%, then the data must be qualified accordingly.

If the ICV does not meet this criteria, a second standard should be prepared. If the ICV still does not meet criteria, analyze an ICV prepared from a third source. If this ICV meets criteria, proceed with sample analysis. If the ICV still does not meet criteria, determine which two standards agree. Make fresh calibration standards and an ICV from the two sources that agree. Recalibrate the instrument.

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7.5.2 Continuing Calibration Verification (CCV)

7.5.2.1 Inject 2ul of the tune evaluation mix at the beginning of each 12-hour shift. Evaluate the resultant peaks against the criteria in section 7.5.1.1. The injection time of this standard starts the 12-hour window.

When the analyst is running an unattended second 12-hour window, they may opt to purge the BFB standard. This can be performed by purging an additional blank (which contains BFB) just prior to the second CCV.

7.5.2.2 Analyze a continuing calibration check standard. The CCV should be at or below the mid-point of the calibration curve.

7.5.2.3 The RF of check standard for SPCC compounds must meet the minimum RF requirement as listed in the table.

7.5.2.4 The %D for the CCC compounds must be ≤ 20%. If the CCCs are not part of the target list, then all target analytes must meet the 20 %D criteria.

7.5.2.5 The %D for all other analytes of interest should be ≤ 20%; however, the large number of analytes in this method presents a substantial probability that a few of the analytes will fall outside of this range. If the %D > 20%, the analysis of samples may still proceed if the analyte failed high and the analyte is not expected to be present in the samples. However, if a reportable analyte is detected in a sample and the %D for that analyte was greater than 20% in the CCV, the sample will need to be reanalyzed on a system with a passing CCV for that analyte, or the data must be qualified.

For any DoD QSM project, the %D for all target compounds should be ≤ 20%. If samples must be reported with an analyte of interest having a %D > 20%, then the data must be qualified accordingly, regardless of whether the analyte was detected or not.

7.5.2.6 The criteria in 7.5.2.3 and 7.5.2.4 must be met for the continuing calibration to be considered valid. Additionally, only analytes that are being reported for a given sample must meet the criteria in 7.5.2.5. If the first continuing calibration verification does not meet criteria, a second standard may be injected.

Rationale for second standard such as instrument maintenance, clipped column, remade standard, etc should be documented in the run log or maintenance log. Reanalysis of second standard without valid rationale may require the analysis of a third

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standard (in which case both the second and third standard would have to pass).

If the second standard (or third) does not meet criteria, the system must be recalibrated.

7.5.2.7 For QSM 5 compliance an additional CCV must be analyzed at the end of each run. The %D for all target compounds in this CCV should be ≤ 50%. If samples must be reported with an analyte of interest having a %D > 50%, then the data must be qualified accordingly, regardless of whether the analyte was detected or not.

7.5.2.8 If any of the internal standard response changes by more than a factor of two (-50% to +100%) or retention time changes by more than 30 seconds from the midpoint standard of the last initial calibration, the mass spectrometer must be inspected for malfunctions and corrections made, as appropriate. Corrective action may include re-calibration (initial Calibration) of the instrument.

7.5.3 Sample Analysis

7.5.3.1 Samples are analyzed in a set referred to as an analysis sequence or batch. A batch consists of the following:

Tune Evaluation Mix
Initial Calibration Standards (or CCV)
QC Samples
Samples

7.5.3.2 One microliter of internal standard/surrogate solution is added to every 5ml of sample in the sparge vessel. Generally, 5ml of sample are transferred to the sparge vessel.

7.5.3.3 After purging, the system will automatically reverse flow and rapidly heat the trap to desorb the sample analytes onto the GC column.

7.5.3.4 Qualitative identification

The target compounds shall be identified by analysts with competent knowledge in the interpretation of mass spectra by comparison of the sample mass spectrum to the mass spectrum of a standard of the suspected compound. The criteria required for a positive identification is:

The intensities of the characteristic ions of a compound maximize in the same scan or within one scan of each other.

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Selection of a peak by a data system target compound search routine where the search is based on the presence of a target chromatographic peak containing ions specific for the target compound at a compound-specific retention time will be accepted as meeting this criterion.

The sample component must elute at the same relative retention time (RRT) as the daily standard. The RRT of sample component must be within ± 0.06 RRT units of the standard.
All ions present in the standard mass spectra at a relative intensity greater than 10% (major abundant ion in the spectrum equals 100%) should be present in the sample spectrum.

The relative intensities of these ions must agree within ± 30% between the daily standard and sample spectra. (Example: For an ion with an abundance of 50% in the standard spectra, the corresponding sample abundance must be between 20 and 80%.)

Structural isomers that produce very similar mass spectra should be identified as individual isomers if they have sufficiently different GC retention times. Sufficient GC resolution is achieved if the height of the valley between two isomer peaks is less than 25% of sum of the two peak heights. Otherwise, structural isomers are identified as isomeric pairs.

If peak identification is prevented by the presence of interferences, the sample must be diluted so that the interference does not mask any analytes.

7.5.3.5 Quantitative analysis

When a target compound has been identified, concentration will be based on the integrated area of the quantitation ion, which is normally the base peak.

The sample matrix may produce an interference with the primary ion. This may be characterized by an excessive background signal of the same ion, which distorts the peak shape beyond a definitive integration. The interference could also, severely inhibit the response of the internal standard ion.

If the analyte response exceeds the linear range of the system, the extract must be diluted and reanalyzed. It is recommended that samples be diluted so that the response falls into the middle of the calibration curve.

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7.5.3.6 Library search for tentatively identified compounds

If a library search is requested, the analyst should perform a forward library search of the NIST mass spectral library to tentatively identify 10 to 20 non-target compounds.

Guidelines for making tentative identification are:

These compounds should have a response greater than 10% of the nearest internal standard. The response is obtained from the Total Ion Chromatogram.

The search is to include a spectral printout of the best library match for a particular substance. The results are to be interpreted by the analyst.

Relative intensities of major ions in the reference spectrum (ions >10% of the most abundant ion) should be present in the sample spectrum.

The relative intensities the major ions should agree within ±20%.

Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination or presence of coeluting compounds.

Ions present in the reference spectrum but not in the sample spectrum should be verified by performing further manual background subtraction to eliminate the interference created by coeluting peaks and/or matrix interference.

Quantitation of the tentatively identified compounds is obtained from the total ion chromatogram based on a response factor of 1 from the nearest internal standard and is to be tabulated on the library search summary data sheet.

7.6 Maintenance and Trouble Shooting

7.6.1 Refer to SOP GC001 for routine instrument maintenance and trouble shooting.

7.6.2 All instrument maintenance must be documented in the appropriate “Instrument Repair and Maintenance” log. The log will include such items as problem, action taken, correction verification, date, and analyst.

7.6.3 Repairs performed by outside vendors must also be documented in the log. The analyst or Department Supervisor responsible for the instrument must complete the log if the repair technician does not.

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7.6.4 PC and software changes must be documented in the "Instrument Repair and Maintenance" log. Software changes may require additional validation.

8.0 METHOD PERFORMANCE

Method performance is monitored through the routine analysis of negative and positive control samples. These control samples include method blanks (MB), blank spikes (BS), matrix spikes (MS), and matrix spike duplicates (MSD). The MB and BS are used to monitor overall method performance, while the MS and MSD are used to evaluate the method performance in a specific sample matrix.

Blank spike, matrix spike, and matrix spike duplicate samples are compared to statistically generated control limits. These control limits are reviewed and updated annually. Control limits are stored in the LIMS. Additionally, blank spike accuracy is regularly evaluated for statistical trends that may be indicative of systematic analytical errors.

9.0 QUALITY ASSURANCE / QUALITY CONTROL

Accuracy and matrix bias are monitored by the use of surrogates and by the analysis of a QC set that is prepared with each batch (maximum of 20 samples) of samples. The QC set consists of a method blank (MB), blank spike (BS), matrix spike (MS), and matrix spike duplicate (MSD).

9.1 Internal Standards

9.1.1 Fluorobenzene, Chlorobenzene-d5, 1,4-Dichlorobenzene-d4, and Tert Butyl Alcohol-d10 are used as internal standards for this method. The response of the internal standard in all subsequent runs should be within a factor of two (-50% to +100%) of the internal standard response in the opening CCV for each sequence. On days that an initial calibration is performed, the internal standard responses should be compared to the internal standard responses for the mid-point standard. The response for Tert Butyl Alcohol-d10 need only be monitored if target analytes are being reported that reference that particular internal standard.

9.1.2 If the internal standard responses are not within limits, the following are required.

9.1.2.1 Check to be sure that there are no errors in calculations, integrations, or internal standards solutions. If errors are found, recalculate the data accordingly.

9.1.2.2 Check instrument performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample. If the recovery is high due to interfering peaks, it may

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be possible to get a more accurate recovery by analyzing the sample on a different column type.

9.1.1.3 If no problem is found, prepare a second aliquot of sample and reanalyze the sample. If there is insufficient sample for reanalysis, footnote this on the report.

9.1.1.4 If upon reanalysis, the responses are still not within limits, the problem is considered matrix interference. The sample may need to be diluted or the results qualified.

9.2 Surrogates

9.2.1 Dibromofluoromethane, 1,2-Dichloroethane-d4, Toluene-d8, and 4-Bromofluorobenzene are used as the surrogate standards to monitor the efficiency of the purge-and-trap system.

A known amount of surrogate standard is added to each sample including the QC set prior to sparging. The percent recovery for each surrogate is calculated as follows:

% Recovery = (Sample Amount / Amount Spiked) X 100

The percent recovery must fall within the established control limits for all surrogates for the results to be acceptable.

9.2.2 If any surrogate recovery is not within the established control limits, the following are required.

9.2.2.1 Check to be sure that there are no errors in calculations, dilutions, integrations, surrogate solutions or internal standard solutions. If errors are found, recalculate the data accordingly.

9.2.2.2 Check instrument performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample. If the recovery is high due to interfering peaks, it may be possible to get a more accurate recovery by analyzing the sample on a different column type.

9.2.2.3 If no problem is found, reanalyze the sample. **NOTE:** If the recoveries are high and the sample is non-detect, then reanalysis may not be necessary. For any DoD QSM projects the resulting data must be qualified accordingly. If there is insufficient sample for reanalysis, footnote this on the report.

9.2.2.4 If upon reanalysis, the recovery is still not within control limits, the problem is considered matrix interference. Surrogates from both sets of analysis should be reported on the final report.

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9.3 Method Blank

9.3.1 The method blank is de-ionized water or de-ionized water with 5 grams of Teflon chips (depending upon sample matrix) to which the surrogate standard has been added. The method blank is then purged along with the other samples to determine any contamination from the system or ambient sources. The method blank must be free of any analytes of interest or interferences at ½ the required reporting level to be acceptable. Common laboratory contaminants such as methylene chloride must be below the RL if present. If the method blank is not acceptable, corrective action must be taken to determine the source of the contamination. Samples associated with a contaminated method blank shall be evaluated as to the best corrective action for each particular sample. This may include reanalyzing the samples or qualifying the results with a “B” or “V” qualifier.

9.3.2 If the MB is contaminated but the samples are non-detect, then the source of contamination should be investigated and documented. The sample results can be reported without qualification.

9.3.3 If the MB is contaminated but the samples results are > 10 times the contamination level, the source of the contamination should be investigated and documented. The samples results may be reported with the appropriate “B” or “V” qualifier. This must be approved by the department supervisor.

9.3.4 If the MB is contaminated but the samples results are < 10 times the contamination level, the source of the contamination should be investigated and documented. The samples should be reanalyzed for confirmation. If there is insufficient sample to reanalyze, or if the sample is reanalyzed beyond hold time, the appropriate footnote and qualifiers should be added to the results. This must be approved by the department supervisor.

9.4 Blank Spike

9.4.1 The blank spike is de-ionized water or de-ionized water with 5 grams of Teflon chips (depending upon sample matrix) to which the surrogate standard and spike standard have been added. The blank spike is then processed along with the other samples to monitor the efficiency of the purge-and-trap procedure. The percent recovery for each analyte is calculated as follows:

% Recovery = (Blank Spike Amount / Amount Spiked) X 100

The percent recovery for each analyte of interest should fall within the established control limits for the results to be acceptable. The large number of analytes in this method presents a substantial probability that a few of the analytes will fall outside of the established control limits. This

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may not indicate that the system is out of control; therefore, corrective action may not be necessary.

Upper and lower marginal exceedance (ME) limits can be established to determine when corrective action is necessary. A marginal exceedance in the Blank Spike is defined as a recovery being outside of 3 standard deviations but within 4 standard deviations of the mean.

The number of allowable marginal exceedances is based on the number of analytes in the Blank Spike. Marginal Exceedances must be random. If the same analyte exceeds the BS control limits repeatedly, it is an indication of a systematic problem and corrective action must be taken.

Marginal exceedances are not permitted for analytes that are deemed to be "Compounds of Interest" for a specific project. "Compounds of Concern" are different from "Target Compounds". "Target Compounds" are all analytes that are being reported for a site where "Compounds of Concern" are those analytes expected to be present at the site.

The number of allowable marginal exceedances is as follows:

1) > 90 analytes in BS, 5 analytes allowed in ME range;

2) 71-90 analytes in BS, 4 analytes allowed in ME range;

3) 51-70 analytes in BS, 3 analytes allowed in ME range;

4) 31-50 analytes in BS, 2 analytes allowed in ME range;

5) 11-30 analytes in BS, 1 analyte allowed in ME range;

6) < 11 analytes in BS, no analytes allowed in ME range.

9.4.2 If the blank spike recoveries are not within the established control limits, the following are required.

9.4.2.1 Check to be sure that there are no errors in calculations, dilutions, integrations, spike solutions or internal standard solutions. If errors are found, recalculate the data accordingly.

9.4.2.2 Check instrument performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample.

9.4.2.3 Check to see if the recoveries that are outside of control limits are analytes of concern. If the analytes are not being reported, additional corrective action is not necessary and the sample results can be reported without qualification.

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9.4.2.4 If the recovery of an analyte in the BS is high and the associated sample is non-detect, the data may be reportable. For any DoD QSM projects the resulting data must be qualified accordingly.

9.4.2.5 If no problem is found, the department supervisor shall review the data and determine what further corrective action is best for each particular sample. That may include reanalyzing the samples or qualifying the results as estimated.

9.4.2.6 If there is insufficient sample to reanalyze, or if the sample is reanalyzed beyond hold time, the appropriate footnote and qualifiers should be added to the results. This must be approved by the department supervisor.

9.4.2.7 Because of their problematic nature, 2-Chloroethyl-vinyl-ether and acrolein are generally not evaluated in the blank spike unless they are of specific concern for a given project.

9.5 Matrix Spike and Matrix Spike Duplicate

9.5.1 Matrix spike and spike duplicates are replicate sample aliquots to which the surrogate standard and spike standard have been added. The matrix spike and spike duplicate are then processed along with the other samples to monitor the precision and accuracy of the purge-and-trap procedure. The percent recovery for each analyte is calculated as follows:

% Recovery = [(Spike Amount – Sample Amount) / Amount Spiked] X 100

The percent recovery for each analyte of interest must fall within the established control limits for the results to be acceptable.

9.5.2 If the matrix spike recoveries are not within the established control limits, the following are required.

9.5.2.1 Check to be sure that there are no errors in calculations, dilutions, integrations, spike solutions or internal standard solutions. If errors are found, recalculate the data accordingly.

9.5.2.2 Check instrument performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample. If the recovery is high due to interfering peaks, it may be possible to get a more accurate recovery by analyzing the sample on a different column type.

9.5.2.3 If no problem is found, compare the recoveries to those of the blank spike. If the blank spike recoveries indicate that the problem is sample related, document this on the run narrative.

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Matrix spike recovery failures are not grounds for reanalysis, but are an indication of the sample matrix effects.

9.5.3 Precision

Matrix spike and spike duplicate recoveries for each analyte are used to calculate the relative percent difference (RPD) for each compound.

RPD = [| MS Result – MSD Result | / Average Result] X 100

The RPD for each analyte should fall within the established control limits. If more than 33% of the RPDs fall outside of the established control limits, the department supervisor shall review the data and determine if any corrective action is necessary. RPD failures are generally not grounds for batch reanalysis.

10.0 CALCULATIONS

The concentration of each target compound in the original sample is calculated as follows:

Water (ug/l) = ($CONC_{inst}$) X DF

Soil (ug/kg) = [($CONC_{inst}$) X (5 / W_I)] / %solids (*low level soils)*

Soil (ug/kg) = [($CONC_{inst}$) X (V_F / V_A) X (5 / W_I) X DF] / %solids (*high level soils)*

$CONC_{inst}$	=	Instrument concentration calculated from the initial calibration using mean RF, linear curve, or quadratic curve
DF	=	Dilution Factor
V_F	=	Volume of methanol extract (ul)
V_A	=	Volume of methanol aliquot (ul)
W_I	=	Weight of sample (g)
%solids	=	Dry weight determination in decimal form

For high level soils, V_F is calculated as follows:

V_F = {ml of solvent + [(%moisture X W_I) / 100]} X 1000 ul/ml

11.0 SAFETY AND POLLUTION PREVENTION

11.1 Safety

The analyst should follow normal safety procedures as outlined in the Accutest Health and Safety Plan and Personal Protection Policy, which includes the use of safety glasses, gloves, and lab coats.

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The toxicity of each reagent and target analyte has not been precisely defined; however, each reagent and sample should be treated as a potential health hazard. Material Safety Data Sheets (MSDS) or Safety Data Sheets (SDS) are available for all reagents and many of the target analytes. Exposure must be reduced to the lowest possible level. Personal protective equipment should be used by all analysts.

11.2 Pollution Prevention

Waste solvents from the sample analysis, methanol extraction, and standards preparation are collected in waste storage bottles and are eventually transferred to the non-chlorinated waste drum.

Old stock standards are disposed of in the waste vial drum.

Samples are archived and stored for 30 days after analysis. After the storage time has elapsed, the remaining aqueous and soil samples are transferred to the appropriate drums for disposal.

12.0 REFERENCES

SW846 Method 8000C Revision 3, March 2003

SW846 Method 8260B Revision 2, December 1996

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TABLE 1

Routine Target Analytes

Dichlorodifluoromethane	**2-Butanone**	n-Propylbenzene
Chloromethane	1,1-Dichloropropene	Bromobenzene
Vinyl Chloride	Propionitrile	1,1,2,2-Tetrachloroethane
Bromomethane	Methacrylonitrile	1,3,5-Trimethylbenzene
Chloroethane	Benzene	2-Chlorotoluene
Trichlorofluoromethane	TAME	**trans-1,4-Dichloro-2-Butene**
Ethyl Ether	1,2-Dichloroethane	1,2,3-Trichloropropane
1,2-Dichlorotrifluoroethane	Trichloroethene	**Cyclohexanone**
1,1-Dichloroethene	Methylcyclohexane	4-Chlorotoluene
Freon 113	Dibromomethane	tert-Butylbenzene
Carbon Disulfide	1,2-Dichloropropane	1,2,4-Trimethylbenzene
Iodomethane	Bromodichloromethane	**Pentachloroethane**
Acrolein	Methyl methacrylate	sec-Butylbenzene
Allyl chloride	**2-Chloroethyl vinyl ether**	4-Isopropyltoluene
Methylene Chloride	cis-1,3-Dichloropropene	1,3-Dichlorobenzene
Acetone	Toluene	1,4-Dichlorobenzene
Methyl acetate	2-Nitropropane	n-Butylbenzene
trans-1,2-Dichloroethene	4-Methyl-2-pentanone	**Benzyl Chloride**
Hexane	trans-1,3-Dichloropropene	1,2-Dichlorobenzene
Methyl Tert Butyl Ether	Tetrachloroethene	**1,2-Dibromo-3-Chloropropane**
Acetonitrile	Ethyl methacrylate	Hexachlorobutadiene
Di-isopropyl ether	1,1,2-Trichloroethane	1,2,4-Trichlorobenzene
Chloroprene	Dibromochloromethane	Naphthalene
1,1-Dichloroethane	1,3-Dichloropropane	1,2,3-Trichlorobenzene
Acrylonitrile	1,2-Dibromoethane	**Ethanol**
ETBE	**2-hexanone**	Tert Butyl Alcohol
Vinyl acetate	1-Chlorohexane	Isobutyl alcohol
cis-1,2-Dichloroethene	Ethylbenzene	Tert Amyl Alcohol
2,2-Dichloropropane	Chlorobenzene	**1,4-Dioxane**
Bromochloromethane	1,1,1,2-Tetrachloroethane	3,3-Dimethyl-1-butanol
Cyclohexane	m,p-Xylene	Tert Amy Alcohol
Chloroform	o-Xylene	Tert Butyl Formate
Ethyl acetate	Styrene	
Tetrahydrofuran	Bromoform	
Carbon Tetrachloride	Isopropylbenzene	
1,1,1-Trichloroethane	cis-1,4-Dichloro-2-butene	

Bolded analytes are considered “Poor Performing”

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TABLE 2

Characteristic Ions

Analyte	Quant. Ion	Q1	Q2	Q3
Fluorobenzene	96	70		
Dichlorodifluoromethane	85	87		
Chloromethane	50	52		
Vinyl Chloride	62	64		
Bromomethane	94	96	93	
Chloroethane	64	66	49	
Trichlorofluoromethane	101	103		
Ethyl Ether	59	45	74	
1,2-Dichlorotrifluoroethane	67	117	85	69
1,1-Dichloroethene	61	96	98	63
Freon 113	101	151	103	85
Carbon Disulfide	76	44		
Iodomethane	142	127	141	
Allyl chloride	41	39	38	76
Methylene Chloride	49	84	86	51
Acetone	58	43		
Methyl acetate	74	43	42	
trans-1,2-Dichloroethene	61	96	98	63
Hexane	56	57	43	41
Methyl Tert Butyl Ether	73	57	43	41
Acetonitrile	40	41	39	
Di-isopropyl ether	45	43	87	
Chloroprene	53	88	51	50
1,1-Dichloroethane	63	65		
Acrylonitrile	53	52	51	
ETBE	59	87	57	
Vinyl acetate	43	42		
cis-1,2-Dichloroethene	96	61	98	63
2,2-Dichloropropane	77	97		
Bromochloromethane	128	49	130	51
Cyclohexane	56	84	41	55
Chloroform	83	85	47	
Ethyl acetate	43	45		
Tetrahydrofuran	42	41	72	
Dibromofluoromethane	113	111	192	
Carbon Tetrachloride	117	119	121	82
1,1,1-Trichloroethane	97	99	61	
2-Butanone	43	72		

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TABLE 2 (cont)

Characteristic Ions

Analyte	Quant. Ion	Q1	Q2	Q3
1,1-Dichloropropene	75	39	110	77
Propionitrile	54	52	55	
Methacrylonitrile	41	39	40	52
Benzene	78	51		
TAME	73	43	55	
1,2-Dichloroethane-d4	65	67	102	
1,2-Dichloroethane	62	49	64	
Trichloroethene	95	130	97	132
Methylcyclohexane	83	55	98	42
Dibromomethane	93	95	174	172
1,2-Dichloropropane	63	62	41	76
Bromodichloromethane	83	85	47	
Methyl methacrylate	41	69	39	100
2-Chloroethyl vinyl ether	63	43	44	65
cis-1,3-Dichloropropene	75	77	39	
Chlorobenzene-d5	117	82		
Toluene-d8	98	100		
Toluene	91	92		
2-Nitropropane	41	43	39	
4-Methyl-2-pentanone	43	58	57	41
trans-1,3-Dichloropropene	75	77	39	49
Tetrachloroethene	166	164	129	131
Ethyl methacrylate	69	41	39	99
1,1,2-Trichloroethane	83	97	61	99
Dibromochloromethane	129	127	131	
1,3-Dichloropropane	76	78	41	39
1,2-Dibromoethane	107	109		
2-hexanone	43	58	57	
1-Chlorohexane	91	55	41	43
Ethylbenzene	91	106		
Chlorobenzene	112	77	114	51
1,1,1,2-Tetrachloroethane	131	133	119	117
m,p-Xylene	91	106	105	
o-Xylene	91	106	105	
Styrene	104	78	103	51
Bromoform	173	175	171	91
Isopropylbenzene	105	120		
1,4-Dichlorobenzene-d4	152	151		

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TABLE 2 (cont)

Characteristic Ions

Analyte	Quant. Ion	Q1	Q2	Q3
4-Bromofluorobenzene	95	174	176	
cis-1,4-Dichloro-2-butene	53	75	88	39
n-Propylbenzene	91	120		
Bromobenzene	156	158		
1,1,2,2-Tetrachloroethane	83	85		
1,3,5-Trimethylbenzene	105	120		
2-Chlorotoluene	91	126	89	
trans-1,4-Dichloro-2-Butene	53	89	75	
1,2,3-Trichloropropane	110	61	112	49
Cyclohexanone	55	98	42	69
4-Chlorotoluene	91	126		
tert-Butylbenzene	91	41	134	
1,2,4-Trimethylbenzene	105	120	119	
Pentachloroethane	167	117	119	165
sec-Butylbenzene	105	134		
4-Isopropyltoluene	119	134		
1,3-Dichlorobenzene	146	111	148	75
1,4-Dichlorobenzene	146	111	148	75
n-Butylbenzene	92	91	134	
Benzyl Chloride	126	91	65	
1,2-Dichlorobenzene	146	111	148	75
1,2-Dibromo-3-Chloropropane	75	155	157	39
Hexachlorobutadiene	225	190	118	260
1,2,4-Trichlorobenzene	180	182	145	109
Naphthalene	128	127		
1,2,3-Trichlorobenzene	180	182	145	109
Tert Butyl Alcohol-d10	65	46		
acrolein	56	55		
Tert Butyl Alcohol	59	41	43	
tert Amyl alcohol	59	55	73	
Isobutyl alcohol	42	43	41	39
1,4-Dioxane	88	58	43	
tert-Butyl Formate	59	57	41	56
Ethanol	45	46		
3,3-Dimethyl-1-butanol	57	69	41	56

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STANDARD OPERATING PROCEDURE FOR THE INTRODUCTION OF VOLATILE ORGANICS ANALYTES USING PURGE-AND-TRAP

Prepared by: Norm Farmer Date: 05/01/14

Approved by: Mark Erstling Date: 05/02/14

Annual Review

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TEST NAME: STANDARD OPERATING PROCEDURE FOR THE INTRODUCTION OF VOLATILE ORGANICS ANALYTES USING PURGE-AND-TRAP

Method: SW846 5030B and 5030C

Dept: OP

Revised Sections: 2.0, 3.1.5, and 12.0 Added 5.4

1.0 Summary, Scope and Application

1.1 Summary

Aqueous samples: Helium is bubbled through a portion of the aqueous sample at ambient or elevated temperature; the volatile components are transferred from the aqueous phase to the vapor phase. The vapor is swept through a sorbent column where the volatile components are adsorbed. After purging is completed, the sorbent column is rapidly heated and backflushed with helium to desorb the components onto a gas chromatographic column.

High-level extracts from Method 5035A: An aliquot of the extract is combined with organic free reagent water in the purging chamber. It is then analyzed following the procedure for aqueous samples.

1.2 Scope and Application

This method describes a purge-and-trap procedure for the analysis of volatile organic compounds (VOCs) in aqueous samples, water miscible liquids, and high-level extracts (prepared in Method 5035A).

2.0 Discussion and Comments

This procedure is adapted from SW-846 method 5030B and 5030C. Cross contamination can occur whenever high concentration samples are analyzed. Any sample that contains analytes an order of magnitude higher than the highest level standard can be described as a possible source for cross contamination.

System contamination is also possible. A high-level sample followed by a low-level sample may show “carryover” of compounds with higher boiling points or water solubility. This type of contamination usually only persists for the analysis immediately following the high-level sample.

The purge efficiency of select oxygenates used in the fuel industry may be improved by using a heated purge. These fuel oxygenated compounds generally include: methyl tert butyl ether (MTBE), ethyl tert butyl ether (ETBE), tert amyl methyl ether (TAME), di-isopropyl ether (DIPE), tert amyl ethyl ether (TAEE),tert amyl alcohol (TAA) and tert butyl alcohol (TBA).

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Extremely high-level samples may cause more persistent system contamination. These samples will cause “carryover” in one or more subsequent analysis.

The analyst must use any available historical data or client supplied information to avoid contaminating the system. Any doubt or suspicion is cause for reanalysis.

3.0 Preservation and Holding Times

3.1 Preservation

3.1.1 Samples should be preserved to a pH < 2. The pH should be checked and recorded immediately after the sample analysis.

3.1.2 If the sample is not preserved to a pH < 2, it must be noted on the report.

3.1.3 Samples should be checked for the presence of residual chlorine. If residual chlorine present, it must be noted on the report.

3.1.4 The samples must be refrigerated at ≤ 6°C from the time of collection until analysis.

3.1.5 If samples containing MTBE, TAME, ETBE or other fuel ethers have been preserved with hydrochloric acid and will be analyzed by purging at elevated temperatures, these samples must be adjusted to pH >10 with trisodium phosphate dodecahydrate (TSP) prior to initiation of the analysis.

3.2 Holding Times

3.2.1 All samples must be analyzed within fourteen days of collection.

3.2.2 Some agencies and project plans may require unpreserved samples to be analyzed within seven days of collection.

4.0 Definitions

4.1 Batch: A group of samples which are similar with respect to matrix and the testing procedures being employed and which are processed as a unit. A sample batch is limited to a maximum of 20 samples or samples loaded on an instrument within the same 12-hour shift, which ever comes first.

4.2 Blank Spike (BS): An analyte-free matrix spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. Blank Spike Recoveries are used to document laboratory performance for a given method. This may also be called a Laboratory Control Sample (LCS).

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4.3 Blank Spike Duplicate (BSD): An analyte-free matrix replicate spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. The Blank Spike Duplicate recoveries are used to document laboratory precision and accuracy for a given method. This may also be called a Laboratory Control Sample Duplicate (LCSD).

4.4 Holding Time: The maximum times that samples may be held prior to preparation and/or analysis and still be considered valid.

4.5 Matrix Spike (MS): A sample aliquot spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. The matrix spike recoveries are used to document the bias of a method in a given sample matrix.

4.6 Matrix Spike Duplicate (MSD): A replicate sample aliquot spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. The matrix spike duplicate recoveries are used to document the precision and bias of a method in a given sample matrix.

4.7 Method Blank (MB): An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank is processed simultaneously with the samples through all the steps of the analytical procedure. The method blank is used to document contamination resulting from the analytical process.

4.8 Sample Duplicate (DUP): A replicate sample which is used to document the precision of a method in a given sample matrix.

4.9 Preservation: Refrigeration and/or reagents added at the time of sample collection (or later) to maintain the chemical integrity of the sample.

4.10 Surrogate: An organic compound which is similar to the target analyte(s) in chemical composition and behavior, but which is not normally found in environmental samples. Surrogates are used to measure the purge efficiency.

4.11 Trip Blank: A sample of analyte-free matrix taken from the laboratory to the sampling site and returned to the laboratory unopened. A trip blank is used to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organic samples.

5.0 Reagents

5.1 Reagent water – distilled or deionized water free of interferences

5.2 Methanol – purge-and-trap grade or equivalent

5.3 Hydrochloric acid (HCl) – ACS reagent grade or equivalent

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5.4 Trisodium phosphate dodecahydrate (TSP) – ACS reagent grade or equivalent

5.5 Surrogate Solution – prepared in methanol at a concentration specified by the analyst.

5.6 Standard Solution – prepared in methanol or water at a concentration specified by the analyst.

5.7 Internal Standard Solution – prepared in methanol at a concentration specified by the analyst.

5.8 Spike Solution – prepared in methanol at a concentration specified by the analyst.

6.0 Glassware and Apparatus

6.1 Microsyringes – 10ul, 25ul, 50ul, 100ul, 250ul, 500ul, and 1000ul. These syringes are gastight with Teflon plunger tips used for spike and surrogate solutions. These may also be employed for sample dilutions.

6.2 Syringes – 5ml, and 10ml syringes with Luer-Lok tip.

6.3 Volumetric flasks – 5ml, 10ml, 50ml, and 100ml class A flasks are used for standard and spike preparation and sample dilution.

6.4 Vials – 40ml vials with Teflon lined septa.

6.5 OI Analytical 4560 and 4660 sample concentrators.

6.6 OI Analytical 4552 (Archon) and 4551 autosamplers.

6.7 OI Analytical #10 trap or equivalent for 8021B or 8260B/C analysis, #7 trap for 8015C and 8021B Aromatics. Other traps may be used for 602 or 8015C analysis provided that they meet method criteria.

6.8 pH paper – narrow range (0.0-3.0) and wide range (1-12)

6.9 Potassium iodide – starch paper (residual chlorine check)

7.0 Procedure for Aqueous Samples

7.1 Prior to sample analysis, the GC system must be calibrated. The procedures for the determinative methods give details on preparation of standards for initial and daily calibrations. The GC-MS methods also require instrument tuning prior to proceeding with calibration.

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7.2 Adjust the purge gas flow rate to 30-40ml/min on the purge-and-trap device. Once the flow is optimized, it is not necessary to set the flow daily, although periodic checking is recommended.

7.3 Traps shall be conditioned according to manufacturer's instructions upon installation. Prior to use, condition the trap daily by stepping the sample concentrator to the "bake" mode. Since bake temperature will vary according to method and trap type, ensure the proper concentrator method is loaded when performing the daily conditioning.

7.4 All samples and standard solutions must be allowed to warm to ambient temperature before analysis.

7.5 OI Analytical 4552 (Archon) or 4551 Procedure

7.5.1 Prepare aqueous standards by injecting aliquots of standard solutions into a 50ml volumetric flask. Vary the concentration of the surrogates in the standards by adding supplemental aliquots of surrogate solution to various levels. Surrogates should be calibrated at a minimum of 5 different concentrations. Invert the flask several times to mix, then transfer to a 40ml vial with Teflon-lined septa cap.

7.5.2 Load standards, samples, and blanks into the auto-sampler tray. Program the auto-sampler methods to perform 5ml, 10ml, or 25ml purges and dilutions when appropriate. Link auto-sampler methods together to build the run sequence. Without disturbing the vial seal, the autosampler will transfer a 5ml, 10ml, or 25ml volume from the vial and transfer it to the purge-and-trap device, along with a 1ul aliquot of internal standard/surrogate mix.

NOTE: Care must be taken when programming the Archon. If the sample size exceeds the capacity of the purge vessel, catastrophic damage to the GC system may result! Consult the user manual if unfamiliar with use of the Archon.

7.6 Purge the sample for the time specified in the determinative method SOP.

7.7 Place the purge-and-trap system in the desorb mode and preheat the trap to the temperature specified in the method SOP. Start the flow of carrier gas, begin the GC temperature program, and start GC data acquisition. Continue the carrier flow for the time specified in the method SOP.

7.8 Recondition the trap by returning the purge-and-trap device to the purge mode. Maintain the trap temperature and bake time as specified in the method SOP.

7.9 Note: Modern purge-and-trap units are computerized and user programmable. The steps discussed in 7.6 to 7.8 are normally automatically controlled throughout an analysis sequence and are not necessarily manually performed by the analyst. Systems using an Archon headspace sampler also incorporate

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additional steps (such as hot water rinses of the purge chamber) between analyses that may reduce contamination.

7.10 Calculate response factors (RF) or calibration factors (CF) for each analyte of interest using the procedure described in Method 8000. Update the calibration levels in the MS Chemstation method and evaluate the response factors. Specific calibration requirements are described in the determinative methods and in Method 8000. The method must be saved to the hard drive after all levels are updated.

7.11 Any compound of interest that exceeds the initial calibration range should be diluted and reanalyzed so that the highest peak of interest falls in the upper half of the linear range of the curve.

7.12 After analyzing the sample, remove the sample cap. Using narrow range pH test paper (0.0 – 3.0) check the sample pH. If the pH is found to be > 3.0, use wide range pH test paper (1 – 12) to check the sample pH. Check for presence of residual chlorine with potassium iodide / starch test paper. Quickly recap the vial. Record sample pH and presence / absence of residual chlorine.

8.0 Analysis of water-miscible liquids

Water-miscible liquids are analyzed as water samples after first diluting them at least 50-fold with reagent water.

9.0 Soil extracts from Method 5035A

9.1 The methanol soils extracts prepared according to Method 5035A are diluted into reagent water at least 50-fold by addition of an aliquot of the methanol extract into a 5ml syringe filled with reagent water. The volume of methanol extract added to 5ml should not exceed 100ul. The volume of methanol added to 5ml of water being purged should be kept constant. Therefore, add to the 5ml syringe whatever volume of clean methanol is necessary to maintain a volume of 100ul per 5ml of water. Higher dilutions are made by introducing smaller aliquots of methanol extract (not less than 1ul into 5ml), or by using a volumetric flask.

9.2 The water/methanol sample is introduced as a water sample as previously described.

9.3 The purge temperature is either ambient or heated depending on the system and method used. All standards and spikes must be treated in the same manner as the samples.

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10.0 Quality Assurance and Quality Control

10.1 A sample batch is defined as samples of a similar matrix that are prepared for a particular parameter. The batch size is limited to 20 samples. A batch may be held open for up to 12 hours. **NOTE:** Some project plans may require different batch definitions.

10.2 A method blank (MB), blank spike (BS), matrix spike (MS), and matrix spike duplicate (MSD) must be analyzed with each new batch of samples. Some methods may also require a blank spike duplicate (BSD) or sample duplicate (DUP).

11.0 Safety and Waste Disposal

11.1 Safety

11.1.1 Safety glasses, gloves and lab coats should be worn when handling samples, standards or solvents.

11.1.2 Material Safety Data Sheets (MSDS) or Safety Data Sheets (SDS) are available for all reagents and solvents used in the lab. Technicians should review the MSDS or SDS prior to using any new reagents or solvents.

11.1.3 For samples containing high levels of VOCs, a carbon filtration hood is available to minimize exposure to vapors.

11.2 Waste Disposal

11.2.1 Expired standards are disposed of in the waste vial drum.

11.2.2 Waste methanol is placed in the “non-chlorinated waste” container

11.2.3 Samples are archived and stored for 30 days after analysis. After the storage time has elapsed, the remaining aqueous samples are transferred to the appropriate drums for disposal.

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12.0 References

SW-846 Method 5030B, Rev. 2, 12/96

SW-846 Method 5030C, Rev. 3, 05/03

SW-846 Method 5035A, Rev. 1, 07/02

SW-846 Method 5000, Rev. 0, 12/96

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LABORATORY ACCREDITATION BUREAU

Certificate of Accreditation

ISO/IEC 17025:2005 Certificate Number L2229

Accutest Laboratories Southeast, Inc.

4405 Vineland Road, Suite C-15
Orlando FL 32811

has met the requirements set forth in L-A-B's policies and procedures, all requirements of ISO/IEC 17025:2005 "General Requirements for the competence of Testing and Calibration Laboratories" and the U.S. Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP).*

The accredited lab has demonstrated technical competence to a defined "Scope of Accreditation" and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009).

Accreditation valid through: December 15, 2015

R. Douglas Leonard, Jr., President, COO
Laboratory Accreditation Bureau
Presented the 29th of January 2013

*See the laboratory's Scope of Accreditation for details of accredited parameters
**Laboratory Accreditation Bureau is found to be in compliance with ISO/IEC 17011:2004 and recognized by ILAC (International Laboratory Accreditation Cooperation) and NACLA (National Cooperation for Laboratory Accreditation).

LABORATORY ACCREDITATION BUREAU

Certificate # L2229

Scope of Accreditation
For
Accutest Laboratories Southeast, Inc.

4405 Vineland Road, Suite C-15
Orlando, FL 32811
Svetlana Izosimova, Ph.D., QA Officer
407-425-6700

In recognition of a successful assessment to ISO/IEC 17025:2005 and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (DoD QSM v4.2) based on the National Environmental Laboratory Accreditation Conference Chapter 5 Quality Systems Standard (NELAC Voted Revision June 5, 2003), accreditation is granted to Accutest Laboratories Southeast, Inc. to perform the following tests:

Accreditation granted through: **December 15, 2015**

Testing - Environmental

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8011	1,2-Dibromoethane (EDB)
GC/ECD	EPA 8011	1,2-Dibromo-3-Chloropropane (DBCP)
GC/FID	EPA 8015C/D	Diesel range organics (DRO)
GC/FID	EPA 8015C/D	Oil Range Organics (ORO)
GC/FID	EPA 8015C/D	Gasoline range organics (GRO)
GC/FID	EPA 8015C/D	Ethanol
GC/FID	EPA 8015C/D	2-Ethoxyethanol
GC/FID	EPA 8015C/D	Isobutyl alcohol (2-Methyl-1-propanol)
GC/FID	EPA 8015C/D	Isopropyl alcohol (2-Propanol)
GC/FID	EPA 8015C/D	Methanol
GC/FID	EPA 8015C/D	n-Butyl alcohol
GC/FID	EPA 8015C/D	n-Propanol
GC/PID	EPA 8021B	Benzene
GC/PID	EPA 8021B	Ethylbenzene
GC/PID	EPA 8021B	Chlorobenzene
GC/PID	EPA 8021B	Toluene
GC/PID	EPA 8021B	1,2-Dichlorobenzene (o-Dichlorobenzene)
GC/PID	EPA 8021B	1,3-Dichlorobenzene (m-Dichlorobenzene)
GC/PID	EPA 8021B	1,4-Dichlorobenzene (p-Dichlorobenzene)
GC/PID	EPA 8021B	m,p-Xylene
GC/PID	EPA 8021B	o-Xylene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/PID	EPA 8021B	Methyl-tert-Butyl Ether
GC/ECD	EPA 608; EPA 8081B	4,4`-DDD
GC/ECD	EPA 608; EPA 8081B	4,4`-DDE
GC/ECD	EPA 608; EPA 8081B	4,4`-DDT
GC/ECD	EPA 608; EPA 8081B	Aldrin
GC/ECD	EPA 608; EPA 8081B	alpha-BHC (alpha-Hexachlorocyclohexane)
GC/ECD	EPA 608; EPA 8081B	beta-BHC (beta-Hexachlorocyclohexane)
GC/ECD	EPA 608; EPA 8081B	delta-BHC
GC/ECD	EPA 608; EPA 8081B	gamma-BHC (Lindane gamma-Hexachlorocyclohexane)
GC/ECD	EPA 608; EPA 8081B	Chlordane (tech.)
GC/ECD	EPA 608; EPA 8081B	alpha-Chlordane
GC/ECD	EPA 608; EPA 8081B	gamma-Chlordane
GC/ECD	EPA 608; EPA 8081B	Dieldrin
GC/ECD	EPA 608; EPA 8081B	Endosulfan I
GC/ECD	EPA 608; EPA 8081B	Endosulfan II
GC/ECD	EPA 608; EPA 8081B	Endosulfan sulfate
GC/ECD	EPA 608; EPA 8081B	Endrin
GC/ECD	EPA 608; EPA 8081B	Endrin aldehyde
GC/ECD	EPA 608; EPA 8081B	Endrin ketone
GC/ECD	EPA 608; EPA 8081B	Heptachlor
GC/ECD	EPA 608; EPA 8081B	Heptachlor epoxide
GC/ECD	EPA 608; EPA 8081B	Methoxychlor
GC/ECD	EPA 608; EPA 8081B	Toxaphene (Chlorinated camphene)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1016 (PCB-1016)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1221 (PCB-1221)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1232 (PCB-1232)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1242 (PCB-1242)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1248 (PCB-1248)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1254 (PCB-1254)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1260 (PCB-1260)
GC/ECD	EPA 8082A	Aroclor-1262 (PCB-1262)
GC/ECD	EPA 8082A	Aroclor-1268 (PCB-1268)
GC/ECD	EPA 8082A	2,4'-diCB bz8
GC/ECD	EPA 8082A	2,2',5-trCB bz18
GC/ECD	EPA 8082A	2,4,4'-trCB bz28
GC/ECD	EPA 8082A	2,2',3,5'-teCB bz44
GC/ECD	EPA 8082A	2,2',4,5'-teCB bz49
GC/ECD	EPA 8082A	2,2',5,5'-teCB bz52
GC/ECD	EPA 8082A	2,3'4,4'-teCB bz66
GC/ECD	EPA 8082A	3,4,4',5-teCB bz81

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8082A	2,2',3,4,5'-peCB bz87
GC/ECD	EPA 8082A	2,2',3,4',5-peCB bz90
GC/ECD	EPA 8082A	2,2',4,5,5'-peCB bz101
GC/ECD	EPA 8082A	2,3,3',4,4'-peCB bz105
GC/ECD	EPA 8082A	2,3',4,4',5-peCB bz118
GC/ECD	EPA 8082A	2',3,4,4',5-peCB bz123
GC/ECD	EPA 8082A	3,3',4,4',5-peCB bz126
GC/ECD	EPA 8082A	2,2',3,3',4,4'-hxCB bz128
GC/ECD	EPA 8082A	2,2',3,4,4',5'-hxCB bz138
GC/ECD	EPA 8082A	2,2',3,5,5',6-hxCB bz151
GC/ECD	EPA 8082A	2,2',4,4',5,5'-hxCB bz153
GC/ECD	EPA 8082A	2,3,3',4,4',5-hxCB bz156
GC/ECD	EPA 8082A	2,3,3',4,4',5'-hxCB bz157
GC/ECD	EPA 8082A	2,3',4,4',5,5'-hxCB bz167
GC/ECD	EPA 8082A	3,3',4,4',5,5'-hxCB bz169
GC/ECD	EPA 8082A	2,2',3,3',4,4',5-hpCB bz170
GC/ECD	EPA 8082A	2,2',3,4,4',5,5'-hpCB bz180
GC/ECD	EPA 8082A	2,2',3,4,4',5',6-hpCB bz183
GC/ECD	EPA 8082A	2,2',3,4,4',6,6'-hpCB bz184
GC/ECD	EPA 8082A	2,2',3,4',5,5',6-hpCB bz187
GC/ECD	EPA 8082A	2,3,3',4,4',5,5'-hpCB bz189
GC/ECD	EPA 8082A	2,2',3,3',4,4',5,6-ocCB bz195
GC/ECD	EPA 8082A	2,2',3,3',4,4',5,5',6-noCB bz206
GC/ECD	EPA 8082A	Decachlorobiphenyl bz209
GC/ECD	EPA 8091	2,4-Dinitrotoluene (2,4-DNT)
GC/ECD	EPA 8091	2,6-Dinitrotoluene (2,6-DNT)
GC/FPD	EPA 8141B	Azinphos-methyl (Guthion)
GC/FPD	EPA 8141B	Bolstar (Sulprofos)
GC/FPD	EPA 8141B	Carbophenothion
GC/FPD	EPA 8141B	Chlorpyrifos
GC/FPD	EPA 8141B	Coumaphos
GC/FPD	EPA 8141B	Demeton-o
GC/FPD	EPA 8141B	Demeton-s
GC/FPD	EPA 8141B	Diazinon
GC/FPD	EPA 8141B	Dichlorovos (DDVP Dichlorvos)
GC/FPD	EPA 8141B	Dimethoate
GC/FPD	EPA 8141B	Disulfoton
GC/FPD	EPA 8141B	EPN
GC/FPD	EPA 8141B	Ethion
GC/FPD	EPA 8141B	Ethoprop
GC/FPD	EPA 8141B	Famphur

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/FPD	EPA 8141B	Fensulfothion
GC/FPD	EPA 8141B	Fenthion
GC/FPD	EPA 8141B	Malathion
GC/FPD	EPA 8141B	Merphos
GC/FPD	EPA 8141B	Methyl parathion (Parathion methyl)
GC/FPD	EPA 8141B	Mevinphos
GC/FPD	EPA 8141B	Monocrotophos
GC/FPD	EPA 8141B	Naled
GC/FPD	EPA 8141B	Parathion ethyl
GC/FPD	EPA 8141B	Phorate
GC/FPD	EPA 8141B	Ronnel
GC/FPD	EPA 8141B	Stirofos
GC/FPD	EPA 8141B	Sulfotepp
GC/FPD	EPA 8141B	Tetraethyl pyrophosphate (TEPP)
GC/FPD	EPA 8141B	Thionazin (Zinophos)
GC/FPD	EPA 8141B	Tokuthion (Prothiophos)
GC/FPD	EPA 8141B	Trichloronate
GC/FPD	EPA 8141B	O,O,O-Triethyl phosphorothioate
GC/ECD	EPA 8151A	2,4,5-T
GC/ECD	EPA 8151A	2,4-D
GC/ECD	EPA 8151A	2,4-DB
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dichloroprop (Dichlorprop)
GC/ECD	EPA 8151A	Dinoseb (2-sec-butyl-4,6-dinitrophenol DNBP)
GC/ECD	EPA 8151A	MCPA
GC/ECD	EPA 8151A	MCPP
GC/ECD	EPA 8151A	Pentachlorophenol
GC/ECD	EPA 8151A	Silvex (2,4,5-TP)
GC/FID	RSK-175	Acetylene
GC/FID	RSK-175	Methane
GC/FID	RSK-175	Ethane
GC/FID	RSK-175	Ethene
GC/FID	RSK-175	Propane
GC/FID	FL-PRO	Total Petroleum Hydrocarbons (TPH)
GC/FID	MA-VPH	Volatile petroleum range organics (VPH)
GC/FID	MA-EPH	Extractable petroleum range organics (EPH)
GC/FID	IA-OA1	Gasoline range organics (GRO)
GC/FID	IA-OA2	Diesel range organics (DRO)
GC/FID	TN-GRO	Gasoline range organics (GRO)
GC/FID	TN-EPH	Extractable petroleum range organics (EPH)

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/FID	WI-DRO	Diesel range organics (DRO)
GC/FID	AK-101	Gasoline range organics (GRO)
GC/FID	AK-102	Diesel range organics (DRO)
GC/FID	OK-GRO	Gasoline range organics (GRO)
GC/FID	OK-DRO	Diesel range organics (DRO)
GC/FID	TX-1005	Total Petroleum Hydrocarbons (TPH)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,1,1,2-Tetrachloroethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,1,1-Trichloroethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,1,2,2-Tetrachloroethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,1,2-Trichloroethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,1-Dichloroethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,1-Dichloroethylene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,1-Dichloropropene
GC/MS	EPA 624; EPA 8260B/C	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2,3-Trichlorobenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2,3-Trichloropropane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2,4-Trichlorobenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2,4-Trimethylbenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2-Dibromo-3-chloropropane (DBCP)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2-Dibromoethane (EDB Ethylene dibromide)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2-Dichlorobenzene (o-Dichlorobenzene)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2-Dichloroethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2-Dichloropropane
GC/MS	EPA 8260B/C	1,2-Dichlorotrifluoroethane (Freon 123)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,3,5-Trimethylbenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,3-Dichlorobenzene (m-Dichlorobenzene)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,3-Dichloropropane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,4-Dichlorobenzene (p-Dichlorobenzene)
GC/MS	EPA 8260B/C	1-Chlorohexane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	2,2-Dichloropropane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	2-Butanone (Methyl ethyl ketone MEK)
GC/MS	EPA 624; EPA 8260B/C	2-Chloroethyl vinyl ether
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	2-Chlorotoluene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	2-Hexanone
GC/MS	EPA 8260B/C	2-Nitropropane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	4-Chlorotoluene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	4-Methyl-2-pentanone (MIBK)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Acetone
GC/MS	EPA 8260B/C	Acetonitrile
GC/MS	EPA 624; EPA 8260B/C	Acrolein (Propenal)
GC/MS	EPA 624; EPA 8260B/C	Acrylonitrile

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B/C	Allyl chloride (3-Chloropropene)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Benzene
GC/MS	EPA 8260B/C	Benzyl Chloride
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Bromobenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Bromochloromethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Bromodichloromethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Bromoform
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	n-Butylbenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	sec-Butylbenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	tert-Butylbenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Carbon disulfide
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Carbon tetrachloride
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Chlorobenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Chloroethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Chloroform
GC/MS	EPA 8260B/C	Chloroprene
GC/MS	EPA 624; EPA 8260B,C	Cyclohexane
GC/MS	EPA 8260B/C	Cyclohexanone
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	cis-1,2-Dichloroethylene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	trans-1,2-Dichloroethylene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	cis-1,3-Dichloropropene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	trans-1,3-Dichloropropylene
GC/MS	EPA 8260B/C	cis-1,4-Dichloro-2-butene
GC/MS	EPA 8260B/C	trans-1,4-Dichloro-2-butene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Di-isopropylether (DIPE)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Dibromochloromethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Dibromomethane (Methylene Bromide)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Dichlorodifluoromethane
GC/MS	EPA 8260B/C	Diethyl ether
GC/MS	EPA 624, EPA 8260B/C	p-Dioxane (1,4-Dioxane)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Ethanol (Ethyl Alcohol)
GC/MS	EPA 8260B/C	Ethyl acetate
GC/MS	EPA 8260B/C	Ethyl methacrylate
GC/MS	EPA 8260B/C	Ethyl tert-butyl alcohol (ETBA)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Ethyl tert-butyl ether (ETBE)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Ethylbenzene
GC/MS	EPA 8260B/C	Ethylene Oxide
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Hexachlorobutadiene
GC/MS	EPA 8260B/C	Hexane
GC/MS	EPA 8260B/C	Iodomethane (Methyl iodide)
GC/MS	EPA 8260B/C	Isobutyl alcohol (2-Methyl-1-propanol)

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	p-Isopropyltoluene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Isopropylbenzene
GC/MS	EPA 8260B/C	Methacrylonitrile
GC/MS	EPA 624; EPA 8260B/C	Methyl Acetate
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Methyl bromide (Bromomethane)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Methyl chloride (Chloromethane)
GC/MS	EPA 624; EPA 8260B,C	Methylcyclohexane
GC/MS	EPA 8260B/C	Methyl methacrylate
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Methyl tert-butyl ether (MTBE)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Methylene chloride
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Naphthalene
GC/MS	EPA 8260B/C	Pentachloroethane
GC/MS	EPA 8260B/C	Propionitrile (Ethyl cyanide)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	n-Propylbenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Styrene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	tert-Amyl alcohol (TAA)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	tert-Amyl methyl ether (TAME)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	tert-Butyl alcohol (TBA)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	tert-Butyl formate (TBF)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Tetrachloroethylene (Perchloroethylene)
GC/MS	EPA 8260B/C	Tetrahydrofuran
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Toluene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Trichloroethene (Trichloroethylene)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Trichlorofluoromethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Vinyl acetate
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Vinyl chloride
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Xylene (total)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	m,p-Xylene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	o-Xylene
GC/MS	EPA 625; EPA 8270D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 625; EPA 8270D	1,2,4-Trichlorobenzene
GC/MS	EPA 625; EPA 8270D	1,2-Dichlorobenzene (o-Dichlorobenzene)
GC/MS	EPA 625; EPA 8270D	1,2-Diphenylhydrazine
GC/MS	EPA 8270D	1,3,5-Trinitrobenzene (1,3,5-TNB)
GC/MS	EPA 625; EPA 8270D	1,3-Dichlorobenzene (m-Dichlorobenzene)
GC/MS	EPA 8270D	1,3-Dinitrobenzene (1,3-DNB)
GC/MS	EPA 625; EPA 8270D	1,4-Dichlorobenzene (p-Dichlorobenzene)
GC/MS	EPA 8270D	1,4-Dithiane
GC/MS	EPA 8270D	1,4-Oxathiane
GC/MS	EPA 8270D	1,4-Naphthoquinone
GC/MS	EPA 8270D	1,4-Phenylenediamine

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270D	1-Chloronaphthalene
GC/MS	EPA 625; EPA 8270D	1-Methylnaphthalene
GC/MS	EPA 8270D	1-Naphthylamine
GC/MS	EPA 625; EPA 8270D	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 625; EPA 8270D	2,4,5-Trichlorophenol
GC/MS	EPA 625; EPA 8270D	2,4,6-Trichlorophenol
GC/MS	EPA 625; EPA 8270D	2,4-Dichlorophenol
GC/MS	EPA 625; EPA 8270D	2,4-Dimethylphenol
GC/MS	EPA 625; EPA 8270D	2,4-Dinitrophenol
GC/MS	EPA 625; EPA 8270D	2,4-Dinitrotoluene (2,4-DNT)
GC/MS	EPA 8270D	2,6-Dichlorophenol
GC/MS	EPA 625; EPA 8270D	2,6-Dinitrotoluene (2,6-DNT)
GC/MS	EPA 8270D	2-Acetylaminofluorene
GC/MS	EPA 625; EPA 8270D	2-Chloronaphthalene
GC/MS	EPA 625; EPA 8270D	2-Chlorophenol
GC/MS	EPA 625; EPA 8270D	2-Methyl-4,6-dinitrophenol (4,6-Dinitro-o-cresol)
GC/MS	EPA 625; EPA 8270D	2-Methylnaphthalene
GC/MS	EPA 625; EPA 8270D	2-Methylphenol (o-Cresol)
GC/MS	EPA 8270D	2-Naphthylamine
GC/MS	EPA 625; EPA 8270D	2-Nitroaniline
GC/MS	EPA 625; EPA 8270D	2-Nitrophenol
GC/MS	EPA 8270D	2-Picoline (2-Methylpyridine)
GC/MS	EPA 625; EPA 8270D	3,3`-Dichlorobenzidine
GC/MS	EPA 8270D	3,3`-Dimethylbenzidine
GC/MS	EPA 8270D	3-Methylcholanthrene
GC/MS	EPA 625; EPA 8270D	3&4-Methylphenol (m,p-Cresol)
GC/MS	EPA 625; EPA 8270D	3-Nitroaniline
GC/MS	EPA 8270D	4-Aminobiphenyl
GC/MS	EPA 625; EPA 8270D	4-Bromophenyl phenyl ether
GC/MS	EPA 625; EPA 8270D	4-Chloro-3-methylphenol
GC/MS	EPA 625; EPA 8270D	4-Chloroaniline
GC/MS	EPA 625; EPA 8270D	4-Chlorophenyl phenylether
GC/MS	EPA 8270D	4-Dimethyl aminoazobenzene
GC/MS	EPA 625; EPA 8270D	4-Nitroaniline
GC/MS	EPA 625; EPA 8270D	4-Nitrophenol
GC/MS	EPA 8270D	4,4’-methylene-bis(2-chloroaniline)
GC/MS	EPA 8270D	5-Nitro-o-toluidine
GC/MS	EPA 8270D	7,12-Dimethylbenz(a) anthracene
GC/MS	EPA 625; EPA 8270D	Acenaphthene
GC/MS	EPA 625; EPA 8270D	Acenaphthylene
GC/MS	EPA 625; EPA 8270D	Acetophenone

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 625; EPA 8270D	Aniline
GC/MS	EPA 8270D	Anilazine
GC/MS	EPA 625; EPA 8270D	Anthracene
GC/MS	EPA 8270D	Aramite
GC/MS	EPA 625; EPA 8270D	Atrazine
GC/MS	EPA 625; EPA 8270D	Benzaldehyde
GC/MS	EPA 625; EPA 8270D	Benzidine
GC/MS	EPA 625; EPA 8270D	Benzo(a)anthracene
GC/MS	EPA 625; EPA 8270D	Benzo(a)pyrene
GC/MS	EPA 625; EPA 8270D	Benzo(b)fluoranthene
GC/MS	EPA 625; EPA 8270D	Benzo(g,, i)perylene
GC/MS	EPA 625; EPA 8270D	Benzo(k)fluoranthene
GC/MS	EPA 625; EPA 8270D	Benzoic acid
GC/MS	EPA 625; EPA 8270D	Benzyl alcohol
GC/MS	EPA 625; EPA 8270D	Biphenyl (1,1'-Biphenyl)
GC/MS	EPA 625; EPA 8270D	bis(2-Chloroethoxy)methane
GC/MS	EPA 625; EPA 8270D	bis(2-Chloroethyl) ether
GC/MS	EPA 625; EPA 8270D	bis(2-Chloroisopropyl) ether (2,2`-Oxybis(1-chloropropane))
GC/MS	EPA 625; EPA 8270D	bis(2-Ethylhexyl) phthalate (DEHP)
GC/MS	EPA 625; EPA 8270D	Butyl benzyl phthalate
GC/MS	EPA 625; EPA 8270D	Carbazole
GC/MS	EPA 625; EPA 8270D	Caprolactam
GC/MS	EPA 8270D	Chlorobenzilate
GC/MS	EPA 625; EPA 8270D	Chrysene
GC/MS	EPA 8270D	Diallate
GC/MS	EPA 625; EPA 8270D	Di-n-butyl phthalate
GC/MS	EPA 625; EPA 8270D	Di-n-octyl phthalate
GC/MS	EPA 625; EPA 8270D	Dibenz(a,h)anthracene
GC/MS	EPA 8270D	Dibenz(a,j)acridine
GC/MS	EPA 625; EPA 8270D	Dibenzofuran
GC/MS	EPA 625; EPA 8270D	Diethyl phthalate
GC/MS	EPA 625; EPA 8270D	Dimethyl phthalate
GC/MS	EPA 8270D	a,a-Dimethylphenethylamine
GC/MS	EPA 8270D	Diphenyl Ether
GC/MS	EPA 8270D	p-Dioxane (1,4-Dioxane)
GC/MS	EPA 8270D	Ethyl methanesulfonate
GC/MS	EPA 625; EPA 8270D	Fluoranthene
GC/MS	EPA 625; EPA 8270D	Fluorene
GC/MS	EPA 625; EPA 8270D	Hexachlorobenzene
GC/MS	EPA 625; EPA 8270D	Hexachlorobutadiene
GC/MS	EPA 625; EPA 8270D	Hexachlorocyclopentadiene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 625; EPA 8270D	Hexachloroethane
GC/MS	EPA 8270D	Hexachlorophene
GC/MS	EPA 8270D	Hexachloropropene
GC/MS	EPA 625; EPA 8270D	Indeno(1,2,3-cd)pyrene
GC/MS	EPA 8270D	Isodrin
GC/MS	EPA 625; EPA 8270D	Isophorone
GC/MS	EPA 8270D	Isosafrole
GC/MS	EPA 8270D	Kepone
GC/MS	EPA 8270D	Methapyrilene
GC/MS	EPA 8270D	Methyl methanesulfonate
GC/MS	EPA 625; EPA 8270D	Naphthalene
GC/MS	EPA 8270D	Nicotine
GC/MS	EPA 625; EPA 8270D	Nitrobenzene
GC/MS	EPA 8270D	Nitroquinoline-1-oxide
GC/MS	EPA 8270D	n-Nitroso-di-n-butylamine
GC/MS	EPA 625; EPA 8270D	n-Nitrosodi-n-propylamine
GC/MS	EPA 8270D	n-Nitrosodiethylamine
GC/MS	EPA 625; EPA 8270D	n-Nitrosodimethylamine
GC/MS	EPA 625; EPA 8270D	n-Nitrosodiphenylamine
GC/MS	EPA 8270D	n-Nitrosodiphenylamine/Diphenylamine (analyte pair)
GC/MS	EPA 8270D	n-Nitrosomethylethylamine
GC/MS	EPA 8270D	n-Nitrosomorpholine
GC/MS	EPA 8270D	n-Nitrosopiperidine
GC/MS	EPA 8270D	n-Nitrosopyrrolidine
GC/MS	EPA 8270D	Pentachlorobenzene
GC/MS	EPA 8270D	Pentachloroethane
GC/MS	EPA 8270D	Pentachloronitrobenzene
GC/MS	EPA 625; EPA 8270D	Pentachlorophenol
GC/MS	EPA 8270D	Phenacetin
GC/MS	EPA 625; EPA 8270D	Phenanthrene
GC/MS	EPA 625; EPA 8270D	Phenol
GC/MS	EPA 8270D	Pronamide (Kerb)
GC/MS	EPA 8270D	Propazine
GC/MS	EPA 625; EPA 8270D	Pyrene
GC/MS	EPA 625; EPA 8270D	Pyridine
GC/MS	EPA 8270D	Resorcinol
GC/MS	EPA 8270D	Safrole
GC/MS	EPA 8270D	Simazine
GC/MS	EPA 8270D	o-Toluidine
GC/MS	EPA 8270D	Dimethoate
GC/MS	EPA 8270D	Disulfoton

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270D	Famphur
GC/MS	EPA 8270D	Methyl parathion (Parathion methyl)
GC/MS	EPA 8270D	Parathion ethyl
GC/MS	EPA 8270D	Phorate
GC/MS	EPA 8270D	O,O,O-Triethyl phosphorothioate
HPLC	EPA 610; EPA 8310	1-Methylnaphthalene
HPLC	EPA 610; EPA 8310	2-Methylnaphthalene
HPLC	EPA 610; EPA 8310	Acenaphthene
HPLC	EPA 610; EPA 8310	Acenaphthylene
HPLC	EPA 610; EPA 8310	Anthracene
HPLC	EPA 610; EPA 8310	Benzo(a)anthracene
HPLC	EPA 610; EPA 8310	Benzo(a)pyrene
HPLC	EPA 610; EPA 8310	Benzo(b)fluoranthene
HPLC	EPA 610; EPA 8310	Benzo(g h i)perylene
HPLC	EPA 610; EPA 8310	Benzo(k)fluoranthene
HPLC	EPA 610; EPA 8310	Chrysene
HPLC	EPA 610; EPA 8310	Dibenz(a,h)anthracene
HPLC	EPA 610; EPA 8310	Fluoranthene
HPLC	EPA 610; EPA 8310	Fluorene
HPLC	EPA 610; EPA 8310	Indeno(1,2,3-cd)pyrene
HPLC	EPA 610; EPA 8310	Naphthalene
HPLC	EPA 610; EPA 8310	Phenanthrene
HPLC	EPA 610; EPA 8310	Pyrene
HPLC	EPA 8330A/B	1,3,5-Trinitrobenzene (1,3,5-TNB)
HPLC	EPA 8330A/B	1,3-Dinitrobenzene (1,3-DNB)
HPLC	EPA 8330A/B	2,4,6-Trinitrotoluene (2,4,6-TNT)
HPLC	EPA 8330A/B	2,4-Dinitrotoluene (2,4-DNT)
HPLC	EPA 8330A/B	2,6-Dinitrotoluene (2,6-DNT)
HPLC	EPA 8330A/B	2-Amino-4,6-dinitrotoluene (2-am-dnt)
HPLC	EPA 8330A/B	2-Nitrotoluene
HPLC	EPA 8330A/B	3,5-Dinitroaniline
HPLC	EPA 8330A/B	3-Nitrotoluene
HPLC	EPA 8330A/B	4-Amino-2,6-dinitrotoluene (4-am-dnt)
HPLC	EPA 8330A/B	4-Nitrotoluene
HPLC	EPA 8330A/B	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
HPLC	EPA 8330A/B	Nitrobenzene
HPLC	EPA 8330A/B; EPA 8332	Nitroglycerin
HPLC	EPA 8330A/B	Methyl-2,4,6-trinitrophenylnitramine (Tetryl)
HPLC	EPA 8330A/B	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
HPLC	EPA 8330A/B; EPA 8332	Pentaerythritoltetranitrate (PETN)
HPLC	EPA 8330A	2,2’,6,6’-Tetranitro-4,4’-azoxytoluene

Non-Potable Water		
Technology	**Method**	**Analyte**
HPLC	EPA 8330A/B	2-amino-6-Nitrotoluene
HPLC	EPA 8330A/B	4-amino-2-Nitrotoluene
HPLC	EPA 8330A/B	2-amino-4-Nitrotoluene
HPLC	EPA 8330A/B	2,4-diamino-6-Nitrotoluene
HPLC	EPA 8330A/B	2,6-diamino-4-Nitrotoluene
HPLC	EPA 8330A/B	DNX
HPLC	EPA 8330A/B	MNX
HPLC	EPA 8330A/B	TNX
LC/MS/MS	EPA 6850	Perchlorate
LC/MS/MS	EPA 537 MOD	Perfluorobutanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluoropentanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorohexanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluoroheptanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorooctanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorononanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorodecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluoroundecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorododecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorotridecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorotridecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorotetradecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorobutanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluorohexanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluorooctanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluorodecanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluorooctanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluorodecanesulfonic Acid
ICP	EPA 6010C	Aluminum
ICP	EPA 6010C	Antimony
ICP	EPA 6010C	Arsenic
ICP	EPA 6010C	Barium
ICP	EPA 6010C	Beryllium
ICP	EPA 6010C	Cadmium
ICP	EPA 6010C	Calcium
ICP	EPA 6010C	Chromium
ICP	EPA 6010C	Cobalt
ICP	EPA 6010C	Copper
ICP	EPA 6010C	Iron
ICP	EPA 6010C	Lead
ICP	EPA 6010C	Magnesium
ICP	EPA 6010C	Manganese

Non-Potable Water		
Technology	**Method**	**Analyte**
ICP	EPA 6010C	Molybdenum
ICP	EPA 6010C	Nickel
ICP	EPA 6010C	Potassium
ICP	EPA 6010C	Selenium
ICP	EPA 6010C	Silver
ICP	EPA 6010C	Sodium
ICP	EPA 6010C	Strontium
ICP	EPA 6010C	Thallium
ICP	EPA 6010C	Tin
ICP	EPA 6010C	Titanium
ICP	EPA 6010C	Vanadium
ICP	EPA 6010C	Zinc
CVAA	EPA 7470A	Mercury
UV/VIS	EPA 7196A	Hexavalent Chromium (Cr6+)
UV/VIS	EPA 9012B	Cyanide (Total)
IC	EPA 300; EPA 9056A	Bromide
IC	EPA 300; EPA 9056A	Chloride
IC	EPA 300; EPA 9056A	Fluoride
IC	EPA 300; EPA 9056A	Nitrate
IC	EPA 300; EPA 9056A	Nitrite
IC	EPA 300; EPA 9056A	Sulfate
IC	EPA 300; EPA 9056A	Total nitrate-nitrite
Automated Colorimetry	EPA 350.1	Ammonia
Automated Colorimetry	EPA 351.2	Total Kjeldahl Nitrogen
Automated Colorimetry	EPA 420.4	Total Phenolics
Automated Colorimetry	EPA 353.2	Nitrate
Automated Colorimetry	EPA 353.2	Nitrite
Automated Colorimetry	EPA 353.2	Nitrate+Nitrite
Manual Colorimetry	EPA 365.3	Orthophosphate
Titrimetric	SM 2320B-11	Alkalinity, Total
Titrimetric	SM 4500S=F-11	Sulfide, Iodometric
Gravimetric Methods	EPA 1664A; EPA 9070A	Oil and Grease
Gravimetric Methods	SM 2540B-11	Total Residue (Total Solids)
Gravimetric Methods	SM 2540C-11	Filterable Residue (Total Dissolved Solids)

Non-Potable Water		
Technology	**Method**	**Analyte**
Gravimetric Methods	SM 2540D-11	Non-Filterable Residue (Total Suspended Solids)
Electrometric Methods	SM 4500H+B-11; EPA 9040C	Hydrogen Ion (Ph)
Electrometric Methods	EPA 120.1	Specific conductivity
Combustion	EPA 9060A	Total Organic Carbon
Ignitability	EPA 1010A	Flash Point
Waste Characterization	EPA Ch.7	Reactive Cyanide and Reactive Sulfide
Waste Characterization	EPA Section 7.3	Reactive Cyanide
Waste Characterization	EPA Section 7.3	Reactive Sulfide
Preparation	**Method**	**Type**
Organic Preparation	EPA 3510C	Separatory Funnel Liquid-Liquid Extraction
Organic Preparation	EPA 3511	Micro-extraction
Organic Preparation	EPA 3535A; EPA 3535A MOD	Solid Phase Extraction
Organic Preparation	EPA 8015C/D	Non-Halogenated Organics (Alcohols), direct injection
Organic Preparation	EPA 8151A	Chlorinated Herbicides, Liquid-Liquid Extraction
Organic Preparation	EPA 608; EPA 610; EPA 625	Separatory Funnel Liquid-Liquid Extraction
Volatile Organic Preparation	SW836 5030B	Closed System Purge and Trap
Volatile Organic Preparation	EPA 624	Closed System Purge and Trap
Volatile Organic Preparation	SM 6200B-11	Closed System Purge and Trap
Lachat MicroDistillation	EPA 9012B	Cyanide MicroDistillation; proprietary method
Inorganic Preparation	EPA 3010C	Metals Acid Digestion by Hotblock
Inorganic Preparation	EPA 7470A	CVAA Digestion by Hotblock
Organics Cleanup	EPA 3660B	Sulfur Cleanup
Organics Cleanup	EPA 3665A	Sulfuric Acid Cleanup

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8011	1,2-Dibromoethane (EDB)
GC/ECD	EPA 8011	1,2-Dibromo-3-Chloropropane (DBCP)
GC/FID	EPA 8015C/D	Diesel range organics (DRO)
GC/FID	EPA 8015C/D	Oil Range Organics (ORO)
GC/FID	EPA 8015C/D	Gasoline range organics (GRO)
GC/FID	EPA 8015C/D	Ethanol
GC/FID	EPA 8015C/D	2-Ethoxyethanol
GC/FID	EPA 8015C/D	Isobutyl alcohol (2-Methyl-1-propanol)
GC/FID	EPA 8015C/D	Isopropyl alcohol (2-Propanol)
GC/FID	EPA 8015C/D	Methanol
GC/FID	EPA 8015C/D	n-Butyl alcohol
GC/FID	EPA 8015C/D	n-Propanol
GC/ECD	EPA 8081B	4,4`-DDD
GC/ECD	EPA 8081B	4,4`-DDE
GC/ECD	EPA 8081B	4,4`-DDT
GC/ECD	EPA 8081B	Aldrin
GC/ECD	EPA 8081B	alpha-BHC (alpha-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	beta-BHC (beta-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	delta-BHC
GC/ECD	EPA 8081B	gamma-BHC (Lindane gamma-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	Chlordane (tech.)
GC/ECD	EPA 8081B	alpha-Chlordane
GC/ECD	EPA 8081B	gamma-Chlordane
GC/ECD	EPA 8081B	Dieldrin
GC/ECD	EPA 8081B	Endosulfan I
GC/ECD	EPA 8081B	Endosulfan II
GC/ECD	EPA 8081B	Endosulfan sulfate
GC/ECD	EPA 8081B	Endrin
GC/ECD	EPA 8081B	Endrin aldehyde
GC/ECD	EPA 8081B	Endrin ketone
GC/ECD	EPA 8081B	Heptachlor
GC/ECD	EPA 8081B	Heptachlor epoxide
GC/ECD	EPA 8081B	Methoxychlor
GC/ECD	EPA 8081B	Toxaphene (Chlorinated camphene)
GC/ECD	EPA 8082A	Aroclor-1016 (PCB-1016)
GC/ECD	EPA 8082A	Aroclor-1221 (PCB-1221)
GC/ECD	EPA 8082A	Aroclor-1232 (PCB-1232)
GC/ECD	EPA 8082A	Aroclor-1242 (PCB-1242)
GC/ECD	EPA 8082A	Aroclor-1248 (PCB-1248)
GC/ECD	EPA 8082A	Aroclor-1254 (PCB-1254)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8082A	Aroclor-1260 (PCB-1260)
GC/ECD	EPA 8082A	Aroclor-1262 (PCB-1262)
GC/ECD	EPA 8082A	Aroclor-1268 (PCB-1268)
GC/ECD	EPA 8082A	2,4’-diCB bz8
GC/ECD	EPA 8082A	2,2’,5-trCB bz18
GC/ECD	EPA 8082A	2,4,4’-trCB bz28
GC/ECD	EPA 8082A	2,2’,3,5’-teCB bz44
GC/ECD	EPA 8082A	2,2’,4,5’-teCB bz49
GC/ECD	EPA 8082A	2,2’,5,5’-teCB bz52
GC/ECD	EPA 8082A	2,3’4,4’-teCB bz66
GC/ECD	EPA 8082A	3,3’,4,4’-teCB bz77
GC/ECD	EPA 8082A	3,4,4’,5-teCB bz81
GC/ECD	EPA 8082A	2,2’,3,4,5’-peCB bz87
GC/ECD	EPA 8082A	2,2’,3,4’,5-peCB bz90
GC/ECD	EPA 8082A	2,2’,4,5,5’-peCB bz101
GC/ECD	EPA 8082A	2,3,3’,4,4’-peCB bz105
GC/ECD	EPA 8082A	2,3’,4,4’,5-peCB bz118
GC/ECD	EPA 8082A	2’,3,4,4’,5-peCB bz123
GC/ECD	EPA 8082A	3,3’,4,4’,5-peCB bz126
GC/ECD	EPA 8082A	2,2’,3,3’,4,4’-hxCB bz128
GC/ECD	EPA 8082A	2,2’,3,4,4’,5’-hxCB bz138
GC/ECD	EPA 8082A	2,2’,3,5,5’,6-hxCB bz151
GC/ECD	EPA 8082A	2,2’,4,4’,5,5’-hxCB bz153
GC/ECD	EPA 8082A	2,3,3’,4,4’,5-hxCB bz156
GC/ECD	EPA 8082A	2,3,3’,4,4’,5’-hxCB bz157
GC/ECD	EPA 8082A	2,3’,4,4’,5,5’-hxCB bz167
GC/ECD	EPA 8082A	3,3’,4,4’,5,5’-hxCB bz169
GC/ECD	EPA 8082A	2,2’,3,3’,4,4’,5-hpCB bz170
GC/ECD	EPA 8082A	2,2’,3,4,4’,5,5’-hpCB bz180
GC/ECD	EPA 8082A	2,2’,3,4,4’,5’,6-hpCB bz183
GC/ECD	EPA 8082A	2,2’,3,4,4’,6,6’-hpCB bz184
GC/ECD	EPA 8082A	2,2’,3,4’,5,5’,6-hpCB bz187
GC/ECD	EPA 8082A	2,3,3’,4,4’,5,5’-hpCB bz189
GC/ECD	EPA 8082A	2,2’,3,3’,4,4’,5,6-ocCB bz195
GC/ECD	EPA 8082A	2,2’,3,3’,4,4’,5,5’,6-noCB bz206
GC/ECD	EPA 8082A	Decachlorobiphenyl bz209
GC/FPD	EPA 8141B	Azinphos-methyl (Guthion)
GC/FPD	EPA 8141B	Bolstar (Sulprofos)
GC/FPD	EPA 8141B	Carbophenothion
GC/FPD	EPA 8141B	Chlorpyrifos
GC/FPD	EPA 8141B	Coumaphos
GC/FPD	EPA 8141B	Demeton-o

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/FPD	EPA 8141B	Demeton-s
GC/FPD	EPA 8141B	Diazinon
GC/FPD	EPA 8141B	Dichlorovos (DDVP Dichlorvos)
GC/FPD	EPA 8141B	Dimethoate
GC/FPD	EPA 8141B	Disulfoton
GC/FPD	EPA 8141B	EPN
GC/FPD	EPA 8141B	Ethion
GC/FPD	EPA 8141B	Ethoprop
GC/FPD	EPA 8141B	Famphur
GC/FPD	EPA 8141B	Fensulfothion
GC/FPD	EPA 8141B	Fenthion
GC/FPD	EPA 8141B	Malathion
GC/FPD	EPA 8141B	Merphos
GC/FPD	EPA 8141B	Methyl parathion (Parathion methyl)
GC/FPD	EPA 8141B	Mevinphos
GC/FPD	EPA 8141B	Monocrotophos
GC/FPD	EPA 8141B	Naled
GC/FPD	EPA 8141B	Parathion ethyl
GC/FPD	EPA 8141B	Phorate
GC/FPD	EPA 8141B	Ronnel
GC/FPD	EPA 8141B	Stirofos
GC/FPD	EPA 8141B	Sulfotepp
GC/FPD	EPA 8141B	Tetraethyl pyrophosphate (TEPP)
GC/FPD	EPA 8141B	Thionazin (Zinophos)
GC/FPD	EPA 8141B	Tokuthion (Prothiophos)
GC/FPD	EPA 8141B	Trichloronate
GC/FPD	EPA 8141B	O,O,O-Triethyl phosphorothioate
GC/ECD	EPA 8151A	2,4,5-T
GC/ECD	EPA 8151A	2,4-D
GC/ECD	EPA 8151A	2,4-DB
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dichloroprop (Dichlorprop)
GC/ECD	EPA 8151A	Dinoseb (2-sec-butyl-4,6-dinitrophenol DNBP)
GC/ECD	EPA 8151A	MCPA
GC/ECD	EPA 8151A	MCPP
GC/ECD	EPA 8151A	Pentachlorophenol
GC/ECD	EPA 8151A	Silvex (2,4,5-TP)
GC/FID	FL-PRO	Total Petroleum Hydrocarbons (TPH)
GC/FID	MA-VPH	Volatile petroleum range organics (VPH)
GC/FID	MA-EPH	Extractable petroleum range organics (EPH)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/FID	IA-OA1	Gasoline range organics (GRO)
GC/FID	IA-OA2	Diesel range organics (DRO)
GC/FID	TN-GRO	Gasoline range organics (GRO)
GC/FID	TN-EPH	Extractable petroleum range organics (EPH)
GC/FID	AK-101	Gasoline range organics (GRO)
GC/FID	AK-102	Diesel range organics (DRO)
GC/FID	AK-103	Residual range organics (RRO)
GC/FID	OK-GRO	Gasoline range organics (GRO)
GC/FID	OK-DRO	Diesel range organics (DRO)
GC/FID	TX-1005	Total Petroleum Hydrocarbons (TPH)
GC/MS	EPA 8260B/C	1,1,1,2-Tetrachloroethane
GC/MS	EPA 8260B/C	1,1,1-Trichloroethane
GC/MS	EPA 8260B/C	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260B/C	1,1,2-Trichloroethane
GC/MS	EPA 8260B/C	1,1-Dichloroethane
GC/MS	EPA 8260B/C	1,1-Dichloroethylene
GC/MS	EPA 8260B/C	1,1-Dichloropropene
GC/MS	EPA 8260B/C	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
GC/MS	EPA 8260B/C	1,2,3-Trichlorobenzene
GC/MS	EPA 8260B/C	1,2,3-Trichloropropane
GC/MS	EPA 8260B/C	1,2,4-Trichlorobenzene
GC/MS	EPA 8260B/C	1,2,4-Trimethylbenzene
GC/MS	EPA 8260B/C	1,2-Dibromo-3-chloropropane (DBCP)
GC/MS	EPA 8260B/C	1,2-Dibromoethane (EDB Ethylene dibromide)
GC/MS	EPA 8260B/C	1,2-Dichlorobenzene (o-Dichlorobenzene)
GC/MS	EPA 8260B/C	1,2-Dichloroethane
GC/MS	EPA 8260B/C	1,2-Dichloropropane
GC/MS	EPA 8260B/C	1,2-Dichlorotrifluoroethane (Freon 123)
GC/MS	EPA 8260B/C	1,3,5-Trimethylbenzene
GC/MS	EPA 8260B/C	1,3-Dichlorobenzene (m-Dichlorobenzene)
GC/MS	EPA 8260B/C	1,3-Dichloropropane
GC/MS	EPA 8260B/C	1,4-Dichlorobenzene (p-Dichlorobenzene)
GC/MS	EPA 8260B/C	1-Chlorohexane
GC/MS	EPA 8260B/C	2,2-Dichloropropane
GC/MS	EPA 8260B/C	2-Butanone (Methyl ethyl ketone MEK)
GC/MS	EPA 8260B/C	2-Chloroethyl vinyl ether
GC/MS	EPA 8260B/C	2-Chlorotoluene
GC/MS	EPA 8260B/C	2-Hexanone
GC/MS	EPA 8260B/C	2-Nitropropane
GC/MS	EPA 8260B/C	4-Chlorotoluene
GC/MS	EPA 8260B/C	4-Methyl-2-pentanone (MBK)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B/C	Acetone
GC/MS	EPA 8260B/C	Acetonitrile
GC/MS	EPA 8260B/C	Acrolein (Propenal)
GC/MS	EPA 8260B/C	Acrylonitrile
GC/MS	EPA 8260B/C	Allyl chloride (3-Chloropropene)
GC/MS	EPA 8260B/C	Benzene
GC/MS	EPA 8260B/C	Benzyl Chloride
GC/MS	EPA 8260B/C	Bromobenzene
GC/MS	EPA 8260B/C	Bromochloromethane
GC/MS	EPA 8260B/C	Bromodichloromethane
GC/MS	EPA 8260B/C	Bromoform
GC/MS	EPA 8260B/C	n-Butylbenzene
GC/MS	EPA 8260B/C	sec-Butylbenzene
GC/MS	EPA 8260B/C	tert-Butylbenzene
GC/MS	EPA 8260B/C	Carbon disulfide
GC/MS	EPA 8260B/C	Carbon tetrachloride
GC/MS	EPA 8260B/C	Chlorobenzene
GC/MS	EPA 8260B/C	Chloroethane
GC/MS	EPA 8260B/C	Chloroform
GC/MS	EPA 8260B/C	Chloroprene
GC/MS	EPA 8260B/C	Cyclohexane
GC/MS	EPA 8260B/C	Cyclohexanone
GC/MS	EPA 8260B/C	cis-1,2-Dichloroethylene
GC/MS	EPA 8260B/C	trans-1,2-Dichloroethylene
GC/MS	EPA 8260B/C	cis-1,3-Dichloropropene
GC/MS	EPA 8260B/C	trans-1,3-Dichloropropylene
GC/MS	EPA 8260B/C	cis-1,4-Dichloro-2-butene
GC/MS	EPA 8260B/C	trans-1,4-Dichloro-2-butene
GC/MS	EPA 8260B/C	Di-isopropylether (DIPE)
GC/MS	EPA 8260B/C	Dibromochloromethane
GC/MS	EPA 8260B/C	Dibromomethane (Methylene Bromide)
GC/MS	EPA 8260B/C	Dichlorodifluoromethane
GC/MS	EPA 8260B/C	Diethyl ether
GC/MS	EPA 8260B/C	p-Dioxane (1,4-Dioxane)
GC/MS	EPA 8260B/C	Ethanol (Ethyl Alcohol)
GC/MS	EPA 8260B/C	Ethyl acetate
GC/MS	EPA 8260B/C	Ethyl methacrylate
GC/MS	EPA 8260B/C	Ethyl tert-butyl alcohol (ETBA)
GC/MS	EPA 8260B/C	Ethyl tert-butyl ether (ETBE)
GC/MS	EPA 8260B/C	Ethylbenzene
GC/MS	EPA 8260B/C	Ethylene Oxide

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B/C	Hexachlorobutadiene
GC/MS	EPA 8260B/C	Hexane
GC/MS	EPA 8260B/C	Iodomethane (Methyl iodide)
GC/MS	EPA 8260B/C	Isobutyl alcohol (2-Methyl-1-propanol)
GC/MS	EPA 8260B/C	p-Isopropyltoluene
GC/MS	EPA 8260B/C	Isopropylbenzene
GC/MS	EPA 8260B/C	Methacrylonitrile
GC/MS	EPA 8260B/C	Methyl Acetate
GC/MS	EPA 8260B/C	Methyl bromide (Bromomethane)
GC/MS	EPA 8260B/C	Methyl chloride (Chloromethane)
GC/MS	EPA 8260B/C	Methylcyclohexane
GC/MS	EPA 8260B/C	Methyl methacrylate
GC/MS	EPA 8260B/C	Methyl tert-butyl ether (MTBE)
GC/MS	EPA 8260B/C	Methylene chloride
GC/MS	EPA 8260B/C	Naphthalene
GC/MS	EPA 8260B/C	Pentachloroethane
GC/MS	EPA 8260B/C	Propionitrile (Ethyl cyanide)
GC/MS	EPA 8260B/C	n-Propylbenzene
GC/MS	EPA 8260B/C	Styrene
GC/MS	EPA 8260B/C	tert-Amyl alcohol (TAA)
GC/MS	EPA 8260B/C	tert-Amyl methyl ether (TAME)
GC/MS	EPA 8260B/C	tert-Butyl alcohol (TBA)
GC/MS	EPA 8260B/C	tert-Butyl formate (TBF)
GC/MS	EPA 8260B/C	Tetrachloroethylene (Perchloroethylene)
GC/MS	EPA 8260B/C	Tetrahydrofuran
GC/MS	EPA 8260B/C	Toluene
GC/MS	EPA 8260B/C	Trichloroethene (Trichloroethylene)
GC/MS	EPA 8260B/C	Trichlorofluoromethane
GC/MS	EPA 8260B/C	Vinyl acetate
GC/MS	EPA 8260B/C	Vinyl chloride
GC/MS	EPA 8260B/C	Xylene (total)
GC/MS	EPA 8260B/C	m,p-Xylene
GC/MS	EPA 8260B/C	o-Xylene
GC/MS	EPA 8270D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270D	1,2,4-Trichlorobenzene
GC/MS	EPA 8270D	1,2-Dichlorobenzene (o-Dichlorobenzene)
GC/MS	EPA 8270D	1,2-Diphenylhydrazine
GC/MS	EPA 8270D	1,3,5-Trinitrobenzene (1,3,5-TNB)
GC/MS	EPA 8270D	1,3-Dichlorobenzene (m-Dichlorobenzene)
GC/MS	EPA 8270D	1,3-Dinitrobenzene (1,3-DNB)
GC/MS	EPA 8270D	1,4-Dichlorobenzene (p-Dichlorobenzene)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270D	1,4-Dithiane
GC/MS	EPA 8270D	1,4-Oxathiane
GC/MS	EPA 8270D	1,4-Naphthoquinone
GC/MS	EPA 8270D	1,4-Phenylenediamine
GC/MS	EPA 8270D	1-Chloronaphthalene
GC/MS	EPA 8270D	1-Methylnaphthalene
GC/MS	EPA 8270D	1-Naphthylamine
GC/MS	EPA 8270D	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 8270D	2,4,5-Trichlorophenol
GC/MS	EPA 8270D	2,4,6-Trichlorophenol
GC/MS	EPA 8270D	2,4-Dichlorophenol
GC/MS	EPA 8270D	2,4-Dimethylphenol
GC/MS	EPA 8270D	2,4-Dinitrophenol
GC/MS	EPA 8270D	2,4-Dinitrotoluene (2,4-DNT)
GC/MS	EPA 8270D	2,6-Dichlorophenol
GC/MS	EPA 8270D	2,6-Dinitrotoluene (2,6-DNT)
GC/MS	EPA 8270D	2-Acetylaminofluorene
GC/MS	EPA 8270D	2-Chloronaphthalene
GC/MS	EPA 8270D	2-Chlorophenol
GC/MS	EPA 8270D	2-Methyl-4,6-dinitrophenol (4,6-Dinitro-o-cresol)
GC/MS	EPA 8270D	2-Methylnaphthalene
GC/MS	EPA 8270D	2-Methylphenol (o-Cresol)
GC/MS	EPA 8270D	2-Naphthylamine
GC/MS	EPA 8270D	2-Nitroaniline
GC/MS	EPA 8270D	2-Nitrophenol
GC/MS	EPA 8270D	2-Picoline (2-Methylpyridine)
GC/MS	EPA 8270D	3,3`-Dichlorobenzidine
GC/MS	EPA 8270D	3,3`-Dimethylbenzidine
GC/MS	EPA 8270D	3-Methylcholanthrene
GC/MS	EPA 8270D	3&4-Methylphenol (m,p-Cresol)
GC/MS	EPA 8270D	3-Nitroaniline
GC/MS	EPA 8270D	4-Aminobiphenyl
GC/MS	EPA 8270D	4-Bromophenyl phenyl ether
GC/MS	EPA 8270D	4-Chloro-3-methylphenol
GC/MS	EPA 8270D	4-Chloroaniline
GC/MS	EPA 8270D	4-Chlorophenyl phenylether
GC/MS	EPA 8270D	4-Dimethyl aminoazobenzene
GC/MS	EPA 8270D	4-Nitroaniline
GC/MS	EPA 8270D	4-Nitrophenol
GC/MS	EPA 8270D	4,4’-methylene-bis(2-chloroaniline)
GC/MS	EPA 8270D	5-Nitro-o-toluidine

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270D	7,12-Dimethylbenz(a) anthracene
GC/MS	EPA 8270D	Acenaphthene
GC/MS	EPA 8270D	Acenaphthylene
GC/MS	EPA 8270D	Acetophenone
GC/MS	EPA 8270D	Aniline
GC/MS	EPA 8270D	Anilazine
GC/MS	EPA 8270D	Anthracene
GC/MS	EPA 8270D	Aramite
GC/MS	EPA 8270D	Atrazine
GC/MS	EPA 8270D	Benzaldehyde
GC/MS	EPA 8270D	Benzidine
GC/MS	EPA 8270D	Benzo(a)anthracene
GC/MS	EPA 8270D	Benzo(a)pyrene
GC/MS	EPA 8270D	Benzo(b)fluoranthene
GC/MS	EPA 8270D	Benzo(g,, i)perylene
GC/MS	EPA 8270D	Benzo(k)fluoranthene
GC/MS	EPA 8270D	Benzoic acid
GC/MS	EPA 8270D	Benzyl alcohol
GC/MS	EPA 8270D	Biphenyl (1,1'-Biphenyl)
GC/MS	EPA 8270D	bis(2-Chloroethoxy)methane
GC/MS	EPA 8270D	bis(2-Chloroethyl) ether
GC/MS	EPA 8270D	bis(2-Chloroisopropyl) ether (2,2`-Oxybis(1-chloropropane))
GC/MS	EPA 8270D	bis(2-Ethylhexyl) phthalate (DEHP)
GC/MS	EPA 8270D	Butyl benzyl phthalate
GC/MS	EPA 8270D	Carbazole
GC/MS	EPA 8270D	Caprolactam
GC/MS	EPA 8270D	Chlorobenzilate
GC/MS	EPA 8270D	Chrysene
GC/MS	EPA 8270D	Diallate
GC/MS	EPA 8270D	Di-n-butyl phthalate
GC/MS	EPA 8270D	Di-n-octyl phthalate
GC/MS	EPA 8270D	Dibenz(a,h)anthracene
GC/MS	EPA 8270D	Dibenz(a,j)acridine
GC/MS	EPA 8270D	Dibenzofuran
GC/MS	EPA 8270D	Diethyl phthalate
GC/MS	EPA 8270D	Dimethyl phthalate
GC/MS	EPA 8270D	a,a-Dimethylphenethylamine
GC/MS	EPA 8270D	Diphenyl Ether
GC/MS	EPA 8270D	p-Dioxane (1,4-Dioxane)
GC/MS	EPA 8270D	Ethyl methanesulfonate
GC/MS	EPA 8270D	Fluoranthene

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270D	Fluorene
GC/MS	EPA 8270D	Hexachlorobenzene
GC/MS	EPA 8270D	Hexachlorobutadiene
GC/MS	EPA 8270D	Hexachlorocyclopentadiene
GC/MS	EPA 8270D	Hexachloroethane
GC/MS	EPA 8270D	Hexachlorophene
GC/MS	EPA 8270D	Hexachloropropene
GC/MS	EPA 8270D	Indeno(1,2,3-cd)pyrene
GC/MS	EPA 8270D	Isodrin
GC/MS	EPA 8270D	Isophorone
GC/MS	EPA 8270D	Isosafrole
GC/MS	EPA 8270D	Kepone
GC/MS	EPA 8270D	Methapyrilene
GC/MS	EPA 8270D	Methyl methanesulfonate
GC/MS	EPA 8270D	Naphthalene
GC/MS	EPA 8270D	Nicotine
GC/MS	EPA 8270D	Nitrobenzene
GC/MS	EPA 8270D	Nitroquinoline-1-oxide
GC/MS	EPA 8270D	n-Nitroso-di-n-butylamine
GC/MS	EPA 8270D	n-Nitrosodi-n-propylamine
GC/MS	EPA 8270D	n-Nitrosodiethylamine
GC/MS	EPA 8270D	n-Nitrosodimethylamine
GC/MS	EPA 8270D	n-Nitrosodiphenylamine
GC/MS	EPA 8270D	n-Nitrosodiphenylamine/Diphenylamine (analyte pair)
GC/MS	EPA 8270D	n-Nitrosomethylethylamine
GC/MS	EPA 8270D	n-Nitrosomorpholine
GC/MS	EPA 8270D	n-Nitrosopiperidine
GC/MS	EPA 8270D	n-Nitrosopyrrolidine
GC/MS	EPA 8270D	Pentachlorobenzene
GC/MS	EPA 8270D	Pentachloroethane
GC/MS	EPA 8270D	Pentachloronitrobenzene
GC/MS	EPA 8270D	Pentachlorophenol
GC/MS	EPA 8270D	Phenacetin
GC/MS	EPA 8270D	Phenanthrene
GC/MS	EPA 8270D	Phenol
GC/MS	EPA 8270D	Pronamide (Kerb)
GC/MS	EPA 8270D	Propazine
GC/MS	EPA 8270D	Pyrene
GC/MS	EPA 8270D	Pyridine
GC/MS	EPA 8270D	Resorcinol
GC/MS	EPA 8270D	Safrole

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270D	Simazine
GC/MS	EPA 8270D	o-Toluidine
GC/MS	EPA 8270D	Dimethoate
GC/MS	EPA 8270D	Disulfoton
GC/MS	EPA 8270D	Famphur
GC/MS	EPA 8270D	Methyl parathion (Parathion methyl)
GC/MS	EPA 8270D	Parathion ethyl
GC/MS	EPA 8270D	Phorate
GC/MS	EPA 8270D	Sulfotepp
GC/MS	EPA 8270D	Thionazin (Zinophos)
GC/MS	EPA 8270D	O,O,O-Triethyl phosphorothioate
HPLC	EPA 8310	1-Methylnaphthalene
HPLC	EPA 8310	2-Methylnaphthalene
HPLC	EPA 8310	Acenaphthene
HPLC	EPA 8310	Acenaphthylene
HPLC	EPA 8310	Anthracene
HPLC	EPA 8310	Benzo(a)anthracene
HPLC	EPA 8310	Benzo(a)pyrene
HPLC	EPA 8310	Benzo(b)fluoranthene
HPLC	EPA 8310	Benzo(g h i)perylene
HPLC	EPA 8310	Benzo(k)fluoranthene
HPLC	EPA 8310	Chrysene
HPLC	EPA 8310	Dibenz(a h)anthracene
HPLC	EPA 8310	Fluoranthene
HPLC	EPA 8310	Fluorene
HPLC	EPA 8310	Indeno(1,2,3-cd)pyrene
HPLC	EPA 8310	Naphthalene
HPLC	EPA 8310	Phenanthrene
HPLC	EPA 8310	Pyrene
HPLC	EPA 8330A/B	1,3,5-Trinitrobenzene (1,3,5-TNB)
HPLC	EPA 8330A/B	1,3-Dinitrobenzene (1,3-DNB)
HPLC	EPA 8330A/B	2,4,6-Trinitrotoluene (2,4,6-TNT)
HPLC	EPA 8330A/B	2,4-Dinitrotoluene (2,4-DNT)
HPLC	EPA 8330A/B	2,6-Dinitrotoluene (2,6-DNT)
HPLC	EPA 8330A/B	2-Amino-4,6-dinitrotoluene (2-am-dnt)
HPLC	EPA 8330A/B	2-Nitrotoluene
HPLC	EPA 8330A/B	3,5-Dinitroaniline
HPLC	EPA 8330A/B	3-Nitrotoluene
HPLC	EPA 8330A/B	4-Amino-2,6-dinitrotoluene (4-am-dnt)
HPLC	EPA 8330A/B	4-Nitrotoluene
HPLC	EPA 8330A/B	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
HPLC	EPA 8330A/B	Nitrobenzene
HPLC	EPA 8330A/B; EPA 8332	Nitroglycerin
HPLC	EPA 8330A/B	Methyl-2,4,6-trinitrophenylnitramine (Tetryl)
HPLC	EPA 8330A/B	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
HPLC	EPA 8330A/B; EPA 8332	Pentaerythritoltetranitrate (PETN)
HPLC	EPA 8330A	2,2’,6,6’-Tetranitro-4,4’-azoxytoluene
HPLC	EPA 8330A/B	2-amino-6-Nitrotoluene
HPLC	EPA 8330A/B	4-amino-2-Nitrotoluene
HPLC	EPA 8330A/B	2-amino-4-Nitrotoluene
HPLC	EPA 8330A/B	2,4-diamino-6-Nitrotoluene
HPLC	EPA 8330A/B	2,6-diamino-4-Nitrotoluene
HPLC	EPA 8330A/B	DNX
HPLC	EPA 8330A/B	MNX
HPLC	EPA 8330A/B	TNX
LC/MS/MS	EPA 6850	Perchlorate
LC/MS/MS	EPA 537 MOD	Perfluorobutanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluoropentanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorohexanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluoroheptanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorooctanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorononanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorodecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluoroundecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorododecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorotridecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorotridecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorotetradecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorobutanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluorohexanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluorooctanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluorodecanesulfonic Acid
ICP	EPA 6010C	Aluminum
ICP	EPA 6010C	Antimony
ICP	EPA 6010C	Arsenic
ICP	EPA 6010C	Barium
ICP	EPA 6010C	Beryllium
ICP	EPA 6010C	Cadmium
ICP	EPA 6010C	Calcium
ICP	EPA 6010C	Chromium
ICP	EPA 6010C	Cobalt
ICP	EPA 6010C	Copper

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
ICP	EPA 6010C	Iron
ICP	EPA 6010C	Lead
ICP	EPA 6010C	Magnesium
ICP	EPA 6010C	Manganese
ICP	EPA 6010C	Molybdenum
ICP	EPA 6010C	Nickel
ICP	EPA 6010C	Potassium
ICP	EPA 6010C	Selenium
ICP	EPA 6010C	Silver
ICP	EPA 6010C	Sodium
ICP	EPA 6010C	Strontium
ICP	EPA 6010C	Thallium
ICP	EPA 6010C	Tin
ICP	EPA 6010C	Titanium
ICP	EPA 6010C	Vanadium
ICP	EPA 6010C	Zinc
CVAA	EPA 7471B	Mercury
UV/VIS	EPA 7196A	Hexavalent Chromium (Cr6+)
UV/VIS	EPA 9012B	Cyanide (Total)
IC	EPA 9056A	Bromide
IC	EPA 9056A	Chloride
IC	EPA 9056A	Fluoride
IC	EPA 9056A	Nitrate
IC	EPA 9056A	Nitrite
IC	EPA 9056A	Sulfate
IC	EPA 9056A	Total nitrate-nitrite
Gravimetric Methods	SM 2540G	% solids
Gravimetric Methods	EPA 9071B	Oil and Grease
Electrometric Methods	EPA 9045D	Hydrogen Ion (pH)
Combustion	EPA 9060A	Total Organic Carbon
Ignitability	EPA 1010A	Flash Point
Waste Characterization	EPA Ch.7	Reactive Cyanide and Reactive Sulfide
Waste Characterization	EPA Section 7.3	Reactive Cyanide
Waste Characterization	EPA Section 7.3	Reactive Sulfide

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Solid and Chemical Materials		
Preparation	**Method**	**Type**
Organics Preparation	EPA 3510C	Separatory Funnel Liquid-Liquid Extraction; Leachates
TCLP Preparation	EPA 1311	Toxicity Characteristic Leaching Procedure
SPLP Preparation	EPA 1312	Synthetic Precipitation Leaching Procedure
Organics Preparation	EPA 8011	Microextraction
Organics Preparation	EPA 3546	Microwave Extraction
Organics Preparation	EPA 3550C	Ultrasonic Extraction
Organics Preparation	EPA 3580A	Waste Dilution for Extractable Organics
Organics Preparation	EPA 8330A; EPA 8332	Ultrasonic Extraction
Organics Preparation	EPA 8330B	Shaker Table Extraction
Volatile Organics Preparation	EPA 3585	Waste Dilution for Volatile Organics
Volatile Organics Preparation	EPA 5030A	Closed System Purge and Trap; Bulk Soils
Volatile Organics Preparation	EPA 5030B	Closed System Purge and Trap; Leachates and Methanol Extracts
Volatile Organics Preparation	EPA 5035; EPA 5035A	Closed System Purge and Trap
Organics Cleanup	EPA 3660B	Sulfur Cleanup
Organics Cleanup	EPA 3665A	Sulfuric Acid Cleanup
Lachat MicroDistillation	EPA 9012B	Cyanide MicroDistillation; proprietary method
Inorganic Preparation	EPA 3010C	Metals Acid Digestion by Hotblock; Leachates
Inorganic Preparation	EPA 3050B	Metals Acid Digestion by Hotblock
Inorganic Preparation	EPA 3060A	Alkaline Digestion, Cr6+
Inorganic Preparation	EPA 7470A	CVAA Digestion by Hotblock; Leachates
Inorganic Preparation	EPA 7471B	CVAA Digestion by Hotblock

Notes:

1) This laboratory offers commercial testing service.

Approved by: _____ Date: January 29, 2014

R. Douglas Leonard
Chief Technical Officer

Re-Issued: 1/29/13 Revised: 1/29/14

LABORATORY ACCREDITATION BUREAU a division of A-S-B

Certificate of Accreditation

ISO/IEC 17025:2005 Certificate Number L2248

Accutest Laboratories – New Jersey

2235 Route 130
Dayton NJ 08810

has met the requirements set forth in L-A-B's policies and procedures, all requirements of ISO/IEC 17025:2005 "General Requirements for the competence of Testing and Calibration Laboratories" and the U.S. Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP).*

The accredited lab has demonstrated technical competence to a defined "Scope of Accreditation" and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009).

Accreditation valid through: April 14, 2016

R. Douglas Leonard, Jr., President, COO
Laboratory Accreditation Bureau
Presented the 10th of July 2013

*See the laboratory's Scope of Accreditation for details of accredited parameters
**Laboratory Accreditation Bureau is found to be in compliance with ISO/IEC 17011:2004 and recognized by ILAC (International Laboratory Accreditation Cooperation) and NACLA (National Cooperation for Laboratory Accreditation).
Form 403.14 – Rev 1 7/3/13

LABORATORY ACCREDITATION BUREAU

Certificate # L2248

Scope of Accreditation For Accutest Laboratories – New Jersey

2235 Route 130
Dayton, NJ 08810
Phillip M. Worby
732-329-0200

In recognition of a successful assessment to ISO/IEC 17025:2005 and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (DoD QSM v4.2) based on the National Environmental Laboratory Accreditation Conference Chapter 5 Quality Systems Standard (NELAC Voted Revision June 5, 2003), accreditation is granted to Accutest Laboratories to perform the following tests:

Accreditation granted through: **April 14, 2016**

Testing – Environmental

Non-Potable Water		
Technology	**Method**	**Analyte**
Membrane Filter (MF)	SM 9222 D-97	Fecal Coliform
Membrane Filter (MF)	SM 9222 B-97	Total Coliform
Pour Plate	SM 9215 B	Heterotrophic Plate Count
Electrometric Titration	SM 2320 B-11	Alkalinity as CaCO3
Automated Phenate	SM 4500-NH3 B+H-11	Ammonia
Dissolved Oxygen, Polarography	SM 5210 B-11	Biochemical Oxygen Demand
Dissolved Oxygen, Polarography	SM 5210 B-11	Carbonaceous Biochemical Oxygen Demand
Titrimetry	SM 5220 B/C (M)-11	Chemical Oxygen Demand
Distillation, Spectrophotometry	EPA 335.4 SM 4500-CN B-11	Cyanide
Distillation, Spectrophotometry	SM 4500-CN C-11 SM 4500-CN G-11	Cyanide – Amenable to Chlorination
Titrimetric, EDTA	SM 2340 B/C-11	Hardness – total as CaCO3
Digestion, Distillation, Semi-automated Colorimetry Digestor	EPA 351.2	Kjeldahl Nitrogen - Total
Spectrophotometry, Manual	SM 4500-NO2-B-11	Nitrite
Combustion/IR	SM 5310 B-11	Total Organic Carbon (TOC)

Non-Potable Water		
Technology	**Method**	**Analyte**
Calculation	EPA 351.2 SM 4500-NH3 B+H-11	Organic Nitrogen
Spectrophotometry	SM 4500-P E-11	Orthophosphate
Distillation Colorimetry Automated	EPA 420.1 EPA 420 .4	Phenols
Persulfate Digestion + Manual Colorimetry	EPA 365.3	Phosphorus (total)
Gravimetry	SM 2540 C-11	Residue – filterable (TDS)
Gravimetry	SM 2540 D-11	Residue – nonfilterable (TSS)
Volumetric (Imhoff Cone)	SM 2540 F-11	Residue – settleable
Gravimetry	EPA 160.4	Residue – volatile
Gravimetry	SM 2540 G-11	Total, fixed, and volatile solids (SQAR)
Electrical Conductivity	SM 2520 B-11	Salinity
Filtration –Colorimetry	SM 4500-Si D-11	Silica – dissolved
Wheatstone Bridge	SM 2510 B-11	Specific Conductance
Wheatstone Bridge	EPA 9050A	Specific Conductance
Titrimetry, Iodometric	SM 4500 S2 B/C/F-11	Sulfides
Colorimetry (Methylene Blue)	SM 5540 C-11	Surfactants
Nephelometry	EPA 180.1	Turbidity
Electrode	SM 4500-O C-11 SM 4500-O G11	Oxygen (dissolved)
Electrometry	SM 4500-H B-11	pH
Colorimetry	SM 3500-Cr B-11	Chromium, VI
Digestion Colorimetry	SM 3500-Fe B-11	Iron, Ferrous
Manual Cold Vapor AA	EPA 245.1	Mercury
ICP-MS	EPA 6020/A EPA 200.8	Aluminum
ICP-MS	EPA 6020/A EPA 200.8	Antimony
ICP-MS	EPA 6020/A EPA 200.8	Arsenic
ICP-MS	EPA 6020/A EPA 200.8	Barium
ICP-MS	EPA 6020/A EPA 200.8	Beryllium
ICP-MS	EPA 6020/A EPA 200.8	Cadmium
ICP-MS	EPA 6020/A EPA 200.8	Calcium

LABORATORY ACCREDITATION BUREAU

Certificate # L2248

Non-Potable Water		
Technology	**Method**	**Analyte**
ICP-MS	EPA 6020/A EPA 200.8	Chromium
ICP-MS	EPA 6020/A EPA 200.8	Cobalt
ICP-MS	EPA 6020/A EPA 200.8	Copper
ICP-MS	EPA 6020/A EPA 200.8	Iron
ICP-MS	EPA 6020/A EPA 200.8	Lead
ICP-MS	EPA 6020/A EPA 200.8	Magnesium
ICP-MS	EPA 6020/A EPA 200.8	Manganese
ICP-MS	EPA 6020/A EPA 200.8	Molybdenum
ICP-MS	EPA 6020/A EPA 200.8	Nickel
ICP-MS	EPA 6020/A EPA 200.8	Potassium
ICP-MS	EPA 6020/A EPA 200.8	Selenium
ICP-MS	EPA 6020/A EPA 200.8	Silver
ICP-MS	EPA 6020/A EPA 200.8	Sodium
ICP-MS	EPA 6020/A	Strontium
ICP-MS	EPA 6020/A EPA 200.8	Thallium
ICP-MS	EPA 6020/A EPA 200.8	Tin
ICP-MS	EPA 6020/A EPA 200.8	Titanium
ICP-MS	EPA 6020/A EPA 200.8	Vanadium
ICP-MS	EPA 6020/A EPA 200.8	Zinc
GC-ECD	EPA 8011	1,2-Dibromomethane (EDB)
GC-ECD	EPA 8011	1,2-Dibromo-3-chloropropane
GC-ECD	EPA 8011	1,2,3-Trichloropropane
GC-FID	EPA 8015 B/C	Diesel range organics (DRO)
GC-FID	EPA 8015 B/C	Gasoline range organics (GRO)
GC-FID	EPA 8015 B/C	Ethanol
GC-FID	EPA 8015 B/C	Isobutyl alcohol (2-Methyl-1-propanol)

Non-Potable Water		
Technology	**Method**	**Analyte**
GC-FID	EPA 8015 B/C	Isopropyl alcohol (2-Propanol)
GC-FID	EPA 8015 B/C	Methanol
GC-FID	EPA 8015 B/C	Tert-butyl alcohol
GC-FID	NJDEP-EPH	Extractable Petroleum Hydrocarbons
GC-FID	EPA 603	Acrolein
GC-FID	EPA 603	Acrylonitrile
GC-ECD	EPA 8081A/B EPA 608	4 4`-DDD
GC-ECD	EPA 8081A/B EPA 608	4 4`-DDE
GC-ECD	EPA 8081A/B EPA 608	4 4`-DDT
GC-ECD	EPA 8081A/B EPA 608	Aldrin
GC-ECD	EPA 8081A/B EPA 608	Chlordane (tech.)
GC-ECD	EPA 8081A/B EPA 608	Dieldrin
GC-ECD	EPA 8081A/B EPA 608	Endosulfan I
GC-ECD	EPA 8081A/B EPA 608	Endosulfan II
GC-ECD	EPA 8081A/B EPA 608	Endosulfan sulfate
GC-ECD	EPA 8081A/B EPA 608	Endrin
GC-ECD	EPA 8081A/B EPA 608	Endrin aldehyde
GC-ECD	EPA 8081A/B EPA 608	Endrin ketone
GC-ECD	EPA 8081A/B EPA 608	Heptachlor
GC-ECD	EPA 8081A/B EPA 608	Heptachlor epoxide
GC-ECD	EPA 8081A/B EPA 608	Methoxychlor
GC-ECD	EPA 8081A/B EPA 608	Toxaphene (Chlorinated camphene)
GC-ECD	EPA 8081A/B EPA 608	alpha-BHC (alpha-Hexachlorocyclohexane)
GC-ECD	EPA 8081A/B EPA 608	alpha-Chlordane
GC-ECD	EPA 8081A/B EPA 608	beta-BHC (beta-Hexachlorocyclohexane)
GC-ECD	EPA 8081A/B EPA 608	delta-BHC
GC-ECD	EPA 8081A/B EPA 608	gamma-BHC (Lindane gamma-Hexachlorocyclohexane)
GC-ECD	EPA 8081A/B EPA 608	gamma-Chlordane
GC-ECD	EPA 8081A/B	Mirex
GC-ECD	EPA 8082/A EPA 608	Aroclor-1016 (PCB-1016)
GC-ECD	EPA 8082/A EPA 608	Aroclor-1221 (PCB-1221)
GC-ECD	EPA 8082/A EPA 608	Aroclor-1232 (PCB-1232)
GC-ECD	EPA 8082/A EPA 608	Aroclor-1242 (PCB-1242)
GC-ECD	EPA 8082/A EPA 608	Aroclor-1248 (PCB-1248)
GC-ECD	EPA 8082/A EPA 608	Aroclor-1254 (PCB-1254)

Non-Potable Water		
Technology	**Method**	**Analyte**
GC-ECD	EPA 8082/A EPA 608	Aroclor-1260 (PCB-1260)
GC-ECD	EPA 8082/A EPA 608	Aroclor-1262 (PCB-1262)
GC-ECD	EPA 8082/A EPA 608	Aroclor-1268 (PCB-1268)
GC-ECD	EPA 8151A	2 4 5-T
GC-ECD	EPA 8151A	2 4-D
GC-ECD	EPA 8151A	2 4-DB
GC-ECD	EPA 8151A	Dalapon
GC-ECD	EPA 8151A	Dicamba
GC-ECD	EPA 8151A	Dichloroprop (Dichlorprop)
GC-ECD	EPA 8151A	Dinoseb (2-sec-butyl-4 6-dinitrophenol DNBP)
GC-ECD	EPA 8151A	MCPA
GC-ECD	EPA 8151A	MCPP
GC-ECD	EPA 8151A	Pentachlorophenol
GC-ECD	EPA 8151A	Silvex (2 4 5-TP)
GC-ECD	EPA 8151A	Picloram
GC-FID	EPA RSK-175	Ethane
GC-FID	EPA RSK-175	Ethene
GC-FID	EPA RSK-175	Methane
GC-FID	EPA RSK-175	Propane
GC-MS	EPA 624	n-Heptane
GC-MS	EPA 624	n-Hexane
GC-MS	EPA 624	Isobutyraldehyde
GC-MS	EPA 624	Isopropanol
GC-MS	EPA 624	Isopropyl acetate
GC-MS	EPA 624	Isopropyl ether
GC-MS	EPA 624	Methyl formate
GC-MS	EPA 624	o-Xylene
GC-MS	EPA 624	m- + p-Xylene
GC-MS	EPA 8260B/C	Ethylene glycol
GC-MS	EPA 8260B/C	Propylene glycol
GC-MS	EPA 8260B/C	1 1 1 2-Tetrachloroethane
GC-MS	EPA 8260B/C EPA 624	1 1 1-Trichloroethane
GC-MS	EPA 8260B/C EPA 624	1 1 2 2-Tetrachloroethane
GC-MS	EPA 8260B/C EPA 624	1 1 2-Trichloroethane
GC-MS	EPA 8260B/C EPA 624	1 1-Dichloroethane

Non-Potable Water		
Technology	**Method**	**Analyte**
GC-MS	EPA 8260B/C EPA 624	1 1-Dichloroethylene
GC-MS	EPA 8260B/C	1 1-Dichloropropene
GC-MS	EPA 8260B/C	1 2 3-Trichlorobenzene
GC-MS	EPA 8260B/C	1 2 3-Trichloropropane
GC-MS	EPA 8260B/C	1 2 4-Trichlorobenzene
GC-MS	EPA 8260B/C EPA 624	1 2 4-Trimethylbenzene
GC-MS	EPA 8260B/C	1 2-Dibromo-3-chloropropane (DBCP)
GC-MS	EPA 8260B/C EPA 624	1 2-Dibromoethane (EDB Ethylene dibromide)
GC-MS	EPA 8260B/C EPA 624	1 2-Dichlorobenzene
GC-MS	EPA 8260B/C EPA 624	1 2-Dichloroethane
GC-MS	EPA 8260B/C EPA 624	1 2-Dichloropropane
GC-MS	EPA 8260B/C EPA 624	1 3 5-Trimethylbenzene
GC-MS	EPA 8260B/C EPA 624	1 3-Dichlorobenzene
GC-MS	EPA 8260B/C	1 3-Dichloropropane
GC-MS	EPA 8260B/C EPA 624	1 4-Dichlorobenzene
GC-MS	EPA 8260B/C	1-Chlorohexane
GC-MS	EPA 8260B/C	2 2-Dichloropropane
GC-MS	EPA 8260B/C EPA 624	2-Butanone (Methyl ethyl ketone MEK)
GC-MS	EPA 8260B/C EPA 624	2-Chloroethyl vinyl ether
GC-MS	EPA 8260B/C	2-Chlorotoluene
GC-MS	EPA 8260B/C EPA 624	2-Hexanone
GC-MS	EPA 8260B/C	2-Nitropropane
GC-MS	EPA 8260B/C	4-Chlorotoluene
GC-MS	EPA 8260B/C EPA 624	4-Methyl-2-pentanone (MIBK)
GC-MS	EPA 8260B/C EPA 624	Acetone
GC-MS	EPA 8260B/C	Acetonitrile
GC-MS	EPA 8260B/C EPA 624	Acrolein (Propenal)
GC-MS	EPA 8260B/C EPA 624	Acrylonitrile
GC-MS	EPA 8260B/C	Allyl chloride (3-Chloropropene)
GC-MS	EPA 8260B/C EPA 624	Benzene
GC-MS	EPA 8260B/C	Bromobenzene
GC-MS	EPA 8260B/C	Bromochloromethane
GC-MS	EPA 8260B/C EPA 624	Bromodichloromethane
GC-MS	EPA 8260B/C EPA 624	Bromoform
GC-MS	EPA 8260B/C EPA 624	Carbon disulfide

Non-Potable Water		
Technology	**Method**	**Analyte**
GC-MS	EPA 8260B/C EPA 624	Carbon tetrachloride
GC-MS	EPA 8260B/C EPA 624	Chlorobenzene
GC-MS	EPA 8260B/C EPA 624	Chloroethane
GC-MS	EPA 8260B/C EPA 624	Chloroform
GC-MS	EPA 8260B/C	Chloroprene
GC-MS	EPA 8260B/C EPA 624	Di-isopropylether (DIPE)
GC-MS	EPA 8260B/C EPA 624	Dibromochloromethane
GC-MS	EPA 8260B	Dibromomethane
GC-MS	EPA 8260B/C EPA 624	Dichlorodifluoromethane
GC-MS	EPA 8260B/C EPA 624	Diethyl ether
GC-MS	EPA 8260B/C	Ethanol
GC-MS	EPA 8260B/C EPA 624	Ethyl acetate
GC-MS	EPA 8260B/C	Ethyl methacrylate
GC-MS	EPA 8260B/C EPA 624	Ethyl-t-butylether (ETBE)
GC-MS	EPA 8260B/C EPA 624	Ethylbenzene
GC-MS	EPA 8260B/C	Hexachlorobutadiene
GC-MS	EPA 8260B/C	Iodomethane (Methyl iodide)
GC-MS	EPA 8260B/C	Isobutyl alcohol (2-Methyl-1-propanol)
GC-MS	EPA 8260B/C EPA 624	Isopropylbenzene
GC-MS	EPA 8260B/C	Methacrylonitrile
GC-MS	EPA 8260B/C EPA 624	Methyl bromide (Bromomethane)
GC-MS	EPA 8260B/C EPA 624	Methyl chloride (Chloromethane)
GC-MS	EPA 8260B/C	Methyl methacrylate
GC-MS	EPA 8260B/C EPA 624	Methyl tert-butyl ether (MTBE)
GC-MS	EPA 8260B/C EPA 624	Methylene chloride
GC-MS	EPA 8260B/C EPA 624	Naphthalene
GC-MS	EPA 8260B/C	Pentachloroethane
GC-MS	EPA 8260B/C	Propionitrile (Ethyl cyanide)
GC-MS	EPA 8260B/C EPA 624	Styrene
GC-MS	EPA 8260B/C EPA 624	T-amylmethylether (TAME)
GC-MS	EPA 8260B/C EPA 624	Tetrachloroethylene (Perchloroethylene)
GC-MS	EPA 8260B/C EPA 624	Toluene
GC-MS	EPA 8260B/C EPA 624	Trichloroethene (Trichloroethylene)
GC-MS	EPA 8260B/C EPA 624	Trichlorofluoromethane
GC-MS	EPA 8260B/C EPA 624	Vinyl acetate

Non-Potable Water		
Technology	**Method**	**Analyte**
GC-MS	EPA 8260B/C EPA 624	Vinyl chloride
GC-MS	EPA 8260B/C EPA 624	Xylene (total)
GC-MS	EPA 8260B/C EPA 624	cis-1 2-Dichloroethylene
GC-MS	EPA 8260B/C EPA 624	cis-1 3-Dichloropropene
GC-MS	EPA 8260B/C	n-Butylbenzene
GC-MS	EPA 8260B/C	n-Propylbenzene
GC-MS	EPA 8260B/C EPA 624	p-Dioxane
GC-MS	EPA 8260B/C	p-Isopropyltoluene
GC-MS	EPA 8260B/C	sec-Butylbenzene
GC-MS	EPA 8260B/C EPA 624	tert-Butyl alcohol
GC-MS	EPA 8260B/C	tert-Butylbenzene
GC-MS	EPA 8260B/C EPA 624	trans-1 2-Dichloroethylene
GC-MS	EPA 8260B/C EPA 624	trans-1 3-Dichloropropylene
GC-MS	EPA 8260B/C	trans-1 4-Dichloro-2-butene
GC-MS	EPA 8260B/C	Cyclohexane
GC-MS	EPA 8260B/C	Cyclohexanone
GC-MS	EPA 8260B/C EPA 624	1-Butanol
GC-MS	EPA 8260B/C EPA 624	Tetrahydrofuran
GC-MS	EPA 8260B EPA 624	1 1 2-Trichloro-1 2 2-trifluoroethane
GC-MS	EPA 8260B/C	Methyl acrylate
GC-MS	EPA 8260B/C	Methyl acetate
GC-MS	EPA 8260B/C	Hexachloroethane
GC-MS	EPA 8260B/C	Benzyl chloride
GC-MS	EPA 8260B/C	Methylcyclohexane
GC-MS	EPA 8260B/C	2,2,4-Trimethylpentane
GC-MS	EPA 625	2,3-Dichloroaniline
GC-MS	EPA 625	1-Methylphenanthrene
GC-MS	EPA 8270C/D EPA 625	1 2 4 5-Tetrachlorobenzene
GC-MS	EPA 8270C/D EPA 625	1 2 4-Trichlorobenzene
GC-MS	EPA 8270C/D	1 2-Dichlorobenzene
GC-MS	EPA 8270C/D EPA 625	1 2-Diphenylhydrazine
GC-MS	EPA 8270C/D	1 3 5-Trinitrobenzene (1 3 5-TNB)
GC-MS	EPA 8270C/D	1 3-Dichlorobenzene
GC-MS	EPA 8270C/D	1 3-Dinitrobenzene (1 3-DNB)
GC-MS	EPA 8270C/D	1 4-Dichlorobenzene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC-MS	EPA 8270C/D	1 4-Naphthoquinone
GC-MS	EPA 8270C/D	1 4-Phenylenediamine
GC-MS	EPA 8270C/D	1-Naphthylamine
GC-MS	EPA 8270C/D EPA 625	2 3 4 6-Tetrachlorophenol
GC-MS	EPA 8270C/D EPA 625	2 4 5-Trichlorophenol
GC-MS	EPA 8270C/D EPA 625	2 4 6-Trichlorophenol
GC-MS	EPA 8270C/D EPA 625	2 4-Dichlorophenol
GC-MS	EPA 8270C/D EPA 625	2 4-Dimethylphenol
GC-MS	EPA 8270C/D EPA 625	2 4-Dinitrophenol
GC-MS	EPA 8270C/D EPA 625	2 4-Dinitrotoluene (2 4-DNT)
GC-MS	EPA 8270C/D	2 6-Dichlorophenol
GC-MS	EPA 8270C/D EPA 625	2 6-Dinitrotoluene (2 6-DNT)
GC-MS	EPA 8270C/D	2-Acetylaminofluorene
GC-MS	EPA 8270C/D EPA 625	2-Chloronaphthalene
GC-MS	EPA 8270C/D EPA 625	2-Chlorophenol
GC-MS	EPA 8270C/D EPA 625	2-Methyl-4 6-dinitrophenol
GC-MS	EPA 8270C/D EPA 625	2-Methylnaphthalene
GC-MS	EPA 8270C/D EPA 625	2-Methylphenol (o-Cresol)
GC-MS	EPA 8270C/D	2-Naphthylamine
GC-MS	EPA 8270C/D EPA 625	2-Nitroaniline
GC-MS	EPA 8270C/D EPA 625	2-Nitrophenol
GC-MS	EPA 8270C/D	2-Picoline (2-Methylpyridine)
GC-MS	EPA 8270C/D EPA 625	3 3`-Dichlorobenzidine
GC-MS	EPA 8270C/D	3 3`-Dimethylbenzidine
GC-MS	EPA 8270C/D	3-Methylcholanthrene
GC-MS	EPA 8270C/D	3-Methylphenol (m-Cresol)
GC-MS	EPA 8270C/D EPA 625	3-Nitroaniline
GC-MS	EPA 8270C/D	4-Aminobiphenyl
GC-MS	EPA 8270C/D EPA 625	4-Bromophenyl phenyl ether
GC-MS	EPA 8270C/D EPA 625	4-Chloro-3-methylphenol
GC-MS	EPA 8270C/D EPA 625	4-Chloroaniline
GC-MS	EPA 8270C/D EPA 625	4-Chlorophenyl phenylether
GC-MS	EPA 8270C/D	4-Dimethyl aminoazobenzene
GC-MS	EPA 8270C/D EPA 625	4-Methylphenol (p-Cresol)
GC-MS	EPA 8270C/D EPA 625	4-Nitroaniline

Non-Potable Water		
Technology	**Method**	**Analyte**
GC-MS	EPA 8270C/D EPA 625	4-Nitrophenol
GC-MS	EPA 8270C/D	5-Nitro-o-toluidine
GC-MS	EPA 8270C/D EPA 625	7 12-Dimethylbenz(a) anthracene
GC-MS	EPA 8270C/D EPA 625	Acenaphthene
GC-MS	EPA 8270C/D EPA 625	Acenaphthylene
GC-MS	EPA 8270C/D EPA 625	Acetophenone
GC-MS	EPA 8270C/D EPA 625	Aniline
GC-MS	EPA 8270C/D EPA 625	Anthracene
GC-MS	EPA 8270C/D	Aramite
GC-MS	EPA 8270C/D EPA 625	Benzidine
GC-MS	EPA 8270C/D EPA 625	Benzo(a)anthracene
GC-MS	EPA 8270C/D EPA 625	Benzo(a)pyrene
GC-MS	EPA 8270C/D EPA 625	Benzo(b)fluoranthene
GC-MS	EPA 8270C/D EPA 625	Benzo(g h i)perylene
GC-MS	EPA 8270C/D EPA 625	Benzo(k)fluoranthene
GC-MS	EPA 8270C/D EPA 625	Benzoic acid
GC-MS	EPA 8270C/D	Benzyl alcohol
GC-MS	EPA 8270C/D EPA 625	Butyl benzyl phthalate
GC-MS	EPA 8270C/D EPA 625	Carbazole
GC-MS	EPA 8270C/D EPA 625	Chrysene
GC-MS	EPA 8270C/D EPA 625	Di-n-butyl phthalate
GC-MS	EPA 8270C/D EPA 625	Di-n-octyl phthalate
GC-MS	EPA 8270C/D EPA 625	Dibenz(a h)anthracene
GC-MS	EPA 8270C/D EPA 625	Dibenz(a h)acridine
GC-MS	EPA 8270C/D EPA 625	Dibenzofuran
GC-MS	EPA 8270C/D EPA 625	Diethyl phthalate
GC-MS	EPA 8270C/D EPA 625	Dimethyl phthalate
GC-MS	EPA 8270C/D	Ethyl methanesulfonate
GC-MS	EPA 8270C/D EPA 625	Fluoranthene
GC-MS	EPA 8270C/D EPA 625	Fluorene
GC-MS	EPA 8270C/D EPA 625	Hexachlorobenzene
GC-MS	EPA 8270C/D EPA 625	Hexachlorobutadiene
GC-MS	EPA 8270C/D EPA 625	Hexachlorocyclopentadiene
GC-MS	EPA 8270C/D EPA 625	Hexachloroethane
GC-MS	EPA 8270C/D	Hexachlorophene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC-MS	EPA 8270C/D	Hexachloropropene
GC-MS	EPA 8270C/D EPA 625	Indeno(1 2 3-cd)pyrene
GC-MS	EPA 8270C/D EPA 625	Isophorone
GC-MS	EPA 8270C/D	Isosafrole
GC-MS	EPA 8270C/D	Methapyrilene
GC-MS	EPA 8270C/D	Methyl methanesulfonate
GC-MS	EPA 8270C/D EPA 625	Naphthalene
GC-MS	EPA 8270C/D EPA 625	Nitrobenzene
GC-MS	EPA 8270C/D	Nitroquinoline-1-oxide
GC-MS	EPA 8270C/D EPA 625	Pentachlorobenzene
GC-MS	EPA 8270C/D	Pentachloronitrobenzene
GC-MS	EPA 8270C/D EPA 625	Pentachlorophenol
GC-MS	EPA 8270C/D	Phenacetin
GC-MS	EPA 8270C/D EPA 625	Phenanthrene
GC-MS	EPA 8270C/D EPA 625	Phenol
GC-MS	EPA 8270C/D	Pronamide (Kerb)
GC-MS	EPA 8270C/D EPA 625	Pyrene
GC-MS	EPA 8270C/D EPA 625	Pyridine
GC-MS	EPA 8270C/D	Safrole
GC-MS	EPA 8270C/D	a-a-Dimethylphenethylamine
GC-MS	EPA 8270C/D EPA 625	bis(2-Chloroethoxy)methane
GC-MS	EPA 8270C/D EPA 625	bis(2-Chloroethyl) ether
GC-MS	EPA 8270C/D EPA 625	bis(2-Chloroisopropyl) ether (2 2`-Oxybis(1-chloropropane))
GC-MS	EPA 8270C/D EPA 625	bis(2-Ethylhexyl) phthalate (DEHP)
GC-MS	EPA 8270C/D EPA 625	n-Nitroso-di-n-butylamine
GC-MS	EPA 8270C/D EPA 625	n-Nitrosodi-n-propylamine
GC-MS	EPA 8270C/D EPA 625	n-Nitrosodiethylamine
GC-MS	EPA 8270C/D EPA 625	n-Nitrosodimethylamine
GC-MS	EPA 8270C/D EPA 625	n-Nitrosodiphenylamine
GC-MS	EPA 8270C/D	n-Nitrosomethylethylamine
GC-MS	EPA 8270C/D	n-Nitrosomorpholine
GC-MS	EPA 8270C/D	n-Nitrosopiperidine
GC-MS	EPA 8270C/D EPA 625	n-Nitrosopyrrolidine
GC-MS	EPA 8270C/D	o-Toluidine
GC-MS	EPA 8270C/D	Chlorobenzilate

Non-Potable Water		
Technology	**Method**	**Analyte**
GC-MS	EPA 8270C/D	Diallate
GC-MS	EPA 8270C/D	Dimethoate
GC-MS	EPA 8270C/D	Disulfoton
GC-MS	EPA 8270C/D	Famphur
GC-MS	EPA 8270C/D	Isodrin
GC-MS	EPA 8270C/D	Kepone
GC-MS	EPA 8270C/D	Methyl parathion (Parathion methyl)
GC-MS	EPA 8270C/D	Phorate
GC-MS	EPA 8270C/D	Thionazin (Zinophos)
GC-MS	EPA 8270C/D	o o o-Triethyl phosphorothioate
GC-MS	EPA 8270C/D	Pentachloroethane
GC-MS	EPA 8270C/D EPA 625	Alpha-terpineol
GC-MS	EPA 8270C/D	Dinoseb
GC-MS	EPA 8270C/D	Parathion
GC-MS	EPA 8270C/D	1,1'-Biphenyl
GC-MS	EPA 8270C/D	Diphenylamine
GC-MS	EPA 8270C/D	Benzaldehyde
GC-MS	EPA 8270C/D EPA 625	n-Decane
GC-MS	EPA 8270C/D EPA 625	n-Octadecane
GC-MS	EPA 8270C/D	Caprolactam
GC-MS	EPA 8270C/D	Atrazine
GC-MS	EPA 8270C/D	Hydroquinone
GC-MS-SIM	EPA 8270C/D	Benzo(a)anthracene
GC-MS-SIM	EPA 8270C/D	Benzo(a)pyrene
GC-MS-SIM	EPA 8270C/D	Benzo(b)fluoranthene
GC-MS-SIM	EPA 8270C/D	Benzo(k)fluoranthene
GC-MS-SIM	EPA 8270C/D	Dibenzo(a,h)anthracene
GC-MS-SIM	EPA 8270C/D	Hexachlorobenzene
GC-MS-SIM	EPA 8270C/D	Indeno(1,2,3-cd)pyrene
GC-MS-SIM	EPA 8270C/D	Pentachlorophenol
ICP-AES	EPA 6010B/C EPA 200.7	Aluminum
ICP-AES	EPA 6010B/C EPA 200.7	Antimony
ICP-AES	EPA 6010B/C EPA 200.7	Arsenic
ICP-AES	EPA 6010B/C EPA 200.7	Barium
ICP-AES	EPA 6010B/C EPA 200.7	Beryllium

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Non-Potable Water		
Technology	**Method**	**Analyte**
ICP-AES	EPA 6010B/C EPA 200.7	Boron
ICP-AES	EPA 6010B/C EPA 200.7	Cadmium
ICP-AES	EPA 6010B/C EPA 200.7	Calcium
ICP-AES	EPA 6010B/C EPA 200.7	Chromium
ICP-AES	EPA 6010B/C EPA 200.7	Cobalt
ICP-AES	EPA 6010B/C EPA 200.7	Copper
ICP	EPA 200.7	Hardness – total as CaCO3
ICP-AES	EPA 6010B/C EPA 200.7	Iron
ICP-AES	EPA 6010B/C EPA 200.7	Lead
ICP-AES	EPA 6010B/C EPA 200.7	Magnesium
ICP-AES	EPA 6010B/C EPA 200.7	Manganese
ICP-AES	EPA 6010B/C EPA 200.7	Molybdenum
ICP-AES	EPA 6010B/C EPA 200.7	Nickel
ICP-AES	EPA 6010B/C EPA 200.7	Potassium
ICP-AES	EPA 6010B/C EPA 200.7	Selenium
ICP	EPA 200.7	Silica - dissolved
ICP-AES	EPA 6010B/C EPA 200.7	Silver
ICP-AES	EPA 6010B/C EPA 200.7	Sodium
ICP-AES	EPA 6010B/C	Strontium
ICP-AES	EPA 6010B/C EPA 200.7	Thallium
ICP-AES	EPA 6010B/C EPA 200.7	Tin
ICP-AES	EPA 6010B/C EPA 200.7	Titanium
ICP-AES	EPA 6010B/C EPA 200.7	Vanadium
ICP-AES	EPA 6010B/C EPA 200.7	Zinc
Atomic Fluorescence	EPA 245.7 EPA 1631E	Mercury
CVAA	EPA 7470A	Mercury
UV-VIS	EPA 7196A	Hexavalent Chromium
IC	EPA 7199	Hexavalent Chromium
IC	EPA 300.0 EPA 9056/A	Bromide
IC	EPA 300.0 EPA 9056/A	Chloride
IC	EPA 300.0 EPA 9056/A	Fluoride
IC	EPA 300.0 EPA 9056/A	Sulfate
Pensky-Martens Closed-Cup	EPA 1010A	Ignitability
Electrometric Measurement	EPA 9040C	pH

Non-Potable Water		
Technology	**Method**	**Analyte**
Gravimetry	EPA 1664A	Silica Gel Treated N-Hexane Extractable Material (Oil and Grease)
Gravimetry	SM 2540 B-11	Total Solids
Gravimetry	EPA 1664A	N-Hexane Extractable Material (Oil and Grease)
Distillation / UV-Vis	EPA 9010B EPA 9012B (M)	Total and Amenable Cyanide
Combustion / IR	EPA 9060A	Total Organic Carbon
Combustion / Titrimetry	EPA 9020B	Total Organic Halides
Titrimetry	EPA 9034	Acid-Soluble and Acid-Insoluble Sulfides
Electrode	EPA 9045C	pH
Colorimetry / Distillation	EPA 9066	Phenolics
Preparation	**Method**	**Type**
TCLP Extraction	EPA 1311	Toxicity Characteristic Leaching Procedure
SPLP	EPA 1312	Synthetic Precipitation Leaching Procedure
Acid Digestion	EPA 3005A EPA 3010A	Waters for Total Recoverable or Dissolved Metals
Purge and Trap	EPA 5030B	Aqueous samples
Liquid Extraction	EPA 3510C	Semivolatile Separatory Funnel Liquid

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
ICP-MS	EPA 6020/A	Aluminum
ICP-MS	EPA 6020/A	Antimony
ICP-MS	EPA 6020/A	Arsenic
ICP-MS	EPA 6020/A	Barium
ICP-MS	EPA 6020/A	Beryllium
ICP-MS	EPA 6020/A	Cadmium
ICP-MS	EPA 6020/A	Calcium
ICP-MS	EPA 6020/A	Chromium
ICP-MS	EPA 6020/A	Cobalt
ICP-MS	EPA 6020/A	Copper
ICP-MS	EPA 6020/A	Iron
ICP-MS	EPA 6020/A	Lead
ICP-MS	EPA 6020/A	Magnesium
ICP-MS	EPA 6020/A	Manganese
ICP-MS	EPA 6020/A	Molybdenum

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
ICP-MS	EPA 6020/A	Nickel
ICP-MS	EPA 6020/A	Potassium
ICP-MS	EPA 6020/A	Selenium
ICP-MS	EPA 6020/A	Silver
ICP-MS	EPA 6020/A	Sodium
ICP-MS	EPA 6020/A	Strontium
ICP-MS	EPA 6020/A	Thallium
ICP-MS	EPA 6020/A	Titanium
ICP-MS	EPA 6020/A	Tin
ICP-MS	EPA 6020/A	Vanadium
ICP-MS	EPA 6020/A	Zinc
GC-ECD	EPA 8011	1,2-Dibromomethane (EDB)
GC-ECD	EPA 8011	1,2-Dibromo-3-chloropropane
GC-ECD	EPA 8011	1,2,3-Trichloropropane
GC-FID	EPA 8015 B/C	Diesel range organics (DRO)
GC-FID	EPA 8015 B/C	Gasoline range organics (GRO)
GC-FID	EPA 8015 B/C	Ethanol
GC-FID	EPA 8015 B/C	Isobutyl alcohol (2-Methyl-1-propanol)
GC-FID	EPA 8015 B/C	Isopropyl alcohol (2-Propanol)
GC-FID	EPA 8015 B/C	Methanol
GC-FID	EPA 8015 B/C	Tert-butyl alcohol
GC-FID	NJDEP-EPH	Extractable Petroleum Hydrocarbons
GC-ECD	EPA 8081A/B	4 4`-DDD
GC-ECD	EPA 8081A/B	4 4`-DDE
GC-ECD	EPA 8081A/B	4 4`-DDT
GC-ECD	EPA 8081A/B	Aldrin
GC-ECD	EPA 8081A/B	Chlordane (tech.)
GC-ECD	EPA 8081A/B	Dieldrin
GC-ECD	EPA 8081A/B	Endosulfan I
GC-ECD	EPA 8081A/B	Endosulfan II
GC-ECD	EPA 8081A/B	Endosulfan sulfate
GC-ECD	EPA 8081A/B	Endrin
GC-ECD	EPA 8081A/B	Endrin aldehyde
GC-ECD	EPA 8081A/B	Endrin ketone
GC-ECD	EPA 8081A/B	Heptachlor

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC-ECD	EPA 8081A/B	Heptachlor epoxide
GC-ECD	EPA 8081A/B	Methoxychlor
GC-ECD	EPA 8081A/B	Toxaphene (Chlorinated camphene)
GC-ECD	EPA 8081A/B	alpha-BHC (alpha-Hexachlorocyclohexane)
GC-ECD	EPA 8081A/B	alpha-Chlordane
GC-ECD	EPA 8081A/B	beta-BHC (beta-Hexachlorocyclohexane)
GC-ECD	EPA 8081A/B	delta-BHC
GC-ECD	EPA 8081A/B	gamma-BHC (Lindane gamma-Hexachlorocyclohexane)
GC-ECD	EPA 8081A/B	gamma-Chlordane
GC-ECD	EPA 8081A/B	Mirex
GC-ECD	EPA 8082/A	Aroclor-1016 (PCB-1016)
GC-ECD	EPA 8082/A	Aroclor-1221 (PCB-1221)
GC-ECD	EPA 8082/A	Aroclor-1232 (PCB-1232)
GC-ECD	EPA 8082/A	Aroclor-1242 (PCB-1242)
GC-ECD	EPA 8082/A	Aroclor-1248 (PCB-1248)
GC-ECD	EPA 8082/A	Aroclor-1254 (PCB-1254)
GC-ECD	EPA 8082/A	Aroclor-1260 (PCB-1260)
GC-ECD	EPA 8082A	Aroclor-1262 (PCB-1262)
GC-ECD	EPA 8082/A	Aroclor-1268 (PCB-1268)
GC-ECD	EPA 8151A	2 4 5-T
GC-ECD	EPA 8151A	2 4-D
GC-ECD	EPA 8151A	2 4-DB
GC-ECD	EPA 8151A	Dalapon
GC-ECD	EPA 8151A	Dicamba
GC-ECD	EPA 8151A	Dichloroprop (Dichlorprop)
GC-ECD	EPA 8151A	Dinoseb (2-sec-butyl-4 6-dinitrophenol DNBP)
GC-ECD	EPA 8151A	MCPA
GC-ECD	EPA 8151A	MCPP
GC-ECD	EPA 8151A	Pentachlorophenol
GC-ECD	EPA 8151A	Silvex (2 4 5-TP)
GC-ECD	EPA 8151A	Picloram
GC-FID	EPA RSK-175	Ethane
GC-FID	EPA RSK-175	Ethene
GC-FID	EPA RSK-175	Methane
GC-FID	EPA RSK-175	Propane

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC-MS	EPA 8260	Ethylene glycol
GC-MS	EPA 8260	Propylene glycol
GC-MS	EPA 8260B/C	1 1 1 2-Tetrachloroethane
GC-MS	EPA 8260B/C	1 1 1-Trichloroethane
GC-MS	EPA 8260B/C	1 1 2 2-Tetrachloroethane
GC-MS	EPA 8260B/C	1 1 2-Trichloroethane
GC-MS	EPA 8260B/C	1 1-Dichloroethane
GC-MS	EPA 8260B/C	1 1-Dichloroethylene
GC-MS	EPA 8260B/C	1 1-Dichloropropene
GC-MS	EPA 8260B/C	1 2 3-Trichlorobenzene
GC-MS	EPA 8260B/C	1 2 3-Trichloropropane
GC-MS	EPA 8260B/C	1 2 4-Trichlorobenzene
GC-MS	EPA 8260B/C	1 2 4-Trimethylbenzene
GC-MS	EPA 8260B/C	1 2-Dibromo-3-chloropropane (DBCP)
GC-MS	EPA 8260B/C	1 2-Dibromoethane (EDB Ethylene dibromide)
GC-MS	EPA 8260B/C	1 2-Dichlorobenzene
GC-MS	EPA 8260B/C	1 2-Dichloroethane
GC-MS	EPA 8260B/C	1 2-Dichloropropane
GC-MS	EPA 8260B/C	1 3 5-Trimethylbenzene
GC-MS	EPA 8260B/C	1 3-Dichlorobenzene
GC-MS	EPA 8260B/C	1 3-Dichloropropane
GC-MS	EPA 8260B/C	1 4-Dichlorobenzene
GC-MS	EPA 8260B/C	1-Chlorohexane
GC-MS	EPA 8260B/C	2 2-Dichloropropane
GC-MS	EPA 8260B/C	2-Butanone (Methyl ethyl ketone MEK)
GC-MS	EPA 8260B/C	2-Chloroethyl vinyl ether
GC-MS	EPA 8260B/C	2-Chlorotoluene
GC-MS	EPA 8260B/C	2-Hexanone
GC-MS	EPA 8260B/C	2-Nitropropane
GC-MS	EPA 8260B/C	4-Chlorotoluene
GC-MS	EPA 8260B/C	4-Methyl-2-pentanone (MIBK)
GC-MS	EPA 8260B/C	Acetone
GC-MS	EPA 8260B/C	Acetonitrile
GC-MS	EPA 8260B/C	Acrolein (Propenal)
GC-MS	EPA 8260B/C	Acrylonitrile

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC-MS	EPA 8260B/C	Allyl chloride (3-Chloropropene)
GC-MS	EPA 8260B/C	Benzene
GC-MS	EPA 8260B/C	Bromobenzene
GC-MS	EPA 8260B/C	Bromochloromethane
GC-MS	EPA 8260B/C	Bromodichloromethane
GC-MS	EPA 8260B/C	Bromoform
GC-MS	EPA 8260B/C	Carbon disulfide
GC-MS	EPA 8260B/C	Carbon tetrachloride
GC-MS	EPA 8260B/C	Chlorobenzene
GC-MS	EPA 8260B/C	Chloroethane
GC-MS	EPA 8260B/C	Chloroform
GC-MS	EPA 8260B/C	Chloroprene
GC-MS	EPA 8260B/C	Di-isopropylether (DIPE)
GC-MS	EPA 8260B/C	Dibromochloromethane
GC-MS	EPA 8260B/C	Dibromomethane
GC-MS	EPA 8260B/C	Dichlorodifluoromethane
GC-MS	EPA 8260B/C	Diethyl ether
GC-MS	EPA 8260B/C	Ethanol
GC-MS	EPA 8260B/C	Ethyl acetate
GC-MS	EPA 8260B/C	Ethyl methacrylate
GC-MS	EPA 8260B/C	Ethyl-t-butylether (ETBE)
GC-MS	EPA 8260B/C	Ethylbenzene
GC-MS	EPA 8260B/C	Hexachlorobutadiene
GC-MS	EPA 8260B/C	Iodomethane (Methyl iodide)
GC-MS	EPA 8260B/C	Isobutyl alcohol (2-Methyl-1-propanol)
GC-MS	EPA 8260B/C	Isopropylbenzene
GC-MS	EPA 8260B/C	Methacrylonitrile
GC-MS	EPA 8260B/C	Methyl bromide (Bromomethane)
GC-MS	EPA 8260B/C	Methyl chloride (Chloromethane)
GC-MS	EPA 8260B/C	Methyl methacrylate
GC-MS	EPA 8260B/C	Methyl tert-butyl ether (MTBE)
GC-MS	EPA 8260B/C	Methylene chloride
GC-MS	EPA 8260B/C	Naphthalene
GC-MS	EPA 8260B/C	Pentachloroethane
GC-MS	EPA 8260B/C	Propionitrile (Ethyl cyanide)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC-MS	EPA 8260B/C	Styrene
GC-MS	EPA 8260B/C	T-amylmethylether (TAME)
GC-MS	EPA 8260B/C	Tetrachloroethylene (Perchloroethylene)
GC-MS	EPA 8260B/C	Toluene
GC-MS	EPA 8260B/C	Trichloroethene (Trichloroethylene)
GC-MS	EPA 8260B/C	Trichlorofluoromethane
GC-MS	EPA 8260B/C	Vinyl acetate
GC-MS	EPA 8260B/C	Vinyl chloride
GC-MS	EPA 8260B/C	Xylene (total)
GC-MS	EPA 8260B/C	cis-1 2-Dichloroethylene
GC-MS	EPA 8260B/C	cis-1 3-Dichloropropene
GC-MS	EPA 8260B/C	n-Butylbenzene
GC-MS	EPA 8260B/C	n-Propylbenzene
GC-MS	EPA 8260B/C	p-Dioxane
GC-MS	EPA 8260B/C	p-Isopropyltoluene
GC-MS	EPA 8260B/C	sec-Butylbenzene
GC-MS	EPA 8260B/C	tert-Butyl alcohol
GC-MS	EPA 8260B/C	tert-Butylbenzene
GC-MS	EPA 8260B/C	trans-1 2-Dichloroethylene
GC-MS	EPA 8260B/C	trans-1 3-Dichloropropylene
GC-MS	EPA 8260B/C	trans-1 4-Dichloro-2-butene
GC-MS	EPA 8260B/C	Cyclohexane
GC-MS	EPA 8260B/C	Cyclohexanone
GC-MS	EPA 8260B/C	1-Butanol
GC-MS	EPA 8260B/C	Tetrahydrofuran
GC-MS	EPA 8260B/C	1 1 2-Trichloro-1 2 2-trifluoroethane
GC-MS	EPA 8260B/C	Methyl acrylate
GC-MS	EPA 8260B/C	Methyl acetate
GC-MS	EPA 8260B/C	Hexachloroethane
GC-MS	EPA 8260B/C	Methylcyclohexane
GC-MS	EPA 8260B/C	2,2,4-Trimethylpentane
GC-MS	EPA 8270C/D	1 2 4 5-Tetrachlorobenzene
GC-MS	EPA 8270C/D	1 2 4-Trichlorobenzene
GC-MS	EPA 8270C/D	1 2-Dichlorobenzene
GC-MS	EPA 8270C/D	1 2-Diphenylhydrazine

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC-MS	EPA 8270C/D	1 3 5-Trinitrobenzene (1 3 5-TNB)
GC-MS	EPA 8270C/D	1 3-Dichlorobenzene
GC-MS	EPA 8270C/D	1 3-Dinitrobenzene (1 3-DNB)
GC-MS	EPA 8270C/D	1 4-Dichlorobenzene
GC-MS	EPA 8270C/D	1 4-Naphthoquinone
GC-MS	EPA 8270C/D	1-Naphthylamine
GC-MS	EPA 8270C/D	2 3 4 6-Tetrachlorophenol
GC-MS	EPA 8270C/D	2 4 5-Trichlorophenol
GC-MS	EPA 8270C/D	2 4 6-Trichlorophenol
GC-MS	EPA 8270C/D	2 4-Dichlorophenol
GC-MS	EPA 8270C/D	2 4-Dimethylphenol
GC-MS	EPA 8270C/D	2 4-Dinitrophenol
GC-MS	EPA 8270C/D	2 4-Dinitrotoluene (2 4-DNT)
GC-MS	EPA 8270C/D	2 6-Dichlorophenol
GC-MS	EPA 8270C/D	2 6-Dinitrotoluene (2 6-DNT)
GC-MS	EPA 8270C/D	2-Acetylaminofluorene
GC-MS	EPA 8270C/D	2-Chloronaphthalene
GC-MS	EPA 8270C/D	2-Chlorophenol
GC-MS	EPA 8270C/D	2-Methyl-4 6-dinitrophenol
GC-MS	EPA 8270C/D	2-Methylnaphthalene
GC-MS	EPA 8270C/D	2-Methylphenol (o-Cresol)
GC-MS	EPA 8270C/D	2-Naphthylamine
GC-MS	EPA 8270C/D	2-Nitroaniline
GC-MS	EPA 8270C/D	2-Nitrophenol
GC-MS	EPA 8270C/D	2-Picoline (2-Methylpyridine)
GC-MS	EPA 8270C/D	3 3`-Dichlorobenzidine
GC-MS	EPA 8270C/D	3-Methylcholanthrene
GC-MS	EPA 8270C/D	3-Methylphenol (m-Cresol)
GC-MS	EPA 8270C/D	3-Nitroaniline
GC-MS	EPA 8270C/D	4-Aminobiphenyl
GC-MS	EPA 8270C/D	4-Bromophenyl phenyl ether
GC-MS	EPA 8270C/D	4-Chloro-3-methylphenol
GC-MS	EPA 8270C/D	4-Chloroaniline
GC-MS	EPA 8270C/D	4-Chlorophenyl phenylether
GC-MS	EPA 8270C/D	4-Dimethyl aminoazobenzene

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC-MS	EPA 8270C/D	4-Methylphenol (p-Cresol)
GC-MS	EPA 8270C/D	4-Nitroaniline
GC-MS	EPA 8270C/D	4-Nitrophenol
GC-MS	EPA 8270C/D	5-Nitro-o-toluidine
GC-MS	EPA 8270C/D	7 12-Dimethylbenz(a) anthracene
GC-MS	EPA 8270C/D	Acenaphthene
GC-MS	EPA 8270C/D	Acenaphthylene
GC-MS	EPA 8270C/D	Acetophenone
GC-MS	EPA 8270C/D	Aniline
GC-MS	EPA 8270C/D	Anthracene
GC-MS	EPA 8270C/D	Benzidine
GC-MS	EPA 8270C/D	Benzo(a)anthracene
GC-MS	EPA 8270C/D	Benzo(a)pyrene
GC-MS	EPA 8270C/D	Benzo(b)fluoranthene
GC-MS	EPA 8270C/D	Benzo(g h i)perylene
GC-MS	EPA 8270C/D	Benzo(k)fluoranthene
GC-MS	EPA 8270C/D	Benzoic acid
GC-MS	EPA 8270C/D	Benzyl alcohol
GC-MS	EPA 8270C/D	Butyl benzyl phthalate
GC-MS	EPA 8270C/D	Carbazole
GC-MS	EPA 8270C/D	Chrysene
GC-MS	EPA 8270C/D	Di-n-butyl phthalate
GC-MS	EPA 8270C/D	Di-n-octyl phthalate
GC-MS	EPA 8270C/D	Dibenz(a h)anthracene
GC-MS	EPA 8270C/D	Dibenz(a j)acridine
GC-MS	EPA 8270C/D	Dibenzofuran
GC-MS	EPA 8270C/D	Diethyl phthalate
GC-MS	EPA 8270C/D	Dimethyl phthalate
GC-MS	EPA 8270C/D	Ethyl methanesulfonate
GC-MS	EPA 8270C/D	Fluoranthene
GC-MS	EPA 8270C/D	Fluorene
GC-MS	EPA 8270C/D	Hexachlorobenzene
GC-MS	EPA 8270C/D	Hexachlorobutadiene
GC-MS	EPA 8270C/D	Hexachlorocyclopentadiene
GC-MS	EPA 8270C/D	Hexachloroethane

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC-MS	EPA 8270C/D	Hexachloropropene
GC-MS	EPA 8270C/D	Indeno(1 2 3-cd)pyrene
GC-MS	EPA 8270C/D	Isophorone
GC-MS	EPA 8270C/D	Isosafrole
GC-MS	EPA 8270C/D	Methyl methanesulfonate
GC-MS	EPA 8270C/D	Naphthalene
GC-MS	EPA 8270C/D	Nitrobenzene
GC-MS	EPA 8270C/D	Nitroquinoline-1-oxide
GC-MS	EPA 8270C/D	Pentachlorobenzene
GC-MS	EPA 8270C/D	Pentachloronitrobenzene
GC-MS	EPA 8270C/D	Pentachlorophenol
GC-MS	EPA 8270C/D	Phenacetin
GC-MS	EPA 8270C/D	Phenanthrene
GC-MS	EPA 8270C/D	Phenol
GC-MS	EPA 8270C/D	Pronamide (Kerb)
GC-MS	EPA 8270C/D	Pyrene
GC-MS	EPA 8270C/D	Pyridine
GC-MS	EPA 8270C/D	Safrole
GC-MS	EPA 8270C/D	a-a-Dimethylphenethylamine
GC-MS	EPA 8270C/D	bis(2-Chloroethoxy)methane
GC-MS	EPA 8270C/D	bis(2-Chloroethyl) ether
GC-MS	EPA 8270C/D	bis(2-Chloroisopropyl) ether (2 2`-Oxybis(1-chloropropane))
GC-MS	EPA 8270C/D	bis(2-Ethylhexyl) phthalate (DEHP)
GC-MS	EPA 8270C/D	n-Nitroso-di-n-butylamine
GC-MS	EPA 8270C/D	n-Nitrosodi-n-propylamine
GC-MS	EPA 8270C/D	n-Nitrosodiethylamine
GC-MS	EPA 8270C/D	n-Nitrosodimethylamine
GC-MS	EPA 8270C/D	n-Nitrosodiphenylamine
GC-MS	EPA 8270C/D	n-Nitrosomethylethylamine
GC-MS	EPA 8270C/D	n-Nitrosomorpholine
GC-MS	EPA 8270C/D	n-Nitrosopiperidine
GC-MS	EPA 8270C/D	n-Nitrosopyrrolidine
GC-MS	EPA 8270C/D	o-Toluidine
GC-MS	EPA 8270C/D	Chlorobenzilate
GC-MS	EPA 8270C/D	Diallate

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC-MS	EPA 8270C/D	Dimethoate
GC-MS	EPA 8270C/D	Disulfoton
GC-MS	EPA 8270C/D	Isodrin
GC-MS	EPA 8270C/D	Kepone
GC-MS	EPA 8270C/D	Methyl parathion (Parathion methyl)
GC-MS	EPA 8270C/D	Phorate
GC-MS	EPA 8270C/D	Thionazin (Zinophos)
GC-MS	EPA 8270C/D	o o o-Triethyl phosphorothioate
GC-MS	EPA 8270C/D	Pentachloroethane
GC-MS	EPA 8270C/D	Alpha-terpineol
GC-MS	EPA 8270C/D	Dinoseb
GC-MS	EPA 8270C/D	Parathion
GC-MS	EPA 8270C/D	1,1'-Biphenyl
GC-MS	EPA 8270C/D	Diphenylamine
GC-MS	EPA 8270C/D	Benzaldehyde
GC-MS	EPA 8270C/D	n-Decane
GC-MS	EPA 8270C/D	n-Octadecane
GC-MS	EPA 8270C/D	Caprolactam
GC-MS	EPA 8270C/D	Atrazine
GC-MS	EPA 8270C/D	Hydroquinone
GC-MS-SIM	EPA 8270C/D	Benzo(a)anthracene
GC-MS-SIM	EPA 8270C/D	Benzo(a)pyrene
GC-MS-SIM	EPA 8270C/D	Benzo(b)fluoranthene
GC-MS-SIM	EPA 8270C/D	Benzo(k)fluoranthene
GC-MS-SIM	EPA 8270C/D	Dibenzo(a,h)anthracene
GC-MS-SIM	EPA 8270C/D	Hexachlorobenzene
GC-MS-SIM	EPA 8270C/D	Indeno(1,2,3-cd)pyrene
GC-MS-SIM	EPA 8270C/D	Pentachlorophenol
ICP-AES	EPA 6010B/C	Aluminum
ICP-AES	EPA 6010B/C	Antimony
ICP-AES	EPA 6010B/C	Arsenic
ICP-AES	EPA 6010B/C	Barium
ICP-AES	EPA 6010B/C	Beryllium
ICP-AES	EPA 6010B/C	Boron
ICP-AES	EPA 6010B/C	Cadmium

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
ICP-AES	EPA 6010B/C	Calcium
ICP-AES	EPA 6010B/C	Chromium
ICP-AES	EPA 6010B/C	Cobalt
ICP-AES	EPA 6010B/C	Copper
ICP-AES	EPA 6010B/C	Iron
ICP-AES	EPA 6010B/C	Lead
ICP-AES	EPA 6010B/C	Magnesium
ICP-AES	EPA 6010B/C	Manganese
ICP-AES	EPA 6010B/C	Molybdenum
ICP-AES	EPA 6010B/C	Nickel
ICP-AES	EPA 6010B/C	Potassium
ICP-AES	EPA 6010B/C	Selenium
ICP-AES	EPA 6010B/C	Silver
ICP-AES	EPA 6010B/C	Sodium
ICP-AES	EPA 6010B/C	Strontium
ICP-AES	EPA 6010B/C	Thallium
ICP-AES	EPA 6010B/C	Tin
ICP-AES	EPA 6010B/C	Titanium
ICP-AES	EPA 6010B/C	Vanadium
ICP-AES	EPA 6010B/C	Zinc
CVAA	EPA 7471A	Mercury
CVAA	EPA 7470A	Mercury
UV-VIS	EPA 7196A	Hexavalent Chromium
IC	EPA 7199	Hexavalent Chromium
IC	EPA 9056/A	Bromide
IC	EPA 9056/A	Chloride
IC	EPA 9056/A	Fluoride
IC	EPA 9056/A	Sulfate
Ignitability	EPA 1010A	Pensky-Martens Closed-Cup
Mix with Water or Calcium Chloride	EPA 9045C	Hydrogen Ion, pH
Automated Colorimetry	EPA 7.3.3.2	Hydrogen Cyanide Released from Wastes: SW 846 Chapter 7
Automated Colorimetry	EPA 7.3.4.2	Hydrogen Sulfide Released from Wastes: SW 846 Chapter 7
Extraction / Gravimetry	EPA 1664A	Silica Gen Treated N-Hexane Extractable Material (Oil and Grease)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
Gravimetry	EPA 9071B	Oil and Grease Extraction Method for sludge and sediment samples
Gravimetry	SM 2540 B (M)	% Solids
Distillation / Colorimetry	EPA 9010B/C EPA 9012B (M)	Total and Amenable Cyanide
Combustion	Lloyd Kahn	Total Organic Carbon
Combustion / IR	EPA 9060A	Total Organic Carbon
Distillation Colorimetry	EPA 9065	Phenols
Titrimetry	EPA 9034	Acid-Soluble and Acid-Insoluble Sulfides
Electrode	EPA 9040C	pH
Preparation	**Method**	**Type**
Acid Digestion	EPA 3050B	Sediments, Sludges, and Soils
Closed-System Purge-and-Trap and Extraction	EPA 5035B	Volatile Organics in Soil and Waste Samples
Soxhlet Extraction	EPA 3540C	Semivolatile Extraction
Pressurized Fluid Extraction (PFE)	EPA 3545/A	Semivolatile Extraction
Ultrasonic Extraction	EPA 3550B/C	Semivolatile Extraction
Alumina Cleanup	EPA 3610B	Semivolatile Extraction - Cleanup
Florisil Cleanup	EPA 3620B/C	Semivolatile Extraction - Cleanup
Silica gel cleanup	EPA 3630C	Semivolatile Extraction - Cleanup
Acid base partition cleanup	EPA 3650B	Semivolatile Extraction - Cleanup
Sulfur cleanup	EPA 3660B	Semivolatile Extraction - Cleanup
Sulfuric Acid / permanganate Cleanup	EPA 3665A	Semivolatile Extraction - Cleanup
Alkaline Digestion	EPA 3060A	Hexavalent Chromium
TCLP Extraction	EPA 1311	Toxicity Characteristic Leaching Procedure
SPLP	EPA 1312	Synthetic Precipitation Leaching Procedure
Extraction / Combustion	EPA 9023	Extractable Organic Halides (EOX)

Air		
Technology	**Method**	**Analyte**
GC-MS	EPA TO-15	Acetaldehyde
GC-MS	EPA TO-15	Acetone
GC-MS	EPA TO-15	Acetophenone
GC-MS	EPA TO-15	Acrolein

Air		
Technology	**Method**	**Analyte**
GC-MS	EPA TO-15	Acrylamide
GC-MS	EPA TO-15	Acrylic acid
GC-MS	EPA TO-15	Allyl chloride
GC-MS	EPA TO-15	Benzene
GC-MS	EPA TO-15	Benzyl chloride
GC-MS	EPA TO-15	Propriolactone (beta-)
GC-MS	EPA TO-15	Bis (2-chloroethyl) ether
GC-MS	EPA TO-15	Bis (chloromethyl) ether
GC-MS	EPA TO-15	Bromodichloromethane
GC-MS	EPA TO-15	Bromoform
GC-MS	EPA TO-15	Bromomethane
GC-MS	EPA TO-15	Butadiene (1,3-)
GC-MS	EPA TO-15	Carbon disulfide
GC-MS	EPA TO-15	Carbon tetrachloride
GC-MS	EPA TO-15	Carbon oxysulfide (Carbonyl sulfide)
GC-MS	EPA TO-15	Catechol
GC-MS	EPA TO-15	Butadiene (2-chloro-1,3-)
GC-MS	EPA TO-15	Chloroacetic acid
GC-MS	EPA TO-15	Chlorobenzene
GC-MS	EPA TO-15	Chloroethane
GC-MS	EPA TO-15	Chloroform
GC-MS	EPA TO-15	Chloromethane
GC-MS	EPA TO-15	Chloromethyl methyl ether
GC-MS	EPA TO-15	Chlorotoluene (2-)
GC-MS	EPA TO-15	Cresols/Cresylic acid
GC-MS	EPA TO-15	Cyclohexane
GC-MS	EPA TO-15	Diazomethane
GC-MS	EPA TO-15	Dibromochloromethane
GC-MS	EPA TO-15	Dibromo-3-chloropropane (1,2-)
GC-MS	EPA TO-15	Dibromoethane (1,2-) (EDB)
GC-MS	EPA TO-15	Dichlorobenzene (1,2-)
GC-MS	EPA TO-15	Dichlorobenzene (1,3-)
GC-MS	EPA TO-15	Dichlorobenzene (1,4-)
GC-MS	EPA TO-15	Dichlorodifluoromethane
GC-MS	EPA TO-15	Dichloroethane (1,1-)
GC-MS	EPA TO-15	Dichloroethane (1,2-)

Air		
Technology	**Method**	**Analyte**
GC-MS	EPA TO-15	Dichloroethene (1,1-)
GC-MS	EPA TO-15	Dichloroethene (cis-1,2-)
GC-MS	EPA TO-15	Dichloroethene (trans-1,2-)
GC-MS	EPA TO-15	Dichlorofluoromethane
GC-MS	EPA TO-15	Dichloropropane (1,2-)
GC-MS	EPA TO-15	Dichloropropene (cis-1,3-)
GC-MS	EPA TO-15	Dichloropropene (trans-1,3-)
GC-MS	EPA TO-15	Dichlorotetrafluoroethane (1,2-)
GC-MS	EPA TO-15	Diethyl sulfate
GC-MS	EPA TO-15	Dimethyl sulfate
GC-MS	EPA TO-15	Dimethylcarbamoyl chloride
GC-MS	EPA TO-15	Dimethyl formamide (N,N-)
GC-MS	EPA TO-15	Dioxane (1,4-)
GC-MS	EPA TO-15	Epichlorohydrin
GC-MS	EPA TO-15	Epoxybutane (1,2-)
GC-MS	EPA TO-15	Ethanol
GC-MS	EPA TO-15	Ethyl acetate
GC-MS	EPA TO-15	Ethyl acrylate
GC-MS	EPA TO-15	Ethyl carbamate (Urethane)
GC-MS	EPA TO-15	Ethylbenzene
GC-MS	EPA TO-15	Ethylene Oxide
GC-MS	EPA TO-15	Ethyltoluene (4-)
GC-MS	EPA TO-15	Formaldehyde
GC-MS	EPA TO-15	Hexachlorobutadiene (1,3-)
GC-MS	EPA TO-15	Hexachloroethane
GC-MS	EPA TO-15	Hexanone (2-)
GC-MS	EPA TO-15	Heptane (n-)
GC-MS	EPA TO-15	Hexane (n-)
GC-MS	EPA TO-15	Isophorone
GC-MS	EPA TO-15	Isopropanol
GC-MS	EPA TO-15	Isopropylbenzene
GC-MS	EPA TO-15	Methyl alcohol (Methanol)
GC-MS	EPA TO-15	Methyl ethyl ketone
GC-MS	EPA TO-15	Methyl iodide
GC-MS	EPA TO-15	Methyl isobutyl ketone
GC-MS	EPA TO-15	Methyl isocyanate

Air		
Technology	**Method**	**Analyte**
GC-MS	EPA TO-15	Methyl methacrylate
GC-MS	EPA TO-15	Methyl tert-butyl ether
GC-MS	EPA TO-15	Methylene chloride (Dichloromethane)
GC-MS	EPA TO-15	Methylphenol (2-)
GC-MS	EPA TO-15	Naphthalene
GC-MS	EPA TO-15	Nitrobenzene
GC-MS	EPA TO-15	Nitropropane (2-)
GC-MS	EPA TO-15	N-Nitrosodimethylamine
GC-MS	EPA TO-15	N-Nitrosomorpholine
GC-MS	EPA TO-15	N-Nitroso-N-methylurea
GC-MS	EPA TO-15	Phenol
GC-MS	EPA TO-15	Phosgene
GC-MS	EPA TO-15	Propionaldehyde
GC-MS	EPA TO-15	Propylene
GC-MS	EPA TO-15	Propylene oxide
GC-MS	EPA TO-15	Propane sultone (1,3-)
GC-MS	EPA TO-15	Styrene
GC-MS	EPA TO-15	Styrene oxide
GC-MS	EPA TO-15	Trichlorobenzene (1,2,4-)
GC-MS	EPA TO-15	Trimethylbenzene (1,3,5-)
GC-MS	EPA TO-15	Trimethylbenzene (1,2,4-)
GC-MS	EPA TO-15	Trimethylpentane (2,2,4-)
GC-MS	EPA TO-15	Tert-butyl alcohol
GC-MS	EPA TO-15	Tetrachloroethane (1,1,2,2-)
GC-MS	EPA TO-15	Tetrachloroethene
GC-MS	EPA TO-15	Tetrahydrofuran
GC-MS	EPA TO-15	Toluene
GC-MS	EPA TO-15	Trichloroethane (1,1,1-)
GC-MS	EPA TO-15	Trichloroethane (1,1,2-)
GC-MS	EPA TO-15	Trichloroethene
GC-MS	EPA TO-15	Trichlorofluoromethane
GC-MS	EPA TO-15	Trichloro (1,1,2) trifluoroethane (1,2,2-)
GC-MS	EPA TO-15	Trifluoromethane
GC-MS	EPA TO-15	Vinyl acetate
GC-MS	EPA TO-15	Vinyl bromide
GC-MS	EPA TO-15	Vinyl chloride

Air		
Technology	**Method**	**Analyte**
GC-MS	EPA TO-15	Xylene (m-)
GC-MS	EPA TO-15	Xylene (o-)
GC-MS	EPA TO-15	Xylene (p-)
GC-MS	EPA TO-15	Xylenes (total)
GC-PID-FID	EPA TO-3	n-Butane
GC-PID-FID	EPA TO-3	Ethane
GC-PID-FID	EPA TO-3	Methane
GC-PID-FID	EPA TO-3	n-Pentane
GC-PID-FID	EPA TO-3	Propane
GC-PID-FID	EPA TO-3	Benzene
GC-PID-FID	EPA TO-3	Ethylbenzene
GC-PID-FID	EPA TO-3	Methyl Tertiary Butyl Ether
GC-PID-FID	EPA TO-3	n-Hexane
GC-PID-FID	EPA TO-3	Toluene
GC-PID-FID	EPA TO-3	Xylene (m,p-)
GC-PID-FID	EPA TO-3	Xylene (o-)
GC-PID-FID	EPA TO-3	Xylenes (total)
GC-PID-FID	EPA TO-3	Tertiary Butyl Alcohol
GC-PID-FID	EPA TO-3	Isopropyl Benzene (Cumene)
GC-PID-FID	EPA TO-3	Total Petroleum Hydrocarbons (C1-C4) as Methane
GC-PID-FID	EPA TO-3	Total Petroleum Hydrocarbons (C1-C4) as Propane
GC-PID-FID	EPA TO-3	Total Petroleum Hydrocarbons (C5-C10) as Pentane
GC-PID-FID	EPA TO-3	Total Petroleum Hydrocarbons (C5-C10) as Hexane
GC-PID-FID	EPA TO-3	Total Petroleum Hydrocarbons as Equivalent Pentane
GC-PID-FID	EPA TO-3	Total Petroleum Hydrocarbons as Equivalent Methane
GC-PID-FID	EPA TO-3	Total Petroleum Hydrocarbons as Equivalent Hexane

Potable Water		
Technology	**Method**	**Analyte**
ONPG-MUG (Colilert)	SM 9223 B-97	Total coliform/E.coli
Pour Plate	SM 9215 B-97	Heterotrophic bacteria
Nephelometry	EPA 180.1	Turbidity
Automated Cd Reduction	EPA 353.2	Nitrate
Spectrophotometry	SM 4500-NO2 B-11	Nitrite
Spectrophotometry, Distill,	EPA 335.4	Cyanide

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Potable Water		
Technology	**Method**	**Analyte**
Semi Automated		
Gravimetry	SM 2540 C-11	Total dissolved solids (TDS)
Titrimetry, EDTA	SM 2340 C-11	Total Hardness
Electrometric Titrimetry	SM 2320 B-11	Alkalinity
Automated Phenate	SM 4500-NH3 G-11	Ammonia
Platinum-Cobalt	SM 2120 B-11	Color
Methylene Blue	SM 5540 C-11	Foaming agents
Conductance	SM 2510 B-11	Conductivity
Molybdosilicate	SM 4500-Si D-11	Silica
Colorimetry	SM 4500-P E-11	Orthophosphate
Combustion/IR	SM 5310 B-11	Total organic carbon (TOC)
Pyrolysis, Titrimetry	SM 5320 B-11	Total organic halides (TOX)
Ion Chromatography	EPA 300.0	Chloride
Ion Chromatography	EPA 300.0	Fluoride
Ion Chromatography	EPA 300.0	Sulfate
Ion Chromatography	EPA 314.0	Perchlorate
Electrometric	SM 4500 H B-11	pH
ICP	EPA 200.7	Aluminum
ICP	EPA 200.7	Barium
ICP	EPA 200.7	Beryllium
ICP	EPA 200.7	Cadmium
ICP	EPA 200.7	Calcium
ICP	EPA 200.7	Chromium
ICP	EPA 200.7	Copper
ICP	EPA 200.7	Iron
ICP	EPA 200.7	Magnesium
ICP	EPA 200.7	Manganese
ICP	EPA 200.7	Nickel
ICP	EPA 200.7	Silica
ICP	EPA 200.7	Silver
ICP	EPA 200.7	Sodium
ICP-Calculation	EPA 200.7	Total Hardness
ICP	EPA 200.7	Zinc
Manual Cold Vapor AA	EPA 245.1	Mercury
ICP-MS	EPA 200.8	Aluminum

Potable Water		
Technology	**Method**	**Analyte**
ICP-MS	EPA 200.8	Antimony
ICP-MS	EPA 200.8	Arsenic
ICP-MS	EPA 200.8	Barium
ICP-MS	EPA 200.8	Beryllium
ICP-MS	EPA 200.8	Cadmium
ICP-MS	EPA 200.8	Chromium
ICP-MS	EPA 200.8	Copper
ICP-MS	EPA 200.8	Lead
ICP-MS	EPA 200.8	Manganese
ICP-MS	EPA 200.8	Nickel
ICP-MS	EPA 200.8	Selenium
ICP-MS	EPA 200.8	Silver
ICP-MS	EPA 200.8	Thallium
ICP-MS	EPA 200.8	Zinc
GC-ECD	EPA 504.1	1,2-Dibromoethane (EDB)
GC-ECD	EPA 504.1	1,2-Dibromo-3-chloropropane (EDCP)
GC-ECD	EPA 504.1	1,2,3-Trichloropropane
GC-MS	EPA 524.2	Bromoform
GC-MS	EPA 524.2	Chloroform
GC-MS	EPA 524.2	Dibromochloromethane
GC-MS	EPA 524.2	Bromodichloromethane
GC-MS	EPA 524.2	Benzene
GC-MS	EPA 524.2	Carbon tetrachloride
GC-MS	EPA 524.2	Chlorobenzene
GC-MS	EPA 524.2	1,2-Dichlorobenzene
GC-MS	EPA 524.2	1,3-Dichlorobenzene
GC-MS	EPA 524.2	1,4-Dichlorobenzene
GC-MS	EPA 524.2	1,1-Dichloroethane
GC-MS	EPA 524.2	1,2-Dichloroethane
GC-MS	EPA 524.2	cis-1,2-Dichloroethene
GC-MS	EPA 524.2	trans-1,2-Dichloroethene
GC-MS	EPA 524.2	Methylene chloride
GC-MS	EPA 524.2	1,2-Dichloropropane
GC-MS	EPA 524.2	Ethylbenzene
GC-MS	EPA 524.2	Methyl tert-butyl ether

Potable Water		
Technology	**Method**	**Analyte**
GC-MS	EPA 524.2	Naphthalene
GC-MS	EPA 524.2	Styrene
GC-MS	EPA 524.2	1,1,2,2-Tetrachloroethene
GC-MS	EPA 524.2	Tetrachloroethene
GC-MS	EPA 524.2	1,1,1-Trichloroethane
GC-MS	EPA 524.2	Trichloroethene
GC-MS	EPA 524.2	Toluene
GC-MS	EPA 524.2	1,2,4-Trichlorobenzene
GC-MS	EPA 524.2	1,1-Dichloroethene
GC-MS	EPA 524.2	1,1,2-Trichloroethane
GC-MS	EPA 524.2	Vinyl chloride
GC-MS	EPA 524.2	Xylenes (total)
GC-MS	EPA 524.2	Bromobenzene
GC-MS	EPA 524.2	Bromochloromethane
GC-MS	EPA 524.2	Bromomethane
GC-MS	EPA 524.2	n-Butyl benzene
GC-MS	EPA 524.2	Sec-butylbenzene
GC-MS	EPA 524.2	Tert-butylbenzene
GC-MS	EPA 524.2	Chloroethane
GC-MS	EPA 524.2	Chloromethane
GC-MS	EPA 524.2	2-Chlorotoluene
GC-MS	EPA 524.2	4-Chlorotoluene
GC-MS	EPA 524.2	1,2-Dibromo-3-chloropropane
GC-MS	EPA 524.2	1,2-Dibromoethane (EDB)
GC-MS	EPA 524.2	Dibromomethane
GC-MS	EPA 524.2	Dichlorodifluoromethane
GC-MS	EPA 524.2	1,3-Dichloropropane
GC-MS	EPA 524.2	2,2-Dichloropropane
GC-MS	EPA 524.2	1,1-Dichloropropene
GC-MS	EPA 524.2	cis-1,3-Dichloropropene
GC-MS	EPA 524.2	trans-1,3-Dichloropropene
GC-MS	EPA 524.2	1,3-Hexachlorobutadiene
GC-MS	EPA 524.2	Isopropylbenzene
GC-MS	EPA 524.2	4-Isopropyltoluene
GC-MS	EPA 524.2	n-Propylbenzene

Potable Water		
Technology	**Method**	**Analyte**
GC-MS	EPA 524.2	1,1,1,2-Tetrachloroethane
GC-MS	EPA 524.2	1,2,3-Trichlorobenzene
GC-MS	EPA 524.2	Trichlorofluoromethane
GC-MS	EPA 524.2	1,2,3-Trichloropropane
GC-MS	EPA 524.2	1,2,4-Trimethylbenzene
GC-MS	EPA 524.2	1,3,5-Trimethylbenzene
GC-MS	EPA 524.2	Nitrobenzene
GC-MS	EPA 524.2	Acetone
GC-MS	EPA 524.2	Acrylonitrile
GC-MS	EPA 524.2	Allyl chloride
GC-MS	EPA 524.2	2-Butanone
GC-MS	EPA 524.2	Carbon disulfide
GC-MS	EPA 524.2	Chloroacetonitrile
GC-MS	EPA 524.2	1-Chlorobutane
GC-MS	EPA 524.2	trans-1,4-Dichloro-2-butene
GC-MS	EPA 524.2	1,1-Dichloropropanone
GC-MS	EPA 524.2	Diethyl ether (Ethyl ether)
GC-MS	EPA 524.2	Ethyl methacrylate
GC-MS	EPA 524.2	n-Hexane
GC-MS	EPA 524.2	Hexachloroethane
GC-MS	EPA 524.2	2-Hexanone
GC-MS	EPA 524.2	Methacrylonitrile
GC-MS	EPA 524.2	Methyl acrylate
GC-MS	EPA 524.2	Methyl iodide
GC-MS	EPA 524.2	Methyl methacrylate
GC-MS	EPA 524.2	4-methyl-2-Pentanone (MIBK)
GC-MS	EPA 524.2	2-Nitropropane
GC-MS	EPA 524.2	Pentachloroethane
GC-MS	EPA 524.2	Propionitrile
GC-MS	EPA 524.2	Tert-butyl alcohol
GC-MS	EPA 524.2	Tetrahydrofuran

Notes:

1) This laboratory offers commercial testing service.
2) (M) = modified.

Approved by: _____ Date: June 4, 2014

R. Douglas Leonard
Chief Technical Officer

Issued: 7/10/13 Revised: 1/2/14 Revised: 5/15/14 Revised: 6/4/14

ATTACHMENT I

COMMENT RESPONSE FORM

No.	Section	Comment	Response to Comment
		USEPA, Patricia Flores-Brown	
1	WS11, S7 p32; WS14, S14.8, p47; WS17, p63	The text states that it is assumed that the air samples will be collected over a 6 – 8 hour period (24-hour period if buildings are occupied by permanent residents). For commercial/industrial buildings, the recommended sampling interval is 8 hours to mimic the length of a typical workday. The recommended sampling interval for residential use is 24 hours. If the building to be sampled may become residential use in the future, it is recommended that the sampling interval be 24 hours in duration.	The two buildings in question are non-residential structures that are operated by a non-profit organization, with the first floors used primarily for meetings, group activities, and counseling. The second and third floors of the main building are offices that are used by full and part time employees/ volunteers. The two buildings are occupied 8 hours per day, Monday through Friday. Accordingly, text will be updated to indicate that the samples will be collected over an 8-hour period to mimic a typical workday.
2	WS11, S7, p32	The text states that sampling will consist of two rounds (separated by 1 to 3 months) of indoor air and ambient background air sampling at up to three readily available locations, including up to two basement structures and a background location. SAP Worksheet #14, Section 14.8, page 46, however, states that sampling will consist of two rounds of up to 11 samples each separated by roughly six months (e.g., October 20 and April 2015), and that air samples will be collected from sub-slab, indoor, and ambient background locations. The two sections have conflicting wording and need to be reconciled. EPA prefers that sub-slab, indoor and ambient air samples be collected in each of the buildings, and one of the sampling rounds should be performed during the winter heating season.	Report text in Worksheets #11 and #14 will be consistently revised to state the following: • Two rounds of sampling will be performed, with up to 14 samples collected per event. • Sampling rounds will be separated by 1-3 months, with every attempt made to collect both rounds of samples during the heating season. • Sub-slab, indoor, and ambient air samples will be collected according to the revised sampling approach presented in detail in Worksheet 17, and discussed in subsequent Comment responses.

3	WS17, p63	Text states that sampling will consist of two rounds (separated by six months: November 2014 and May 2015) of indoor air (16 locations), sub-slab locations (four locations) and two ambient background air sampling locations. The text is not clear as to how many subslab samples will be installed per building, nor does it specify the rationale of how the number of subslab samples was chosen. The number of subslab and indoor air samples in a building are normally chosen by the size of the building to provide adequate spatial coverage. Unless the buildings to be sampled are under 1,000 square feet or have an atypical construction, at least 3 subslab samples are recommended per building. SAP Worksheet #18 and Worksheet #20 may need to be updated to reflect any changes to the number of samples to be collected.	The text in Worksheet 17 was revised to indicate the number of air samples that will be collected as follows:
			• Main Building (>1,000 sq ft multi-story) – 10 locations
			  ○ 1 indoor air sample from sub-basement
			  ○ 2 indoor air samples from basement; 1 sample from each room
			  ○ 3 indoor air samples from the first floor; 1 sample each from two meeting rooms and the office
			  ○ 1 indoor air sample from the second floor
			  ○ 1 indoor air sample from the third floor
			  ○ 2 sub-slab air samples from the basement; one each from the radon vent pipe and one from a second vent pipe in the basement storage room.

No.	Section	Comment	Response to Comment

			• Outbuilding (<1,000 sq ft single story) – 3 locations
			  ○ 1 indoor air sample from first floor
			  ○ 2 subslab samples from beneath the first floor, one each from office and meeting room(building constructed on concrete slab)
			• Ambient Air – 1 sample from upwind location
			
			Text in Worksheets #18 and #20 will be revised accordingly to reflect these changes, as will associated text in the remainder of the report.

4	Att G	Attachment G contains the SOPs for ambient, indoor air, and subslab vapor sample collection. The SOP for at least the subslab samples should be replaced because it does not list procedures for leak testing of the subslab sampling port, uses 1 Liter canisters instead of 6 Liters, and it does not allow for an equilibration time of at least 2 hours.	The air sampling SOP will be revised to include documentation of leak testing of the subslab sampling port(s), to reflect the use of 6L summa canisters, and to discuss the required equilibration time prior to sample collection, consistent with the EPA OSWER draft VI guidance.
USEPA, Kathy Davies (Review of Revised and Original Worksheets)			
1	WS10, P5	Please explain the rationale behind the statement "It should be noted, however, that the dedicated pump used to sample EW-A8 did not work and the well was sampled using a three purge volume approach followed by a peristaltic pump, which may have affected the sampling result."	This statement was included to note that the sampling procedure in EW-A8 deviated from that used for the other sampled wells. Sentence will be removed from the text.
2	WS10, P6	The discharge from the pump and treat system should be added here.	The discharge line from the groundwater treatment system is discussed in the final bullet ("Other Locations") as a potential source for releasing PFCs into the environment. The GWETS effluent is already sampled as it leaves the treatment building, with results reported monthly as part of O&M.
3	WS10, P6	The point of discharge from the wastewater treatment plant into the creek and back into the surface water/groundwater system should be discussed.	See response to Comment 2. The text in this paragraph will be expanded to include a more comprehensive discussion of the treatment system discharge as a potential PFC source.
4	WS10, Fig 3	Please provide the basis for the solid line contours to the south of the runway.	The base-wide general groundwater contour maps were prepared for the PFC source evaluation report (Tetra Tech, 2014), and were constructed using monitoring well groundwater level information from historical investigations conducted at the site. The figure caption will be retitled to state that the figure is a general groundwater contour map, and the original source will be cited.

No.	Section	Comment	Response to Comment
5	WS10, Fig 4	Please provide the basis for the solid line contours in and to the south of Area B.	See response to Comment 4.
6	WS10, Fig 6,7	To appropriately evaluate the locations of new monitoring wells, please amend these figures or provide new figures depicting all locations with sampling data, both on and off the site. This information/figure should also be provided for Area B.	A comprehensive site-wide PFC sampling map will be prepared showing all on-site and offsite PFC sampling results, including those measured in private wells. Proposed new monitoring well locations and surface water, sediment, and soil sampling locations will be overlain on this map.
7	WS11, S2	What is of concern here? Surface runoff or groundwater discharge to surface water or both?	The primary concern is groundwater discharge to surface water. Accordingly, surface water sampling will be scheduled in the spring, several days after a rainfall event to maximize the potential for collecting surface water samples that include a groundwater discharge component. Text will be amended accordingly to state the primary concern and reflect the sampling approach. This information could be used for additional future well placement if necessary.
8	WS11, S3	The discharge point from the wastewater treatment should be added here as a potential source. Discharge points from other pumping wells (e.g. Area D) with PFC contamination should also be included.	See response to Comments 2 and 3. The proposed surface water and sediment sampling locations will be modified to include locations near the wastewater and treatment system discharge locations, including the Area D sump that discharges to the Area A stream.
9	WS11, S4	As previously noted above, the discharge point from the wastewater treatment plant and the discharge points from pumping wells with PFC contamination should also be addressed here.	See response to Comments 2, 3, and 8. Text in this section will be updated to reflect the new surface water sampling locations in the vicinity of the discharge locations.
10	WS11, S4	A figure needs to be provided with groundwater contours, and municipal wells, home wells and monitoring wells with positive detections of PFC so that the proposed new monitoring well locations can be evaluated. It does not appear that wells are located downgradient of Sites 1 and 8 in Area B. The basis for the new well depths of up to 100 feet bgs, as stated, should be provided.	See response to Comment 6. Shallow groundwater contours will be included on the comprehensive PFC detection figure. Proposed wells 2 and 3 are located downgradient of Sites 1 and 8 in Area C, and two surface water/sediment samples are proposed in the retention pond currently. New monitoring well depths will be based on several factors, including an evaluation of lithology during drilling, the depth of nearby monitoring/extraction/private well screens, and the regional strike and dip of the sandstone and mudstone units. Text in the report will be updated to indicate how monitoring well depths will be determined.
11	WS11, S5	Soil gas samples are not recommended for determining the potential for VI impacts in a nearby building. Please identify what is meant here by including soil gas samples.	Agree with comment. The outbuilding where soil gas samples were recommended is relatively small in size (<1,000 sq ft), and is completed on a concrete slab (e.g., no

No.	Section	Comment	Response to Comment
			basement). Text will be updated to indicate that two subslab samples will be collected from the ground floor of the outbuilding, one from each room.
12	WS14, S14.3	This worksheet should be updated to reflect the work identified in Revised Worksheet #11, modified as necessary by comments above and below. It is unclear as to why the wells are proposed to be screened across the bottom 10 feet of the borehole. Please provide an explanation as to why this decision making process deviates from that previously used at the site with borehole geophysics and packer sampling.	As noted in Comment 6, a comprehensive site-wide PFC sampling map will be prepared showing all on-site and offsite PFC sampling results, including those measured in private wells to assist with justifying the placement of new monitoring wells. As noted in Comment 10, new monitoring well depths will be based on several factors, including an evaluation of lithology during drilling, the depth of nearby monitoring/extraction/private well screens, and the regional dip of the sandstone and mudstone units. The objective of the RI is to identify an old, diffuse PFC plume, which is why the rigorous well installation procedures required for the original VOC RI are not necessary.
13	WS14, S14.5	It should be noted here that sampling will be conducted no sooner than 2 weeks after development. Groundwater sampling should be consistent with that previously used at the NAWC site: pumping rate should be just slightly less than yield; stabilization of field parameters is not 10% across the board, but differs from parameter to parameter, consistent with Region III guidance; a straight two hour cut-off is not appropriate – at least one well volume must be removed; and the well is never pumped dry – it should be pumped until the water level is brought down, allowed to recover, the process is repeated and then when sufficient recharge has taken place, a sample can then be taken.	Text will be updated to state that sampling will be conducted no sooner than two weeks after well development. Sampling procedures will be consistent with those identified in the current long-term monitoring sampling and analysis plan and modified slightly to take into account procedures necessary to minimize cross-contamination associated with PFCs.
14	WS14, S14.6	The basis for the locations should be provided. Concerns about overland run-off, groundwater discharge into surface water and discharge points from pumping wells with PFC contamination should all be identified.	The proposed surface water and sediment sampling locations will be modified to include locations near the wastewater and treatment system discharge locations. A rationale for the surface water locations will be provided in Worksheet 17.
15	WS14, S14.8	Indoor air samples should only be taken during the heating season.	Agree with comment and will amend text accordingly. Every attempt will be made to collect both rounds of VI sampling during the heating season.
16	WS17, Soil	Why will soil samples be collocated with monitoring well samples and not in locations of known or suspected use of PFCs?	Agree with comments. Text will be revised to state that soil samples will primarily be collected from areas that have known and/or suspected PFC use. Therefore, monitoring wells installed far from potential PFC source areas will not include collection of soil samples.

No.	Section	Comment	Response to Comment
17	WS17, Soil	Provide the criteria to be used in the field to determine the soil sample depths.	Text will be updated to show that one sample will be collected per 5 ft of unconsolidated soil at each proposed soil sampling location in the vicinity of potential PFC source areas.
18	WS17, SW	Please modify per comments above.	See response to Comment 14.
19	WS17, GW	Please provide information/figures as noted above so that proposed locations can be appropriately evaluated.	See response to Comments 6 and 12.
20	WS17	Two rounds of sampling are proposed to be performed separated by two months; the first in February 2015 and the second in April 2015. Samples should only be taken in the heating season.	Report text will be updated to state that two rounds of sampling will be performed, with up to 14 samples collected per event. Sampling rounds will be separated by 1-3 months, with every attempt made to collect both rounds of samples during the heating season.
21	WS17	Samples for VI should only be collected within the structure – indoor air and sub-slab sampling. No soil gas samples should be taken outside the structure.	See response to Comment 11.
		USEPA, QAO	
1	WS21	The Project Sampling SOP Reference Table incorporates the use of a peristaltic pump for groundwater sampling. However, Subsection 14.3 Groundwater Monitoring Well Installation and Development Procedures first sentence of the fifth paragraph reads, **"The drilling contractor will clear the borehole and well of any fluids or substances that interfere with the free flow of groundwater through the well screen using approved development methods, including surging (2-inch surge block), pumping with a downhole submersible pump (Grundfos or similar), and/or by air lifting."** Peristaltic pumps cause sample degassing, pH modifications and loss of Volatile Organic Compounds (VOCs). The device used to purge the well should also be used to sample the well. The use of a submersible pump (or other positive displacement pump) for well purging and sample collection is recommended.	Text in the "Equipment Type" column for groundwater sampling will be revised by removing the term "peristaltic pump" and replacing it with "submersible pump" per the SOP and consistent with the long-term monitoring sampling and analysis plan. Section 14.3 discusses the procedures for well development, and does not describe the procedures for groundwater sampling. It should be noted that no groundwater VOC sampling is proposed in this RI.
2	WS14, S14.3	Groundwater Monitoring Well Installation and Development Procedures second from the last sentence of the fourth paragraph of the QAPP reads, **"All drill cuttings are assumed to be non-hazardous Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)-generated waste."** It is strongly recommended that the waste derived from	Agree with comment. All waste generated during the field operations will be representatively sampled and analyzed to determine the hazard classification prior to transport offsite. All applicable text throughout the document will be updated accordingly to reflect this approach.

No.	Section	Comment	Response to Comment
		groundwater monitoring well installations as well as all other generated waste be properly characterized by collecting a composite sample from each clearly labeled drum and having each sample analyzed by a fixed-base lab for site related COCs. It should be noted that Subsection 14.9 Post-Sampling Decontamination of Equipment, Waste Characterization and Disposal reads, "**Waste generated during the field operations will be representatively sampled and analyzed to determine the hazard classification prior to transport offsite."** The later above quote is the proper procedure that should be followed and the two sections should be made to agree.	
3	WS14, S14.9	Subsection 14.9 Post-Sampling Decontamination of Equipment, Waste Characterization and Disposal reads, "**(2) Reassemble the equipment and place it on a clean surface and air dry on PFC-free plastic sheeting."** To avoid the potential for contamination of equipment, the PFC plastic material to be used (Polyethylene only) should be clearly stated.	Agree with comment. Text will be revised to state that polyethylene sheeting will be used.
4	WS27	Sample Custody Requirements Table first sentence of the second paragraph reads, **"The samples will be wrapped in bubble wrap to prevent breakage, placed in a cooler, and packed in ice."** To prevent contamination from melted ice and possibly from samples that may break in transit, it is recommended that samples are sealed in individual (PFC free) bags before being bubble wrapped and placed in the coolers for transport.	Agree with comments. Text will be updated to state that samples will be sealed in individual bags before being bubble-wrapped and placed in coolers for transport to minimize the potential for cross contamination.
5	EC and WS10	There is a contradiction with respect to Perfluorinated Compound (PFC) concentrations within Area C. The Executive Summary reads, **"Maximum detected concentrations within Area C monitoring and extraction wells were 2.6 µg/L for PFOA and 16 µg/L for PFOS, both of which were detected in monitoring well OB-11."** While SAP Worksheet #10 – Problem Definition of the SAP reads, **"Maximum detected concentrations within Area C were 2.2 µg/L for PFOA (well EW-C19) and 1.7 µg/L for PFOS (well DG-14)."** The two sections should be made to agree with respect to the correct found concentrations.	Agree with comments. Text in the executive summary and in Worksheet #10 will be updated for consistency to state that the highest concentrations of PFOA were observed in OB-11 (2.6 µg /L), OB-13 (2 µg /L), and EW-C16 (1.8 µg/L), and the highest concentrations of PFOS were observed in OB-11 (16 J µg /L), OB-13 (6.5 µg /L), and EW-C16 (3.2 µg/L).
6	WS28, Table 28-2 and 28-3	Precision and Accuracy for Surface Water Samples/Air Samples with respect to Chlorinated Volatile Organic Compounds (CVOCs) lists the Project Relative Percent Difference (RPD) and the acceptable percent recovery range. However, when the Project	The information contained in Worksheet #28 was supplied by the ELAP-certified laboratory, and is consistent with information provided in previously approved UFP-SAPs. Neither the laboratory nor Battelle personnel are aware of

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		Relative Percent Difference (RPD) is added to the minimum percent recovery or subtracted from the maximum percent recovery the total does not equal 100 percent (e.g., Carbon Tetrachloride Precision (%RPD) is 23, but the Accuracy MS/MSD % recovery range is 76-136).	guidelines that require the RPD plus the minimum recovery and the RPD minus the maximum recovery to be equal to 100.
7	WS11, S11.7	Develop the detailed Plan for Obtaining Data under the header Study Question 2 (VI Evaluation) next to last sentence of the final paragraph of the QAPP reads, **"Sampling will consist of two rounds (separated by 1 to 3 months) of indoor air and ambient background air sampling at up to three readily available locations, including up to two basement structures and a background location."** It is strongly recommended that sampling for possible Vapor Intrusion (VI) of site related COCs be conducted with enough time in between sampling events to account for the seasonal variations that occur with respect to indoor air COC concentrations (e.g., Summer and Winter). It should be noted that Subsection 14.8 Air Sampling Procedures second sentence of the QAPP reads, **"Sampling will consist of two rounds of up to 11 samples each separated by roughly six months (e.g., October 2014 and April 2015)."** The two subsections quoted should be made to agree.	Per the EPA's VI sampling expert (See Comment 2 from Patricia Flores-Brown) and EPAs hydrogeologist (See Comments 15 and 20 from Kathy Davies), every attempt will be made perform both rounds of VI sampling during the heating season. Text throughout the document regarding VI sampling will be made consistent to reflect the following: • Two rounds of sampling will be performed, with up to 14 samples collected per event. • Sampling rounds will be separated by 1-3 months, with every attempt made to collect both rounds of samples during the heating season. • Sub-slab, indoor, and ambient air samples will be collected according to the revised sampling approach presented in detail in Worksheet 17.
8	WS22	Field Equipment Calibration, Maintenance, Testing, and Inspection Table lists the use of a Photovac Micro FID and MultiRAE Plus PID or equivalent (for measuring organic vapors during soil sampling). Each device measures in the part per million range, but the quantitation limits for site related COCs are in the part per billion range. The use of field equipment (e.g., ppbRAE 3000) that is capable of measurements in the part per billion range is strongly recommended. It is recommended that each piece of equipment used to measure Chlorinated Volatile Organic Compound (CVOC) be calibrated using a 10ppb standard and an activated charcoal canister to zero the device. All calibration sources used for field equipment should be listed in the field logbook.	It should be noted that PFCs are not VOCs, and will not be detected by a PID/FID. Also note that at Areas A, C, and D, the PFC plume and VOC plume are not co-located. The FID/PID will be used to screen soils for VOCs for health and safety concerns associated with sample handling by field personnel. Therefore, field screening equipment capable of measurements in the ppm range will be sufficient for this study. Calibration will be performed per manufacturer instrument specifications (calibration ranges ± 10% of standard gasses).
9	Gen	It is the reviewers recommendation that a Quality Control (QC) standard, at or below the lowest target analyte reporting limit for site COCs in soil be used to demonstrate the field equipment's ability to effectively be used as a field screening device. The QC	See response to Comment 8. Calibration will be performed at the beginning and end of each day of field sampling during borehole completion per manufacturer instrument specifications (calibration ranges ± 10% of standard gasses)

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		should be analyzed using the field screening equipment after calibration, but before any field samples are screened and at the end of the daily sample screening sequence. The QC results should be recorded in the field logbook.	as outlined in Worksheet 22.
10	Gen	The use of a submersible pump (or other positive displacement pump) for well purging and sample collection is strongly recommended.	See response to Comment 1.
		USEPA, Sarah Kloss	
1	WS10, p22, P2	I am also slightly confused because although the analysis will report these 6 PFCs, the investigations have really been focused on PFOS/PFOA. If we are truly including these other PFCs as part of the investigation, we should describe possible sources.	Per the DON policy memorandum on PFCs issued on October 21, 2014 and the NAVFAC PFC guidance document released January 29, 2015, analysis for only 2 PFCs (PFOS and PFOA) is required, as these are the only 2 PFCs for which a USEPA provisional health advisory (PHA) value has been developed. The analysis of the remaining 4 PFCs is being performed (a) to be consistent with measurement of six PFCs as part of UCMR3 for supply wells or for EPA analysis of private wells, and (b) for informational purposes to facilitate design of a future remedial strategy for treating PFCs in groundwater. Text will be revised accordingly to better state this approach.
2	WS10, p22, P5	Should clarify that this SAP focuses on likely sources in Area C, PFC investigations for Areas A/D are forthcoming. Also need to decide about south of the runway.	The remedial investigation described in the UFP-SAP has been revised to include all potential PFC source areas at the former NAWC Warminster, as identified in the evaluation of potential sources of PFCs (Tetra Tech, 2014).
3	WS10, p22, P5	What was the removal based on? What kind of waste was disposed of at Site 4?	Site 4 was used as a landfill that was composed of several trenches. Materials disposed of in the trenches include non-industrial solid waste, paints, waste oils, construction debris, solvents, and sewer sludge. The site was in use from 1966 to 1973, and the landfill was excavated and all wastes removed in 1996. A description of the Site 4 activities is included earlier in Worksheet #10.
4	WS10, p23, P2	"PHA" should read "provisional HALs" throughout the documents. The acronym "HALs" would be consistent without fact sheets.	The reference to the criteria will be changed to "PHA value" throughout the report, consistent with the EPA report that documents the development of the criteria.
5	WS10, p23, P2	Should be 0.2 not 0.20.	Agree with comment. All references to the PHA values will be revised as necessary to include one significant digit.
6	WS10, Fig	This figure should also include the NAWC boundary.	Agree with comment. The former NAWC Warminster site

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	2		boundary will be included on the figure.
7	WS11, p28, S2, GW	While this may define the boundaries for action, we should step out to a lower number to ensure that we are fully capturing the areas where we need to take action, and accounting for variability. Section 5 implies that we are actually trying to define the extent at detectable levels.	Agree with comment. The text in this Section and in Section 5 will be revised to include the following questions. • What are the concentrations of PFCs in groundwater? • What and where are the source(s) of PFCs in groundwater? • What is the extent of PFC concentrations in groundwater exceeding the EPA PHA values?
8	WS11, p31, S5, Q1B	Are you referring to the HALs? Detectable levels? If PFC concentrations are below detectable levels, I would agree action is not warranted; however, the upgradient argument is not well explained. If there is a shallow groundwater divide on-site, I am not sure how there could be an upgradient off-site source of PFCs in groundwater. I would delete the reference to upgradient sources in this section.	See response to Comment 7. Text will be revised to state that the extent of PFC contamination will be defined by the extent above EPA PHA values. All references to upgradient concentrations/sources will be removed, but text will be added to explain that upgradient locations are still within the boundary of the former NAWC Warminster.
9	WS11, p32, S7, Q1A	Again, the reference to upgradient is confusing, particularly for boundary wells. If the shallow groundwater is generally flowing radially from the runway, I am not sure how there could be an upgradient source. For off-site contamination, the Navy would have to show that the PFC contamination is coming from another source.	See response to Comment 8.
10	WS1, p32, S7, Q2	Why is subslab not included?	The report has been revised to include subslab VI sampling. Text throughout the document regarding VI sampling will be made consistent to reflect the following: • Two rounds of sampling will be performed, with up to 14 samples collected per event. • Sampling rounds will be separated by 1-3 months, with every attempt made to collect both rounds of samples during the heating season. • Sub-slab, indoor, and ambient air samples will be collected according to the revised sampling approach presented in detail in Worksheet 17.
11	WS14, p42, S14.2	Do we have data to support that decontamination is possible? The SOP mentions decontamination procedures, but it is not clear how effective they are.	All sampling will be performed by an experienced field crew who has previously performed PFC sampling at the site and met pre-established QA/QC requirements. Decontamination procedures are discussed in Section 14.10 of Worksheet #14. The comprehensive QA/QC program established for this

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			UFP-SAP will identify any issues associated with potential cross-contamination.
12	WS14, p44, S14.4	What types of field screening will be used to select PFC sampling locations?	It should be noted that PFCs are not VOCs, and will not be detected by a PID/FID. Currently, there are no PFC screening tools available. The FID/PID will be used to screen the soil for health and safety concerns associated with sample handling by field personnel. Soil sampling locations will be collocated with monitoring wells installed in potential PFC source areas, as identified during the PFC source evaluation. At least one soil sample will be collected per 5 ft of unconsolidated soil per location within potential PFC source areas. Text will be updated accordingly to reflect this change.
13	WS17, p63, P2	Dates are not consistent with Section 14.8.	As noted in Comment 10, VI sampling rounds will be separated by 1-3 months, with every attempt made to collect both rounds of samples during the heating season. All references to actual dates will be removed.
		USEPA, Dawn Ioven	
1	WS11, p31, Q2	Ambient air conditions do not impact subslab concentrations of VOCs. Consequently, if subslab levels exceed risk-based screening criteria, further evaluation is warranted, irrespective of ambient bg concentrations.	Agree with comment. The ambient air concentrations are being collected for comparison to indoor air samples. Text will be revised to state that if subslab samples exceed risk-based screening criteria, further evaluation will be warranted.
2	WS11, p32, Q2	Why aren't all the chlorinated breakdown products of PCE proposed for inclusion in the VI study?	Breakdown products of PCE, with the exception of TCE, have not been observed in groundwater at levels above regulatory standards and therefore are not included in the study.
3	WS11, p32, Q2	Samples should be collected for a minimum of 8 hours under a commercial/industrial worker scenario, to reflect the number of hours an individual works.	The two buildings in question are non-residential structures that are operated by a non-profit organization, with the first floors used primarily for meetings, group activities, and counseling. The second and third floors of the main building are offices that are used by full and part time employees/ volunteers. The two buildings are occupied 8 hours per day, Monday through Friday. Accordingly, air samples will be collected for an 8 hour period from 9 am to 5 pm during the heating season to mimic the length of a typical workday. Accordingly, Text will be updated to indicate that the samples will be collected over an 8-hour period to mimic the

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			length of a typical workday.
4	WS14, p46, S14.8	This differs from the approach described in Section 7. These contradictory statements should be reconciled in the report.	Agree with comment. Text throughout the document regarding VI sampling will be made consistent to reflect the following: • Two rounds of sampling will be performed, with up to 14 samples collected per event. • Sampling rounds will be separated by 1-3 months, with every attempt made to collect both rounds of samples during the heating season. • Sub-slab, indoor, and ambient air samples will be collected according to the revised sampling approach presented in detail in Worksheet 17.
5	WS14, p47, S14.8	Please see my previous comment regarding sample collection time under a commercial/industrial exposure scenario.	See response to Comment 3.
6	WS17, p63	More detail should be provided regarding the rationale for sample placement and quantity.	Agree with comment. Additional detail regarding proposed monitoring well location, and location of soil, sediment, and surface water samples will be added to Worksheet 17. See response to Comment 4.
USGS, Ron Sloto			
1	WS11, p10, S4, P1	A sump inside a building is not a suitable sediment sampling location. Sumps are surface-drainage or groundwater-discharge points.	Agree with comment. Text will be revised to indicate that sediment samples will not be collected from the sumps.
2	WS11, p10, S4, P5	How and where "background levels" are determined should be described. I would assume that background levels would be determined by sampling wells outside of the boundary area described on page 9.	Text will be modified to state that the extent of PFC contamination will be defined by the spatial area in surface water, sediment, soil and groundwater with PFC concentrations above PHA values. All references to "background levels" will be removed.
3	Fig 1-4	The explanation ("legend") on figure 1-4 (page 12) is unreadable.	Figure 1-4 will be updated to include a legible legend.

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USEPA, Kathy Davies			
1	WS11 Figure 11	SAP Worksheet #11 Section 4 Surface water samples are shown in Figure 11. It is recommended that in further submissions the sampling point (blue) is a different color from the blue surface water feature, as the sampling points are difficult to discern.	Agree with comment. Surface water/sediment sampling location symbols will be larger in size and of a different color.
2	WS11 Section 4 Page 40	To better understand the distribution of contamination associated with wells which have concentrations above the PHAL, it is recommended that additional samples are taken a) in the intermittent stream to the west in proximity to the two closely spaced red dots; b) in the stream running west-northeast, north of the GWETS discharge point and immediately south of the red dot; and c) in the stream due east of the GWETS discharge point and presumably downgradient of the cluster of red dots north of Site 4 and the drainage area.	a) The elevated PFC concentrations in the wells on Ivy Street, and possibly within the drainage feature are not likely the result of transport of PFCs via surface drainage from the former NAWC. This conclusion is based on maps provided by Warminster Township and physical inspection of the topography. Three surface water/sediment sampling locations will be added in this area. b) It is agreed that additional sampling of the unnamed tributary north and immediately south of the GWETS discharge point is necessary. Six additional surface water/sediment sampling locations will be added in this area. c) It is not anticipated that sampling of the additional stream east of the discharge location will be necessary because it does not drain areas downgradient of Site 4.
3	WS11 Figure 12	Proposed groundwater monitoring locations (both existing and new) are depicted on Figure 12. Although it is very helpful to see the site holistically, It is exceeding difficult to evaluate the proposed locations as the scale of the figure is too small. It is recommended that additional figures, at larger scale and with the water elevation contours and well locations noted, are provided for each of the areas of concern (similar to Figs 6 and 7).	Figure 12 will be amended to show three inset boxes delineating the perimeter of additional figures (e.g., 12a, 12b, and 12c) that will be constructed to show the proposed monitoring well and groundwater sampling locations zoomed in on a larger scale.
4	WS11 Figure 13	Soil sampling locations are depicted on Figure 13. Please provide a rationale as to why the potential source area near Bldg 90 has not been targeted for	The absence of soil sampling locations near former Building 90 was an inadvertent omission. Soil sampling locations will be added on Figure 13 near Building 90 in the vicinity of the two

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		soil sampling.	new monitoring wells proposed at this location.
5	WS 14 Sect. 14.3 Page 57	SAP Worksheet #14 Section 14.3 has not been modified per the RTCs to discuss the basis for screening the bottom 10 feet of the borehole. More explicit criteria should be provided as to the basis for how the wells will be screened, in lieu of using standard techniques (i.e. geophysics and packer testing) in fractured rock.	The SAP text in Section 14 will identify/define shallow versus intermediate wells. Geophysical logging will be performed in borings that are installed at parks and in open space, but not for borings installed on private property because of the extended period of time required for the geophysical logging. The goal of this approach is to keep disruptions to a minimum while on private property. Text in Section 14 also will specify that screen intervals will be selected based on lithologic observations and/or results of the geophysical logging, with the goal of monitoring fractured intervals in the desired aquifer zones. The borehole of proposed well cluster 17 on Figure 12b will be logged and the intermediate interval will be screened within the same stratigraphic unit as the fire training area, although other sources of PFCs are likely present.
6	WS 14 Sect. 14.5 Page 59	Section 14. 5 has not been modified per the comments submitted and the RTCs regarding sampling protocol.	The second to last paragraph on Page 63 within Section 14.5 includes information discussed in the previous responses to comments regarding a two week equilibrium time for newly installed wells prior to sample collection.
7	WS 14 Sect. 14.9 Page 61	Section 14.9 should specify that the water is allowed to run 15 minutes prior to sample collection to ensure representative groundwater samples.	It is recommended that for the sake of consistency, the same "purging" time that was used by EPA for the previous private well sampling will be used during the private well sampling proposed in this SAP. Text will be updated accordingly. Also please note the Interagency Agreement (Navy/EPA) has been extended through FY16 so it is unlikely private wells will be sampled via this SAP.
8	WS17 Page 76	SAP Worksheet #17 The RTC indicated that a rationale for the proposed surface water locations will be provided in this worksheet. There is no rational provided here.	Section 17 will be updated to state that surface water samples will be collected from intermittent/permanent streams, catchment basins and surface water retention ponds, areas where overland runoff has been observed, areas of observed/suspected groundwater discharge, and from wastewater and treatment system discharge locations.